VOLUME 2

APPENDIX A

GLADYS McCALL SITE (CAMERON PARISH, LA)

IGT REVIEW OF PAST PRODUCTION DATA
AND
FINAL SITE REPORT

RESEARCH AND DEVELOPMENT FOR THE
GEOPRESSURED-GEOTHERMAL ENERGY PROGRAM

FLOW TESTS OF THE GLADYS McCALL WELL

Final Report for the Period October 1985-October 1990

Prepared by

INSTITUTE OF GAS TECHNOLOGY

for

EATON OPERATING COMPANY

IGT/EOC Subcontract
IGT/EOC-85-4

DOE Prime Contract
DE-AC07-85ID12578

April 1992

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Final Report for the Period October 1985-October 1990

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EXECUTIVE SUMMARY

This report pulls together the data from all of the geopressured-geothermal field research conducted at the Gladys McCall well. It includes testing performed by the prior prime contractor, Technadril-Fenix & Scisson, as well as work performed while the prime contractor was Eaton Operating Company (EOC) with the Institute of Gas Technology (IGT) as a subcontractor.

The U.S. Department of Energy (DOE) Gladys McCall well in Cameron Parish, Louisiana, was drilled in 1981 and subsequently tested as part of the DOE Geopressured-Geothermal Energy Program. The well produced geopressured brine containing dissolved natural gas from the Lower Miocene sands at a depth of 15,150 to 16,650 feet. More than 25 million barrels of brine and 727 million standard cubic feet of natural gas were produced in a series of flow tests between December 1982 and October 1987 at various brine flow rates up to 28,000 barrels per day. The well is now (1990) in a multiyear long-term pressure-buildup test.

Initial short-term flow tests for the Number 9 Sand found the permeability to be 67 to 85 md (millidarcies) for a brine volume of 85 to 170 million barrels. Initial short-term flow tests for the Number 8 Sand found a permeability of 113 to 132 md for a reservoir volume of 430 to 550 million barrels of brine. The long-term flow and buildup test of the Number 8 Sand found that the high-permeability reservoir connected to the wellbore (measured by the short-term flow test) was connected to a much larger, low-permeability reservoir. Numerical simulation of the flow and buildup tests required this large connected reservoir to have a volume of about 8 billion barrels (two cubic miles of reservoir rock) with effective permeabilities in the range of 0.2 to 20 md. Detailed chemical analysis of the brine and gas found the brine to be slightly undersaturated with gas at about 29 SCF/STB (standard cubic feet/stock tank barrel). The produced gas/brine ratio was invariant with production time and flow rate.

Calcium carbonate scale formation in the well tubing and separator equipment was a problem. During the first 2 years of production, scale formation was prevented in the surface equipment by injection of an inhibitor upstream of the choke. But scale had to be periodically removed from the production tubing with hydrochloric acid or prevented by limiting the flow rate to less than 15,000 barrels per day. Starting in 1985, scale formation in the production tubing was successfully prevented by injecting inhibitor "pills" directly into the reservoir.

Corrosion and/or erosion of surface piping and equipment, as well as disposal well tubing, was also significant. The biggest problem was in high-turbulance areas immediately downstream of chokes or separator level control valves. Choke life was greatly extended by cladding the tailpiece with stainless steel. Piping in turbulent areas downstream of the separators was replaced.

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FLOW TESTS OF THE GLADYS McCALL WELL THROUGH OCTOBER 1990

1.0. INTRODUCTION

The Gladys McCall well is one of the Design Wells tested in the Department of Energy's (DOE) Geopressured-Geothermal Energy Program. The objective of the program is to evaluate the geopressured-geothermal resource as a possible source of energy for the nation. The Gulf Coast geopressured-geothermal wells, such as the McCall well, produce hot brine and the hydrocarbons dissolved in the brine. The possible energy sources from these wells consist of the heat, pressure, and recoverable hydrocarbons. The McCall test focused on evaluating the reservoir response to production, mitigating operating problems such as scale formation, and determining the quantity and characteristics of the recoverable hydrocarbons.

This report focuses on the data obtained from the well-test program and the analysis of the data as performed by several organizations. The intent is to provide a summary of physical and chemical mechanisms involved in the testing of the Gladys McCall well and to provide information that may be useful for future production of other geopressured-geothermal wells. A report covering the test program from 1982 to 1985 was previously prepared by Technadril-Fenix & Scisson when they were the site operator.[17,18] This previous report sets forth the program objectives and describes the well drilling and facilities installation in detail; therefore these items are only briefly summarized in this report.

Exhibit 1.0-1 shows the location of the Gladys McCall well in southwestern Louisiana. The site is in the coastal marsh about 3 miles southeast of Grand Chenier, Cameron Parish, Louisiana. Access to the location is via a gravel road on a levee that intersects Highway 82 just past mile marker 68. The site is about 2 miles south of Highway 82 at the end of a gravel road on a pad of approximately 4 acres. The pad is comprised of shell fill (more than 1000 yards) and boards to elevate the pad surface above the water level of the marsh.

2.0. SUMMARY OF GEOLOGY

The geology of the site and surrounding area was originally described in terms of the Geopressured-Geothermal Program by Bebout and others connected with the Louisiana Geologic Survey.[1,10] The most recent summary, which brings together the work of the previous authors and adds the latest information, was prepared by C. J. John.[8]

Exhibit 2.0-1 shows a geologic structure map contoured at the top of the "A" sand in the prospect area. Exhibit 2.0-2 shows the figure presented by C. J. John that illustrates his interpretation that the reservoir was originally created from ancient rivers in meander channels.

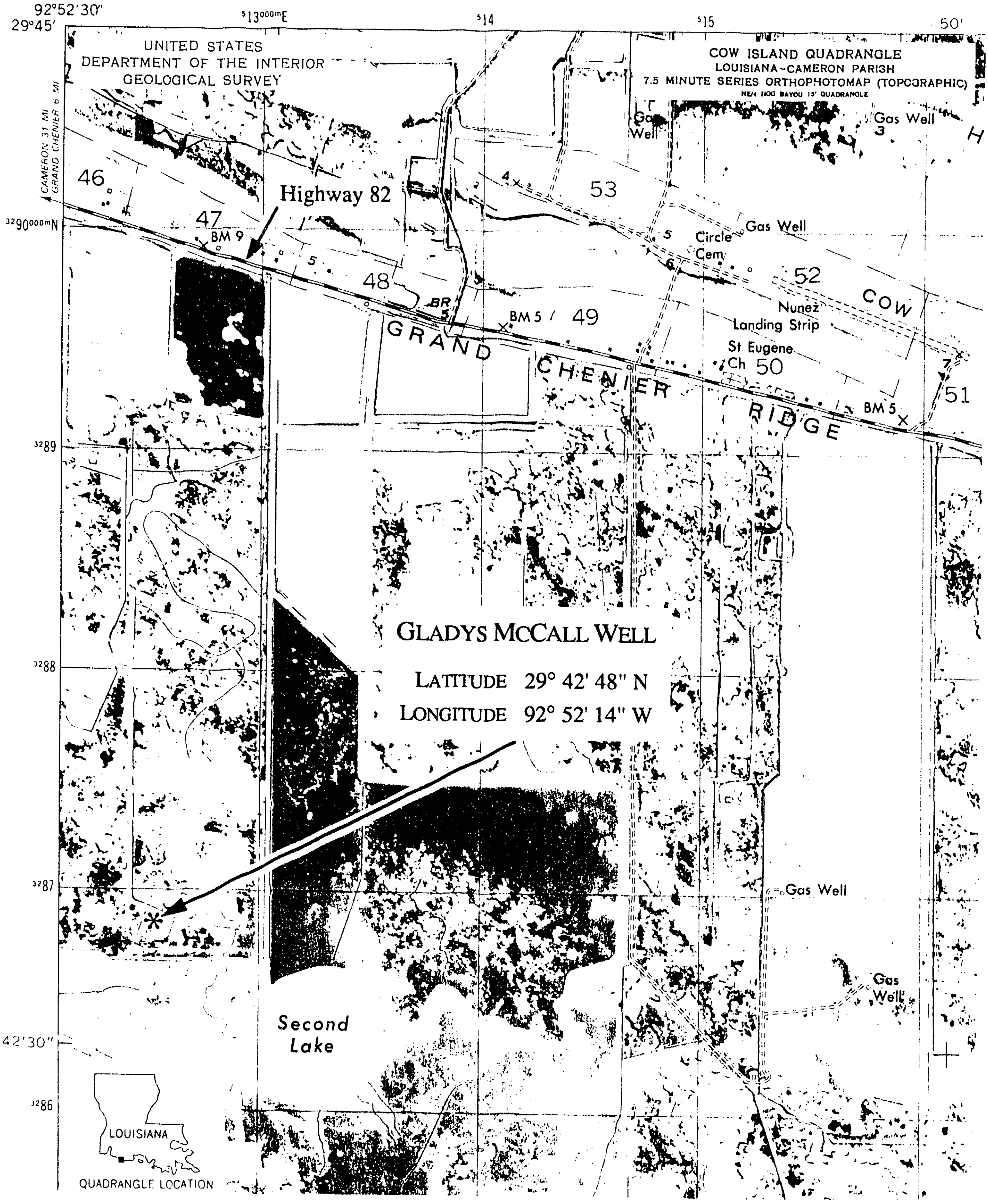


Exhibit 1.0-1. LOCATION OF THE DOE GLADYS McCALL WELL IN CAMERON PARISH, LOUISIANA

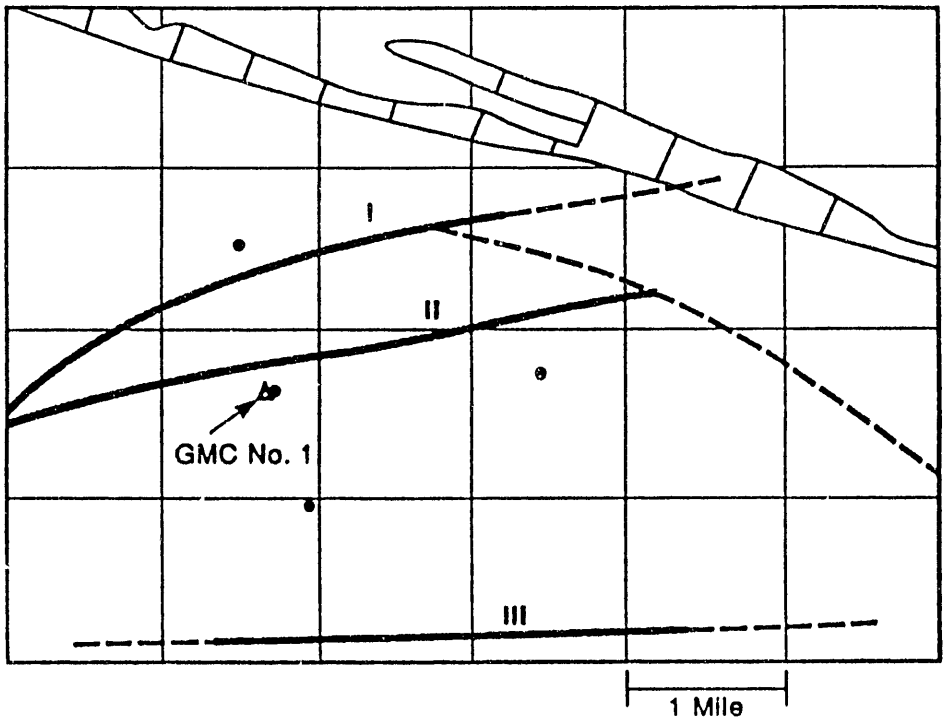


Exhibit 2.0-1. STRUCTURE MAP SHOWING MAJOR GROWTH FAULTS IN THE AREA OF THE GLADYS McCALL WELL

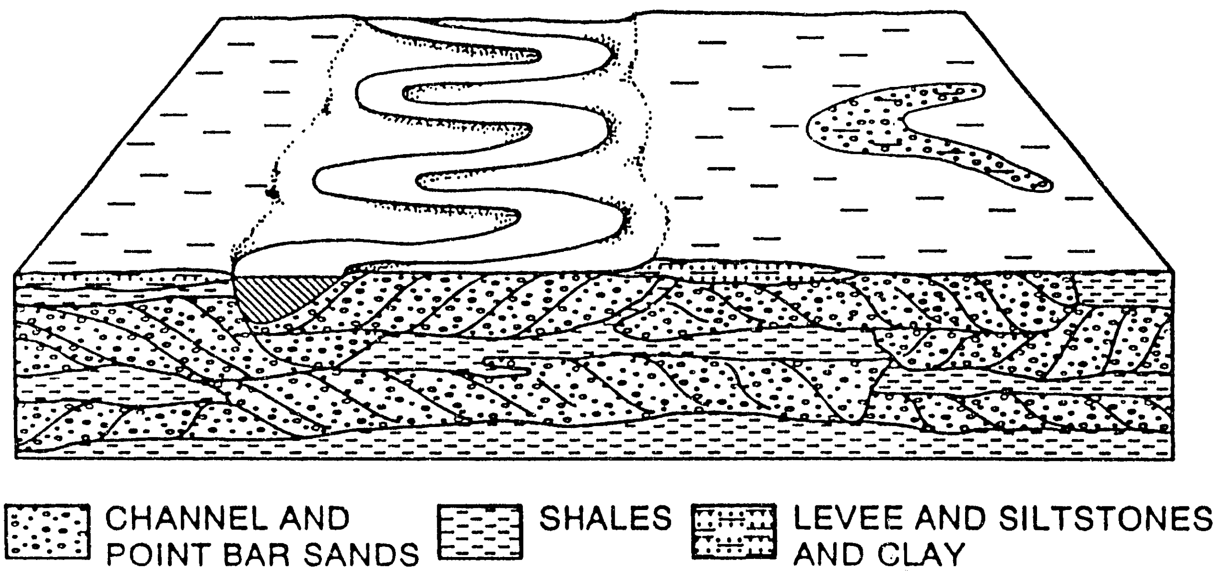


Exhibit 2.0-2. SCHEMATIC DIAGRAM SHOWING THE MECHANISM FOR FORMATION OF THE SAND AND SHALE SECTIONS IN THE AREA OF THE GLADYS McCALL WELL

The weight of the depositions over time causes the system to subside but continue to grow vertically as additional sediments are deposited over the subsiding layers. Because the reservoir rock consists of shales interspersed with channel and point bar sands, it is difficult to tell from the wireline logs which sands are interconnected. John speculates that, even though the wireline electric logs show the sands to be separate, they may behave as an interconnected single sand body for brine production.

Below 11,000 feet the shale and sand sections are quite massive. Exhibit 2.0-3 shows eleven potentially brine-productive zones below the top of geopressure at about 14,500 feet. The wireline log indicates almost 1100 feet of net sand. The reservoir is structurally controlled by major growth faults that are subparallel to the Gulf of Mexico. Starting inland and moving toward the Gulf, the fault blocks are successively down-dropped toward the coast. The growth faults are generally near-vertical at the surface, but then curve toward the coast and become sub-horizontal at great depths. The down-dropping of the fault block also rotates the block, and at the McCall site the target sands dip northward at angles of 10 to 30 degrees. One fault that cuts the Gladys McCall well at 16,350 feet may be a sealing or partial sealing fault that defines the northern boundary of the reservoir.

The exact geologic structure of the reservoir is not well defined because of the sparseness of other wells in the area drilled deep enough to correlate with the McCall well. One correlation in the approximate north-south direction, however, was done using one well north of the McCall well and two wells south of the McCall well. Good correlation of the sands was found, along with some missing sections due to faulting. Correlation in the east-west direction was not possible because of the lack of other wells in this direction. The faults in the area were located primarily by use of available seismic prospect data.

The available geological information is insufficient to accurately describe the reservoir size or shape. From the general structure of the area where the growth faults tend to be subparallel to the Gulf of Mexico, it is suspected that the reservoir would be comprised of the sandstone sections trapped between east-west trending faults. This would possibly render the reservoir shorter in the north-south direction and longer in the east-west direction, if the faults were sealing.

Whole cores were cut in the intervals from 15,167 to 15179 feet, 15,179 to 15,198 feet, and 15,348 to 15,375 feet. Twenty-eight sidewall core samples were obtained in the interval from 14,570 to 16,455 feet. The analysis of the core samples by Core Laboratories, Inc.,[6] (shown in Appendix A) found the reservoir sandstones to be a very fine-grained composition of about 90% to 94% quartz, 5% to 7% feldspar, with the remainder being minor amounts of clay, calcite, and other minerals. The studies were made using petrographic thin sections, X-ray diffraction, and

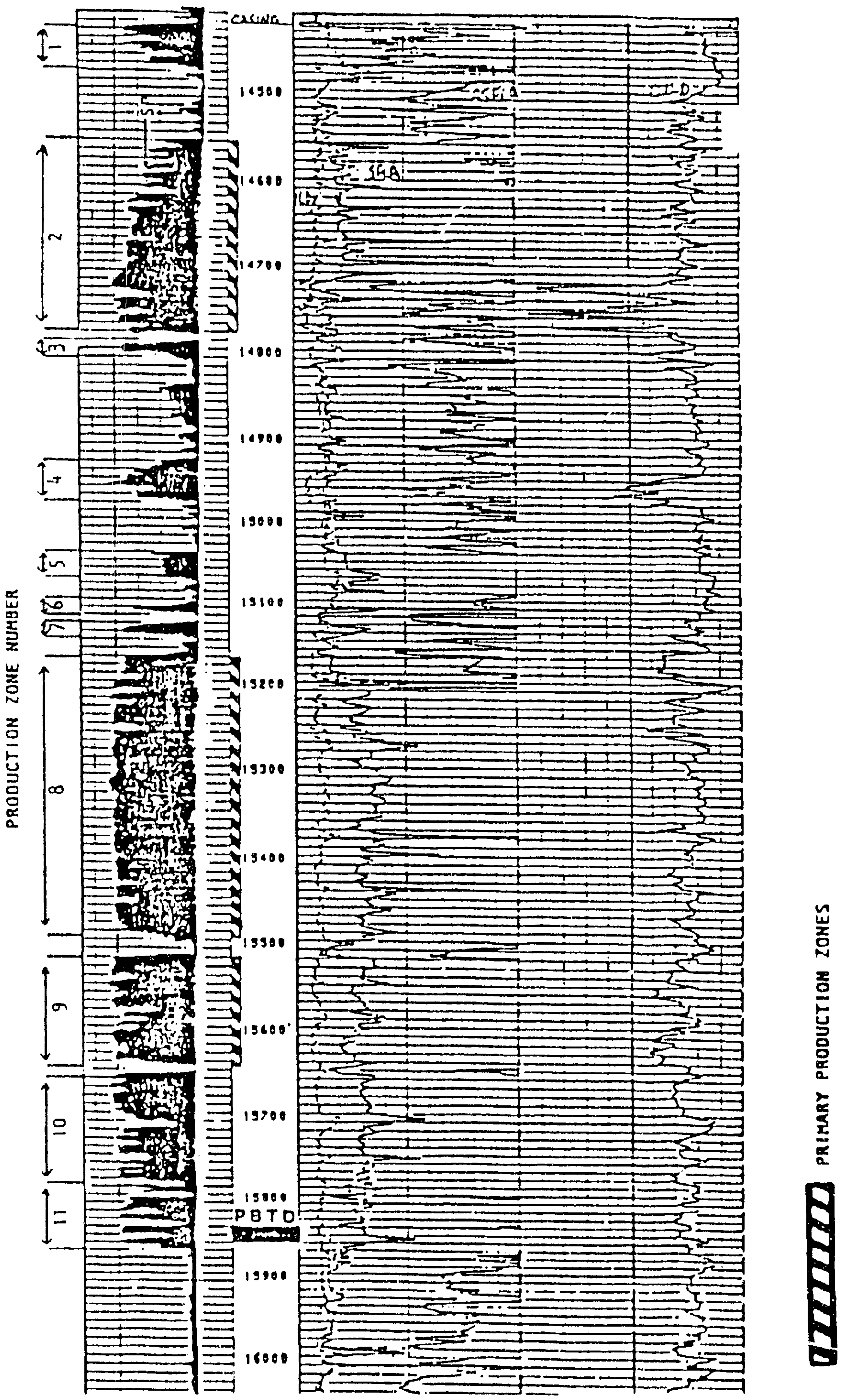


Exhibit 2.0-3. PORTION OF WIRELINE LOG FOR THE GLADYS McCALL WELL SHOWING POTENTIAL PRODUCTION ZONES

a scanning electron microscope. Oil content was found to range from 0% to 5.4% of the pore space. Conventional air permeability estimations on the sidewall samples ranged between 10 and 415 md. Conventional analysis of the cores found the average porosity to be 15.4% and the average permeability to range from 74 to 126 md depending on the method used to do the averaging.[17] Additional core studies by Terra Tek found effective porosities in the range of 17% to 20%.

Exhibit 2.0-4 shows the subsurface temperature as measured in five different wells in the area of the Gladys McCall well and the temperature measured in the McCall well just before perforation. In the hydropressured strata above 14,500 feet, the thermal gradient is 1.5°F per 100 feet. In the geopressured region below 14,500 feet, the thermal gradient is about 2.07°F per 100 feet.

3.0. SUMMARY OF DRILLING

DOE field activity at the Gladys McCall site began in March 1978 with the decision to attempt reentry of the Buttes Gas & Oil/Getty Oil Company No. 1 Gladys McCall well. This well was selected from several alternatives in the area because of the thick Miocene sand (800 gross feet) in the geopressured interval between 15,050 and 16,600 feet. The access road and site were prepared during the summer, and reentry operations were started in September 1978. Attempts to reenter the old well were unsuccessful. When the well was previously plugged, explosives were used to remove some of the casing. Attempts to drill through these damaged points resulted in the bit sidetracking out of the old wellbore. The well was finally replugged in December 1978.[6]

After the failure to reenter the old well, the decision was made to drill a new well at the same site. A drilling contract was awarded and drilling of the new test well started in May 1981. The new Gladys McCall well was drilled to 16,510 feet, plugged back to 15,958 feet, and completed in September 1981. A 5-inch production-tubing string was installed to a depth of 13,933 feet through a polished-bore receptacle packer at 13,921 feet in January 1982. Exhibit 3.0-1 shows a schematic cross section of the well as it was completed. During drilling, a dozen wireline logging runs were made to obtain 30 logs, and whole cores were cut in the intervals from 15,167 to 15179 feet, 15,179 to 15,198 feet, and 15,348 to 15375 feet.

The original well, which had been unsuccessfully reentered as a production well, was again reentered in November 1981. The well was cleaned out to a depth of 3514 feet and recompleted as a disposal well in December 1981. Exhibit 3.0-2 shows a schematic cross section of the disposal well as it was completed. This well was then renamed as the T-F&S/DOE Gladys McCall Salt Water Disposal Well No. 1. Four sands with a total thickness of 230 feet were perforated between 3050 and 3500 feet using a Schlumberger casing gun with four shots per foot of holes reported to be 0.91 inches in diameter.

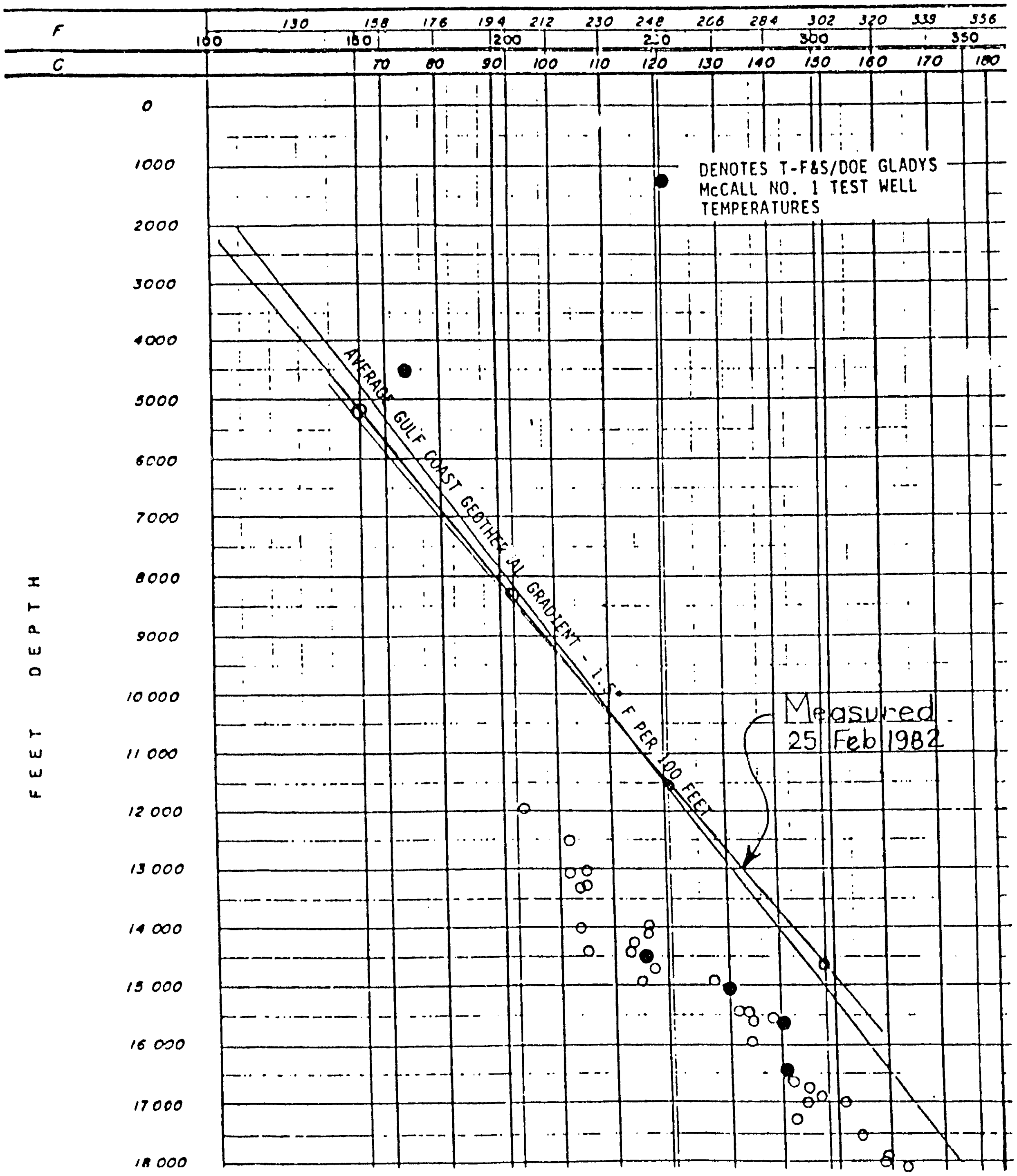
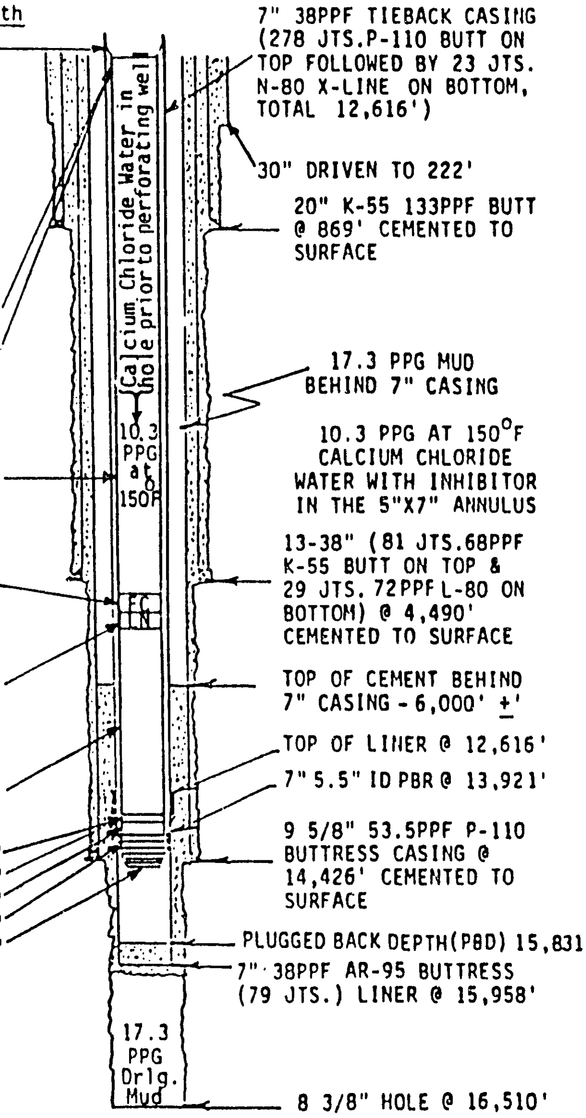


Exhibit 2.0-4. SUBSURFACE TEMPERATURES IN THE AREA OF THE GLADYS McCALL WELL

Material Description	Length	Setting Depth
Gray Tool Co. Tubing Hanger - 5" AB-TC-4S pin connection on bottom and 5 1/2" 8-Rd thread box connection on top for 5 1/2" 8-Rd lift joint	1.66'	1.66'
1-5" 18 ppf P-110 AB-TC-4S pup joint with modified V-150 coupling	14.10'	15.76'
1-5" ditto above	5.42'	21.18'
128-Joints 5" 18 ppf P-110 AB-TC-4S Range 3 tubing with modified V-150 couplings	5004.48'	5,025.66'
1-5" Otis Flow Coupling with AB-TC-4S double box connections	0.86'	5,026.52'
1-5" Otis Type "X" Landing Nipple with AB-TC-4S double pin connections	7.02'	5,033.54'
226 Joints 5" 18 ppf P-110 AB-TC-4S Range 3 tubing with modified V-150 couplings	8870.05'	13,903.59'
TIW Seal Assembly		
Fish Neck	0.99'	13,904.58'
Locator Sub	0.50'	13,905.08'
Blank Extension	18.90'	13,923.98'
6 Sections of Seals	8.57'	13,932.55'
Nose Piece	0.38'	13,932.93'



NOTE: TIW locator sub set down on the PBR and picked up and spaced out 16' above the PBR to allow for heat expansion of the 5" tubing.

All tubing and associated equipment measurements are from the 5" tubing hanger.

Casing lengths are as run (engineers tally).

DIAMETERS	ID	OD
Tubing Hanger	4.276"	8 5/8"
5" 18# Tubing	4.276"	5"
Tubing Couplings	4.276"	5.40"
Otis Flow Coupling	3.875"	5.40"
Otis Landing Nipple	3.688"	5.40"
TIW Seal Assembly	4.250"	5 15/32"
7" 38# Casing	5.920"	7"

COMPLETION
T-F&S/DOE GLADYS MC CALL NO. 1
CRAB LAKE FIELD
CAMERON PARISH, LOUISIANA

Exhibit 3.0-1. SCHEMATIC DIAGRAM OF GLADYS McCALL NO. 1 PRODUCTION WELL COMPLETION

MATERIAL DESCRIPTION	LENGTH	SETTING DEPTH
7"OD 23PPF N-80 BUTTRESS THRD. 50 JOINTS, RG. 3	2014.12'	2014.12'
CROSSOVER, 7" 23# BUTT BOX UP, 4" 10.9# 8 RD THRD PIN DOWN	0.80'	2014.92'
LOCATOR MANDREL, OTIS	0.87'	2015.79'
SEAL ASSEMBLY, OTIS	10.47'	2026.26'
MULE SHOE	1.88'	2028.14'

NOTE: OTIS LOCATOR MANDREL SPACED 3.06' ABOVE PACKER TO ALLOW FOR HEAT EXPANSION OF THE 7" TUBING.

ALL TUBING AND ASSOCIATED EQUIPMENT MEASUREMENTS ARE FROM THE TOP OF THE 10 3/4" CASINGHEAD FLANGE. LOGGING & PERFORATING DEPTHS FROM WIRE LINE MEASUREMENT PLUS RKB DATUM OF 32.02'.

DIAMETERS	ID	OD
7" 23# TUBING	6.241"	7"
CROSSOVER	3.50"	7"
LOCATOR MANDREL	3.50"	5.55"
SEAL ASSEMBLY	3.50"	4.95"
MULE SHOE	3.53"	4.54"
PACKER	5.00"	9.26"
SEALBORE EXTENSION	5.00"	6.26"

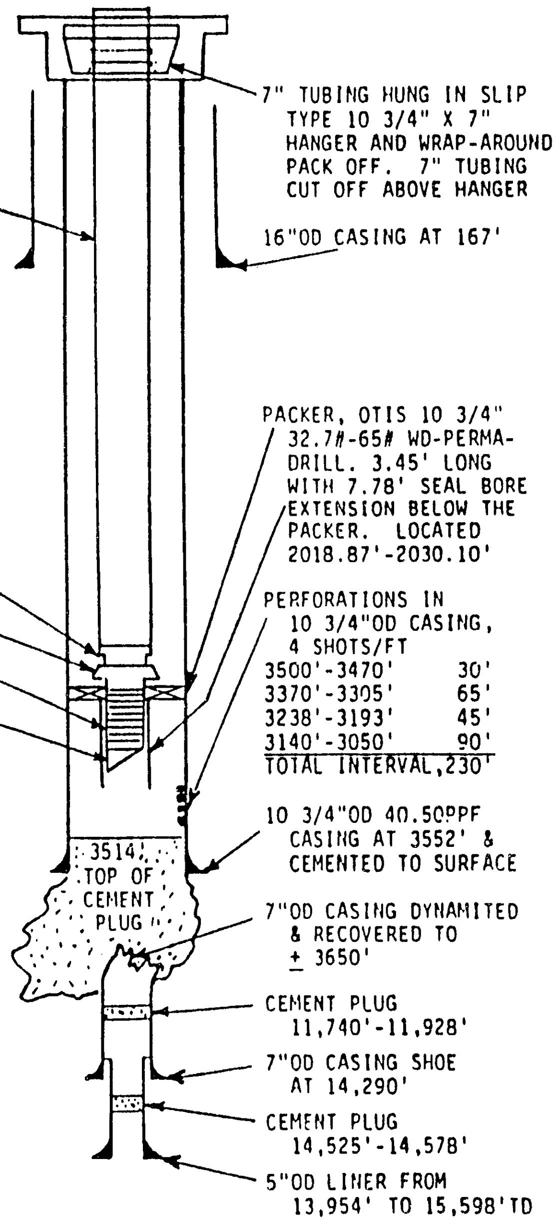


Exhibit 3.0-2. SCHEMATIC DIAGRAM OF THE GLADYS McCALL SALT WATER DISPOSAL WELL NO. 1 COMPLETION

The Number 9 Sand was initially perforated in the interval from 15,597 to 15,627 feet in February 1982 with four shots per foot using a 2-3/4 inch perforating gun and 11-gram charges. When a leak was found between the tubing and annulus, further perforation was delayed until workover activities were completed in December 1982. The additional intervals perforated in December 1982 were the 15,511 to 15,541-foot interval and the 15,567 to 15,627-foot interval in three runs using the same type of perforating gun as was previously used. This sand was tested and then plugged and abandoned.

Perforation of the Number 8 Sand was done in September 1983, after the Number 9 Sand had been tested and plugged off. The interval between 15,180 and 15,450 feet was perforated with eleven runs of the perforating gun. Welex 2-3/4 inch Sidewinder 11-gram SSB charges were used, with 1107 of the 1240 charges used in the gun successfully fired.

4.0. SURFACE TEST EQUIPMENT AND FACILITIES

Components of the wellhead are rated at 10,000 psi, while shut-in wellhead pressure was about 5500 psi. The wellhead assembly includes manually operated master valves above and below a hydraulically operated emergency shutdown valve. A kill valve ties a kill line into the wellhead between the hydraulically operated emergency shutdown valve and the upper master valve.

To accommodate the high brine flow rate through the wellhead and to control stresses, a block "Y" was installed on the wellhead that diverted the flow into two 45-degree heavy-walled flow loops. There is a swab valve for wireline operations above the "Y" block. The two flow loops made sweeping curves to the ground to another steel flow block that recombined the flow into a single stream before it entered the high-pressure horizontal pipe run. The produced fluids then passed through a block valve and a second emergency shutdown valve.

The brine flow rate was controlled by a Willis choke mounted in a block at the end of the high-pressure flow line about 50 feet away from the wellhead. Willis chokes operate by passing the fluid through off-axis holes in two tungsten-carbide disks that face each other. The upstream disk can be rotated to vary the alignment of the holes between the two disks. The degree of overlap of these holes determines the effective size of the opening through which the fluid must pass. Setting of the choke was accomplished manually using an external handle to rotate the internal yoke attached to the moveable disk. The carbide disks in the choke withstood the forces of the large pressure drop (several thousand psi) quite well. Immediately downstream of the choke, however, the intense turbulence of the fluid leaving the choke caused erosion of the interior pipe wall. This section of pipe was initially low-carbon steel but was subsequently clad with stainless steel. The stainless steel cladding had the metallurgical toughness to withstand the abrasive turbulence characteristic of the high-velocity brine exiting the choke.

Exhibit 4.0-1 is a schematic diagram of the surface processing facilities. The piping and valves used to carry brine flow were generally 6-inch diameter or larger, to accommodate rates up to 40,000 barrels per day (BPD). Equipment downstream of the choke was initially designed to operate at a pressure of 1290 psi and a temperature of 300°F. Brine from the choke originally went to one separator, but a second separator was operating in series with the first starting in 1984. The separators were of standard design -- with an oil weir, an internal diameter of 54 inches, and a length of 30 feet. The working-pressure rating of 1440 psi was downgraded to 1290 psi for operation at 300°F. Brine from the separators was filtered prior to injection into the disposal well.

The gas from the separator was cooled, dehydrated, and sold. Carbon dioxide was not removed because a sales contract was obtained that allowed up to 10% carbon dioxide in the gas. Some gas was occasionally flared on location because of compressor malfunction or other reasons when the gas could not be sent to the sales line. Detailed engineering drawings of the equipment are given in the Technadril-Fenix & Scisson report.[18]

Initially, there was only one separator in the system, but in July 1984 the second separator was added. The two separators operated in series. Gas was separated from the brine in the first separator, called the high-pressure separator, at pressures high enough to enter the gas into the sales line without further compression. The high-pressure separator operating pressure was typically 1000 psig. The brine then passed to the second separator, called the low-pressure separator, which was operated at a pressure dictated by either the carbon dioxide content of the sales gas or the pressure needed to drive brine down the disposal well. The low-pressure separator was typically controlled in the range of 400 to 500 psi. The second separator recovered the gas that came out of solution between 1000 and 500 psi. Gas from this separator had to be compressed back up to the sales-line pressure. The dissolved gas remaining in the brine after passing through the low-pressure separator went through the filter and then into the disposal well. The sales gas carbon dioxide criterion that influenced the operating pressures of the separators was that the carbon dioxide content of the gas sent to sales had to be less than 10%. The gas that came out of solution in the second separator contained roughly 15% carbon dioxide, whereas gas from the high-pressure separator contained only 8% carbon dioxide. The lower the low-pressure separator operating pressure, the higher the contribution of the high carbon dioxide fraction to the total gas. Lowering the pressure in the low-pressure separator recovers additional hydrocarbons -- but with a higher carbon dioxide content. Therefore the pressure in the second separator was maintained at a sufficient level to keep the commingled sales-gas carbon dioxide content below 10%.

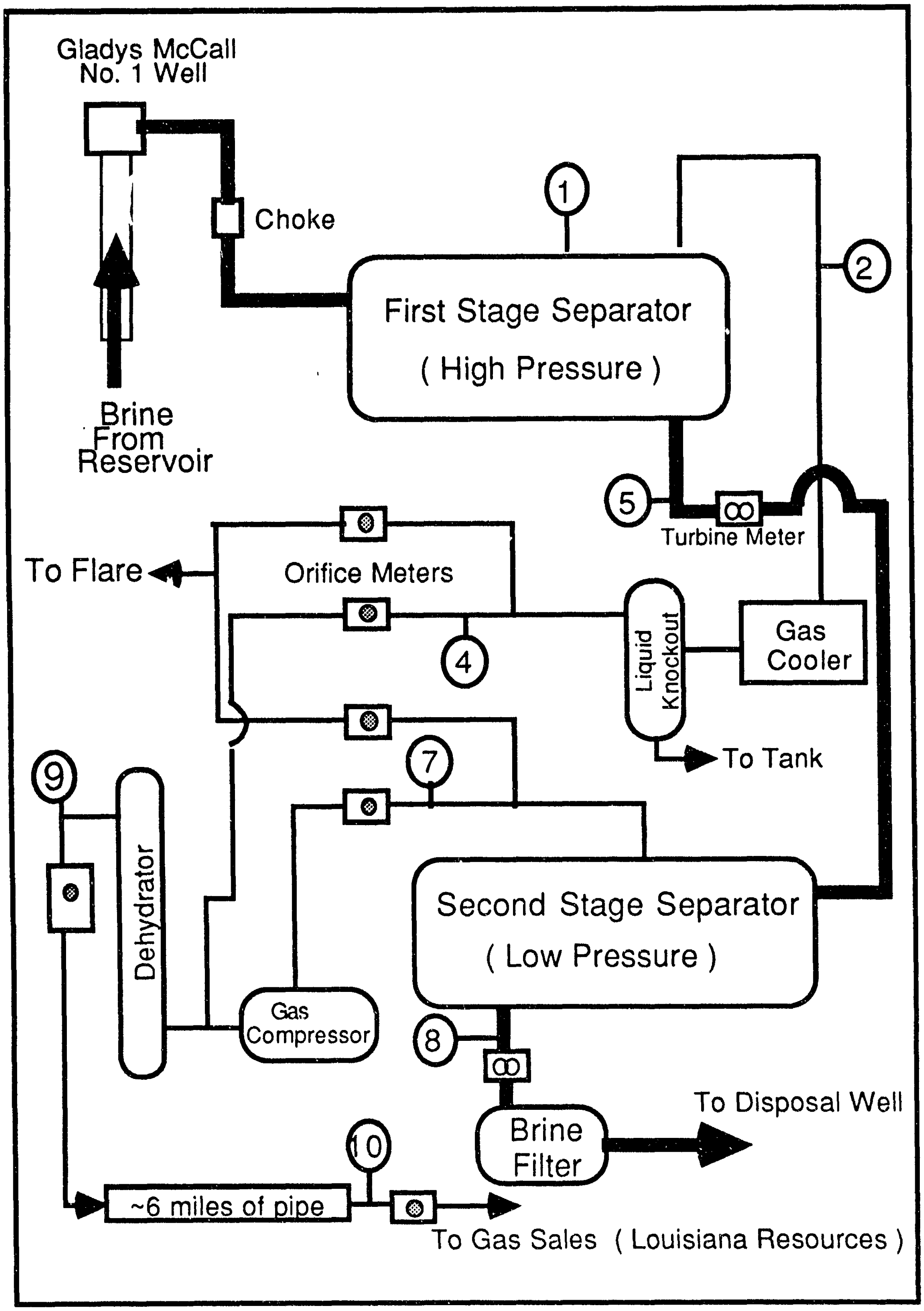


Exhibit 4.0-1. SCHEMATIC DIAGRAM OF THE GLADYS McCALL WELL
SURFACE GAS/BRINE PROCESSING FACILITIES

5.0. SAND 9 TESTING

5.1. Sand 9 Initial Production

The first short-term Sand 9 flow test occurred in December 1982 for the purpose of well cleanup and sampling. The reported gas/brine ratio was 25.56 SCF/STB of gas recovered by the separator and an additional 5.35 SCF/STB of gas still dissolved in the brine injected into the disposal well, for a total produced gas/brine ratio of 30.91 SCF/STB. The second flow test was a short-term reservoir limit test performed in April and May 1983. A total of 100,000 barrels of brine were produced during the 23.8-day duration of this second test. Data analysis suggested the reservoir was too small for long-term production, so the Sand 9 was plugged and abandoned.

Several samples of brine were taken during these flow tests and analyzed by various parties. A summary of the results of brine analyses are presented in Exhibit 5.1-1.

Exhibit 5.1-1. ANALYSIS OF BRINE FROM GLADYS McCALL NO. 9 SAND

Date	12/2/82	3/22/83	3/31/83
Alkalinity, as mg HCO_3/L	547	571	532
Calcium, mg/L	4,130	4,080	4,200
Chloride, mg/L	57,900	58,600	54,600
Dissolved Solids, mg/L	96,300	95,500	97,600
Hardness, as mg $CaCO_3$/L	12,000	13,700	11,400
Iron, mg/L	35	34	34
Silica, mg SiO_2/L	135	140	141
Specific Gravity	1.062		1.066
Sulfate, mg SO_4/L	<5	<5	<5
Sulfide, mg S/L	<1	<1	

These analyses indicated the brine had a significant capacity to produce calcium carbonate scale during long-term production. The brine was salty, containing roughly three times the total dissolved solids of seawater.

Samples of gas were also collected and analyzed. The results of these analyses are presented in Exhibit 5.1-2. These analyses pointed to a problem with marketing gas from these wells. Normal sales contracts for natural gas have stringent carbon dioxide concentration limits, generally specifying 2% or less carbon dioxide. The operator was able to obtain a sales-gas contract that

Exhibit 5.1-2. GAS CHROMATOGRAPHIC ANALYSIS

Sample Date	12/22/82[a]	3/23/83[b]
Mole Percent of:		
Carbon Dioxide	9.50	8.94
Nitrogen	0.28	0.26
Methane	86.91	86.93
Ethane	2.45	2.43
Propane	0.56	0.55
iso-Butane	0.09	0.08
n-Butane	0.09	0.08
iso-Pentane	0.02	0.04
n-Pentane	0.01	0.03
Hexanes	0.03	0.51
Heptanes+	0.06	0.15

[a] Separator at 500 psig.
[b] Separator at 700 psig.

specified the carbon dioxide concentration remain below 10%. This is an exception to the norm, and such contracts must be in place to sell the gas at an economical price. Technology to remove carbon dioxide from the gas, such as amine plants or membranes, exist but will substantially detract from the economics of producing geopressured-geothermal gas.

5.2. Sand 9 Gas and Brine Recombination Study and Gas Saturation

A separator study was made to determine the produced gas/brine ratio. For this study, samples of brine taken at separator temperature and pressure were flashed to atmospheric pressure and room temperature. The amount of gas flashed from the sample was measured and the gas was analyzed. The results of analysis of the gas flashed from the separator brine sample are given in Exhibit 5.2-1. This gas contains a substantial amount of carbon dioxide and is of limited value.

From the flow rate of brine through the separator and the gas production it was determined that the gas/brine ratio for the produced gas was 25.56 SCF separator gas per barrel of separator brine at stock tank conditions. The gas flashed from the separator brine sample provides an additional 5.35 SCF/STB, for a total gas/brine ratio of 30.91 SCF/STB. This ratio is for dry gas at 15.025 psia and 60°F and brine at stock tank conditions at atmospheric pressure and 60°F.

Exhibit 5.2-1. ANALYSIS OF GAS FLASHED FROM SEPARATOR BRINE ON MARCH 23, 1983, SEPARATOR AT 700 psia

Mole Percent of:	
Carbon Dioxide	41.00
Nitrogen	0.0
Methane	57.03
Ethane	1.38
Propane	0.24
iso-Butane	0.02
n-Butane	0.03
iso-Pentane	0.00
n-Pentane	0.00
Hexanes	0.07
Heptanes+	0.23

A laboratory PVT (pressure-volume-temperature) recombination of Gladys McCall gas and brine was performed by Weatherly Laboratories, Inc. (Appendix B). Recombination of the measured 24.66 SCF of separator gas per barrel of separator brine had a bubble-point pressure of 10,030 psia at 298°F. It appears that the authors of the Technadril-Fenix & Scisson Final Report (Page 130)[17] performed an erroneous comparison to conclude that the reservoir brine was saturated with natural gas. They compared an extrapolated value of 30.4 SCF separator gas at 15.025 psia and 60°F per barrel and separator water at 700 psig and 212°F for the bubble point at 12,936 psia with the sum of gas from the separator plus gas remaining in solution in brine leaving the separator. Unfortunately, such a comparison is in error by the amount of gas in solution in the separator brine, or about 5.35 SCF/STB. In different terms, the gas remaining in brine leaving the separator is about the difference in gas content of brine for bubble points of 10,030 and 12,936 psia.

It is now clear that the brine in Sand 9 was not saturated with natural gas. The bubble point was about 2900 psi less than the initial reservoir pressure.

5.3. Sand 9 Reservoir Limit Test

The well was produced from March 21, 1983, through April 14, 1983, for a reservoir limit test. A bottomhole pressure gauge was lowered into the well on March 20 and was operational most of the time to April 17. The buildup test was interrupted after only 3 days when the mast on the truck supporting the wire collapsed, causing the wireline to drop into the hole. A total of

99,416 barrels of brine were produced in 23.8 days for an average rate of 4181 barrels per day. Exhibits 5.3-1 and 5.3-2 show plots of the flow rate and resulting bottomhole pressures for both the pressure draw-down and buildup tests.

The draw-down and buildup data were independently analyzed by four parties: 1) J. Donald Clark, Petroleum Consultant; 2) Dowdel, Fairchild and Ancell, Inc.; 3) S-Cubed; and 4) Scientific Software-Intercomp. Their results were as follows:

1. Clark[17] noted five possible straight-line slopes on the semilog plot of bottomhole pressure ranging from 16.7 to 45.2 psi/cycle during the first 24 hours (Exhibit 5.3-1). None of the adjacent segments reached the 2:1 ratio indicative of a boundary, therefore he concluded that the changes were due to lenticularity of the formation rather than being caused by sealing geological faults. He calculated a hydraulic flow capacity of 10,153 md-ft, a permeability to brine of 84.6 md, and a skin factor of +1.98. He further calculated that the transient pressure wave explored the reservoir to a radial distance of 13,019 feet and that the in-place volume of brine was about 170 million barrels. These conclusions were all reached with generally accepted reservoir engineering methods based on various plots of the data.

2. Dowdle, Fairchild & Ancell[17] used a single-phase, two-dimensional numerical reservoir simulator to match the experimental pressure data. The active grid blocks and properties of the grid blocks were adjusted until the calculated pressures were a good match to the experimental pressures. Exhibit 5.3-2 shows their final match. This match resulted for a model that assumed two separate reservoirs and parallel faults: one about 750 feet from the well, and the other about 1000 feet from the well. The resulting flow capacity was about 11,700 md-ft, and the permeability was about 90 md. The transient pressure wave was calculated to have explored the reservoir to a distance of about 20,000 feet, and the in-place brine was calculated at about 184 million barrels. Predictive calculations for flow rates in the range of 15,000 to 35,000 barrels showed that this level of production would exhaust this size of a reservoir in about a year.

3. S-Cubed[17] noted that the semilog plot of the draw-down data had slopes of 25, 46, and 92 psi/cycle in the first 100 hours of the test and that a doubling of the initial slope occurred at about 29 hours. From this they concluded that there was a boundary at a distance of about 960 feet from the well. From a Horner plot they derived a permeability of 67 md and a skin factor of +0.54. Noting that the last 145 hours of the test gave an apparent constant slope of 0.332 psi/hour, they calculated that the in-place brine was at least 85 million barrels. They cautioned, however, that this was a minimum value and that the reservoir could be larger.

4. Scientific Software-Intercomp[15] first analyzed the data using the normal plots of the data and reservoir engineering methods to determine the reservoir properties. From the semilog

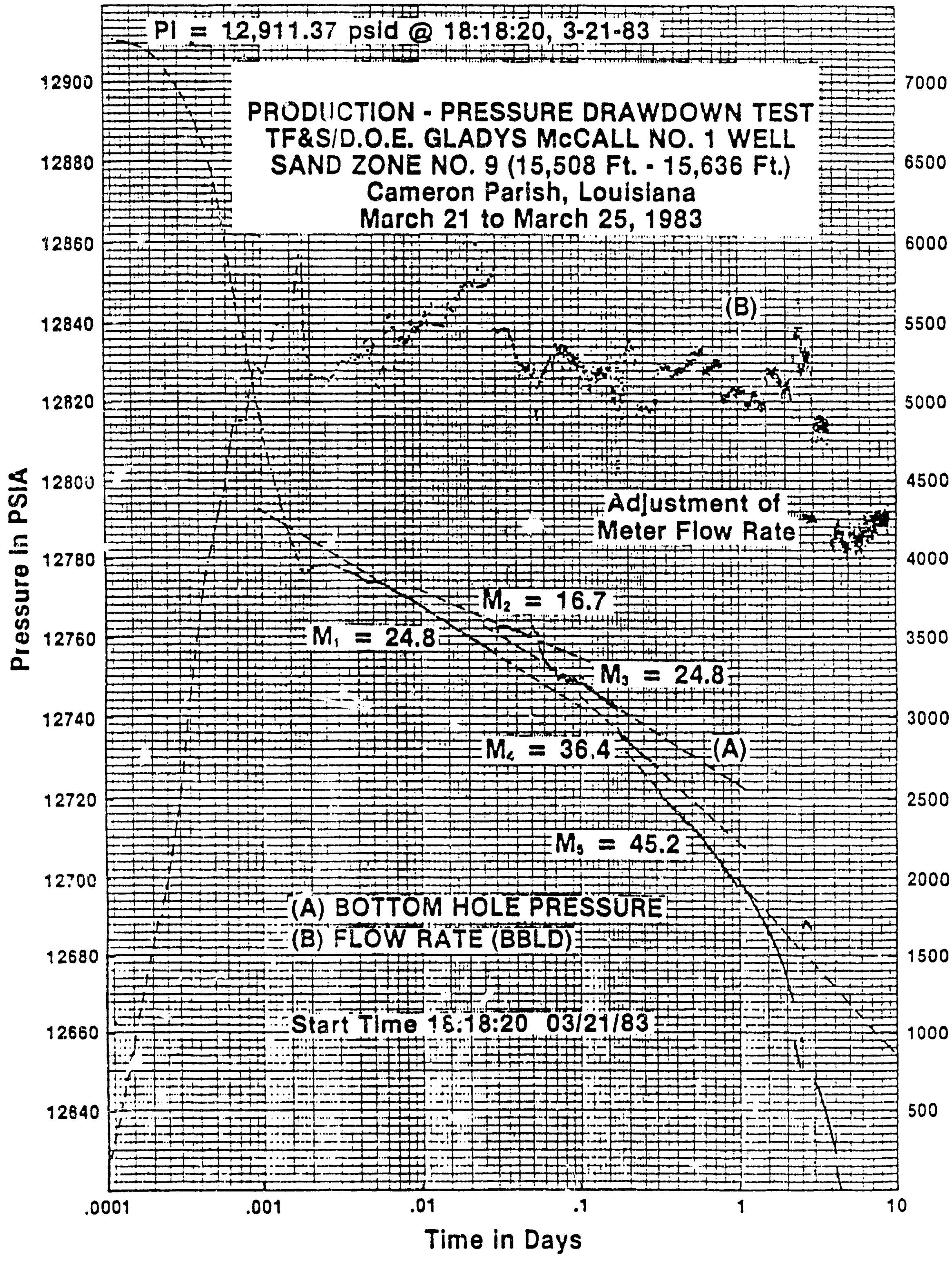


Exhibit 5.3-1. ANALYSIS OF SAND 9 DRAW-DOWN TEST BY CLARK[17]

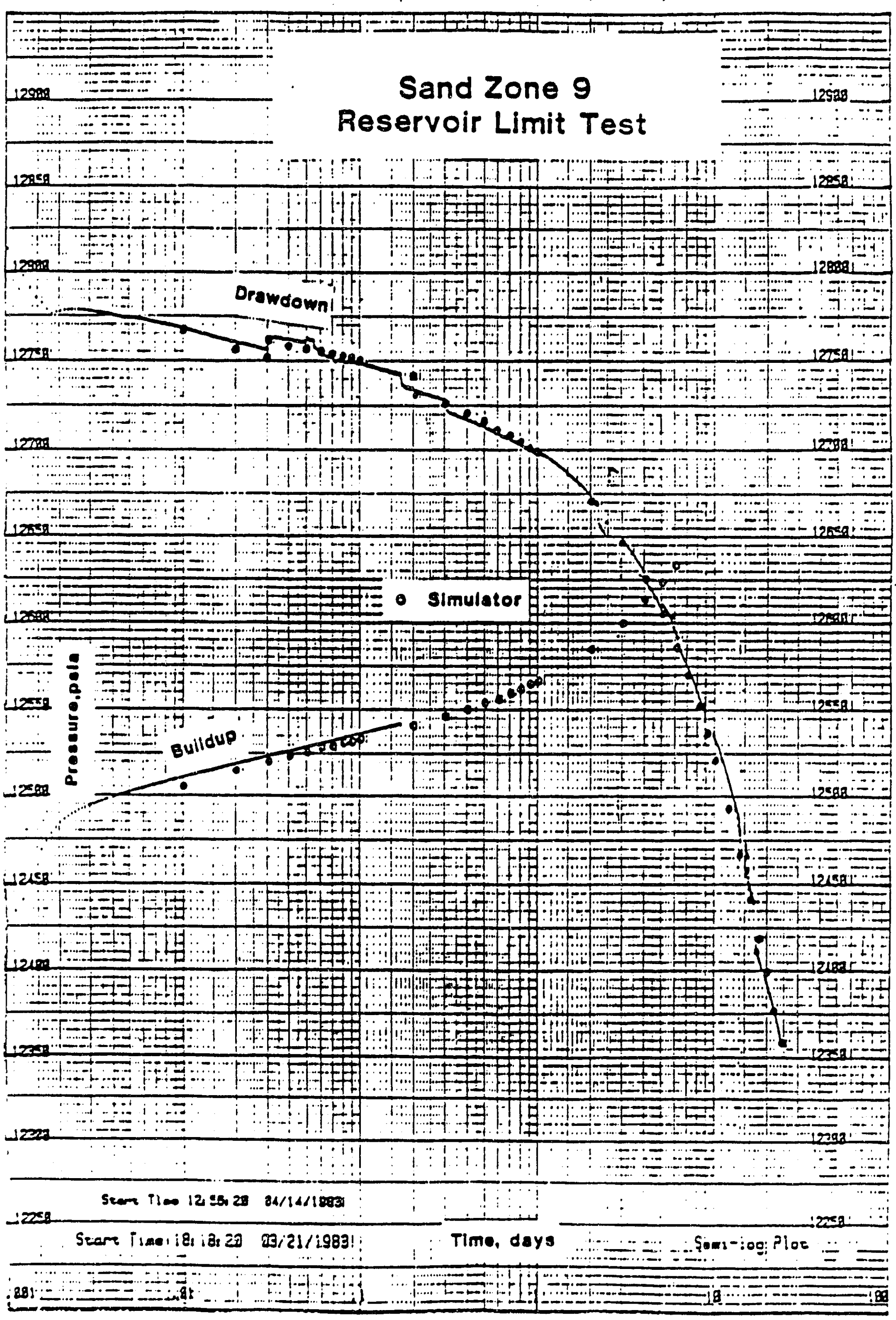


Exhibit 5.3-2. MATCH OF DATA WITH NUMERICAL MODEL BY DOWDLE, FAIRCHILD & ANCELL, INC.[17]

pressure draw-down plot they derived a flow capacity of 9544 md-ft, a permeability of 74.6 md, and a skin factor of -0.74. From a Horner-type pressure-buildup plot they calculated the flow capacity to be 10,689 md-ft, the permeability to be 83.5 md, and the skin factor to be +0.17. Finally, they used a numerical reservoir simulator (BETA II) to model the test. Exhibits 5.3-3 and 5.3-4 show the grid block structure they used and the grid blocks that were zeroed out such that the active grid blocks modeled barriers some 3500 to 4000 feet from the well. The grid blocks and properties of the reservoir rock in the grid blocks were then adjusted as needed in repeated simulation runs until the calculated pressures matched the experimental pressures. Exhibit 5.3-5 shows their final match. To achieve this match, the permeability thickness in the outer blocks needed to be reduced. The final match model had an in-place brine volume of about 135 million barrels.

Although there are some differences in the exact values of the reservoir parameters as calculated by the four different groups, they are in general agreement that the reservoir was rather small and would not support long-term production. With this conclusion there was no need to test this sand further. Sand 9 was therefore plugged and attention was given to the next higher aquifer, Sand 8.

6.0. SAND 8 TESTING

Sand 8 testing consisted of relatively short reservoir limit tests, a 4-year period of production during which over 25 million barrels of brine and 0.7 billion SCF of gas were produced, and a multiyear buildup test that is still in progress. A short-term production test is planned prior to plugging and abandoning the well. Details of the tests are presented in subsections below.

6.1. Sand 8 Short-Term Reservoir Limit Tests

The first pressure transient test of Sand 8 was initiated on September 27, 1983. The flow rate started at 14,520 BPD and then was reduced to 13,703 BPD. This test lasted only 9 hours because of several equipment problems that required removing the bottomhole pressure tool from the hole and discontinuing production. This flow test provided adequate data for an interpretation of the reservoir properties relatively near the wellbore, as reported by J. D. Clark.[3] He reported a productivity of 39,568 md-ft and a skin factor of +1.05. Assuming 300 feet of net pay, the average permeability was 132 md.

After the equipment was repaired, the pressure transient test was restarted on October 7, 1983, with an initial flow rate of 13,407 BPD. Flow was continued for 21 days, until October 28, with an average production rate of 12,985 BPD. The bottomhole pressure gauge was placed in the

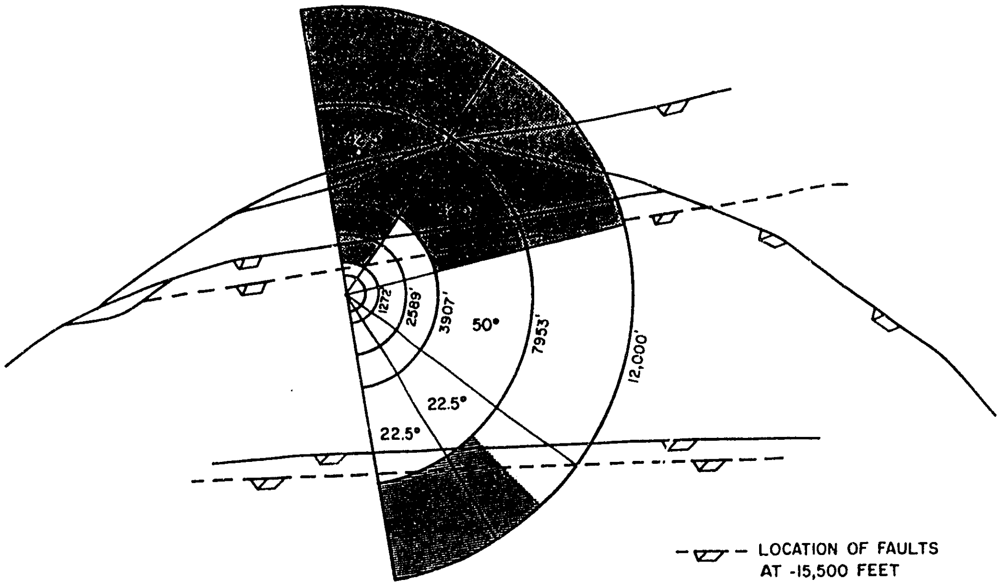


Exhibit 5.3-3. GRID STRUCTURE OF NUMERICAL MODEL BY SCIENTIFIC SOFTWARE-INTERCOMP[15]

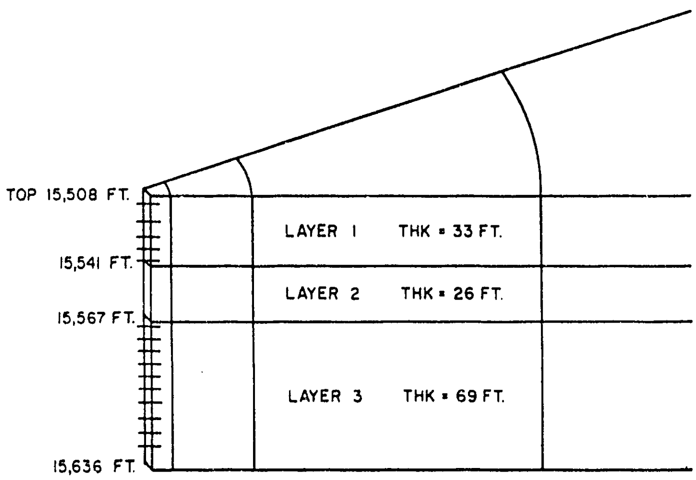


Exhibit 5.3-4. LAYERS IN NUMERICAL MODEL BY SCIENTIFIC SOFTWARE-INTERCOMP[15]

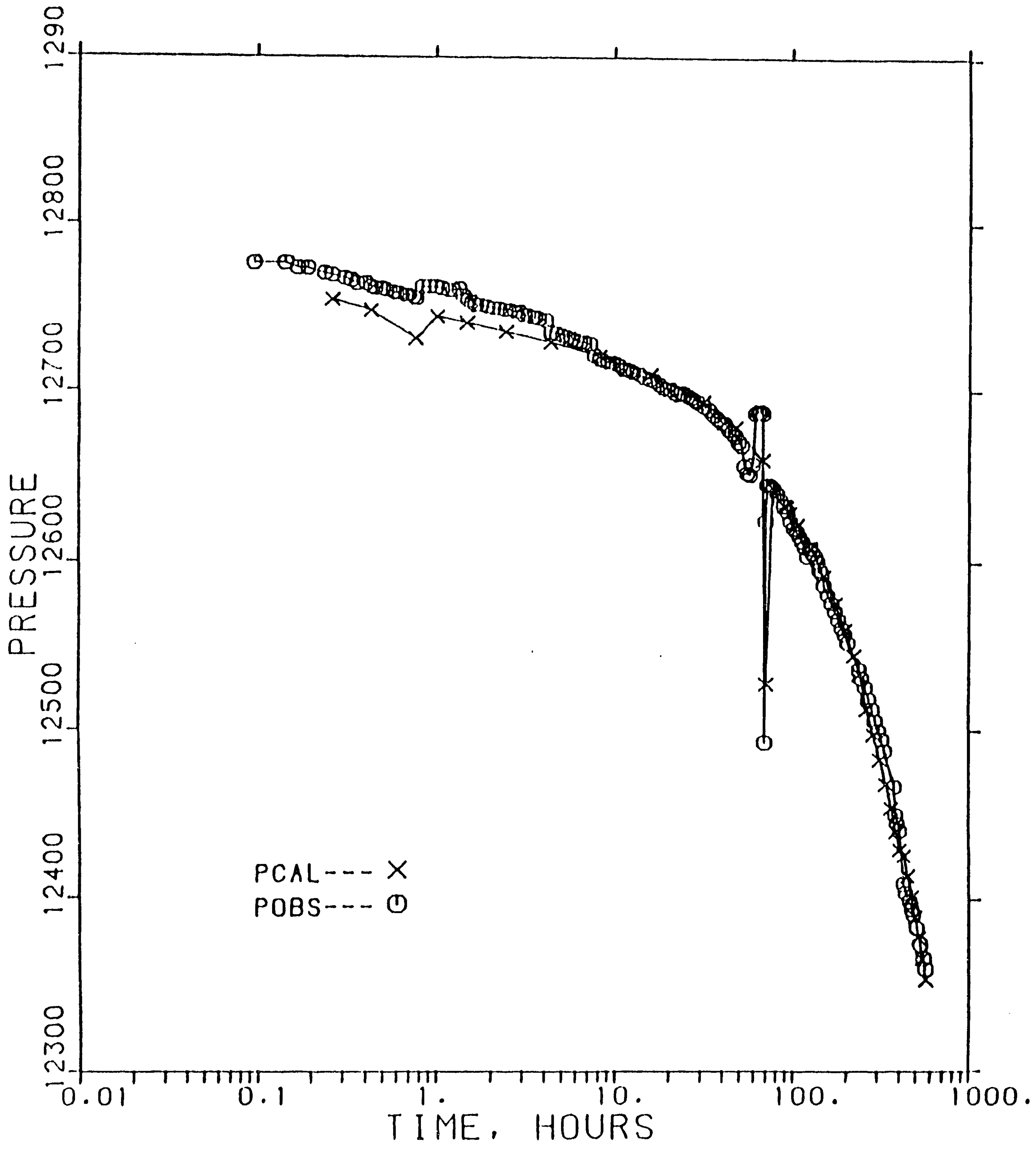


Exhibit 5.3-5. MATCH OF DATA TO NUMERICAL MODEL
BY SCIENTIFIC SOFTWARE-INTERCOMP[15]

hole on October 5 and removed on November 30, thus providing a continuous record for the drawdown and 32 days of buildup. The data were analyzed by both J. D. Clark and S-Cubed.

J. D. Clark[3] reported that the curved lines on the semilog graphs he used to interpret the data were an excellent example of lenticular-type sand deposits and that there was no evidence of a linear-type permeability barrier (such as a nearby sealing fault). For the early-time production data he calculated a productivity of 37,057 md-ft and a permeability of 123 md for a 300-foot sand. This compared well with previous results from the aborted September 27 test. He then calculated the reservoir volume with a graphical method that indicates when steady-state production apparently occurs. This graph suggested a reservoir volume of about 550 million barrels of brine. Similarly, graphical analysis of the pressure-buildup data yielded an initial productivity of 39,752 md-ft. The line on the semilog time plot and Horner plot was straight only for times less than 1 day, therefore the reported value for productivity of approximately 39,000 md-ft is valid for only a relatively small volume of the reservoir near the wellbore. Clark made no attemp to interpret the data beyond the time that it deviated upwards, away from the straight-line portion of the plot.

S-Cubed did a similar, but more extensive, analysis of the October-through-November 1983 pressure transient test data.[13] They fitted both the draw-down and buildup data to four straight-line segments on the usual semilog time plot. They then made conjectures about how each of these straight-line segments related to the reservoir geometry. On the basis of the slopes of the plots doubling at 9.5 and 31.5 hours, they estimated the distances to the two nearest faults to be 780 and 1410 feet. Using the second straight-line segment on the draw-down plot, they calculated a reservoir permeability of 113 md for an assumed height of 330 feet (124 md for an assumed height of 300 feet). Similar calculations for the buildup data gave a calculated productivity of 44,090 md-ft and a permeability of 133 md for a 330-foot-thick sand. To estimate the reservoir volume, they hypothesized that the pressure was approaching the final pressure exponentially. With this hypothesis they calculated a reservoir volume of 433 million barrels.

To numerically simulate the reservoir test data, S-Cubed used a simple rectangular reservoir with parallel edges at the distances of 780 and 1410 feet from the well, as estimated from their analysis of the pressure transient data. This was a reasonable assumption based on the geological analysis of east-west growth faults through the reservoir area. With these widths and a height of 328 feet, the long distance out to the end boundaries was 10,827 feet. By using a permeability of 160 md near the wellbore and 20 md for distances beyond 3600 feet, they were able to calculate a pressure draw-down and buildup curve that closely matched the actual test data.

6.2. Sand 8 Long-Term Production

The Number 8 Sand was completed in September 1983 with perforations in the interval between 15,180 and 15,450 feet. Long-term flow testing was initiated in December 1983 and concluded almost 4 years later in October 1987. This sand proved to be a very large reservoir and capable of sustaining long-term brine production.

Early production was curtailed by scale formation in the wellbore and surface facilities. Scale deposition in the surface facilities was controlled by injection of scale inhibitor prior to the chokes. Scale inhibition in the wellbore was eventually controlled after inhibitor "pills," consisting of many hundreds of pounds of scale inhibitor, were successfully displaced into the producing formation. Prior to these inhibitor pills, however, production rates were limited to below 15,000 barrels of brine per day so that the cooling of brine during transit up the wellbore and the higher wellhead pressures associated with the lower rates counteracted the tendency of the brine to form scale as pressure was reduced.

Once scale deposition in the wellbore was controlled with inhibitor pills, brine rates were increased. The limitation on the flow rates was the operation of the large separator at 1000 psig pressure, which required a wellhead pressure of a little less than 1200 psig. The gradual decline in brine rate in 1986 through the first few months of 1987 reflected the drawdown of the reservoir pressure near the wellbore. The reduction of brine rates to just below 10,000 barrels per day in 1987 were to allow pressures to stabilize at a rate low enough for a bottomhole pressure sensor to be run into the well prior to shut-in for buildup testing.

A flow-test program was established where the flow rates and other production measurements were manually taken at 2-hour intervals and then manually summarized each day for daily reports. A computerized data acquisition system was installed in January 1986 to evaluate whether such a system could be used as the primary data collection system for the Pleasant Bayou well. The computer system was operated in parallel with the manual data acquisition, and the manually obtained data continued to be the reported data.

The initial daily reported data included the production and gas sales, but did not include the gas remaining in solution sent to the disposal well or account for the fact that the brine flow measurements were made at nonstandard conditions. Much of this field data has been previously reported.[17] For this current analysis, the reported daily volumes were adjusted to standard conditions and revised to include the gas remaining in solution after going through the separators. Plots of this revised data for brine production and gas production for Sand 8 are shown in Exhibits 6.2-1 and 6.2-2. Daily production data are provided in tabular form in Appendix C and in graphical form in Appendix D.

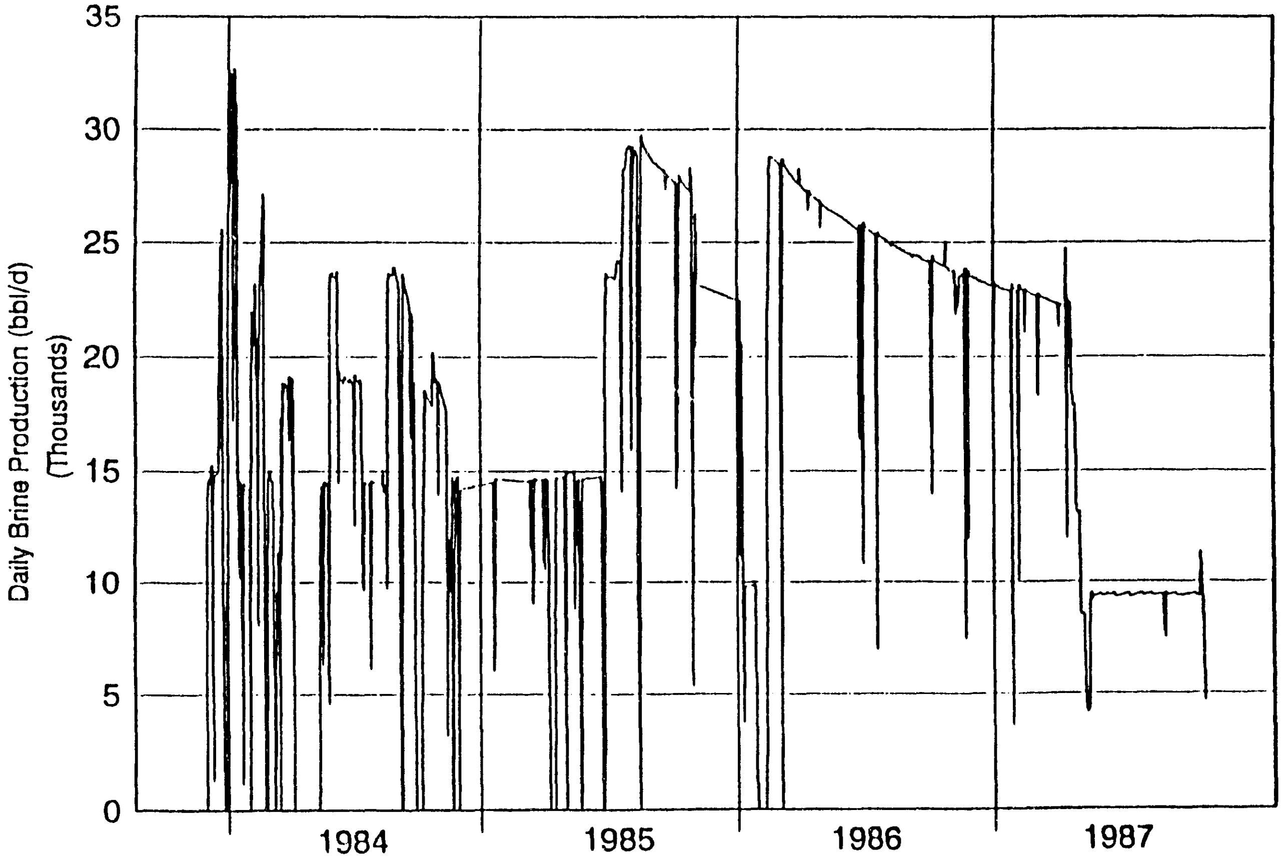


Exhibit 6.2-1. SAND 8 LONG-TERM TEST BRINE PRODUCTION

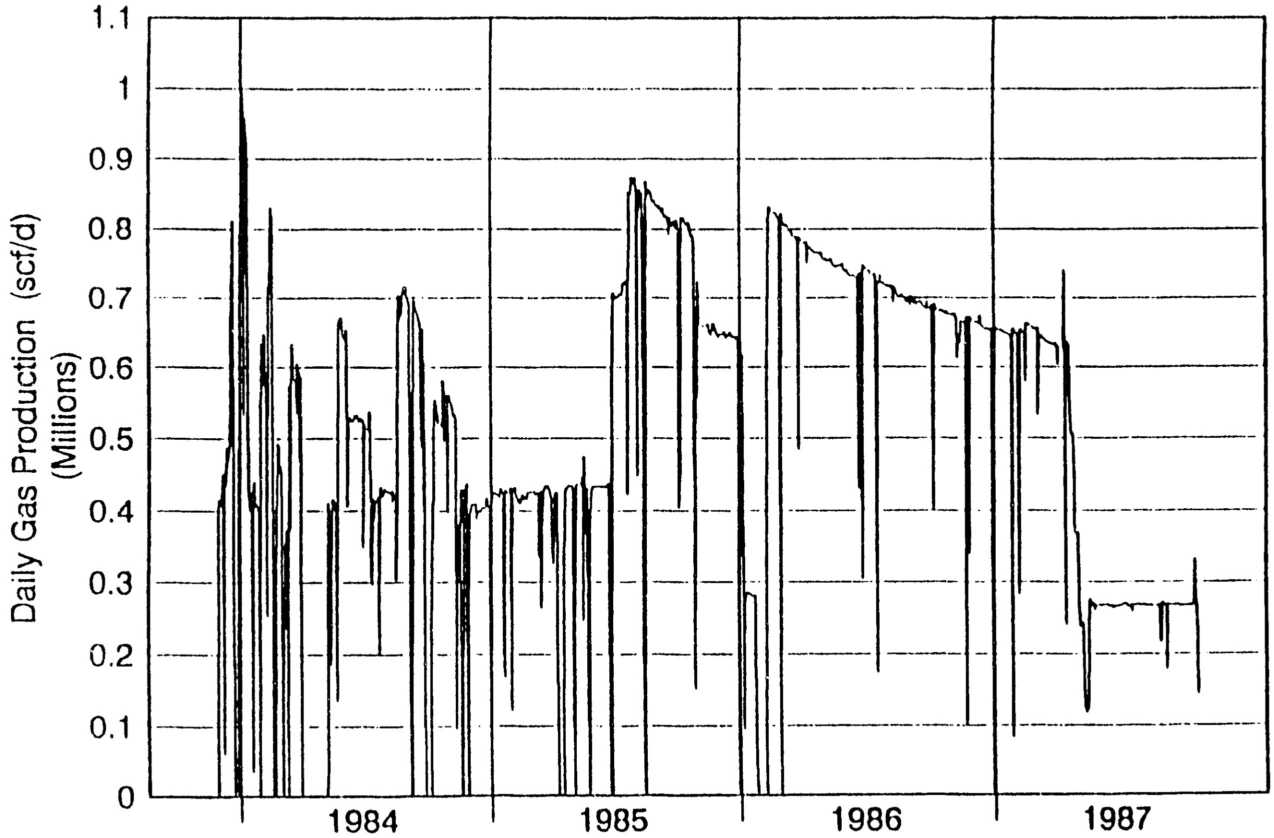


Exhibit 6.2-2. SAND 8 LONG-TERM TEST GAS PRODUCTION

The revised brine volumes are 6% to 7% less than the field-reported volumes. The gas volumes were adjusted to include gas remaining in the brine after the separator with a computer algorithm developed at IGT, and they were typically 10% to 20% higher than the field-reported volumes. The plots of gas rate in Exhibit 6.2-2 and in Appendix D present the total amount of gas produced from the reservoir in the brine rather than the amount that was recovered or sold. The basis for these corrections is discussed in Appendix E.

The gas/brine ratio shown in Exhibit 6.2-3 plots the gas volumes in Exhibit 6.2-1 divided by the brine volumes in Exhibit 6.2-2. If the brine and gas measurements had been perfect, the gas/brine ratio plot should be very close to a straight line. In practice, however, there are spurious high or low values in the gas/brine ratio because there were some difficulties in the manual reading and reporting of the flow-rate data. During the first few months of production, the difficulties with meter calibrations and manual readings were more severe compared to the later time when the operations became more routine.

Cumulative perforation gas production versus cumulative brine production from these calculations is presented in Exhibit 6.2-4. The overall gas/brine ratio (the slope of the line) is 28.9 SCF/STB for production up to about 10 million barrels. A slight bend in the curve then occurs, and subsequent production had an average gas/brine ratio of 28.6 SCF/STB. This slight change in the ratio (slope) at 12 million barrels may reflect the point where the flowing bottomhole pressure fell below the bubble-point pressure of the brine. This change occurred during the latter half of 1985, which is the time the sustained brine rate was increased to more than 20,000 STB/d and the flowing bottomhole pressure was drawn down below 10,000 psi. The overall average gas/brine ratio is calculated to be 28.7 SCF/STB.

6.3. Sand 8 Long-Term Reservoir Test Data Interpretation

6.3.1. Reservoir Simulation

Reservoir simulation was updated as additional information was obtained. When S-Cubed prepared their report for the Sixth Geopressured-Geothermal Conference in 1985,[13] they had a year's worth of production data from the long-term flow test discussed below. As this long-term test progressed, they found that the actual bottomhole pressures were higher than their simulated pressures. They regularly needed to increase the size of the reservoir used in their model to match the data from the ongoing long-term flow test. Because the model fit the early time well, they simply added the additional volume to the remote ends of the model. There was no accurate geological information about where the extra volume should be placed to match the actual reservoir. Several cases with different assumptions of volume were run, and a good fit to the data was found for a revised reservoir volume of 1.2 billion barrels. This revised volume was

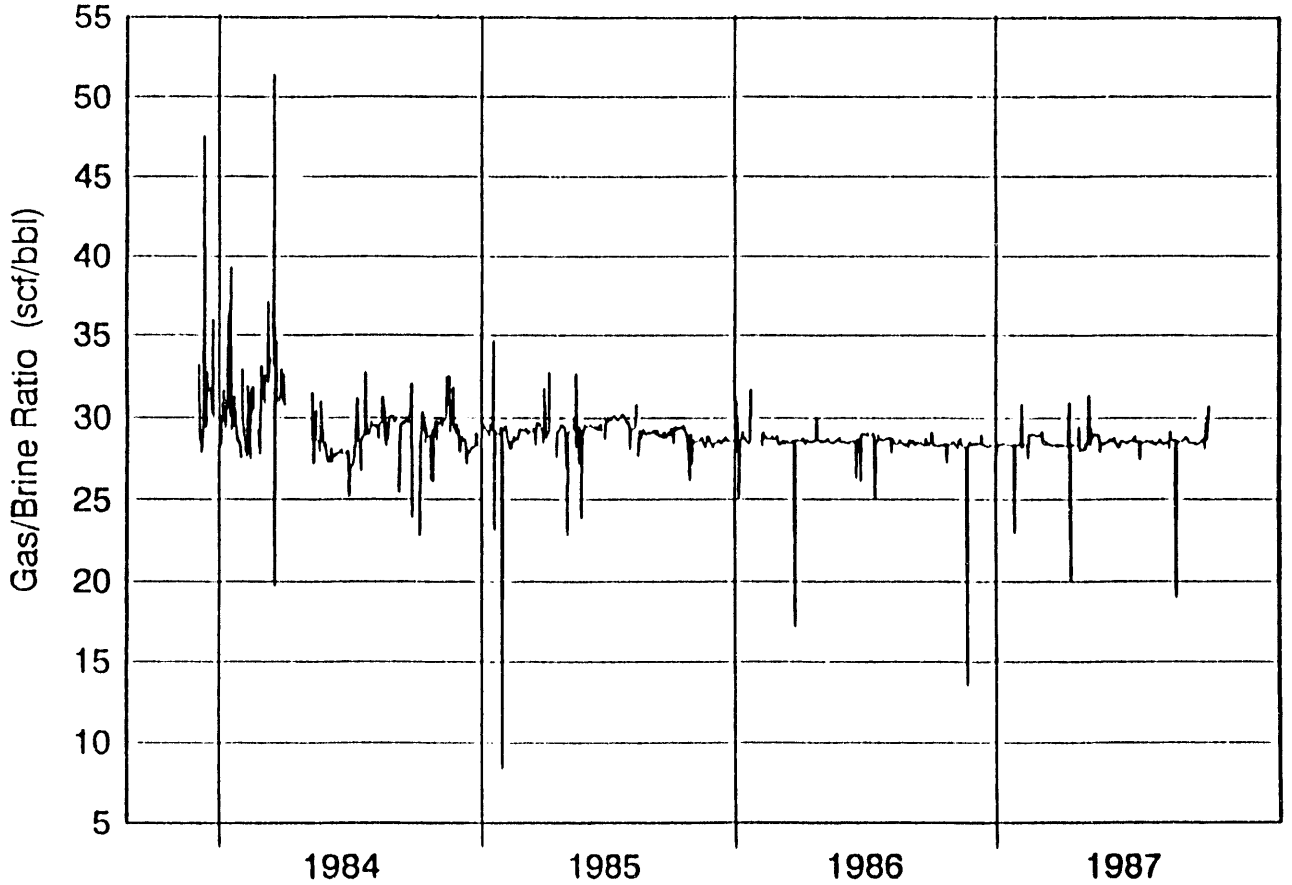


Exhibit 6.2-3. SAND 8 GAS/BRINE RATIO FROM PRODUCTION DATA

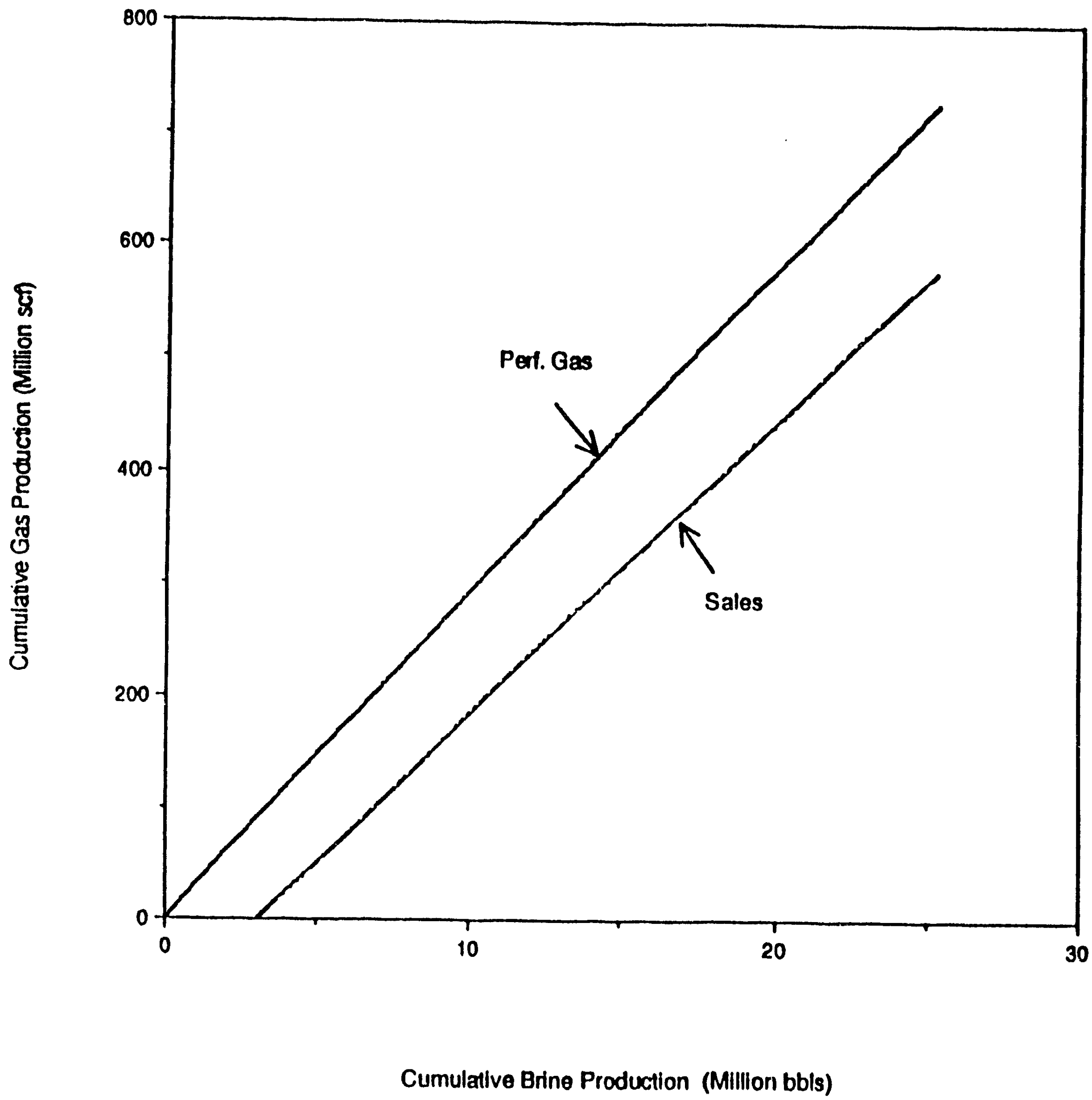


Exhibit 6.2-4. SAND 8 CUMULATIVE GAS VERSUS BRINE PRODUCTION

approximately three times the volume initially deduced from the 21-day pressure transient test, although even this volume was eventually shown to be too small. During the 4 years of production, S-Cubed periodically updated the model in light of the most recent data.

In April 1985 and January 1986 there were short-term buildup tests from which the flow capacity could be recalculated. For both of these tests the flow capacity was calculated to be 28,340 md-ft rather than the previous 44,090 md-ft. These tests were done after scale-inhibitor injection into the well, so S-Cubed interpreted this reduction to be caused by partial plugging of the perforations or formation below a shale stringer in the formation. The numerical model was therefore modified to include a stringer in the production interval that partially penetrated the formation. There were also increases in the skin factor attributed to the inhibitor injection (discussed below). To continue matching the pressure data through early 1986 with the model, the total reservoir volume in the model needed to be increased from 1.2 to 2.5 billion barrels.

In continuing to model the reservoir behavior during pressure buildup, S-Cubed found that the connected volume in the model needed to be increased even more. Exhibit 6.3.1-1 shows the dimensions of the model as it had evolved by 1990.[14] By this time, the reservoir volume in the model that was needed to match the field data had been increased from the previous 2.5 billion barrels to a new volume of 7.8 billion barrels. This large increase in volume was needed to match the long-term bottomhole pressure buildup, which has continued to rise with no indication of reaching a plateau. Where the influx of fluid (presumed to be water) came from was unknown, but it was speculated to be either from shale de-watering or an influx from adjacent sands either above or below Sand 8. In the model, the extra volume was placed above the previous grid and partially isolated from the previous grid by a partial penetrating barrier. The permeability of this new volume was set low (0.2 md). Both the horizontal and vertical permeability of this layer and the vertical permeability of the Sand 8 below it were set to this low value. Exhibit 6.3.1-2 shows the simulated pressure (sandface adjusted to 15,100-foot datum level) compared to similar values calculated from the flowing wellhead pressure, and Exhibit 6.3.1-3 is the simulated pressure compared to the bottomhole pressures for the buildup test. There was no need to invoke any nonlinear mechanisms for the model, such as irreversible pore volume compaction. Their conclusion was that if there were any nonlinear effects, they would be close to the wellbore and would probably be masked by the skin factor.

6.3.2. Use of Horner Plot to Estimate Reservoir Size

The reservoir drained by the Gladys McCall well was so large that the reservoir had not clearly reached a pseudo-steady-state drawdown after years of production. The total reservoir volume could therefore not be accurately assessed by the computer model. Therefore, reservoir

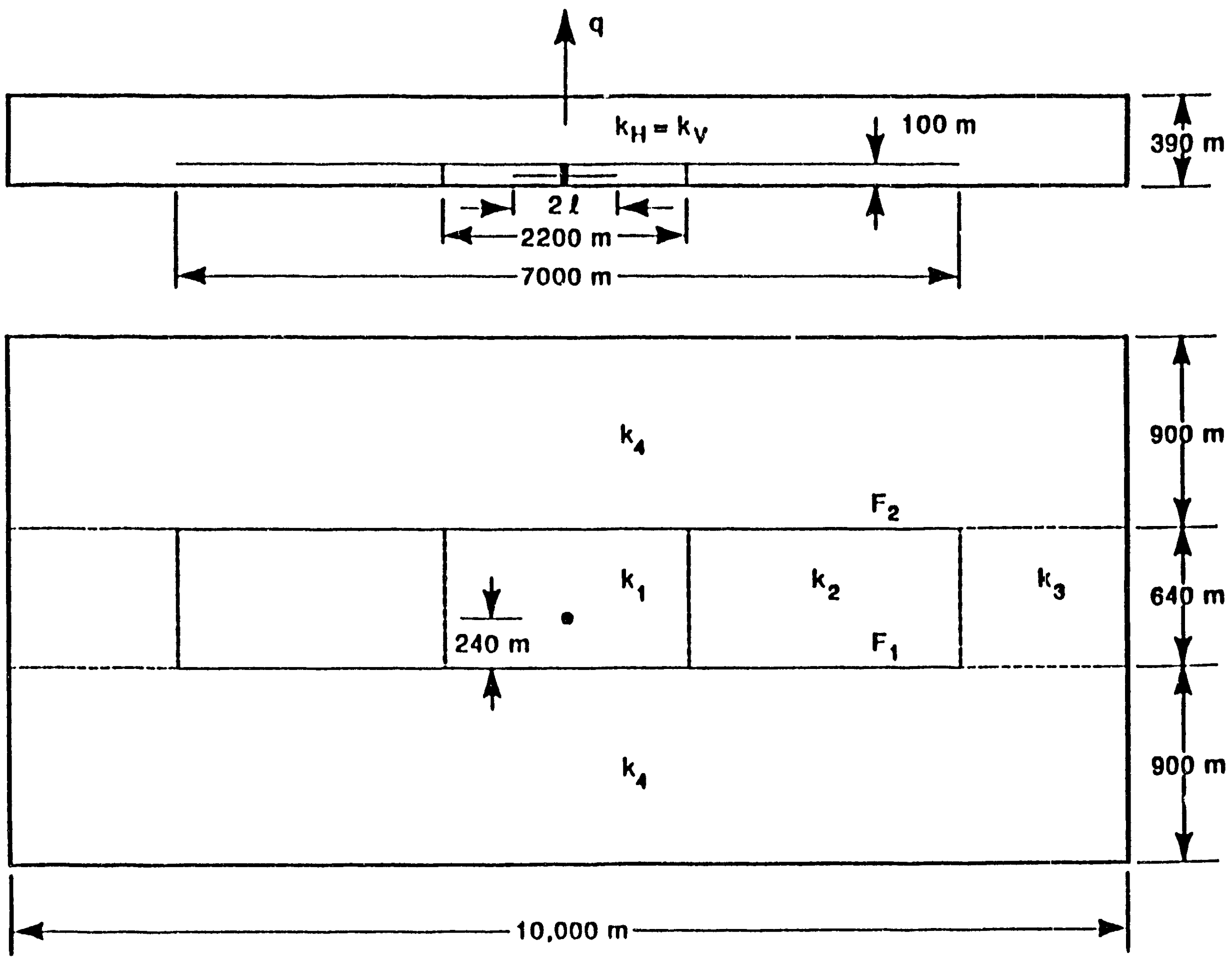


Exhibit 6.3.1-1. SCHEMATIC DIAGRAM OF THE GRID FOR THE NUMERICAL MODEL USED BY S-CUBED TO MODEL DATA[14]

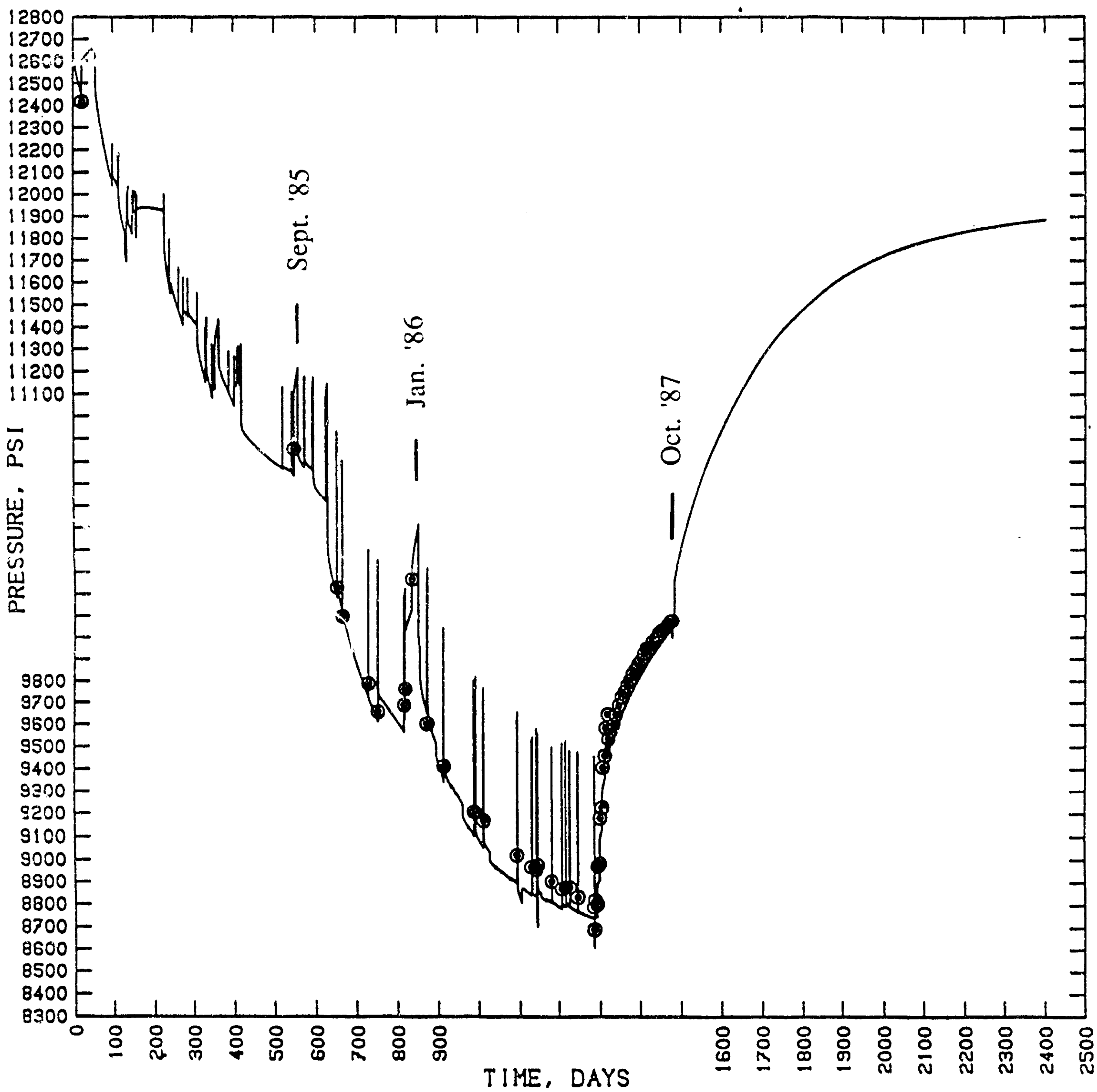


Exhibit 6.3.1-2. SIMULATED SANDFACE PRESSURES COMPARED TO VALUES ESTIMATED FROM FLOWING WELLHEAD PRESSURES

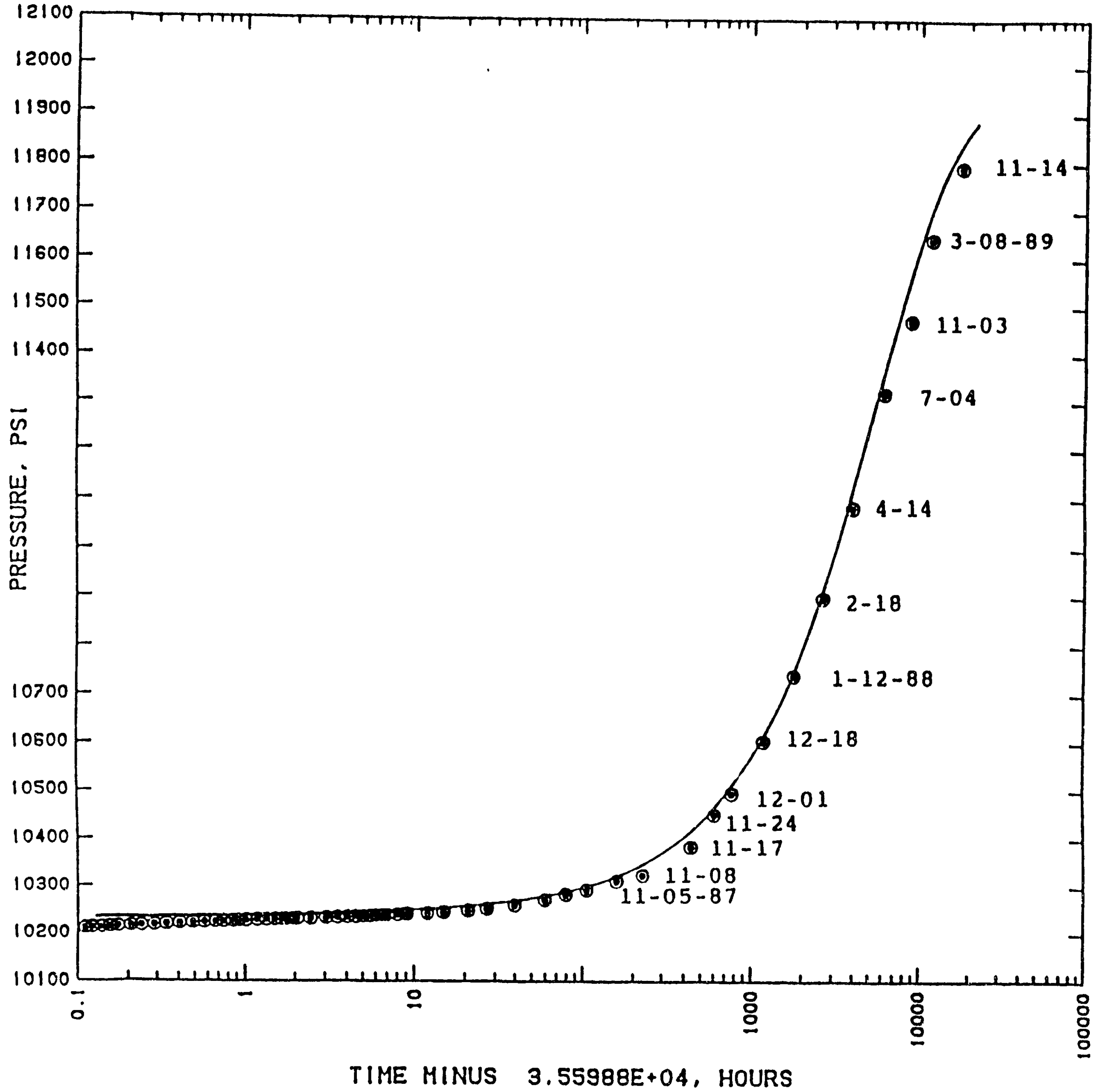


Exhibit 6.3.1-3. SIMULATED PRESSURE BUILDUP COMPARED TO ACTUAL BUILDUP

size was estimated with a Horner plot using long-term buildup data. The pressure-buildup data following the long-term production are plotted on a Horner plot in Exhibit 6.3.2-1. On the Horner plot, the final pressure to which the reservoir will recover after production is found where the extrapolation of the buildup curve intersects the $(T+\Delta t)/\Delta t = 1$ axis. From this pressure and the material-balance equation, the reservoir volume can be estimated. A discussion of the engineering assumptions and input data that make up the basis of this graph is given in Appendix F.

For the McCall Horner plot, the pressure-buildup data curve is not expected to extrapolate as a straight line to the $(T+\Delta t)/\Delta t = 1$ axis. The point marked P_f is the end point that should be reached for the S-Cubed model with 7.8 billion barrels of reservoir volume. Whether the buildup would continue to build up to the value used by S-Cubed in the latest computer model is uncertain because the extrapolation requires a curved line that is not supported by the data. It may well be that the pressure, if left to build up indefinitely, would continue to rise to a value close to the original reservoir pressure. This would follow a more or less straight-line extrapolation that the data appears to be following. This hypothesized pressure response would require a much larger aquifer than the current model. It is anticipated that the well will be plugged and abandoned before definitive data can be obtained.

A possible conclusion from the Horner plot combined with the S-Cubed model is that there is a part of the reservoir intersected by the wellbore that contains 430,000 to 550,000 barrels of brine and has a high flow capacity (39,000 to 44,000 md-ft) and that this high-flow-capacity part of the reservoir is in contact with a huge volume (at least as large as the 7.8 billion barrels used in the S-Cubed model) that has a very low flow capacity. The shape and orientation of the reservoir is not well-known because of the lack of other wells in the area that can be used to establish the geology and formation properties at the distances indicated by its size. The S-Cubed model takes all of the known geology into account even though the model describes the reservoir as being rectangular. The fact that the S-Cubed model matches the data so well is an indication that the volumes are approximately correct even if the exact shape is not known.

6.4. Change in Sand 8 Reservoir Transmissibility

Early determinations of the transmissibility (permeability times height, or kh) of the reservoir from short-term flow tests were presented in Section 6.1, and results of computer modeling were presented in Section 6.3. Additional draw-down or buildup testing with bottomhole pressure measurement was performed in 1985, 1986, and 1987. The results from the determinations of transmissibility for all of these tests are tabulated in Exhibit 6.4-1.

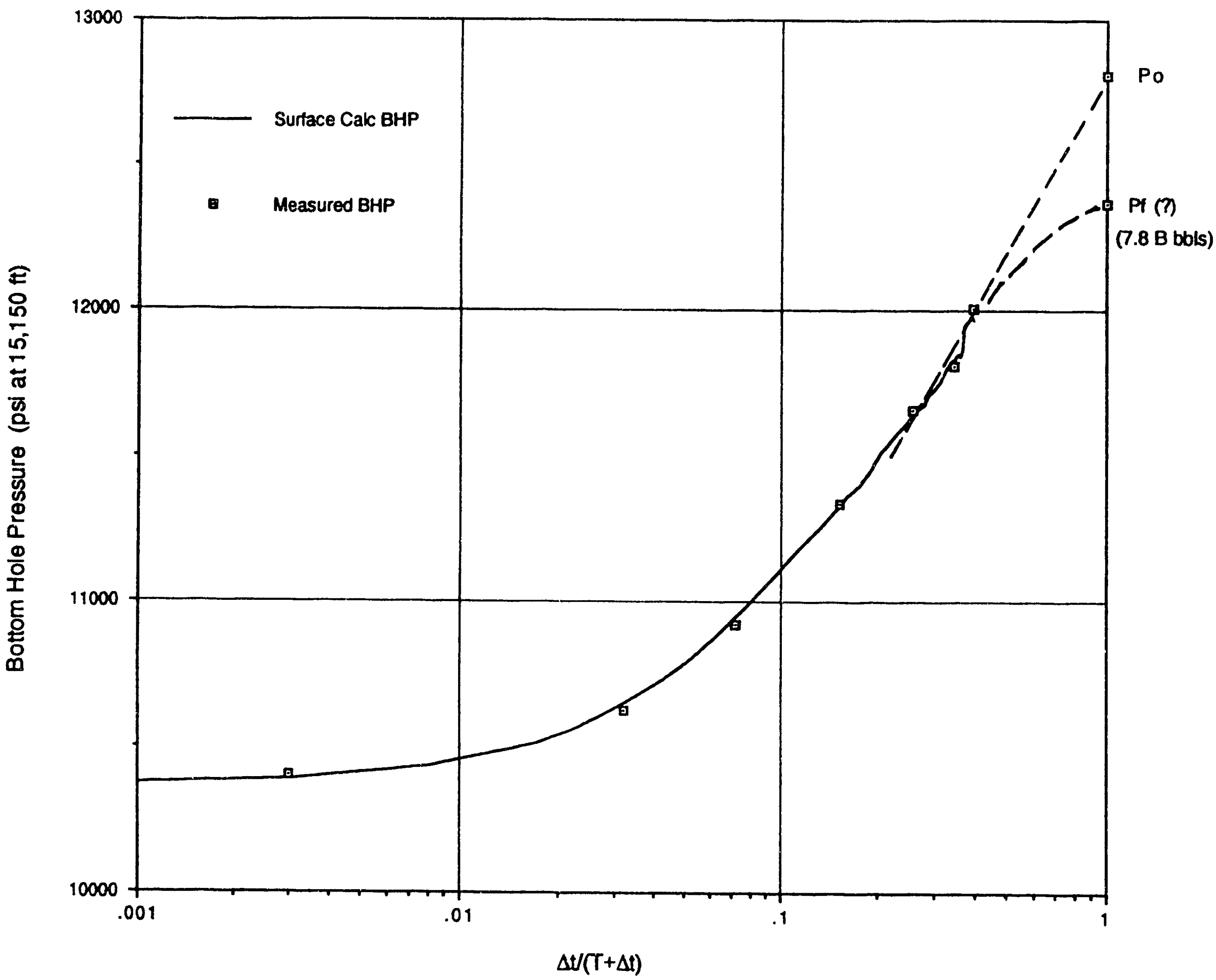


Exhibit 6.3.2-1. HORNER PLOT OF SAND 8 LONG-TERM BUILDUP TEST

Exhibit 6.4-1. CHANGE IN TRANSMISSIBILITY

Date of Test	Transmissibility, md-ft	Type of Test	Interpretation by
September 1983	39,568	Draw-Down	J.D. Clark
October 1983	37,057	Draw-Down	J.D. Clark
October 1983	39,752	Buildup	J.D. Clark
October 1983	44,090	Buildup	S-Cubed
April 1985	28,340	Buildup	S-Cubed
January 1986	28,340	Buildup	S-Cubed
January 1986	28,770	Buildup	Eaton Oper. Co.
October 1987	28,340	Draw-Down	S-Cubed
October 1987	28,340	Buildup	S-Cubed

6.4.1. Possible Reasons for Lower Transmissibility

The change from about 40,000 md-ft through October 1983 to about 28,000 md-ft subsequent to April 1985 is not understood. Four hypotheses have been that 1) the wellbore had become plugged such that the lower one-third of the perforated interval no longer contributed to production, 2) inhibitor-pill injection had reduced permeability in the vicinity of the wellbore, 3) drawdown of reservoir pressure to below the bubble point had reduced the relative permeability to brine, and 4) the increased compressive stress on the rock matrix due to drawdown of reservoir pressure had decreased the area available to flow between sand grains. Each of these is discussed below.

1. Plugging of the Wellbore: This possible reason for the decrease in transmissibility was triggered by the observation that the wireline trip into the well in April 1985 stopped at a depth of about 15,365 feet when resistance was encountered. Then, in response to a request from S-Cubed personnel, a University of Texas expert on interpretation of wireline logs observed that there was a shale stringer at that depth that could conceivably combine with a plug in the wellbore to preclude production from the lower one-third of the perforated sandstone.

S-Cubed modeling of production with the assumption that perforations below 15,365 feet could not contribute to production gave a nice fit to the data. However, in January 1986, the wireline was run to the depth of the bottom perforation. No obstruction was found in the perforated area. Additional doubt upon the viability of this hypothesis resulted from a spinner survey attempted in August 1987. The spinner data will be discussed later under a separate heading.

2. Permeability Reduction by Inhibitor Pills: The April 1985 test was performed after the attempt to inject an inhibitor pill into the formation in November 1984. The reported skin factor for the April 1985 test was 8.5. This is considerably higher than the skin factor of 2.5 calculated for the 1983 tests. There was another unsuccessful attempt to inject an inhibitor pill during May 1985, and the first successful attempt was made in June 1985.

The January 1986 buildup test was performed after the successful attempt to inject an inhibitor pill into the reservoir. The skin factor value reported by S-Cubed was 5.1. One possible interpretation was that a portion of the reservoir remained plugged, and there was no efficient mechanism to flush precipitates from pores. However, following another successful inhibitor pill injection in February 1986 and the production of many millions of barrels of brine, the skin factor calculated for the October 1987 shut-in was down to 3.0. This is only slightly higher than the value of 2.5 for the 1983 reservoir limit test.

3. Lowering of Relative Permeability to Water by Free Gas: Drawdown of pore pressure to below the bubble-point pressure for gas in solution in the brine would result in gas coming out of solution and residing in pores as a free-gas phase. This gas would not become mobile until the amount was sufficient to exceed a critical gas saturation of at least 3% of the pore volume. At the same time, the fractional gas saturation of the pore space would decrease the relative permeability to brine.

The identical values of 28,340 md-ft for transmissibility in April 1985 and October 1987 make it unlikely that this lower value is caused by a partial gas saturation of pore space. The lowest flowing bottomhole pressure prior to April 1985 was above 10,500 psi and clearly above the bubble-point pressure of the reservoir brine. In contrast, the calculated flowing bottomhole pressure was almost down to 8600 psia in April 1987. Even after accounting for skin pressure drop, the pore pressure near the wellbore is believed to have been well below the bubble point.

4. Permeability Reduction Due to Stress on the Rock Matrix: Assuming an average overburden pressure gradient of 1.000 psi/ft of depth, the pressure due to the column of rock from ground level to the top perforation is about 15,145 psia. For the initial reservoir pressure of 12,821 psia measured at this depth, the net overburden compressive stress of the rock matrix was the difference between these values or about 2324 psi. The lowest flowing bottomhole pressure before completion of the 1983 measurements of transmissibility was about 12,400 psia, and the maximum net stress on the reservoir rock was about 2750 psi.

In contrast, bottomhole pressure had been drawn down to 10,500 psi for a net stress on the rock matrix of about 4650 psia in April 1985. At the maximum drawndown to almost 8600 psia in April 1987, the net stress on the rock matrix may have been as high as 6500 psi. But at the reduced flow rate of about 10,000 BPD at the times of shut-in in January 1986 and October 1987, the values of maximum net stress on the rock matrix adjacent to the wellbore were about 4850 and 5050 psi, respectively.

The above values suggest that compression of the rock matrix could be a reason for the change in transmissibility. The reduction in transmissibility from about 40,000 to about 24,000 md-ft correlates with doubling of net stress on rock adjacent to the wellbore from about 2500 to about 5000 psi.

6.4.2. August 27, 1987, Spinner Survey

To test whether a portion of the formation was plugged and not contributing to the total flow, a spinner survey across the perforated interval (15,160 to 15,470 feet) was attempted on August 27, 1987. The effort was partially successful, but interpretation of the data is complicated because of poor and decaying response of the tool. Brine production was constant at about 10,000 STB/d, but non-zero readings were obtained with the tool below the packer only when the logging tool was moving downward.

Exhibit 6.4.2-1 shows the response of the spinner while logging down through the packer at a rate of 65 ft/min. Above 13,860 feet, the tool was moving through 4.276-inch-ID tubing. The higher spinner rate between about 13,865 and 13,880 feet is caused by the 3.480-inch ID of the seal assembly. The 12 feet of lower spinner rate and then the 8 feet of higher spinner rate are caused by the larger diameter inside the polished bore receptacle and the smaller diameter inside the packer, respectively. The low spinner rate below 13,910 feet reflects tool and fluid movement in the 7-inch, 38-pound-per-foot casing (5.920-inch ID).

The seal bore extension is above the packer and the distance from its top to the bottom of the packer is 34 feet. The spinner data in Exhibit 6.4.2-1 show 20 feet from the bottom of the packer to the bottom of the seal assembly. Thus, the seal assembly was found to extend 14 feet into the seal bore extension. This is in excellent agreement with the 12 feet reported at the time of well completion.

The logging pass through the packer shown in Exhibit 6.4.2-2 differs from subsequent logging passes in that the tool output was greater than zero in the casing for a tool velocity of only 1.1 foot per second. It is noted that the data in Exhibit 6.4.2-2 show that the tool response was a nonlinear function of fluid velocity relative to the logging tool. For a 10,000-BPD production rate, fluid velocity in the tubing was 6.5 ft/s in the tubing and 3.4 ft/s in the casing. Adding the 1.1-ft/s downward velocity of the logging tool, the fluid velocities relative to the logging tool were 7.6 ft/s in the tubing and 4.5 ft/s in the casing. The ratio of these velocities was 1.7:1. But the ratio of tool responses was 7.3:2.6 or 2.8:1.

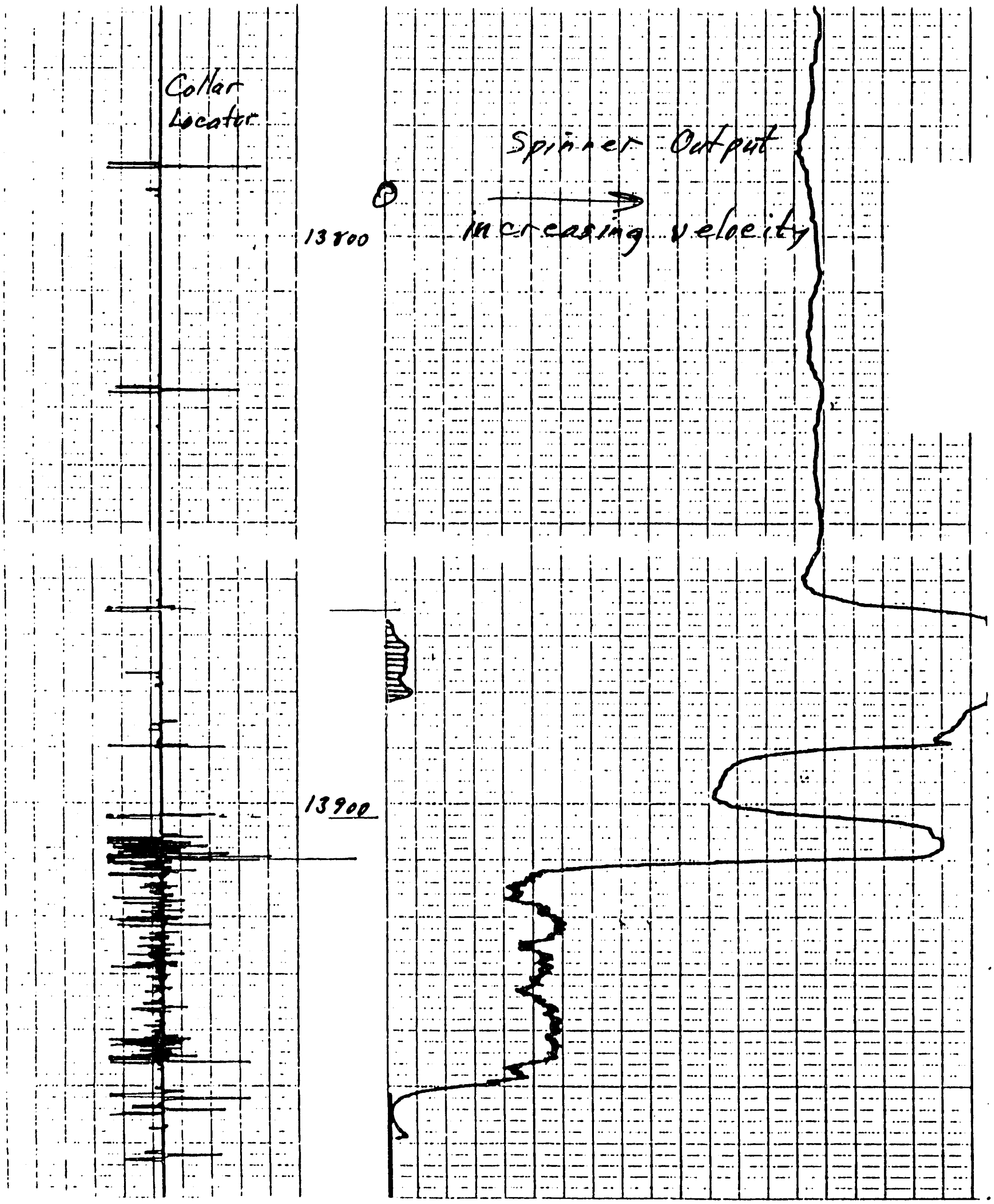


Exhibit 6.4.2-1. SPINNER LOGGING DOWN THROUGH THE PACKER AT 65 ft/min

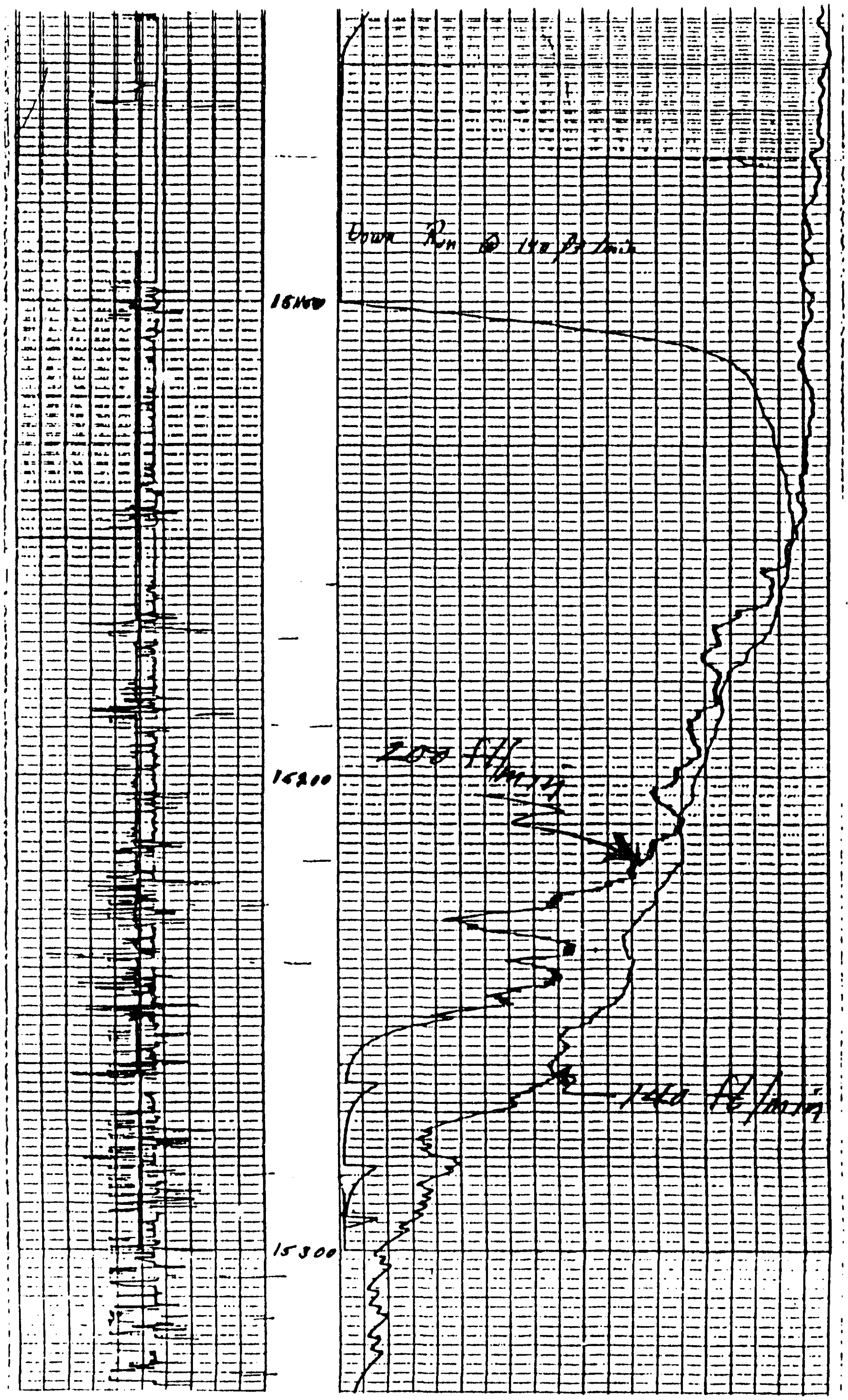


Exhibit 6.4.2-2. SPINNER LOGGING DOWN ACROSS PERFORATIONS AT 140 AND 200 ft/min

Logging passes were recorded through portions of the perforated interval using logging speeds of 150, 140, 130, and 200 ft/min. However, the tool response was deteriorating with time.

Exhibit 6.4.2-2 is an overlay of spinner response for downward logging speeds of 140 and 200 ft/min. The higher speed pass was later in time and suggests a cutoff in fluid entry at a shallower depth than the lower speed pass. This is the opposite of what would have been observed if the logging tool repsonse were not deteriorating with time.

Although the data are not adequate to profile fluid entry as a function of depth, it provides a basis for the following qualified conclusions:

1. Fluid entry is roughly a linear function of depth for the first 100 feet of perforations (15,160 to 15,260 feet). This was observed on a half dozen logging passes and the last, at 200 ft/min, is the only exception.
2. About half of the produced brine enters the wellbore below the midpoint of the perforations at 15,315 feet. This is about the depth where spinner response went to zero for the majority of downward logging passes. But the zero output corresponded to a fluid velocity of 4.0 to 4.5 ft/s relative to the logging tool. Downward logging tool velocity was most often about 2.5 ft/s (150 ft/min). Thus, tool output dropped to zero at the depth where fluid velocity dropped to about 1.5 to 2.0 ft/s relative to the casing. This corresponds to a brine rate in the range of 4400 to 5900 BPD. Thus, brine rate at the midpoint of perforations appears to be about one-half of the production rate of 10,000 BPD.
3. Some fluid is entering the wellbore from near the deepest perforations (15,470 ft). The logging tool was lowered to this depth with a loss of only about 40 to 60 pounds of weight (much less than the weight of the tool and sinker bars). A pickup of that weight was observed at 14,466 ft. Thus, it is clear that any solids shallower than that depth are either carried out of the wellbore or fluidized by deeper fluid entry.
4. The entire reservoir thickness was shown to be contributing to the flow, thereby casting doubt on the interpretation that a large portion of the perforations below the shale stringer were plugged off.

7.0. CHARACTERISTICS OF HYDROCARBONS PRODUCED FROM SAND 8

Natural gas that was in solution in the brine in the reservoir constitutes the majority of produced hydrocarbons. The recovered gas has a relatively high content of carbon dioxide and aromatics (benzene, toluene, etc.). After gas sales began in 1984, separator pressures were kept high enough to limit the carbon dioxide content of gas to 10% because of specifications in the gas sales contract. The aromatic compounds have higher solubility in brine than alkanes with comparable molecular weight. At the temperature of about 280°F of natural gas leaving the separators, the aromatics constitute a major portion of C6+ hydrocarbons in the high-temperature gas stream.

Initially, gas leaving the single separator was flared and the only constraint on separator pressure was the pressure required to drive brine into the disposal well. In 1984, a gas sales contract was agreed to. It provided for delivery of gas containing up to 10% carbon dioxide into a line with a normal operating pressure of about 1000 psig. At this pressure, about one-fourth of the produced gas remains in the brine. After a separator study revealed that lower pressure operation of a second separator and purchase of a gas compressor would pay out in terms of increased gas sales, a second large separator, previously used at the Sweet Lake Design Well test, was installed for low-pressure operation.

When the gas from the separators was cooled prior to dehydration, both hydrocarbons and water vapor condensed from the gas stream. The condensing hydrocarbons had a high aromatic content. In addition, a small amount of paraffinic oil collected in the high-pressure separator. This was periodically flowed over the oil weir and manually bled off from the oil outlet of the three-phase separator.

Details of the collection and analysis of samples of the produced gas are presented in Section 7.1 below. Similar details for the recovered liquid hydrocarbons are in Section 7.2.

7.1. Produced Gas Composition

Numerous gas samples were collected from several different points in the process stream and were analyzed by various parties during the course of this project. Sample points include the high-pressure (HP) and low-pressure (LP) separator meter runs, sample points located directly on the separators, cooled and dehydrated gas commingled from the separators, and gas flashed from brine from the separators while lowering the pressure to atmospheric. The sample points were shown in the schematic diagram in Exhibit 4.0-1. The composition of the gas at a sample point depended on the pressure and temperature at the point and upon whether gas separation had preceded it. Appendix G gives the results of all gas analyses available. Some of these were previously reported.[17]

Typical analyses of a first-stage separator gas, a second-stage separator gas, and of gas flashed off brine after the second separator are shown in Exhibit 7.1-1. Also included is a computational recombination of these gases to estimate the composition of the total gas. A more detailed analysis of a sales-gas sample (LP separator gas compressed and commingled with HP separator gas), collected on October 21, 1987, is shown in Exhibit 7.1-2. This analysis gives a breakdown of the heavy hydrocarbons that constitute the C6 fraction of the gas. The gas contains a little less than 10% carbon dioxide and the C6+ fraction contains more than twice as much aromatics as alkanes.

Exhibit 7.1-1. TYPICAL GAS ANALYSES, FEBRUARY 19, 1987

Sample Source	HP Sep Gas	LP Sep Gas	Gas in Brine Leaving LP Sep	Total Gas, Calculated
Pressure, psia	1015	285	285	
GWR, SCF/STB	22.86	4.44	1.75	29.05
Mole Percent of:				
Carbon Dioxide	7.91	20.52	37.39	11.61
Nitrogen	0.25	0.16	0.81	0.27
Methane	88.57	77.22	60.25	85.13
Ethane	2.40	1.64	1.05	2.20
Propane	0.53	0.24	0.10	0.46
iso-Butane	0.08	0.02	0.01	0.07
n-Butane	0.07	0.02	0.00	0.06
iso-Pentane	0.02	0.01	0.00	0.02
n-Pentane	0.02	0.00	0.00	0.02
C6+	0.15	0.17	0.08	0.15
Gas Grav (air = 1)	0.656	0.769	0.927	0.690
Heating Value, Btu/SCF	968	828	637	927
Liquids	0.93	0.60	0.35	0.85

7.1.1. Separator Studies

Early flow tests on this well were performed using only one separator. The long-term production test plan included selling the produced gas. The sales-gas line operating pressure was about 1000 psig. It had been shown on previous wells that about 7 cubic feet of gas remain in the brine at a separator pressure of 1000 psig. This is almost one-fourth of the total produced gas, although the concentration of carbon dioxide in this gas is generally above 20%.

An early priority was to determine whether two-stage separation, with the costs associated with installing a second separator and a compressor, could be justified based on incremental recovery of the low-pressure separator. Relevant constraints in gas sales contracts were that the gas contain less than 10% carbon dioxide and less than 35 ppmv hydrogen sulfide. Lowering separator pressure increases the carbon dioxide and hydrogen sulfide content of the gas. Single-stage separator pressure below about 700 psig caused the carbon dioxide concentration to exceed the 10% limitation.

A series of tests were performed with a small separator borrowed from another location in series with the original separator. The separator study involved collecting gas samples from the separator and collecting brine from the brine outlet of the separator at a variety of separator pressures. The gas samples were analyzed. The brine was then flashed to atmospheric pressure

Exhibit 7.1-2. GAS ANALYSIS OF McCALL SALES GAS
BY GC/TCD/FID, OCTOBER 21, 1987

Mole Percent of:	
Helium	BDL[a]
Hydrogen	0.07
Oxygen/Argon	BDL
Nitrogen	0.33
Carbon Dioxide	9.38
Methane	87.1
Ethane	2.40
Propane	0.51
iso-Butane	0.08
n-Butane	0.07
neo-Pentane	BDL
iso-Pentane	0.03
n-Pentane	0.01
Sum of Hexanes	0.007
Sum of Heptanes	0.005
Sum of Octanes	0.003
Sum of Nonanes	0.001
Sum of Decanes	0.001
Sum of Undecanes	0.001
Sum of Dodecanes & Heavier	0.001
Benzene	0.029
Toluene	0.014
o, *m*, *p*-Xylene & Ethylbenzene	0.009
C3 Benzenes	0.001
Calculated Heating Values, Btu/SCF (60°F, 15.025 psia, dry)	960
Calculated Gravity (air = 1)	0.668

[a] BDL = Component concentration below detection limit (0.01%).

and the gas that exsolved was measured and analyzed. Separator pressure was varied, and the effect of separator pressure on both the quantity of gas remaining in the disposal well brine and the quality of the separator gas was determined. These tests showed that for a two-stage separation, second-stage pressures well below 400 psig were achievable while keeping the carbon dioxide content of the combined gas below the contractual gas-sales maximum of less than 10%.

A second large DOE-owned separator became available early in 1984 after production testing of the Sweet Lake Design Well was completed. This separator, which was identical to the high-pressure separator, was installed in series after the first separator. The first separator was operated at the gas sales pressure of about 1000 psig so that the majority of the produced gas could be sold without compression. The second separator was operated at the lowest practicable pressure, which was dictated either by the carbon dioxide ceiling in the sales gas contract or by the pressure required to inject brine down the disposal well.

The carbon dioxide content of the commingled sales gas is plotted versus the second-stage separator pressure in Exhibit 7.1.1-1. The scatter in this graph reflects the effects of brine temperature. The effect of temperature on carbon dioxide solubility is very pronounced. At brine rates above 20,000 STB/d, the brine temperature remained within a few degrees of 280°F. However, during the reduced flow rate of 9300 STB/d in October 1987, the brine temperature at the separator was 268°F. At the lower brine temperature, the carbon dioxide has a stronger tendency to remain with the brine. The two points on the lower left-hand corner of the graph reflect data obtained at this lower temperature and are obviously outside the trend of the data obtained at higher temperatures. A similar variation of carbon dioxide content with temperature was observed in the IGT separator studies on the HO&M Prairie Canal Well.[7]

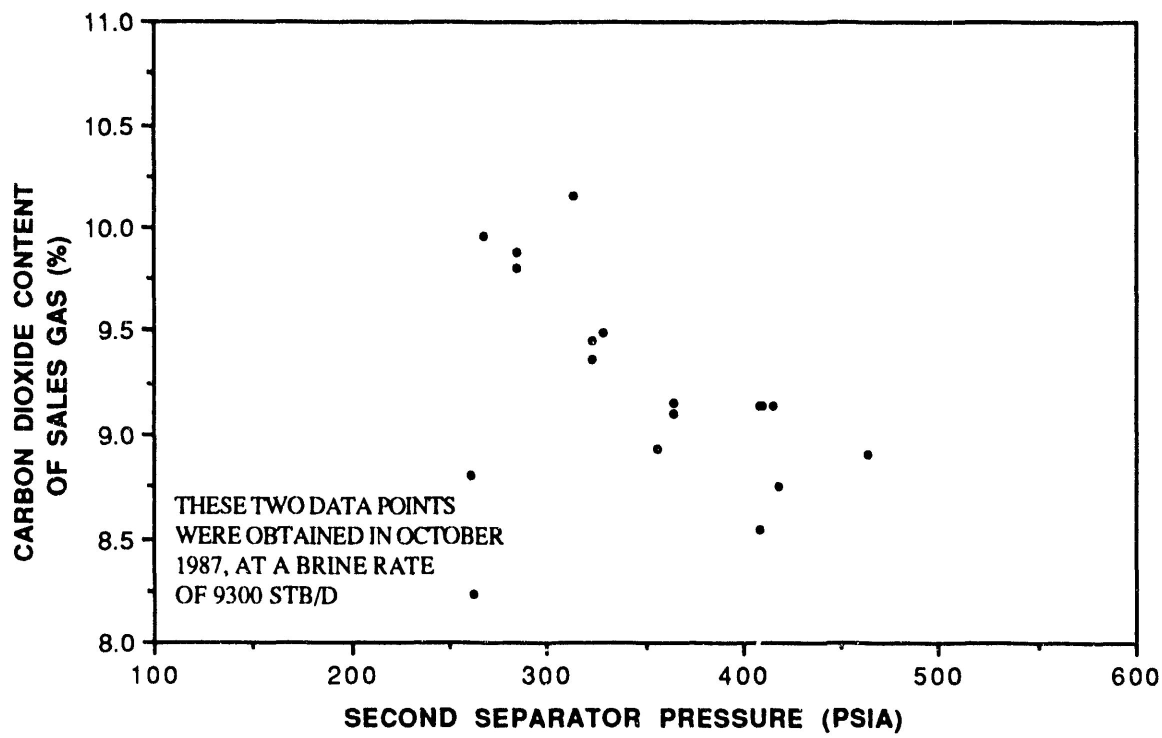


Exhibit 7.1.1-1. SALES GAS CARBON DIOXIDE CONCENTRATION VERSUS SECOND-STAGE SEPARATOR PRESSURE

The relationship between the separator operating pressure and the gas contained in the brine after the separator is shown in Exhibit 7.1.1-2. At the first-stage separator pressures, generally near 1000 psig, about 7 SCF gas/STB brine would not be recovered by the separator. This is roughly 25% of the total gas produced. The hydrocarbon fraction of this gas is about 5 cubic feet. Exhibit 7.1.1-3 shows the gross heating value of the gas remaining in each stock tank barrel of brine leaving separator versus the separator pressure.

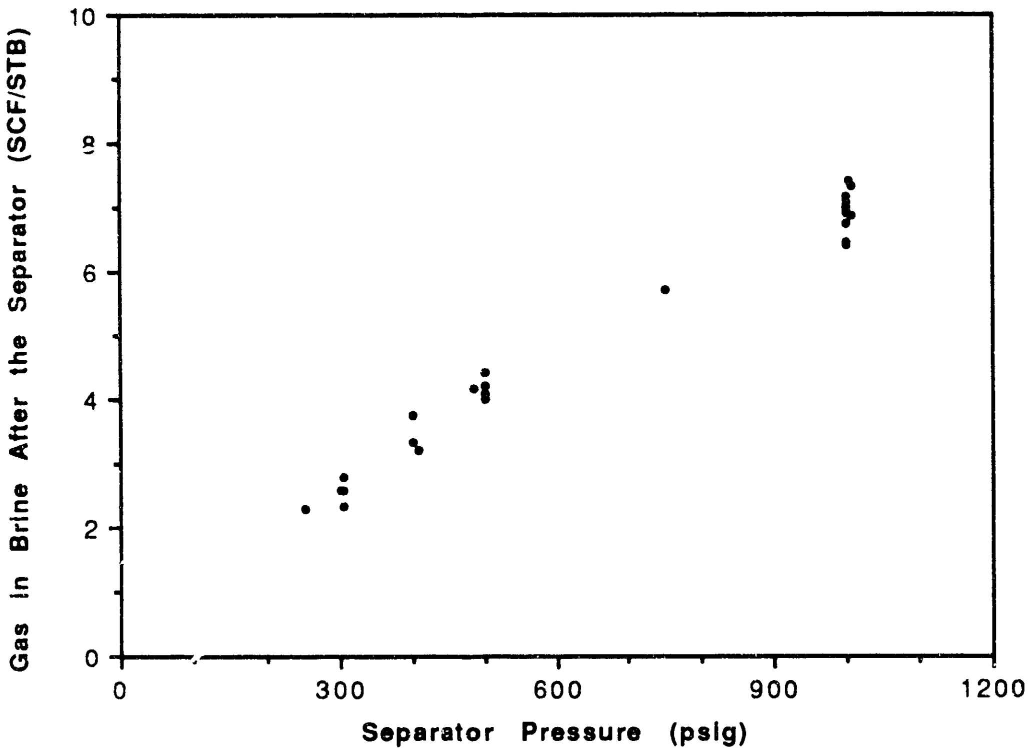


Exhibit 7.1.1-2. GAS REMAINING IN BRINE AFTER THE SEPARATOR

An additional 2 to 5 cubic feet of gas per barrel of brine could be recovered by the second-stage separator, depending on the second separator operating pressure. Operating the second-stage separator at 400 psig pressure recovered roughly 4 SCF of gas containing about 3000 Btu's of combustion energy that would otherwise be injected into the disposal well with the injected brine.

7.1.2. Correcting Gas Production Rates for Gas Remaining in the Brine After the Separator

The high-pressure separator was kept at the sales-line gas pressure of about 1000 psig pressure during the long-term test of Sand 8. The low-pressure separator pressure was kept high enough to limit the carbon dioxide content of the commingled gas from the two separators to below

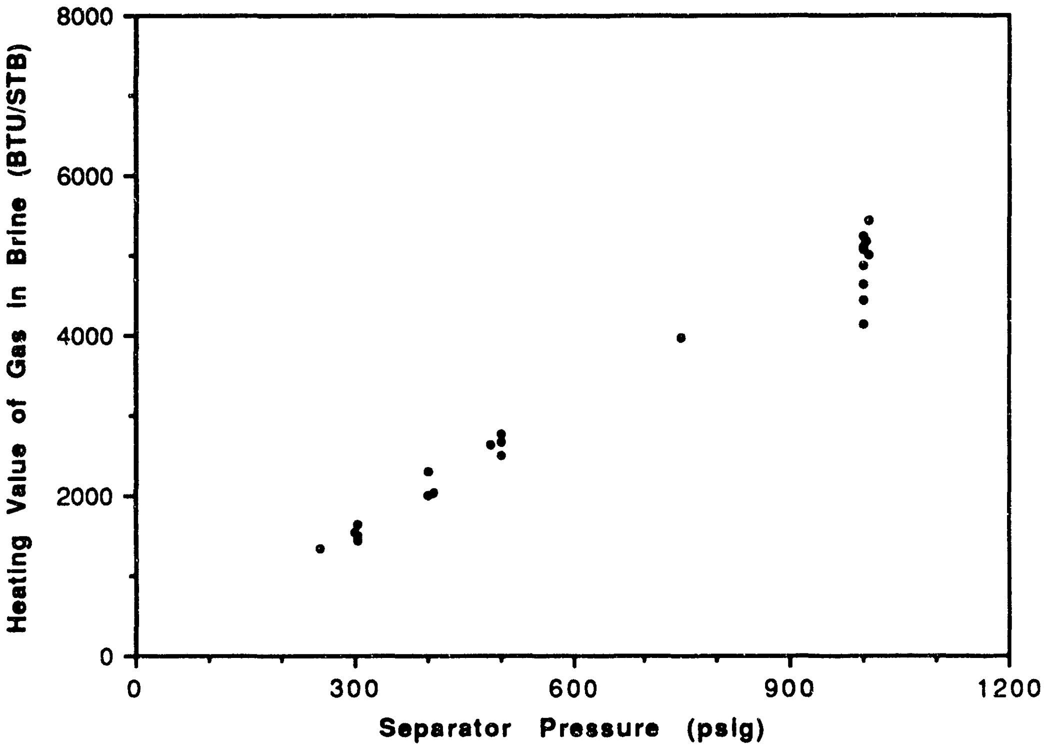


Exhibit 7.1.1-3. HEATING VALUE OF GAS REMAINING IN BRINE LEAVING THE SEPARATOR

10% or to maintain a pressure high enough to inject brine into the disposal well. There was still a considerable quantity of gas remaining in the brine after the low-pressure separator. IGT had developed an algorithm (based on the solubility of methane in brine) to estimate the quantity of this gas, and this quantity was added to the recovered gas to obtain a total produced gas from this well.

The diamonds in Exhibit 7.1.2-1 are the amounts of gas obtained by flashing separator brine to atmospheric pressure (performed by IGT and Weatherly). The squares with the dots in the middle represent calculated values using the IGT algorithm. The calculated value is lower than the measured flashed gas by about 20% to 30%. The algorithm is based only on methane solubility in brine, not natural gas containing carbon dioxide and heavier hydrocarbons. Exhibit 7.1.2-2 is a plot of the methane content of the brine against the methane partial pressure rather than the total gas pressure. The IGT algorithm is reproduced on this graph. With this adjustment there is excellent agreement between the field data and the algorithm derived from laboratory data. Nevertheless, the reported gas production and gas/brine ratio are low. The amount of the error is roughly 1/2 cubic foot per barrel of brine. The justification for continuing use of this algorithm is that it accurately reflects the hydrocarbon content of the dissolved gas, which is most important to end users.

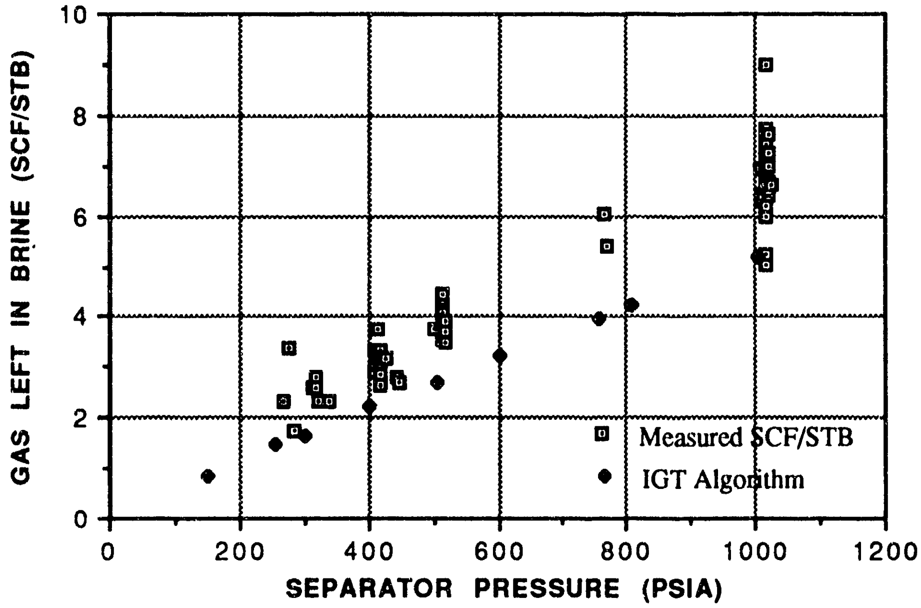


Exhibit 7.1.2-1. GAS LEFT IN BRINE VERSUS SEPARATOR PRESSURE

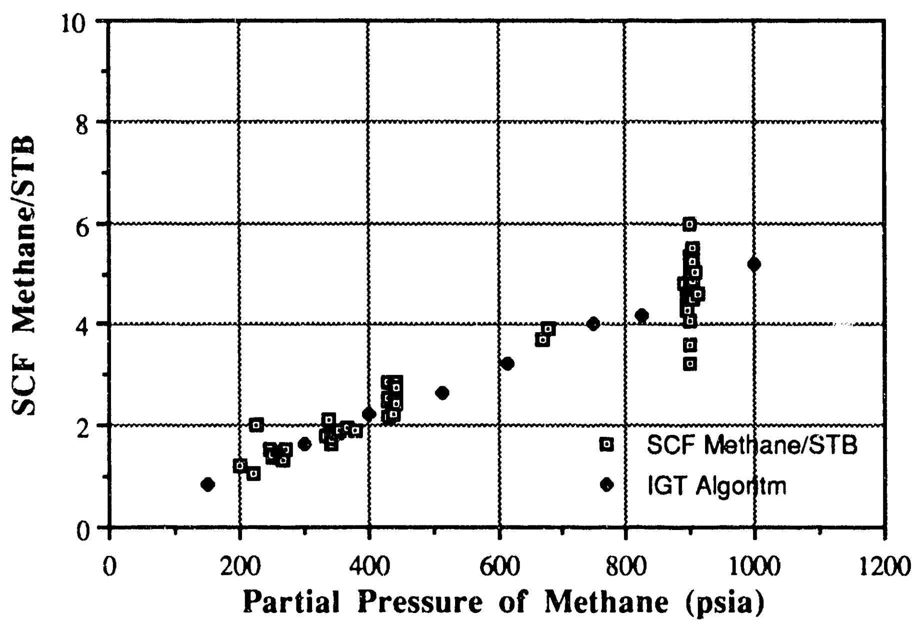


Exhibit 7.1.2-2. METHANE LEFT IN BRINE VERSUS METHANE PARTIAL PRESSURE

It is clear from Exhibit 7.1.2-2 that the methane content remaining in the brine after the separator is consistent with Henry's Law in that its solubility is close to a linear dependence. For every 100 psi of methane partial pressure, 0.56 SCF/STB of methane will remain in the brine. This value for the Gladys McCall well can be compared with similar values for other DOE projects. IGT found a value of 0.62 SCF/STB/100 psi for the Wainoco P. R. Girouard No. 1 well, 0.60 SCF/STB/100 psi for the Pleasant Bayou No. 2 well, and 0.53 SCF/STB/100 psi for the HO&M Prairie Canal No. 1 well.

This linear relationship between partial pressure and the solubility of the gas holds for ethane and propane. Exhibit 7.1.2-3 is a plot of ethane content of disposal brine versus the ethane partial pressure in the separator. Again, there is a simple linear relationship that follows Henry's Law, with 0.0040 SCF ethane/STB/psi, which compares favorably with 0.0038 SCF ethane/STB/psi ethane partial pressure at the HO&M Prairie Canal No. 1 Well. Note that these values for solubility are valid only for partial pressures, not total separator pressure.

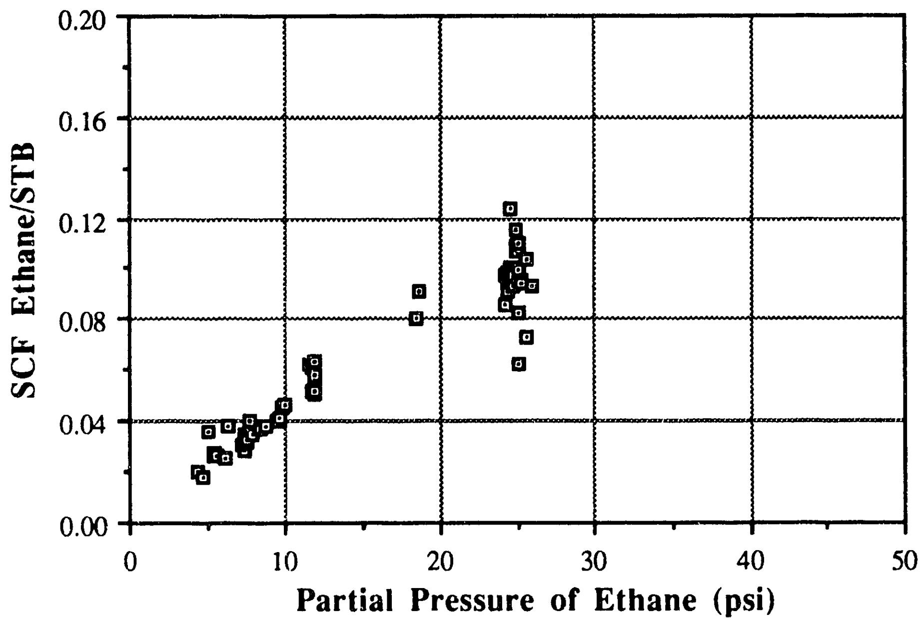


Exhibit 7.1.2-3. ETHANE LEFT IN BRINE VERSUS ETHANE PARTIAL PRESSURE

These simple relationships, which do not change with flow rate, indicate that the separators are at equilibrium and the only way to recover more methane would be to lower the separator pressure.

7.1.3. Field Measurements of Hydrogen Sulfide and Carbon Dioxide

Throughout most of the long-term flow test of Sand 8, measurements of the carbon dioxide and hydrogen sulfide content in the gas were made on a routine, daily basis. The tests were made with a hand-held apparatus where a sample of gas is aspirated by a calibrated squeeze bulb through a small glass tube, which is pre-charged with an indicating medium that changes color depending on the amount of CO_2 or H_2S in the gas (Draeger Tubes). Exhibit 7.1.3-1 shows the reported carbon dioxide content in the first separator (high-pressure) and second separator (low-pressure) for the entire 4-year test period. Exhibit 7.1.3-2 is a similar plot for the hydrogen sulfide content of gas from the two separators. Exhibit 7.1.3-3 plots both the carbon dioxide and hydrogen sulfide measurements for the combined gas sent to sales. The hydrogen sulfide content of the combined gas stream was comfortably below the sales-gas contract specification of 35 ppm.

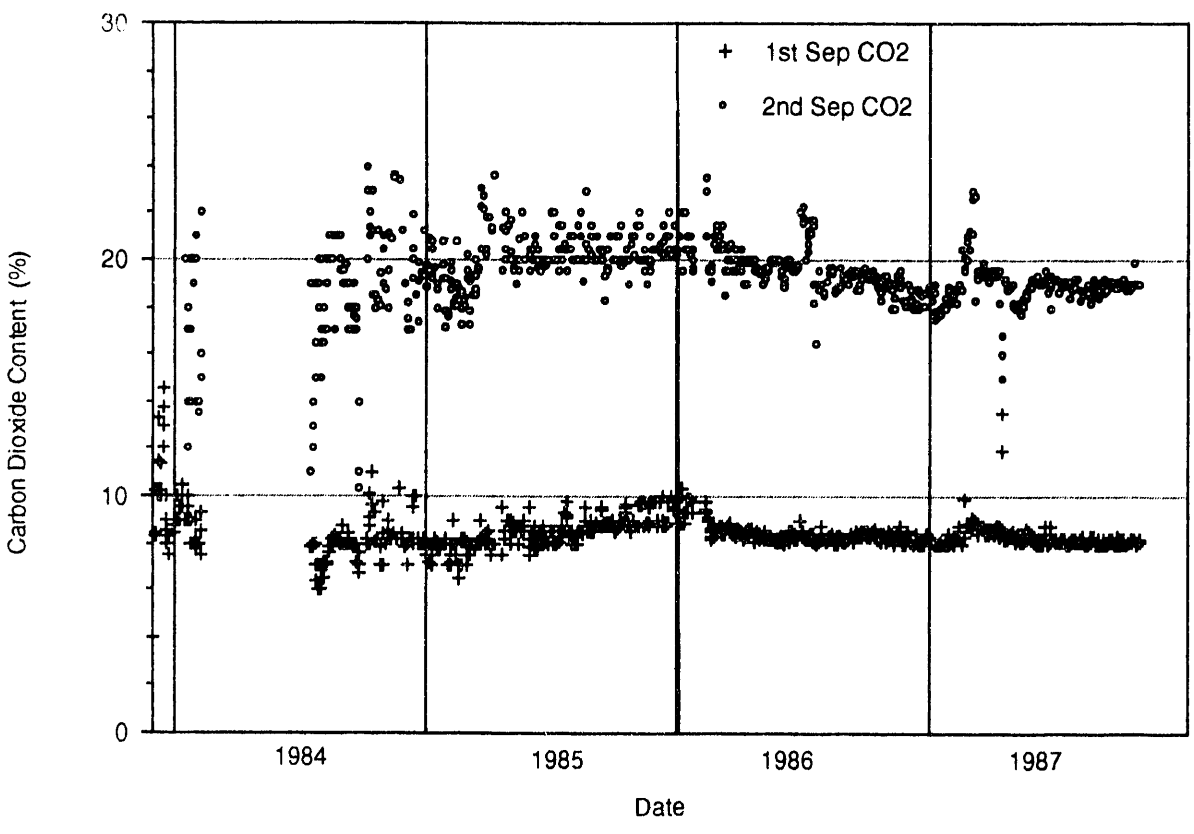


Exhibit 7.1.3-1. FIELD MEASUREMENTS OF CARBON DIOXIDE IN SEPARATORS

There is considerable scatter in the data. Nevertheless, the lack of a trend or significant change is apparent. The change in character of the carbon dioxide data between 1985 and 1986 is

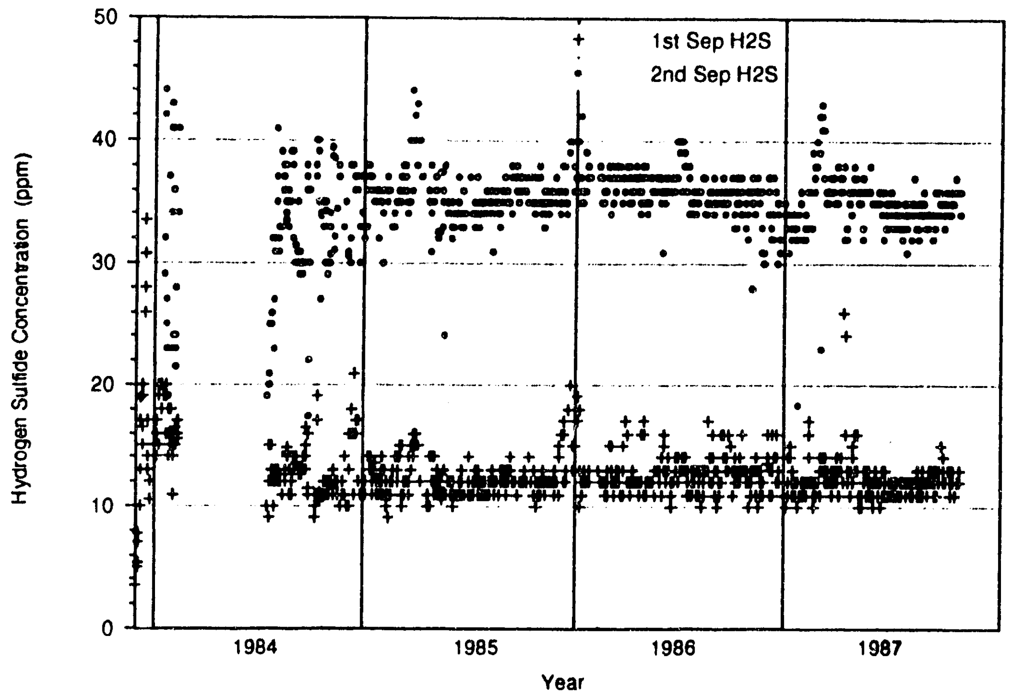


Exhibit 7.1.3-2. FIELD MEASUREMENTS OF HYDROGEN SULFIDE IN SEPARATORS

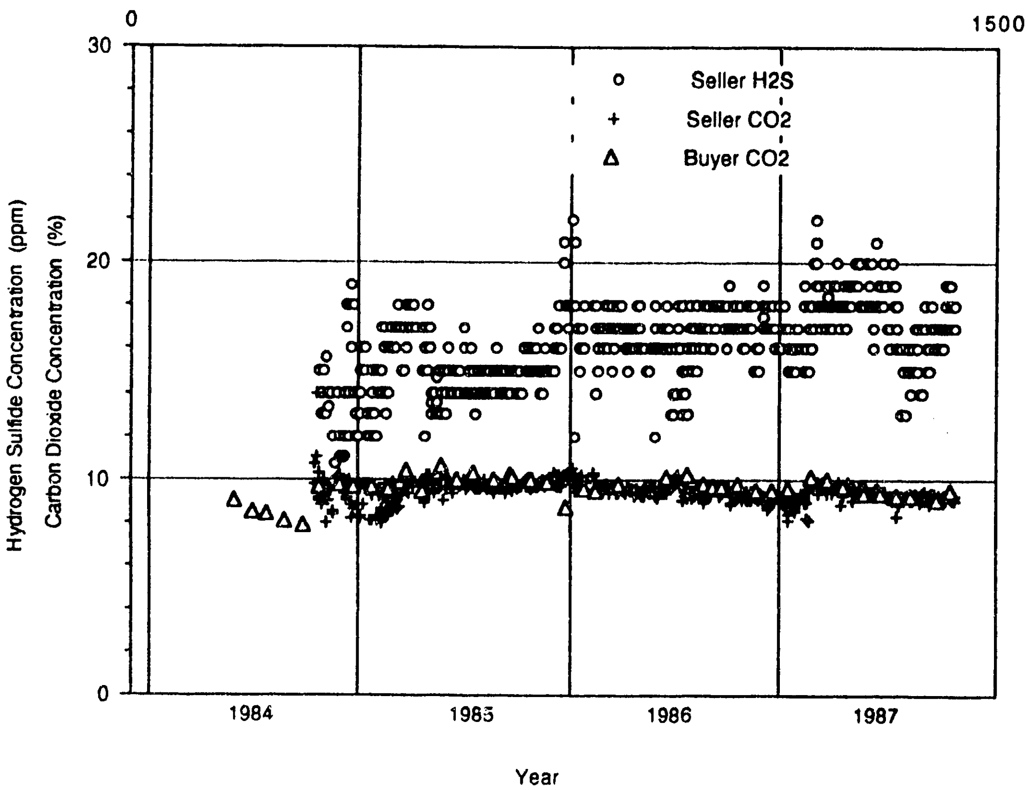


Exhibit 7.1.3-3. CARBON DIOXIDE AND HYDROGEN SULFIDE CONCENTRATIONS IN SALES GAS

believed to be caused by a technique change after the change in contractors, rather than a change in the produced gas. Much of the scatter is caused by the inherent inaccuracy of the measurement method. Variations result from differences in how the aspirator bulb was squeezed, how the tube was located in the sample gas stream, or how well the different operators could interpret the color-change points on the indicator. The readings were taken each day primarily for quality control, to ensure that the gas being sent to sales was within the contract limits for carbon dioxide and hydrogen sulfide. The carbon dioxide measurements were the most accurate because they were taken multiple times a day and averaged. The gas buyer was also making gas composition measurements for the purpose of custody transfer. The close agreement between the seller and buyer measurements can be seen in Exhibit 7.1.3-3.

7.1.4. Total Produced Gas Composition

The gas partitioning between free gas and gas dissolved in the brine depends upon separator pressure. Thus, deducing the total gas content and composition of each barrel of brine passing through the perforations into the wellbore requires the summation of gas volume and composition measurements for the gas streams from the separators and accounting for the gas remaining in brine leaving the low-pressure separator. The gas analyses are combined by weighting each of the measured compositional percentages by the gas/brine ratio at each sample point. Appendix H gives the details of the computational recombinations. Exhibit 7.1.4-1 plots the resulting gas/brine ratios for total gas through the perforations, Exhibit 7.1.4-2 plots the fraction of carbon dioxide in the total gas, and Exhibit 7.1.4-3 presents the fraction of ethane in the total gas.

The gas that is separated and recovered in the first-stage separator generally comprises about 23 SCF/STB out of a total of about 29 SCF/STB, so the composition of the first-stage gas greatly affects the composition of the total gas. In contrast, the gas flashed from the second-stage separator brine generally provides less than 3 SCF/STB. Although the composition of this flashed gas is very different from that of the first-stage gas, it has only a modest effect upon the calculated composition of the total gas. In cases where the first-stage separator brine was flashed, the second-stage separator gas was not needed to calculate the composition of the total gas.

There was considerable variability in the resulting gas compositions and gas/brine ratios. Nevertheless, small trends are discernable in the data. The quantity of ethane and propane declined slightly. The significance of this is discussed in a subsequent section.

7.2. Characteristics of Produced Liquid Hydrocarbons

Three categories of liquid hydrocarbons were collected and measured during this test. These are 1) "cryocondensates," 2) gas knockout-pot liquids, and 3) heavy separator oil. The total

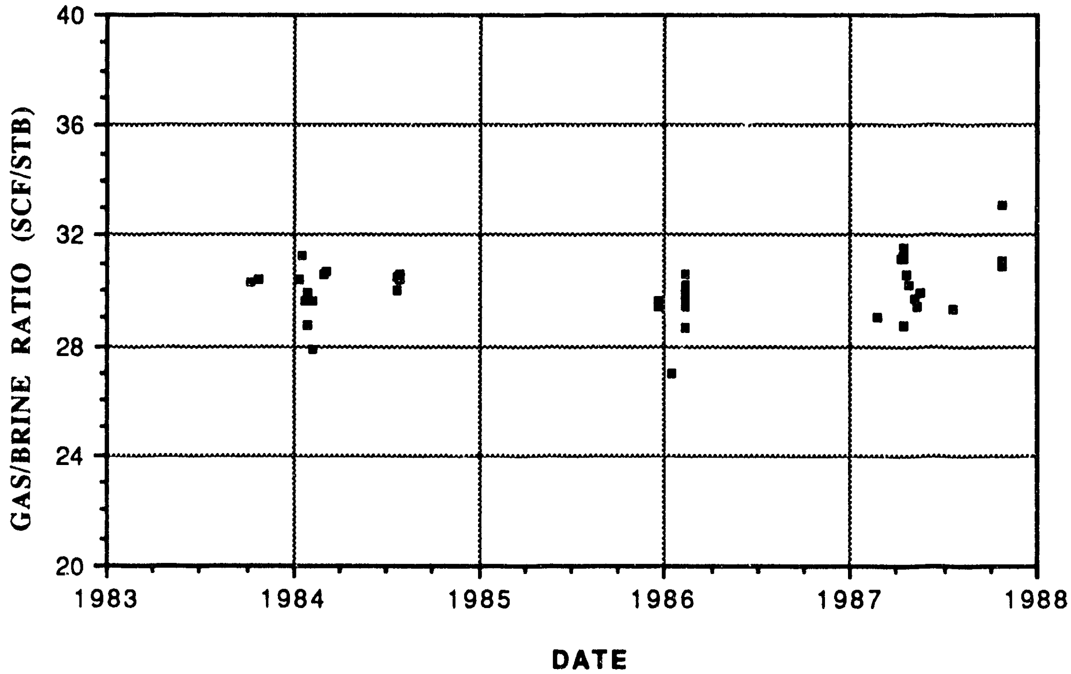


Exhibit 7.1.4-1. GAS/BRINE RATIO FROM RECOMBINATION STUDY

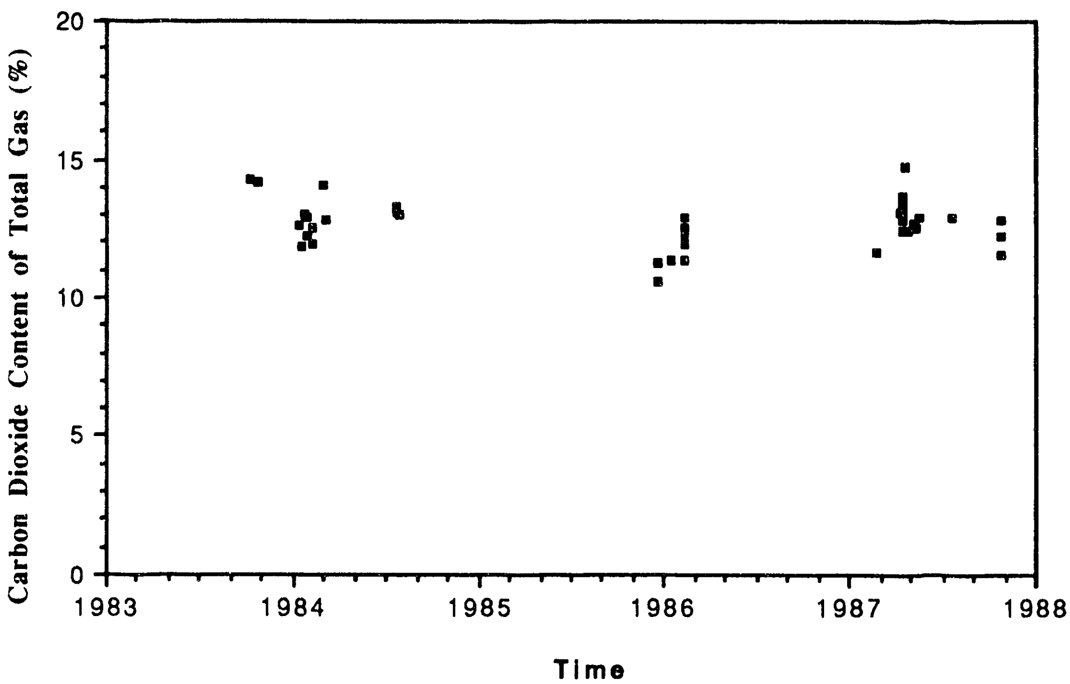


Exhibit 7.1.4-2. CARBON DIOXIDE CONTENT OF TOTAL GAS

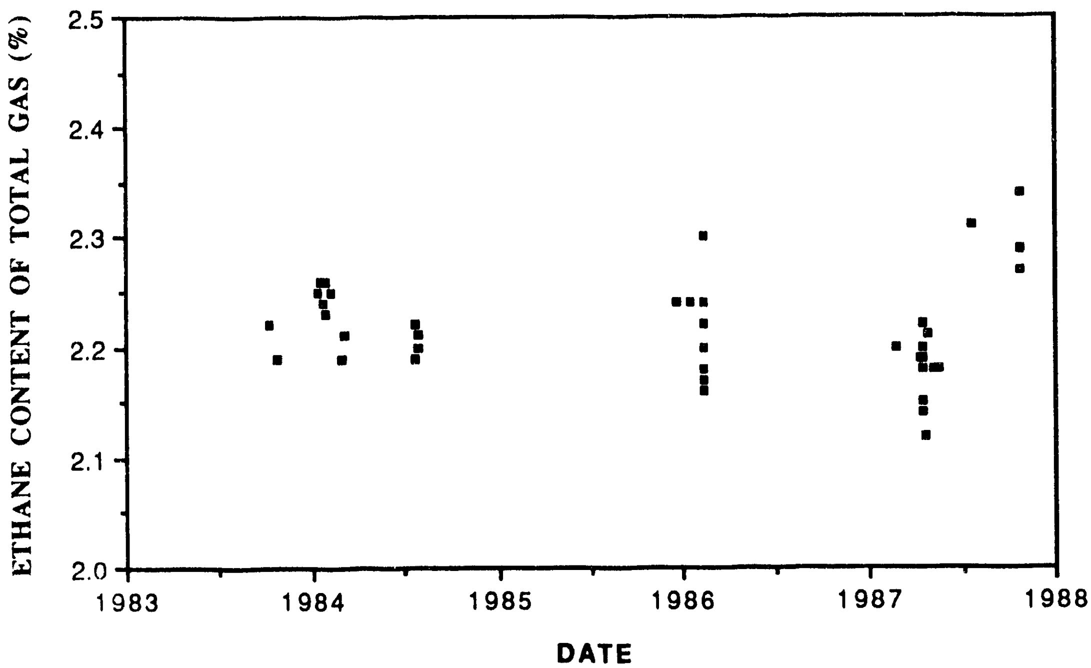


Exhibit 7.1.4-3. ETHANE CONTENT OF TOTAL GAS

quantity of liquid hydrocarbons produced was only a very small fraction of the produced brine. Recovered liquid hydrocarbons had no positive effect on project economics. Total liquid hydrocarbon recovery was less than 300 hundred barrels, or about 1 barrel per week, averaged over the entire flow test.

The "cryocondensates" are named after the method of collecting samples. Gas is passed through dry ice/acetone baths to cool the gas to almost -60°F. An apparatus is in-line to trap liquid hydrocarbons that condense out of a measured volume of gas. In addition, brine is cooled, collected in bottles, and then extracted for hydrocarbons in the laboratory. These samples were collected, quantified, and analyzed by Drs. Keeley and Meriwether of the University of Southwestern Louisiana. These cryocondensates are predominantly aromatic in nature.

The concentrations of cryocondensates, reported herein as parts per million in the brine phase, are shown in Exhibit 7.2-1. The cryocondensate concentration has averaged somewhat below 35 ppm, and there was no real trend in the concentration over time. Cumulative production of these cryocondensates has totaled just under 1000 barrels. Almost none of the cryocondensates are separated and recovered -- a portion remains with the brine that is injected into the disposal well and a portion is sold with the gas. Separation and recovery of the cryocondensate from both the gas phase and the brine phase are not economically feasible.

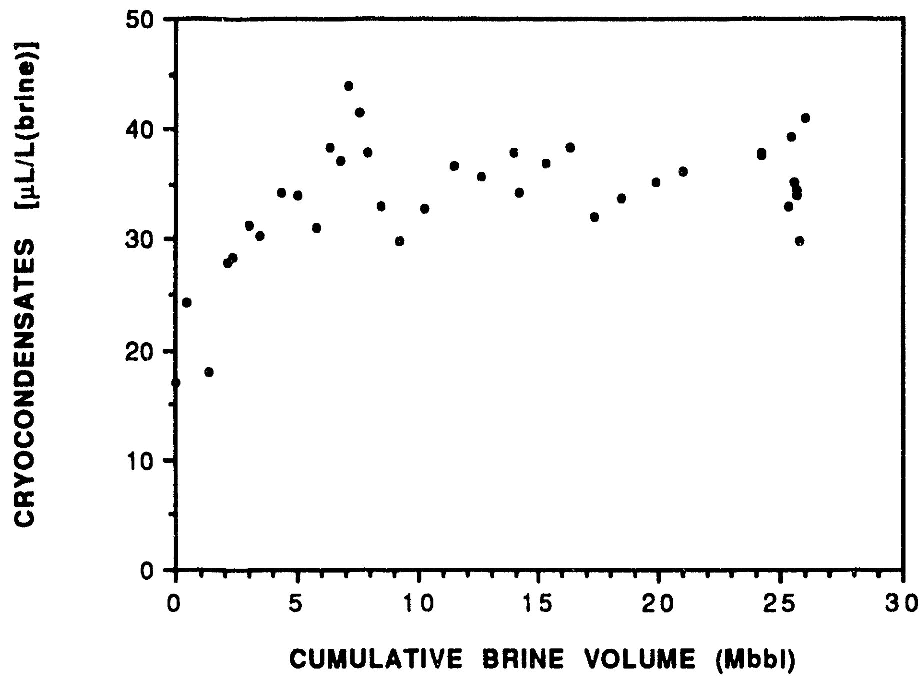


Exhibit 7.2-1. CRYOCONDENSATE CONCENTRATIONS

Cryocondensates are primarily composed of aromatic hydrocarbons that are much more water soluble than are aliphatic hydrocarbons of similar molecular weight. These include benzene, biphenyl, indene, naphthalene, fluorene, phenantrene, and their derivatives.[9] The cryocondensate is believed to be soluble in the brine at reservoir conditions.

The second oil fraction is those hydrocarbons that drop out of the gas phase as it cools and is compressed prior to entering the sales line. This liquid is rich in the very high-boiling-point fraction of the cryocondensates, but does not contain an appreciable fraction of the heavy aliphatics found in the heavy oil that was recovered from the separator. The composition of numerous samples of gas knockout liquids is presented in Appendix I. The sample from the gas-cooler knockout contains hydrocarbons that leave the high-pressure separator as gas but condense as the gas temperature is reduced to near ambient. Until the liquids from the cooler knockout were collected in a tank beginning in 1986, the liquids went unmeasured down the disposal well. Liquid hydrocarbons are also flowed to the tank from the glycol dehydration unit. This liquid was not quantified but was in the range of a gallon or less per day. This liquid was lighter than the gas knockout sample and is very highly aromatic.

Cumulative measurement of liquid collected after the tank was installed is shown in Exhibit 7.2-2. Brine production during the time that 79 barrels of liquid accumulated in the tank

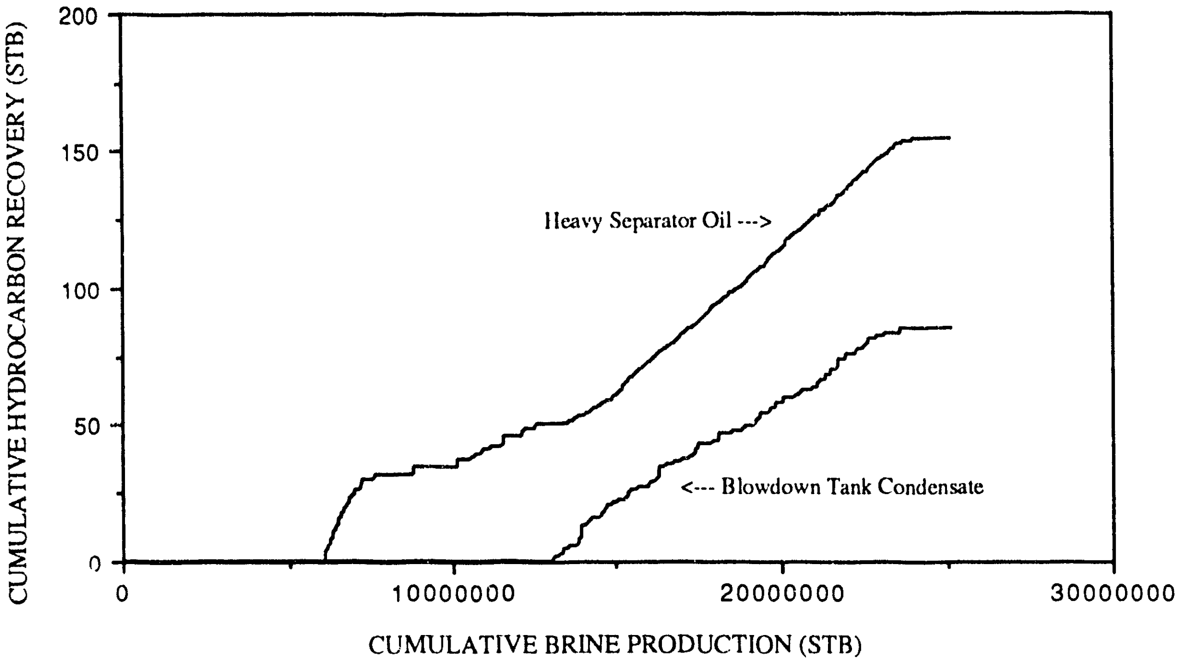


Exhibit 7.2-2. HEAVY OIL PRODUCTION AND CONDENSED HYDROCARBON RECOVERY VERSUS CUMULATIVE BRINE PRODUCTION

was about 10.4 million barrels. These values indicate that recovery of liquid hydrocarbons from the knockout is about 7.6 parts per million of produced brine by volume.

The heavy separator oil was found in the separators at the gas/brine interface. This oil was first observed in January 1985. It has the appearance of a very heavy, aliphatic fraction of a crude oil and does not contain the high percentage of aromatics present in the cryocondensate. Only a few percent of the heavy oil is comprised of light hydrocarbons that are volatile at 300°F.

Exhibit 7.2-2 shows heavy oil production versus cumulative brine production. Whereas the amount of oil produced varied with time, the heavy oil production averaged about 6 ppm by volume in the brine, or 5 ppm by weight. The heavy oil recovery changed with time but was similar in volume to the knockout-pot condensate recovery. This heavy oil was analyzed by gas chromatography. Representative chromatograms of the heavy oil recovered from both separators and of a gas knockout oil are provided in Exhibit 7.2-3. The normal alkane backbone is apparent in these chromatograms. Breakdowns either by carbon number or by boiling point (the simulated distillation technique) are provided in Appendix I.

It is not known whether the oil flowing into the wellbore is transported through a continuous hydrocarbon phase or dissolved in the brine. Summaries of the proposed methods of oil transport

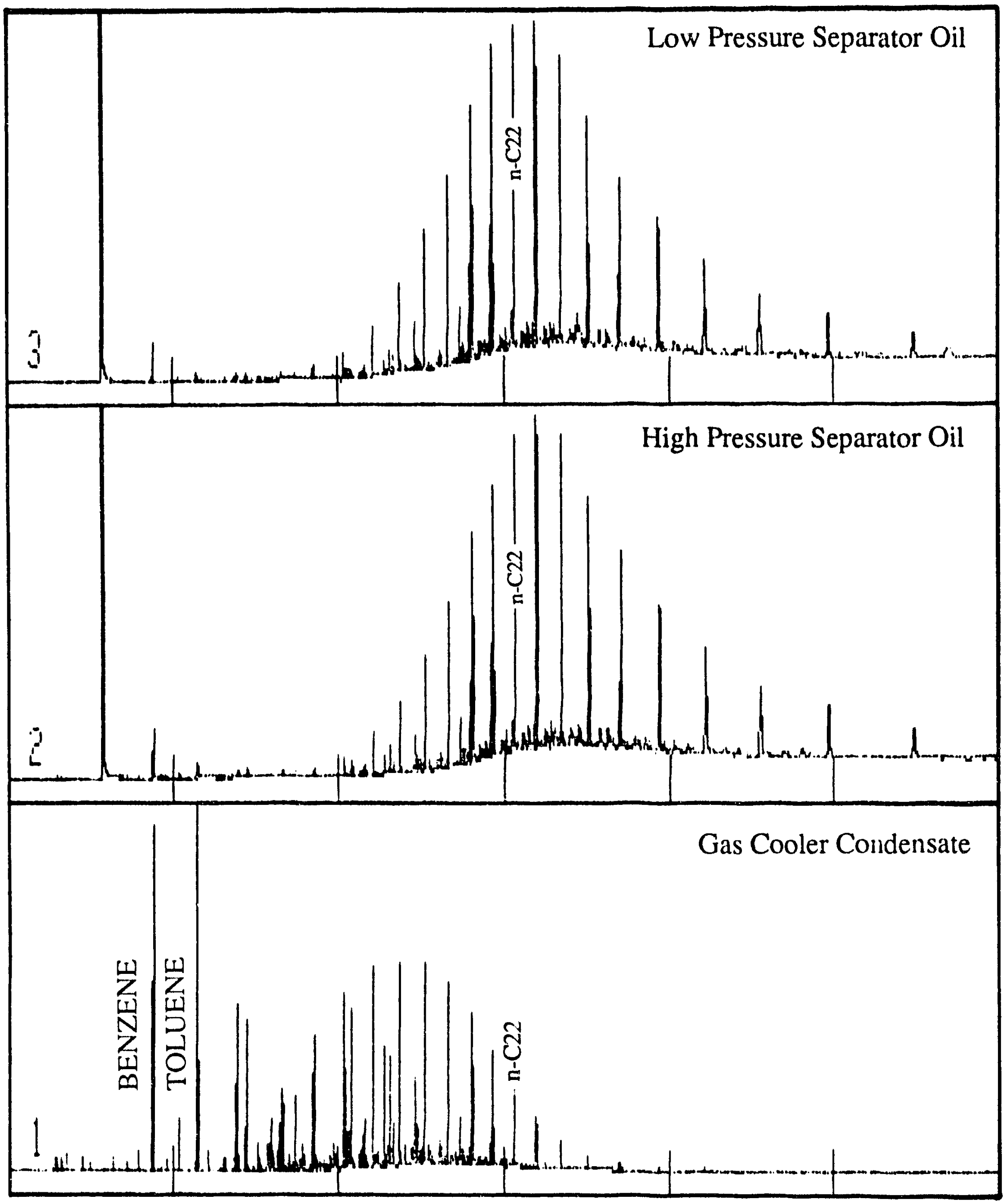


Exhibit 7.2-3. REPRESENTATIVE CHROMATOGRAMS OF RECOVERED OILS

in the reservoir are presented in Appendix I. It is unlikely that the quantity of oil produced will become economical with continued production. Oil production from the Gladys McCall Sand 8 would be expected to remain only at a nuisance level of a few parts per million in the brine.

8.0. GAS SATURATION OF RESERVOIR BRINE RELATIVE TO THE BUBBLE POINT

The Gladys McCall well Sand 8 was initially undersaturated with natural gas at reservoir pressure. During the long-term production phase, however, the flowing bottomhole pressure was drawn down below the 9200 psia believed to be the reservoir bubble-point pressure. The flowing bottomhole pressure reached a low of about 500 psi below this bubble-point pressure in 1986. Evidence -- including the decline in the produced gas/brine ratio, changes in the produced gas composition, and special short-term transient tests developed by IGT -- suggests the reservoir pressure was drawn down below the bubble-point pressure. Observed changes were very small, however, as would be expected if the flowing bottomhole pressure was within a few hundred psi of the reservoir bubble-point pressure.

The laboratory data on bubble-point pressure for the reservoir brine is discused below in Section 8.1. Then, changes in the produced gas/brine ratio and transient testing to determine whether the reservoir has been drawn down to below the bubble-point pressure are discussed in Sections 8.2 and 8.3.

8.1. Sand 8 Gas and Brine Recombination Studies

On October 8, 1983, after 24 hours of production at 13,400 STB/d, separator gas and brine samples were collected at a pressure of 500 psi for laboratory PVT analyses. This 1983 PVT study (Appendix J) was performed by the same personnel and laboratory facility as similar prior studies of samples from the Wells of Opportunity Program. Their experience from this prior work was in good agreement with other laboratories studying solubility of natural gas in brine. The laboratory recombined at the ratio of produced fluids measured from the separator, 25.01 SCF of gas per barrel of separator brine. The bubble-point pressure of this mixture was 9200 psia, whereas the initial reservoir pressure had been reported to be 12,783 psia. This laboratory result was the basis for reporting that the reservoir was undersaturated with respect to natural gas.[2,3] Gas content below saturation was unexpected because the brine in Sand 9 was erroneously believed to be saturated with natural gas. We now recognize that the bubble point in Sand 9 was about 2900 psi below the reservoir pressure and the bubble point in Sand 8 was about 3600 psi below the reservoir pressure.

Exhibit 8.1-1 presents the gas/brine ratios from laboratory recombination studies (Appendix J) in terms of SCF/separator barrel, SCF/STB, and the resulting bubble-point pressures. Because of equipment pressure limitations, the bubble-point pressure could not be measured at the actual reservoir pressure of 12,783 psia. Five bubble-point pressures were measured at separator gas/brine ratios of 25 and lower SCF of separator gas/barrel of separator brine. The results tabulated in Exhibit 8.1-1 were extrapolated out to the reservoir pressure (pages 12 and 20 of Appendix J). The plot of the bubble-point curve indicated that the reservoir brine is only about 80% saturated and the ratio of separator gas to separator brine would have been about 31.9 SCF of separator gas per barrel of separator brine if the reservoir brine had been saturated with natural gas. The right-hand column of Exhibit 8.1-1 is methane solubility calculated from equations developed for DOE by C. W. Blount and his students.[12]

Exhibit 8.1-1. WEATHERLY PVT RECOMBINATION DATA

-----Gas To Brine Ratios-----		Bubble Point,	Blount Solubility,[b]
SCF/Sep Barrel	SCF/STB[a]	psia	SCF/STB
10.01	14.36	2855	15.85
15.00	19.64	4550	20.68
18.00	22.82	5785	23.64
20.00	24.94	6730	25.67
25.01	30.25	9200	30.30
31.9+	37.5	12783	35.84

[a] Gas at 15.025 psia and 60°F.

[b] Calculated for 294°F and 95,000 ppm NaCl.

Only the highest laboratory pressure, 9200 psia, is near reservoir conditions, and the only entries in Exhibit 8.1-1 near the actual well conditions are the three highest pressures. The agreement between recombination gas content and laboratory solubility of pure methane in pure NaCl brine is close at bubble-point pressures of 6780 and 9200 psia. Unfortunately, page 12 of the PVT report (and the fifth line of Exhibit 8.1-1) reflects the author's questionable extrapolation to 31.9 SCF of separator gas per barrel of separator water at 500 psig and 268°F for the initial reservoir pressure of 12,783 psia. Correcting the water volume to atmospheric pressure and 60°F and adding the 3.75 SCF/STB of gas flashed from the separator brine results in the high value of 37.5 SCF/STB for gas solubility in reservoir brine. The author's extrapolation on page 23 of the same report (to 35.8 SCF/STB) is in much better agreement with expectations based on pure components. As shown in Exhibit 8.1-2, a simple least-squares polynomial fit to the data provides excellent agreement with the measured data and suggests the gas solubility at a pressure of 12,783 psia would be 35.3 SCF/STB.

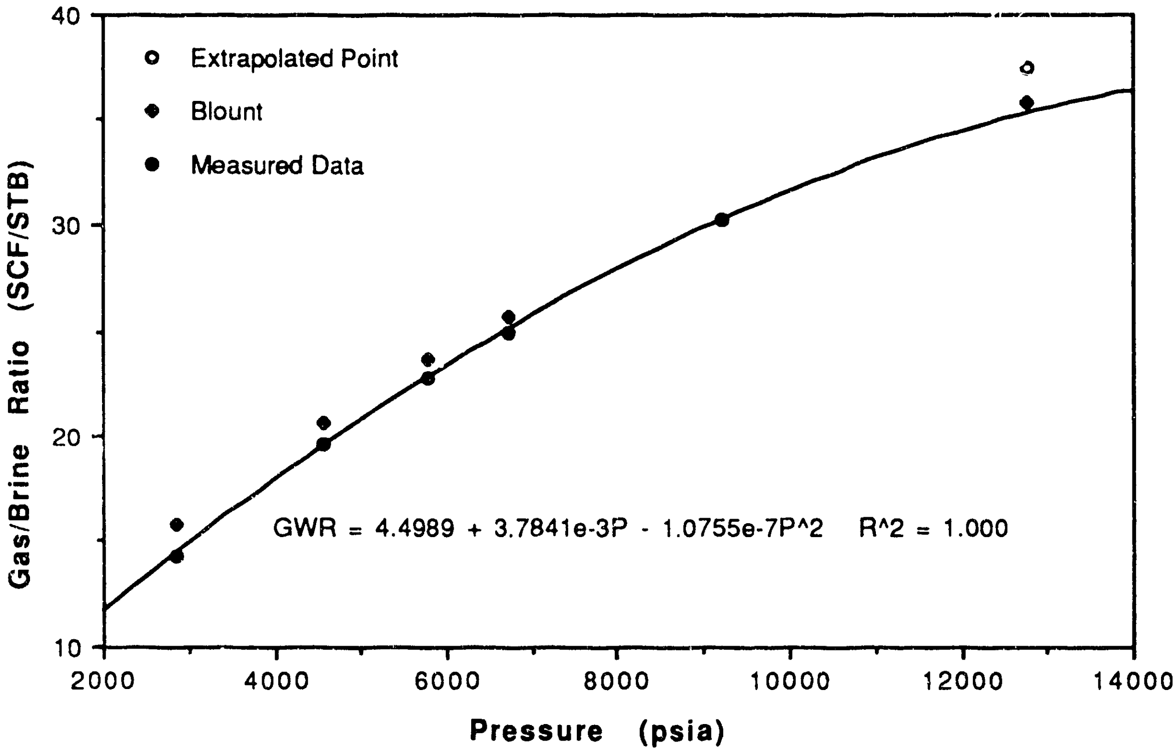


Exhibit 8.1-2. GRAPH OF PVT RECOMBINATION DATA AND CALCULATED METHANE SOLUBILITY

Nevertheless, it was clear the recombination of separator fluids at the rates that were measured resulted in a system with a bubble-point pressure several thousands of psi below the measured reservoir pressure. One concern regarding the 1983 PVT work is whether an incorrect ratio of separator gas and brine was recombined because of problems or errors in flow-rate measurement. The primary uncertainty was whether rate-measurement problems had resulted in laboratory recombination of the wrong gas/brine ratio. This concern has been put to rest. The gas/brine ratio derived from the adjusted data from long-term testing (Exhibits 6.2-1 and 6.2-2) is in agreement with the laboratory recombination PVT data and supports the conclusion that Sand 8 was not saturated with gas.

The oil accumulation in the separators that became apparent more than a year after the start of production provides another concern. It is virtually impossible to collect and recombine samples of three fluid phases (gas, oil, and water) in the correct proportions. Also, careful work in the same laboratory had previously revealed that trace amounts of oil precluded reproducible measurement of the gas/brine bubble point for samples from the Lear G.M. Koelemay well, and in all cases raised the apparent bubble-point. Whether these early measurements were affected by traces of oil that were not seen is conjectural.

8.2. Changes in Composition of the Produced Gas

The natural gas in this reservoir is a mixture containing methane, ethane, propane, butanes, carbon dioxide, and other gases. Because the individual components have different solubilities, a gas phase in equilibrium with brine will have a different composition than the gas in solution in the brine. The heavier hydrocarbon/methane ratios are higher in the free gas than in the dissolved gas. The effect becomes more pronounced as still heavier hydrocarbons are examined. For instance, the propane/methane ratio contrast is greater than the ethane/methane ratio contrast.

This effect is demonstrated in Exhibits 8.2-1 and 8.2-2, which present data from differential liberation studies performed by Weatherly Laboratories as a part of the PVT studies of samples from Sands 8 and 9 (Appendixes J and B). Gas and brine from Sand 8 were recombined at 30.19 SCF/STB. The bubble-point pressure was 9200 psia. This fluid is representative of the reservoir brine prior to production. The pressure on the brine was reduced until a bubble large enough to sample had exsolved from the brine. This bubble was then removed for analysis in a gas chromatograph and the pressure was lowered further until another bubble could be sampled. Each column of the table gives the composition of gas liberated by the pressure step at the top of the column. The total volume of gas liberated was 31.6 SCF/STB. The difference from the amount recombined is in part caused by the necessity of cooling the brine before dropping pressure to atmospheric and the associated shift in carbonate/bicarbonate equilibrium in the brine.

It is noted that there is an apparent problem with the carbon dioxide concentrations for the differential liberation steps in Exhibit 8.2-1. The values should monotonically increase as the pressure decreases. As shown in Exhibit 8.2-2, the carbon dioxide concentrations reported for differential liberation steps to the same pressures for the sample from Sand 9 exhibited the normal trend. For Sand 9, differential liberation steps ending at pressures of 6000, 4000, 2000, and 15 psia resulted in reported carbon dioxide concentrations in the ascending order 2.82%, 3.37%, 9.00%, and 23.58%, respectively.

Both of the differential liberation studies show the normal lower concentration of heavier hydrocarbons with successive pressure drops. It is clear from these tables that, if bubbles of gas formed in the reservoir as the pressure was drawn down below the bubble-point pressure, the gas would be richer in the heavy hydrocarbons than the original solution gas. At the same time, the

Exhibit 8.2-1. SAND 8 GAS DIFFERENTIAL LIBERATION DATA

Pressure, psia	Total Gas	9200-6000	6000-4000	4000-2000	2000-15
Gas Remaining in Brine, SCF/STB	31.60	27.53	22.89	15.80	0
Mole Percent of:					
Carbon Dioxide	14.26	4.20	3.10	3.87	24.79
Methane	82.62	89.03	91.74	92.34	73.93
Ethane	2.22	4.34	3.50	2.75	1.06
Propane	0.54	1.53	0.99	0.63	0.11
Butanes	0.14	0.40	0.32	0.18	0.00
Pentanes	0.03	0.12	0.06	0.03	0.00
C6+	0.19	0.38	0.29	0.20	0.11

Exhibit 8.2-2. SAND 9 GAS DIFFERENTIAL LIBERATION DATA

Pressure, psia	Total Gas	10300-6000	6000-4000	4000-2000	2000-15
Gas Remaining in Brine, SCF/STB	31.14	26.76	22.30	15.30	0
Mole Percent of:					
Carbon Dioxide	14.67	2.82	3.37	9.00	23.58
Methane	81.88	89.56	91.25	86.51	75.08
Ethane	2.22	4.00	3.18	3.16	1.06
Propane	0.48	1.37	0.84	0.56	0.10
Butanes	0.14	0.51	0.28	0.10	0.03
Pentanes	0.05	0.17	0.10	0.05	0.00
C6+	0.58	1.57	0.98	0.62	0.18

gas remaining in solution in the brine and produced up the wellbore would become slightly depleted in ethane and heavier hydrocarbons. Exhibit 8.2-3 presents the ethane/methane and propane/methane ratios from the calculated composition of the total produced gas tabulated in Appendix H. These plots suggest that the reservoir may have been below the bubble point by December 1985. At that time, the hydrocarbon ratios were clearly below those at the start of the long-term flow test.

We can estimate the change in solution-gas composition as the pressure drops below the bubble point. For a 500-psi drop from a bubble point of 9200 psi, the difference of solutions of the equation in Exhibit 8.1-2 reveals that approximately 0.93 SCF/STB of gas should have been exsolved and trapped in the reservoir. Using the gas compositions in the first two columns of Exhibit 8.2-1 and assuming that all of the exsolved gas is trapped in the reservoir, we can calculate that the ethane content of the produced (solution) gas should drop from 2.22% to 2.15%. The propane content should drop from 0.48% to 0.45%. The ethane/methane ratio should drop from 0.0269 to 0.0262, and the propane/methane ratio should drop from 0.0058 to 0.0054. These changes, both in the produced gas/brine ratio and in the hydrocarbon ratios, are about what was observed between the 1984 samples and the 1986-to-1987 samples.

The gaps of more than a year between total gas measurements preclude interpretation of Exhibit 8.2-3 to determine when the reservoir pressure fell below the bubble-point pressure. Some of the gaps in time were examined by making a similar plot (Exhibit 8.2-4) from analyses of samples from the first-stage separator at times when the pressure was near 1000 psi. Overall trends of the two plots are similar, but they do not resolve the question of whether the change during 1985 was caused by dropping below the bubble point or caused by some other phenomena such as changes in the source of brine. The latter possibility cannot be ignored. Oil accumulation in the separators began early in 1985. Changes in the concentration of some species in solution in the produced brine were reported for samples collected in February and May 1985. The most notable was a reported, but questionable, increase in barium concentration from about 100 to about 500 mg/L.

8.2.1. Variation in the Produced Gas/Brine Ratio Due to Bottomhole Pressure

The curve fit to Weatherly's PVT data in Exhibit 8.1-2 suggests that, for every psi the brine is below the bubble point, 0.018 SCF/STB of gas will come out of solution. If the well were produced at a high rate, and long enough to lower the pressure around the well to below the bubble pressure, then gas would come out of solution and form a free-gas phase in the formation. This gas would be trapped in the reservoir rock pores until the critical gas saturation (about 3% of the pore volume) is reached. The volume of this portion of the cone of depression would increase

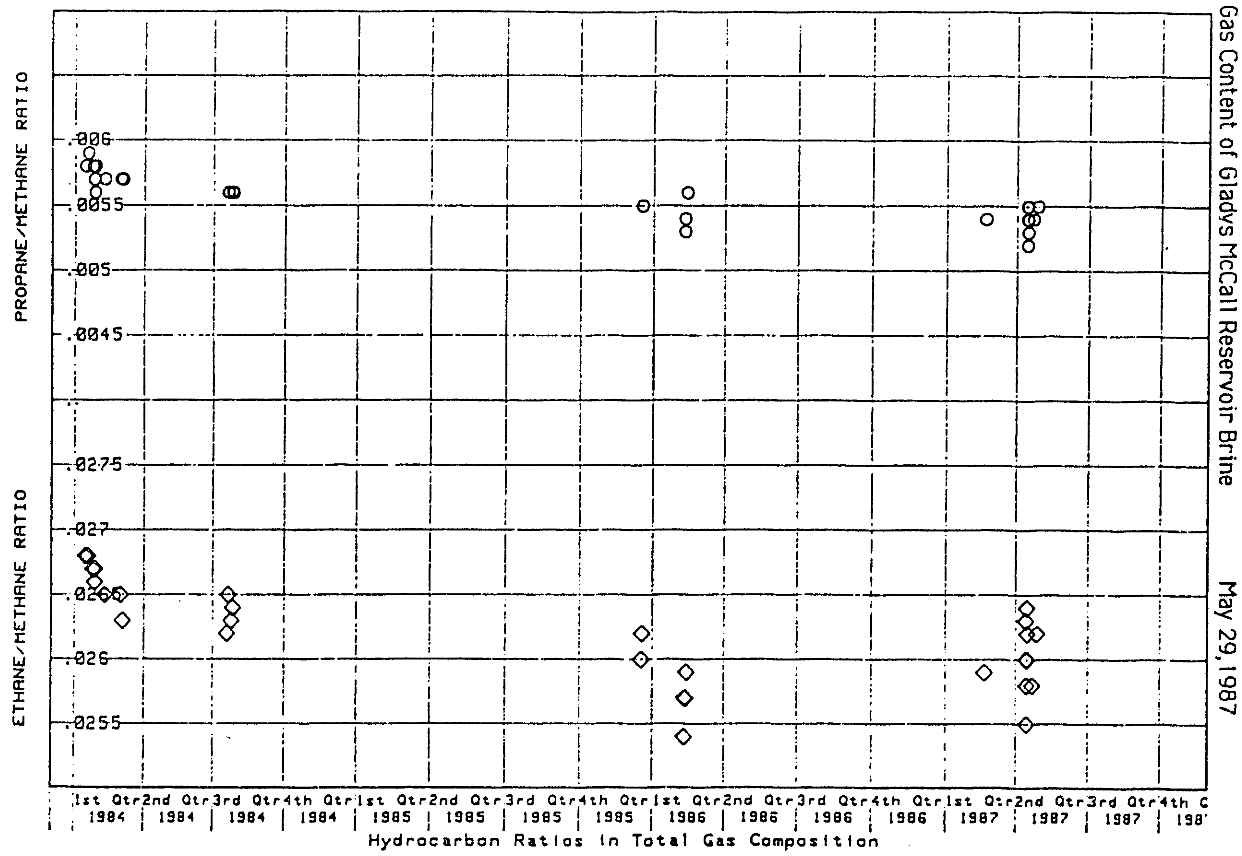


Exhibit 8.2-3. ETHANE/METHANE AND PROPANE/METHANE RATIOS IN TOTAL PRODUCED GAS

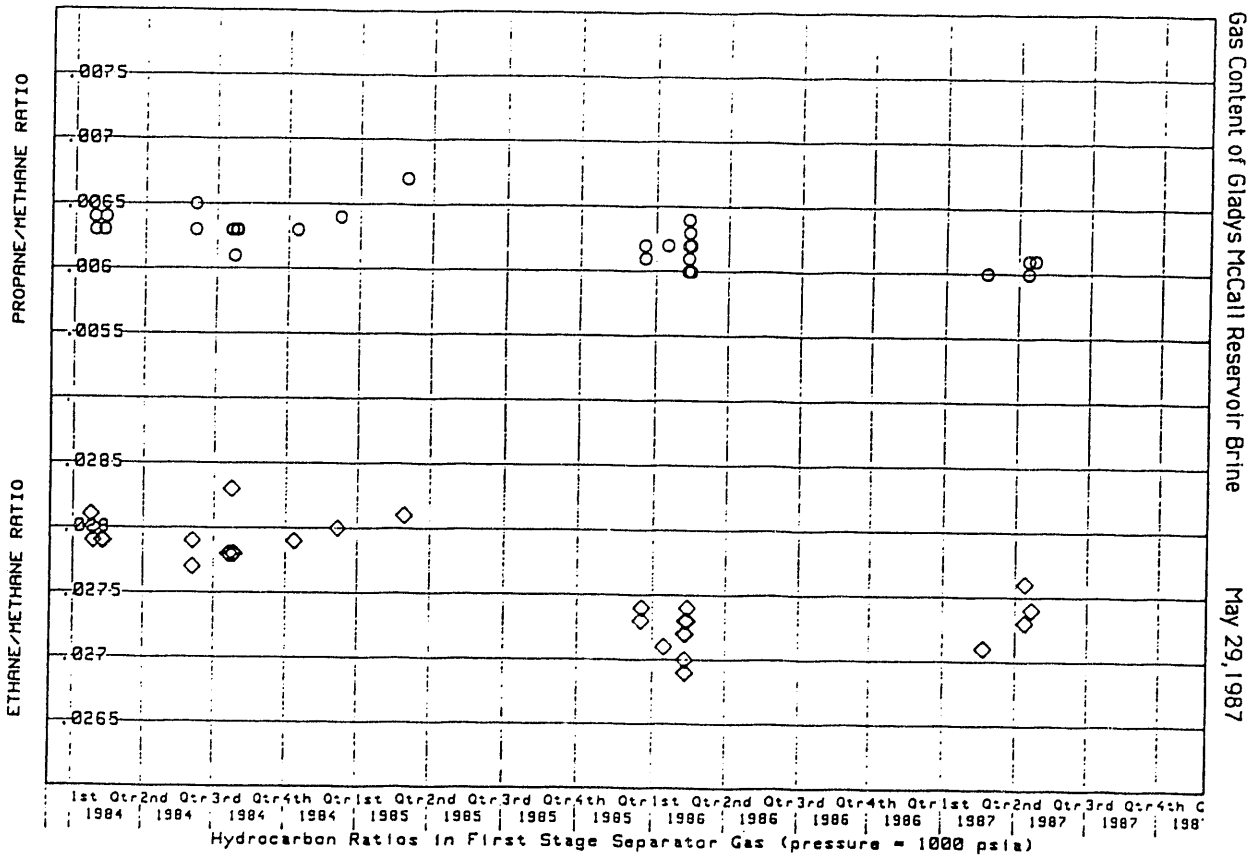


Exhibit 8.2-4. ETHANE/METHANE AND PROPANE/METHANE RATIOS IN FIRST-STAGE SEPARATOR GAS

with time, and only a small portion of the gas being trapped would flow. This gas remaining behind in the cone of depression would detract from the amount of gas that would otherwise be produced. The produced gas/brine ratio is expected to reflect some value between the solubility of gas at the pressure that exists within a few feet of the wellbore and the gas content of original reservoir brine.

The difficulty in measuring the gas rates during the first portion of the test is apparent in the scatter of values for the gas/brine ratio (Exhibit 6.2-3). By late 1984 the operational problems had been largely overcome and the data accuracy was improved. Whether the drop in the gas/brine ratio during the third and fourth quarters of 1985 are caused by the bottomhole pressure falling below the bubble-point pressure is conjectural, but it is within the realm of possibility. Since the first successful scale-inhibitor pill had been pumped, sustained brine rates were higher than had previously been practicable and flowing bottomhole pressure was correspondingly lower than had previously been experienced (roughly 9500 psi).

The slight decline in the slope of the cumulative gas versus cumulative brine plot (Exhibit 6.2-4) at about 10 million barrels of brine is hypothesized to have been caused by the near-wellbore pressure falling below the bubble-point pressure. The change in the gas/brine ratio is very slight and occurred gradually in the third quarter of 1985. There was less than 1 SCF/STB decline throughout the test. This is consistent with the bottomhole pressure falling less than 500 psi below the bubble-point pressure. Calculated flowing bottomhole pressure is shown in Exhibit 8.2.1-1. During the third quarter of 1985 the flowing bottomhole pressure ranged from 9700 to about 9400 psia. This suggests that the bubble-point pressure is in the same range. That range is in reasonable agreement with the 9200 psia deduced from the PVT studies.

On the other hand, if the reservoir brine had been saturated with natural gas at original reservoir pressure of 12,783 psia, the trapping of exsolved gas in the reservoir would have been expected to reduce the gas/brine ratio through the perforations by about 4 to 5 SCF/STB over the time span shown in Exhibit 8.2.1-1. Such a change would have been clearly apparent. This strongly supports the notion that the reservoir brine was not initially saturated with gas.

8.2.2. "Bubble Test" for Free Gas Adjacent to the Wellbore

IGT developed a "bubble test" to determine whether there was free gas at critical saturation in the formation near the wellbore. As the flowing bottomhole pressure falls below the bubble-point pressure of the brine, gas is exsolved. This gas remains trapped in the reservoir until the gas saturation reaches the critical gas saturation. A small amount of the free gas then flows into the wellbore and the gas saturation near the wellbore is maintained at the critical gas saturation. The "bubble test" involves increasing the rate in a stepwise manner. This stepwise increase in flow rate

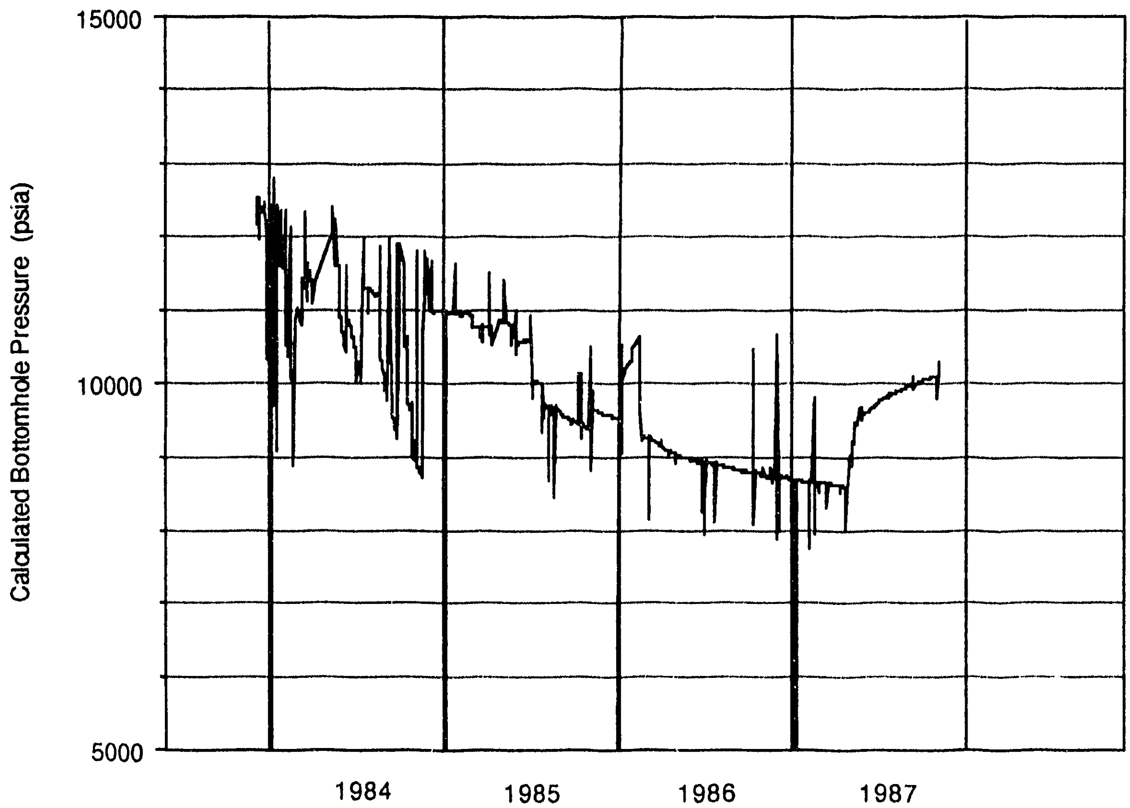


Exhibit 8.2.1-1. SAND 8 CALCULATED BOTTOMHOLE PRESSURE

creates an instantaneous drop in the bottomhole pressure, which in turn causes gas caught in the reservoir to expand slightly. As the gas expands, the gas saturation exceeds the critical gas saturation, so the free gas flows. The amount of gas produced is dependent on the pressure decline, which is small for these high-permeability reservoirs. The excess gas is produced for a short period, and then the produced gas/brine ratio should drop to a level slightly lower than its level before the rate increase because more gas exsolves from the brine further out in the reservoir.

IGT monitored gas rates and composition following a step increase in drawdown on two occasions as a "bubble test" to determine whether the flowing bottomhole pressure was below the bubble-point pressure of reservoir brine -- or, in other words, to determine whether free gas was in pores of the reservoir rock near the wellbore. Excess gas production is generally hard to spot because of transients in the surface facilities caused by the flow rate change. Changes in gas composition, caused by the addition of a small amount of rich gas in equilibrium with the brine at reservoir conditions, are generally easier to determine.

The first test was on February 12, 1986, and the second was on April 14, 1987. Both suggested that the bottomhole pressure was below the bubble-point pressure. But the amount of free gas in pores at near the critical gas saturation was very small. Details of the procedure, the test results, and interpretation are given in Appendix K.

9.0. PRODUCED BRINE CHARACTERISTICS

In the 17-month period between November 1983 and May 1985, seven suites of brine samples were collected and analyzed using the Standard Sampling and Analytical Methods for Geopressured Fluids prepared by McNeese State University in 1980 (Appendix L). After the change in prime contractors, budget restrictions resulted in suites of samples being collected for comprehensive analyses only in December 1985, September 1986, and June 1987. Inductively coupled plasma (ICP) arc spectroscopy was used to determine the concentrations of most of the species in the latter three suites of samples. Results of all the comprehensive analyses are presented in Exhibit 9.0-1, Parts 1 and 2.

Weekly, or often daily, samples were collected by site personnel for chloride and/or alkalinity measurements in relation to scale control. In 1987 IGT subcontracted for Rice University to do a detailed study of the brine chemistry at various flow rates. Between April and June 1987 Rice took samples almost daily and analyzed the data to better understand the constitutive nature of the produced brine and how it related to the production rate. Rice also performed chloride analyses of a portion of the daily samples that had been previously collected by site personnel. Appendix M includes the report submitted by Rice.

Most of the elements/compounds in the brine showed no significant change with either time or flow rate. The noteworthy exception is flow-rate dependence of iron concentration. There were minor changes that may correlate with accuracy or procedure differences between the different laboratories that analyzed the samples. There were some unexplained differences in the compositions for the 1985 and early 1986 samples. Relevant aspects of these topics are discussed under subheadings below.

9.1. Iron Concentration Change With Flow Rate

The concentration of iron in the brine was inversely related to the flow rate. This is shown in Exhibit 9.1-1. At an iron concentration of 30 mg/L and a flow rate of 10,000 STB/d, about 105 pounds of iron is produced each day. The Rice researchers interpreted the variable concentration as the effect of a mass-transport controlled rate without discussing the mechanism. A reasonable mechanistic model to explain the iron concentration variation is to postulate that the concentration of iron in the produced brine is the sum of the iron in the native brine plus the iron

Exhibit 9.0-1, Part 1. SAND 8 BRINE COMPOSITION

Sample Date		11/83	2/7/84	8/7/84	10/12/84	12/1/84
Analysis for:	Units					
Alkalinity (HCO_3^-)	mg/L	-	232	288	285	288
Alpha (Gross)	pCi/L	40	1570	72	68	60
Ammonia	mg/L	-	280	135	50	100
Arsenic	mg/L	0.013	0.004	<0.005	<0.005	<0.005
Barium	mg/L	420	60	80	44	125
Beta (Gross)	pCi/L	340	1870	380	345	310
Boron	mg/L	36	38.5	40.8	41.5	41.5
Cadmium	mg/L	0.015	0.022	0.005	0.02	0.03
Calcium	mg/L	4,040	3,643	4,330	3,840	3,830
Chloride	mg/L	59,290	58,700	57,750	56,300	55,200
Chromium	mg/L	0.04	<0.02	<0.02	<0.02	0.11
Conductivity	µmho/cm	-	111,800	117,800	109,000	111,400
Copper	mg/L	0.015	0.075	0.035	0.020	0.020
Dissolved Solids	mg/L	97,800	94,900	95,100	93,600	91,700
Fluoride	mg/L	0.14	0.40	0.17	0.27	0.16
Gamma (Gross)	pCi/L	1530	1290	180	150	230
Hardness ($CaCO_3$)	mg/L	-	-	-	-	-
Iodide	mg/L	-	-	-	-	-
Iron	mg/L	14.0	18.6	23.6	22.0	89.3
Lead	mg/L	<0.05	<0.05	<0.05	<0.05	0.16
Lithium	mg/L	-	-	-	-	-
Magnesium	mg/L	354	318	370	348	300
Manganese	mg/L	2.1	1.4	1.6	1.73	3.05
Mercury	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
pH	--	-	7.2	6.9	6.18	6.34
Potassium	mg/L	430	780	833	825	807
Radium	pCi/L	17	33	72	41	45
Radon (Gas)	pCi/L	-	49.3	26	20	30
Silica (SiO_2)	mg/L	100	127	129	130	128
Sodium	mg/L	29,750	30,200	38,400	33,900	32,150
Specific Gravity	g/ml	1.0639	1.0637	1.0626	1.0610	1.0632
Strontium	mg/L	540	473	420	440	427
Sulfate	mg/L	<1	<1	<1	<1	2.0
Sulfide	mg/L	-	<0.5	<0.5	<0.5	<0.5
Suspended Solids	mg/L	-	0.40	3.3	1.1	0.6
Zinc	mg/L	0.29	0.26	0.28	0.24	0.21
Laboratory [a]		SCAI	SCAI	SCAI	SCAI	SCAI

[a] SCAI = Scientific Consulting and Analysis, Inc., Lake Charles, LA.

Exhibit 9.0-1, Part 2. SAND 8 BRINE COMPOSITION

Sample Date		2/28/85	5/1/85	12/17/85	9/4/86	6/5/87
Analysis for:	Units					
Alkalinity (HCO_3^-)	mg/L	337	281	488	306	477
Alpha (Gross)	pCi/L	56	35	-	-	-
Ammonia	mg/L	60	81	71	-	-
Arsenic	mg/L	<0.005	<0.005	-	<2.5	-
Barium	mg/L	95	470	576	536	468
Beta (Gross)	pCi/L	470	510	-	-	-
Boron	mg/L	40.3	40.4	-	33	39
Cadmium	mg/L	0.015	0.015	0.11	<0.5	0.12
Calcium	mg/L	3,730	3,690	3,900	3,760	3,574
Chloride	mg/L	56,600	56,100	55,200	55,770	55,000
Chromium	mg/L	0.04	0.03	0.06	<0.5	0.03
Conductivity	µmho/cm	107,200	110,000	-	-	-
Copper	mg/L	0.035	0.035	0.14	<0.5	0.02
Dissolved Solids	mg/L	93,500	91,600	96,500	-	-
Fluoride	mg/L	0.20	0.19	-	0.5	-
Gamma (Gross)	pCi/L	180	250	-	-	-
Hardness ($CaCO_3$)	mg/L	-	-	11,200	-	-
Iodide	mg/L	-	-	44	-	-
Iron	mg/L	25.6	26.5	26.6	28	31
Lead	mg/L	<0.05	0.08	<0.2	-	<1
Lithium	mg/L	-	-	24.8	25	29
Magnesium	mg/L	305	306	280	300	256
Manganese	mg/L	2.36	2.09	1.88	2.0	2.1
Mercury	mg/L	<0.001	<0.001	<0.005	-	-
pH	--	6.56	6.3	6.8	-	-
Potassium	mg/L	810	817	788	862	749
Radium	pCi/L	47	53	-	-	-
Radon (Gas)	pCi/L	33	36	-	-	-
Silica (SiO_2)	mg/L	128	132	149	101	151
Sodium	mg/L	31,700	32,550	34,000	31,930	29,560
Specific Gravity	g/ml	1.0666	1.0627	-	-	-
Strontium	mg/L	400	433	324	336	381
Sulfate	mg/L	1.1	3.3	<2.0	<10	-
Sulfide	mg/L	<0.5	<0.5	-	-	-
Suspended Solids	mg/L	0.5	2.5	-	-	-
Zinc	mg/L	0.28	0.37	0.11	<0.5	0.16
Laboratory [a]		SCAI	SCAI	IGT	MSL	Rice

[a] SCAI = Scientific Consulting and Analysis, Inc., Lake Charles, LA.
IGT = Institute of Gas Technology.
MSL = Mineral Studies Laboratory, U of Texas B.E.G. Average of two analyses of 9/4/86 sample.
Rice = Rice University (Dr. M. Tomson). Average of analyses of five 6/5/87 samples.

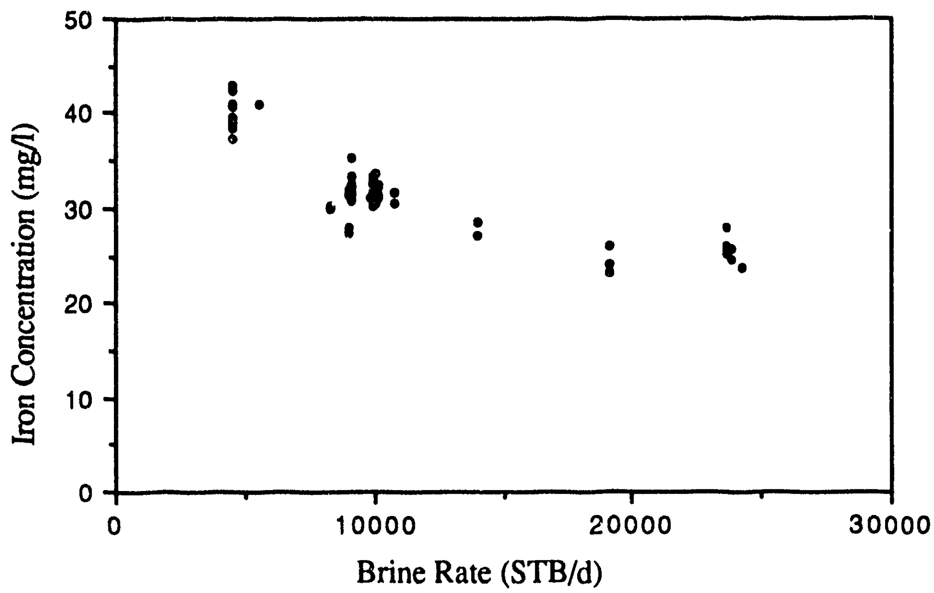


Exhibit 9.1-1. IRON CONCENTRATION VERSUS FLOW RATE

that corrodes off the well tubing as the brine flows up the well. The rate of corrosion is assumed to be independent of flow rate. For this model the data can be fit with the equation --

$$Fe = C_0 + C_1/Flow$$

where -- C_0 = 22.6 mg/L (Natural concentration of iron in formation water)
C_1 = 83033 mg/L /STB/d (Rate of iron dissolution in tubing/casing).

The values for C_0 and C_1 were found by plotting the measured iron concentrations against the reciprocal of flow rate and fitting the data with a straight line (Exhibit 9.1-2).

The validity of this model was cross-checked with a measurement of the hydrogen concentration in the produced gas. Hydrogen content is a measure of the iron dissolved because, in an acidic brine environment, each atom of metallic iron that dissolves into the brine liberates one molecule of hydrogen gas. A hydrogen content of 0.07% was measured in the produced gas on October 21, 1987, when the brine flow rate was 9375 STB/d. This corresponds to 8 mg/L of iron from corrosion. Adding this amount of iron to the natural iron concentration of 23 mg/L gives a total iron concentration of about 31 mg/L. This value falls on the line in Exhibit 9.1-2, indicating excellent correlation with the model.

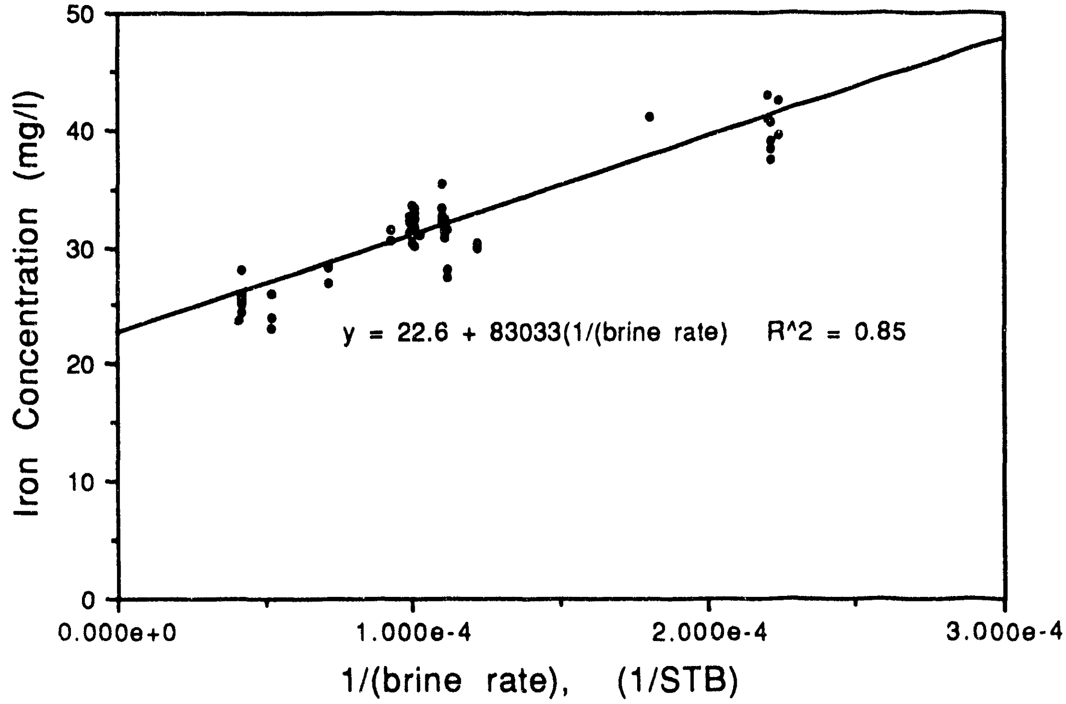


Exhibit 9.1-2. IRON CONCENTRATION VERSUS 1/BRINE RATE

9.2. Questionable Change in Barium Concentration With Time

The largest reported change in concentration was the increase in the barium concentration that occurred between October 1984 and May 1985. The concentration of barium was reported to have dropped from 420 mg/L in 1983 (very early into the flow test) to the range of 44 to 125 mg/L between February 1984 and February 1985. Then, inexplicably, the last analysis performed by SCAI showed the concentration had increased to 470 mg/L. Subsequent analyses by IGT, MSL and Rice averaged 500 mg/L. There is reason to suspect the lower values reported in 1984 and 1985. Rice University analyzed archived Gladys McCall brine samples collected during that time and found they contained about 500 mg/L barium.[19]

The source of this barium is not residual drilling mud being flushed from the reservoir. If the barium concentration of the original reservoir brine is assumed to be 60 ppm, then the excess production of barium since March 1985 would exceed 2000 tons. This is many times more barium than could be accounted for by a wellbore full of drilling mud.

9.3. Other Changes in Concentrations

Some deviations from the averages, such as reported calcium and chloride concentrations of 4330 and 38,400 mg/L, respectively in an August 1984 sample, remain a mystery and are assumed to reflect sampling or analytical error. Both the Gross Beta and Gross Gamma values for the SCAI sample for February 7, 1984, as well as the Gross Gamma value for the November 1983 sample, are an order of magnitude different from all the other samples. Again, analytical or transcription error is suspected.

Concentration changes, on the order of a few percent, may be caused by sampling technique. It is known that if geothermal brines are collected without prior cooling, a portion of the brine flashes at atmospheric pressure. Assuming that the sample bottle is capped when the sample cools to 203°F, the calculated percent of brine that would vaporize from a sample collected from high pressure lines without pre-cooling is shown in Exhibit 9.3-1.

Exhibit 9.3-1. WATER LOSS FROM BRINE SAMPLES DUE TO VAPORIZATION

Temperature at Sample Point, °F	% Water Vaporized
284	7.2
266	5.6
248	4.1
230	2.5
212	0.8

The site personnel historically collected daily samples in 500-ml Nalgene bottles without cooling. A portion of the archived daily brine samples that had been collected by site personnel (every 6 days) was analyzed by Rice University. The concentration of chloride appeared to have decreased by about 4% between 1984 and 1987. Most of this change occurred in the first 12 months of flow. The decline between 1985 and 1987 was 1% or less. The sensitivity of salinity to brine handling was brought to the operator's attention in 1985, and this may have affected sample-handling procedures. The chloride also showed a cyclic variation with a period of between 30 and 60 days and an amplitude between 1500 and 4000 mg/L (2.5% and 7.5%). The amplitude of the cycles increased with time. These changes raised the question about whether fresher water was being introduced into the produced brine either through shale de-watering or flow from an adjacent zone that is less saline. The data is not considered to be definitive because 1) the salinity can be strongly affected by sample-collection procedures and 2) no correlation with the reported periodicity has been found.

10.0. CHARACTERISTICS OF SUSPENDED SOLIDS

The Gladys McCall-produced brine contained a very low concentration of suspended solids. The disposal well injection pressure did not increase with cumulative flow as would be expected with an increasing skin factor caused by particulate plugging. Solids did not accumulate in volumes large enough to cause operational problems in the surface facilities. The brine from the Gladys McCall well was successfully injected into disposal formations without use of advanced filtration methodologies such as deep-bed filtration.

The flow rate through the large separators (54-inch ID X 30 feet long) was low enough that particles with the density of sand and a diameter in excess of 40 microns would settle out therein. Brine was occasionally blown from the bottom of the separators to "blowdown tanks" on the location. The amount of solids in those tanks from production of more than 20 million barrels of brine is estimated to be less than 200 cubic feet, or 20 tons. This corresponds to an upper limit of 1000 pounds of solids per million barrels of brine.

Additional data on the amount and character of produced solids are discussed under sub-headings below.

10.1. Filter Element Usage

The brine was filtered using cartridge-type polishing filters prior to injecting it into the disposal well. Produced brine was put through three parallel filter pots (pressure vessels), each of which contained either eleven or twelve tubular elements that were 40 inches long and about 2.5 inches in diameter. The elements were cotton wound around a stainless steel core and had a nominal rating of 50 microns. The filter pots were located just upstream of the disposal well.

A detailed study of the filter usage was not made, but an indication of the need for filters can be seen in Exhibit 10.1-1, which plots the number of changes of the filter pots as a function of produced brine for part of the flowing time in 1986 and 1987. During the first 1 million barrels after the flow rate was raised to about 22,000 barrels per day, the rate of changing filter pots was about 15 pots per million barrels of brine. At the end of the high flow-rate period, the rate of pot changes had decreased to about 6 pots per million barrels of brine. This decreasing rate of filter usage suggests that the high flow rate initially conveyed an increased amount of solids from the formation, but as flow continued, the solids production decreased. During the final flow period at a rate of about 9000 barrels per day, the rate of filter-pot changes remained at about 6 pots per million barrels of brine.

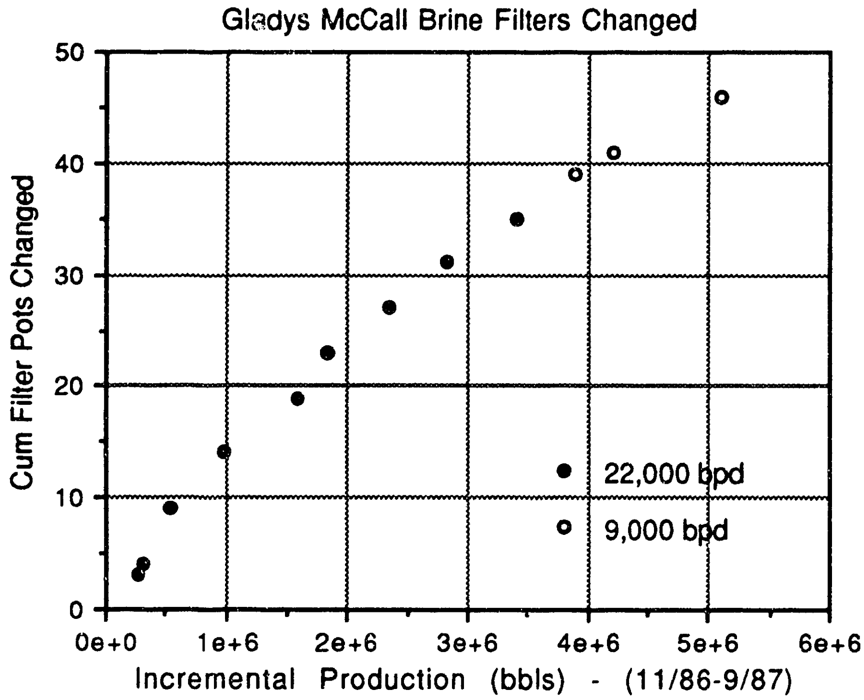


Exhibit 10.0-1. FILTER-POT USAGE VERSUS PRODUCED BRINE

The filters were located after the separators. Stokes Law on the settling velocity for sand particles suggests that most grains with a size larger than 40 microns should have settled out in the separators. Because the separator should have caught the majority of the solids as large as the 50-micron rating of the filter elements, filter loading is only a general indication of solids production. Work at Pleasant Bayou has shown that each filter pot can trap between 0.5 and 1 pound of solids before the filters are plugged. At 15 pots per million barrels of brine, the solids loading of the 50-micron filters averaged 11 pounds per million barrels of brine or 0.03 mg/L. At 6 pots per million barrels of brine, the solids loading on the 50-micron filters is only 5 pounds per million barrels of brine, or 0.01 mg/L.

10.2. Total Suspended Solids in the Brine

The suspended-solids concentration in the brine was measured six times between February 1984 and May 1985 by Scientific Consulting and Testing, Inc., and once by IGT in October 1987. The suspended-solids samples were caught on 0.3 to 0.45-micron filters from sample-collection points located after the separators. The measured values are presented in Exhibit 10.2-1. The average value was 1.2 mg/L (430 lbs/million barrels), although there was considerable scatter in the data.

Exhibit 10.2-1. SUSPENDED-SOLIDS CONCENTRATION AFTER SEPARATORS

	-------------Concentration-------------	
Date	mg/L	lbs/million barrels
2 Feb 1984	0.4	140
7 Aug 1974	3.3	1150
12 Oct 1984	1.1	380
1 Dec 1984	0.6	210
28 Feb 1985	0.5	170
1 May 1985	2.5	870
20 Oct 1987	0.6	230

These values are more than an order of magnitude higher than the 5 to 11 pounds per million barrels of brine caught by the 50-micron polishing filters. This suggests that most of the suspended solids in brine leaving the separators are smaller than 50 microns. These observations are consistent with the calculation using Stokes Law on settling velocity, which suggests that most particles with a size larger than 40 microns should settle out in the separators.

Additional suspended-solids tests were run on October 20 through 21, 1987, using 5 and 10-micron filters. These data are summarized in Exhibit 10.2-2. Half of the suspended solids are smaller than 5 microns and half are larger than 5 microns in diameter.

Exhibit 10.2-2. SUSPENDED SOLIDS AT OUTLET OF LOW-PRESSURE SEPARATOR, OCTOBER 20-21, 1987

Nominal Filter Size,	-------------Concentration-------------	
micron	mg/L	lbs/million STB
10	0.27	90
5	0.31	110
0.3	0.60	230

An X-ray diffraction of an October 21 suspended-solids sample indicated the solids were primarily sand and clays. Iron, presumably from corrosion of tubulars or from the iron-rich chlorite clays present in the reservoir, was only a small fraction of the collected solids.

10.3. Relative Plugging Index

Filtration data from tests performed on October 1987, while the well was flowing at the reduced rate of 10,000 STB/d, indicate high quality for the water leaving the separators. For example, a correlation of the cumulative volume through the filter as a function of time, developed by Amoco, is called the Relative Plugging Index (RPI). The Gladys McCall RPI is about 0.8, which is rated as excellent. The data and interpretation leading to this conclusion are discussed below.

The Relative Plugging Index is an empirical method to estimate the quality of water. It involves passing a sample of water through a filter apparatus and determining the quality of the water as it relates to plugging of the filter. The data is plotted on a semilog plot of flow rate versus cumulative volume throughput. The slope, which is the rate of change of flow, is the indicator of the "quality" or the degree of plugging that has occurred. Exhibit 10.3-1 gives the data for a sample of McCall brine and Exhibit 10.3-2 shows a plot of the data.

Exhibit 10.3-1. DATA FROM BRINE-FILTERING TEST

Δt, s	V, ml	ΔV, ml	$\Delta V/\Delta t$, ml/s
60	0.25	250	4.17
90	0.50	250	2.78
100	0.75	250	2.50
93	1.00	250	2.69
92	1.25	250	2.72
105	1.50	250	2.38
105	1.75	250	2.38
115	2.00	250	2.17
115	2.25	250	2.17
130	2.50	250	1.92
132	2.75	250	1.89
133	3.00	250	1.88

The Relative Plugging Index is defined as follows:

RPI = TSS - MTSN

where -- RPI = Relative Plugging Index

TSS = Total Suspended Solids, ppm

MTSN = Millipore Test Slope Number.

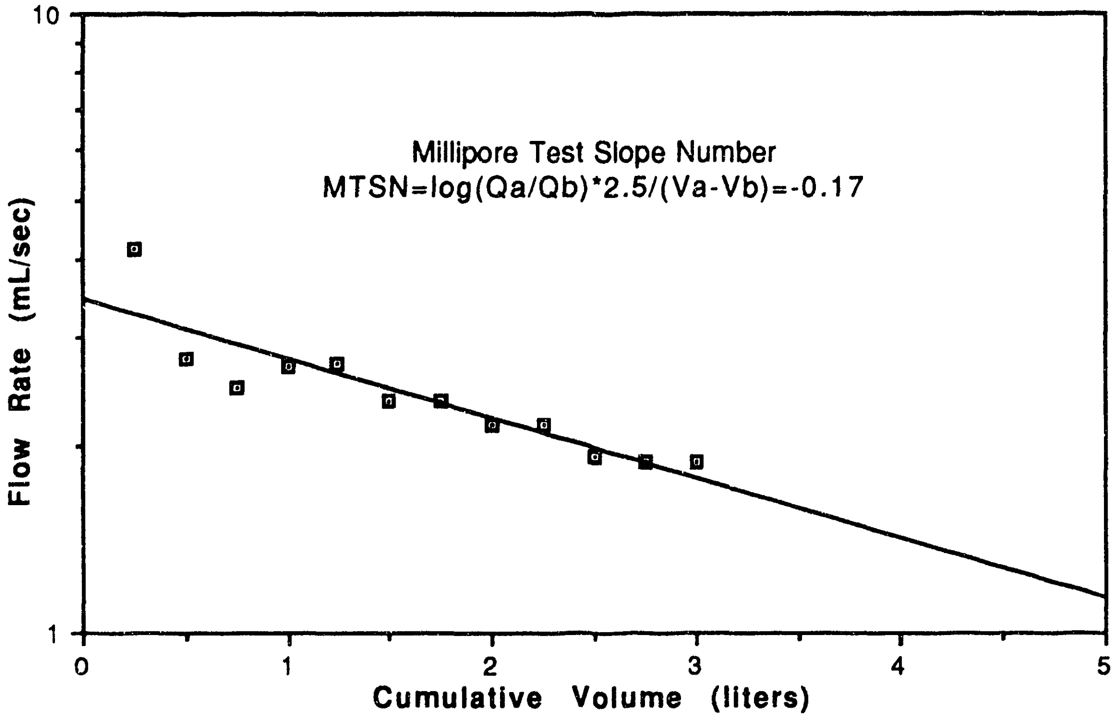


Exhibit 10.3-2. PLOT OF DATA FOR RELATIVE PLUGGING INDEX (RPI)

For the brine from the low-pressure separator in October 1987, Exhibit 10.2-2 reveals a value of 0.60 mg/L for the amount of solids that were caught on a 0.3-micron millipore filter (TSS) and the slope of Exhibit 10.3-2 gives a value of -0.17 for MTSN. Thus, the value of RPI is --

$$RPI = 0.60 -(-0.17) = 0.77$$

Amoco gives a water quality rating guide --

RPI	General Quality Rating
<3	Excellent
3-10	Good to Fair
10-15	Questionable
>15	Poor

The RPI of 0.77 calculated above corresponds to a general quality rating of excellent.

11.0. SCALE INHIBITION

Analysis of the initial brine samples from the McCall well revealed that calcium carbonate scale formation in the brine flow lines would be a problem unless measures were taken to counteract it. Therefore, scale inhibitor was set up to inject into the surface flow lines from the beginning of the flow tests. But scale deposition in the production-well tubing was a significant problem during the first 2 years of flow. This problem was eventually solved with scale-inhibitor squeezes, or pills, that were injected directly into the reservoir.

The inhibitor used for most of the flow test was a polyphosphonate (Dequest 2000) manufactured by Monsanto Chemical Company. The pure chemical was diluted with water to an active strength of about 2% to 3% and then injected by a chemical pump into the brine flow line upstream of the choke so that the concentration in the brine was about 0.5 ppm phosphonate by weight. Initially, the acid form of the polyphosphonate was used. This proved to be excessively corrosive to the injection piping and equipment, so a switch was made to the neutralized form of the chemical.

Although the injection of scale inhibitor upstream of the choke protected the surface piping and equipment from scale formation, it did not protect the tubing in the well or the surface hardware upstream of the inhibitor-injection point. Formation of scale in the production well tubing soon became apparent from degraded well performance. Inspection of the flow lines revealed calcium carbonate scale. Acid was used to remove the scale. From March 7 through 14, 1984, the first of several series of acid treatments and intervening evaluations was performed. Although this treatment removed the scale, it was only a temporary measure.

With resumption of brine production, scale immediately began reforming. To monitor the scale buildup, the flow line between the wellhead and the surface inhibitor-injection point was periodically inspected. The increased friction pressure in the flowing well was also monitored. When the scale buildup became a problem -- with its weight on the tubing, too much pressure drop, or problems with the equipment, such as seizing of the valves -- another acid treatment was performed. A typical acid treatment was about 150 barrels of 15% HCl pumped into the well with spacer pads of brine to spot the acid at the desired points in the tubing. Each treatment was allowed to soak for about an hour before back-flowing it out of the well. Exhibit 11.0-1 tabulates the total amount of acid used for each treatment series and the estimated amount of calcium carbonate scale removed.

Exhibit 11.0-1. ACID TREATMENTS TO REMOVE WELLBORE SCALE

Dates	15% HCl Acid, Bbls	Scale Removed, lbs
Mar. 7-14, 1984	360	33,700
Jul. 10-12, 1984	410	24,800
Nov. 12-16,1984	754	49,900
May 16, 1985	150	3,000

The rate of calcium carbonate scale buildup was calculated by plotting the cumulative amount of scale removed by the acid treatments as a function of the cumulative amount of brine produced. This is shown in Exhibit 11.0-2 for the treatments up through November 1984. Each of these treatments removed all of the wellbore scale. Flow rates during this period were generally 20,000 STB/d and higher. A linear relationship was found for the buildup rate (slope of the line) of 19.4 pounds of scale formation per 1000 barrels of brine produced. This amount of scaling should have reduced the alkalinity in the brine by 55 mg $CaCO_3$/L. After the November 19, 1984, acid treatment of the Gladys McCall production string, the strength of the returned acid indicated that the string was completely free of scale.

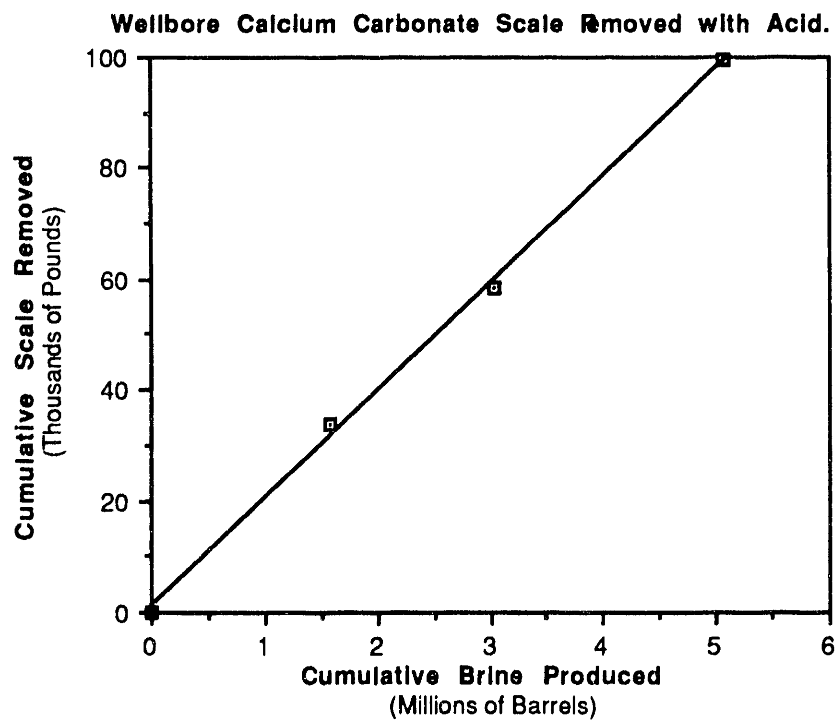


Exhibit 11.0-2. FORMATION OF CALCIUM CARBONATE SCALE IN WELLBORE WITH PRODUCTION

Flow was then limited to below 15,000 STB/d to keep the wellhead pressure high enough to minimize scale formation in the wellbore. On May 17, 1985, another acid job was done. From the amount of acid spent, it was calculated that 3018 pounds of scale were removed and that the string was again scale-free. Between the acid jobs, about 2,300,000 barrels of brine were produced at a fairly constant rate of about 14,500 BPD. Assuming a constant scale-formation rate, the scaling would reduce the alkalinity by 4 mg $CaCO_3$/L. This is considerably less scale deposition than had been experienced at the higher rates. It is not known whether the reduced rate or perhaps a small quantity of inhibitor injected during the unsuccessful pill, or both, were responsible for the reduced rate of scale deposition.

There was an unsuccessful attempt to inject an inhibitor pill in November 1984 and another in May 1985. Inhibitor pills were successfully injected in June 1985 and February 1986.

Inhibitor pills are composed of what would be many months supply of a scale inhibitor that is stable at the reservoir temperature. The intent is to inject, or "squeeze," this inhibitor into the reservoir. In the reservoir matrix, a portion of this inhibitor would either adsorb to sand grains or form a pseudoscale. This portion of the injected inhibitor then leaches out of the rock slowly as brine is produced. This inhibitor residual should be at a concentration high enough to prevent scale formation in the wellbore. The "inhibitor squeeze" treatments were performed with consultation from Rice University.[11,16] The treatments consist of first mixing a "pill" of a few percent phosphonate in brine. The pill is then pumped into the well and forced out into the reservoir formation with a brine chaser.

When brine production is resumed, the inhibitor slowly redissolves into the brine that passes through the treatment zone next to the wellbore, thus inhibiting scale formation in the brine before it enters the wellbore.

The first inhibitor squeeze treatment for the McCall well was attempted on November 28, 1984. This attempt was not successful. The pill consisted of 23 drums of Champion Chemical T-120 (Equivalent to Monsanto Dequest 2000) and 20 barrels of 15% HCl mixed with 450 barrels of hot brine produced from the well. This mixture was pumped into the well. The pumping pressure abruptly increased when the pill reached the perforations. Plugging was occurring, so the job was aborted. Back-flushing the pill revealed a large amount of calcium phosphonate and iron phosphonate solids. The source of the calcium was the 450 barrels of produced brine, which contains 280 kilograms (600 pounds) of dissolved calcium. The iron source was steel dissolved from the mixing tanks and well tubulars by the acid. The dissolved calcium and iron then reacted with the phosphonate to precipitate insoluble calcium and iron phosphonate solids. Production was resumed and the treatment was redesigned to use a neutralized form of the chemical.

A second inhibitor squeeze was attempted on May 28, 1985. As before, this treatment was also not successful. A 300-barrel slug of 15% synthetic sodium chloride brine was injected into the well. A small 27-barrel slug of 3% neutralized phosphonate inhibitor (Champion Chemical T-132) diluted in 15% synthetic sodium chloride brine was then displaced down the well with the synthetic sodium chloride brine. Injected fluids were preheated and filtered. The resistance to pumping suddenly increased as the pill reached the perforations which again stopped further injection. Back-flushing of the pill still in the wellbore produced some solids consisting of calcium-inhibitor salts and/or iron oxides. A second small inhibitor pill was blended and injected, with the same results. The source of the problem was believed to be sodium chloride salt used to make the synthetic brine. Although a sample of the solid salt used to make the synthetic brine was analyzed and found free of calcium, it turned out that the supplier had provided salt from two different sources, and only one of the sources was sampled. The chemists were unaware that two sources had been used. The unsampled salt from the second source turned out to be contaminated with calcium chloride, and the brine had about 250 mg/L of calcium. The pill and synthetic brine had been mixed and stored in several different tanks on location so that the problem with the calcium-contaminated brine was not known until they were mixed during pumping into the well.

Following these two unsuccessful inhibitor squeeze treatments, the procedure was replanned and successfully accomplished on June 25, 1985. Stringent quality control was exercised to ensure that the fluids were not contaminated and that precipitate would not form in the wellbore. This included stringent quality-control specifications that essentially required the use of reagent-grade sodium chloride for preparation of the 15% synthetic sodium chloride brine. A 10% calcium chloride brine was prepared as an overflush. Iron concentration of the delivered brine was less than 1 mg/L. EDTA was added to the brine to tie up what little iron was present. Plastic-lined or fiberglass trucks and mixing vessels were used to the greatest extent possible.

The precautions were only marginally successful. The injection rate was decreased by a factor of three and the injection pressure jumped 1000 psi while the pill was being displaced into the formation. Rates decreased even further as a calcium chloride brine chaser reached the perforations. Nevertheless, the inhibitor pill and 120 barrels of brine chaser were displaced into the formation.

This pill consisted of 550 gallons of Champion T-132 dissolved in 87 barrels of 15% sodium chloride brine. The pill was pumped into the formation with a 300-barrel spearhead of 15% sodium chloride brine ahead of the pill, followed by two 100-barrel overflushes of 15% sodium chloride brine and 10 pounds per gallon (10%) calcium chloride brine behind the pill. The purpose of the calcium chloride was to enhance precipitation of the phosphonate inhibitor in the formation. The well was then shut in for 24 hours to enhance the absorption/precipitation of the inhibitor before resumption of production. Sampling of the initial production (flow-back of the injected fluids) revealed that only 30% of the inhibitor was retained in the formation rock and that 70% of the inhibitor was flushed back out within a few days.

A caliper run before another pill job (on February 4, 1986) indicated that the June 25, 1985, pill job was completely effective in preventing scale formation. This inhibitor squeeze effectively stopped the formation of scale in the wellbore. The concentration of phosphonate in the produced brine was in the range of about 1 ppm shortly after the inhibitor squeeze and decreased to levels near the detection limit of the analysis procedure (a tenth of a part per million) while effective scale inhibition was continuing to occur. Inhibition was occurring at inhibitor concentration levels lower than were expected to be effective.

The last inhibitor squeeze was performed on February 5, 1986. For this squeeze, the pill consisted of 100 barrels of 3% phosphonate (Champion T-132) in 10% synthetic sodium chloride brine. It was pumped in with a 100-barrel spearhead of synthetic brine and an overflush of 1200 barrels of synthetic brine. There was no calcium chloride overflush included in this pill. This treatment successfully controlled scale formation in the wellbore until the termination of the flow test in October 1987.

During the time of the Rice study (April through June 1987) the phosphonate concentration in the produced brine from the previous inhibitor squeeze operations remained at about 0.15 mg/L and was sufficient to prevent scale formation in the wellbore.

12.0. CORROSION

Corrosion was less severe at the Gladys McCall well than had been observed during prior testing of the Pleasant Bayou well. Corrosion inhibitor was not used at Gladys McCall. Prior to successful down-hole treatment with scale inhibitor, calcite scale probably had a significant role in preventing corrosion of the tubing in the production well. The extent to which scale provided protection of surface facilities is not apparent. But it is clear that corrosion/erosion at turbulent areas in the surface piping resulted in penetration of the pipe wall by pits and the necessity for repair.

Production-well and surface-facility corrosion are discussed under separate headings below.

12.1. Corrosion in the Production Well

Corrosion rates in the production wellbore were monitored periodically through iron analyses of the brine, molecular hydrogen analysis of the gas, and caliper surveys. As discussed in Section 9.2, analysis of the iron concentration in brine suggested that the rate of corrosion was a very weak function of brine rate (that is, the concentration of iron in the brine was inversly proportional to the brine rate). In other words, for rates in excess of 10,000 barrels per day, down-hole corrosion was occurring at the constant rate of about 25 to 29 pounds per day and was independent of the flow rate.

A handle on the absolute corrosion rate was provided by the detailed gas analysis of a sales-gas sample collected on October 21, 1987. This sample was analyzed at IGT for gases other than those normally reported in a natural gas analysis. The gas sample was found to contain 0.07 mole percent molecular hydrogen. Molecular hydrogen is not normally found in the produced gas but is produced during the corrosion of iron in an acidic brine as follows:

$$(Fe^0)_{solid} + 2(H^+)_{aqueous} \rightarrow (Fe^{+2})_{aqueous} + (H_2)_{gas}$$

Hydrogen content is a direct measure of the iron dissolved because, in an acidic brine environment, each atom of metallic iron that dissolves into the brine liberates one molecule of hydrogen gas. The hydrogen content of 0.07% was measured in the produced gas on October 21, 1987, when the brine flow rate was 9375 STB/d. This corresponds to an iron loss of 25 pounds per day from the wellbore, wellhead, and plumbing through the separators. This value is consistent with the value of 29 pounds per day estimated from brine analysis data. This iron loss would add 8 mg/L of iron from corrosion. Adding this amount of iron to the natural iron concentration gives a total iron concentration of about 31 mg/L. This equals the average iron concentration value reported by Rice University for that flow rate (Appendix M).

For the approximately 1200 days of production, an iron loss rate of 25 pounds per day corresponds to a total of 30,000 pounds, or about 12% of the weight of the 13,933 feet of 18-pound-per-foot tubing that is in the well. If all of the corrosion was uniform from the tubing, the metal loss would correspond to 12% of the thickness. In practice, we would expect a substantial portion of the down-hole corrosion to occur in the perforated interval. The reason is the higher velocity and turbulance associated with the brine flowing through the perforations and then making a 90-degree change in direction to move up the wellbore. Indeed, on some GRI co-production wells, caliper logging has revealed that the casing has completely eroded away in the perforated interval.

An amount of down-hole corrosion that is consistent with the above discussion was detected by a multi-feeler caliper logging tool run down the tubing. A Kinley Caliper Survey run in July 1988 found only one large pit. This pit was 0.16 inches in depth, which is 44% of the tubing wall thickness. This pit was found in Joint 73, which is at a depth of approximately 2720 feet. The pit was found in the middle of the joint, rather than near the threaded connections. There was also "minor," but detectable, corrosion reported for 217 of the 372 tubing joints inspected during the survey. Minor corrosion is defined in the report as less than 20% of the total wall thickness and may be only a few percent of the wall thickness (on the order of 0.01 inch). This minor corrosion extended the entire length of the tubing, although it seemed more pervasive between 7500 and 11200 feet. Minor corrosion includes shallow pits, shallow general corrosion, roughness, and irregular interior diameters. The number of joints with "minor" corrosion is summarized below.

Depth, ft	Number of Tubing Joints	Number of Joints in Interval With Minor Corrosion
0 - 1870	1 - 50	27
1870 - 3740	51 - 100	27
3740 - 5600	101 - 150	19
5600 - 7470	151 - 200	28
7470 - 9340	201 - 250	38
9340 - 11210	251 - 300	39
11210 - 13080	301 - 350	25
13080 - 13900	351 - 372	14

12.2. Corrosion of Surface Piping

Two types of data were obtained on corrosion of surface piping. The first was from the use of corrosion coupons and is discussed in Section 12.2.1. Additional data have come from direct observation of corrosion, including the occurance of leaks due to corrosion pits penetrating the pipe. The direct observations are described in Section 12.2.2.

12.2.1. Corrosion Coupon Data

Corrosion coupons were in place at one or more locations in the surface facilities throughout the flow-testing of both Sands 9 and 8. The coupons used downstream of the chokes were cut from 1/8-inch-thick "mild steel" by a local machine shop. Details of composition are not known.

An overview of the corrosion coupon data is in Exhibit 12.2.1-1, and comprehensive data on the coupons is in Appendix N. The locations at the heads of the columns in Exhibit 12.2.1-1 relate to the pressure. The "Before Sep" column refers to a location between the choke and the first separator. Pressure at that point is the same as the first separator. There are entries in the "Btw Seps" column only when two separators were in operation in the brine flowpath. The pressure at the coupons is the pressure of the second, or low-pressure, separator. The "Disp Line" coupon point was downstream of the dump valve on the lowest pressure separator and upstream of the filter skid. Pressure exceeded disposal well injection pressure by up to a few tens of psi because of the flowing pressure drop in the surface piping and across the filters.

The rows in Exhibit 12.2.1-1 are in chronological order for the sequence of tests of the Gladys McCall well. Each entry in the exhibit is an average for all coupons used during that flow period. In some cases, the tabulated value reflects results from as many as three separate coupon

EXHIBIT 12.2.1-1. OVERVIEW OF CORROSION COUPON DATA

	-------Metal Loss Rate, mils per year-------		
	Before Sep	Btw Seps	Disp Line
Sand 9 - 24 -Day Test	-10.4		-8.4
Sand 8 - 21-Day Test	-0.7		92.9
Sand 8 - 1 Separator	1.7		247.3
Sand 8 - 2 Separators		8.6	553.5
Sand 8 - 1 Separator			202.1
Sand 8 - 2 Separator			
7/17/84 > 12/30/84		374.5	138.7
12/30/84 > 12/30/85		161.0	2.3
12/30/85 > 1/1/87		-1.2	61.8
1/1/87 > 10/26/87		-0.1	388.9

holders that were examined daily, weekly, and monthly. The tabulated average involved weighing each coupon by the number of days that it was in service. Negative values represent gaining weight. This was most often caused by scale formation on the coupon.

There are a large number of reservations and qualifications regarding the coupon data. Nevertheless, the overall observation that corrosion severity increased with removal of gas from the flowstream and the associated lowering of pressure is consistent with the direct observations of corroded piping.

In addition to the reservations and qualifications regarding the coupon data that are set forth in Appendix N, the balance between scaling and corrosion must be borne in mind when evaluating the coupon data. Both scale and pseudoscale (precipitation caused by an excessive amount of inhibitor) form an impervious coating on steel and thereby retard or prevent corrosion. During 1986 and 1987, the surface scale-inhibitor-injection rate was adjusted on the basis of examining the coupon from between the separators every few days. The same coupon was used for 2 years. A thin layer of scale was usually present, but the coupon was ocassionally cleaned with acid.

12.2.2. Direct Observations of Corrosion

Fortunately the corrosion of the pipe was less extensive than the coupon data would suggest. If the piping had uniformly lost between 200 and 500 mils per year, as suggested by the coupon data, the majority of piping would require replacement.

In practice, the onset of leaks and replacement of portions of the piping was after less than 2 years of production. But after the end of almost 4 years of testing, the majority of the long runs of piping exhibited little, if any, corrosion. To the extent that corrosion was a problem, it was concentrated in regions characterized by high velocity (such as downstream of chokes) or areas where turbulence was induced by changes in direction, weld penetration into the pipe, or other sources of internal roughness.

The leaks that were experienced were in the form of pits penetrating the pipe wall. Onset of leakage was characterized by either 1) growth of crystaline salt or 2) visible water vapor from condensing of water vapor that had evaporated in conjunction with passage through the hole at the temperature of 270° to 290°F. Growth of observed leaks was slow. Leaks were observed for as long as a week while parts needed to repair it were being procured. Then the repairs were made with a down time of only a few hours.

The first leaks occurred in elbows or changes of diameter near the level-control valves just upstream of the coupon located between the separators. This area continued to intermittently spring leaks. Leaks also appeared at similar points in the brine line between the low-pressure separator and the disposal well, although at a lower frequency than the piping after the large separator.

The other location where leaks formed was at the Willis chokes. After a few months of flow, the chokes were opened; one choke had enough corrosion to warrant immediate replacement whereas corrosion was also noted on the other choke. The second choke was removed later that month and both were repaired. Repair consisted of 1) building up the corroded area, 2) machining out 1/4 inch of the total interior diameter, 3) welding in a layer of 309L stainless steel, 4) welding in a layer of 316L stainless steel, and 5) stress relieving the body at 1200°F for 2 hours. This stainless steel overlay was found to be very effective at preventing corrosion in the choke body. Subsequent to this, stainless steel overlays were found to be needed also in the spool pieces, on flange faces and near ring gaskets in the turbulent region downstream of the chokes.

In summary, corrosion in the surface facilities was extensive where 1) brine velocity was in excess of 15 feet per second or 2) there was turbulence induced by restrictions in the flow line or elbows. Internal corrosion along with leaks immediately after control valves and chokes were common, whereas corrosion in the separators -- where flow is essentially laminar -- was minimal. Leaks that eventually did form in the pipe started small and grew slowly, over a period of hours or days. Catastrophic failure of piping, wherein leaks develop quickly and become very large in a short time, was not observed. The onsite personnel became adept at repairing or replacing pipe that had sprung leaks with a minimum of down time.

13.0. CONCLUSIONS

The Gladys McCall well was a successful test as part of the DOE Geopressured-Geothermal Energy Program. The well produced geopressured brine containing dissolved natural gas from the Lower Miocene sands at a depth of 15,150 to 16,650 feet. More than 25 million barrels of brine were produced in a series of flow tests between December 1982 and October 1987 at various flow rates up to about 30,000 barrels per day.

More than 727 million SCF of gas were produced. Of this, 577 million SCF were sold, 90 million SCF were flared, and 60 million SCF remained with the brine injected down the disposal well.

The well is now (1990) in a multiyear long-term pressure-buildup test. Initial short-term flow tests for the Number 9 Sand found the permeability to be 67 to 85 md for a brine volume of 85 to 170 million barrels. Initial short-term flow tests for the Number 8 Sand found a permeability of 113 to 132 md for a reservoir volume of 430 to 550 million barrels of brine. The long-term flow and buildup test of the Number 8 Sand found that the volume of the reservoir as measured by the short-term flow test was connected to a much larger, low-permeability reservoir. Numerical simulation of the flow and buildup tests required this large, connected reservoir to have a pore volume of about 8 billion barrels (two cubic miles of reservoir rock) with an effective permeability in the range of 0.2 to 20 md.

Detailed analyses of the brine and gas found the brine to be undersaturated with gas. The gas content of about 30 SCF/STB was at about 85% of saturation at reservoir pressure and temperature. The corresponding bubble-point presure is about 9200 psi, or about 3700 psi below the initial reservoir pressure. The produced gas/brine ratio was largely invariant with production, time, and flow rate. This is consistent with expectations when it is recognized that the lowest flowing bottomhole pressure inside the wellbore was in the range of 8600 to 8700 psi. This was during the first 4-1/2 months of 1987.

Very small, non-economical quantities of liquid hydrocarbons were also produced. The only data during the first year was from "cryocondensate" analyses. Over the lifetime of the production, the average concentration of hydrocarbons with high aromatic content in the produced brine was found to be about 35 ppmv (parts per million by volume). After accumulation of a heavy aliphatic fraction of crude oil was observed in the high-pressure separator in January 1985, it was found to accumulate at a rate corresponding to a concentration of about 6 ppmv of brine. Measurement of the rate of hydrocarbon recovery by condensation of liquid with high aromatic content from the gas began in January 1986. Recovery rate was found to average 7.6 ppmv.

Substantial inprovements were made in procedures for inhibiting calcium carbonate scale formation in the well tubing and separator equipment. Initially, scale inhibitor was injected into the brine stream upstream of the separator. But scale formed in the production tubing and had to be periodically removed with hydrochloric acid during 1984 and the first half of 1985. For the last half of 1985, brine rate was limited to 15,000 BPD to avoid scale formation in the tubing. Successful injection of inhibitor "pills" into the formation made possible production with the choke wide open for a substantial portion of the last 2 years of production.

Corrosion and/or erosion of surface piping was significant. The problem was most severe in the high-turbulence region immediately downstream of the choke aperture. Use of stainless steel components, or cladding of the inpacted surfaces with stainless steel, was found to remove the problem. The lifetime of A-53 or A-106 carbon steel was found to be only 1 to 3 years downstream of the separators in regions of turbulence due to control valves, elbows, or weld penetrations. Leaks developed because of pitting and grew slowly over a period of hours to days. There was no indication of sudden onset of large or catostrophic leak rates.

14.0. RECOMMENDATIONS

The main objectives of the McCall well-test program have been achieved. The question now is to define the remaining few things to be completed before abandoning the location.

Several recommendations have been made by the involved DOE contractors in recent planning meetings. IGT's positions in relation to these various proposals are as follows:

1. Periodic measurement of bottomhole pressure should continue as long as possible. This is because the pressure-buildup data for the long-term flow test has provided surprising evidence that the geopressured reservoir is very large and that the concept of a sealed reservoir to provide the geopressure may not be as simple as previously thought.

2. The proposal to drill a sidetrack hole to core through the producing zone near the wellbore is a good technical idea on how to obtain direct information on the reservoir rock and how it responded to the production and inhibitor squeezes. Although the procedure to do the coring is a straight-forward drilling practice, the core analysis procedures are not. It would be a mistake to simply cut a core and send it to a commercial core-analysis laboratory for either their routine or special core analysis. Before cutting core, a program needs to be established to identify the experts who are going to do the analysis and to define and initiate the analysis program. It would take a year to assemble the required equipment and verify the special test procedures that will be needed. An important part of such a program would be to make comparisons between the new core and the old core taken when the well was originally drilled. The coring program should not be undertaken until adequate baseline data from the original core is in hand.

3. A brief flow test of the previously produced Number 8 Sand will be useful in comparing the flow capacity (kh) of the well now to what it was when it was shut in 3 years ago. It may not be possible to compare this proposed test to the initial well completion, however, because the down-hole conditions changed with the inhibitor-squeeze operations. This proposed test needs to be done with a bottomhole pressure gauge in the well. The test has been proposed to be 4 to 5 days days of flow time followed by 3 weeks of pressure buildup. This proposed flow time may be longer than necessary. A flow period of 1 day at a low flow rate, followed by 3 to 4 days of pressure buildup, should be adequate to determine the flow characteristics near the wellbore. The longer programmed time allows for detection of the first reservoir boundaries and evaluation of whether the compressibility has changed. If the disposal well is not in a condition to accept the produced brine, the flow time and rate should be down-sized so that it is practical to haul the produced brine to a commercial disposal well rather than perform an expensive workover of the McCall disposal well.

4. Perforating two or three zones above the Number 8 Sand, but still in the geopressured region, and measuring their pressure, will be useful in helping to determine which zones are hydraulically connected to the Number 8 Sand and contribute to the large volume determined from the pressure-buildup data and numerical modeling. Testing of zones above the geopressured horizon will not contribute to analysis of the geopressured energy and should not be undertaken with the limited program funds. Solicitation of bids for companies to perform the test at their own expense could concievably lead to discovering conventional hydrocarbons that will give the well commercial value for sale rather than abandonment.

In addition to the recommendations for which a consensus has been reached in the recent program meetings, IGT recommends the following actions on the Gladys McCall location.

5. Utilize the full suite of production logging technologies in seeking resolution of the confusion regarding the apparent change of a factor of two in formation kh after the first reservoir limit test. This would include nuclear logging to look for changes below the "shale break" near the mid-point of the perforations. Gamma-ray logging would provide insight into whether precipitation of radioactive species was greater for the perforations above or below the "shale break." This result could be further resolved by use of the photoelectric effect and gamma spectrum-analysis logging.

6. Evaluate the effects of disposal of tens of millions of barrels of high-temperature brine. This brine has created a region in the disposal well (presumed to be circular) whose temperature is about 150°F above the normal temperature. The circular region has a diameter of roughly half a mile at a depth of about half a mile. Also, the density of the injected brine is probably lower than the density of the native brine. Whether this perturbation of the normal geothermal gradient or pore-pressure relationship to depth will have significant effects, either positive or negative, needs to be evaluated.

7. Document the corrosion of surface hardware and wellbore tubulars. Substantial amounts of corrosion of surface hardware was observed during the test of the Gladys McCall well, but documentation thereof has been minimal. Also, corrosion of disposal well tubulars was observed but not documented. While dismantling the surface equipment and plugging and

abandoning the two wells, it is important that there be rigorous documentation of the corrosion and any other effects on the equipment from the production. Understanding the corrosion mechanisms and means to minimize costs related thereto is an important element of the cost of future energy supply, whether from geothermal wells or from production of hydrocarbons with a high water cut.

15.0. ACKNOWLEDGMENTS

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APPENDIX A

Compositional Analysis of Core by Core Laboratories, Inc.

Special Core Analysis Study

for

TECHNIDRIL-FENIX & SCISSON

Gladys McCall Well No. 1
Petrographic Analysis

Special Core Analysis LAB

7501 STEMMONS FREEWAY BOX 47547 DALLAS, TEXAS 75247 · 214/631-8270

CORE LABORATORIES, INC.
Special Core Analysis LAB

December 28, 1981

Technadril-Fenix & Scisson
3 Northpoint Drive
Suite 200
Houston, Texas 77060

Attention: Mr. Art Pyron

Subject: Combination Petrology Study
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana
File Number: SCAL-308-81328

Gentlemen:

On August 24, 1981, eighteen core samples from the subject well were submitted to the Special Core Analysis Department of Core Laboratories, Inc. at Dallas, Texas, by Charles Chiasson, Core Laboratories, Inc., Lafayette, Louisiana, with a request on behalf of Technadril-Fenix & Scisson for a Combination Petrographic Study to be performed on each sample. This combination study consisted of Petrographic Thin Section Analyses, Mineral Content Determinations by X-Ray Diffraction and Scanning Electron Microscope (SEM) Study. The results of these analyses are presented herein, and the original set of SEM photomicrographs appears as an appendix to one copy of the report.

A thin section slide was prepared from each submitted sample and described in detail with the aid of a polarizing microscope. The results of these analyses appear on Pages 1 through 18.

An additional portion of each sample was prepared for mineral content determinations. The total sample and clay-sized (less than 4 microns in diameter) fractions were analyzed separately using an x-ray diffraction technique with monochromatic CuKα radiation. The results of these tests appear on Pages 19 through 28.

Technadril-Fenix & Scisson
File Number: SCAL-308-81328
Page Two

A third portion of each submitted sample was prepared for SEM study by creating freshly broken surfaces and coating these surfaces with a thin (750A) film of gold-palladium. A discussion of the features revealed in the SEM photomicrographs appears on Pages 23 through 32.

It has been a pleasure performing this study on behalf of Technadril-Fenix & Scisson. Should any questions arise concerning the results of this study, or if we can be of further assistance, please do not hesitate to contact us.

Very truly yours,

Core Laboratories, Inc.

John A. Koerner
hgk

John A. Koerner, Laboratory Supervisor
Special Core Analysis

JAK:SRO:sd
7 cc. - Addressee

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

PETROGRAPHIC ANALYSIS

Technidril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,182.7-84

Fine Sandstone: Subarkose

This sample is a moderately sorted, moderately packed fine sandstone consisting of 90 percent quartz, 5 percent feldspar, 3 percent rock fragments, 1 percent calcite and 1 percent clay. Also present are traces of organic matter, pyrite, muscovite and tourmaline. Framework grains averaging 0.16mm are subangular to subrounded and subelongate to equant. Contacts between grains are planar, concavo-convex and occasionally sutured.

Monocrystalline quartz predominates, exhibiting straight or undulose extinction. Less common are ploycrystalline quartz grains displaying undulatory extinction. Vacuoles, some forming linear "bubble trains", are present in these quartz grains in addition to microlite inclusions of zircon, tourmaline, rutile and muscovite. The feldspar present is mostly potassium-rich orthoclase and less commonly albite-twinned plagioclase. Most of these grains show partial to extensive alteration marked by significant dissolution creating secondary porosity. Vacuolization, sericitization and minor replacement by calcite are also noted. Especially common representing the lithic portion of the sample is detrital chert, which is composed of microcrystalline quartz and megaquartz. Minor alteration is evident in these chert grains, resulting in clayey overlays, sericitization and replacement by calcite. In addition to these framework grains, organic matter, tourma-line and muscovite are scattered throughout the section.

An early to intermediate stage of quartz overgrowth development is the primary source of cementation. Characterized by euhedral grain terminations, "dust rim" inclusions and concavo-convex contacts, these overgrowths significantly reduce primary intergranular porosity. Additional porosity loss is enhanced by calcite replacement in feldspars and replacement of organic matter by pyrite concentrated within the pore space. Minor clays are also evident coating grains, suggesting a possible authigenic origin

Remnant primary and secondary porosities account for 15 percent of this sample.

All percentages were obtained by point count.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

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File SCAL-308-81328

PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,184.8-86.0

Fine Sandstone: quartz arenite

This sample is a moderately sorted, moderately packed fine sandstone consisting of 92 percent quartz, 3 percent feldspar, 3 percent clay and 2 percent rock fragments. Traces of tourmaline, zircon, pyrite and organic matter are also present. Framework grains are angular to subrounded and subelongate to equant. Averaging 0.20mm, grain size ranges from silt to medium sand. Grain contacts are tangential, planar and occasionally concavo-convex.

The predominant framework grain is monocrystalline quartz displaying straight or undulose extinction. Less common is polycrystalline quartz showing undulose extinction. These quartz grains occasionally contain vacuoles and microlite inclusions of acicular rutile, muscovite, zircon and tourmaline. The feldspar present consists of potassium-rich orthoclase and plagioclase marked by albite twinning. Most of the feldspar grains have undergone partial to extensive alteration resulting in vacuolization, replacement by sericite or calcite and dissolution creating secondary porosity. The lithic portion of the sample is mostly detrital chert composed of microcrystalline quartz. These chert grains are characterized by clayey overlays, replacement by sericite and minor dissolution created as a result of alteration. Organic matter, tourmaline and zircon occur as accessories scattered throughout the section.

The primary source of cementation is an early stage of quartz overgrowth development. These overgrowths are characterized by "dust rim" inclusions, euhedral grain terminations and minor concavo-convex contacts. As a result of overgrowth cementation, primary intergranular porosity is considerably reduced. Secondary calcite occuring as pore-filling cement and as a minor replacement of feldspars also contributes to porosity loss. Pore-filling authigenic kaolinite forms stacked booklets of pseudohexagonal platelets which create some microporosity. Additional clay, possibly chlorite, appears to coat some grains. Organic matter is dispersed throughout the section.

Remnant primary and secondary porosities account for 21 percent of the sample.

All percentages were obtained by point count.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,186.0-87.0

Fine Sandstone: quartz arenite

This sample is a loosely to moderately packed, moderately sorted fine sandstone consisting of 92 percent quartz, 3 percent clay, 3 percent feldspar, 1 percent rock fragments and 1 percent calcite. Traces of organic matter, pyrite and tourmaline are also present. Framework grains are angular to subrounded and subelongate to equant, averaging 0.18mm. Grain to grain contacts are planar or concavo-convex.

Monocrystalline quartz is the predominant framework element. It exhibits straight or undulatory extinction, and occasionally contains vacuoles and microlite inclusions of rutile, zircon and tourmaline. Polycrystalline quartz containing planar or crenulate subcrystals and showing undulose extinction is much less common. The feldspar present includes plagioclase and the potassium feldspars, orthoclase and microcline. Plagioclase is marked by albite twinning, and grid-iron twinning characterizes microcline. Although some feldspars appear fresh, most grains show partial to extensive alteration resulting in clayey overlays, replacement by sericite or calcite and minor dissolution creating secondary porosity. The lithic portion of the sample is mostly detrital chert. Composed of microcrystalline quartz and megaquartz, these chert grains show minor alteration resulting in clayey overlays and some replacement by sericite. In addition to these framework grains, organic matter and tourmaline are scattered throughout the section.

Secondary quartz overgrowths are the predominant cementing agent in this sample. Euhedral grain terminations, concavo-convex contacts and "dust rim" inclusions characterize these quartz overgrowths, and an early to intermediate stage of overgrowth development substantially reduces primary intergranular porosity. Secondary calcite plays a minor role in cementation, replacing feldspar grains and occurring as a minor pore-filling cement. Pyrite is also evident partially replacing organic matter finely dispersed throughout the pore space. Patches of pore-filling authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets creating significant microporosity. Additional clay, rich in chlorite, appears to coat some framework grains.

Remnant primary and secondary porosities account for 21 percent of the sample.

All percentages were obtained by point count.

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File SCAL-308-81328

PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,187.5-89.0

Fine sandstone: quartz arenite

This sample is a moderately packed, moderately sorted fine sandstone consisting of 90 percent quartz, 3 percent feldspar, 2 percent rock fragments, 2 percent clay, 2 percent organic residue and 1 percent calcite. Also present are traces of pyrite, zircon and tourmaline. Framework grains are subangular to subrounded, subelongate to equant and average 0.19mm in size. Grain contacts are planar, concavo-convex and occasionally sutured.

The major framework constituent is monocrystalline quartz showing straight or undulose extinction. Polycrystalline quartz occurs much less frequently and displays undulose extinction. Vacuoles, "bubble trains" and inclusions of muscovite, zircon and tourmaline are evident in these quartz grains. Orthoclase, grid-iron twinned microcline and plagioclase marked by albite twinning represent the feldspathic fraction of the sample. Most of the feldspars have undergone partial to extensive alteration resulting in clayey overlays, sericitization, replacement by calcite and minor dissolution. The lithic portion of the sample is almost entirely detrital chert. Minor alteration in these chert grains shows clayey overlays, replacement by sericite or calcite and some dissolution. Organic residue is concentrated within the pore space, and additional trace accessories of zircon and tourmaline are dispersed throughout the section.

The major cementing agent is an early to intermediate stage of secondary quartz overgrowths characterized by euhedral grain terminations, "dust rim" inclusions and concavo-convex or sutured contacts. As a result of this overgrowth cementation, primary intergranular porosity is significantly reduced. Calcite occurring as a pore-filling cement and partially replacing feldspar grains also contributes to cementation. Some pore-lining clays are present, suggesting a possible authigenic origin. Rare patches of authigenic kaolinite form stacked booklets of pseudohexagonal platelets creating microporosity. In addition, organic residue scattered throughout the section has been replaced by pyrite.

Remnant primary and secondary porosities account for 15 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,189.0-91.0

Fine sandstone: subarkose

This sample is a loosely packed, moderately sorted fine sandstone consisting of 90 percent quartz, 5 percent feldspar, 3 percent clay and 2 percent rock fragments. Traces of organic residue, tourmaline, pyrite and calcite are also present. Subangular to subrounded framework grains are subelongate to equant, averaging 0.17mm. Contacts between grains are tangential, planar or concavo-convex.

Quartz, the major framework element, is predominantly monocrystalline and shows straight or undulose extinction. Less common is polycrystalline quartz exhibiting undulose extinction. Vacuoles, some as linear "bubble trains," and inclusions of muscovite, zircon and rutile are occasionally evident in these quartz grains. The feldspar present includes orthoclase and plagioclase marked by albite twinning. Most of these feldspars show partial to extensive alteration along cleavage traces and twinning planes, resulting in clayey overlays, replacement by sericite or calcite and dissolution. The lithic fraction of the sample is mostly detrital chert. Minor alteration of these chert fragments reveals clayey overlays and replacement by sericite. In addition to these framework grains, traces of tourmaline and organic residue are scattered throughout the section.

The primary source of cementation is an early stage of secondary quartz overgrowth development. Delineated by "dust rim" inclusions, concavo-convex contacts and euhedral grain terminations, these overgrowths considerably reduce primary intergranular porosity. A trace of secondary calcite occurs as a pore-filling cement and occasionally replaces feldspar grains. Minor patches of authigenic kaolinite also contribute to porosity reduction. In addition, Organic residue is partially replaced by pyrite scattered throughout the pore system.

Remnant primary and secondary porosities account for 24 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,348.0-50.0

Fine sandstone: subarkose

This sample is a moderately sorted, loosely to moderately packed fine sandstone composed of 87 percent quartz, 7 percent feldspar, 3 percent rock fragments and 3 percent clay. Traces of organic residue, pyrite, zircon, tourmaline and calcite are also present. Framework grains are subangular to subrounded and subelongate to equant, averaging 0.19mm. Contacts between grains are planar or concavo-convex.

The predominant framework element is monocrystalline quartz exhibiting straight or undulose extinction. Less common are polycrystalline quartz grains showing undulatory extinction. Occasionally, vacuoles and inclusions of muscovite, zircon, tourmaline and rutile are present in these quartz grains. The feldspathic portion of the sample is comprised of plagioclase and the potassium feldspars, orthoclase and microcline. Microcline shows characteristic grid-iron twinning, and plagioclase is marked by albite or pericline twinning. Most of the feldspars appear relatively fresh with only minor alterations resulting in clayey overlays, replacement by sericite and leaching creating secondary porosity. Lithic fragments present include detrital chert and less common claystone clasts. Composed of microcrystalline quartz and megaquartz, these chert grains reveal clayey overlays and replacement by calcite, sericite and pyrite created as a result of alteration. Trace accessories of zircon, tourmaline and organic residue are scattered throughout the section.

An intermediate to advanced stage of secondary quartz overgrowths and concavo-convex contacts is the major cementing agent. As a result of this interlocking texture, primary intergranular porosity is substantially reduced. Rare patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets which create significant microporosity. In addition, possible grain-coating authigenic clay contributes to cementation. Organic residue partially replaced by pyrite is also dispersed throughout the section.

Remnant primary and secondary porosities account for 16 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,350.0-52.0

Fine sandstone: subarkose

This sample is a moderately sorted, loosely to moderately packed fine sandstone composed of 89 percent quartz, 6 percent feldspar, 3 percent rock fragments and 2 percent clay. Also present are traces of organic residue, muscovite, tourmaline and zircon. Framework grains are subangular to subrounded, subelongate to equant and average 0.16mm. Contacts between grains are planar, concavo-convex and sutured.

Monocrystalline quartz exhibiting straight or undulatory extinction is the predominant framework element. Polycrystalline quartz displaying undulose extinction is much less common. Vacuoles, some as linear "bubble trains," and inclusions of zircon, muscovite, tourmaline and rutile are evident in these quartz grains. Orthoclase, grid-iron twinned microcline and plagioclase marked by albite and pericline twinning represent the feldspathic fraction of the sample. Although some of the feldspars appear fresh, most of the grains show alteration resulting in clayey overlays, replacement by sericite and minor dissolution. The lithic portion of the sample is mostly detrital chert and minor claystone clasts. Minor alteration of these rock fragments results in clayey overlays, sericitization and dissolution creating secondary porosity. In addition, traces of muscovite, organic residue, tourmaline and zircon are scattered throughout the section.

Overgrowths of secondary quartz are the primary cementing agent and are characterized by "dust rim" inclusions, euhedral grain terminations and concavo-convex or sutured contacts. As a result of an early to intermediate stage of overgrowth cementation, primary intergranular porosity is significantly reduced. In addition, patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets which create substantial microporosity.

Remnant primary and secondary porosities account for 14 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,352.0-54.0

Fine sandstone: subarkose

This sample is a moderately sorted, moderately packed fine sandstone consisting of 90 percent quartz, 6 percent feldspar, 3 percent rock fragments and 1 percent clay. Also present are traces of organic residue, pyrite, tourmaline and zircon. Subangular to subrounded framework grains are subelongate to equant and average 0.18mm. Contacts between grains are planar or concavo-convex.

Quartz, the predominant framework element, is generally monocrystalline and exhibits straight or undulatory extinction. Polycrystalline quartz displaying undulose extinction is much less common. Vacuoles, "bubble trains" and inclusion of rutile, tourmaline and zircon occasionally are present in these quartz grains. The feldspar present consists of plagioclase and the potassium feldspars, orthoclase and microcline. Plagioclase is marked by albite or percline twinning, and microcline is characterized by grid-iron twinning. Most of the feldspars appear to have undergone partial to extensive alteration resulting in clayey overlays, replacement by sericite and dissolution. The lithic portion of the sample includes detrital chert and minor claystone clasts. As a result of alteration, clayey overlays and sericitization are evident in these chert fragments. In addition, zircon, tourmaline, and organic residue are scattered throughout the section.

The primary source of cementation is an early stage of secondary quartz overgrowths. Delineated by concavo-covex contacts, euhedral grain terminations and "dust rim" inclusions, the development of overgrowth cement has substantially reduced primary intergranular porosity. Additional porosity loss is attributed to rare patches of pore-filling authigenic kaolinite. Organic residue is partially replaced by pyrite and finely dispersed throughout the pore space.

Remnant primary and secondary porosities account for 24 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,354.0-56.0

Fine sandstone: subarkose

This sample is a moderately sorted, loosely to moderately packed fine sandstone composed of 85 percent quartz, 9 percent feldspar, 4 percent rock fragments, and 2 percent clay. Traces of organic residue, pyrite, zircon and muscovite are also present. Framework grains are subangular to subrounded, subelongate to equant and average 0.20mm. Contacts between grains are planar or concavo-convex.

The predominant framework element is monocrystalline quartz displaying straight or undulose extinction. Less common are polycrystalline quartz grains exhibiting undulose extinction. Vacuoles, some as linear "bubble trains," and inclusions of zircon, muscovite, tourmaline and rutile are evident in these quartz grains. Orthoclase, grid-iron twinned microcline and plagioclase marked by albite or pericline twinning represent the feldspathic fraction of the sample. Although some grains appear relatively fresh, most of the feldspars show minor to extensive alteration resulting in clayey overlays, replacement by sericite and dissolution. The lithic portion of the sample is mostly detrital chert. The chert fragments are composed of microcrystalline quartz and show minor alteration to clay and sericite. Traces of organic residue, zircon and muscovite are scattered throughout the section.

An early to intermediate stage of secondary quartz overgrowth development is the major cementing agent. These overgrowths are delineated by "dust rim" inclusions, concavo-convex contacts and euhedral grain terminations. As a result of overgrowth cementation, primary intergranular porosity is considerably reduced. Minor patches of pore-filling authigenic kaolinite also contribute to porosity reduction. In addition, organic residue finely dispersed throughout the section is partially replaced by pyrite.

Remnant primary and secondary porosities account for 19 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,356.0-58.0

Fine sandstone: subarkose

This sample is a moderately sorted, loosely to moderately packed fine sandstone composed of 88 percent quartz, 6 percent feldspar, 4 percent clay and 2 percent rock fragments. Traces of zircon, tourmaline, organic residue, pyrite and muscovite are also present. Framework grains are subangular to subrounded, subelongate to equant and average 0.17mm. Grain to grain contacts are either planar or concavo-convex.

Monocrystalline quartz showing straight or undulose extinction is the major framework constituent and occasionally contains vacuoles and microlite inclusions of rutile, zircon, tourmaline and muscovite. Polycrystalline quartz exhibiting undulose extinction is much less common. The feldspar present consists of plagioclase and the potassium feldspars, orthoclase and microcline. Microcline shows characteristic grid-iron twinning, and albite or pericline twinning is evident in the plagioclase feldspars. Minor to extensive alteration of these feldspars has resulted in clayey overlays and replacement by sericite. Leaching has further created appreciable secondary porosity. The lithic portion of the sample is mostly detrital chert. Pronounced alteration of these chert grains to clay and sericite is noted. Traces of organic residue, zircon, tourmaline and muscovite are scattered throughout the section.

Secondary quartz overgrowths, as characterized by euhedral grain terminations, "dust rim" inclusions and concavo-convex contacts, are the primary source of cementation. This early to intermediate stage of overgrowth development has resulted in a reduced primary intergranular porosity. Patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets which create significant microporosity. In addition, possible authigenic clay appears to coat grains. Organic matter partially altered to pyrite is dispersed throughout the pore space.

Remnant primary and secondary porosities account for 18 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,358.0-60.0

Fine sandstone: subarkose

This sample is a moderately sorted, moderately packed fine sandstone consisting of 85 percent quartz, 8 percent feldspar, 5 percent clay and 2 percent rock fragments. Also present are traces of organic residue, pyrite, muscovite, tourmaline and zircon. Framework grains are subangular to subrounded and subelongate to equant,averaging 0.16mm. Contacts between grains are planar, concavo-convex and occasionally sutured.

The predominate framework element is monocrystalline quartz exhibiting straight or undulose extinction and containing vacuoles and inclusions of muscovite, rutile, tourmaline and zircon. Less common is polycrystalline quartz displaying undulatory extinction. Orthoclase and plagioclase marked by albite or pericline twinning are the most abundant feldspars present. Pronounced alteration to clay and sericite is evident in most of these feldspars along with dissolution creating appreciable secondary porosity. Microcline characterized by grid-iron twinning is much less common,and only slight alteration to clay and sericite is noted in these grains. The lithic portion of the sample is mostly detrital chert composed of microcrystalline quartz and megaquartz. Minor alteration is evident in these chert grains,resulting in clayey overlays, replacement by sericite and dissolution. In addition, traces of organic residue, zircon, tourmaline and muscovite are scattered throughout the section.

An early stage of secondary quartz overgrowth development characterized by euhedral grain terminations, "dust rim" inclusions and concavo-convex or sutured contacts is the primary cementing agent. As a result of this interlocking texture, primary intergranular porosity is significantly reduced. Patchy interstitial clay appears sericitized and further contributes to porosity reduction. Rare patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets creating significant microporosity. In addition, organic residue is finely dispersed throughout the section, partially replaced by pyrite.

Remnant primary and secondary porosities account for 11 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,360.0-62.0

Fine sandstone: subarkose

This sample is a moderately sorted, loosely packed fine sandstone consisting of 88 percent quartz, 6 percent feldspar, 4 percent rock fragments and 2 percent clay. Also present are traces of organic matter, pyrite, muscovite, tourmaline and zircon. Framework grains averaging 0.18mm are subangular to subrounded and subelongate to equant. Contacts between grains are planar or concavo-convex.

The predominant framework element is monocrystalline quartz displaying straight or undulose extinction. Less common is polycrystalline quartz exhibiting undulose extinction. Vacuoles, some as linear "bubble trains," and microlite inclusions of rutile, zircon, tourmaline and muscovite are evident in these quartz grains. Orthoclase, grid-iron twinned microcline and plagioclase marked by albite or pericline twinning represent the feldspathic fraction of the sample. Although some feldspars appear fresh, most grains show minor to extensive alteration resulting in clayey overlays, replacement by sericite and dissolution along cleavage traces and twinning planes. The lithic portion of the sample consists of detrital chert and less common claystone clasts. Clayey overlays, sericitization and minor dissolution are evident forms of alteration in these chert grains. Traces of organic matter, tourmaline, muscovite and zircon are scattered throughout the section in addition to the above framework elements.

Overgrowths of secondary quartz are the primary source of cementation and are delineated by euhedral grain terminations, "dust rim" inclusions and concavo-convex contacts. As a result of this early to intermediate stage of overgrowth development, primary intergranular porosity has been reduced significantly. Rare patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets which create some microporosity. Traces of possible authigenic clays are noted as grain coatings. Organic matter has been partially replaced by pyrite and is scattered throughout the section.

Remnant primary and secondary porosities account for 20 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,362.0-64.0

Fine sandstone: sublithic subarkose

This sample is a moderately sorted, loosely packed fine sandstone consisting of 88 percent quartz, 5 percent feldspar, 5 percent rock fragments and 2 percent clay. Also present are traces of zircon, tourmaline, organic matter, muscovite and pyrite. Framework grains are subangular to subrounded and subelongate to equant. Averaging 0.20mm, grains range from silt to medium sand-size. Contacts between grains are planar or concavo-convex.

The predominant framework element is monocrystalline quartz exhibiting straight or undulose extinction. Polycrystalline quartz displaying undulose extinction is much less common. Vacuoles, some as linear "bubble trains," and inclusions of tourmaline, apatite, zircon, rutile and muscovite occasionally occur in these quartz grains. The feldspar present consists of plagioclase and the potassium feldspars, orthoclase and microcline. Relatively fresh, microcline shows typical grid-iron twinning. Plagioclase is marked by albite or pericline twinning. Alteration to clay and sericite is quite pronounced in most of the plagioclase and orthoclase grains. In addition, extensive leaching in some of these grains has created appreciable secondary porosity. The lithic portion of the sample includes detrital chert and lesser amounts of claystone clasts. Alteration resulting in clayey overlays, sericitization, replacement by pyrite and minor dissolution is evident in these rock fragments. Organic matter, zircon, tourmaline and muscovite are scattered throughout the section as trace accessories.

Framework elements are cemented primarily by an early stage of secondary quartz overgrowths. Delineated by concavo-convex contacts, "dust rim" inclusions and euhedral grain terminations, these overgrowths have considerably reduced primary intergranular porosity. Authigenic kaolinite occurs as a pore-filling cement further contributing to porosity loss. Additional clay appears to coat grains, suggesting an authigenic origin. Finely dispersed throughout the section is organic matter which has been partially replaced by pyrite.

Remnant primary and secondary porosities account for 2 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,364.0-66.0

Fine sandstone: subarkose

This sample is a moderately packed, moderately sorted fine sandstone composed of 87 percent quartz, 7 percent feldspar, 4 percent rock fragments and 2 percent clay. Also present are traces of organic matter, pyrite, zircon and muscovite. Framework grains are subangular to subrounded, subelongate to equant and average 0.18mm. Grain contacts are planar, concavo-convex and occasionally sutured.

Monocrystalline quartz displaying straight or undulose extinction is the major framework constituent and occasionally contains vacuoles and inclusions of zircon, muscovite, tourmaline and rutile. Less common is polycrystalline quartz exhibiting undulatory extinction. Orthoclase, plagioclase and minor amounts of microcline represent the feldspathic fraction of the sample. Plagioclase is marked by albite or pericline twinning and grid-iron twinning characterizes microcline. Microcline grains appear relatively fresh; however the remaining feldspars show appreciable alteration to clay and sericite along cleavage traces and twinning planes. Extensive leaching creating secondary porosity is evident in some of the feldspar grains. The lithic fragments present are mostly detrital chert and minor claystone clasts. Minor alteration resulting in clayey overlays, sericitization and replacement by pyrite are common in these chert fragments. In addition, traces of muscovite, zircon and organic matter are scattered throughout the section.

The primary source of cementation is an early stage of secondary quartz overgrowth development. These overgrowths are characterized by "dust rim" inclusion, euhedral grain terminations and concavo-convex or sutured contacts. Patches of authigenic kaolinite and rare grain-coating clays further contribute to cementation. In addition, organic matter partially replaced by pyrite is finely dispersed throughout the sample.

Remnant primary and secondary porosities account for 15 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,366.0-68.0

Fine sandstone: subarkose

This sample is a loosely to moderately packed, moderately sorted fine sandstone consisting of 88 percent quartz, 5 percent feldspar, 4 percent rock fragments and 3 percent clay. Also present are traces of organic matter, pyrite, muscovite and tourmaline. Subangular to subrounded framework grains are subelongate to equant and average 0.21mm. Grain contacts are planar or concavo-convex.

Quartz, the major framework constituent, is generally monocrystalline showing straight or undulose extinction. Scattered polycrystalline quartz grains display undulatory extinction. Vacuoles and occasional inclusions of rutile, zircon, muscovite and tourmaline are evident in these quartz grains. The feldspar present consists of orthoclase, grid-iron twinned microcline and plagioclase showing albite or pericline twinning. Although some of the grains appear fresh, most feldspars show minor to extensive alteration resulting in clayey overlays, replacement by sericite and dissolution along cleavage traces and twinning planes. The lithic portion of the sample is mostly detrital chert. These chert grains reveal clayey overlays, sericitization, replacement by pyrite and minor dissolution created as a result of alteration. In addition to these framework grains, accessories of muscovite, tourmaline and organic matter are scattered throughout the section.

The development of secondary quartz overgrowths marked by concavo-convex contacts, euhedral grain terminations and "dust rim" inclusions is the major source of cementation. An early to intermediate stage of overgrowth cementation has considerably reduced primary intergranular porosity. Minor patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets creating significant microporosity. Additional clay appears to be pore-lining further reducing porosity. Organic matter dispersed throughout the section has been partially replaced by pyrite.

Remnant primary and secondary porosities account for 20 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,368.0-70.0

Fine sandstone: sublithic subarkose

This sample is a moderately sorted, loosely to moderately packed fine sandstone composed of 86 percent quartz, 6 percent feldspar, 5 percent rock fragments and 3 percent clay. Also present are traces of organic matter, pyrite and muscovite. Framework grains are subangular to subrounded and subelongate to equant. Ranging from silt to medium sand, grains average 0.20mm. Contacts between grains are planar or concavo-convex.

The predominant framework element is monocrystalline quartz exhibiting straight or undulose extinction and occasionally containing vacuoles and inclusions of tourmaline, muscovite, apatite, rutile and zircon. Polycrystalline quartz is much less abundant, displaying undulatory extinction. The feldspar present includes orthoclase, albite or pericline-twinned plagioclase and less prevalent microcline marked by grid-iron twinning. Although some feldspars appear fresh, most grains show alteration resulting in clayey overlays, replacement by sericite and dissolution. The lithic portion of the sample is mostly detrital chert composed of microcrystalline quartz and megaquartz. Minor alteration to clay and sericite is evident. In addition, traces of organic matter and muscovite are scattered throughout the section.

Framework grains are primarily cemented by an early to intermediate stage of secondary quartz overgrowth development. Characterized by euhedral grain terminations, "dust rim" inclusions and concavo-convex contacts, these overgrowths substantially reduce primary intergranular porosity. Patches of authigenic kaolinite occur as stacked booklets of pseudohexagonal platelets which creats significant microporosity. Additional pore-lining clays are indistinguishable; however, their high birefringence suggests an authigenic origin. Trace amounts of pyrite partially replace organic debris finely dispersed throughout the section.

Remnant primary and secondary porosities account for 17 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,370.0-72.0

Fine sandstone: subarkose

This sample is a moderately sorted, moderately packed fine sandstone consisting of 86 percent quartz, 8 percent feldspar, 3 percent rock fragments and 3 percent clay. Traces of calcite, organic matter, pyrite, zircon, tourmaline and muscovite are also present. Framework grains are subangular to subrounded and subelongate to equant. Averaging 0.23mm, grains range in size from silt to coarse sand. Contacts between grains are planar, concavo-convex and sutured.

Monocrystalline quartz exhibiting straight or undulose extinction is the predominant framework element,occasionally containing vacuoles and microlite inclusions. Less common is polycrystalline quartz displaying undulatory extinction. Orthoclase, grid-iron twinned microcline and plagioclase marked by albite or pericline twinning represent the feldspathic fraction of the sample. Most of the feldspars show pronounced alteration to clay and sericite. Leaching of these grains is also noted,creating secondary porosity. The lithic portion of the sample is mostly detrital chert and minor claystone clasts. These rock fragments show alteration resulting in clayey overlays, sericitization and replacement by pyrite. Traces of zircon, tourmaline, muscovite and organic matter are scattered throughout the section.

The primary source of cementation is an early stage of secondary quartz overgrowth development. Euhedral grain terminations, "dust rim" inclusions and concavo-convex or sutured contacts characterize these overgrowths. As a result of this interlocking texture, primary intergranular porosity is appreciably reduced. Sericitized clay appears to form stringers as a result of pressure solution, and accessory minerals in addition to organic matter partially replaced by pyrite are closely associated with these stringers of clay. Minor patches of authigenic kaolinite are present filling some pore spaces. These stacked, pseudo-hexagonal platelets create significant microporosity.

Remnant primary and secondary porosities account for 10 percent of the sample.

All percentages were obtained by point count.

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PETROGRAPHIC ANALYSIS

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,372.0-74.0

Fine sandstone: sublithic subarkose

This sample is a moderately sorted, moderately packed fine sandstone consisting of 82 percent quartz, 11 percent feldspar, 5 percent rock fragment and 2 percent clay. Traces of calcite, organic matter, pyrite, tourmaline and muscovite are also present. Framework elements are subangular to subrounded and subelongate to equant, averaging 0.17mm. Grain to grain contacts are planar, concavo-convex and occasionally sutured.

Monocrystalline quartz displaying straight or undulatory extinction is the major framework constituent. Less common is polycrystalline quartz displaying undulose extinction. Vacuoles, some as linear "bubble trains," and inclusions of tourmaline, zircon, muscovite and rutile occasionally are evident in these quartz grains. The feldspar present includes plagioclase and the potassium feldspars, orthoclase and microcline. Grid-iron twinning is characteristic of microcline, and the plagioclase shows albite or pericline twinning. Many feldspars show pronounced alteration to clay and sericite. Leaching creating secondary porosity is also noted. The lithic portion of the sample is mostly detrital chert in which minor alteration has resulted in clayey overlays, sericitization and replacement by calcite or pyrite. Accessories of muscovite, tourmaline and organic matter are scattered throughout the section.

The primary source of cementation is an intermediate stage of secondary quartz overgrowth development. These overgrowths are characterized by "dust rim" inclusions, euhedral grain terminations and concavo-convex or sutured contacts. As a result of the interlocking texture, primary intergranular porosity is substantially reduced. Scattered patches of calcite occur as a replacement for feldspars, quartz and chert grains. Authigenic pyrite also replaces organic matter dispersed throughout the section. Pore-filling authigenic kaolinite and indistinguishable pore-lining clays further contribute to cementation.

Remnant primary and secondary porosities account for 18 percent of the sample.

All percentages were obtained by point count.

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MINERAL CONTENT DETERMINATION

(by X-ray Diffraction)

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Sample Identification:	1		2		3		4		5	
Sample Depth, feet:	15,182.7-84.0		15,184.8-86.0		15,186.0-87.0		15,187.5-89.0		15,189.0-91.0	
Particle Size of Sample Fraction:	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay
Estimate of Net Percent Clay Minerals:	1.4		3.3		3.1		1.9		2.7	
Mineral	Fraction of Sample Analyzed									
Quartz	92		94		93		94		91	
Feldspars	7		3		4		4		6	
Barite	Trace		Trace		Trace		Trace		Trace	
Kaolinite			2	48	2	59	<1	42	2	66
Chlorite (Fe-Rich)	1	97	1	44	1	31	1	46	<1	24
Illite/Mica	Trace	3	Trace	8	Trace	10	Trace	12	Trace	10

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MINERAL CONTENT DETERMINATION

(by X-ray Diffraction)

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Sample Identification:	6		7		8		9		10	
Sample Depth, feet:	15,348.0-50.0		15,350.0-52.0		15,352.0-54.0		15,354.0-56.0		15,356.0-58.0	
Particle Size of Sample Fraction:	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay
Estimate of Net Percent Clay Minerals:	3.0		2.1		1.8		1.8		4.0	
Mineral	Fraction of Sample Analyzed									
Quartz	91		91		93		90		92	
Feldspars	6		7		5		8		4	
Barite	Trace		Trace		Trace		Trace		Trace	
Kaolinite	2	57	<1	35	1	47	<1	41	2	42
Chlorite (Fe-Rich)	1	31	Trace	24	<1	32	<1	25	<1	20
Illite/Mica	Trace	12	<1	27	Trace	21	<1	25	1	24
Mixed Layer Clay*			Trace	14			Trace	8	Trace	14

*Illite/Chlorite

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MINERAL CONTENT DETERMINATION

(by X-ray Diffraction)

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Sample Identification:	11		12		13		14		15	
Sample Depth, feet:	15,358.0-60.0		15,360.0-62.0		15,362.0-64.0		15,364.0-660		15,366.0-68.0	
Particle Size of Sample Fraction:	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay
Estimate of Net Percent Clay Minerals:	5.0		1.9		2.1		2.6		2.5	
Mineral	**Fraction of Sample Analyzed**									
Quartz	87		94		94		91		93	
Feldspars	8		4		4		6		4	
Barite	Trace		Trace		Trace		Trace		Trace	
Kaolinite	1	25	1	52	1	52	Trace	12	<1	27
Chlorite (Fe-Rich)	<1	18	<1	24	<1	26	<1	19	<1	25
Illite/Mica	2	45	<1	24	Trace	22	1	50	1	32
Mixed Layer Clay*	<1	12					<1	19	Trace	16

*Illite/Chlorite

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MINERAL CONTENT DETERMINATION

(by X-ray Diffraction)

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Sample Identification:	16		17		18	
Sample Depth, feet:	15,368.0-70.0		15,370.0-72.0		15,372.0-74.0	
Particle Size of Sample Fraction:	Whole Rock	Clay	Whole Rock	Clay	Whole Rock	Clay
Estimate of Net Percent Clay Minerals:	3.5		2.7		2.4	
Mineral	**Fraction of Sample Analyzed**					
Quartz	90		88		89	
Feldspars	6		9		9	
Barite	Trace		Trace		Trace	
Kaolinite	2	43	<1	23	1	48
Chlorite (Fe-Rich)	1	26	1	35	<1	27
Illite/Mica	1	31	1	42	Trace	25

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SCANNING ELECTRON MICROSCOPE STUDY

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,182.7-84.0

Sample 1 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early to intermediate state of secondary quartz overgrowths and authigenic clay. Primary intergranular porosity has been greatly reduced by the cements; however, photomicrographs B1 (300X) and C1 (400X) indicate significant remnant porosity. In addition, microporosity has been created by the crystalline morphologies of authigenic clays. A more detailed examination, provided by photomicrograph C2 (2000X), reveals idiomorphic plates of pore-lining authigenic chlorite. Idiomorphic plates of authigenic chlorite occur with morphologies resembling pyrite in photomicrograph B2 (1500X).

Depth, feet: 15,184.8-86.0

Sample 2 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand and silt grains cemented by an early stage of quartz overgrowths and pore-filling authigenic clays. Although primary intergranular porosity has been substantially reduced by the cements, photomicrograph B1 (300X) indicates significant porosity remains. In addition, microporosity occurs in association with the delicate crystalline morphologies of authigenic clays. Photomicrograph B2 (1500X) provides a more detailed examination of these morphologies and reveals idiomorphic plates of authigenic chlorite. The presence of poorly defined clay material in association with authigenic chlorite in this photomicrograph suggests recrystallization of detrital clays. Stacked pseudohexagonal plates of authigenic kaolinite are shown by photomicrograph B1 (300X).

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SCANNING ELECTRON MICROSCOPE STUDY

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,186.0-87.0

Sample 3 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine and silt grains cemented by an early stage of secondary quartz overgrowths and pore-filling authigenic clay. Primary intergranular porosity has been substantially reduced by the cements; however, photomicrographs B1 (300X) and C1 (400X) indicate significant interparticle porosity remains. Additional porosity in the form of microporosity occurs as a result of the crystalline morphology of authigenic clay. A more detailed view, provided by photomicrograph C2 (2000X), reveals idiomorphic plates of pore-lining authigenic chlorite occurring with delicate lath-like terminations of authigenic illite. In addition, photomicrograph B2 (1500X) examines stacked, pseudohexagonal plates of pore-filling authigenic kaolinite.

Depth, feet: 15,187.5-89.0

Sample 4 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand and silt grains cemented by an early stage of secondary quartz overgrowths and authigenic clay. Although primary intergranular porosity has been substantially reduced by the cements, photomicrographs B1 (300X) and C1 (600X) suggest significant remnant porosity. In addition, microporosity occurs as a result of the crystalline morphologies of authigenic clays. A more detailed view, provided by photomicrograph B2 (1500X), reveals idiomorphic plates of authigenic chlorite and delicate lath-like terminations of authigenic illite. The occurrence of these authigenic clays with poorly defined clay material suggests recrystallization of detrital clays. Photomicrograph C1 (600X) shows authigenic chlorite and stacked, pseudohexagonal plates of authigenic kaolinite.

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SCANNING ELECTRON MICROSCOPE STUDY

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,189.0-91.0

Sample 5 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand and silt grains cemented by an early stage of quartz overgrowths and authigenic clay. Primary intergranular porosity has been greatly reduced by the cements; however, photomicrograph B1 (300X) suggests significant interparticle porosity remains. In addition, microporosity has been created by the crystalline morphologies of authigenic clays. Photomicrograph B2 (1500X) provides a more detailed examination of these morphologies and reveals booklets of pore-filling authigenic kaolinite and delicate lath-like terminations resembling authigenic illite. Pore-lining authigenic chlorite is shown by photomicrograph B1 (300X).

Depth, feet: 15,348.0-50.0

Sample 6 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of quartz overgrowths and pore-filling authigenic clay. Although primary intergranular porosity has been reduced by the cements, photomicrograph B1 (300X) indicates substantial remnant porosity. In addition, significant microporosity has been created by the crystalline structures of authigenic clays. A more detailed examination of these structures, provided by photomicrograph B2 (1500X), reveals stacked pseudohexagonal plates of authigenic kaolinite and delicate projections resembling authigenic illite.

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Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,350.0-52.0

Sample 7 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cement by an early stage of secondary quartz overgrowths and authigenic clay. Primary intergranular porosity has been substantially reduced by the cements; however, photomicrographs B1 (300X) and C1 (300X) indicate significant porosity remains. In addition, microporosity occurs in association with crystalline morphologies of authigenic clays. Photomicrograph B2 (1500X) provides a more detailed view of these clays, revealing delicate lath-like projections of authigenic illite and illustrating the pore-bridging habit of this clay. In addition, stacked pseudohexagonal plates of authigenic kaolinite and delicate projections of authigenic illite are shown in photomicrograph C2 (1500X).

Depth, feet: 15,352.0-54.0

Sample 8 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of quartz overgrowths and pore-filling authigenic clay. Primary intergranular porosity has been substantially reduced by the cements; however, photomicrograph B1 (300X) suggests significant remnant porosity. Additional microporosity occurs as a result of the delicate crystalline morphology of authigenic clay. Photomicrograph B2 (1500X) examines this morphology in greater detail and reveals stacked pseudohexagonal plates of authigenic kaolinite.

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SCANNING ELECTRON MICROSCOPE STUDY

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,354.0-56.0

Sample 9 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of quartz overgrowths and pore-filling authigenic clay. The cements in this sample have substantially reduced primary intergranular porosity; however, photomicrograph B1 (300X) suggests significant interparticle porosity remains. In addition, microporosity occurs in association with the crystalline structures of authigenic clays. Photomicrograph B2 (1500X) provides a more detailed view of these structures revealing delicate lath-like projections of authigenic illite. Photomicrograph B1 (300X) shows morphologies resembling authigenic kaolinite booklets.

Depth, feet: 15,356.0-58.0

Sample 10 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of fine sand grains cemented by an early stage of quartz overgrowths and pore-filling authigenic clay. Although primary intergranular porosity, viewed in photomicrograph B1 (300X), has been significantly reduced by the cements, substantial interparticle porosity remains. In addition, microporosity occurs in association with crystalline morphologies of authigenic clays. A more detailed examination, provided by photomicrograph B2 (1500X), reveals delicate laths of authigenic illite. Booklets of authigenic kaolinite are shown in photomicrograph B1 (300X).

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Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,358.0-60.0

Sample 11 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of secondary quartz overgrowths and pore-filling authigenic clay. Primary intergranular porosity has been substantially reduced; however, significant remnant porosity is indicated by photomicrographs B1 (400X) and C1 (300X). In addition, microporosity has been created by the crystalline morphologies of authigenic clays. A more detailed view, provided by photomicrograph B2 (2000X), reveals delicate lath-like terminations of authigenic illite and illustrates the pore-bridging habit of this authigenic clay. Photomicrograph C2 (1500X) examines stacked, pseudohexagonal plates of pore-filling authigenic kaolinite occurring with wisps of authigenic illite.

Depth, feet: 115,360.0-62.0

Sample 12 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of quartz overgrowths and authigenic clay. Although primary intergranular porosity, viewed in photomicrograph B1 (300X), has been significantly reduced by the cements, substantial interparticle porosity remains. In addition, microporosity occurs in association with the crystalline morphologies in greater detail and reveals delicate lath-like terminations of authigenic illite occurring with idiomorphic plates resembling authigenic chlorite.

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SCANNING ELECTRON MICROSCOPE STUDY

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,362.0-64.0

Sample 13 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of quartz overgrowths and pore-filling authigenic clay. Primary intergranular porosity, viewed in photomicrographs B1 (300X) and C1 (300X) has been substantially reduced by the cements; however, significant interparticle porosity remains. In addition, microporosity has been created by the crystalline morphologies of authigenic clays. Photomicrograph B2 (1500X) provides a more detailed view of these morphologies, revealing delicate laths of authigenic illite. Stacked pseudohexagonal plates of pore-filling authigenic kaolinite are shown by photomicrograph C2 (1500X).

Depth, feet: 15,364.0-66.0

Sample 14 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand and silt grains cemented by an early stage of secondary quartz overgrowths and pore-filling authigenic clay. Although primary intergranular porosity has been substantially reduced by the cements, photomicrograph B1 (300X) suggests significant remnant porosity. In addition, microporosity occurs as a result of the crystalline morphologies of authigenic clays. A more detailed examination of these morphologies, provided by photomicrograph B2 (500X), reveals delicate laths of authigenic illite.

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Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,366.0-68.0

Sample 15 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of secondary quartz overgrowths. Primary intergranular porosity has been somewhat reduced by the cements; however, photomicrograph B1 (300X) indicates substantial porosity remains. A more detailed view of the clay material in this sample, provided by photomicrograph B2 (1500X), reveals a poorly defined structure suggesting a primarily detrital origin.

Depth, feet: 15,368.0-70.0

Sample 16 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand grains cemented by an early stage of secondary quartz overgrowths and pore-filling authigenic clay. Although primary intergranular porosity, examined by photomicrograph B1 (300X), has been significantly reduced by the cements, substantial interparticle porosity remains. In addition, microporosity has been created by the delicate structure of authigenic clays. Photomicrograph B2 (1500X) provides a more detailed view of these structures, revealing stacked pseudohexagonal plates of pore-filling authigenic kaolinite and morphologies resembling authigenic illite.

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SCANNING ELECTRON MICROSCOPE STUDY

Technadril-Fenix & Scisson
Gladys McCall Well No. 1
Grand Chenier Field
Cameron Parish, Louisiana

Depth, feet: 15,370.0-72.0

Sample 17 is a light gray, moderately sorted, moderately consolidated, fine-grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of angular to subrounded fine sand and silt grains cemented by an early stage of quartz overgrowths. Primary intergranular porosity, viewed in photomicrographs B1 (300X) and C1 (400X), has been reduced by the cement and a silty matrix such that only microporosity associated with the matrix particles remains. A more detailed view of these particles, provided by photomicrographs B2 (1500X) and C2 (2000X), reveals a poorly defined structure suggesting a primarily detrital origin.

Depth, feet: 15,372.0-74.0

Sample 18 is a light gray, moderately sorted, moderately consolidated, fine grain sandstone. Photomicrograph A1 (50X) shows a moderately packed aggregate of subangular to subrounded fine sand and silt grains cemented by an early to intermediate stage of quartz overgrowths and pore-filling authigenic clay. Although primary intergranular porosity has been substantially reduced by the cements and a silty matrix, photomicrographs B1 (300X) and C1 (400X) indicate significant porosity remains. In addition, microporosity occurs in association with the particles of the matrix and the morphologies of authigenic clays. A more detailed view, provided by photomicrograph B2 (1500X), reveals the poorly defined structure of detrital clay; however, photomicrograph C2 (2000X) shows delicate lath-like projections of pore-lining authigenic illite.

APPENDIX B

PVT Analysis for Sand 9 by Weatherly Laboratories, Inc.

RESERVOIR FLUID ANALYSIS

FOR

TECHNADRIL-FENIX & SCISSON, INC.

GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD
CAMERON PARISH, LOUISIANA

WEATHERLY LABORATORIES, INC.

WEATHERLY LABORATORIES, INC.

J. E. WEATHERLY, JR.
CHAIRMAN

223 GEORGETTE LAFAYETTE, LA 70506
PHONE (318) 232-4877

JOHN D. NEAL
PRESIDENT
BRYAN SONNIER
VICE PRESIDENT

APRIL 30, 1983

TECHNADRIL-FENIX & SCISSON, INC.
3 NORTHPOINT DRIVE
SUITE 200
HOUSTON, TEXAS 77060

ATTENTION: MR. LARRY DURRETT

RE: RESERVOIR FLUID STUDY
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD
CAMERON PARISH, LOUISIANA

GENTLEMEN:

ATTACHED ARE THE RESULTS OF THE ANALYSES OF THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF A RECOMBINED RESERVOIR FLUID SAMPLE FROM THE SUBJECT WELL. SURFACE SEPARATOR SAMPLES WERE COLLECTED FROM THIS WELL BY A REPRESENTATIVE OF WEATHERLY LABORATORIES, INC. ON MARCH 23, 1983. THE GAS-WATER RATIO (GWR) MEASURED ON THIS TEST, 24.66 CUBIC FEET OF SEPARATOR GAS PER BARREL OF SEPARATOR LIQUID, WAS USED AS THE BASIS FOR ONE RECOMBINATION. THE RESULTANT RESERVOIR FLUID EXHIBITED A BUBBLE POINT OF 10,030 PSIA AT THE RESERVOIR TEMPERATURE 298 DEGREES FAHRENHEIT.

OTHER RECOMBINATIONS WERE DONE TO DETERMINE A BUBBLE POINT -VS- GWR RELATIONSHIP. A DIFFERENTIAL LIBERATION AND VISCOSITY MEASUREMENTS WERE PERFORMED USING RESERVOIR FLUID RECOMBINED TO THE PRODUCED GWR AT THE TIME OF SAMPLING.

WE WISH TO THANK YOU FOR THIS OPPORTUNITY OF SERVING YOU. SHOULD THERE BE ANY QUESTIONS CONCERNING THIS REPORT, PLEASE CONTACT US.

YOURS VERY TRULY

John Neal

JOHN NEAL

CC: MR. JONNE BERNING
TECHNADRIL-FENIX & SCISSON, INC.
P. O. BOX 231
GRAND CHENIER, LA 70643

LAB. NO. N1901-10224

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

GEOPRESSURE/GEOTHERMAL PROJECT SAMPLING AND LABORATORY PROCEDURE

1) WATER VAPOR CONTENT OF SEPARATOR GAS WAS DETERMINED BY FLOWING GAS FROM A METERING VALVE ON THE SEPARATOR GAS METER RUN THROUGH A WEIGHING TUBE (INDICATOR DRIERITE ($CaSO_4$) WEIGHED TO 0.1 MILLIGRAM) TO A G.C.A./PRECISION SCIENTIFIC WET TEST METER. SEPARATOR GAS SAMPLES WERE TAKEN FROM THE SAME PLACE INTO EVACUATED 1 GALLON STAINLESS STEEL (S.S.) CYLINDERS AFTER THOROUGH PURGING OF TRANSFER LINE AT SEPARATOR PRESSURE. SEPARATOR LIQUID SAMPLE CYLINDERS (500 ML. S.S.) WERE FIRST CHARGED WITH SEPARATOR GAS TO FULL SEPARATOR PRESSURE. THE LIQUID CYLINDERS WERE THEN CONNECTED TO THE SEPARATOR WATER SAMPLING POINT BY A S.S. TUBE LONG ENOUGH TO LOOP THROUGH A COOLING BATH. THE WATER TRANSFER LINE WAS THEN SLOWLY AND THOROUGHLY PURGED AT THE CYLINDER. SEPARATOR WATER WAS LET INTO THE CYLINDER BY SLOWLY BLEEDING GAS FROM THE TOP VALVE. AT NO TIME WAS THE WATER CAUGHT IN THE CYLINDER ALLOWED TO DROP BELOW SEPARATOR PRESSURE.

2) FLASH LIBERATION OF GAS FROM SEPARATOR WATER WAS ACCOMPLISHED BY USING A WEIGHED SEPARATOR FLASK. THIS SEPARATOR FLASK WAS CONNECTED TO THE OUTLET OF A SEPARATOR WATER CYLINDER BY A SHORT CAPILLARY LINE. GAS FROM THE SEPARATOR FLASK PASSED THROUGH A WEIGHED DRYING TUBE THROUGH A GLASS CYLINDER (~ 300 ML.) TO A RUSKA GASOMETER. A VACUUM VALVE AND A MERCURY MANOMETER WAS CONNECTED TO THE GAS MANIFOLD BETWEEN THE DRYING TUBE AND THE GASOMETER. BEFORE COMMENCING THE FLASH, THE ENTIRE FLASH GAS MANIFOLD WAS EVACUATED AND THEN FILLED WITH HELIUM TO ATMOSPHERIC PRESSURE. A KNOWN VOLUME OF SEPARATOR WATER WAS PUSHED OUT OF THE SAMPLE CYLINDER AT A PRESSURE SLIGHTLY ABOVE FIELD SEPARATOR PRESSURE BY USE OF A CALIBRATED MERCURY PUMP. THE VOLUME OF STOCK TANK WATER PRODUCED WAS DETERMINED BY ITS WEIGHT AND DENSITY. THE VOLUME OF DRY GAS EVOLVED WAS DETERMINED WITH THE GASOMETER. THIS GAS VOLUME WAS SUBJECT TO ± 2 % ERROR DUE TO THE VERY SMALL AMOUNTS MEASURED. THE GAS WAS CHARGED TO A CHROMOTOGRAPH FOR ANALYSIS FROM THE GLASS CYLINDER.

3) PHYSICAL RECOMBINATION OF SEPARATOR EFFLUENTS:
SEPARATOR GAS WAS CHARGED INTO A TEMPERATURE CONTROLLED CELL. THE VOLUME OF THIS WINDOWED CELL IS KNOWN FOR ANY PRESSURE AND TEMPERATURE. THE PRESSURE OF THE GAS IN THE CELL WAS MEASURED WITH A MERCURY MANOMETER AND A BAROMETER. THIS CALCULATED GAS VOLUME WAS SUBJECT TO A ± 1 % ERROR DUE TO THE SMALL AMOUNT CHARGED TO THE CELL. A VOLUME OF SEPARATOR WATER WAS CHARGED INTO THE WINDOWED CELL BY USE OF A CALIBRATED MERCURY PUMP. THE WATER WAS METERED AND MEASURED AT A PRESSURE SLIGHTLY ABOVE FIELD SEPARATOR PRESSURE. FOUR RECOMBINATIONS WERE DONE IN ORDER TO PRODUCE A SATURATION PRESSURE-VS-GAS WATER RATIO CURVE. RESERVOIR FLUID RESULTING FROM RECOMBINATION OF THE PRODUCED GWR (FIFTH RECOMBINATION) WAS USED TO PERFORM A DIFFERENTIAL LIBERATION AND VISCOSITY MEASUREMENT.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

4) PRESSURE-VOLUME RELATIONS OF RECOMBINED RESERVOIR FLUID AT RESERVOIR TEMPERATURE:
EACH DATUM OF PRESSURE-VOLUME RELATIONS WAS CORRECTED FOR MERCURY PUMP CALIBRATION, MANIFOLD EXPANSION, CELL EXPANSION, MERCURY COMPRESSIBILITY AND MERCURY THERMAL EXPANSION. LIQUID VOLUME PERCENT WAS DETERMINED BY CALIBRATED CATHETOMETER AND BY DATA INTERPRETATION.

5) DIFFERENTIAL LIBERATION OF RESERVOIR FLUID AT RESERVOIR TEMPERATURE:
GAS FROM EACH PRESSURE DECREMENT OF THE DIFFERENTIAL LIBERATION WAS ANALYZED IN THE SAME MANNER AS DESCRIBED IN 2), (FLASH LIBERATION). DIFFERENTIAL LIQUID CHANGES WERE NOTED.

6) VISCOSITY OF RESERVOIR FLUID WAS MEASURED BY MR. J. R. COMEAU OF WEATHERLY LABORATORIES. A DESCRIPTION OF MR. COMEAU'S EXPERIMENTAL PROCEDURES IS GIVEN BELOW:
GEOTHERMAL WATER VISCOSITIES WERE MEASURED USING AN E.L.I. ROLLING BALL VISCOMETER WITH AN ELECTRONIC DETECTION SYSTEM TO PREVENT ELECTROLYSIS. THE DETECTION SYSTEM CONSISTS OF A SENSITIVE AUDIO AMPLIFIER WITH POSITIVE FEEDBACK ADJUSTED JUST BELOW OSCILLATION. FEEDBACK WAS TURNED ON BY AN AUTOMATIC SWITCH AS THE VISCOMETER WAS INVERTED AT THE BEGINNING OF THE CYCLE AND TURNED OFF WHEN THE BALL MADE CONTACT. PART OF THE SIGNAL WAS USED TO TURN THE DIGITAL TIMER ON AND OFF. TIMES WERE MEASURED TO 1/100TH OF A SECOND AND AVERAGED. THE VISCOMETER WAS CALIBRATED AT EACH OF THREE ANGLES USING SEVERAL KNOWN VISCOSITY STANDARDS WHICH WERE CHECKED AGAINST CANNON-FENSKE VISCOMETERS AND THE RESULTS ($t\Delta p$ vs. μ) PLOTTED. THE VISCOMETER WAS RECALIBRATED USING DISTILLED WATER AT SEVERAL TEMPERATURES. THESE RESULTS WERE USED ALONG WITH PREVIOUS RESULTS TO OBTAIN NEW CALIBRATION CURVES.

t = ROLL TIME, (SECONDS)

Δp = DENSITY DIFFERENCE BETWEEN BALL AND RESERVOIR FLUID, (gm./ml.)

μ = VISCOSITY, (CENTIPOISE)

THE VISCOMETER WAS CHARGED WITH RESERVOIR FLUID AND RUN AT 298°F AT 1000 LB. INTERVALS. THE VISCOSITIES HAD A PROBABLE ERROR OF $\pm$ 0.007 CENTIPOISE.

NOTE: ALL DATA FOR PRESSURES GREATER THAN 11,000 PSI WERE OBTAINED BY EXTRAPOLATION.

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FIELD DATA FOR WEATHERLY LABORATORY INVESTIGATION

WELL RECORD

COMPANY	TECHNADRIL-FENIX & SCISSON, INC.
WELL	GLADYS MCCALL NO. 1
FIELD	EAST CRAB LAKE
PARISH AND STATE	CAMERON, LOUISIANA

FIELD CHARACTERISTICS

FORMATION NAME
SAND NAME AND DESIGNATION
DATE COMPLETED
ORIGINAL RESERVOIR PRESSURE

WELL CHARACTERISTICS

ORIGINAL PRODUCED GAS-LIQUID RATIO

PERFORATIONS		
ELEVATIONS		
TOTAL DEPTH		
LAST RESERVOIR PRESSURE	12,936	PSIA
RESERVOIR TEMPERATURE	298	DEGREES F

SAMPLING CONDITIONS

DATE SAMPLED	1000 TO 1523 HOURS,	3-23-83	
TUBING PRESSURE, FLOWING		5835	PSIG
PRIMARY SEPARATOR TEMPERATURE	(METER RUN)	72	DEGREES F, (SEP.) 212'F
PRIMARY SEPARATOR PRESSURE		700	PSIG
PRIMARY SEPARATOR GAS RATE	(WET GAS)	102.1	MCF/DAY
SEPARATOR LIQUID RATE		4140	BBLS./DAY
GAS-LIQUID RATIO (SEPARATOR)		24.66	SCF/BBL.SEP.WATER
SHRINKAGE FACTOR (VOL.S.T.WATER @ 60'F/VOL.SEP.WATER)		0.9637	
GAS-LIQUID RATIO (STOCK TANK)		25.59	SCF/BBL.S.T.WATER
PRESSURE BASE		15.025	PSIA @ 60 DEGREES F

NOTE: FOR DRY GAS, 24.63 SCF/BBL. SEP. WATER @ SEP. CONDITIONS.
25.56 SCF/BBL. S.T. WATER @ 60'F.

LAB. NO. N1901-10224

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

CALCULATION OF GAS RATE, 3-23-83 TEST

(Factors from GPSA Engineering Data Book)

$\sqrt{Hw\ Pf}$	=	268.4890	Hw =	100.82 "H2O ,	Pf	=	715 psia
Fb	=	12.7121	D =	2.626 " ,	d	=	0.250 "
Fpb	=	0.9804		15.025 psia			
Fr	=	1.0004	b =	0.0979			
Y2	=	1.0009	Hw/Pf =	0.141 ,	d/D	=	0.095
Fg	=	1.2121	Gravity =	0.6807 ,	Fg	=	$\sqrt{1 / 0.6807}$
Ftf	=	0.9887	Temp. =	72 degrees F ,	Ftf	=	$\sqrt{520 / 532}$
Fpv	=	1.0597	pTr' =	1.471 ,	pPr'	=	1.049
			Z =	0.8905 ,	Fpv	=	$\sqrt{1 / Z}$

Q = $\sqrt{Hw\ Pf}$ x Fb x Fpb x Fr x Y2 x Fg x Ftf x Fpv x 24

Q = 102.1 MCF/day @ 15.025 PSIA @ 60 Degrees F (WET)

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

RESERVOIR FLUID SUMMARY

Reservoir Temperature, Degrees F		298
Saturation Pressure at 298 Degrees, Psia		10030
Compressibility of Reservoir Oil at 298 Degrees F		
Vol. per Vol. per Psi x 10 6		
From 10030 Psia to 10500 Psia		2.98
From 10500 Psia to 11000 Psia		2.80
From 11000 Psia to 12936 Psia		2.75
		DIFF. LIB.
Saturated Oil at 10030 Psia, 298 Degrees F		
Density, Gms. per Ml.		1.01318
Lbs. per Bbl.		355.1
Specific Volume, Cu.Ft. per Lb.		0.015810
Viscosity, Centipoise		0.375
Formation Volume Factor, Bbls. per Bbl.		
"Equivalent Stock Tank Oil" at 60 Degrees F	1.0565 * ,	1.0567
Solution Gas-Oil Ratio, Cu.Ft. per Bbl.	31.09 * ,	32.92 WET
"Equivalent Stock Tank Oil" at 60 Degrees F	30.91 * ,	31.14 DRY
Reservoir Oil at 12936 Psia 298 Degrees F		
Density, Gms. per Ml.		1.02242
Lbs. per Bbl.		358.4
Specfic Volume, Cu.Ft. per Lb.		0.015667
Viscosity, Centipoise		0.388
Formation Volume Factor, Bbl. per Bbl.		
"Equivalent Stock Tank Oil" at 60 Degrees F	1.0479 * ,	1.0481

NOTE: REFERENCES TO 'OIL' ABOVE SHOULD READ 'WATER'.

* BASED ON SEPARATOR WATER FLASH.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 298 DEGREES F

RECOMBINATION (1) 20.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME cu. ft. per Pound	LIQUID VOLUME PERCENT	OIL VISCOSITY CENTIPOISES	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: WET **
12936 RES.	0.9853	0.015684			1.0467		26.08	26.25
11000	0.9908	0.015772			1.0525		26.08	26.25
10000	0.9935	0.015815			1.0554		26.08	26.25
9000	0.9962	0.015858			1.0583		26.08	26.25
8000	0.9992	0.015905			1.0614		26.08	26.25
7720 B.P.	1.0000	0.015918	100.00		1.0623		26.08	26.25
7000	1.0024	0.015956	99.97					
6000	1.0065	0.016021	99.86					
5000	1.0110	0.016093	99.70					
4000	1.0163	0.016177	99.47					
3000	1.0240	0.016300	99.00					
2000	1.0395	0.016547	97.82					
1000	1.0877	0.017314	93.75					
500	1.2034	0.019156	84.86					
143	2.1269	0.033856	48.06					
96	3.3600	0.053484	30.43					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

LAB. NO. N1901-10224

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 298 DEGREES F

RECOMBINATION (2) 18.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME cu. ft. per Pound	LIQUID VOLUME PERCENT	OIL VISCOSITY CENTIPOISES	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: WET **
12936 RES.	0.9826	0.015683			1.0463		24.01	24.18
11000	0.9879	0.015768			1.0519		24.01	24.18
10000	0.9907	0.015813			1.0549		24.01	24.18
8000	0.9964	0.015904			1.0579		24.01	24.18
7000	0.9993	0.015950			1.0610		24.01	24.18
9000	0.9935	0.015857			1.0641		24.01	24.18
6755 B.P.	1.0000	0.015961	100.00		1.0648		24.01	24.18
6000	1.0023	0.015998	99.99					
5000	1.0060	0.016057	99.91					
4000	1.0102	0.016124	99.78					
3000	1.0179	0.016247	99.31					
2000	1.0316	0.016465	98.27					
1000	1.0755	0.017166	94.53					
963	1.0793	0.017227	94.21					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
' EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 298 DEGREES F

RECOMBINATION (3) 15.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME cu. ft. per Pound	LIQUID VOLUME PERCENT	OIL VISCOSITY CENTIPOISES	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: WET **
12936 RES.	0.9788	0.015678			1.0456		20.90	21.07
11000	0.9841	0.015763			1.0512		20.90	21.07
10000	0.9869	0.015808			1.0542		20.90	21.07
9000	0.9896	0.015851			1.0571		20.90	21.07
8000	0.9925	0.015898			1.0602		20.90	21.07
7000	0.9954	0.015944			1.0633		20.90	21.07
6000	0.9983	0.015991			1.0664		20.90	21.07
5425 B.P.	1.0000	0.016018	100.00		1.0682		20.90	21.07
5000	1.0016	0.016044	99.96					
4000	1.0055	0.016106	99.86					
3000	1.0117	0.016205	99.54					
2000	1.0234	0.016393	98.69					
1000	1.0610	0.016995	95.47					
892	1.0706	0.017149	94.64					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 298 DEGREES F

RECOMBINATION (4) 10.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME cu. ft. per Pound	LIQUID VOLUME PERCENT	OIL VISCOSITY CENTIPOISES	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F WET **
12936 RES.	0.9734	0.015668			1.0441		15.72	15.88
11000	0.9787	0.015753			1.0498		15.72	15.88
10000	0.9815	0.015798			1.0528		15.72	15.88
9000	0.9843	0.015843			1.0558		15.72	15.88
8000	0.9871	0.015888			1.0587		15.72	15.88
7000	0.9899	0.015933			1.0618		15.72	15.88
6000	0.9928	0.015980			1.0649		15.72	15.88
5000	0.9957	0.016027			1.0680		15.72	15.88
4000	0.9987	0.016075			1.0712		15.72	15.88
3575 P.B.	1.0000	0.016096	100.00		1.0726		15.72	15.88
3000	1.0022	0.016131	99.95					
2000	1.0104	0.016263	99.44					
1000	1.0372	0.016695	97.15					
738	1.0582	0.017033	95.29					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 298 DEGREES F

RECOMBINATION (3) 15.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME cu. ft. per Pound	LIQUID VOLUME PERCENT	OIL VISCOSITY CENTIPOISES	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F WET **
12936 RES.	0.9788	0.015678			1.0456		20.90	21.07
11000	0.9841	0.015763			1.0512		20.90	21.07
10000	0.9869	0.015808			1.0542		20.90	21.07
9000	0.9896	0.015851			1.0571		20.90	21.07
8000	0.9925	0.015898			1.0602		20.90	21.07
7000	0.9954	0.015944			1.0633		20.90	21.07
6000	0.9983	0.015991			1.0664		20.90	21.07
5425 B.P.	1.0000	0.016018	100.00		1.0682		20.90	21.07
5000	1.0016	0.016044	99.96					
4000	1.0055	0.016106	99.86					
3000	1.0117	0.016205	99.54					
2000	1.0234	0.016393	98.69					
1000	1.0610	0.016995	95.47					
892	1.0706	0.017149	94.64					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

EFFECT OF GAS-WATER RATIO UPON BUBBLE POINT PRESSURES @ 298'F

GAS-WATER RATIO (SCF SEP. GAS @ 15.025 PSIA 7 60'F) / (BBL. SEP. WATER @ 700 PSIG & 212)	BUBBLE POINT (PSIA)
~ 30.4 EXTRAPOLATED	12936 RES. PRESSURE
24.66 (PRODUCED)	10030
20.00	7720
18.00	6755
15.00	5425
10.00	3575

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SEPARATOR WATER FLASH TO 0 PSIG & 72'F

SOLUTION GAS-WATER RATIO, DRY = 5.35

, WET = 5.50 SCF GAS @ 15.025 PSIA & 60'F / BBL. WATER @ 0 PSIG & 60 'F

SHRINKAGE = 0.9637 VOL. S.T. WATER @ 60'F / VOL. SEP. H2O @ 700 PSIG & 212'F

STOCK TANK WATER DENSITY = 1.0646 Gm/Ml. @ 60'F

GAS GRAVITY , DRY = 0.9684 (SEE ANALYSIS)

, WET = 0.9593

PRODUCED MARCH 23, 1983:

GWR = 25.56 + 5.35 = 30.91 SCF TOTAL DRY GAS @ 15.025 PSIA & 60'F / BBL. STOCK TANK WATER @ 60'F

GWR = 25.59 + 5.50 = 31.09 SCF TOTAL WET GAS @ 15.025 PSIA & 60'F / BBL. STOCK TANK WATER @ 60'F

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SEPARATOR GAS SAMPLED:
MARCH 23, 1983 @
700 PSIG & 72'F

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		0.10 ± .04
CARBON DIOXIDE	8.94	8.93
NITROGEN	0.26	0.26
METHANE	86.93	86.84
ETHANE	2.43	2.43
PROPANE	0.55	0.55
ISO-BUTANE	0.08	0.08
N-BUTANE	0.08	0.08
ISO-PENTANE	0.04	0.04
N-PENTANE	0.03	0.03
HEXANES	0.51	0.51
HEPTANES PLUS	0.15	0.15
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6805	0.6807

NOTE: WATER VAPOR MEASURED ON SITE, AVERAGE 6 RUNS.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
SEPARATOR WATER FLASH
@ 0 PSIG & 72'F
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		2.65
CARBON DIOXIDE	41.00	39.91
NITROGEN	-----	-----
METHANE	57.03	55.53
ETHANE	1.38	1.34
PROPANE	0.24	0.23
ISO-BUTANE	0.02	0.02
N-BUTANE	0.03	0.03
ISO-PENTANE	0.00	0.00
N-PENTANE	0.00	0.00
HEXANES	0.07	0.07
HEPTANES PLUS	0.23	0.22
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.9684	0.9593

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
6000 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		2.00
CARBON DIOXIDE	2.82	2.76
NITROGEN	----	----
METHANE	89.56	87.77
ETHANE	4.00	3.92
PROPANE	1.37	1.34
ISO-BUTANE	0.26	0.25
N-BUTANE	0.25	0.25
ISO-PENTANE	0.10	0.10
N-PENTANE	0.07	0.07
HEXANES	1.24	1.22
HEPTANES PLUS	0.33	0.32
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6648	0.6640

GAS DEVIATION FACTOR (Z) = 1.107 @ 6000 PSIA & 298'F

BBLS. GAS IN RES./MMSCF (Bg) = 720 @ 6000 PSIA & 298'F

LAB. NO. N1901-10224

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
4000 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		2.50
CARBON DIOXIDE	3.37	3.29
NITROGEN	----	----
METHANE	91.25	88.96
ETHANE	3.18	3.10
PROPANE	0.84	0.82
ISO-BUTANE	0.14	0.14
N-BUTANE	0.14	0.14
ISO-PENTANE	0.06	0.06
N-PENTANE	0.04	0.04
HEXANES	0.75	0.73
HEPTANES PLUS	0.23	0.22
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6413	0.6408

GAS DEVIATION FACTOR (Z) = 0.997 @ 4000 PSIA & 298'F

BBLS. GAS IN RES./MMSCF (Bg) = 972 @ 4000 PSIA & 298'F

LAB. NO. N1901-10224 PAGE 17 OF 25

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
2000 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		3.40
CARBON DIOXIDE	9.00	8.69
NITROGEN	----	----
METHANE	86.51	83.57
ETHANE	3.16	3.05
PROPANE	0.56	0.54
ISO-BUTANE	0.04	0.04
N-BUTANE	0.06	0.06
ISO-PENTANE	0.03	0.03
N-PENTANE	0.02	0.02
HEXANES	0.48	0.46
HEPTANES PLUS	0.14	0.14
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6799	0.6780

GAS DEVIATION FACTOR (Z) = 0.942 @ 2000 PSIA & 298'F

BBLS. GAS IN RES./MMSCF (Bg) = 1837 @ 2000 PSIA & 298'F

LAB. NO. N1901-10224 PAGE 18 OF 25

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
15 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY	WET
	MOLE %	
WATER		8.00
CARBON DIOXIDE	23.58	21.69
NITROGEN	----	----
METHANE	75.05	69.04
ETHANE	1.06	0.98
PROPANE	0.10	0.09
ISO-BUTANE	0.01	0.01
N-BUTANE	0.02	0.02
ISO-PENTANE	0.00	0.00
N-PENTANE	0.00	0.00
HEXANES	0.08	0.07
HEPTANES PLUS	0.10	0.09
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.7932	0.7795

GAS DEVIATION FACTOR (Z) = 1.000 @ 15 PSIA & 298'F

BBLS. GAS IN RES./MMSCF (Bg) = 259,633 @ 15.025 PSIA & 298'F

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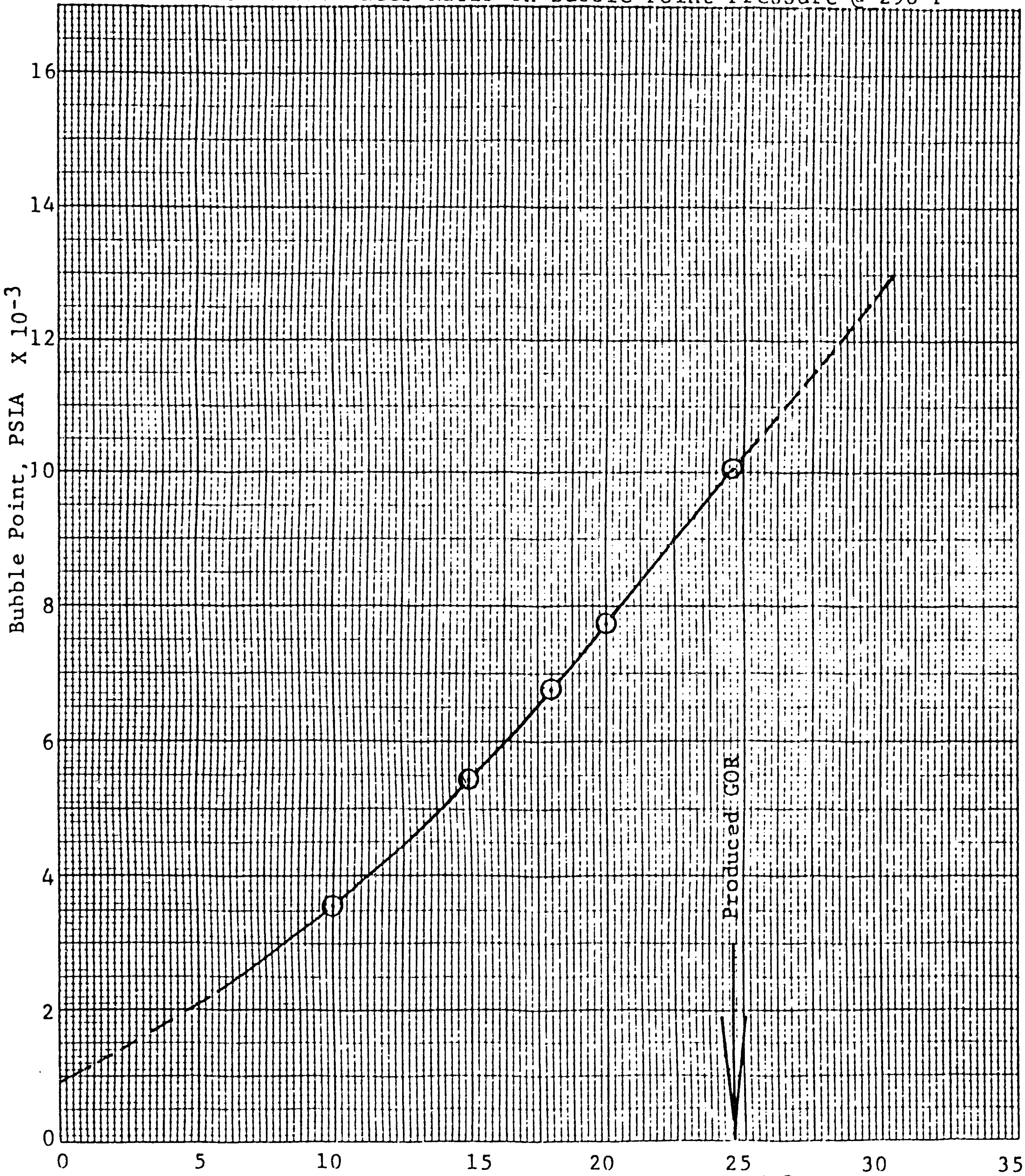
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir ______ Field East Crab Lake

FIG. 1: Effect of Gas-Water Ratio on Bubble Point Pressure @ 298°F



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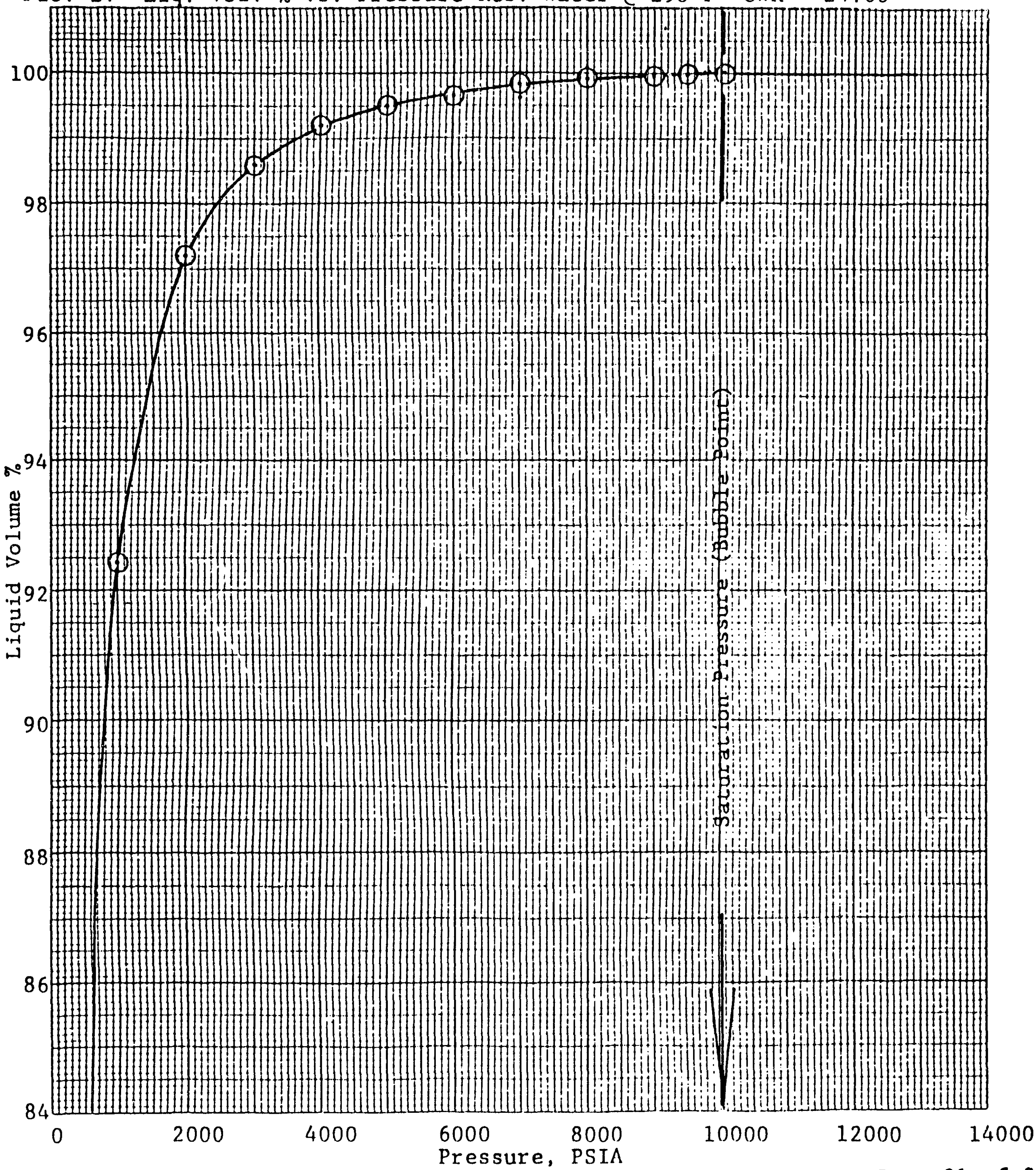
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Field East Crab Lake

FIG. 2: Liq. Vol. % vs. Pressure-Res. Water @ 298°F GWR = 24.66



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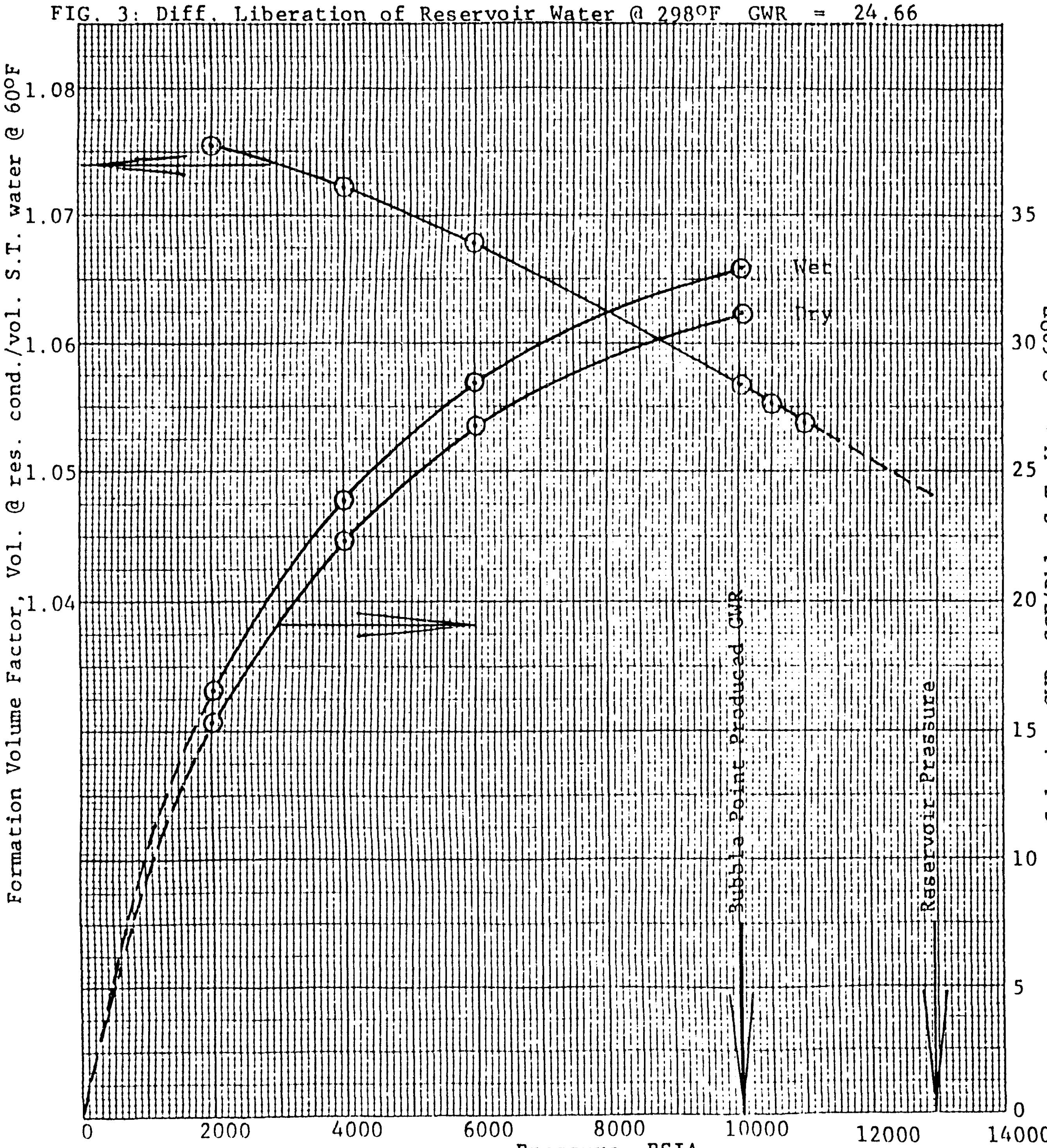
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Field East Crab Lake

FIG. 3: Diff. Liberation of Reservoir Water @ 298°F GWR = 24.66



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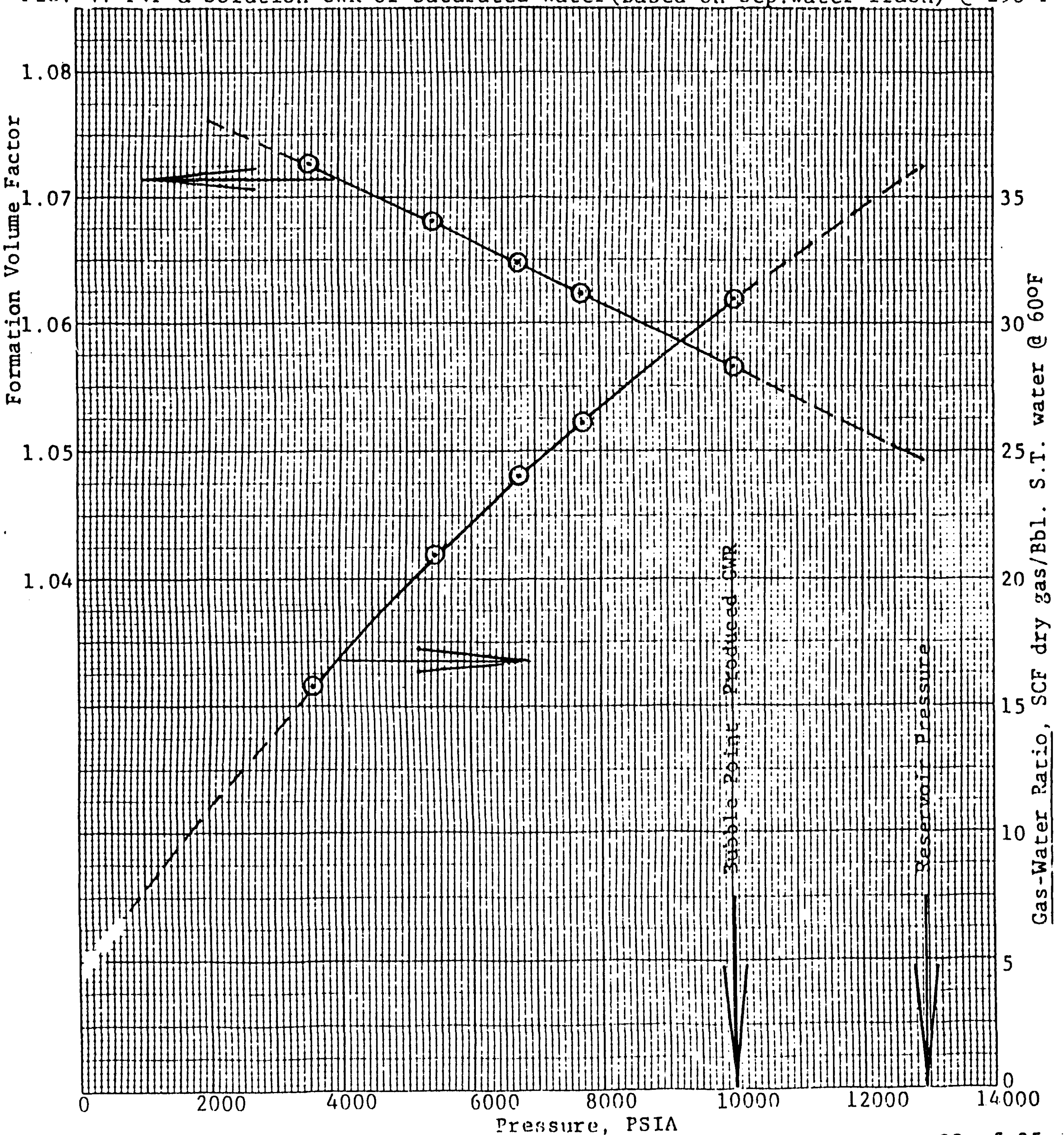
Company Technadril-Fenix & Scisson　Well Gladys McCall No. 1
Reservoir　Field East Crab Lake

FIG. 4: FVF & Solution GWR of Saturated Water (Based on sep.water flash) @ 298°F



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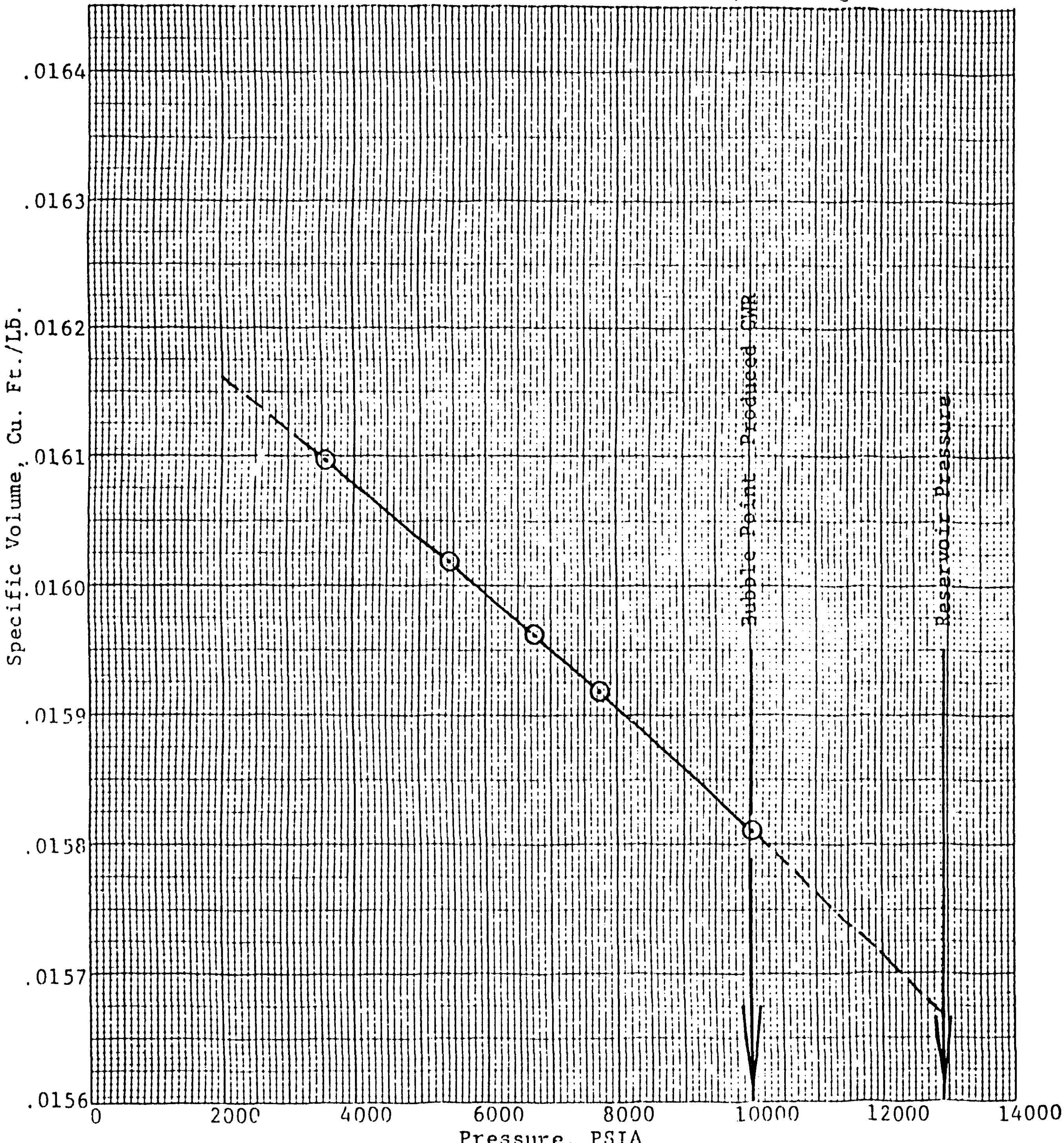
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Field East Crab Lake

FIG. 5: Specific Volume of Saturated (Bubble Point) Water @ 298°F



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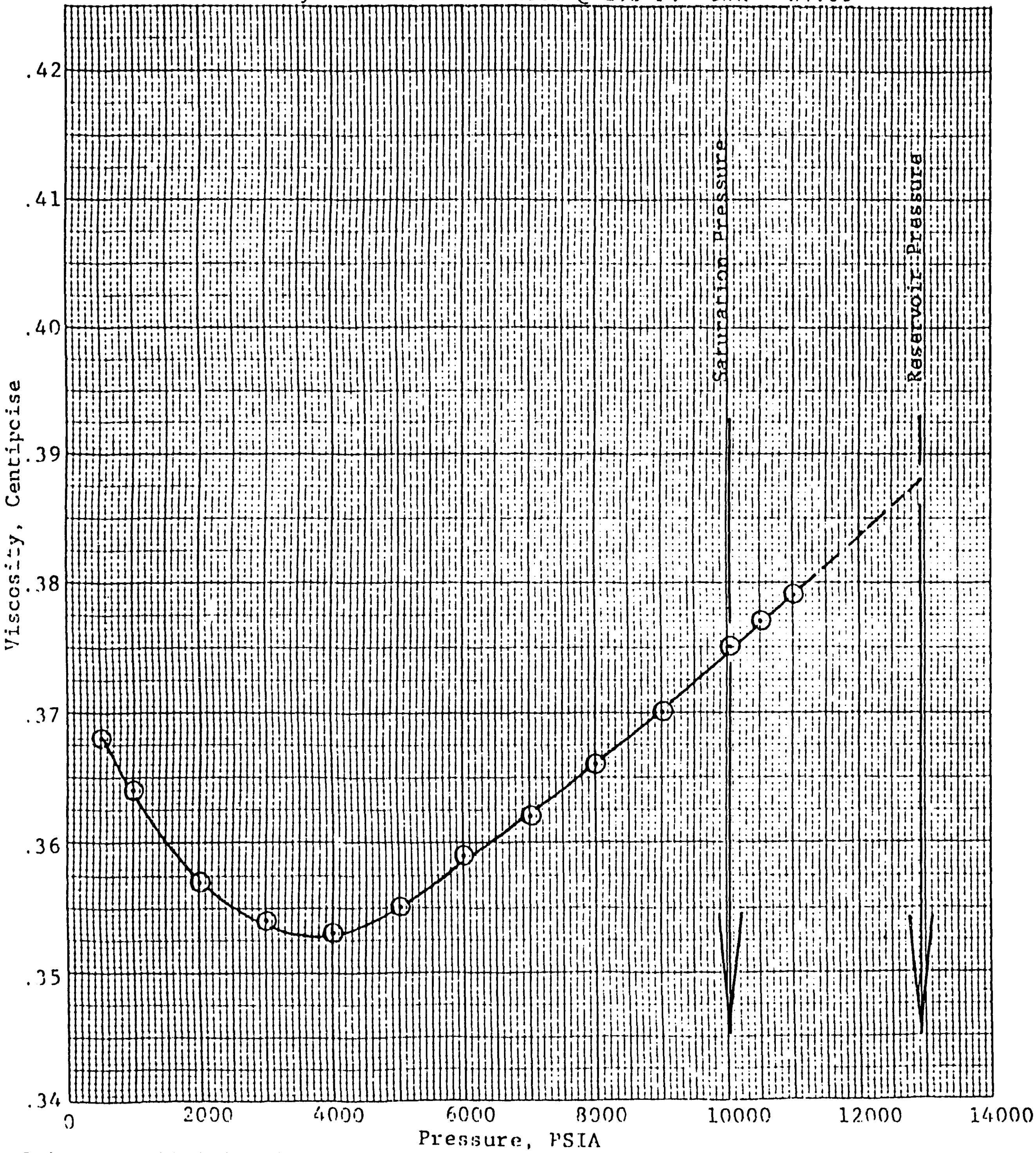
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Field East Crab Lake

FIGURE 6: Viscosity of Reservoir Water @ 298°F. GWR = 24.66



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APPENDIX C

Sand 8 Daily Production Data

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Dec-83	0	0	0	0	0	0	5800	0	0	0.00	0.00	0	0	0		
2-Dec-83	101[illegible]	12812	335317	0	0	0	5200	177	12014	27.91	27.91	33.17	12177	398504	398504	12014
3-Dec-83	1007	15491	339631	0	0	0	5200	183	14525	23.38	23.38	28.58	12300	415125	813629	26539
4-Dec-83	1013	15421	339631	0	0	0	5200	188	14460	23.49	23.49	28.72	12297	415291	1228920	40999
5-Dec-83	1017	15455	339631	0	0	0	5200	196	14492	23.44	23.44	28.69	12299	415775	1644696	55491
6-Dec-83	770	15646	348769	0	0	0	5423	196	14659	23.79	23.79	27.85	12535	408253	2052949	70150
7-Dec-83	772	15659	355228	0	0	0	5424	195	14671	24.21	24.21	28.28	12537	414896	2467845	84821
8-Dec-83	754	15742	355228	0	0	0	5386	205	14748	24.09	24.09	28.07	12502	413976	2881821	99569
9-Dec-83	750	16231	389482	0	0	0	5370	205	15206	25.61	25.61	29.57	12508	449641	3331462	114775
10-Dec-83	500	1358	56861	0	0	0	5274	128	1271	44.73	44.73	47.44	11956	60296	3391759	116046
11-Dec-83	501	13902	399868	0	0	0	5270	128	13012	30.73	30.73	33.44	12293	435121	3826880	129058
12-Dec-83	502	15849	396195	0	0	0	5264	131	14835	26.71	26.71	29.43	12381	436594	4263474	143893
13-Dec-83	501	15837	399868	0	0	0	5253	133	14824	26.98	26.98	29.69	12368	440125	4703599	158717
14-Dec-83	504	15819	394675	0	0	0	5226	136	14807	26.65	26.65	29.38	12340	435030	5138628	173524
15-Dec-83	502	15884	446651	0	0	0	5225	316	14868	30.04	30.04	32.76	12338	487076	5625704	188392
16-Dec-83	254	15918	449233	0	0	0	5219	135	14886	30.18	30.18	31.61	12334	470546	6096250	203278
17-Dec-83	254	15899	449233	0	0	0	5209	140	14869	30.21	30.21	31.65	12323	470604	6566854	218147
18-Dec-83	254	15851	448533	0	0	0	5192	146	14824	30.26	30.26	31.69	12303	469773	7036627	232971
19-Dec-83	1018	18024	448533	0	0	0	5218	192	16901	26.54	26.54	31.79	12444	537283	7573910	249872
20-Dec-83	1018	22284	538300	0	0	0	4968	218	20895	25.76	25.76	31.02	12449	648163	8222072	270767
21-Dec-83	1008	26482	620980	0	0	0	4544	251	24831	25.01	25.01	30.21	12324	750145	8972217	295598
22-Dec-83	1001	24826	595074	0	0	0	4360	250	23278	25.56	25.56	30.74	12008	715566	9687783	318876
23-Dec-83	1011	24055	693329	0	0	0	4620	275	22555	30.74	30.74	35.96	12209	811078	10498860	341431
24-Dec-83	1008	27244	634296	0	0	0	3905	250	25545	24.83	24.83	30.04	11733	767372	11266232	366976
25-Dec-83	990	3634	0	0	0	0	3645	250	3407	0.00	0.00	5.12	10354	17444	11283676	370383
26-Dec-83	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	11283676	370383
27-Dec-83	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	11283676	370383
28-Dec-83	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	11283676	370383
29-Dec-83	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	11283676	370383
30-Dec-83	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	11283676	370383
31-Dec-83	1002	10595	434624	0	0	0	5634	211	9934	43.75	43.75	48.93	12501	486071	11769747	380317

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jan-84	1005	28175	653256	0	0	0	4509	297	26418	24.73	24.73	29.92	12426	790427	12560173	406735
2-Jan-84	1009	29830	647273	0	0	0	3382	316	27970	23.14	23.14	28.35	11421	792950	13353123	434705
3-Jan-84	1005	29532	642720	0	0	0	3379	321	27691	23.21	23.21	28.4	11392	786424	14139547	462396
4-Jan-84	1008	34582	832375	0	0	0	3367	383	32426	25.67	25.67	30.88	11862	1001315	15140862	494822
5-Jan-84	1004	34153	798543	0	0	0	2103	381	32023	24.94	24.94	30.12	10527	964533	16105395	526845
6-Jan-84	760	30862	799515	0	0	0	2880	384	28913	27.65	27.65	31.66	10996	915386	17020780	555758
7-Jan-84	756	18363	462563	0	0	0	5543	314	17203	26.89	26.89	30.88	12795	531229	17552009	572961
8-Jan-84	763	34804	826165	0	0	0	1570	328	32607	25.34	25.34	29.36	10046	957342	18509351	605568
9-Jan-84	760	34235	816488	0	0	0	1532	340	32073	25.46	25.46	29.47	9947	945191	19454542	637641
10-Jan-84	768	32362	805183	0	0	0	1504	349	30319	26.56	26.56	30.6	9727	927761	20382303	667960
11-Jan-84	760	33217	791612	0	0	0	1464	356	31119	25.44	25.44	29.45	9773	916455	21298758	699079
12-Jan-84	763	26331	787089	0	0	0	1434	363	24669	31.91	31.91	35.93	9095	886357	22185115	723748
13-Jan-84	756	16098	488538	0	0	0	4688	227	15081	32.39	32.39	36.38	11790	548647	22733762	738829
14-Jan-84	776	15229	370673	0	0	0	4688	186	14268	25.98	25.98	30.07	11762	429039	23162801	753097
15-Jan-84	757	12606	361687	0	0	0	5457	194	11810	30.63	30.63	34.62	12429	408862	23571663	764907
16-Jan-84	799	10895	358108	0	0	0	5435	136	10208	35.08	35.08	39.28	12332	400970	23972633	775115
17-Jan-84	778	15487	364390	0	0	0	4519	143	14510	25.11	25.11	29.2[illegible]	11603	423837	24396470	789625
18-Jan-84	805	15356	364390	0	0	0	4511	150	14389	25.32	25.32	29.55	11588	425195	24821665	804014
19-Jan-84	787	15403	364390	0	0	0	4509	151	14432	25.25	25.25	29.39	11588	424156	25245821	818446
20-Jan-84	502	1245	31498	0	0	0	5425	146	1165	27.03	27.03	29.75	12154	34659	25280480	819611
21-Jan-84	757	12885	329211	0	0	0	5370	158	12071	27.27	27.27	31.27	12357	377460	25657940	831682
22-Jan-84	761	15405	369393	0	0	0	4506	159	14432	25.59	25.59	29.61	11585	427332	26085272	846114
23-Jan-84	769	15379	380097	0	0	0	4511	154	14408	26.38	26.38	30.43	11587	438435	26523707	860522
24-Jan-84	1001	15180	332987	0	0	0	4586	159	14233	23.40	23.40	28.57	11658	406637	26930344	874755
25-Jan-84	1004	15151	335940	0	0	0	4526	161	14206	23.65	23.65	28.84	11595	409701	27340045	888961
26-Jan-84	1004	15164	335940	0	0	0	4511	165	14218	23.63	23.63	28.81	11581	409621	27749666	903179
27-Jan-84	1007	15117	329328	0	0	0	4512	173	14174	23.23	23.23	28.44	11580	403109	28152774	917353
28-Jan-84	1006	15149	331591	0	0	0	4500	175	14204	23.34	23.34	28.54	11569	405382	28558157	931557
29-Jan-84	1008	15124	331591	0	0	0	4490	186	14181	23.38	23.38	28.59	11558	405435	28963591	945738
30-Jan-84	1007	15118	316688	0	0	0	4489	190	14175	22.34	22.34	27.54	11558	390380	29353971	959913
31-Jan-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	29353971	959913

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Feb-84	1004	13614	353691	0	0	0	5336	200	12765	27.71	27.71	32.9	12350	419969	29773939	972678
2-Feb-84	1005	18701	435615	0	0	0	4267	220	17535	24.84	24.84	30.04	11511	526751	30300691	990213
3-Feb-84	1005	23435	519336	0	0	0	3015	264	21974	23.63	23.63	28.83	10532	633510	30934201	1012187
4-Feb-84	1014	22810	516831	0	0	0	3394	264	21388	24.16	24.16	29.4	10876	628807	31563008	1033575
5-Feb-84	1001	21999	468839	0	0	0	3380	250	20627	22.73	22.73	27.9	10809	575493	32138502	1054202
6-Feb-84	1002	21904	475696	0	0	0	3363	254	20538	23.16	23.16	28.34	10785	582047	32720549	1074740
7-Feb-84	1003	24520	526924	0	0	0	3337	254	22991	22.92	22.92	28.1	10942	646047	33366596	1097731
8-Feb-84	1003	24681	520522	0	0	0	2761	247	23142	22.49	22.49	27.68	10364	640571	34007166	1120873
9-Feb-84	1005	20646	516831	0	0	0	3562	247	19359	26.70	26.70	31.89	10901	617359	34624525	1140232
10-Feb-84	1005	20169	428231	0	0	0	3551	228	18911	22.64	22.64	27.84	10868	526482	35151007	1159143
11-Feb-84	503	8595	230775	0	0	0	5298	153	8045	28.69	28.69	31.41	12140	252693	35403700	1167188
12-Feb-84	504	20588	512408	0	0	0	3458	156	19271	26.59	26.59	29.32	10794	565026	35968726	1186459
13-Feb-84	505	20539	476552	0	0	0	3440	161	19225	24.79	24.79	27.52	10775	529072	36497798	1205684
14-Feb-84	505	24131	654804	0	0	0	3424	193	22587	28.99	28.99	31.72	10994	716460	37214258	1228271
15-Feb-84	506	24867	643891	0	0	0	2488	198	23276	27.66	27.66	30.4	10088	707590	37921848	1251547
16-Feb-84	505	24965	643891	0	0	0	2455	205	23368	27.55	27.55	30.29	10062	707817	38629665	1274915
17-Feb-84	518	27806	756046	0	0	0	2345	239	26028	29.05	29.05	31.85	10173	828992	39458657	1300943
18-Feb-84	506	28936	751456	0	0	0	1151	239	27085	27.74	27.74	30.48	9035	825551	40284207	1328028
19-Feb-84	506	28466	741556	0	0	0	1125	237	26645	27.83	27.83	30.57	8966	814538	41098745	1354673
20-Feb-84	507	28000	731563	0	0	0	1096	240	26209	27.91	27.91	30.66	8895	803568	41902313	1380882
21-Feb-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	41902313	1380882
22-Feb-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	41902313	1380882
23-Feb-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	41902313	1380882
24-Feb-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	41902313	1380882
25-Feb-84	1007	9109	205499	0	0	0	4052	172	8541	24.06	24.06	29.26	10882	249910	42152223	1389423
26-Feb-84	1006	15654	332248	0	0	0	3956	179	14678	22.64	22.64	27.83	11037	408489	42560711	1404101
27-Feb-84	998	15657	332248	0	0	0	3946	181	14680	22.63	22.63	27.79	11027	407957	42968669	1418781
28-Feb-84	991	15931	415448	0	0	0	3925	182	14937	27.81	27.81	32.94	11007	492025	43460693	1433718
29-Feb-84	511	15773	447827	0	0	0	3935	173	14764	30.33	30.33	33.1	11008	488688	43949382	1448482

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Mar-84	309	15599	433929	0	0	0	3927	145	14591	29.74	29.74	31.46	10995	459033	44408415	1463073
2-Mar-84	311	15584	431148	0	0	0	3928	151	14577	29.58	29.58	31.31	10996	456406	44864821	1477650
3-Mar-84	405	15522	429456	0	0	0	3929	159	14524	29.57	29.57	31.79	10993	461718	45326539	1492174
4-Mar-84	406	15570	417796	0	0	0	3930	165	14569	28.68	28.68	30.9	10999	450182	45776721	1506743
5-Mar-84	406	12912	366829	0	0	0	3917	170	12082	30.36	30.36	32.59	10864	393752	46170473	1518825
6-Mar-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	46170473	1518825
7-Mar-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	46170473	1518825
8-Mar-84	422	3748	104306	0	0	0	4109	136	3507	29.74	29.74	32.05	10821	112399	46282872	1522332
9-Mar-84	518	10165	325686	0	0	0	4244	146	9515	34.23	34.23	37.03	11089	352340	46635213	1531847
10-Mar-84	400	10219	294102	0	0	0	4552	160	9562	30.76	30.76	32.95	11419	315068	46950281	1541409
11-Mar-84	414	7871	219522	0	0	0	4634	157	7365	29.81	29.81	32.07	11439	236196	47186476	1548774
12-Mar-84	403	12087	347501	0	0	0	4373	208	11310	30.73	30.73	32.94	11300	372551	47559028	1560084
13-Mar-84	397	10498	308431	0	0	0	5404	187	9823	31.40	31.40	33.58	12301	329856	47888884	1569907
14-Mar-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	47888884	1569907
15-Mar-84	424	8321	266105	0	0	0	5492	207	7786	34.18	34.18	36.49	12320	284111	48172995	1577693
16-Mar-84	410	18508	534148	0	0	0	4336	211	17318	30.84	30.84	33.09	11564	573053	48746048	1595011
17-Mar-84	409	11686	537405	0	0	0	4290	222	10935	49.15	49.15	51.39	11148	561950	49307997	1605946
18-Mar-84	411	20156	330246	0	0	0	4288	235	18860	17.51	17.51	19.76	11622	372674	49680671	1624806
19-Mar-84	410	20104	537405	0	0	0	4265	243	18812	28.57	28.57	30.82	11588	579786	50260457	1643618
20-Mar-84	409	20058	535805	0	0	0	4251	244	18768	28.55	28.55	30.79	11571	577867	50838324	1662386
21-Mar-84	999	19476	537777	0	0	0	4217	258	18261	29.45	29.45	34.61	11496	632013	51470337	1680647
22-Mar-84	403	20109	542379	0	0	0	4203	249	18816	28.83	28.83	31.04	11524	584049	52054385	1699463
23-Mar-84	403	20063	542379	0	0	0	4190	245	18773	28.89	28.89	31.1	11508	583840	52638226	1718236
24-Mar-84	403	20043	540662	0	0	0	4178	232	18754	28.83	28.83	31.04	11495	582124	53220350	1736990
25-Mar-84	403	20008	540662	0	0	0	4178	232	18721	28.88	28.88	31.09	11493	582036	53802386	1755711
26-Mar-84	402	19990	537405	0	0	0	4150	236	18704	28.73	28.73	30.94	11463	578702	54381088	1774415
27-Mar-84	401	17411	500218	0	0	0	4136	236	16291	30.70	30.70	32.91	11298	536137	54917224	1790706
28-Mar-84	412	20408	561654	0	0	0	4079	240	19096	29.41	29.41	31.67	11415	604770	55521995	1809802
29-Mar-84	406	20371	548954	0	0	0	4063	246	19061	28.80	28.80	31.03	11397	591463	56113457	1828863
30-Mar-84	407	20343	550433	0	0	0	4052	253	19035	28.92	28.92	31.15	11384	592940	56706398	1847898
31-Mar-84	406	15354	436207	0	0	0	4047	252	14367	30.36	30.36	32.59	11105	468221	57174618	1862265

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Apr-84	403	20338	543382	0	0	0	4040	248	19030	28.55	28.55	30.77	11372	585553	57760171	1881295
2-Apr-84	402	20301	544426	0	0	0	4031	249	18995	28.66	28.66	30.87	11360	586376	58346547	1900290
3-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
4-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
5-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
6-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
7-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
8-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
9-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
10-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
11-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
12-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
13-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
14-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
15-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
16-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
17-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
18-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
19-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
20-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
21-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
22-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
23-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
24-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
25-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
26-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
27-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
28-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
29-Apr-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
30-Apr-84	0	0	0	0	0	0	5397	0	0	0.00	0.00	0	0	0	58346547	1900290

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
2-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
3-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
4-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
5-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
6-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
7-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
8-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
9-May-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	58346547	1900290
10-May-84	0	1400	37240	0	0	0	5296	0	1308	28.47	28.47	28.55	12025	37343	58383890	1901598
11-May-84	516	13910	373483	0	0	0	5354	286	13021	28.68	28.68	31.47	12382	409771	58793661	1914619
12-May-84	1003	15119	312440	0	0	0	4543	284	14176	22.04	22.04	27.22	11613	385871	59179532	1928795
13-May-84	1017	15249	315494	0	0	0	4539	289	14299	22.06	22.06	27.31	11615	390506	59570038	1943094
14-May-84	1010	15230	319503	0	0	0	4542	291	14281	22.37	22.37	27.59	11617	394013	59964050	1957375
15-May-84	1005	6673	152544	0	0	0	5381	291	6257	24.38	24.38	29.57	12182	185019	60149070	1963632
16-May-84	1027	8563	201915	0	0	0	5381	272	8030	25.15	25.15	30.44	12226	244433	60393503	1971662
17-May-84	1003	15468	340198	0	0	0	4565	173	14503	23.46	23.46	28.64	11650	415366	60808869	1986165
18-May-84	1003	15435	340170	0	0	0	4559	179	14472	23.50	23.50	28.69	11643	415202	61224071	2000637
19-May-84	1006	15421	337204	0	0	0	4552	182	14459	23.32	23.32	28.52	11635	412371	61636441	2015096
20-May-84	1008	15416	331122	0	0	0	4539	184	14455	22.91	22.91	28.11	11622	406330	62042772	2029551
21-May-84	1019	15396	327255	0	0	0	4532	188	14437	22.67	22.67	27.93	11614	403225	62445997	2043988
22-May-84	1001	15388	328715	0	0	0	4531	193	14428	22.78	22.78	27.96	11613	403407	62849404	2058416
23-May-84	1001	7045	170489	0	0	0	4534	192	6606	25.81	25.81	30.98	11320	204654	63054058	2065022
24-May-84	1014	4886	113208	0	0	0	4512	153	4581	24.71	24.71	29.95	11257	137201	63191259	2069603
25-May-84	1010	23889	543505	0	0	0	3349	260	22400	24.26	24.26	29.48	10906	660352	63851611	2092003
26-May-84	1011	25085	540937	0	0	0	3289	269	23521	23.00	23.00	28.22	10935	663763	64515373	2115524
27-May-84	1011	25155	544376	0	0	0	3269	278	23587	23.08	23.08	28.3	10920	667512	65182885	2139111
28-May-84	1011	25098	544637	0	0	0	3204	282	23533	23.14	23.14	28.36	10849	667396	65850281	2162644
29-May-84	1010	25143	548062	0	0	0	3189	286	23576	23.25	23.25	28.46	10837	670973	66521254	2186220
30-May-84	1011	25223	541326	0	0	0	3104	290	23651	22.89	22.89	28.11	10756	664830	67186084	2209871
31-May-84	1010	25004	525328	0	0	0	3068	304	23445	22.41	22.41	27.62	10703	647551	67833635	2233316

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jun-84	1005	25004	519677	0	0	0	3068	304	23445	22.17	22.17	27.36	10704	641455	68475090	2256761
2-Jun-84	1023	25017	517114	0	0	0	3046	309	23458	22.04	22.04	27.32	10682	640873	69115962	2280219
3-Jun-84	1028	24992	516352	0	0	0	3006	281	23435	22.03	22.03	27.33	10639	640479	69756441	2303654
4-Jun-84	1014	24970	517524	0	0	0	2982	293	23414	22.10	22.10	27.34	10613	640139	70396580	2327068
5-Jun-84	1004	25164	530196	0	0	0	2912	283	23595	22.47	22.47	27.66	10555	652638	71049217	2350663
6-Jun-84	1011	25248	521976	0	0	0	2814	287	23674	22.05	22.05	27.27	10462	645590	71694807	2374337
7-Jun-84	1015	15449	330680	0	0	0	4235	288	14486	22.83	22.83	28.07	11313	406622	72101429	2388823
8-Jun-84	1008	20631	427416	0	0	0	4236	207	19345	22.09	22.09	27.3	11598	528119	72629548	2408168
9-Jun-84	1008	20386	426738	0	0	0	3551	215	19115	22.32	22.32	27.53	10882	526236	73155784	2427283
10-Jun-84	1008	20351	430633	0	0	0	3549	220	19082	22.57	22.57	27.77	10877	529907	73685691	2446365
11-Jun-84	1009	20310	427404	0	0	0	3543	224	19044	22.44	22.44	27.65	10869	526567	74212258	2465409
12-Jun-84	1004	20263	425506	0	0	0	3523	228	18999	22.40	22.40	27.58	10845	523992	74736250	2484408
13-Jun-84	1017	20198	427017	0	0	0	3519	233	18939	22.55	22.55	27.8	10837	526504	75262754	2503347
14-Jun-84	1006	20137	423811	0	0	0	3500	236	18881	22.45	22.45	27.64	10814	521871	75784625	2522228
15-Jun-84	1008	20082	425868	0	0	0	3486	238	18830	22.62	22.62	27.82	10796	523851	76308476	2541058
16-Jun-84	1005	20225	427353	0	0	0	3466	240	18964	22.54	22.54	27.73	10784	525872	76834347	2560022
17-Jun-84	1003	20400	433115	0	0	0	3377	243	19128	22.64	22.64	27.83	10704	532332	77366680	2579150
18-Jun-84	1003	20348	432809	0	0	0	3366	245	19079	22.69	22.69	27.87	10689	531732	77898411	2598229
19-Jun-84	1009	20292	432070	0	0	0	3356	247	19027	22.71	22.71	27.92	10675	531234	78429645	2617256
20-Jun-84	1003	20242	433901	0	0	0	3339	248	18980	22.86	22.86	28.04	10654	532199	78961844	2636236
21-Jun-84	1007	20190	430777	0	0	0	3327	249	18931	22.75	22.75	27.96	10639	529311	79491155	2655167
22-Jun-84	1005	20128	426904	0	0	0	3311	250	18873	22.62	22.62	27.81	10619	524858	80016013	2674040
23-Jun-84	1007	20062	424565	0	0	0	3288	251	18811	22.57	22.57	27.77	10592	522381	80538395	2692851
24-Jun-84	1007	20223	427373	0	0	0	3275	253	18962	22.54	22.54	27.74	10588	526006	81064401	2711813
25-Jun-84	1006	20289	430215	0	0	0	3197	251	19024	22.61	22.61	27.81	10512	529057	81593458	2730837
26-Jun-84	1008	20215	427061	0	0	0	3188	252	18955	22.53	22.53	27.74	10498	525812	82119270	2749792
27-Jun-84	1005	20159	427674	0	0	0	3178	252	18902	22.63	22.63	27.82	10484	525854	82645123	2768694
28-Jun-84	1005	20085	428311	0	0	0	3151	229	18833	22.74	22.74	27.94	10452	526194	83171317	2787527
29-Jun-84	1005	20025	426258	0	0	0	3138	235	18776	22.70	22.70	27.89	10435	523663	83694980	2806303
30-Jun-84	1005	13402	283809	0	0	0	3093	207	12566	22.58	22.58	27.78	10049	349083	84044064	2818869

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jul-84	1005	20223	380652	0	0	0	3018	200	18962	20.07	20.07	25.27	10328	479170	84523233	2837831
2-Jul-84	1005	20454	419924	0	0	0	2968	207	19179	21.90	21.90	27.09	10288	519559	85042792	2857010
3-Jul-84	1005	20376	415042	0	0	0	2951	212	19105	21.72	21.72	26.92	10266	514307	85557099	2876115
4-Jul-84	1005	20302	415095	0	0	0	2932	216	19036	21.81	21.81	27	10242	513972	86071071	2895151
5-Jul-84	1005	20227	414796	0	0	0	2918	221	18966	21.87	21.87	27.06	10223	513220	86584291	2914117
6-Jul-84	1007	20155	414537	0	0	0	2902	221	18898	21.94	21.94	27.14	10202	512892	87097183	2933015
7-Jul-84	1006	20071	413319	0	0	0	2898	225	18820	21.96	21.96	27.16	10192	511151	87608334	2951835
8-Jul-84	1006	20135	424720	0	0	0	2872	229	18880	22.50	22.50	27.69	10169	522787	88131121	2970715
9-Jul-84	1005	20262	437810	0	0	0	2785	232	18999	23.04	23.04	28.24	10086	536532	88667653	2989714
10-Jul-84	1005	20195	436264	0	0	0	2759	234	18936	23.04	23.04	28.23	10055	534563	89202216	3008650
11-Jul-84	1008	12712	301782	0	0	0	5002	191	11919	25.32	25.32	30.53	11976	363887	89566103	3020569
12-Jul-84	1006	10562	256867	0	0	0	5024	173	9903	25.94	25.94	31.13	11919	308280	89874384	3030472
13-Jul-84	1009	10269	248099	0	0	0	5024	143	9629	25.77	25.77	30.98	11910	298306	90172690	3040101
14-Jul-84	1005	15449	342109	0	0	0	4238	144	14486	23.62	23.62	28.81	11314	417342	90590032	3054587
15-Jul-84	1005	15460	337606	0	0	0	4238	147	14496	23.29	23.29	28.48	11315	412846	91002878	3069083
16-Jul-84	1007	15457	338359	0	0	0	4235	149	14493	23.35	23.35	28.55	11312	413775	91416653	3083576
17-Jul-84	1004	15431	319563	500	28857	348420	4229	132	14469	22.09	24.08	26.79	11307	387625	91804277	3098045
18-Jul-84	1003	15417	332974	500	39442	372416	4225	132	14456	23.03	25.76	28.47	11300	411562	92215840	3112501
19-Jul-84	1003	15410	329512	500	45214	374726	4231	135	14449	22.81	25.93	28.64	11306	413819	92629659	3126950
20-Jul-84	1005	15402	331436	500	46098	377534	4231	137	14442	22.95	26.14	28.85	11305	416652	93046311	3141392
21-Jul-84	1003	15400	331004	400	52641	383645	4225	133	14440	22.92	26.57	28.76	11299	415294	93461605	3155832
22-Jul-84	1003	15399	331483	400	56447	387930	4219	133	14439	22.96	26.87	29.06	11292	419597	93881203	3170271
23-Jul-84	1002	9471	207303	300	38352	245655	4229	131	8880	23.34	27.66	29.34	11074	260539	94141742	3179151
24-Jul-84	1003	6526	157840	300	31985	189825	4228	117	6119	25.79	31.02	32.7	10989	200091	94341833	3185270
25-Jul-84	1006	15500	330463	300	65887	396350	4223	120	14534	22.74	27.27	28.95	11301	420759	94762592	3199804
26-Jul-84	1005	15492	333797	300	73397	467194	4220	121	14526	22.98	28.03	29.71	11296	431567	95194160	3214330
27-Jul-84	1005	15484	336540	250	68880	405420	4215	122	14518	23.18	27.92	29.34	11292	425958	95620118	3228848
28-Jul-84	1004	15471	330515	251	68468	398983	4209	123	14506	22.78	27.50	28.92	11286	419514	96039631	3243354
29-Jul-84	1005	15461	335102	251	68777	403879	4205	124	14497	23.12	27.86	29.28	11280	424472	96464104	3257851
30-Jul-84	1005	15448	331508	250	68559	400067	4190	124	14485	22.89	27.62	29.03	11265	420500	96884603	3272336
31-Jul-84	1004	15441	337446	251	68456	405902	4191	127	14478	23.31	28.04	29.46	11265	426522	97311125	3286814

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Aug-84	1008	15432	341199	313	64240	406360	4191	133	14470	23.58	28.02	29.76	11264	430627	97741752	3301284
2-Aug-84	1007	15424	337950	310	63218	401551	4184	133	14462	23.37	27.74	29.47	11257	426195	98167947	3315746
3-Aug-84	1007	15421	338833	315	63465	402300	4178	135	14460	23.43	27.82	29.58	11250	427727	98595674	3330206
4-Aug-84	1006	15415	337080	300	65319	402587	4180	131	14454	23.32	27.84	29.52	11252	426682	99022356	3344660
5-Aug-84	1006	15407	336954	300	66630	403349	4158	134	14446	23.32	27.94	29.61	11229	427746	99450102	3359106
6-Aug-84	1007	15398	333069	300	67026	400525	4152	137	14438	23.07	27.71	29.39	11223	424333	99874435	3373544
7-Aug-84	1007	15394	336225	300	66281	402180	4151	138	14434	23.29	27.89	29.56	11221	426669	100301104	3387978
8-Aug-84	1007	15384	334771	300	66166	402840	4146	139	14425	23.21	27.79	29.47	11216	425105	100726209	3402403
9-Aug-84	1006	15381	333972	305	65481	399000	4140	140	14422	23.16	27.70	29.4	11210	424007	101150216	3416825
10-Aug-84	1005	15374	334573	306	66085	400689	4135	141	14415	23.21	27.79	29.5	11204	425243	101575458	3431240
11-Aug-84	1005	15826	335592	298	66385	402206	4132	142	14839	22.62	27.09	28.76	11224	426770	102002228	3446079
12-Aug-84	1005	14972	324752	301	65086	392192	4168	141	14038	23.13	27.77	29.45	11219	413419	102415647	3460117
13-Aug-84	1007	15263	334589	298	65788	400141	4144	143	14311	23.38	27.98	29.64	11208	424178	102839825	3474428
14-Aug-84	1004	15152	332222	306	64979	397562	4137	139	14207	23.38	27.96	29.67	11195	421522	103261347	3488635
15-Aug-84	1007	15142	333395	302	65021	398215	4138	141	14198	23.48	28.06	29.75	11196	422391	103683737	3502833
16-Aug-84	1008	15135	333580	303	65451	398633	4126	142	14191	23.51	28.12	29.81	11183	423034	104106771	3517024
17-Aug-84	1005	10402	247567	303	40255	287822	4962	129	9753	25.38	29.51	31.2	11851	304294	104411065	3526777
18-Aug-84	1006	15560	341554	302	55097	396651	4072	130	14590	23.41	27.19	28.87	11149	421213	104832278	3541367
19-Aug-84	1005	24166	546343	306	110213	665699	4059	200	22659	24.11	28.98	30.68	11652	695178	105527456	3564026
20-Aug-84	1005	25207	553053	303	110044	663297	2718	208	23635	23.40	28.06	29.75	10356	703141	106230597	3587661
21-Aug-84	1007	25100	549827	0	0	549827	2696	234	23535	23.36	23.36	28.56	10327	672160	106902757	3611196
22-Aug-84	1006	25152	550337	304	77544	627881	2684	218	23584	23.34	26.62	28.32	10319	667899	107570656	3634780
23-Aug-84	1006	25176	553306	306	106783	660316	2611	235	23606	23.44	27.96	29.67	10243	700390	108271046	3658386
24-Aug-84	1006	25076	551735	0	0	551735	2588	242	23512	23.47	23.47	28.66	10214	673854	108944900	3681898
25-Aug-84	1006	25138	553983	0	0	553983	2570	245	23571	23.50	23.50	28.7	10200	676488	109621387	3705469
26-Aug-84	1006	25145	550785	309	116299	666714	2497	232	23577	23.36	28.29	30.02	10123	707782	110329169	3729046
27-Aug-84	1008	25059	548786	308	117415	666100	2478	236	23497	23.36	28.35	30.07	10097	706555	111035724	3752543
28-Aug-84	1006	25437	556028	323	116600	672663	2456	239	23851	23.31	28.20	30	10103	715530	111751254	3776394
29-Aug-84	1004	25436	556647	322	116451	672418	2324	241	23850	23.34	28.22	30.01	9967	715739	112466992	3800244
30-Aug-84	1012	25311	560086	324	111943	672883	2301	243	23733	23.60	28.32	30.12	9933	714838	113181830	3823977
31-Aug-84	1005	25193	551051	352	106063	657861	2290	243	23622	23.33	27.82	29.77	9914	703227	113885057	3847599

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Sep-84	1006	25058	545875	355	104689	650406	2268	245	23496	23.23	27.69	29.65	9881	696656	114581713	3871095
2-Sep-84	1006	24928	545671	356	104341	649758	2252	246	23374	23.35	27.81	29.78	9854	696078	115277791	3894469
3-Sep-84	1007	24800	542105	358	104112	646512	2236	250	23254	23.31	27.79	29.77	9828	692272	115970063	3917723
4-Sep-84	1009	24666	541839	358	103318	647388	2210	252	23128	23.43	27.89	29.87	9791	690833	116660896	3940851
5-Sep-84	1009	15119	339696	358	56153	380034	4790	252	14176	23.96	27.92	29.9	11862	423862	117084759	3955027
6-Sep-84	1009	9386	206451	357	38743	245194	4779	205	8801	23.46	27.86	29.83	11634	262534	117347292	3963828
7-Sep-84	0	0	0	0	0	0	4738	13	0	0.00	0.00	0	0	0	117347292	3963828
8-Sep-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	117347292	3963828
9-Sep-84	1008	18176	338094	407	58328	211127	4745	288	17043	19.84	23.26	25.49	11975	434426	117781718	3980871
10-Sep-84	1009	25158	547842	409	94861	643007	2045	288	23590	23.22	27.25	29.49	9658	695669	118477388	4004461
11-Sep-84	1009	24982	546667	404	94907	640847	2029	283	23425	23.34	27.39	29.61	9628	693614	119171002	4027886
12-Sep-84	1009	24809	542516	404	95497	638250	2009	282	23262	23.32	27.43	29.64	9594	689486	119860487	4051148
13-Sep-84	1009	24639	536585	404	95567	632813	2006	284	23103	23.23	27.36	29.58	9578	683387	120543874	4074251
14-Sep-84	1009	24472	537327	402	95779	633548	1984	285	22946	23.42	27.59	29.8	9542	683791	121227665	4097197
15-Sep-84	1009	24346	534345	403	93713	606261	1962	285	22828	23.41	27.51	29.72	9510	678448	121906113	4120025
16-Sep-84	1008	24213	532392	400	93174	625413	1939	285	22703	23.45	27.55	29.75	9476	675414	122581527	4142728
17-Sep-84	1009	24037	526846	399	91547	618452	1918	271	22538	23.38	27.44	29.63	9442	667801	123249328	4165266
18-Sep-84	1007	23872	524816	398	92486	617790	1904	272	22384	23.45	27.58	29.76	9415	666148	123915476	4187650
19-Sep-84	1008	23706	524918	402	92569	617498	1890	273	22228	23.62	27.78	29.99	9387	666618	124582094	4209878
20-Sep-84	1008	23547	517208	398	92742	609608	1875	272	22079	23.43	27.63	29.81	9361	658175	125240269	4231957
21-Sep-84	1008	17549	385683	396	65771	455220	4712	220	16455	23.44	27.44	29.61	11904	487233	125727501	4248412
22-Sep-84	1010	23376	514719	389	92135	606197	1823	225	21919	23.48	27.69	29.83	9294	653844	126381345	4270331
23-Sep-84	1008	23205	511703	409	92931	604166	1807	227	21758	23.52	27.79	30.03	9265	653393	127034738	4292089
24-Sep-84	1009	23039	510731	409	95240	605486	1804	232	21603	23.64	28.05	30.29	9249	654355	127689093	4313692
25-Sep-84	1008	14215	332488	494	37004	382243	4113	403	13329	24.95	27.72	30.4	11127	405202	128094294	4327021
26-Sep-84	1008	20194	478193	602	66842	545035	3328	508	18935	25.25	28.78	32.01	10632	606109	128700404	4345956
27-Sep-84	1010	17185	290639	620	41932	331090	4722	517	16114	18.04	20.64	23.95	11900	385930	129086334	4362070
28-Sep-84	0	0	0	0	0	0	4710	0	0	0.00	0.00	0	0	0	129086334	4362070
29-Sep-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	129086334	4362070
30-Sep-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	129086334	4362070

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Oct-84	0	0	0	0	0	0	4680	0	0	0.00	0.00	0	0	0	129086334	4362070
2-Oct-84	0	0	0	0	0	0	4698	0	0	0.00	0.00	0	0	0	129086334	4362070
3-Oct-84	0	0	0	0	0	0	4715	0	0	0.00	0.00	0	0	0	129086334	4362070
4-Oct-84	0	0	0	0	0	0	4715	0	0	0.00	0.00	0	0	0	129086334	4362070
5-Oct-84	0	0	0	0	0	0	4752	0	0	0.00	0.00	0	0	0	129086334	4362070
6-Oct-84	0	0	0	0	0	0	4730	0	0	0.00	0.00	0	0	0	129086334	4362070
7-Oct-84	1025	9956	170601	310	26562	169501	4718	80	9336	18.27	21.12	22.85	11596	213328	129299662	4371406
8-Oct-84	1027	15211	313066	320	64574	377790	3468	88	14264	21.95	26.48	28.26	10514	403101	129702762	4385670
9-Oct-84	1028	15219	322777	320	67748	390374	3474	101	14271	22.62	27.36	29.15	10519	416000	130118762	4399941
10-Oct-84	1028	17705	393223	320	80393	478067	3470	102	16602	23.68	28.53	30.31	10638	503207	130621969	4416543
11-Oct-84	1010	19766	438007	325	81081	507255	2547	103	18534	23.63	28.01	29.81	9806	552499	131174467	4435077
12-Oct-84	1019	19687	434741	326	81893	495468	2530	104	18460	23.55	27.99	29.8	9783	550108	131724575	4453537
13-Oct-84	1031	19591	431974	329	80909	478117	2520	107	18371	23.51	27.92	29.75	9767	546537	132271112	4471908
14-Oct-84	1027	19519	433379	312	77782	484500	2515	107	18303	23.68	27.93	29.67	9758	543050	132814162	4490211
15-Oct-84	1024	19459	428721	310	58001	479540	2480	106	18247	23.50	26.67	28.4	9722	518215	133332377	4508458
16-Oct-84	1025	19390	422636	313	80229	493037	2475	106	18182	23.24	27.66	29.4	9710	534551	133866928	4526640
17-Oct-84	1023	19314	417562	389	70740	475629	2460	110	18111	23.06	26.96	29.1	9691	527030	134393958	4544751
18-Oct-84	1024	19253	410701	399	68820	453872	2442	110	18054	22.75	26.56	28.75	9669	519053	134913011	4562805
19-Oct-84	1004	19215	413688	402	66384	409370	2438	111	18017	22.96	26.65	28.85	9662	519790	135432801	4580822
20-Oct-84	1005	19141	412756	407	66250	468262	2418	111	17947	23.00	26.69	28.92	9637	519027	135951828	4598769
21-Oct-84	1004	19059	410902	403	66250	472544	2410	110	17871	22.99	26.70	28.91	9624	516651	136468479	4616640
22-Oct-84	1003	19007	410344	395	66303	468739	2391	110	17822	23.02	26.75	28.92	9601	515412	136983891	4634462
23-Oct-84	1002	21516	411686	402	72728	460242	2378	110	20174	20.41	24.01	26.22	9750	528962	137512853	4654636
24-Oct-84	1002	21393	463735	402	72728	460242	1692	109	20059	23.12	26.74	28.95	9023	580708	138093561	4674695
25-Oct-84	1003	20494	440897	349	84532	536226	1684	105	19216	22.94	27.34	29.28	8955	562644	138656206	4693911
26-Oct-84	1004	20139	436108	360	20139	502739	1942	108	18883	23.10	24.16	26.15	9212	493790	139149996	4712794
27-Oct-84	1030	20252	426174	358	86270	482704	1941	108	18991	22.44	26.98	28.96	9210	549979	139699976	4731785
28-Oct-84	1006	20299	438268	364	83742	508807	1833	109	19033	23.03	27.43	29.44	9098	560332	140260307	4750818
29-Oct-84	1010	20184	436899	357	84637	507933	1794	109	18926	23.08	27.56	29.53	9050	558885	140819192	4769744
30-Oct-84	1010	20067	435394	339	89965	504226	1791	107	18816	23.14	27.92	29.8	9039	560717	141379909	4788560
31-Oct-84	1015	14856	313527	354	56961	360861	4731	105	13930	22.51	26.60	28.55	11792	397702	141777610	4802490

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Nov-84	1016	20175	434130	354	85944	507018	1675	105	18918	22.95	27.49	29.45	8925	557135	142334745	4821408
2-Nov-84	1015	20047	433661	355	89663	501627	1655	105	18798	23.07	27.84	29.8	8895	560180	142894926	4840206
3-Nov-84	1015	19933	428938	354	87133	497119	1636	104	18691	22.95	27.61	29.57	8869	552693	143447619	4858897
4-Nov-84	1010	19808	423978	352	91724	493615	1625	105	18573	22.83	27.77	29.71	8849	551804	143999423	4877470
5-Nov-84	1010	19668	418830	351	93705	493990	1623	104	18442	22.71	27.79	29.73	8838	548281	144547703	4895912
6-Nov-84	1012	19530	416710	350	92207	488798	1609	104	18313	22.76	27.79	29.73	8815	544445	145092149	4914225
7-Nov-84	1019	19391	415295	353	93870	486134	1605	102	18183	22.84	28.00	29.96	8802	544763	145636911	4932408
8-Nov-84	1021	19233	403504	353	92565	477797	1608	102	18035	22.37	27.51	29.46	8797	531311	146168222	4950443
9-Nov-84	1021	19104	407867	355	91675	475226	1595	100	17914	22.77	27.89	29.85	8774	534733	146702955	4968357
10-Nov-84	1020	18974	405989	351	91414	471920	1589	101	17792	22.82	27.96	29.9	8760	531981	147234936	4986149
11-Nov-84	1019	18840	404143	351	90272	472787	1582	100	17666	22.88	27.99	29.93	8745	528743	147763680	5003815
12-Nov-84	1019	18704	398549	358	91609	468973	1584	91	17539	22.72	27.95	29.93	8739	524942	148288622	5021354
13-Nov-84	1008	3396	78787	0	0	0	4000	118	3184	24.74	24.74	29.95	10711	95361	148383983	5024538
14-Nov-84	1020	10790	251838	356	56539	390578	4288	83	10118	24.89	30.48	32.45	11169	328329	148712312	5034656
15-Nov-84	1010	11402	266692	350	54615	254378	4870	94	10691	24.94	30.05	31.99	11789	342005	149054317	5045347
16-Nov-84	1011	12729	298368	349	59699	286275	4303	94	11936	25.00	30.00	31.93	11257	381116	149435433	5057283
17-Nov-84	1015	10243	242246	351	39333	232618	4762	85	9605	25.22	29.32	31.26	11640	300252	149735686	5066888
18-Nov-84	1018	10588	247335	350	55798	303133	4837	83	9928	24.91	30.53	32.47	11726	322362	150058048	5076816
19-Nov-84	1015	15690	326437	352	73693	377198	4144	84	14712	22.19	27.20	29.14	11229	428708	150486755	5091528
20-Nov-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	150486755	5091528
21-Nov-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	150486755	5091528
22-Nov-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	150486755	5091528
23-Nov-84	1023	9014	214643	355	37408	245723	4873	84	8452	25.39	29.82	31.78	11716	268605	150755360	5099980
24-Nov-84	1017	15505	336092	354	64362	385546	3940	89	14539	23.12	27.54	29.5	11010	428901	151184260	5114519
25-Nov-84	1019	15544	334460	352	64511	382862	3962	90	14575	22.95	27.37	29.32	11035	427339	151611599	5129094
26-Nov-84	1019	15540	335266	359	64499	384223	3963	91	14572	23.01	27.43	29.42	11036	428708	152040308	5143666
27-Nov-84	1019	15693	336647	354	61411	382706	3965	91	14715	22.88	27.05	29.01	11046	426882	152467190	5158381
28-Nov-84	1020	15708	346716	342	61568	388574	3965	67	14729	23.54	27.72	29.61	11045	436126	152903316	5173110
29-Nov-84	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	152903316	5173110
30-Nov-84	0	1800	0	0	0	0	0	0	1682	0.00	0.00	0.08	6615	135	152903450	5174792

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Dec-84	1000	9311	207542	347	31564	190298	4816	90	8730	23.77	27.39	29.31	11671	255876	153159326	5183522
2-Dec-84	1010	15052	306767	349	59306	347844	3944	92	14114	21.74	25.94	27.87	10996	393357	153552684	5197636
3-Dec-84	1010	15066	308814	350	59532	350631	3948	92	14127	21.86	26.07	28.01	11001	395697	153948381	5211763
4-Dec-84	1010	15097	312278	346	59062	352048	3937	92	14156	22.06	26.23	28.15	10991	398491	154346872	5225919
5-Dec-84	1013	15096	321096	349	58954	315329	3934	93	14155	22.68	26.85	28.78	10986	407381	154754253	5240074
6-Dec-84	1013	15152	322016	358	59446	336121	3927	93	14208	22.67	26.85	28.83	10982	409617	155163870	5254282
7-Dec-84	1012	15186	319789	368	59352	357375	3940	95	14239	22.46	26.63	28.66	10997	408090	155571960	5268521
8-Dec-84	1014	15217	320093	357	59954	357634	3940	97	14269	22.43	26.64	28.61	10998	408236	155980196	5282790
9-Dec-84	1015	15200	319512	358	60764	360162	3940	97	14253	22.42	26.68	28.66	10998	408491	156388687	5297043
10-Dec-84	1014	15201	320781	357	60010	359867	3939	97	14254	22.51	26.72	28.69	10996	408947	156797634	5311297
11-Dec-84	1030	15203	318826	358	60663	359656	3946	93	14256	22.36	26.62	28.6	11004	407722	157205355	5325553
12-Dec-84	1012	15196	300625	350	59824	357020	3940	93	14249	21.10	25.30	27.23	11000	388000	157593356	5339802
13-Dec-84	1010	15219	314165	348	58487	360240	3941	93	14270	22.02	26.11	28.04	11001	400131	157993487	5354072
14-Dec-84	1014	15213	311358	351	59029	359728	3940	93	14265	21.83	25.97	27.91	10999	398136	158391623	5368337
15-Dec-84	1014	15222	311019	347	59683	357899	3940	93	14273	21.79	25.97	27.89	11000	398074	158789697	5382610
16-Dec-84	1014	15236	311019	351	58874	356196	3938	94	14286	21.77	25.89	27.83	10999	397579	159187276	5396896
17-Dec-84	1012	15235	310608	353	59055	358396	3939	94	14285	21.74	25.88	27.83	11000	397552	159584828	5411181
18-Dec-84	1012	15219	311581	352	60021	358720	3940	94	14270	21.83	26.04	27.99	11000	399417	159984245	5425451
19-Dec-84	1013	15228	312533	353	61119	358398	3942	95	14279	21.89	26.17	28.12	11002	401525	160385770	5439730
20-Dec-84	1014	15241	314281	352	61209	362252	3943	95	14291	21.99	26.27	28.22	11003	403292	160789062	5454021
21-Dec-84	1014	15328	315901	350	60212	364377	3940	95	14373	21.98	26.17	28.11	11004	404025	161193087	5468394
22-Dec-84	1013	15258	314956	356	60291	365426	3940	94	14307	22.01	26.23	28.2	11001	403457	161596545	5482701
23-Dec-84	1014	15264	316908	352	58276	362511	3937	94	14313	22.14	26.21	28.16	10998	403054	161999599	5497014
24-Dec-84	1013	15269	317884	353	59165	365392	3939	96	14317	22.20	26.34	28.29	11000	405028	162404627	5511331
25-Dec-84	1014	15276	317340	350	59874	366203	3939	95	14324	22.15	26.33	28.27	11001	404939	162809566	5525655
26-Dec-84	1014	15294	329275	352	58924	370428	3940	94	14341	22.96	27.07	29.02	11001	416176	163225742	5539996
27-Dec-84	1014	15300	327787	347	60276	367745	3936	95	14346	22.85	27.05	28.97	10998	415604	163641346	5554342
28-Dec-84	1014	15315	318387	350	59733	367790	3935	94	14360	22.17	26.33	28.27	10998	405957	164047303	5568702
29-Dec-84	1013	15328	319137	350	59733	367790	3931	95	14373	22.20	26.36	28.3	10995	406756	164454059	5583075
30-Dec-84	1013	15332	318892	352	59331	369748	3931	95	14376	22.18	26.31	28.26	10995	406266	164860325	5597451
31-Dec-84	1012	15331	319049	349	59884	369272	3929	95	14375	22.19	26.36	28.29	10993	406669	165266993	5611826

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jan-85	1014	15339	322734	352	60587	371792	3929	93	14383	22.44	26.65	28.6	10993	411354	165678347	5626209
2-Jan-85	1011	15324	323614	350	60839	367963	3920	92	14369	22.52	26.76	28.69	10983	412247	166090594	5640578
3-Jan-85	1014	15337	335646	355	60312	360216	3912	92	14381	23.34	27.53	29.5	10974	424240	166514833	5654959
4-Jan-85	1018	15329	334839	356	62192	365682	3922	94	14374	23.30	27.62	29.59	10983	425327	166940160	5669333
5-Jan-85	1012	15350	333365	358	64131	366863	3922	96	14393	23.16	27.62	29.6	10984	426033	167366193	5683726
6-Jan-85	1016	15365	331132	353	65337	372871	3923	96	14407	22.98	27.52	29.47	10986	424574	167790767	5698133
7-Jan-85	1013	15369	330736	358	65086	374620	3919	97	14411	22.95	27.47	29.45	10982	424404	168215171	5712544
8-Jan-85	1013	15367	329232	357	62548	371716	3921	97	14409	22.85	27.19	29.16	10985	420166	168635337	5726953
9-Jan-85	1014	15370	331017	353	63458	373034	3921	96	14412	22.97	27.37	29.32	10985	422560	169057897	5741365
10-Jan-85	1013	15369	331490	353	62321	374501	3916	96	14411	23.00	27.33	29.28	10980	421954	169479851	5755776
11-Jan-85	1014	15378	331331	349	62523	373584	3911	93	14420	22.98	27.31	29.25	10975	421785	169901636	5770196
12-Jan-85	1005	15374	328851	359	59904	355785	3911	93	14415	22.81	26.97	28.95	10975	417314	170318951	5784611
13-Jan-85	1003	15478	336486	258	60666	322646	3907	93	14513	23.19	27.37	28.82	10976	418265	170737215	5799124
14-Jan-85	1001	15469	339167	350	61995	337336	3917	94	14504	23.38	27.66	29.6	10985	429318	171166534	5813628
15-Jan-85	1005	15448	336025	349	61016	366566	3918	94	14485	23.20	27.41	29.34	10985	424990	171591524	5828113
16-Jan-85	1004	15453	332815	350	62623	375674	3919	94	14489	22.97	27.29	29.23	10987	423513	172015037	5842602
17-Jan-85	1005	15454	335889	354	61744	379483	3919	93	14490	23.18	27.44	29.4	10986	426006	172441043	5857092
18-Jan-85	1003	15451	334024	356	60206	378551	3914	96	14487	23.06	27.21	29.18	10982	422731	172863774	5871579
19-Jan-85	1004	6435	166752	350	30627	188980	4848	93	6034	27.64	32.71	34.65	11619	209078	173072852	5877613
20-Jan-85	1005	7712	140821	35	24908	154270	4798	96	7231	19.47	22.92	23.19	11616	167687	173240539	5884844
21-Jan-85	1005	15597	340535	353	56956	333981	3903	96	14624	23.29	27.18	29.13	10977	425997	173666536	5899468
22-Jan-85	1005	15624	339702	356	59706	351749	3915	99	14650	23.19	27.26	29.23	10991	428220	174094755	5914118
23-Jan-85	1006	15629	337309	355	61040	374862	3920	98	14654	23.02	27.18	29.15	10996	427164	174521919	5928772
24-Jan-85	1007	15621	335149	351	61517	374969	3912	96	14647	22.88	27.08	29.02	10988	425056	174946975	5943419
25-Jan-85	1006	15617	334463	355	61467	376306	3914	97	14643	22.84	27.04	29	10990	424647	175371622	5958062
26-Jan-85	1005	15614	332605	351	61366	377172	3918	97	14640	22.72	26.91	28.85	10994	422364	175793986	5972702
27-Jan-85	1007	15600	335896	354	61040	379895	3912	96	14627	22.96	27.14	29.09	10987	425499	176219486	5987329
28-Jan-85	1006	15594	335551	353	60236	379340	3906	96	14622	22.95	27.07	29.02	10981	424330	176643816	6001951
29-Jan-85	1001	15604	341860	354	59412	374308	3918	96	14631	23.37	27.43	29.38	10993	429859	177073675	6016582
30-Jan-85	1001	15602	335175	350	61040	378925	3909	96	14629	22.91	27.08	29.02	10984	424534	177498209	6031211
31-Jan-85	1002	15600	33365	351	60581	375764	3907	97	14627	2.28	6.42	8.37	10981	122428	177620637	6045838

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Feb-85	1001	15582	342331	355	56990	367591	3898	96	14610	23.43	27.33	29.29	10971	427927	178048563	6060448
2-Feb-85	1001	15554	340778	350	57849	365668	3868	99	14584	23.37	27.33	29.27	10939	426874	178475437	6075032
3-Feb-85	1002	15590	343643	350	58678	373554	3893	95	14618	23.51	27.52	29.46	10966	430646	178906083	6089650
4-Feb-85	1000	15585	344914	348	57371	363873	3878	95	14613	23.60	27.53	29.46	10951	430499	179336582	6104263
5-Feb-85	1003	15590	343167	352	59532	376585	3895	97	14618	23.48	27.55	29.5	10968	431231	179767813	6118881
6-Feb-85	1002	15597	335757	352	59517	377739	3895	97	14624	22.96	27.03	28.98	10969	423804	180191617	6133505
7-Feb-85	1003	15596	334047	350	58793	371738	3892	96	14623	22.84	26.86	28.8	10967	421142	180612759	6148128
8-Feb-85	1003	15559	334586	350	54322	364017	3895	98	14589	22.93	26.66	28.6	10968	417245	181030005	6162717
9-Feb-85	1007	15576	330210	352	54679	367178	3896	99	14605	22.61	26.35	28.3	10971	413322	181443326	6177322
10-Feb-85	1007	15577	327927	354	55061	378407	3894	99	14606	22.45	26.22	28.18	10969	411597	181854923	6191928
11-Feb-85	1007	15576	326759	349	54994	379465	3887	98	14605	22.37	26.14	28.07	10962	409962	182264886	6206533
12-Feb-85	1005	15567	334248	350	54206	334248	3885	98	14596	22.90	26.61	28.55	10959	416716	182681601	6221129
13-Feb-85	1007	15573	327540	354	56264	378070	3897	103	14602	22.43	26.28	28.24	10972	412360	183093962	6235731
14-Feb-85	1008	15573	325256	356	56495	377536	3895	103	14602	22.27	26.14	28.11	10970	410462	183504424	6250333
15-Feb-85	1008	15565	331790	352	56472	377341	3885	103	14595	22.73	26.60	28.55	10959	416687	183921111	6264928
16-Feb-85	1008	15561	336857	350	55717	377230	3891	103	14591	23.09	26.91	28.84	10964	420804	184341916	6279519
17-Feb-85	1008	15559	335557	355	55915	378757	3889	104	14589	23.00	26.83	28.8	10962	420163	184762079	6294108
18-Feb-85	1008	15560	330660	355	56609	379240	3887	105	14590	22.66	26.54	28.51	10960	415961	185178040	6308698
19-Feb-85	1008	15557	332007	357	57048	380254	3889	104	14587	22.76	26.67	28.64	10962	417772	185595812	6323285
20-Feb-85	1009	15555	332097	356	56817	377911	3886	104	14585	22.77	26.66	28.63	10959	417569	186013380	6337870
21-Feb-85	1009	15550	334405	349	56371	379784	3881	102	14581	22.93	26.80	28.73	10953	418912	186432292	6352451
22-Feb-85	1008	15535	332827	352	55509	372054	3880	100	14566	22.85	26.66	28.61	10952	416733	186849026	6367017
23-Feb-85	1003	15558	335751	354	56894	375387	3879	90	14588	23.02	26.92	28.87	10951	421156	187270181	6381605
24-Feb-85	1006	15549	338332	353	57187	374179	3883	91	14579	23.21	27.13	29.08	10955	423957	187694138	6396184
25-Feb-85	1006	15516	340682	349	57179	374156	3879	90	14549	23.42	27.35	29.28	10949	425995	188120133	6410733
26-Feb-85	1006	15520	339469	351	58480	373592	3881	92	14552	23.33	27.35	29.29	10951	426228	188546361	6425285
27-Feb-85	1007	15518	338567	351	59422	375847	3722	92	14550	23.27	27.35	29.29	10787	426170	188972531	6439835
28-Feb-85	1008	15517	338887	351	59622	374968	3721	90	14550	23.29	27.39	29.33	10786	426752	189399282	6454385

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Mar-85	1006	15532	338079	353	59405	373384	3720	91	14564	23.21	27.29	29.25	10786	425997	189825279	6468949
2-Mar-85	1009	15540	336995	354	59890	374984	3718	92	14571	23.13	27.24	29.2	10785	425473	190250752	6483520
3-Mar-85	1008	15540	336165	349	61831	380531	3715	92	14571	23.07	27.31	29.25	10781	426202	190676954	6498091
4-Mar-85	1013	15519	337201	349	61100	381167	3717	91	14552	23.17	27.37	29.3	10782	426374	191103328	6512643
5-Mar-85	1013	15515	338656	354	59820	382656	3718	91	14548	23.28	27.39	29.35	10783	426984	191530312	6527191
6-Mar-85	1012	15504	337300	353	59173	380439	3715	90	14538	23.20	27.27	29.23	10780	424946	191955257	6541729
7-Mar-85	1012	15501	333827	354	60319	374416	3716	94	14535	22.97	27.12	29.08	10781	422678	192377935	6556264
8-Mar-85	1015	15494	330332	350	62439	378542	3710	93	14528	22.74	27.03	28.97	10775	420876	192798811	6570792
9-Mar-85	1003	15499	335485	351	60630	382535	3711	93	14532	23.09	27.26	29.2	10775	424334	193223146	6585324
10-Mar-85	1003	15532	337547	352	59691	382939	3711	94	14563	23.18	27.28	29.22	10777	425531	193648677	6599887
11-Mar-85	1003	15540	336744	352	59458	381558	3709	93	14571	23.11	27.19	29.14	10775	424599	194073275	6614458
12-Mar-85	1004	15513	335760	351	59404	344646	3709	93	14546	23.08	27.17	29.11	10774	423434	194496710	6629004
13-Mar-85	1013	12280	265380	349	48233	280145	3721	91	11515	23.05	27.24	29.17	10648	335893	194832602	6640519
14-Mar-85	1008	15494	332994	351	62386	382782	3716	92	14528	22.92	27.22	29.16	10780	423636	195256239	6655047
15-Mar-85	1011	15528	335891	350	60412	380062	3716	89	14560	23.07	27.22	29.16	10782	424570	195680808	6669607
16-Mar-85	1009	15506	337545	350	60814	378024	3717	90	14539	23.22	27.40	29.34	10782	426574	196107382	6684146
17-Mar-85	1025	9611	209417	352	37931	235691	3727	91	9012	23.24	27.45	29.39	10562	264863	196372245	6693158
18-Mar-85	1009	15592	334082	356	60560	372010	3723	95	14620	22.85	26.99	28.96	10793	423395	196795640	6707778
19-Mar-85	1017	14993	314938	354	55814	351589	3724	97	14059	22.40	26.37	28.33	10767	398291	197193932	6721837
20-Mar-85	1019	15588	333006	356	60685	376872	3721	96	14617	22.78	26.93	28.9	10791	422431	197616363	6736454
21-Mar-85	1015	15541	332863	323	70788	378861	3719	93	14572	22.84	27.70	29.5	10785	429874	198046237	6751026
22-Mar-85	1009	15556	334530	320	72643	384329	3719	93	14586	22.93	27.91	29.7	10785	433204	198479441	6765612
23-Mar-85	1005	15589	334447	319	73687	381367	3718	94	14617	22.88	27.92	29.7	10786	434125	198913566	6780229
24-Mar-85	1001	15603	333717	320	72363	382469	3721	94	14630	22.81	27.76	29.54	10790	432170	199345736	6794859
25-Mar-85	1009	15582	333604	320	73858	385013	3716	95	1461[illegible]	22.83	27.89	29.67	10784	433508	199779245	6809470
26-Mar-85	1013	15559	332318	321	74295	381533	3716	95	14589	22.78	27.87	29.66	10783	432710	200211955	6824059
27-Mar-85	1011	15557	330610	330	69740	379614	3712	93	14587	22.66	27.45	29.28	10779	427107	200639062	6838646
28-Mar-85	1008	15574	333341	330	69071	377770	3710	94	14603	22.83	27.56	29.39	10778	429182	201068244	6853249
29-Mar-85	1008	15571	333190	325	62542	374318	3709	101	14600	22.82	27.10	28.91	10777	422086	201490330	6867849
30-Mar-85	1009	15561	332238	320	57855	377324	3709	101	14591	22.77	26.74	28.52	10778	416135	201906465	6882440
31-Mar-85	1008	15560	333589	311	58589	333589	3711	101	14590	22.86	26.88	28.61	10780	417420	202323885	6897030

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Apr-85	1008	11672	277604	313	50534	316999	4581	103	10944	25.37	29.98	31.73	11503	347253	202671138	6907974
2-Apr-85	998	12760	275914	313	50534	316999	3735	105	11964	23.06	27.29	29.03	10681	347315	203018453	6919938
3-Apr-85	1005	11288	260188	320	46393	248490	4588	103	10584	24.58	28.97	30.75	11498	325458	203343911	6930522
4-Apr-85	1007	15586	334150	304	61315	389848	3725	104	14614	22.86	27.06	28.76	10795	420299	203764210	6945136
5-Apr-85	1008	15572	334304	302	62042	390925	3721	105	14601	22.90	27.14	28.83	10790	420947	204185157	6959737
6-Apr-85	1003	15539	336854	302	62870	391580	3724	107	14570	23.12	27.43	29.12	10791	424278	204609435	6974307
7-Apr-85	1003	15514	337240	320	60125	387448	3723	109	14547	23.18	27.32	29.1	10789	423318	205032753	6988854
8-Apr-85	1003	15510	337371	316	59530	389115	3720	108	14543	23.20	27.29	29.05	10786	422474	205455227	7003397
9-Apr-85	1003	10300	239305	316	59530	389115	3698	109	9658	24.78	30.94	32.7	10544	315817	205771044	7013055
10-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
11-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
12-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
13-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
14-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
15-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
16-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
17-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
18-Apr-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	205771044	7013055
19-Apr-85	1010	12451	256365	314	45641	295270	3806	117	11675	21.96	25.87	27.62	10745	322464	206093507	7024730
20-Apr-85	1009	15689	340723	315	61309	393734	3800	118	14711	23.16	27.33	29.08	10876	427796	206521303	7039441
21-Apr-85	1009	15681	342456	315	61122	394849	3793	118	14703	23.29	27.45	29.2	10868	429328	206950631	7054144
22-Apr-85	1009	15700	342504	307	61976	396261	3788	119	14721	23.27	27.48	29.19	10864	429706	207380337	7068865
23-Apr-85	1010	15697	343236	310	61667	399199	3786	121	14718	23.32	27.51	29.24	10862	430354	207810691	7083583
24-Apr-85	1009	15699	343848	315	61983	399159	3783	122	14720	23.36	27.57	29.32	10859	431590	208242281	7098303
25-Apr-85	1009	15689	343704	315	62456	396810	3790	124	14711	23.36	27.61	29.36	10865	431915	208674196	7113014
26-Apr-85	1009	15694	347535	309	62660	397550	3772	123	14716	23.62	27.87	29.6	10847	435594	209109790	7127730
27-Apr-85	1010	15699	346068	315	61595	394277	3773	123	14720	23.51	27.69	29.45	10848	433504	209543294	7142450
28-Apr-85	1010	15696	347170	318	61085	394822	3780	124	14718	23.59	27.74	29.51	10855	434328	209977622	7157168
29-Apr-85	1010	15699	347170	330	59664	397455	3773	128	14720	23.58	27.64	29.47	10848	433798	210411420	7171888
30-Apr-85	1010	15656	346814	330	59786	398089	3771	113	14680	23.62	27.70	29.53	10844	433500	210844921	7186568

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-May-85	1010	15733	347080	326	59425	395693	3770	112	14752	23.53	27.56	29.37	10847	433266	211278187	7201320
2-May-85	1008	15644	335680	320	58998	399296	3776	113	14669	22.88	26.91	28.69	10850	420854	211699041	7215989
3-May-85	0	7823	167480	0	29117	196401	4604	0	7309	22.91	26.90	26.98	11416	197197	211896238	7223298
4-May-85	0	0	0	0	0	0	4600	19	0	0.00	0.00	0	0	0	211896238	7223298
5-May-85	1014	15953	277735	149	51012	316525	3772	149	14959	18.57	21.98	22.86	10869	341963	212238200	7238257
6-May-85	1010	15920	343732	320	61096	402149	3764	148	14928	23.03	27.12	28.9	10851	431419	212669619	7253185
7-May-85	1010	15925	347533	318	61418	400942	3762	146	14932	23.27	27.39	29.16	10848	435417	213105037	7268117
8-May-85	1011	15922	348153	320	60878	400635	3748	145	14929	23.32	27.40	29.18	10834	435628	213540665	7283046
9-May-85	1011	15917	349006	320	60730	400278	3749	146	14925	23.38	27.45	29.23	10835	436258	213976923	7297971
10-May-85	1010	15912	349556	319	61476	399209	3750	150	14920	23.43	27.55	29.33	10835	437604	214414526	7312891
11-May-85	1009	15903	349566	321	60727	398583	3738	151	14912	23.44	27.52	29.3	10822	436922	214851448	7327803
12-May-85	1009	15901	351027	321	60259	400093	3735	153	14910	23.54	27.59	29.37	10819	437907	215289354	7342713
13-May-85	1010	15900	349374	320	59587	385066	3741	155	14909	23.43	27.43	29.21	10826	435492	215724846	7357622
14-May-85	1010	15894	350697	320	59991	400021	3729	153	14903	23.53	27.56	29.34	10813	437254	216162100	7372525
15-May-85	1010	15903	359150	320	60427	400441	3731	156	14912	24.09	28.14	29.92	10814	446167	216608267	7387437
16-May-85	1010	15896	352856	321	61252	401516	3739	151	14905	23.67	27.78	29.57	10823	440741	217049008	7402342
17-May-85	1010	9360	196245	320	34235	225016	3703	144	8777	22.36	26.26	28.04	10533	246107	217295115	7411119
18-May-85	1002	15482	389520	316	58406	389520	3715	147	14516	26.83	30.86	32.62	10771	473512	217768627	7425635
19-May-85	1003	15492	337850	318	57588	380542	3720	144	14526	23.26	27.22	28.99	10785	421109	218189736	7440161
20-May-85	1002	15512	333820	316	63475	392550	3728	143	14545	22.95	27.32	29.08	10794	422969	218612705	7454706
21-May-85	1001	15534	339163	315	63628	397797	3715	135	14565	23.29	27.65	29.41	10781	428357	219041061	7469271
22-May-85	1003	12098	249535	332	38494	288487	3736	172	11344	22.00	25.39	27.24	10660	309011	219350072	7480615
23-May-85	998	15587	344414	311	60616	407958	3746	164	14615	23.57	27.71	29.45	10815	430412	219780484	7495230
24-May-85	0	4698	0	0	0	0	3936	0	4390	0.00	0.00	0.08	10660	351	219780835	7499620
25-May-85	0	0	0	0	0	0	4280	0	0	0.00	0.00	0	0	0	219780835	7499620
26-May-85	1011	3177	55563	0	0	55563	4287	138	2979	18.65	18.65	23.87	11013	71109	219851943	7502599
27-May-85	1010	13464	303279	338	42494	339206	3440	186	12625	24.02	27.39	29.26	10406	369408	220221351	7515224
28-May-85	1010	15623	341861	338	42494	339206	3492	182	14649	23.34	26.24	28.11	10559	411783	220633134	7529873
29-May-85	1012	15617	342230	325	60606	398344	3486	168	14644	23.37	27.51	29.32	10550	429362	221062496	7544517
30-May-85	1009	15610	341990	319	59759	386929	3488	174	14637	23.37	27.45	29.22	10552	427693	221490190	7559154
31-May-85	1010	15633	347929	319	59506	404041	3491	174	14658	23.74	27.80	29.57	10555	433437	221923627	7573812

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jun-85	1014	15644	346422	319	59872	403154	3496	176	14669	23.62	27.70	29.47	10561	432295	222355922	7588481
2-Jun-85	1020	15642	344194	321	61705	403838	3499	177	14667	23.47	27.67	29.46	10564	432090	222788012	7603148
3-Jun-85	1020	15654	343944	321	61705	403838	3504	178	14679	23.43	27.64	29.42	10570	431856	223219868	7617827
4-Jun-85	1020	15672	345385	321	61817	402838	3510	171	14696	23.50	27.71	29.5	10577	433532	223653400	7632523
5-Jun-85	1018	15692	346078	320	61698	404805	3509	174	14714	23.52	27.71	29.49	10576	433916	224087316	7647237
6-Jun-85	1018	15711	346540	320	61694	405502	3513	178	14732	23.52	27.71	29.49	10582	434447	224521763	7661969
7-Jun-85	1015	15648	345958	320	61895	405944	3519	179	14673	23.58	27.80	29.58	10584	434027	224955790	7676642
8-Jun-85	1019	15639	346279	320	61200	406769	3519	178	14665	23.61	27.79	29.57	10584	433644	225389434	7691307
9-Jun-85	1007	15663	347373	321	60874	406609	3515	179	14686	23.65	27.80	29.58	10581	434412	225823846	7705993
10-Jun-85	1012	15664	347043	321	61026	406240	3518	180	14688	23.63	27.78	29.57	10584	434324	226258170	7720681
11-Jun-85	1012	15664	345573	321	61048	404682	3518	179	14688	23.53	27.68	29.47	10584	432855	226691025	7735369
12-Jun-85	1009	15663	344652	321	61286	404674	3525	181	14687	23.47	27.64	29.43	10592	432238	227123264	7750056
13-Jun-85	1000	15661	344065	318	62200	402170	3528	181	14684	23.43	27.67	29.44	10595	432297	227555561	7764740
14-Jun-85	1000	15715	345544	319	61309	405031	3527	180	14735	23.45	27.61	29.39	10596	433062	227988622	7779475
15-Jun-85	1001	15720	347088	318	61092	406193	3529	182	14740	23.55	27.69	29.46	10598	434240	228422863	7794215
16-Jun-85	1000	15688	346551	319	60880	405455	3538	184	14710	23.56	27.70	29.47	10606	433504	228856367	7808925
17-Jun-85	1010	15672	345238	319	60388	406885	3527	182	14695	23.49	27.60	29.38	10594	431739	229288106	7823620
18-Jun-85	1003	15706	344120	320	60533	406111	3527	179	14727	23.37	27.48	29.26	10596	430912	229719018	7838347
19-Jun-85	1001	15723	344835	321	60207	405309	3533	181	14742	23.39	27.47	29.26	10603	431351	230150369	7853089
20-Jun-85	1002	15746	345038	322	60054	405224	3533	183	14764	23.37	27.44	29.23	10604	431552	230581920	7867853
21-Jun-85	990	15746	349722	320	59800	402675	3529	181	14763	23.69	27.74	29.52	10600	435804	231017724	7882616
22-Jun-85	1001	15754	349652	319	60308	405374	3532	182	14771	23.67	27.75	29.53	10603	436188	231453912	7897387
23-Jun-85	1002	15753	349897	321	61058	40684	3549	184	14771	23.69	27.82	29.61	10620	437369	231891281	7912158
24-Jun-85	1005	15757	349643	323	61537	406292	3543	182	14774	23.67	27.83	29.63	10614	437754	232329035	7926932
25-Jun-85	1003	14665	320629	320	56288	374165	3541	184	13750	23.32	27.41	29.19	10562	401363	232730397	7940682
26-Jun-85	0	0	0	0	0	0	4604	0	0	0.00	0.00	0	0	0	232730397	7940682
27-Jun-85	0	0	0	0	0	0	4174	40	0	0.00	0.00	0	0	0	232730397	7940682
28-Jun-85	0	2508	0	0	0	0	4190	81	2343	0.00	0.00	0.08	10892	187	232730585	7943025
29-Jun-85	1015	2573	0	0	0	0	4223	128	2413	0.00	0.00	5.24	10931	12644	232743229	7945438
30-Jun-85	1010	21330	458353	316	79817	553331	2467	176	20000	22.92	26.91	28.67	9825	573400	233316629	7965438

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Jul-85	1010	25179	559894	320	104481	651266	2455	179	23609	23.71	28.14	29.92	10082	706381	234023010	7989047
2-Jul-85	988	25136	560214	319	101995	657361	2441	180	23567	23.77	28.10	29.87	10065	703946	234726956	8012614
3-Jul-85	1004	25128	559619	321	101852	653829	2442	181	23561	23.75	28.07	29.86	10065	703531	235430488	8036175
4-Jul-85	1005	25064	555238	321	101482	651914	2442	183	23501	23.63	27.94	29.73	10061	698685	236129172	8059676
5-Jul-85	1004	25083	559751	320	102111	657152	2441	181	23519	23.80	28.14	29.92	10061	703688	236832861	8083195
6-Jul-85	1004	25051	555917	323	101292	651337	2438	183	23489	23.67	27.98	29.78	10055	699502	237532363	8106684
7-Jul-85	1004	25029	556577	321	102918	652735	2442	183	23468	23.72	28.10	29.89	10058	701459	238233822	8130152
8-Jul-85	1005	25012	555358	322	103273	654850	2442	183	23452	23.68	28.08	29.88	10056	700746	238934568	8153604
9-Jul-85	1004	25066	557200	320	104138	654747	2415	183	23503	23.71	28.14	29.92	10033	703210	239637777	8177107
10-Jul-85	1006	25055	558676	322	100647	654456	2418	182	23493	23.78	28.06	29.86	10035	701501	240339278	8200600
11-Jul-85	1004	25024	565499	318	99367	652211	2415	182	23464	24.10	28.34	30.11	10029	706501	241045779	8224064
12-Jul-85	1003	25005	563636	318	100315	650369	2415	183	23446	24.04	28.32	30.09	10027	705490	241751270	8247510
13-Jul-85	1002	24976	563822	320	100154	646333	2410	183	23418	24.08	28.35	30.13	10020	705584	242456854	8270928
14-Jul-85	1011	24949	561977	318	100655	653572	2409	184	23394	24.02	28.33	30.1	10017	704159	243161013	8294322
15-Jul-85	1012	24917	560977	319	100757	651963	2406	183	23364	24.01	28.32	30.1	10012	703256	243864270	8317686
16-Jul-85	1020	25499	572147	332	101601	661768	2355	188	23910	23.93	28.18	30.02	10004	717778	244582048	8341596
17-Jul-85	1022	25746	575837	342	100136	657063	2346	188	24142	23.85	28.00	29.9	10014	721846	245303894	8365738
18-Jul-85	1022	25803	575509	341	101393	670843	2346	188	24195	23.79	27.98	29.87	10019	722705	246026598	8389933
19-Jul-85	1020	25784	574855	341	101732	668198	2340	188	24177	23.78	27.98	29.87	10011	722167	246748765	8414110
20-Jul-85	1022	25771	574406	340	101647	676053	2340	189	24165	23.77	27.98	29.86	10010	721567	247470332	8438275
21-Jul-85	1019	25778	578020	339	101000	671438	2341	188	24172	23.91	28.09	29.97	10011	724435	248194767	8462447
22-Jul-85	1021	25748	578514	340	101212	668636	2333	188	24144	23.96	28.15	30.04	10001	725286	248920053	8486591
23-Jul-85	1020	15042	337570	342	58619	390160	2373	175	14105	23.93	28.09	29.98	9370	422868	249342921	8500696
24-Jul-85	1020	25686	579629	341	101855	664956	2363	177	24086	24.07	28.29	30.18	10026	726915	250069836	8524782
25-Jul-85	1004	27782	626375	340	108573	764293	1740	203	26050	24.05	28.21	30.1	9554	784105	250853941	8550832
26-Jul-85	1005	30089	682636	344	115999	785715	1744	205	28213	24.20	28.31	30.21	9762	852315	251706256	8579045
27-Jul-85	1005	30126	682249	345	115279	784539	1741	205	28247	24.15	28.23	30.14	9762	851365	252557620	8607292
28-Jul-85	1002	30090	683129	342	114512	785567	1739	206	28213	24.21	28.27	30.17	9757	851186	253408807	8635505
29-Jul-85	1002	30076	681231	343	113716	781106	1731	206	28200	24.16	28.19	30.09	9747	848538	254257345	8663705
30-Jul-85	1003	31060	694929	343	122042	804218	1570	212	29123	23.86	28.05	29.95	9673	872234	255129579	8692828
31-Jul-85	1003	31078	692908	331	122666	802056	1583	211	29140	23.78	27.99	29.83	9688	869246	255998825	8721968

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Aug-85	1002	31135	691280	332	122257	801708	1585	213	29193	23.68	27.87	29.71	9696	867324	256866149	8751161
2-Aug-85	1007	31224	696448	330	121809	804819	1593	211	29277	23.79	27.95	29.78	9713	871869	257738018	8780438
3-Aug-85	998	31233	696652	328	122376	796375	1590	212	29285	23.79	27.97	29.79	9710	872400	258610418	8809723
4-Aug-85	1026	31131	685687	338	123139	797562	1608	213	29192	23.49	27.71	29.58	9720	863499	259473917	8838915
5-Aug-85	1020	31034	682298	330	124094	796035	1596	214	29100	23.45	27.71	29.54	9698	859614	260333531	8868015
6-Aug-85	1000	16967	359423	324	59339	418762	1618	208	15909	22.59	26.32	28.12	8685	447361	260780892	8883924
7-Aug-85	1011	31171	679981	328	120676	799771	1611	211	29228	23.26	27.39	29.22	9727	854042	261634935	8913152
8-Aug-85	1021	31036	675864	328	123574	790209	1616	212	29102	23.22	27.47	29.29	9719	852398	262487332	8942254
9-Aug-85	1002	29[illegible]34	648331	329	11[illegible]192	748331	1607	211	27880	23.25	27.46	29.29	9589	816605	263303937	8970134
10-Aug-85	999	31023	679597	328	122555	794726	1603	212	29088	23.36	27.58	29.4	9704	855187	264159125	8999222
11-Aug-85	1002	31003	678674	328	121614	792441	1602	212	29069	23.35	27.53	29.35	9702	853175	265012300	9028291
12-Aug-85	1003	30950	676740	326	122023	794176	1602	211	29020	23.32	27.52	29.34	9697	851447	265863747	9057311
13-Aug-85	1002	30874	677022	331	120995	792802	1602	212	28949	23.39	27.57	29.41	9689	851390	266715137	9086260
14-Aug-85	1002	30836	677022	333	120487	790560	1602	212	28913	23.42	27.58	29.43	9686	850910	267566046	9115173
15-Aug-85	997	12836	295550	333	52557	343728	1592	213	12035	24.56	28.92	30.77	8451	370317	267936363	9127208
16-Aug-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	267936363	9127208
17-Aug-85	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	267936363	9127208
18-Aug-85	999	14356	297783	344	49195	342651	1566	246	13461	22.12	25.78	27.68	8503	372600	268308964	9140669
19-Aug-85	999	31682	691782	341	119299	798565	1559	247	29706	23.29	27.30	29.19	9722	867118	269176082	9170375
20-Aug-85	999	31556	691541	338	116024	799272	1554	246	29588	23.37	27.29	29.17	9705	863082	270039164	9199963
21-Aug-85	999	31453	685158	335	110785	788692	1551	245	29491	23.23	26.99	28.85	9693	850815	270889979	9229454
22-Aug-85	997	31394	683414	332	108237	785378	1552	244	29436	23.22	26.89	28.74	9688	845991	271735970	9258890
23-Aug-85	1000	31318	685109	330	107058	784129	1550	242	29365	23.33	26.98	28.81	9679	846006	272581975	9288255
24-Aug-85	1000	31226	682163	342	118816	790289	1543	240	29278	23.30	27.36	29.25	9662	856382	273438357	9317533
25-Aug-85	1006	31146	680547	342	118452	786925	1543	239	29204	23.30	27.36	29.25	9654	854217	274292574	9346737
26-Aug-85	1009	31082	678391	340	117901	787253	1548	238	29144	23.28	27.32	29.21	9654	851296	275143870	9375881
27-Aug-85	1009	31017	674483	339	118072	785194	1549	233	29083	23.19	27.25	29.13	9649	847188	275991058	9404964
28-Aug-85	1012	30939	671167	338	117481	782155	1546	232	29010	23.14	27.18	29.06	9638	843031	276834089	9433974
29-Aug-85	1008	30885	666612	345	116608	778576	1544	233	28959	23.02	27.05	28.96	9631	838653	277672741	9462933
30-Aug-85	1015	30828	666943	345	117036	779935	1541	232	28907	23.07	27.12	29.03	9623	839170	278511911	9491840
31-Aug-85	1013	30827	667997	345	116802	778203	1537	231	28906	23.11	27.15	29.06	9618	840008	279351920	9520746

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Sep-85	1013	30732	669557	345	115852	778863	1534	231	28816	23.24	27.26	29.17	9606	840563	280192482	9549562
2-Sep-85	1012	30684	667019	346	115522	775018	1533	231	28771	23.18	27.20	29.12	9601	837812	281030294	9578333
3-Sep-85	1013	30631	664688	342	114368	772092	1532	230	28722	23.14	27.12	29.02	9595	833512	281863806	9607055
4-Sep-85	1013	30580	663572	343	114210	771260	1531	231	28674	23.14	27.13	29.03	9589	832406	282696213	9635729
5-Sep-85	1014	30534	664936	345	114454	770195	1530	231	28631	23.22	27.22	29.13	9584	834021	283530234	9664360
6-Sep-85	1014	30476	661932	345	114288	768108	1528	231	28577	23.16	27.16	29.07	9576	830733	284360967	9692937
7-Sep-85	1007	30435	660547	346	114336	763649	1524	231	28537	23.15	27.15	29.07	9568	829571	285190538	9721474
8-Sep-85	1005	30417	664318	343	114719	765169	1526	232	28520	23.29	27.32	29.22	9568	833354	286023892	9749994
9-Sep-85	1007	30402	663871	346	114000	763620	1529	231	28506	23.29	27.29	29.2	9570	832375	286856267	9778500
10-Sep-85	1005	30382	661443	341	114219	763202	1522	232	28488	23.22	27.23	29.12	9561	829571	287685838	9806988
11-Sep-85	1011	30312	656391	341	114052	760399	1522	231	28422	23.09	27.11	29	9555	824238	288510076	9835410
12-Sep-85	1009	30284	658212	345	114728	772940	1520	231	28396	23.18	27.22	29.13	9550	827175	289337251	9863806
13-Sep-85	1013	30246	659892	346	114492	765666	1528	229	28361	23.27	27.30	29.22	9555	828708	290165960	9892167
14-Sep-85	1013	30230	657630	353	110569	758042	1518	229	28346	23.20	27.10	29.05	9543	823451	290989411	9920513
15-Sep-85	1011	30217	656309	353	110327	753282	1517	228	28333	23.16	27.06	29.01	9541	821940	291811351	9948846
16-Sep-85	1010	30186	651320	353	110155	755230	1516	229	28304	23.01	26.90	28.86	9537	816853	292628205	9977150
17-Sep-85	1010	30173	653817	357	109745	752237	1515	230	28292	23.11	26.99	28.96	9535	819336	293447541	10005442
18-Sep-85	1013	30130	653094	351	109960	763054	1519	229	28252	23.12	27.01	28.95	9535	817895	294265436	10033694
19-Sep-85	1010	30097	652977	356	110099	753041	1513	229	28221	23.14	27.04	29.01	9526	818691	295084128	10061915
20-Sep-85	1010	30063	652037	353	109911	751110	1511	229	28189	23.13	27.03	28.98	9521	816917	295901045	10090104
21-Sep-85	1014	29998	643896	356	110068	739390	1526	230	28128	22.89	26.80	28.77	9531	809243	296710287	10118232
22-Sep-85	1012	29941	641782	356	111207	737689	1530	229	28075	22.86	26.82	28.79	9529	808279	297518567	10146307
23-Sep-85	1012	29133	627822	360	111312	724474	1520	229	27317	22.98	27.06	29.05	9446	793559	298312126	10173624
24-Sep-85	1012	29881	644453	357	116280	742500	1519	224	28018	23.00	27.15	29.12	9512	815884	299128010	10201642
25-Sep-85	1011	29828	638279	356	116193	737018	1521	226	27969	22.82	26.98	28.94	9509	809423	299937433	10229611
26-Sep-85	1010	29793	638528	355	114810	739136	1517	226	27936	22.86	26.97	28.93	9502	808188	300745621	10257547
27-Sep-85	1011	29750	633087	352	114833	730868	1516	227	27895	22.69	26.81	28.76	9498	802260	301547881	10285442
28-Sep-85	1011	29721	631389	360	120089	733393	1516	227	27868	22.66	26.97	28.95	9495	806779	302354660	10313310
29-Sep-85	1011	29689	631914	354	120834	732554	1516	227	27838	22.70	27.04	29	9492	807302	303161962	10341148
30-Sep-85	1011	29654	634464	358	121330	7340[illegible]	1514	227	27805	22.82	27.18	29.16	9486	810794	303972756	10368953

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Oct-85	1011	29611	625860	353	123033	729033	1516	226	27765	22.54	26.97	28.93	9485	803241	304775997	10396718
2-Oct-85	1012	29567	625190	359	125629	729322	1516	227	27724	22.55	27.08	29.07	9480	805937	305581934	10424442
3-Oct-85	1014	29534	622240	364	122481	721648	1516	228	27693	22.47	26.89	28.9	9478	800328	306382261	10452135
4-Oct-85	1015	29506	629583	364	126611	732419	1510	228	27667	22.76	27.33	29.34	9468	811750	307194011	10479802
5-Oct-85	1012	29464	636974	352	120003	744152	1509	226	27627	23.06	27.40	29.35	9463	810852	308004864	10507429
6-Oct-85	1013	29424	628038	349	119649	742408	1509	226	27590	22.76	27.10	29.03	9460	800938	308805801	10535019
7-Oct-85	1009	15175	322234	355	54474	368665	3049	152	14229	22.65	26.47	28.44	10081	404673	309210474	10549248
8-Oct-85	1006	16376	361171	339	60152	420770	3059	155	15355	23.52	27.44	29.32	10147	450209	309660683	10564603
9-Oct-85	1008	16401	360515	345	60678	416955	3070	154	15378	23.44	27.39	29.3	10160	450575	310111258	10579981
10-Oct-85	1004	26833	587956	348	104743	672950	1525	225	25160	23.37	27.53	29.46	9252	741214	310852472	10605141
11-Oct-85	1015	29758	645019	355	115528	747251	1526	224	27903	23.12	27.26	29.22	9508	815326	311667797	10633044
12-Oct-85	1012	29676	645343	355	115972	745906	1508	221	27826	23.19	27.36	29.32	9481	815858	312483656	10660870
13-Oct-85	1011	29581	642366	356	115172	746833	1508	221	27737	23.16	27.31	29.28	9473	812139	313295795	10688607
14-Oct-85	1007	29561	648016	357	112534	744247	1494	223	27718	23.38	27.44	29.41	9456	815186	314110982	10716325
15-Oct-85	1018	29513	650249	361	109451	745121	1490	222	27674	23.50	27.45	29.45	9448	814999	314925981	10743999
16-Oct-85	1001	29451	646132	360	107978	743060	1488	222	27614	23.40	27.31	29.3	9440	809090	315735071	10771613
17-Oct-85	1000	29400	646293	367	107120	744482	1492	222	27566	23.45	27.33	29.36	9440	809338	316544409	10799179
18-Oct-85	1010	29351	645860	362	106582	742490	1487	222	27521	23.47	27.34	29.34	9430	807466	317351875	10826700
19-Oct-85	1002	29301	644573	362	106768	739809	1486	221	27474	23.46	27.35	29.35	9425	806362	318158237	10854174
20-Oct-85	1000	29258	646622	365	106585	738572	1488	222	27433	23.57	27.46	29.47	9423	808451	318966687	10881607
21-Oct-85	1000	29210	644394	365	109297	739272	1481	221	27388	23.53	27.52	29.53	9411	808768	319775455	10908995
22-Oct-85	1026	29171	643170	362	105874	737252	1484	222	27354	23.51	27.38	29.38	9411	803661	320579115	10936349
23-Oct-85	1001	29130	641866	367	102502	740080	1476	225	27313	23.50	27.25	29.28	9399	799725	321378840	10963662
24-Oct-85	1001	29082	638929	369	98909	732208	1479	225	27268	23.43	27.06	29.09	9398	793226	322172066	10990930
25-Oct-85	1002	29034	638820	360	96667	734323	1471	225	27223	23.47	27.02	29.01	9386	789739	322961805	11018153
26-Oct-85	1001	28990	638863	358	96336	731744	1473	224	27182	23.50	27.05	29.03	9384	789093	323750899	11045335
27-Oct-85	1002	30155	637866	360	96699	728413	1478	222	28274	22.56	25.98	27.97	9497	790824	324541723	11073609
28-Oct-85	1001	28894	631615	360	93981	724397	1476	219	27092	23.31	26.78	28.77	9379	779437	325321160	11100701
29-Oct-85	0	5754	131917	0	19632	139302	3774	0	5376	24.54	28.19	28.27	10518	151980	325473139	11106077
30-Oct-85	1005	15088	301040	388	39886	340840	2058	321	14147	21.28	24.10	26.23	9057	371076	325844215	11120224
31-Oct-85	1005	25105	552166	385	73726	625892	2052	302	23540	23.46	26.59	28.71	9663	675833	326520048	11143764

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Nov-85	1007	25076	556512	375	75865	626137	2055	302	23513	23.67	26.90	28.96	9664	680936	327200985	11167277
2-Nov-85	1000	21849	450014	406	61398	497193	1483	325	20486	21.97	24.96	27.19	8841	557014	327757999	11187763
3-Nov-85	1003	27936	588346	356	82907	664515	2087	298	26194	22.46	25.63	27.59	9930	722692	328480692	11213957
4-Nov-85	1000	24691	536767	365	79474	610366	2086	305	23151	23.19	26.62	28.63	9667	662813	329143505	11237108
5-Nov-85	1000	24695	538659	366	78800	611692	2079	318	23155	23.26	26.67	28.69	9660	664317	329807822	11260263
6-Nov-85	1003	24688	529919	390	80313	598118	2080	325	23148	22.89	26.36	28.51	9661	659949	330467771	11283411
7-Nov-85	1008	24652	534040	383	76442	592125	2079	328	23115	23.10	26.41	28.52	9657	659240	331127011	11306526
8-Nov-85	1007	24631	533111	390	75802	591652	2075	329	23095	23.08	26.37	28.51	9652	658438	331785449	11329621
9-Nov-85	1006	24620	533446	390	75731	583128	2073	336	23085	23.11	26.39	28.53	9649	658615	332444064	11352706
10-Nov-85	1008	24612	534962	390	76151	593381	2072	340	23078	23.18	26.48	28.63	9647	660723	333104788	11375784
11-Nov-85	1007	24599	532264	403	74941	591060	2070	343	23065	23.08	26.33	28.54	9644	658275	333763063	11398849
12-Nov-85	1007	24587	531507	412	74249	589321	2073	344	23054	23.05	26.28	28.53	9646	657731	334420793	11421903
13-Nov-85	1009	24575	532663	408	74434	588486	2073	345	23043	23.12	26.35	28.58	9645	658569	335079362	11444946
14-Nov-85	1008	24565	533526	409	74688	592640	2065	345	23033	23.16	26.41	28.65	9636	659895	335739258	11467979
15-Nov-85	1008	24550	533872	408	74597	592100	2065	348	23019	23.19	26.43	28.67	9635	659955	336399212	11490998
16-Nov-85	1008	24539	535485	411	74597	594820	2061	350	23009	23.27	26.51	28.77	9630	661969	337061181	11514007
17-Nov-85	1002	24530	533564	408	74513	591753	2062	350	23000	23.20	26.44	28.68	9630	659640	337720821	11537007
18-Nov-85	1009	24514	533783	409	74340	590334	2060	352	22986	23.22	26.46	28.7	9627	659698	338380520	11559993
19-Nov-85	1008	24497	524626	402	74157	590942	2057	351	22970	22.84	26.07	28.27	9623	649362	339029881	11582963
20-Nov-85	1008	24485	525174	402	74228	590669	2058	349	22958	22.87	26.11	28.31	9624	649941	339679822	11605921
21-Nov-85	1009	24465	520686	420	73549	591305	2064	353	22940	22.70	25.90	28.2	9628	646908	340326730	11628861
22-Nov-85	1008	24459	520588	408	74986	591312	2061	354	22934	22.70	25.97	28.21	9625	646968	340973699	11651795
23-Nov-85	1005	24448	529097	406	74642	590092	2054	352	22924	23.08	26.34	28.56	9616	654709	341628408	11674719
24-Nov-85	1008	24432	534661	409	74736	587857	2056	353	22909	23.34	26.60	28.84	9616	660696	342289104	11697628
25-Nov-85	1006	24418	534640	413	74451	587928	2051	352	22895	23.35	26.60	28.87	9610	660979	342950082	11720523
26-Nov-85	1006	24405	528956	407	74299	587600	2047	354	22883	23.12	26.36	28.59	9605	654225	343604307	11743406
27-Nov-85	1007	24389	530820	414	73916	586517	2044	356	22868	23.21	26.44	28.71	9601	656540	344260847	11766274
28-Nov-85	1004	24370	527072	413	73652	587143	2045	357	22850	23.07	26.29	28.55	9601	652368	344913215	11789124
29-Nov-85	1006	24351	525482	409	73831	587149	2048	357	22833	23.01	26.25	28.49	9603	650512	345563727	11811957
30-Nov-85	1005	24342	521956	411	73875	586477	2046	357	22824	22.87	26.11	28.36	9600	647289	346211016	11834781

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Dec-85	1009	24331	522888	409	73425	587458	2043	357	22814	22.92	26.14	28.38	9596	647461	346858477	11857595
2-Dec-85	1009	24312	519986	403	72774	584296	2048	343	22796	22.81	26.00	28.21	9601	643075	347501552	11880391
3-Dec-85	1003	24311	523857	415	72407	586575	2045	353	22795	22.98	26.16	28.43	9597	648062	348149614	11903186
4-Dec-85	1003	24304	521553	419	73964	586274	2040	361	22788	22.89	26.13	28.43	9591	647863	348797477	11925974
5-Dec-85	1006	24289	523569	421	71630	580540	2043	362	22775	22.99	26.13	28.44	9593	647721	349445198	11948749
6-Dec-85	1006	24272	522613	387	77044	581881	2042	330	22759	22.96	26.35	28.48	9591	648176	350093374	11971508
7-Dec-85	1004	24263	520939	398	77399	582616	2036	340	22750	22.90	26.30	28.49	9584	648148	350741522	11994258
8-Dec-85	1007	24251	521189	408	75646	583403	2033	345	22739	22.92	26.25	28.48	9580	647607	351389128	12016997
9-Dec-85	1005	24240	521641	407	75036	577255	2031	348	22728	22.95	26.25	28.48	9577	647293	352036422	12039725
10-Dec-85	1008	24229	524947	402	75732	579363	2032	340	22718	23.11	26.44	28.65	9577	650871	352687293	12062443
11-Dec-85	1009	24218	523497	409	74637	579292	2029	349	22708	23.05	26.34	28.58	9573	648995	353336287	12085151
12-Dec-85	1008	24205	524050	416	73188	582449	2033	356	22696	23.09	26.31	28.59	9576	648879	353985166	12107847
13-Dec-85	1009	24185	522498	415	72565	582621	2032	354	22677	23.04	26.24	28.51	9574	646521	354631687	12130524
14-Dec-85	1006	24154	519491	416	71306	582462	2030	346	22648	22.94	26.09	28.36	9570	642297	355273984	12153172
15-Dec-85	1003	24158	522691	413	72492	581321	2026	349	22651	23.08	26.28	28.54	9566	646460	355920444	12175823
16-Dec-85	1005	24152	519794	418	73593	577799	2024	357	22646	22.95	26.20	28.49	9563	645185	356565629	12198469
17-Dec-85	1006	24131	522539	415	74613	579756	2030	355	22626	23.09	26.39	28.67	9567	648687	357214316	12221095
18-Dec-85	1005	24080	516046	420	76083	575037	2025	361	22578	22.86	26.23	28.52	9559	643925	357858240	12243673
19-Dec-85	1004	24074	521597	418	75187	577390	2024	347	22573	23.11	26.44	28.73	9557	648522	358506763	12266246
20-Dec-85	1009	24060	521020	425	76384	584820	2028	359	22560	23.09	26.48	28.81	9560	649954	359156716	12288806
21-Dec-85	1008	24066	517054	425	76384	584820	2021	357	22566	22.91	26.30	28.62	9553	645839	359802555	12311372
22-Dec-85	1007	24058	516096	424	75815	580239	2016	363	22558	22.88	26.24	28.56	9548	644256	360446812	12333930
23-Dec-85	1006	24041	517739	425	75975	584865	2018	363	22542	22.97	26.34	28.66	9548	646054	361092866	12356472
24-Dec-85	1008	24041	517256	419	73648	582852	2020	358	22542	22.95	26.21	28.51	9551	642672	361735538	12379014
25-Dec-85	1006	24017	517065	424	74632	583305	2016	355	22519	22.96	26.27	28.59	9545	643818	362379356	12401533
26-Dec-85	1006	23996	519653	422	70915	585271	2019	360	22500	23.10	26.25	28.56	9546	642600	363021956	12424033
27-Dec-85	1006	23996	517632	417	74608	583310	2013	356	22500	23.01	26.32	28.61	9540	643725	363665681	12446533
28-Dec-85	1010	23978	515394	411	74193	585005	2016	350	22483	22.92	26.22	28.48	9542	640316	364305997	12469016
29-Dec-85	1003	23968	514968	435	74784	579556	2014	366	22473	22.91	26.24	28.62	9539	643177	364949174	12491489
30-Dec-85	1008	23959	516429	420	74571	578514	2007	363	22465	22.99	26.31	28.61	9531	642724	365591898	12513954
31-Dec-85	1000	23941	516717	418	74228	580249	2006	361	22448	23.02	26.33	28.61	9529	642237	366234135	12536402

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jan-86	1002	23938	519284	420	72155	582688	2007	342	22445	23.14	26.35	28.65	9529	643049	366877184	12558847
2-Jan-86	1002	23923	516867	423	72199	581914	2006	358	22431	23.04	26.26	28.58	9527	641078	367518262	12581278
3-Jan-86	0	11963	302639	0	42990	338573	3645	31	11178	27.08	30.92	31	10551	346518	367864780	12592456
4-Jan-86	1000	12875	272498	425	36676	299553	2159	374	12072	22.57	25.61	27.94	9060	337292	368202072	12604528
5-Jan-86	1004	21929	500342	427	69199	569541	2161	372	20562	24.33	27.70	30.03	9544	617477	368819549	12625090
6-Jan-86	0	11425	252707	150	33942	278100	3651	51	10675	23.67	26.85	27.74	10546	296125	369115673	12635765
7-Jan-86	1006	4000	75651	303	11891	85751	3335	224	3751	20.17	23.34	25.03	10045	93888	369209561	12639516
8-Jan-86	1000	10381	223586	326	36217	258206	3340	241	9734	22.97	26.69	28.5	10190	277419	369486980	12649250
9-Jan-86	1000	10418	222189	330	35596	222913	3350	250	9768	22.75	26.39	28.22	10202	275653	369762633	12659018
10-Jan-86	998	10417	226423	328	37167	256651	3358	252	9767	23.18	26.99	28.81	10209	281387	370044020	12668785
11-Jan-86	1000	10458	227582	332	36699	257735	3367	56	9806	23.21	26.95	28.8	10220	282413	370326433	12678591
12-Jan-86	1000	10507	231969	339	36194	259217	3374	261	9852	23.55	27.22	29.1	10228	286693	370613126	12688443
13-Jan-86	1000	10534	229066	338	36404	259272	3381	259	9877	23.19	26.88	28.75	10237	283964	370897090	12698320
14-Jan-86	999	10531	230355	342	34451	260340	3387	261	9874	23.33	26.82	28.71	10243	283483	371180572	12708194
15-Jan-86	1000	10540	230686	340	32134	258243	3418	266	9883	23.34	26.59	28.48	10276	281468	371462040	12718077
16-Jan-86	1002	10523	230095	349	34994	254992	3419	266	9867	23.32	26.87	28.8	10275	284170	371746210	12727944
17-Jan-86	1002	10492	227820	348	34622	255580	3431	264	9838	23.16	26.68	28.6	10287	281367	372027577	12737782
18-Jan-86	1003	10492	227646	348	34622	255580	3439	265	9838	23.14	26.66	28.59	10295	281268	372308845	12747620
19-Jan-86	1001	10514	227329	350	34547	252666	3448	265	9858	23.06	26.56	28.5	10306	280953	372589798	12757478
20-Jan-86	1002	10512	227558	357	33371	252483	3453	267	9856	23.09	26.47	28.45	10311	280403	372870201	12767334
21-Jan-86	1002	10520	227452	348	33715	251962	3457	268	9864	23.06	26.48	28.4	10315	280138	373150339	12777198
22-Jan-86	1002	10516	228568	348	33753	252488	3458	270	9860	23.18	26.60	28.53	10316	281306	373431645	12787058
23-Jan-86	1001	10492	227751	340	33808	252711	3457	266	9838	23.15	26.59	28.47	10314	280088	373711733	12796896
24-Jan-86	0	1749	44956	0	6659	49810	3810	0	1634	27.51	31.58	31.66	10495	51732	373763465	12798530
25-Jan-86	0	0	0	0	0	0	3810	0	0	0.00	0.00	0	0	0	373763465	12798530
26-Jan-86	0	0	0	0	0	0	3812	0	0	0.00	0.00	0	0	0	373763465	12798530
27-Jan-86	0	0	0	0	0	0	3817	0	0	0.00	0.00	0	0	0	373763465	12798530
28-Jan-86	0	0	0	0	0	0	3817	0	0	0.00	0.00	0	0	0	373763465	12798530
29-Jan-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
30-Jan-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
31-Jan-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Feb-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
2-Feb-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
3-Feb-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
4-Feb-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
5-Feb-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
6-Feb-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	373763465	12798530
7-Feb-86	501	2474	0	0	0	0	3928	82	2316	0.00	0.00	2.71	10628	6276	373769741	12800846
8-Feb-86	863	2441	0	0	0	0	3954	119	2288	0.00	0.00	4.51	10656	10319	373780060	12803134
9-Feb-86	1009	22602	477941	234	93163	530541	2632	94	21193	22.55	26.95	28.28	10081	599338	374379398	12824327
10-Feb-86	1008	24382	519363	259	111364	621264	2045	111	22862	22.72	27.59	29.05	9601	664141	375043539	12847189
11-Feb-86	1000	24482	523743	299	105151	617232	2042	112	22955	22.82	27.40	29.07	9605	667302	375710841	12870144
12-Feb-86	1032	29739	634329	336	116376	745999	1248	140	27887	22.75	26.92	28.78	9218	802588	376513429	12898031
13-Feb-86	1004	30680	655246	324	123300	768073	1233	141	28767	22.78	27.06	28.87	9290	830503	377343932	12926798
14-Feb-86	1005	30684	656669	323	122329	770026	1225	141	28771	22.82	27.08	28.87	9282	830619	378174551	12955569
15-Feb-86	1006	30684	655924	328	120989	776116	1235	142	28771	22.80	27.00	28.83	9292	829468	379004019	12984340
16-Feb-86	1005	30691	654918	324	121244	763680	1228	144	28777	22.76	26.97	28.77	9286	827914	379831933	13013117
17-Feb-86	1006	30664	651803	324	120418	764773	1227	144	28752	22.67	26.86	28.66	9282	824032	380655966	13041869
18-Feb-86	1006	30623	651747	325	120780	765305	1227	145	28714	22.70	26.90	28.71	9278	824379	381480345	13070583
19-Feb-86	1006	30582	650931	326	121603	763350	1225	146	28675	22.70	26.94	28.75	9272	824406	382304751	13099258
20-Feb-86	1006	30558	651408	326	120221	762115	1227	146	28653	22.73	26.93	28.74	9272	823487	383128238	13127911
21-Feb-86	1007	30544	651218	327	118773	765296	1228	147	28640	22.74	26.89	28.7	9272	821968	383950206	13156551
22-Feb-86	1001	30526	654964	313	118285	766695	1226	145	28622	22.88	27.02	28.76	9268	823169	384773375	13185173
23-Feb-86	1001	30476	653664	315	118810	768575	1231	146	28575	22.88	27.03	28.79	9269	822674	385596049	13213748
24-Feb-86	1000	30441	652252	316	120339	766281	1225	147	28542	22.85	27.07	28.83	9259	822866	386418915	13242290
25-Feb-86	1001	30398	648249	316	119598	764701	1230	147	28502	22.74	26.94	28.7	9260	818007	387236922	13270792
26-Feb-86	1002	30369	646986	316	119017	763370	1222	147	28475	22.72	26.90	28.66	9249	816094	388053016	13299267
27-Feb-86	1012	30324	647882	318	119036	762770	1231	145	28434	22.79	26.97	28.74	9255	817193	388870209	13327701
28-Feb-86	1005	30259	646984	310	119560	761198	1225	147	28372	22.80	27.02	28.75	9242	815695	389685904	13356073

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Mar-86	0	0	0	0	0	0	0	0	0	0.00	0.00	0	0	0	389685904	13356073
2-Mar-86	1005	15089	327500	405	49557	372110	1234	315	14148	23.15	26.65	28.87	8180	408453	390094357	13370221
3-Mar-86	1000	30573	657315	401	100672	745107	1237	306	28666	22.93	26.44	28.64	9284	820994	390915351	13398887
4-Mar-86	1001	30531	648915	401	100054	742469	1225	304	28627	22.67	26.16	28.36	9268	811862	391727213	13427514
5-Mar-86	1002	30423	645873	404	100085	737451	1231	303	28526	22.64	26.15	28.37	9265	809283	392536495	13456040
6-Mar-86	1020	30344	646971	395	99274	735972	1240	301	28453	22.74	26.23	28.4	9267	808065	393344561	13484493
7-Mar-86	1003	30279	643161	399	99408	732655	1226	302	28391	22.65	26.16	28.35	9246	804885	394149445	13512884
8-Mar-86	1003	30231	646620	396	99548	739881	1225	302	28346	22.81	26.32	28.5	9240	807861	394957306	13541230
9-Mar-86	1003	30168	645168	399	99198	741722	1218	302	28287	22.81	26.32	28.51	9227	806462	395763769	13569517
10-Mar-86	1003	30108	645881	394	98952	741220	1218	303	28230	22.88	26.38	28.55	9221	805967	396569735	13597747
11-Mar-86	1004	30059	645603	399	99114	742317	1221	304	28185	22.91	26.42	28.61	9220	806373	397376108	13625932
12-Mar-86	1003	30007	640431	391	98659	736769	1218	302	28136	22.76	26.27	28.42	9212	799625	398175733	13654068
13-Mar-86	1003	29924	636215	398	99455	733074	1221	303	28058	22.68	26.22	28.41	9208	797128	398972861	13682126
14-Mar-86	1003	29890	[illegible]	402	99431	730878	1223	302	28026	22.78	26.33	28.53	9207	799582	399772443	13710152
15-Mar-86	1003	29840	[illegible]	398	99465	733382	1225	301	27979	22.83	26.38	28.57	9204	799360	400571803	13738131
16-Mar-86	1003	29794	636952	402	99506	731456	1217	301	27936	22.80	26.36	28.57	9191	798132	401369934	13766067
17-Mar-86	1003	29746	636566	403	99124	729571	1224	301	27891	22.82	26.38	28.59	9194	797404	402167338	13793958
18-Mar-86	1004	29689	635326	396	98283	727318	1212	302	27838	22.82	26.35	28.53	9177	794218	402961556	13821796
19-Mar-86	1004	29638	631805	394	98420	725372	1217	302	27790	22.74	26.28	28.44	9177	790348	403751904	13849586
20-Mar-86	1004	29596	630384	394	98420	725372	1216	301	27750	22.72	26.26	28.43	9173	788933	404540836	13877336
21-Mar-86	1003	29571	631272	393	97253	723124	1218	302	27727	22.77	26.28	28.43	9172	788279	405329115	13905063
22-Mar-86	1004	29521	630350	405	96981	721702	1220	300	27680	22.77	26.28	28.5	9170	788880	406117995	13932743
23-Mar-86	1024	29466	630161	403	97956	723067	1227	299	27630	22.81	26.35	28.56	9172	789113	406907108	13960373
24-Mar-86	1000	29406	628002	393	98014	722314	1213	302	27572	22.78	26.33	28.49	9152	785526	407692634	13987945
25-Mar-86	1001	29426	627910	400	96759	720088	1213	304	27591	22.76	26.26	28.46	9154	785240	408477874	14015536
26-Mar-86	1006	29367	629981	403	96440	719960	1215	302	27536	22.88	26.38	28.59	9150	787254	409265128	14043072
27-Mar-86	1004	30089	367967	396	56273	419741	1209	305	28213	13.04	15.04	17.21	9228	485546	409750674	14071285
28-Mar-86	1004	29383	631418	390	96713	722152	1208	305	27551	22.92	26.43	28.57	9145	787132	410537806	14098836
29-Mar-86	1003	29329	631379	397	95466	721876	1207	304	27500	22.96	26.43	28.61	9139	786775	411324581	14126336
30-Mar-86	1004	29284	628994	394	97143	720848	1206	305	27458	22.91	26.45	28.61	9134	785573	412110154	14153794
31-Mar-86	1003	29234	629328	397	95956	720461	1201	303	27411	22.96	26.46	28.64	9124	785051	412895205	14181205

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press	Brine Rate	Gas Rate	Press	Gas Rate		Prod Well	Disp Well		1st Stage	2nd Stg	Disp Well				
	(psig)	(RB/d)	(scf/d)	(psig)	(scf/d)	(scf/d)	(psig)	(psig)	(stb/d)	(scf/stb)	(scf/stb)	(scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Apr-86	1004	29189	627720	398	95833	718378	1198	304	27369	22.94	26.44	28.62	9117	783301	413678506	14208574
2-Apr-86	1003	29152	626985	393	95622	716109	1200	304	27334	22.94	26.44	28.6	9115	781752	414460258	14235908
3-Apr-86	1005	29094	625780	396	95618	712863	1196	302	27280	22.94	26.44	28.62	9106	780754	415241012	14263188
4-Apr-86	999	29084	625996	391	94604	715348	1191	302	27270	22.96	26.42	28.57	9100	779104	416020116	14290458
5-Apr-86	1000	29057	626361	393	94113	711568	1192	300	27245	22.99	26.44	28.6	9099	779207	416799323	14317703
6-Apr-86	1000	29025	625302	398	94349	710120	1194	299	27215	22.97	26.43	28.62	9098	778893	417578216	14344918
7-Apr-86	999	28998	627605	393	94607	712062	1194	297	27189	23.08	26.56	28.72	9095	780868	418359084	14372107
8-Apr-86	999	28951	625567	399	95357	707874	1190	293	27145	23.05	26.56	28.75	9087	780419	419139503	14399252
9-Apr-86	999	28099	604146	398	89420	689155	1190	296	26346	22.93	26.32	28.51	9012	751124	419890628	14425598
10-Apr-86	999	29009	619323	401	96691	708798	1193	292	27200	22.77	26.32	28.53	9095	776016	420666644	14452798
11-Apr-86	1003	28954	614675	402	96574	704340	1198	287	27148	22.64	26.20	28.4	9096	771003	421437647	14479946
12-Apr-86	1003	28911	616109	399	97348	701469	1191	284	27108	22.73	26.32	28.51	9085	772849	422210496	14507054
13-Apr-86	1004	28867	616226	404	97964	701273	1196	281	27067	22.77	26.39	28.6	9086	774116	422984612	14534121
14-Apr-86	1003	28837	617463	403	96944	702199	1190	279	27039	22.84	26.42	28.63	9077	774127	423758739	14561160
15-Apr-86	1003	28793	616498	399	95589	701178	1193	275	26997	22.84	26.38	28.57	9076	771304	424530043	14588157
16-Apr-86	1003	28758	612801	399	96244	698848	1193	274	26965	22.73	26.30	28.49	9073	768233	425298276	14615122
17-Apr-86	1003	28729	613312	399	96560	702721	1194	271	26937	22.77	26.35	28.54	9072	768782	426067058	14642059
18-Apr-86	1003	28714	613627	393	95931	702710	1190	269	26923	22.79	26.35	28.51	9066	767575	426834632	14668982
19-Apr-86	1003	28703	615750	386	96128	701132	1190	268	26913	22.88	26.45	28.57	9065	768904	427603537	14695895
20-Apr-86	1002	28588	611377	384	96390	683763	1187	269	26805	22.81	26.40	28.52	9052	764479	428368015	14722700
21-Apr-86	1004	28671	612282	369	98572	698126	1188	262	26883	22.78	26.44	28.48	9060	765628	429133643	14749583
22-Apr-86	1001	28624	612132	379	99138	704878	1188	265	26839	22.81	26.50	28.59	9056	767327	429900970	14776422
23-Apr-86	1000	28602	610647	381	99588	703863	1186	265	26818	22.77	26.48	28.58	9052	766458	430667429	14803240
24-Apr-86	1000	28586	610429	381	98769	701926	1190	264	26803	22.77	26.46	28.56	9055	765494	431432922	14830043
25-Apr-86	1002	28548	609696	383	98750	701970	1185	266	26768	22.78	26.47	28.57	9046	764762	432197684	14856811
26-Apr-86	1001	28501	611239	382	98134	701844	1182	267	26723	22.87	26.54	28.65	9039	765614	432963298	14883534
27-Apr-86	1000	27308	612046	387	97665	700929	1183	264	25605	23.90	27.72	29.85	8933	764309	433727607	14909139
28-Apr-86	1101	28448	612825	383	96737	698836	1183	265	26683	22.97	26.59	28.7	9036	765802	434493410	14935822
29-Apr-86	1001	28422	612610	382	97167	698818	1189	262	26649	22.99	26.63	28.74	9039	765892	435259302	14962471
30-Apr-86	1001	28389	608658	381	97327	698543	1183	264	26618	22.87	26.52	28.62	9030	761807	436021109	14989089

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-May-86	1001	28355	606859	383	97627	696273	1182	265	26587	22.83	26.50	28.61	9026	760654	436781763	15015676
2-May-86	1001	28328	606606	374	97598	695182	1185	264	26561	22.84	26.51	28.57	9027	758848	437540611	15042237
3-May-86	1000	28291	603621	370	97390	697142	1184	263	26526	22.76	26.43	28.47	9023	755195	438295806	15068763
4-May-86	1001	28265	603851	373	97438	696322	1185	263	26502	22.78	26.46	28.52	9021	755837	439051643	15095265
5-May-86	1000	28238	605523	370	97702	694600	1180	263	26477	22.87	26.56	28.6	9014	757242	439808885	15121742
6-May-86	1001	28210	605435	374	97238	692520	1180	263	26451	22.89	26.57	28.63	9011	757292	440566177	15148193
7-May-86	1001	28187	604166	370	96952	689979	1178	263	26429	22.86	26.53	28.57	9007	755077	441321254	15174622
8-May-86	1001	28165	602735	370	96477	690556	1180	262	26408	22.82	26.48	28.52	9008	753156	442074410	15201030
9-May-86	1002	28137	603976	369	96481	691323	1182	262	26382	22.89	26.55	28.59	9007	754261	442828671	15227412
10-May-86	1000	28123	603569	377	96719	691139	1180	262	26369	22.89	26.56	28.63	9004	754944	443583616	15253781
11-May-86	1001	28116	603558	372	97269	692190	1186	263	26362	22.89	26.58	28.64	9009	755008	444338624	15280143
12-May-86	1000	28120	604192	372	97128	685894	1180	262	26366	22.92	26.60	28.65	9003	755386	445094009	15306509
13-May-86	1001	28093	605550	374	96800	684935	1181	263	26341	22.99	26.66	28.73	9002	756777	445850786	15332850
14-May-86	1001	28074	601645	351	99584	686005	1177	263	26323	22.86	26.64	28.58	8996	752311	446603098	15359173
15-May-86	1001	28042	599505	354	99027	691565	1183	258	26293	22.80	26.57	28.53	9000	750139	447353237	15385466
16-May-86	1001	28021	599122	352	99538	690343	1178	260	26273	22.80	26.59	28.54	8993	749831	448103068	15411739
17-May-86	1000	28002	598411	348	99144	691196	1177	258	26255	22.79	26.57	28.49	8990	748005	448851073	15437994
18-May-86	1001	27978	597047	348	99477	690096	1178	260	26233	22.76	26.55	28.48	8989	747116	449598189	15464227
19-May-86	1000	27961	594871	348	100094	690000	1178	260	26217	22.69	26.51	28.44	8988	745611	450343801	15490444
20-May-86	1001	27944	593436	353	99876	690361	1180	261	26201	22.65	26.46	28.41	8989	744370	451088171	15516645
21-May-86	1000	27933	595724	358	100053	690710	1184	261	26191	22.75	26.57	28.54	8992	747491	451835662	15542836
22-May-86	1001	27908	595800	354	99204	689451	1175	263	26167	22.77	26.56	28.52	8980	746283	452581945	15569003
23-May-86	1001	27895	596289	352	98788	688401	1175	258	26155	22.80	26.58	28.52	8979	745941	453327886	15595158
24-May-86	1000	27871	597591	354	99024	687715	1176	260	26133	22.87	26.66	28.61	8978	747665	454075551	15621291
25-May-86	1001	27849	597712	352	99117	688088	1178	261	26112	22.89	26.69	28.63	8978	747587	454823137	15647403
26-May-86	1001	27830	596645	350	99751	687407	1174	258	26094	22.86	26.69	28.62	8972	746810	455569948	15673497
27-May-86	1000	27814	597515	353	99526	686731	1180	260	26079	22.91	26.73	28.68	8977	747946	456317893	15699576
28-May-86	1000	27794	597031	353	100009	686199	1175	260	26060	22.91	26.75	28.7	8970	747922	457065815	15725636
29-May-86	1000	27767	598593	355	99682	685321	1184	259	26035	22.99	26.82	28.78	8977	749287	457815103	15751671
30-May-86	1002	27743	594236	356	95588	683825	1181	258	26013	22.84	26.52	28.49	8972	741110	458556213	15777684
31-May-86	1000	27708	589984	358	98735	684286	1186	259	25980	22.71	26.51	28.49	8974	740170	459296383	15803664

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jun-86	1000	27690	589560	358	98185	682538	1185	259	25963	22.71	26.49	28.47	8972	739167	460035550	15829627
2-Jun-86	1000	27668	590404	360	97912	681919	1186	259	25942	22.76	26.53	28.52	8971	739866	460775416	15855569
3-Jun-86	1000	27665	591391	358	97827	679960	1182	256	25939	22.80	26.57	28.55	8966	740558	461515974	15881508
4-Jun-86	1002	27609	591054	358	97102	680639	1176	257	25887	22.83	26.58	28.56	8955	739333	462255307	15907395
5-Jun-86	1002	27586	587795	360	97291	678735	1175	255	25866	22.72	26.49	28.48	8953	736664	462991971	15933261
6-Jun-86	999	27571	588845	357	97155	681333	1174	254	25851	22.78	26.54	28.51	8950	737012	463728983	15959112
7-Jun-86	1001	27553	588633	355	97001	679763	1173	252	25835	22.78	26.54	28.5	8948	736298	464465280	15984947
8-Jun-86	1001	27523	586787	359	97024	678591	1173	251	25806	22.74	26.50	28.48	8945	734955	465200235	16010753
9-Jun-86	1002	27488	585001	357	96489	677649	1178	249	25774	22.70	26.44	28.41	8948	732239	465932474	16036527
10-Jun-86	1001	27471	585909	348	96916	677352	1173	249	25758	22.75	26.51	28.44	8941	732558	466665032	16062285
11-Jun-86	1002	27452	585002	350	97410	677522	1174	249	25740	22.73	26.51	28.45	8940	732303	467397335	16088025
12-Jun-86	1002	27425	584712	351	97644	678262	1177	248	25715	22.74	26.54	28.48	8941	732363	468129698	16113740
13-Jun-86	1002	27406	585345	352	98220	675759	1174	243	25697	22.78	26.60	28.55	8936	733649	468863347	16139437
14-Jun-86	1002	27383	584401	350	99103	676061	1179	241	25675	22.76	26.62	28.56	8939	733278	469596625	16165112
15-Jun-86	1010	27352	583660	352	99366	674760	1193	241	25647	22.76	26.63	28.58	8951	732991	470329617	16190759
16-Jun-86	1002	27321	583578	348	99814	676181	1183	242	25617	22.78	26.68	28.6	8938	732646	471062263	16216376
17-Jun-86	1003	27305	581454	351	98751	676827	1172	228	25602	22.71	26.57	28.51	8926	729913	471792176	16241978
18-Jun-86	1003	27292	581877	351	99103	677978	1186	243	25590	22.74	26.61	28.55	8939	730595	472522770	16267568
19-Jun-86	1003	27289	579165	353	98916	673492	1182	243	25587	22.63	26.50	28.45	8935	727950	473250721	16293155
20-Jun-86	1004	27278	579770	342	101609	673691	1177	242	25577	22.67	26.64	28.54	8928	729968	473980688	16318732
21-Jun-86	1001	17434	339566	351	58994	393645	1190	286	16347	20.77	24.38	26.32	8265	430253	474410941	16335079
22-Jun-86	1001	27449	583358	352	100939	677104	1183	282	25737	22.67	26.59	28.54	8949	734534	475145475	16360816
23-Jun-86	1000	27388	585394	345	100794	676543	1182	283	25680	22.80	26.72	28.63	8943	735218	475880694	16386496
24-Jun-86	1000	27351	584528	346	101508	677201	1181	288	25645	22.79	26.75	28.67	8938	735242	476615936	16412141
25-Jun-86	999	27321	583664	344	101350	675961	1177	292	25617	22.78	26.74	28.65	8932	733927	477349863	16437758
26-Jun-86	995	11520	243095	348	41230	279590	1170	290	10801	22.51	26.32	28.25	7962	305128	477654991	16448559
27-Jun-86	1009	20172	385504	293	79039	457211	1184	179	18914	20.38	24.56	26.2	8420	495547	478150538	16467473
28-Jun-86	999	27512	587338	298	116777	694454	1176	178	25796	22.77	27.30	28.96	8946	747052	478897590	16493269
29-Jun-86	999	27447	588633	298	114862	692102	1174	179	25735	22.87	27.34	29	8938	746315	479643905	16519004
30-Jun-86	1002	27388	587369	298	115070	689848	1174	179	25680	22.87	27.35	29.02	8933	745234	480389139	16544684

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Jul-86	1001	27349	585800	298	115178	688572	1178	178	25643	22.84	27.34	29	8934	743647	481132786	16570327
2-Jul-86	1002	27305	586429	298	114660	689334	1178	177	25602	22.91	27.38	29.05	8930	743738	481876524	16595929
3-Jul-86	1002	27279	585032	298	114252	688996	1172	177	25578	22.87	27.34	29.01	8922	742018	482618541	16621507
4-Jul-86	1002	27226	583527	297	113560	687464	1190	177	25528	22.86	27.31	28.97	8936	739546	483358088	16647035
5-Jul-86	999	27230	583929	299	112795	684619	1179	176	25532	22.87	27.29	28.96	8925	739407	484097494	16672567
6-Jul-86	1004	27194	582502	302	111853	681390	1186	177	25498	22.84	27.23	28.92	8930	737402	484834896	16698065
7-Jul-86	1002	27154	583527	302	113560	687464	1193	176	25461	22.92	27.38	29.07	8933	740151	485575048	16723526
8-Jul-86	1001	27143	582141	298	110082	683362	1184	179	25450	22.87	27.20	28.87	8923	734742	486309789	16748976
9-Jul-86	1000	27108	581199	298	110117	682742	1187	178	25417	22.87	27.20	28.87	8924	733789	487043578	16774393
10-Jul-86	1001	27088	581901	299	109308	682000	1171	179	25399	22.91	27.21	28.89	8905	733777	487777355	16799792
11-Jul-86	1002	27068	580043	302	110455	682679	1176	178	25380	22.85	27.21	28.89	8909	733228	488510583	16825172
12-Jul-86	1001	27048	579652	300	110961	681816	1175	179	25361	22.86	27.23	28.91	8906	733187	489243770	16850533
13-Jul-86	1001	27050	579923	300	111903	683315	1178	182	25363	22.86	27.28	28.95	8909	734259	489978029	16875896
14-Jul-86	1002	27014	581927	299	110764	688463	1186	182	25329	22.97	27.35	29.02	8914	735048	490713076	16901225
15-Jul-86	1000	26970	577937	301	111919	686696	1185	181	25288	22.85	27.28	28.96	8910	732340	491445417	16926513
16-Jul-86	1004	26950	576676	300	110584	686522	1180	181	25269	22.82	27.20	28.87	8903	729516	492174933	16951782
17-Jul-86	1004	7440	138909	407	19956	153486	1427	334	6976	19.91	22.77	25	8127	174400	492349333	16958758
18-Jul-86	1004	26940	573819	419	84168	655144	1193	348	25260	22.72	26.05	28.34	8917	715868	493065201	16984018
19-Jul-86	1004	27099	579642	424	84543	664185	1187	340	25409	22.81	26.14	28.46	8924	723140	493788341	17009427
20-Jul-86	1003	27038	578578	424	84875	663453	1184	337	25352	22.82	26.17	28.49	8916	722278	494510620	17034779
21-Jul-86	1003	26996	578401	413	85968	650819	1183	336	25312	22.85	26.25	28.51	8911	721645	495232265	17060091
22-Jul-86	1003	26966	577744	408	97256	650789	1186	334	25284	22.85	26.70	28.93	8911	731466	495963731	17085375
23-Jul-86	1002	26936	577491	402	89878	650994	1183	333	25256	22.87	26.42	28.63	8906	723079	496686810	17110631
24-Jul-86	1003	26903	577411	399	90729	650476	1181	331	25225	22.89	26.49	28.68	8901	723453	497410263	17135856
25-Jul-86	1003	26864	573678	407	89711	650662	1182	330	25189	22.78	26.34	28.57	8899	719650	498129913	17161045
26-Jul-86	1002	26845	577058	402	90288	655593	1181	330	25171	22.93	26.51	28.72	8896	722911	498852824	17186216
27-Jul-86	1000	26837	575396	399	89767	655167	1177	328	25163	22.87	26.43	28.62	8891	720165	499572989	17211379
28-Jul-86	999	26818	575508	402	89207	650632	1176	328	25145	22.89	26.44	28.64	8889	720153	500293142	17236524
29-Jul-86	999	26791	575330	398	88289	653005	1177	327	25120	22.90	26.42	28.6	8887	718432	501011574	17261644
30-Jul-86	1001	26788	572548	399	89706	653173	1180	327	25117	22.79	26.37	28.56	8891	717342	501728916	17286761
31-Jul-86	1000	26771	573326	403	89804	647850	1181	327	25101	22.84	26.42	28.63	8890	718642	502447557	17311862

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press	Brine Rate	Gas Rate	Press	Gas Rate		Prod Well	Disp Well		1st Stage	2nd Stg	Disp Well				
	(psig)	(RB/d)	(scf/d)	(psig)	(scf/d)	(scf/d)	(psig)	(psig)	(stb/d)	(scf/stb)	(scf/stb)	(scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Aug-86	1002	26722	573886	387	91850	652051	1181	325	25055	22.90	26.57	28.7	8886	719079	503166636	17336917
2-Aug-86	1005	26690	573328	386	92457	651999	1182	324	25026	22.91	26.60	28.73	8884	718997	503885633	17361943
3-Aug-86	1022	26625	568468	392	93188	650260	1208	324	24966	22.77	26.50	28.66	8906	715526	504601158	17386909
4-Aug-86	1022	26593	569631	395	93798	648805	1205	322	24936	22.84	26.61	28.78	8900	717658	505318816	17411845
5-Aug-86	1006	26613	571916	392	93200	637436	1192	321	24954	22.92	26.65	28.81	8888	718925	506037741	17436799
6-Aug-86	1010	26606	569114	386	94517	653679	1189	320	24947	22.81	26.60	28.72	8885	716478	506754219	17461746
7-Aug-86	1024	26431	563863	389	96038	651820	1196	319	24784	22.75	26.63	28.76	8877	712788	507467007	17486530
8-Aug-86	998	26584	567752	384	95212	647228	1173	322	24926	22.78	26.60	28.71	8866	715625	508182632	17511456
9-Aug-86	1001	26601	568557	384	94911	641100	1174	324	24942	22.80	26.60	28.71	8868	716085	508898717	17536398
10-Aug-86	1001	26559	547037	383	94880	640793	1174	324	24903	21.97	25.78	27.89	8867	694545	509593262	17561301
11-Aug-86	1001	26554	566351	383	95845	555288	1184	325	24898	22.75	26.60	28.7	8875	714573	510307834	17586199
12-Aug-86	1002	26510	566305	382	94372	644159	1177	319	24857	22.78	26.58	28.68	8864	712899	511020733	17611056
13-Aug-86	1001	26509	567312	383	90304	560947	1175	319	24856	22.82	26.46	28.57	8862	710136	511730869	17635912
14-Aug-86	1002	26490	566105	381	89341	641026	1184	319	24838	22.79	26.39	28.49	8870	707635	512438504	17660750
15-Aug-86	1006	26423	563540	381	89548	643388	1175	316	24775	22.75	26.36	28.46	8856	705097	513143600	17685525
16-Aug-86	1004	26395	561851	380	89583	640761	1174	316	24749	22.70	26.32	28.41	8852	703119	513846719	17710274
17-Aug-86	1002	26351	561569	377	89024	642328	1173	315	24708	22.73	26.33	28.41	8848	701954	514548673	17734982
18-Aug-86	1002	26402	562939	376	88971	644316	1171	315	24755	22.74	26.33	28.41	8850	703290	515251963	17759737
19-Aug-86	999	26377	562572	383	87804	600527	1170	316	24732	22.75	26.30	28.41	8847	702636	515954599	17784469
20-Aug-86	1006	26349	563174	386	87427	643806	1176	315	24706	22.79	26.33	28.46	8851	703133	516657732	17809175
21-Aug-86	1002	26348	564055	383	87977	640906	1173	315	24705	22.83	26.39	28.5	8847	704093	517361824	17833880
22-Aug-86	1013	26240	561996	389	89863	645272	1184	314	24604	22.84	26.49	28.63	8850	704413	518066237	17858484
23-Aug-86	1001	26238	562267	380	89188	643084	1168	312	24602	22.85	26.48	28.57	8833	702879	518769116	17883086
24-Aug-86	1002	26295	564226	381	87846	643737	1175	313	24655	22.88	26.45	28.55	8845	703900	519473016	17907741
25-Aug-86	1001	26286	561808	382	87840	641509	1168	313	24647	22.79	26.36	28.46	8837	701454	520174470	17932388
26-Aug-86	1001	26261	560598	381	87835	597303	1170	312	24623	22.77	26.33	28.43	8837	700032	520874502	17957011
27-Aug-86	1000	26251	560416	382	87855	639507	1172	313	24614	22.77	26.34	28.44	8838	700022	521574524	17981625
28-Aug-86	1010	26203	556343	383	88744	594069	1174	309	24570	22.64	26.26	28.36	8837	696805	522271329	18006195
29-Aug-86	1001	26176	555524	376	87227	609294	1163	308	24543	22.63	26.19	28.26	8823	693585	522964914	18030738
30-Aug-86	1000	26184	559364	375	86841	399055	1161	306	24551	22.78	26.32	28.39	8822	697003	523661917	18055289
31-Aug-86	1001	26180	557902	382	86984	638203	1166	308	24547	22.73	26.27	28.37	8827	696398	524358316	18079836

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Sep-86	1013	26135	557460	387	87138	636942	1179	307	24506	22.75	26.30	28.43	8836	696706	525055021	18104342
2-Sep-86	1007	26105	556268	382	87457	633510	1174	307	24477	22.73	26.30	28.4	8829	695147	525750168	18128819
3-Sep-86	1010	26115	550818	381	88360	631413	1176	308	24487	22.49	26.10	28.2	8832	690533	526440701	18153306
4-Sep-86	1000	26148	563606	403	83682	619657	1162	303	24517	22.99	26.40	28.61	8819	701431	527142133	18177823
5-Sep-86	1001	26121	559390	400	82943	634127	1169	303	24492	22.84	26.23	28.42	8825	696063	527838195	18202315
6-Sep-86	1003	26058	558510	400	83771	630567	1170	304	24433	22.86	26.29	28.48	8821	695852	528534047	18226748
7-Sep-86	1014	26025	560313	406	83565	633413	1174	303	24403	22.96	26.39	28.61	8822	698170	529232217	18251151
8-Sep-86	1021	25917	554695	401	83621	634154	1180	304	24302	22.82	26.27	28.47	8820	691878	529924095	18275453
9-Sep-86	1005	26066	562670	400	83105	636108	1169	310	24441	23.02	26.42	28.62	8820	699501	530623596	18299894
10-Sep-86	1010	26062	558932	399	83377	628419	1173	311	24437	22.87	26.28	28.47	8824	695721	531319318	18324331
11-Sep-86	1000	26063	556666	393	82458	629966	1158	310	24437	22.78	26.15	28.31	8809	691811	532011129	18348768
12-Sep-86	1004	26063	557745	397	81649	632362	1163	312	24438	22.82	26.16	28.34	8814	692573	532703702	18373206
13-Sep-86	1004	26029	555040	396	82302	632164	1162	311	24406	22.74	26.11	28.29	8810	690446	533394148	18397612
14-Sep-86	1001	26053	560018	395	82328	636730	1161	310	24428	22.93	26.30	28.47	8811	695465	534089613	18422040
15-Sep-86	1004	26004	557567	399	82426	634473	1164	312	24382	22.87	26.25	28.44	8810	693424	534783037	18446422
16-Sep-86	1003	26016	557987	398	82302	633819	1166	311	24394	22.87	26.25	28.43	8813	693521	535476559	18470816
17-Sep-86	1001	26011	560364	395	82355	636218	1164	313	24389	22.98	26.35	28.52	8810	695574	536172133	18495205
18-Sep-86	1001	25994	558456	397	82022	633062	1162	313	24373	22.91	26.28	28.46	8807	693656	536865788	18519578
19-Sep-86	1032	25933	557337	405	82304	633885	1189	309	24318	22.92	26.30	28.52	8831	693549	537559338	18543896
20-Sep-86	1003	25916	557446	395	83488	635187	1164	311	24300	22.94	26.38	28.55	8803	693765	538253103	18568196
21-Sep-86	1007	25896	554351	398	82395	632602	1167	311	24281	22.83	26.22	28.41	8805	689823	538942926	18592477
22-Sep-86	1005	25890	553592	396	82308	633783	1165	311	24276	22.80	26.20	28.37	8802	688710	539631636	18616753
23-Sep-86	1016	25806	551498	398	82548	618473	1173	310	24198	22.79	26.20	28.39	8804	686981	540318617	18640951
24-Sep-86	1014	25819	550995	397	82737	629387	1167	310	24210	22.76	26.18	28.36	8799	686596	541005213	18665161
25-Sep-86	1010	25828	549724	391	82384	629366	1164	310	24218	22.70	26.10	28.25	8797	684159	541689371	18689379
26-Sep-86	1012	25787	549670	394	82011	628458	1167	310	24180	22.73	26.12	28.29	8796	684052	542373424	18713559
27-Sep-86	1010	25765	556562	396	84464	628066	1168	313	24159	23.04	26.53	28.71	8794	693605	543067029	18737718
28-Sep-86	1021	25744	550273	395	84992	627490	1176	312	24140	22.80	26.32	28.49	8802	687749	543754777	18761858
29-Sep-86	1010	25730	550573	397	84692	627585	1167	314	24126	22.82	26.33	28.51	8791	687832	544442609	18785984
30-Sep-86	1000	25758	548591	400	81756	622186	1154	315	24151	22.71	26.10	28.3	8780	683473	545126083	18810135

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Oct-86	999	25814	551052	400	80910	624217	1153	315	24204	22.77	26.11	28.31	8784	685215	545811298	18834339
2-Oct-86	999	25751	550762	400	81396	620095	1154	315	24145	22.81	26.18	28.38	8779	685235	546496533	18858484
3-Oct-86	1012	25764	552233	400	83478	625313	1164	313	24158	22.86	26.31	28.51	8791	688745	547185278	18882642
4-Oct-86	1020	25657	548679	406	82641	622740	1173	314	24058	22.81	26.24	28.47	8792	684931	547870209	18906700
5-Oct-86	1000	21338	466330	400	71210	528943	3102	55	20007	23.31	26.87	29.06	10479	581403	548451612	18926707
6-Oct-86	1003	14872	324744	450	43100	367844	1157	350	13945	23.29	26.38	28.83	8087	402034	548853647	18940652
7-Oct-86	1010	26006	557700	443	73426	621002	1161	348	24385	22.87	25.88	28.3	8808	690096	549543742	18965037
8-Oct-86	1000	25966	555090	448	74253	614073	1162	345	24346	22.80	25.85	28.29	8805	688748	550232491	18989383
9-Oct-86	1021	25891	551751	451	75386	609653	1176	341	24278	22.73	25.83	28.29	8814	686825	550919315	19013661
10-Oct-86	1009	25776	548886	441	75837	603156	1167	341	24169	22.71	25.85	28.25	8796	682774	551602089	19037830
11-Oct-86	1013	25748	549170	446	76258	604472	1175	342	24143	22.75	25.91	28.34	8801	684213	552286302	19061973
12-Oct-86	1022	25760	548230	444	76933	603542	1177	341	24155	22.70	25.88	28.3	8805	683587	552969889	19086128
13-Oct-86	1006	25723	549245	427	77281	605248	1163	340	24119	22.77	25.98	28.31	8787	682809	553652697	19110247
14-Oct-86	1015	25724	548850	431	76248	606259	1176	341	24121	22.75	25.92	28.27	8801	681901	554334598	19134368
15-Oct-86	1015	25692	546849	437	76058	605356	1175	342	24091	22.70	25.86	28.24	8797	680330	555014928	19158459
16-Oct-86	999	25671	547431	430	76640	603453	1161	343	24070	22.74	25.93	28.28	8781	680700	555695628	19182529
17-Oct-86	1001	25675	549147	428	75838	603693	1162	341	24074	22.81	25.96	28.3	8782	681294	556376922	19206603
18-Oct-86	1002	25654	549283	432	76425	604299	1160	341	24054	22.84	26.01	28.37	8778	682412	557059334	19230657
19-Oct-86	1002	25653	548477	415	76297	604372	1157	340	24053	22.80	25.97	28.25	8775	679497	557738831	19254710
20-Oct-86	1002	25631	548386	418	76408	603700	1157	340	24033	22.82	26.00	28.29	8773	679894	558418725	19278743
21-Oct-86	1002	25594	545802	426	77367	602041	1157	340	23998	22.74	25.97	28.3	8770	679143	559097868	19302741
22-Oct-86	1002	25563	546760	425	78413	601624	1155	339	23969	22.81	26.08	28.41	8765	680959	559778827	19326710
23-Oct-86	1008	25537	544081	414	78951	602153	1157	339	23945	22.72	26.02	28.29	8766	677404	560456231	19350655
24-Oct-86	1000	25540	545243	423	78435	602729	1151	336	23947	22.77	26.04	28.36	8760	679137	561135368	19374602
25-Oct-86	1002	25539	545490	417	77706	602848	1155	338	23946	22.78	26.02	28.31	8764	677911	561813279	19398548
26-Oct-86	1002	26586	544013	424	78214	602155	1154	339	24928	21.82	24.96	27.28	8850	680036	562493315	19423476
27-Oct-86	1002	25504	543902	422	78467	601385	1156	339	23913	22.74	26.03	28.34	8762	677694	563171010	19447389
28-Oct-86	1002	25483	542793	420	78358	601285	1156	338	23894	22.72	26.00	28.3	8760	676200	563847210	19471283
29-Oct-86	1000	25464	542856	419	78156	600282	1152	336	23876	22.74	26.01	28.3	8755	675691	564522901	19495159
30-Oct-86	1001	25462	544698	418	78044	601176	1154	336	23874	22.82	26.08	28.37	8756	677305	565200206	19519033
31-Oct-86	999	25440	544496	418	78327	605283	1151	334	23853	22.83	26.11	28.4	8751	677425	565877631	19542886

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Nov-86	1020	25341	540798	422	78974	603128	1170	332	23762	22.76	26.08	28.39	8764	674603	566552234	19566648
2-Nov-86	1000	25312	543321	415	78644	606755	1150	333	23733	22.89	26.21	28.48	8740	675916	567228150	19590381
3-Nov-86	1018	25311	543351	421	78935	605646	1164	332	23734	22.89	26.22	28.52	8755	676894	567905044	19614115
4-Nov-86	1016	25299	542653	422	76819	600384	1164	331	23722	22.88	26.11	28.42	8754	674179	568579223	19637837
5-Nov-86	1013	25275	546165	419	75608	607394	1162	332	23700	23.05	26.24	28.53	8750	676161	569255384	19661537
6-Nov-86	1001	25305	541416	426	79446	609212	1154	335	23727	22.82	26.17	28.5	8744	676220	569931604	19685264
7-Nov-86	1001	25320	541264	424	74215	609245	1151	332	23741	22.80	25.92	28.24	8743	670446	570602050	19709005
8-Nov-86	1002	25314	541698	423	74107	605347	1149	332	23735	22.82	25.94	28.26	8740	670751	571272801	19732740
9-Nov-86	1002	25294	541586	429	74170	605053	1152	333	23717	22.84	25.96	28.31	8741	671428	571944229	19756457
10-Nov-86	1002	23313	498312	386	70050	558847	1348	316	21859	22.80	26.00	28.12	8799	614675	572558904	19778316
11-Nov-86	1023	23768	510319	388	79424	581684	1362	314	22287	22.90	26.46	28.59	8845	637185	573196089	19800603
12-Nov-86	1025	23829	511816	388	79222	583527	1354	316	22345	22.91	26.45	28.58	8841	638620	573834709	19822948
13-Nov-86	1002	23902	515634	379	78847	586158	1334	317	22411	23.01	26.53	28.61	8826	641179	574475888	19845359
14-Nov-86	1027	23590	512921	445	67417	550203	1196	360	22121	23.19	26.24	28.66	8657	633988	575109876	19867480
15-Nov-86	1036	25049	536719	436	73386	602602	1200	352	23490	22.85	25.97	28.35	8773	665942	575775817	19890970
16-Nov-86	1039	24996	534350	429	75799	602708	1196	351	23440	22.80	26.03	28.38	8764	665227	576441045	19914410
17-Nov-86	1022	25060	535913	425	74846	604231	1178	351	23499	22.81	25.99	28.32	8751	665492	577106536	19937909
18-Nov-86	1021	25073	536695	433	72855	604684	1176	350	23511	22.83	25.93	28.29	8750	665126	577771663	19961420
19-Nov-86	1002	25144	538213	430	72154	601901	1162	351	23576	22.83	25.89	28.24	8740	665786	578437449	19984996
20-Nov-86	1002	25180	539390	432	70837	603155	1158	350	23610	22.85	25.85	28.21	8739	666038	579103487	20008606
21-Nov-86	1011	25061	536324	435	70817	601273	1171	348	23499	22.82	25.84	28.21	8744	662907	579766394	20032105
22-Nov-86	1008	23564	502827	435	66573	601892	3052	340	22095	22.76	25.77	28.15	10581	621974	580388368	20054200
23-Nov-86	1003	7939	66460	430	16615	152002	1161	340	7444	8.93	11.16	13.51	7899	100568	580488936	20061644
24-Nov-86	1003	25399	543489	430	72070	610184	1160	343	23815	22.82	25.85	28.2	8758	671583	581160519	20085459
25-Nov-86	1004	25386	542510	430	73085	608596	1160	341	23803	22.79	25.86	28.21	8757	671483	581832002	20109262
26-Nov-86	1000	24675	529743	440	70730	607053	3068	350	23136	22.90	25.95	28.36	10678	656137	582488139	20132398
27-Nov-86	1001	12717	274527	440	36949	304728	1166	364	11924	23.02	26.12	28.52	8003	340072	582828211	20144322
28-Nov-86	1013	25288	542280	445	71778	604010	1176	363	23712	22.87	25.90	28.32	8766	671524	583499735	20168034
29-Nov-86	1013	25167	539102	442	72751	607367	1176	362	23598	22.84	25.93	28.34	8757	668767	584168503	20191632
30-Nov-86	1017	25162	537727	447	72907	604027	1178	362	23594	22.79	25.88	28.32	8758	668182	584836685	20215226

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Dec-86	1004	25118	538070	449	74476	603499	1162	364	23552	22.85	26.01	28.46	8738	670290	585506975	20238778
2-Dec-86	1030	25078	535166	449	72832	605070	1189	359	23516	22.76	25.85	28.3	8764	665503	586172477	20262294
3-Dec-86	1001	24975	534522	456	73754	599664	1169	364	23417	22.83	25.98	28.46	8734	666448	586838925	20285711
4-Dec-86	1003	25072	537344	458	71392	595138	1168	361	23508	22.86	25.89	28.39	8741	667392	587506317	20309219
5-Dec-86	1012	25046	537023	442	72123	598488	1176	362	23485	22.87	25.94	28.35	8747	665800	588172117	20332704
6-Dec-86	1005	24971	535070	442	73167	596241	1166	361	23414	22.85	25.98	28.39	8731	664723	588836841	20356118
7-Dec-86	1019	24954	535700	447	73767	598089	1175	361	23399	22.89	26.05	28.48	8739	666404	589503244	20379517
8-Dec-86	1000	24971	534629	445	73150	600007	1157	365	23414	22.83	25.96	28.39	8721	664723	590167968	20402931
9-Dec-86	998	24988	535041	442	73017	599025	1154	364	23429	22.84	25.95	28.36	8719	664446	590832414	20426360
10-Dec-86	1001	24987	536568	443	71509	598314	1162	359	23429	22.90	25.95	28.37	8728	664681	591497095	20449789
11-Dec-86	1001	24951	538105	450	70272	596476	1164	350	23395	23.00	26.00	28.46	8727	665822	592162916	20473184
12-Dec-86	1035	24837	532170	439	72877	591557	1194	354	23291	22.85	25.98	28.37	8750	660766	592823682	20496475
13-Dec-86	1006	24821	542684	441	74426	598167	1166	357	23273	23.32	26.52	28.92	8717	673055	593496737	20519748
14-Dec-86	999	24898	533462	439	73273	595997	1155	358	23345	22.85	25.99	28.39	8713	662765	594159502	20543093
15-Dec-86	1008	24887	532378	438	72884	597491	1161	353	23335	22.81	25.94	28.33	8719	661081	594820582	20566428
16-Dec-86	1012	24840	533083	442	70501	596761	1169	356	23292	22.89	25.91	28.33	8724	659862	595480445	20589720
17-Dec-86	1022	24750	531000	440	72262	596138	1175	356	23208	22.88	25.99	28.4	8723	659107	596139552	20612928
18-Dec-86	1008	24762	528139	438	73003	595875	1163	357	23218	22.75	25.89	28.28	8712	656605	596796157	20636146
19-Dec-86	1001	24821	532254	444	68860	592743	1160	350	23273	22.87	25.83	28.25	8713	657462	597453619	20659419
20-Dec-86	1002	24801	532846	443	69114	596786	1161	352	23254	22.91	25.89	28.3	8713	658088	598111707	20682673
21-Dec-86	1000	24778	530375	438	69245	595852	1158	352	23233	22.83	25.81	28.2	8708	655171	598766878	20705906
22-Dec-86	1013	24774	530651	438	69064	595968	1168	350	23230	22.84	25.82	28.21	8718	655318	599422196	20729136
23-Dec-86	1003	24710	530457	444	67549	594550	1159	356	23169	22.90	25.81	28.23	8704	654061	600076257	20752305
24-Dec-86	1006	24712	529858	447	69035	595348	1162	353	23171	22.87	25.85	28.28	8707	655276	600731533	20775476
25-Dec-86	1006	24679	528491	440	72180	596221	1165	355	23140	22.84	25.96	28.36	8707	656250	601387783	20798616
26-Dec-86	1005	24650	526661	436	72558	596841	1162	358	23113	22.79	25.93	28.31	8702	654329	602042112	20821729
27-Dec-86	1000	24679	527425	439	71011	598464	1158	350	23140	22.79	25.86	28.26	8700	653936	602696049	20844869
28-Dec-86	1017	24595	526554	438	70326	599747	1173	347	23062	22.83	25.88	28.27	8710	651963	603348012	20867931
29-Dec-86	999	24640	527166	435	72379	597972	1158	347	23103	22.82	25.95	28.33	8697	654508	604002520	20891034
30-Dec-86	999	24666	527322	434	72137	598293	1156	353	23127	22.80	25.92	28.29	8697	654263	604656782	20914161
31-Dec-86	1000	24639	527585	431	72253	595019	1152	344	23102	22.84	25.96	28.32	8691	654249	605311031	20937263

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Jan-87	1018	24550	524196	443	73079	428103	1173	344	23020	22.77	25.95	28.36	8706	652847	605963878	20960283
2-Jan-87	1000	21684	452307	444	63755	594500	1160	361	20332	22.25	25.38	27.8	8488	565230	606529108	20980615
3-Jan-87	1000	24712	528885	441	72380	593574	1153	360	23171	22.83	25.95	28.36	8697	657130	607186237	21003786
4-Jan-87	1001	24675	529496	441	70058	593094	1157	360	23136	22.89	25.91	28.32	8699	655212	607841449	21026922
5-Jan-87	1000	24652	528049	445	70145	590691	1159	359	23114	22.85	25.88	28.31	8699	654357	608495806	21050036
6-Jan-87	1000	24631	526668	443	71825	592103	1152	358	23095	22.80	25.91	28.33	8690	654281	609150088	21073131
7-Jan-87	1004	24611	526706	444	72193	590177	1154	357	23076	22.82	25.95	28.38	8690	654897	609804985	21096207
8-Jan-87	998	24579	526135	438	72194	588795	1150	355	23046	22.83	25.96	28.35	8684	653354	610458339	21119253
9-Jan-87	1001	24575	527690	440	70974	589590	1150	353	23042	22.90	25.98	28.38	8683	653932	611112271	21142295
10-Jan-87	1019	24512	525078	447	71008	589482	1173	352	22985	22.84	25.93	28.37	8703	652084	611764355	21165280
11-Jan-87	1002	24464	524452	446	71988	589253	1157	352	22938	22.86	26.00	28.43	8682	652127	612416482	21188218
12-Jan-87	1002	24508	525992	446	71960	589260	1160	353	22980	22.89	26.02	28.45	8689	653781	613070263	21211198
13-Jan-87	1006	24497	524272	446	71979	588885	1160	352	22970	22.82	25.96	28.39	8688	652118	613722382	21234168
14-Jan-87	1002	24451	522672	442	72842	586274	1152	349	22926	22.80	25.98	28.39	8676	650869	614373251	21257094
15-Jan-87	1002	24481	524420	440	72204	587073	1152	349	22954	22.85	25.99	28.39	8678	651664	615024915	21280048
16-Jan-87	1004	24408	522560	438	71760	589130	1154	344	22886	22.83	25.97	28.36	8675	649047	615673962	21302934
17-Jan-87	1001	24444	524197	434	71011	589356	1147	346	22919	22.87	25.97	28.34	8670	649524	616323486	21325853
18-Jan-87	1001	24436	524071	431	71230	588998	1148	346	22912	22.87	25.98	28.34	8671	649326	616972812	21348765
19-Jan-87	1001	24404	523250	445	70615	587806	1154	341	22882	22.87	25.95	28.38	8675	649391	617622204	21371647
20-Jan-87	1000	24395	522454	440	71223	589334	1155	345	22873	22.84	25.95	28.36	8675	648678	618270882	21394520
21-Jan-87	1000	24388	523606	440	70798	589942	1153	331	22867	22.90	25.99	28.4	8672	649423	618920305	21417387
22-Jan-87	1001	24413	522955	430	71380	588902	1154	338	22890	22.85	25.96	28.31	8675	648016	619568321	21440277
23-Jan-87	1001	24382	521286	434	71502	585908	1158	343	22861	22.80	25.93	28.3	8677	646966	620215287	21463138
24-Jan-87	1000	24375	520778	433	71310	586008	1151	343	22855	22.79	25.91	28.27	8670	646111	620861398	21485993
25-Jan-87	1001	24335	521653	433	71270	583840	1153	341	22817	22.86	25.99	28.35	8668	646862	621508260	21508810
26-Jan-87	1001	24336	520075	431	71423	584607	1154	343	22818	22.79	25.92	28.28	8670	645293	622153553	21531628
27-Jan-87	1001	23801	509704	430	69244	582448	1152	343	22317	22.84	25.94	28.29	8627	631348	622784901	21553945
28-Jan-87	1009	3868	65295	416	9871	75166	1163	311	3627	18.00	20.72	23	7788	83421	622868322	21557572
29-Jan-87	1000	24624	525786	411	76166	590951	1151	322	23088	22.77	26.07	28.32	8688	653852	623522174	21580660
30-Jan-87	1001	24536	525504	414	74837	589475	1152	322	23006	22.84	26.10	28.36	8682	652450	624174624	21603666
31-Jan-87	1002	24490	523723	420	74104	585812	1151	324	22963	22.81	26.03	28.33	8678	650542	624825166	21626629

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Feb-87	1000	24448	522617	415	74059	585533	1147	324	22923	22.80	26.03	28.3	8671	648721	625473887	21649552
2-Feb-87	1019	24392	522048	415	73336	587696	1167	321	22872	22.82	26.03	28.3	8688	647278	626121164	21672424
3-Feb-87	1000	24383	521335	411	75638	586438	1148	323	22862	22.80	26.11	28.36	8667	648366	626769531	21695286
4-Feb-87	1019	24302	521229	411	76355	586443	1162	320	22788	22.87	26.22	28.48	8675	649002	627418533	21718074
5-Feb-87	1000	24334	520158	402	74781	580610	1149	321	22816	22.80	26.08	28.28	8664	645236	628063769	21740890
6-Feb-87	1000	10738	228905	402	32460	257349	2953	321	10068	22.74	25.96	28.17	9804	283616	628347385	21750958
7-Feb-87	1000	12368	291506	403	40350	329257	1156	327	11597	25.14	28.62	30.83	7967	357536	628704920	21762555
8-Feb-87	999	24645	527903	411	72418	592686	1154	330	23108	22.85	25.98	28.23	8693	652339	629357259	21785663
9-Feb-87	1000	24574	526625	409	70306	589794	1155	329	23041	22.86	25.91	28.15	8689	648604	630005863	21808704
10-Feb-87	1000	24523	526106	417	75407	591374	1149	330	22993	22.88	26.16	28.44	8678	653921	630659784	21831697
11-Feb-87	1005	24439	523264	412	76374	589047	1151	329	22915	22.83	26.17	28.43	8674	651473	631311258	21854612
12-Feb-87	1001	24475	523135	409	76158	588490	1149	329	22949	22.80	26.11	28.36	8675	650834	631962091	21877561
13-Feb-87	1002	24421	521810	412	75778	588750	1149	328	22898	22.79	26.10	28.36	8671	649387	632611479	21900459
14-Feb-87	1002	24420	522414	416	75496	589193	1149	327	22897	22.82	26.11	28.39	8670	650046	633261524	21923356
15-Feb-87	1002	24388	522113	408	74361	589258	1146	323	22867	22.83	26.08	28.32	8665	647593	633909118	21946223
16-Feb-87	1000	22473	474523	351	65021	538661	1152	138	21071	22.52	25.61	27.55	8534	580506	634489624	21967294
17-Feb-87	1002	24447	524378	285	100256	614276	1155	140	22922	22.88	27.25	28.85	8677	661300	635150924	21990216
18-Feb-87	1000	24385	523282	286	102913	616112	1153	143	22864	22.89	27.39	28.99	8670	662827	635813751	22013080
19-Feb-87	1000	24373	523684	287	102099	613758	1154	144	22853	22.92	27.38	28.99	8670	662508	636476259	22035933
20-Feb-87	1000	24343	523513	286	101556	615465	1146	144	22825	22.94	27.39	28.99	8659	661697	637137956	22058758
21-Feb-87	1005	24294	522406	286	101315	614563	1154	144	22779	22.93	27.38	28.98	8664	660135	637798092	22081537
22-Feb-87	1001	24303	523028	285	101597	615721	1151	146	22787	22.95	27.41	29.01	8661	661051	638459142	22104324
23-Feb-87	1000	24280	522065	286	101593	614960	1150	144	22766	22.93	27.39	29	8659	660214	639119356	22127090
24-Feb-87	1000	24268	519830	285	102309	613780	1150	145	22754	22.85	27.34	28.94	8658	658501	639777857	22149844
25-Feb-87	1001	24234	521102	287	101451	613411	1144	147	22723	22.93	27.40	29.01	8649	659194	640437051	22172567
26-Feb-87	1001	24225	520226	285	101549	610425	1149	146	22714	22.90	27.37	28.97	8654	658025	641095076	22195281
27-Feb-87	1000	24220	518409	284	101700	606081	1146	147	22709	22.83	27.31	28.9	8650	656290	641751366	22217990
28-Feb-87	1001	24204	517644	282	100854	602268	1147	146	22694	22.81	27.25	28.84	8650	654495	642405861	22240684

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Mar-87	1000	24176	517166	286	100499	604088	1150	147	22668	22.81	27.25	28.85	8651	653972	643059833	22263352
2-Mar-87	1001	24166	517048	286	103061	601904	1153	147	22659	22.82	27.37	28.97	8653	656431	643716264	22286011
3-Mar-87	1000	24154	517363	285	101592	603168	1151	148	22647	22.84	27.33	28.93	8651	655178	644371442	22308658
4-Mar-87	1001	24134	516879	282	100937	601299	1151	147	22629	22.84	27.30	28.89	8649	653752	645025194	22331287
5-Mar-87	1000	24133	517469	281	101370	595309	1148	149	22628	22.87	27.35	28.93	8646	654628	645679822	22353915
6-Mar-87	1000	24105	518171	281	102591	598609	1148	149	22602	22.93	27.47	29.04	8643	656362	646336184	22376517
7-Mar-87	1000	19541	416815	404	76288	488868	1150	320	18322	22.75	26.91	29.13	8333	533720	646869904	22394839
8-Mar-87	1000	24218	520150	396	76761	580193	1151	320	22707	22.91	26.29	28.46	8657	646241	647516145	22417546
9-Mar-87	1001	24180	518428	398	76540	581269	1148	318	22672	22.87	26.24	28.43	8651	644565	648160710	22440218
10-Mar-87	1000	24152	516971	395	76930	579071	1149	317	22646	22.83	26.23	28.4	8650	643146	648803856	22462864
11-Mar-87	1000	24126	516128	395	76798	579349	1151	316	22621	22.82	26.21	28.38	8650	641984	649445840	22485485
12-Mar-87	1000	24104	517987	408	76807	581292	1150	319	22601	22.92	26.32	28.55	8647	645259	650091099	22508086
13-Mar-87	1001	24078	516767	414	75238	577722	1154	329	22576	22.89	26.22	28.49	8650	643190	650734289	22530662
14-Mar-87	1000	24068	514472	416	75132	578555	1150	333	22567	22.80	26.13	28.41	8645	641128	651375417	22553229
15-Mar-87	1000	24049	515384	416	74891	578944	1145	333	22549	22.86	26.18	28.46	8638	641745	652017162	22575778
16-Mar-87	1001	24037	514802	415	74891	578949	1142	332	22538	22.84	26.16	28.44	8634	640981	652658143	22598316
17-Mar-87	1001	24016	514325	404	74490	578571	1142	329	22518	22.84	26.15	28.36	8633	638610	653296753	22620834
18-Mar-87	1001	24007	513868	413	74223	577710	1143	332	22510	22.83	26.13	28.39	8633	639059	653935812	22643344
19-Mar-87	1001	24010	512366	410	74020	576094	1146	333	22513	22.76	26.05	28.29	8637	636893	654572705	22665857
20-Mar-87	1001	23989	512361	407	75484	577520	1148	325	22493	22.78	26.13	28.37	8637	638126	655210831	22688350
21-Mar-87	1001	23973	511541	409	75022	572129	1144	326	22478	22.76	26.10	28.34	8632	637027	655847858	22710828
22-Mar-87	1002	23958	511325	403	75119	575625	1141	324	22464	22.76	26.11	28.32	8627	636180	656484038	22733292
23-Mar-87	1001	23934	511642	407	74445	574092	1139	323	22441	22.80	26.12	28.35	8623	636202	657120241	22755733
24-Mar-87	1001	23925	511112	410	74533	572830	1144	325	22433	22.78	26.11	28.35	8628	635976	657756216	22778166
25-Mar-87	1001	23921	510743	405	74719	572896	1145	324	22429	22.77	26.10	28.32	8629	635189	658391405	22800595
26-Mar-87	1001	23903	509843	400	74502	576320	1144	324	22412	22.75	26.07	28.27	8627	633587	659024993	22823007
27-Mar-87	1002	23882	510010	407	73895	574636	1144	323	22393	22.78	26.08	28.31	8625	633946	659658939	22845400
28-Mar-87	1007	23862	510150	415	73856	573023	1145	324	22374	22.80	26.10	28.37	8624	634750	660293689	22867774
29-Mar-87	1002	23857	509477	398	74060	572912	1142	321	22369	22.78	26.09	28.27	8621	632372	660926061	22890143
30-Mar-87	1000	23821	509888	406	72608	574428	1147	320	22335	22.83	26.08	28.31	8624	632304	661558364	22912478
31-Mar-87	1000	23804	510016	405	72327	574033	1147	322	22319	22.85	26.09	28.31	8622	631851	662190215	22934797

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Apr-87	1001	23806	509762	405	74607	575121	1142	322	22321	22.84	26.18	28.4	8617	633916	662824132	22957118
2-Apr-87	1000	23795	509254	411	73297	572504	1140	322	22311	22.83	26.11	28.36	8614	632740	663456872	22979429
3-Apr-87	1002	23776	508976	404	72016	571976	1147	319	22293	22.83	26.06	28.28	8620	630446	664087318	23001722
4-Apr-87	1000	23781	509512	406	71871	569987	1138	321	22298	22.85	26.07	28.3	8611	631033	664718351	23024020
5-Apr-87	1000	22738	488424	401	69360	549553	1143	321	21320	22.91	26.16	28.36	8541	604635	665322986	23045340
6-Apr-87	1000	23733	508290	401	72080	574140	1147	321	22253	22.84	26.08	28.28	8617	629315	665952301	23067593
7-Apr-87	1000	23730	507739	402	72060	571448	1144	321	22250	22.82	26.06	28.26	8614	628785	666581086	23089843
8-Apr-87	1000	23727	506981	407	72043	579024	1142	320	22247	22.79	26.03	28.26	8612	628700	667209786	23112090
9-Apr-87	1001	23721	507120	410	71867	570132	1140	321	22242	22.80	26.03	28.28	8609	629004	667838790	23134332
10-Apr-87	1000	23705	506891	409	71855	570709	1137	320	22226	22.81	26.04	28.28	8605	628551	668467341	23156558
11-Apr-87	1001	23696	506572	411	72352	570038	1137	320	22218	22.80	26.06	28.31	8604	628992	669096333	23178776
12-Apr-87	1001	23684	506385	405	72846	571512	1138	318	22207	22.80	26.08	28.31	8604	628680	669725013	23200983
13-Apr-87	1002	23672	506387	402	72454	569336	1138	315	22196	22.81	26.08	28.29	8603	627925	670352938	23223179
14-Apr-87	503	23596	605888	406	27048	142666	1156	311	22086	27.43	28.66	30.88	8604	682016	671034954	23245265
15-Apr-87	505	26364	654408	438	25897	0	717	348	24677	26.52	27.57	29.96	8356	739323	671774277	23269942
16-Apr-87	1002	12756	186540	455	24008	207863	1147	374	11960	15.60	17.60	20.08	8022	240157	672014433	23281902
17-Apr-87	1000	23930	513645	450	68792	576265	1140	374	22437	22.89	25.96	28.41	8624	637435	672651869	23304339
18-Apr-87	1001	23868	510356	456	68118	572300	1141	374	22379	22.80	25.85	28.33	8621	633997	673285866	23326718
19-Apr-87	1000	23830	511404	452	67687	574064	1140	373	22344	22.89	25.92	28.38	8617	634123	673919988	23349062
20-Apr-87	1000	23801	508690	452	68558	573565	1139	373	22316	22.79	25.87	28.33	8614	632212	674552201	23371378
21-Apr-87	1000	23764	507637	455	67466	571544	1138	372	22282	22.78	25.81	28.29	8610	630358	675182558	23393660
22-Apr-87	1000	21257	459135	441	59290	516691	1700	299	19931	23.04	26.01	28.42	9025	566439	675748997	23413591
23-Apr-87	1000	19036	408137	445	53251	459327	1703	302	17849	22.87	25.85	28.28	8889	504770	676253767	23431440
24-Apr-87	1000	19054	408822	437	53944	458821	1703	301	17866	22.88	25.90	28.29	8891	505429	676759196	23449306
25-Apr-87	1000	19070	408873	443	53384	459135	1704	303	17881	22.87	25.85	28.27	8893	505496	677264692	23467187
26-Apr-87	1000	19088	408916	447	53629	462545	1705	304	17897	22.85	25.84	28.28	8895	506127	677770819	23485084
27-Apr-87	1002	19104	408516	449	54134	459033	1706	304	17913	22.81	25.83	28.28	8897	506580	678277399	23502997
28-Apr-87	1000	15818	357883	415	44927	401389	2210	226	14831	24.13	27.16	29.43	9240	436476	678713875	23517828
29-Apr-87	1002	14097	300150	402	40278	311023	2221	230	13218	22.71	25.76	27.96	9176	369575	679083451	23531046
30-Apr-87	1000	13943	298487	414	39728	317180	2238	228	13073	22.83	25.87	28.14	9187	367874	679451325	23544119

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-May-87	1001	13981	299125	402	40426	325260	2249	229	13109	22.82	25.90	28.11	9200	368494	679819819	23557228
2-May-87	1000	14002	299181	404	40281	328852	2248	229	13129	22.79	25.86	28.07	9200	368531	680188350	23570357
3-May-87	1000	14025	299243	401	40167	331224	2253	229	13150	22.76	25.81	28.01	9206	368332	680556681	23583507
4-May-87	1000	14044	299984	400	40052	327031	2258	227	13168	22.78	25.82	28.02	9212	368967	680925649	23596675
5-May-87	1001	10781	230757	401	31241	252677	2651	150	10109	22.83	25.92	28.12	9493	284265	681209914	23606784
6-May-87	999	9027	195485	399	23313	214919	2659	152	8464	23.10	25.85	28.04	9446	237331	681447244	23615248
7-May-87	1002	9047	196065	398	26609	214323	2667	152	8483	23.11	26.25	28.44	9454	241257	681688501	23623731
8-May-87	1001	9068	196215	404	24604	213431	2676	154	8502	23.08	25.97	28.19	9465	239671	681928172	23632233
9-May-87	999	9093	196863	402	24049	214381	2684	156	8526	23.09	25.91	28.12	9474	239751	682167923	23640759
10-May-87	1001	9093	196783	402	27783	214917	2694	155	8526	23.08	26.34	28.55	9483	243417	682411341	23649285
11-May-87	1002	8967	194741	400	27133	213986	2711	150	8408	23.16	26.39	28.59	9497	240385	682651725	23657693
12-May-87	1001	5563	131571	401	20193	143770	2939	89	5216	25.22	29.10	31.3	9644	163261	682814986	23662909
13-May-87	1002	4512	97785	398	16273	101342	2946	90	4231	23.11	26.96	29.15	9641	123334	682938320	23667140
14-May-87	1000	4470	97262	400	16530	105944	2960	89	4191	23.21	27.15	29.35	9654	123006	683061326	23671331
15-May-87	1000	4455	93350	399	15733	104608	2972	91	4177	22.35	26.11	28.31	9669	118251	683179576	23675508
16-May-87	1001	4531	98194	401	15717	105182	2981	91	4248	23.11	26.81	29.01	9678	123234	683302811	23679756
17-May-87	1000	4525	97930	400	15916	104391	2996	91	4243	23.08	26.83	29.03	9693	123174	683425985	23683999
18-May-87	1001	4529	96641	400	16040	103994	3004	92	4247	22.76	26.53	28.73	9702	122016	683548002	23688246
19-May-87	998	8215	174966	398	31246	186507	2746	173	7703	22.72	26.77	28.96	9511	223079	683771080	23695949
20-May-87	1001	10051	217510	402	34906	236541	2751	174	9424	23.08	26.78	28.99	9570	273202	684044282	23705373
21-May-87	1002	10088	218595	407	35183	236382	2751	175	9459	23.11	26.83	29.06	9571	274879	684319161	23714832
22-May-87	1004	10092	218498	406	34151	252649	2762	175	9463	23.09	26.70	28.93	9583	273765	684592925	23724295
23-May-87	1000	9799	212348	405	33252	231843	2771	174	9188	23.11	26.73	28.95	9583	265993	684858918	23733483
24-May-87	999	9955	214990	402	35094	235019	2776	175	9334	23.03	26.79	29	9593	270686	685129604	23742817
25-May-87	1001	9953	215078	406	33971	230839	2780	175	9332	23.05	26.69	28.91	9597	269788	685399392	23752149
26-May-87	1000	9981	215867	401	33480	235947	2782	176	9358	23.07	26.64	28.85	9600	269978	685669370	23761507
27-May-87	1002	9965	215932	400	30504	235079	2788	175	9344	23.11	26.38	28.57	9607	266958	685936328	23770851
28-May-87	1002	9939	215217	402	24353	242161	2792	176	9319	23.09	25.71	27.91	9612	260093	686196422	23780170
29-May-87	1002	9992	216512	398	29170	240874	2797	176	9369	23.11	26.22	28.41	9617	266173	686462595	23789539
30-May-87	1001	10006	216845	402	29295	239789	2805	177	9382	23.11	26.24	28.44	9626	266824	686729419	23798921
31-May-87	1000	10029	217237	399	29674	240646	2810	178	9403	23.10	26.26	28.45	9632	267515	686996934	23808324

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Jun-87	1001	10040	217358	401	29710	240905	2809	179	9414	23.09	26.25	28.45	9631	267828	687264763	23817738
2-Jun-87	1001	10062	217965	402	28947	240940	2812	178	9434	23.10	26.17	28.38	9635	267737	687532500	23827172
3-Jun-87	1002	10068	217938	399	28948	241079	2826	172	9440	23.09	26.15	28.34	9650	267530	687800029	23836612
4-Jun-87	1000	10091	218029	400	30597	242325	2823	174	9462	23.04	26.28	28.47	9647	269383	688069412	23846074
5-Jun-87	1002	10042	217367	395	30423	244437	2836	173	9416	23.09	26.32	28.49	9659	268262	688337674	23855490
6-Jun-87	1002	9959	216227	402	29414	241644	2834	175	9338	23.16	26.31	28.51	9654	266226	688603901	23864828
7-Jun-87	1002	9981	215954	401	29773	240207	2848	175	9359	23.08	26.26	28.46	9670	266357	688870258	23874187
8-Jun-87	1000	9983	215977	400	30401	240094	2851	177	9360	23.07	26.32	28.52	9673	266947	689137205	23883547
9-Jun-87	1001	10001	216980	399	31096	240729	2856	177	9377	23.14	26.46	28.65	9678	268651	689405856	23892924
10-Jun-87	1000	9985	216683	402	30827	240833	2859	178	9362	23.14	26.44	28.64	9681	268128	689673984	23902286
11-Jun-87	999	10014	216931	399	31656	241640	2860	176	9389	23.10	26.48	28.67	9682	269183	689943166	23911675
12-Jun-87	1001	10032	217398	402	30805	241828	2867	179	9406	23.11	26.39	28.59	9690	268918	690212084	23921081
13-Jun-87	1002	10062	217616	400	31165	240656	2870	178	9434	23.07	26.37	28.57	9695	269529	690481613	23930515
14-Jun-87	1001	10082	218104	399	30852	241244	2874	179	9453	23.07	26.34	28.53	9699	269694	690751307	23939968
15-Jun-87	1000	10043	217669	402	30892	240379	2887	178	9417	23.12	26.40	28.6	9711	269326	691020634	23949385
16-Jun-87	998	10010	217682	401	31180	241683	2898	179	9386	23.19	26.52	28.72	9721	269566	691290199	23958771
17-Jun-87	999	10019	218185	400	30816	239831	2895	180	9394	23.23	26.51	28.7	9719	269608	691559807	23968165
18-Jun-87	1001	10021	217828	402	28967	237739	2903	179	9396	23.18	26.27	28.47	9728	267504	691827311	23977561
19-Jun-87	1002	10027	217159	403	29504	239589	2907	172	9402	23.10	26.24	28.45	9732	267487	692094798	23986963
20-Jun-87	1000	10043	217334	403	28834	239501	2912	177	9417	23.08	26.14	28.35	9738	266972	692361770	23996380
21-Jun-87	999	10054	217304	401	27635	239850	2913	177	9427	23.05	25.98	28.18	9740	265653	692627423	24005807
22-Jun-87	1000	10080	217718	402	27983	238693	2920	178	9451	23.04	26.00	28.2	9748	266518	692893941	24015258
23-Jun-87	1002	10083	219339	407	27408	240363	2938	179	9454	23.20	26.10	28.33	9766	267832	693161773	24024712
24-Jun-87	1002	10088	218403	400	28004	236924	2939	173	9459	23.09	26.05	28.25	9768	267217	693428990	24034171
25-Jun-87	1002	9935	215541	402	27917	241699	2944	172	9315	23.14	26.14	28.34	9768	263987	693692977	24043486
26-Jun-87	1001	9909	214493	405	29515	238965	2952	174	9291	23.09	26.26	28.48	9775	264608	693957585	24052777
27-Jun-87	1000	9915	214970	395	30598	240114	2955	175	9297	23.12	26.41	28.58	9778	265708	694223293	24062074
28-Jun-87	1002	9927	215394	396	30552	240187	2961	175	9308	23.14	26.42	28.6	9784	266209	694489502	24071382
29-Jun-87	1002	9941	214998	400	30965	238674	2966	177	9321	23.07	26.39	28.58	9790	265394	694755896	24080703
30-Jun-87	1000	9948	215325	398	30621	239682	2961	176	9328	23.08	26.37	28.55	9785	266314	695022210	24090031

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Jul-87	1001	9958	216029	400	30331	240216	2964	177	9337	23.14	26.39	28.58	9788	266851	695289062	24099368
2-Jul-87	1001	9970	216132	396	29797	239732	2980	176	9348	23.12	26.31	28.48	9806	266231	695555293	24108716
3-Jul-87	1002	9982	216034	401	29454	237918	2982	178	9359	23.08	26.23	28.43	9808	266076	695821369	24118075
4-Jul-87	1000	9991	216792	398	30092	237998	2977	177	9368	23.14	26.35	28.54	9803	267363	696088732	24127443
5-Jul-87	1000	9999	216328	408	29475	238538	2982	176	9375	23.07	26.22	28.46	9809	266813	696355544	24136818
6-Jul-87	1001	10015	216657	407	29181	239095	2987	179	9390	23.07	26.18	28.41	9815	266770	696622314	24146208
7-Jul-87	1000	10015	217024	404	29663	238403	2991	179	9390	23.11	26.27	28.49	9818	267521	696889835	24155598
8-Jul-87	999	10028	217538	401	30288	239327	2996	179	9403	23.14	26.36	28.56	9824	268550	697158385	24165001
9-Jul-87	1000	10043	217931	400	30617	241505	3007	178	9417	23.14	26.39	28.59	9836	269232	697427617	24174418
10-Jul-87	1000	10056	218102	401	30925	241758	3006	181	9429	23.13	26.41	28.61	9835	269764	697697381	24183847
11-Jul-87	1000	10065	218146	400	31548	240656	3015	180	9437	23.12	26.46	28.65	9844	270370	697967751	24193284
12-Jul-87	1002	10073	218267	402	31674	240484	3008	181	9445	23.11	26.46	28.67	9837	270788	698238539	24202729
13-Jul-87	1002	10084	218391	401	31573	241191	3004	180	9455	23.10	26.44	28.64	9834	270791	698509330	24212184
14-Jul-87	999	10093	218002	402	30886	241008	3014	180	9463	23.04	26.30	28.51	9845	269790	698779120	24221647
15-Jul-87	1000	10054	217564	404	31723	242025	3016	182	9427	23.08	26.44	28.66	9845	270178	699049298	24231074
16-Jul-87	1001	9921	217452	420	29717	241051	3045	178	9302	23.38	26.57	28.87	9870	268549	699317847	24240376
17-Jul-87	1002	9895	215270	412	29056	239680	3039	177	9278	23.20	26.33	28.59	9864	265258	699583105	24249654
18-Jul-87	1000	9944	215523	403	29449	238637	3046	178	9324	23.12	26.27	28.49	9873	265641	699848746	24258978
19-Jul-87	1001	9981	216159	399	29797	238874	3041	180	9358	23.10	26.28	28.47	9869	266422	700115168	24268336
20-Jul-87	1001	9984	216937	392	29588	236252	3040	174	9361	23.17	26.33	28.49	9868	266695	700381863	24277697
21-Jul-87	1000	9991	216543	408	29552	238047	3046	173	9368	23.12	26.27	28.51	9874	267082	700648944	24287065
22-Jul-87	1001	10003	216967	411	30130	237620	3051	176	9379	23.13	26.35	28.6	9880	268239	700917184	24296444
23-Jul-87	1002	10021	217323	399	20556	240537	3057	178	9396	23.13	25.32	27.51	9889	258484	701175668	24305840
24-Jul-87	1002	10030	217413	399	30018	240758	3058	179	9404	23.12	26.31	28.5	9888	268014	701443682	24315244
25-Jul-87	1001	10037	217530	401	29507	240726	3058	178	9411	23.11	26.25	28.45	9888	267743	701711425	24324655
26-Jul-87	1001	10040	217597	398	29690	240468	3058	180	9414	23.11	26.27	28.45	9889	267828	701979253	24334069
27-Jul-87	1001	10046	217596	402	29966	240152	3060	181	9419	23.10	26.28	28.49	9891	268347	702247600	24343488
28-Jul-87	1001	10056	217618	400	29910	240188	3061	181	9429	23.08	26.25	28.45	9892	268255	702515855	24352917
29-Jul-87	1001	10062	218195	397	30181	241011	3062	181	9434	23.13	26.33	28.51	9893	268963	702784819	24362351
30-Jul-87	1001	10069	217753	401	30383	241311	3067	182	9441	23.06	26.28	28.48	9899	268880	703053698	24371792
31-Jul-87	1001	10064	217855	402	30860	241748	3072	182	9436	23.09	26.36	28.56	9903	269492	703323191	24381228

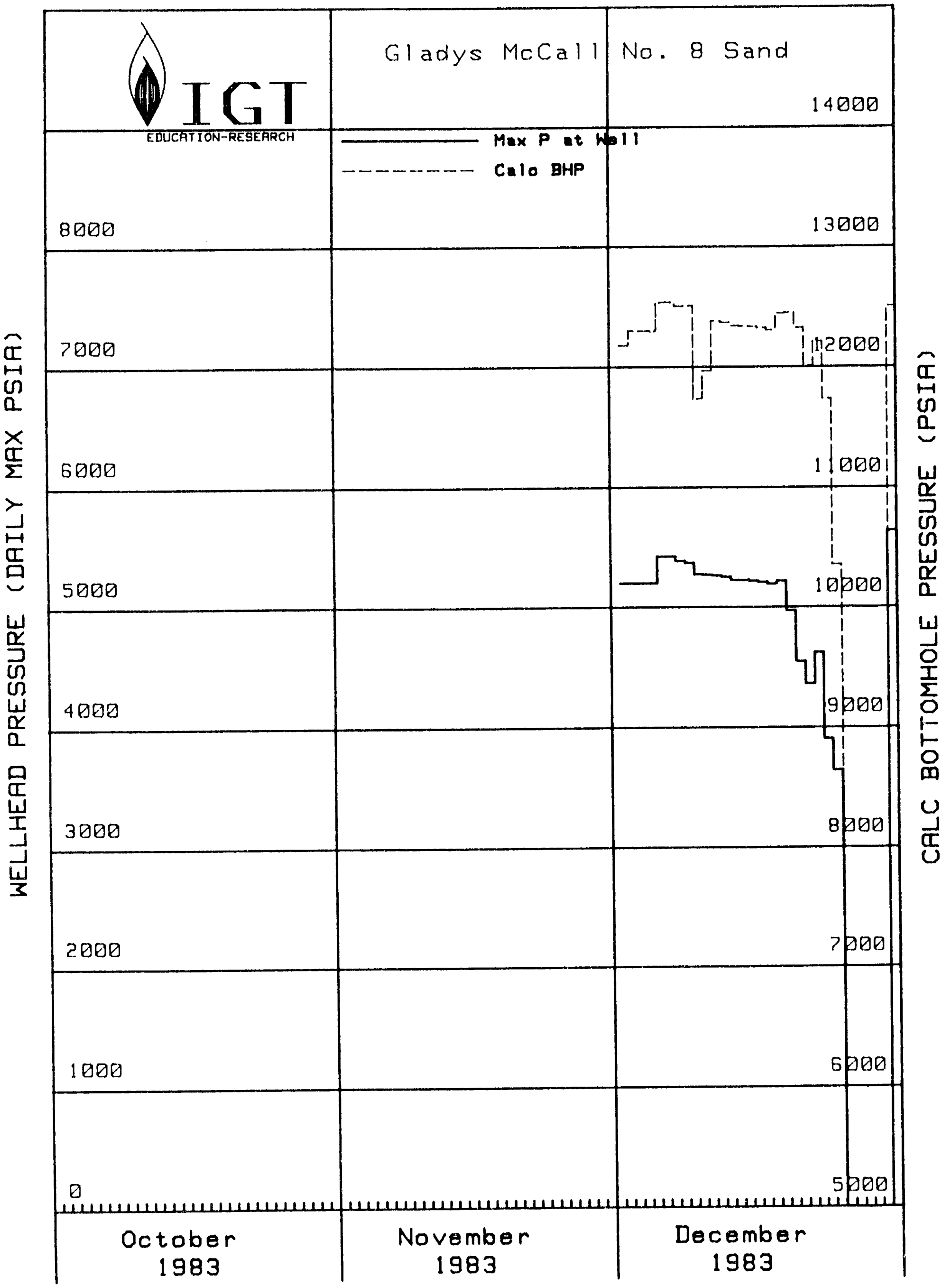
Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Aug-87	1001	10041	218192	399	30636	242229	3076	181	9415	23.18	26.43	28.62	9907	269457	703592648	24390643
2-Aug-87	1003	10074	218376	404	30708	243929	3075	182	9446	23.12	26.37	28.59	9907	270061	703862709	24400089
3-Aug-87	1001	10085	218140	403	30627	243421	3084	178	9456	23.07	26.31	28.52	9917	269685	704132394	24409545
4-Aug-87	1001	9995	217066	399	30036	242782	3088	181	9372	23.16	26.37	28.56	9918	267664	704400059	24418917
5-Aug-87	1000	10005	217270	401	30340	242958	3091	181	9381	23.16	26.39	28.6	9921	268297	704668355	24428298
6-Aug-87	1000	10014	217181	401	30258	241381	3093	181	9389	23.13	26.35	28.55	9924	268056	704936411	24437687
7-Aug-87	1000	10021	217008	396	29989	241208	3102	182	9396	23.10	26.29	28.46	9933	267410	705203821	24447083
8-Aug-87	1001	10039	217489	399	30640	241580	3110	183	9413	23.11	26.36	28.55	9942	268741	705472562	24456496
9-Aug-87	999	10050	217385	408	30469	241196	3109	183	9423	23.07	26.30	28.54	9941	268932	705741495	24465919
10-Aug-87	1002	10035	217367	410	30282	242169	3103	179	9409	23.10	26.32	28.57	9935	268815	706010310	24475328
11-Aug-87	1000	10054	217607	398	30011	241557	3108	180	9427	23.08	26.27	28.45	9941	268198	706278508	24484755
12-Aug-87	1001	10062	217522	409	29022	241509	3110	181	9434	23.06	26.13	28.37	9943	267643	706546151	24494189
13-Aug-87	1002	10064	217926	397	29260	243253	3114	182	9436	23.09	26.20	28.38	9947	267794	706813944	24503625
14-Aug-87	1002	10074	218344	400	29595	242406	3117	179	9446	23.12	26.25	28.44	9951	268644	707082589	24513071
15-Aug-87	1001	10085	218629	406	29323	242741	3125	182	9456	23.12	26.22	28.45	9959	269023	707351612	24522527
16-Aug-87	1002	10087	218052	395	29317	243208	3124	181	9458	23.05	26.15	28.32	9959	267851	707619462	24531985
17-Aug-87	1001	10034	217840	395	29206	242328	3134	178	9408	23.15	26.26	28.43	9967	267469	707886932	24541393
18-Aug-87	1000	9976	216529	400	29146	241918	3137	181	9354	23.15	26.26	28.46	9968	266215	708153147	24550747
19-Aug-87	1001	9997	216863	404	29423	241850	3147	182	9374	23.14	26.27	28.49	9979	267065	708420212	24560121
20-Aug-87	1000	10010	217103	402	29710	240853	3155	182	9386	23.13	26.30	28.5	9988	267501	708687713	24569507
21-Aug-87	1000	10015	217015	401	31426	241030	3157	183	9390	23.11	26.46	28.66	9989	269117	708956830	24578897
22-Aug-87	1000	10016	216907	402	30234	241795	3154	180	9391	23.10	26.32	28.52	9987	267831	709224662	24588288
23-Aug-87	1001	10017	216937	399	30080	241168	3158	181	9392	23.10	26.30	28.49	9991	267578	709492240	24597680
24-Aug-87	1000	10031	217189	400	29605	240784	3158	182	9405	23.09	26.24	28.44	9992	267478	709759718	24607085
25-Aug-87	1000	10033	217048	401	30199	240694	3160	183	9407	23.07	26.28	28.48	9994	267911	710027629	24616492
26-Aug-87	998	10034	217320	404	29821	241050	3153	183	9408	23.10	26.27	28.49	9986	268034	710295663	24625900
27-Aug-87	999	10057	217513	403	28637	241684	3153	183	9430	23.07	26.10	28.32	9988	267058	710562721	24635330
28-Aug-87	1001	10031	217359	403	29225	241729	3158	193	9405	23.11	26.22	28.43	9992	267384	710830105	24644735
29-Aug-87	1002	10041	217343	404	29858	241364	3162	194	9415	23.09	26.26	28.47	9996	268045	711098150	24654150
30-Aug-87	999	10042	217813	397	29841	242108	3161	193	9416	23.13	26.30	28.48	9995	268168	711366318	24663566
31-Aug-87	1000	10036	217451	401	30091	241941	3167	194	9410	23.11	26.31	28.51	10001	268279	711634597	24672976

Date	1st Stage Separator			2nd Stage Separator		Sales Gas	Max Surface Pressure		Brine Rate	Cum Gas/Brine Ratios			Calc BHP	Perf Gas	Cum Gas	Cum Brine
	Press (psig)	Brine Rate (RB/d)	Gas Rate (scf/d)	Press (psig)	Gas Rate (scf/d)	(scf/d)	Prod Well (psig)	Disp Well (psig)	(stb/d)	1st Stage (scf/stb)	2nd Stg (scf/stb)	Disp Well (scf/stb)	(psia)	(scf/d)	(scf)	(stb)
1-Oct-87	1000	9991	216282	402	30549	241996	3245	186	9368	23.09	26.35	28.55	10080	267456	719754259	24960128
2-Oct-87	1010	9992	216430	400	30205	242554	3252	189	9369	23.10	26.32	28.52	10087	267204	720021463	24969497
3-Oct-87	1000	10007	216548	400	29893	242169	3248	186	9383	23.08	26.27	28.46	10084	267040	720288503	24978880
4-Oct-87	998	10023	216896	403	29416	242427	3255	192	9398	23.08	26.21	28.42	10091	267091	720555594	24988278
5-Oct-87	1000	10031	217517	400	29535	241921	3254	189	9405	23.13	26.27	28.46	10091	267666	720823261	24997683
6-Oct-87	1001	10027	216904	400	30236	241516	3252	190	9402	23.07	26.29	28.48	10088	267769	721091030	25007085
7-Oct-87	1000	10039	217107	401	29983	241885	3259	192	9413	23.06	26.25	28.45	10096	267800	721358829	25016498
8-Oct-87	1023	10015	217157	405	29746	241248	3260	192	9391	23.12	26.29	28.51	10096	267737	721626567	25025889
9-Oct-87	1000	10008	215735	405	30646	241919	3285	193	9384	22.99	26.26	28.48	10122	267256	721893823	25035273
10-Oct-87	1000	10048	216885	398	30124	242833	3259	195	9421	23.02	26.22	28.4	10096	267556	722161379	25044694
11-Oct-87	1009	10048	217370	400	29609	242441	3263	194	9422	23.07	26.21	28.41	10100	267679	722429059	25054116
12-Oct-87	1015	10046	217400	402	30295	241057	3269	193	9420	23.08	26.29	28.5	10106	268470	722697529	25063536
13-Oct-87	1000	10055	217258	402	29626	241954	3269	191	9428	23.04	26.19	28.39	10107	267661	722965189	25072964
14-Oct-87	1015	10053	217067	409	29475	242420	3269	192	9426	23.03	26.15	28.4	10107	267698	723232888	25082390
15-Oct-87	999	10061	217192	404	29715	243105	3265	193	9433	23.02	26.17	28.39	10103	267803	723500691	25091823
16-Oct-87	1000	10068	217505	402	29617	242699	3269	193	9440	23.04	26.18	28.38	10107	267907	723768598	25101263
17-Oct-87	1011	10088	218025	400	29796	243274	3269	192	9459	23.05	26.20	28.39	10108	268541	724037139	25110722
18-Oct-87	1018	10069	217872	401	30504	242956	3273	193	9442	23.08	26.31	28.51	10111	269191	724306330	25120164
19-Oct-87	1014	10077	217774	398	30579	242587	3276	192	9449	23.05	26.28	28.47	10115	269013	724575343	25129613
20-Oct-87	1008	9951	215563	402	29879	240851	3284	192	9331	23.10	26.31	28.51	10119	266027	724841370	25138944
21-Oct-87	1001	9937	215846	403	30498	241311	3289	190	9317	23.17	26.44	28.65	10123	266932	725108302	25148261
22-Oct-87	1006	9922	215714	409	29775	242284	3293	194	9303	23.19	26.39	28.63	10127	266345	725374647	25157564
23-Oct-87	1001	9935	215097	405	30984	241030	3289	193	9315	23.09	26.42	28.64	10123	266782	725641429	25166879
24-Oct-87	1022	9948	216044	399	31765	242615	3292	195	9328	23.16	26.57	28.76	10126	268273	725909702	25176207
25-Oct-87	1001	11438	241031	407	36701	272736	2928	252	10725	22.47	25.90	28.13	9802	301694	726211396	25186932
26-Oct-87	1002	12074	264283	402	40698	287846	3281	402	11321	23.34	26.94	29.15	10187	330007	726541403	25198253
27-Oct-87	1004	9955	215383	397	41669	238665	3288	191	9334	23.07	27.54	29.72	10120	277406	726818810	25207587
28-Oct-87	1010	9950	215649	400	31529	241581	3295	192	9330	23.11	26.49	28.69	10130	267678	727086488	25216917
29-Oct-87	1003	9952	215396	400	31529	241827	3289	192	9331	23.08	26.46	28.66	10124	267426	727353914	25226248
30-Oct-87	1003	4988	116874	400	16513	131317	3584	192	4677	24.99	28.52	30.72	10303	143677	727497591	25230925

Date	1st Stage Separator Press (psig)	1st Stage Separator Brine Rate (RB/d)	1st Stage Separator Gas Rate (scf/d)	2nd Stage Separator Press (psig)	2nd Stage Separator Gas Rate (scf/d)	Sales Gas (scf/d)	Max Surface Pressure Prod Well (psig)	Max Surface Pressure Disp Well (psig)	Brine Rate (stb/d)	Cum Gas/Brine Ratios 1st Stage (scf/stb)	Cum Gas/Brine Ratios 2nd Stg (scf/stb)	Cum Gas/Brine Ratios Disp Well (scf/stb)	Calc BHP (psia)	Perf Gas (scf/d)	Cum Gas (scf)	Cum Brine (stb)
1-Sep-87	1001	10037	217437	397	30157	242677	3165	188	9411	23.10	26.31	28.49	9999	268119	711902716	24682387
2-Sep-87	1001	10040	217808	403	30154	241855	3166	191	9414	23.14	26.34	28.55	10000	268770	712171486	24691801
3-Sep-87	1000	8220	180385	402	19021	196388	3322	143	7707	23.40	25.87	28.08	10109	216413	712387898	24699508
4-Sep-87	1000	9434	203115	400	26537	222524	3173	185	8846	22.96	25.96	28.16	9989	249103	712637002	24708354
5-Sep-87	1000	7956	176683	400	23964	195116	3163	197	7460	23.68	26.90	29.09	9936	217011	712854013	24715814
6-Sep-87	1009	10092	219259	400	31454	247210	3183	189	9463	23.17	26.49	28.69	10019	271493	713125507	24725277
7-Sep-87	1000	10072	218533	400	31398	243074	3190	189	9444	23.14	26.47	28.66	10025	270665	713396172	24734721
8-Sep-87	1000	9985	216350	400	30966	242438	3193	191	9362	23.11	26.42	28.61	10026	267847	713664018	24744083
9-Sep-87	998	9990	216626	402	30925	242840	3193	191	9367	23.13	26.43	28.63	10026	268177	713932196	24753450
10-Sep-87	1012	10011	217068	408	30292	243774	3194	192	9387	23.12	26.35	28.59	10028	268374	714200570	24762837
11-Sep-87	1008	10002	217234	407	30525	243984	3197	190	9378	23.16	26.42	28.65	10030	268680	714469250	24772215
12-Sep-87	1005	10044	218150	408	30348	243170	3205	193	9418	23.16	26.39	28.62	10040	269543	714738793	24781633
13-Sep-87	1014	10041	127950	406	29951	242841	3203	192	9415	13.59	16.77	19	10053	178885	714917678	24791048
14-Sep-87	1005	10058	218009	403	30465	242257	3208	192	9431	23.12	26.35	28.56	10044	269349	715187027	24800479
15-Sep-87	1001	10056	218065	400	30378	241849	3204	192	9429	23.13	26.35	28.55	10040	269198	715456225	24809908
16-Sep-87	999	10081	218444	406	30027	242086	3205	191	9452	23.11	26.29	28.51	10041	269477	715725702	24819360
17-Sep-87	1000	10088	218534	399	30118	243734	3209	191	9459	23.10	26.29	28.48	10046	269392	715995094	24828819
18-Sep-87	1019	10081	218483	405	29823	242293	3213	192	9453	23.11	26.27	28.49	10050	269316	716264410	24838272
19-Sep-87	1009	10069	218293	402	30506	242239	3213	192	9441	23.12	26.35	28.56	10049	269635	716534045	24847713
20-Sep-87	999	10075	218323	399	30704	243193	3215	192	9447	23.11	26.36	28.55	10051	269712	716803757	24857160
21-Sep-87	1000	9988	216851	398	30227	242300	3226	191	9365	23.16	26.38	28.57	10060	267558	717071315	24866525
22-Sep-87	1006	9967	216012	402	29995	241024	3228	191	9346	23.11	26.32	28.53	10062	266641	717337956	24875871
23-Sep-87	999	9970	216059	402	30447	241208	3229	188	9348	23.11	26.37	28.58	10063	267166	717605122	24885219
24-Sep-87	1001	9983	217155	407	30574	242833	3231	191	9360	23.20	26.47	28.7	10065	268632	717873754	24894579
25-Sep-87	1001	9986	216908	402	30826	242330	3235	189	9363	23.17	26.46	28.66	10069	268344	718142098	24903942
26-Sep-87	1001	9995	216987	402	31093	242504	3239	188	9372	23.15	26.47	28.68	10073	268789	718410887	24913314
27-Sep-87	1002	9972	216994	405	31541	242482	3241	188	9350	23.21	26.58	28.8	10074	269280	718680167	24922664
28-Sep-87	1001	9984	216960	404	31214	242466	3242	188	9361	23.18	26.51	28.73	10076	268942	718949108	24932025
29-Sep-87	1011	9990	217058	403	31183	242827	3244	188	9367	23.17	26.50	28.71	10078	268927	719218035	24941392
30-Sep-87	1020	9990	217294	408	30513	242864	3242	190	9368	23.20	26.45	28.69	10076	268768	719486803	24950760

APPENDIX D

Sand 8 Graphical Production Data



IGT
EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
Max P at Well
Calc BHP
WELLHEAD PRESSURE (DAILY MAX PSIA)
CALC BOTTOMHOLE PRESSURE (PSIA)
8000
7000
6000
5000
4000
3000
2000
1000
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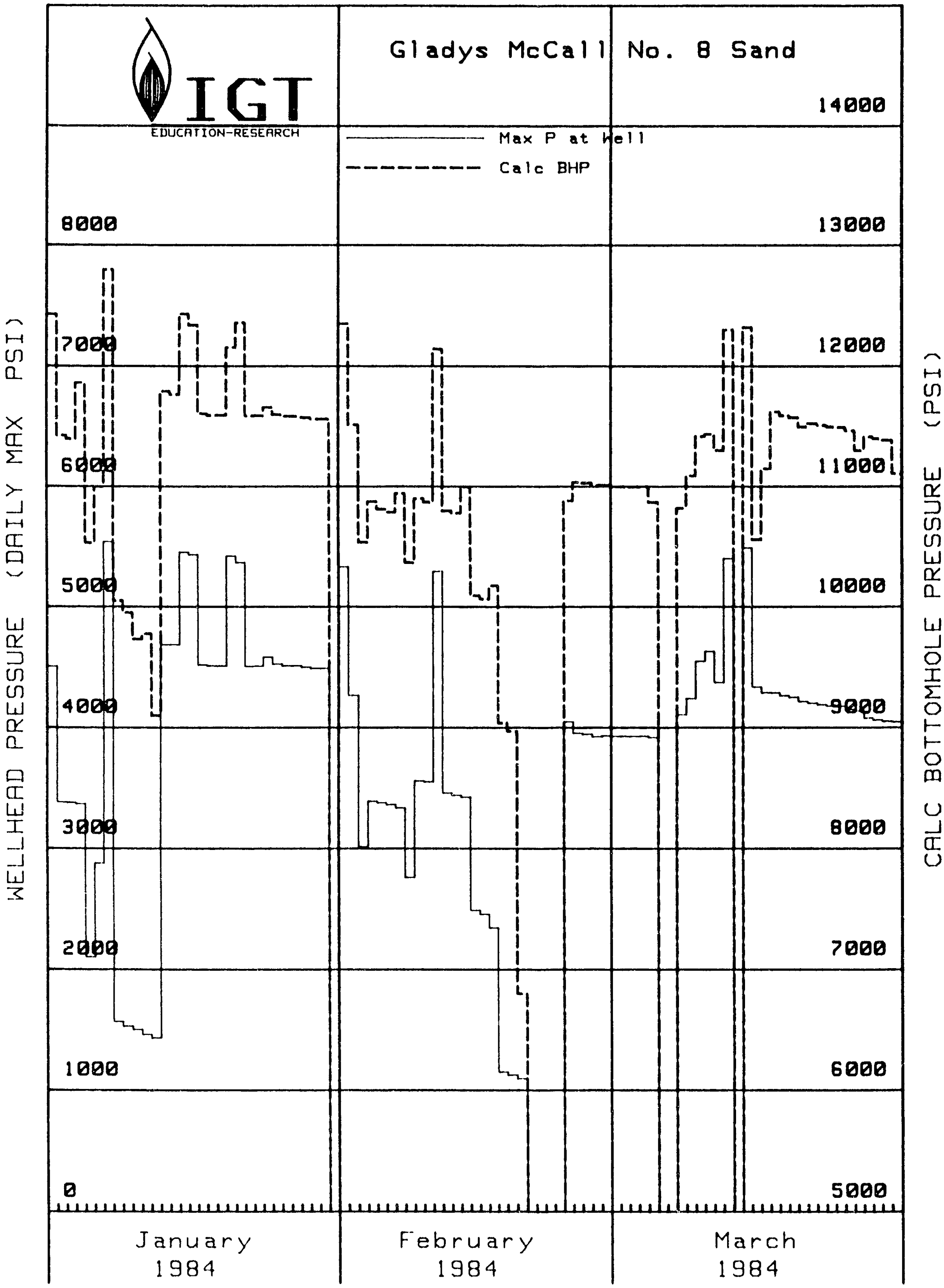
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
October 1983
November 1983
December 1983


IGT
EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
Max P at Well
Calc BHP
WELLHEAD PRESSURE (DAILY MAX PSI)
CALC BOTTOMHOLE PRESSURE (PSI)
8000
7000
6000
5000
4000
3000
2000
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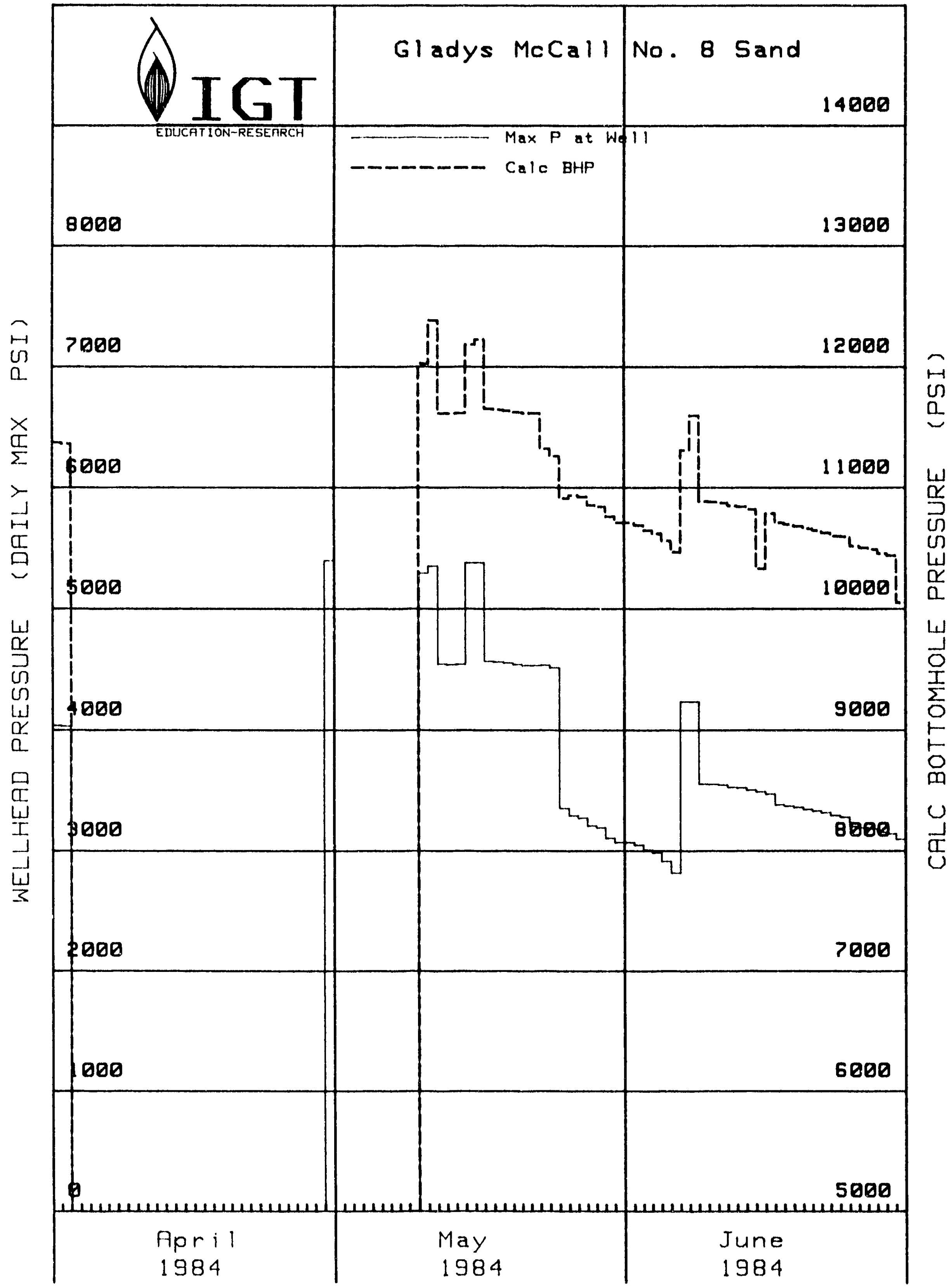
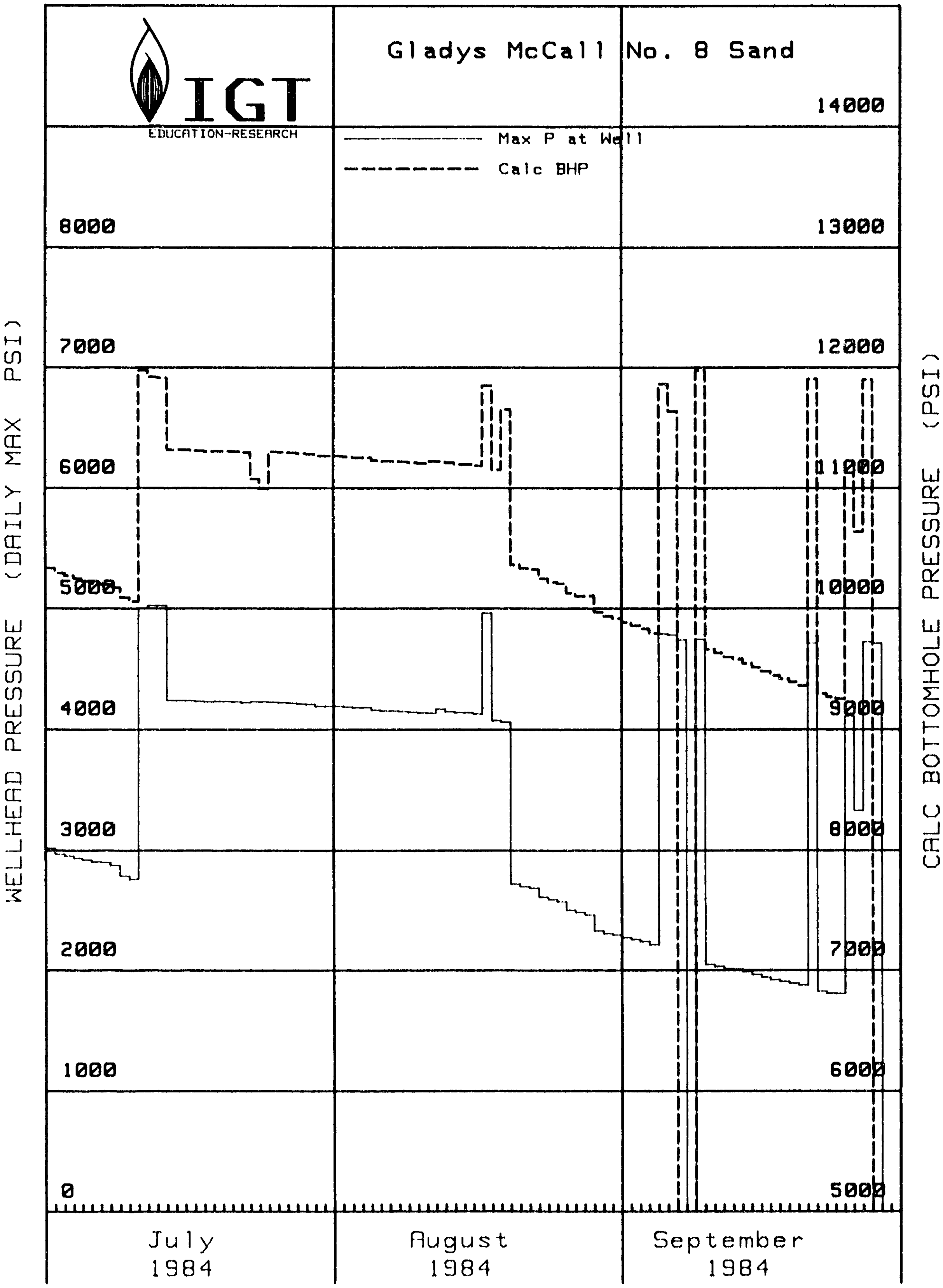
8000
7000
6000
5000
January 1984
February 1984
March 1984


IGT
EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
Max P at Well
Calc BHP
WELLHEAD PRESSURE (DAILY MAX PSI)
CALC BOTTOMHOLE PRESSURE (PSI)
8000
7000
6000
5000
4000
3000
2000
1000
0
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
April 1984
May 1984
June 1984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Calc BHP
WELLHEAD PRESSURE (DAILY MAX PSI)
CALC BOTTOMHOLE PRESSURE (PSI)
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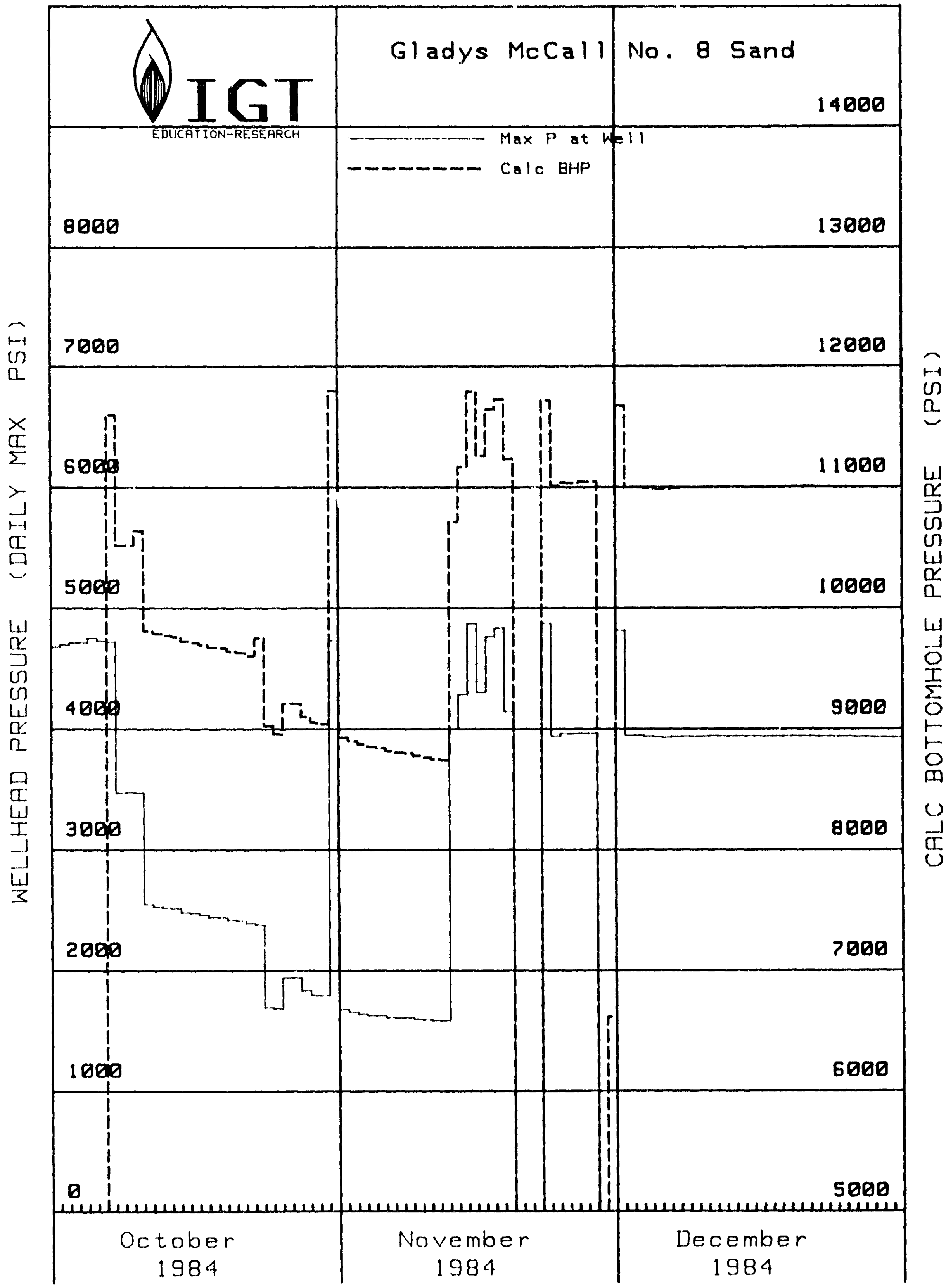
September 1984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EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
Max P at Well
Calc BHP
WELLHEAD PRESSURE (DAILY MAX PSI)
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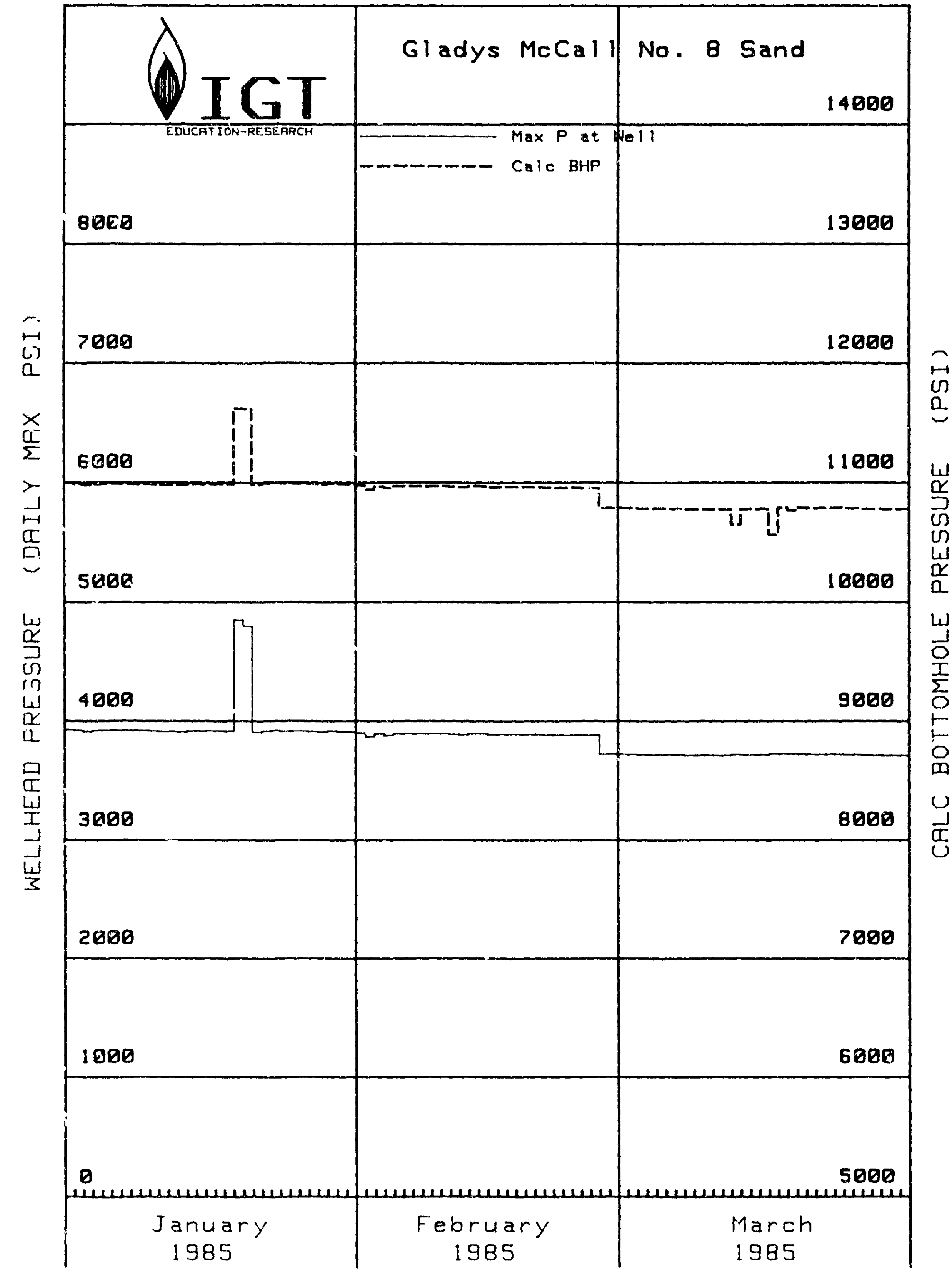
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EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
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Calc BHP
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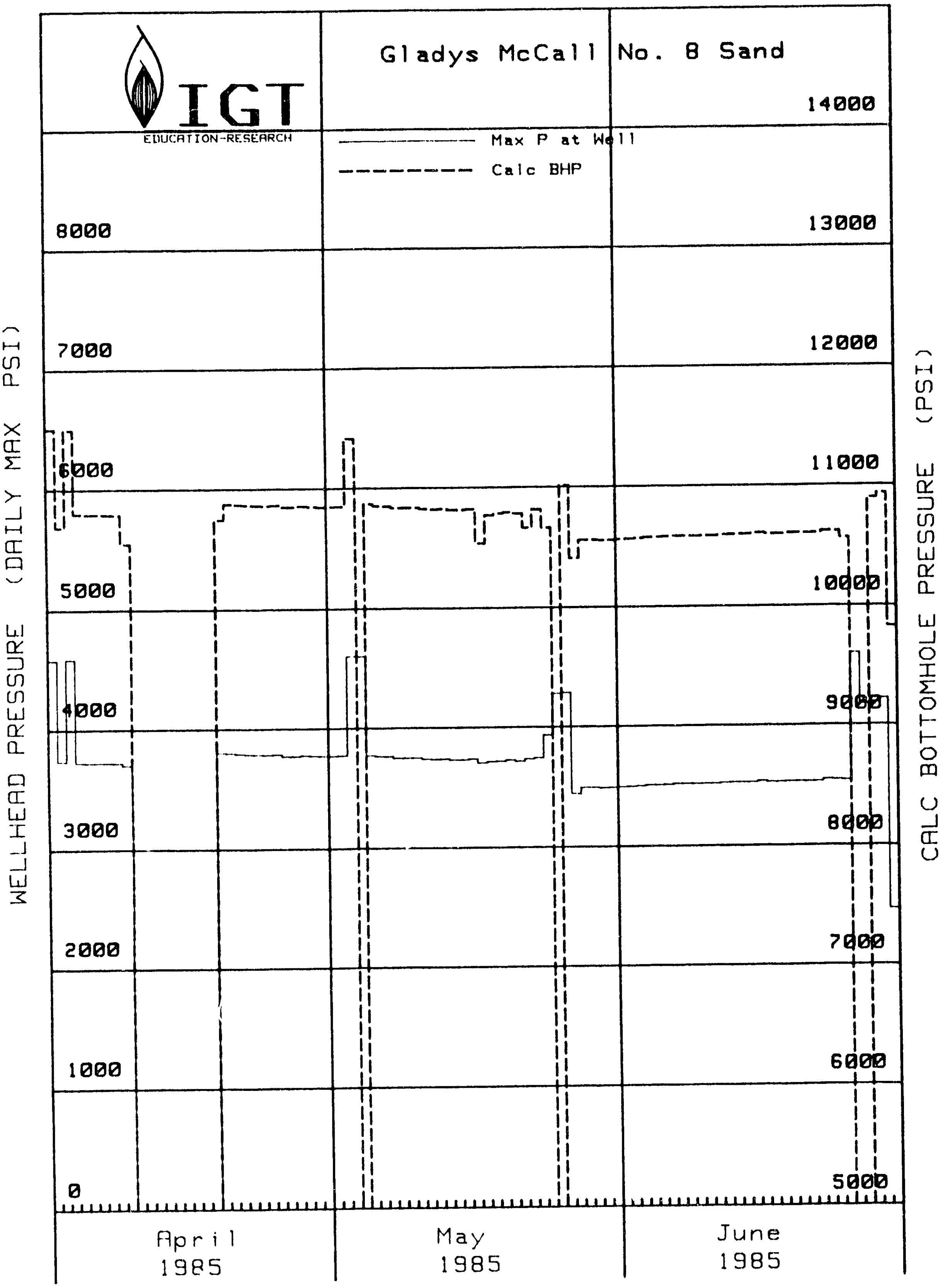

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EDUCATION-RESEARCH
Max P at Well
Calc BHP
WELLHEAD PRESSURE (DAILY MAX PSI)
CALC BOTTOMHOLE PRESSURE (PSI)
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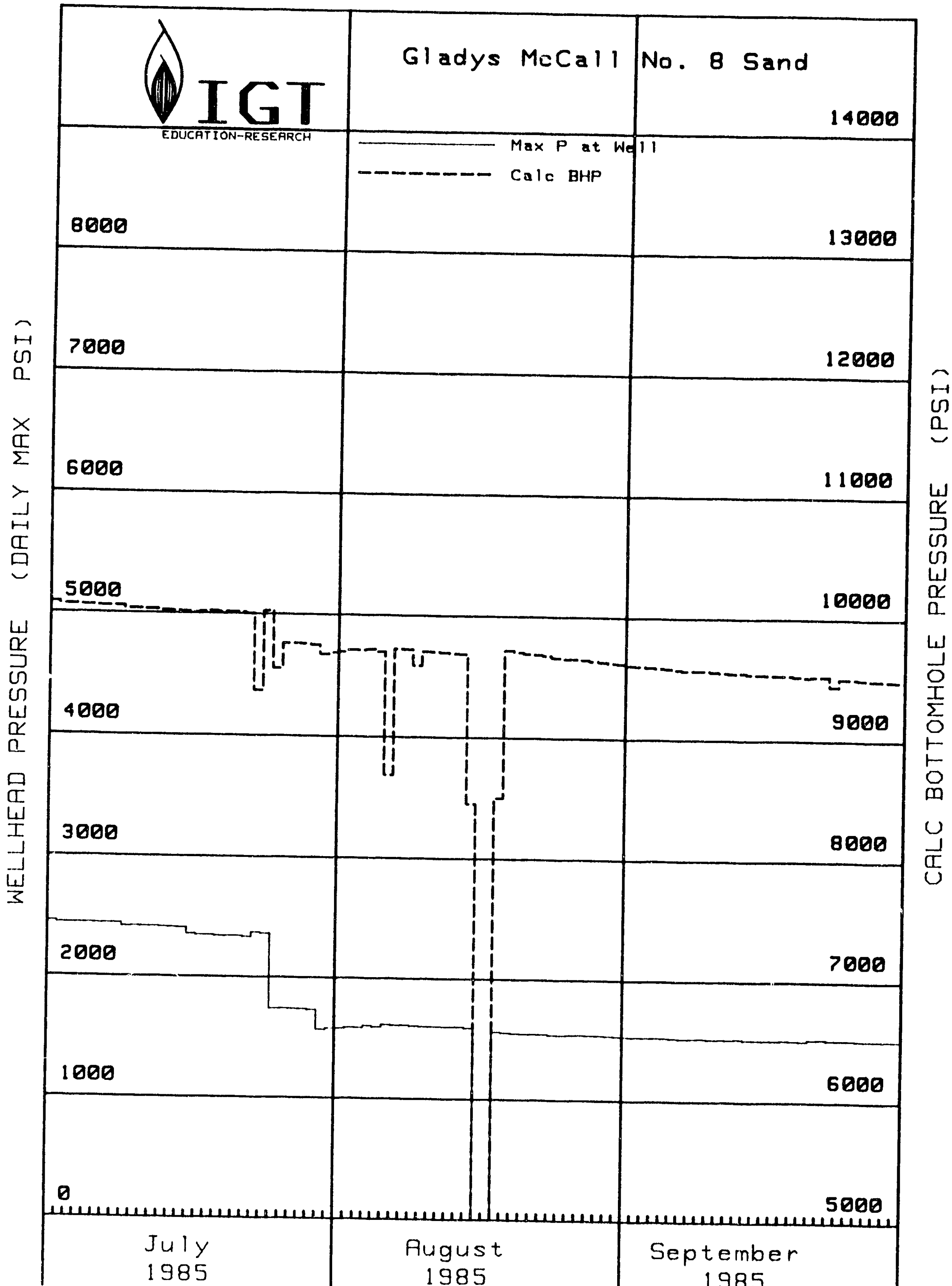

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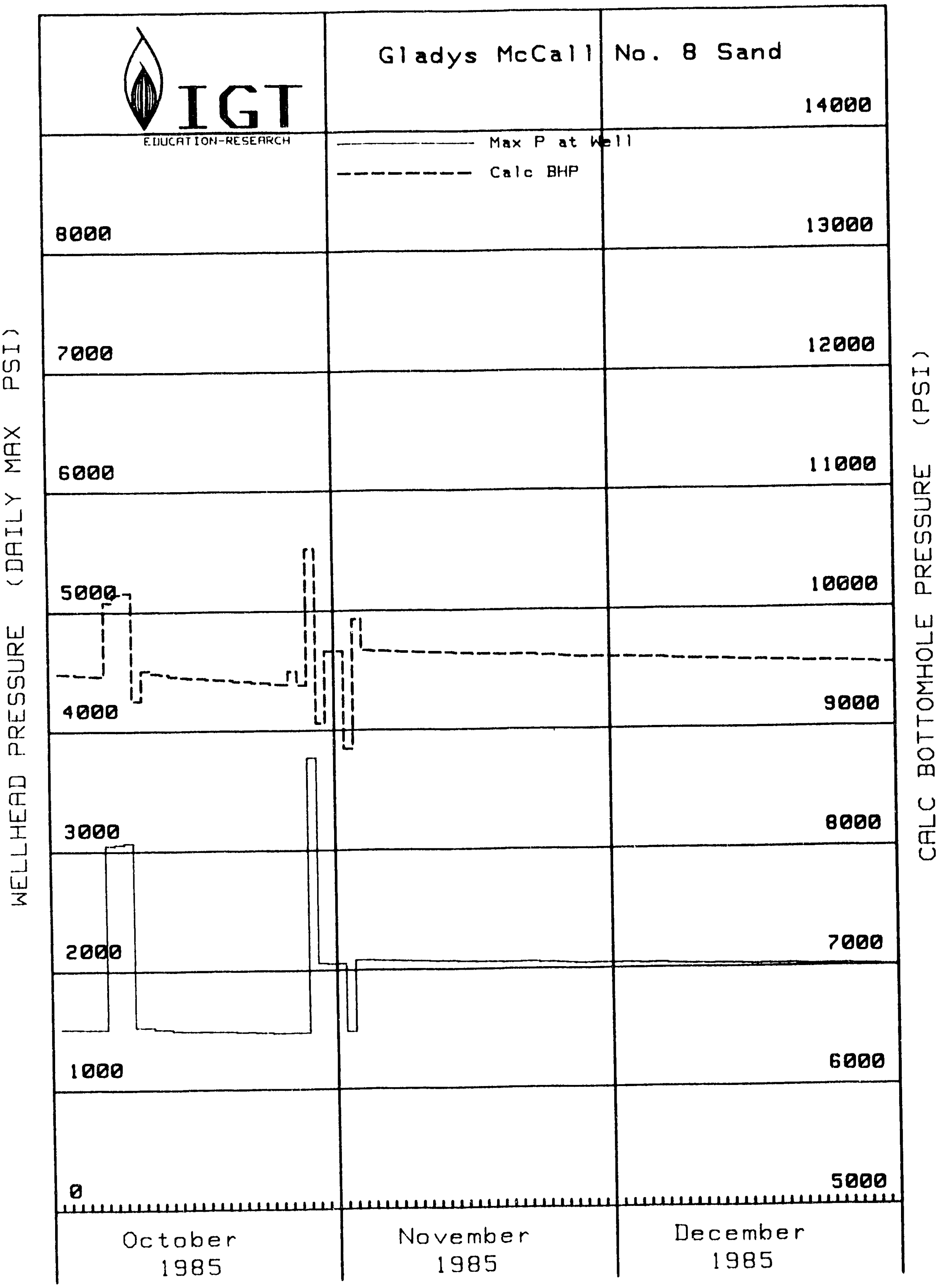
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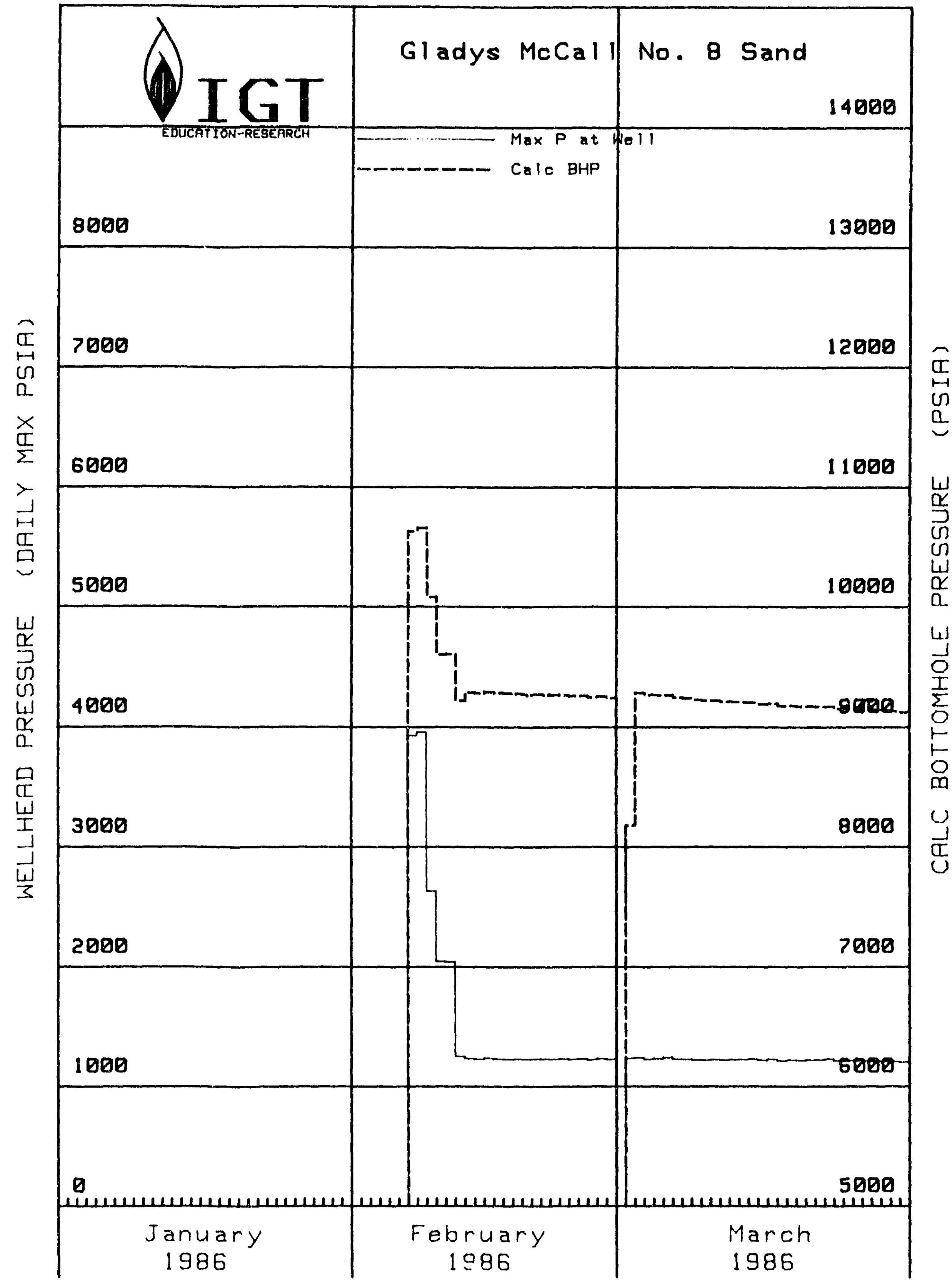
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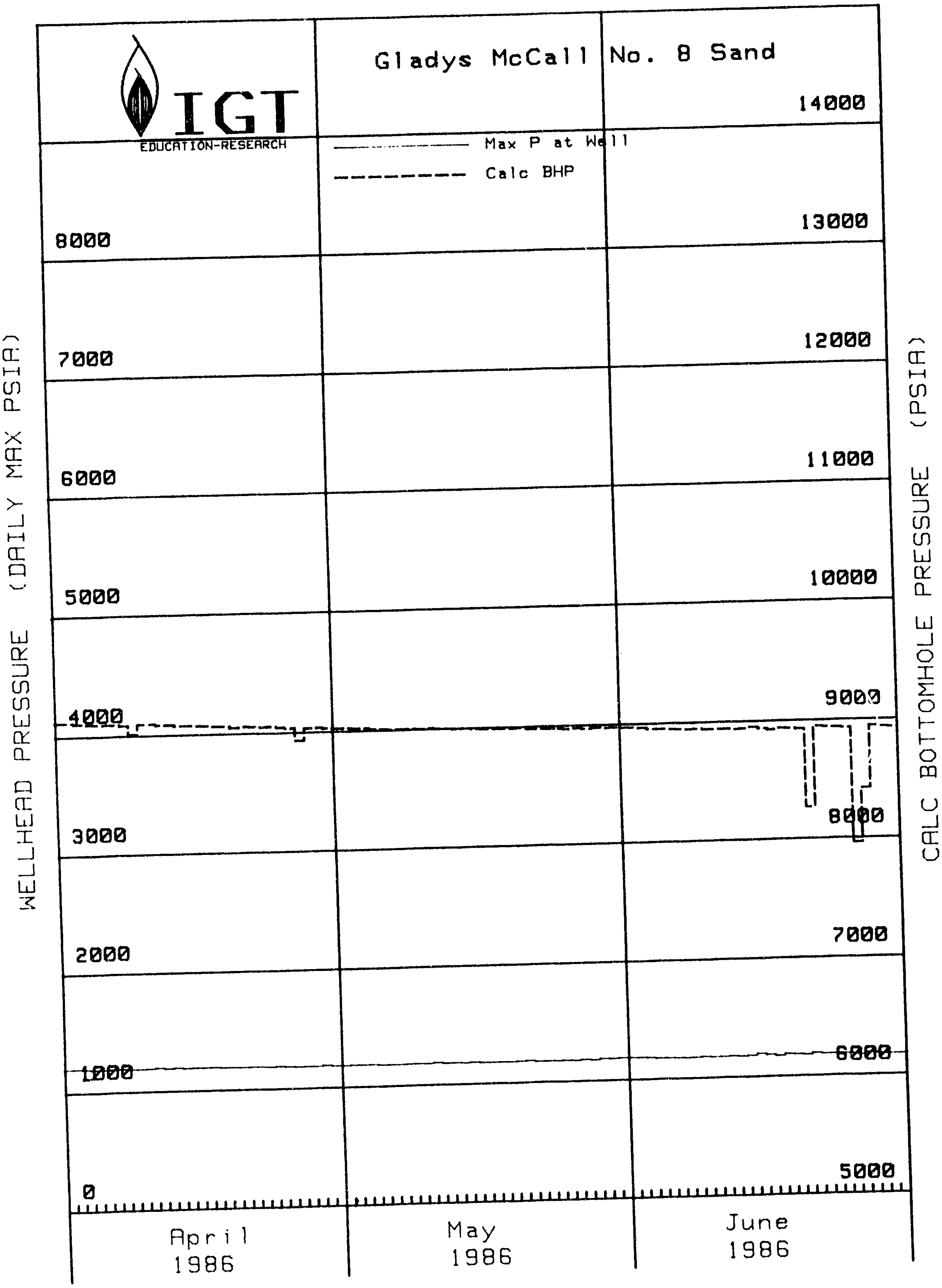
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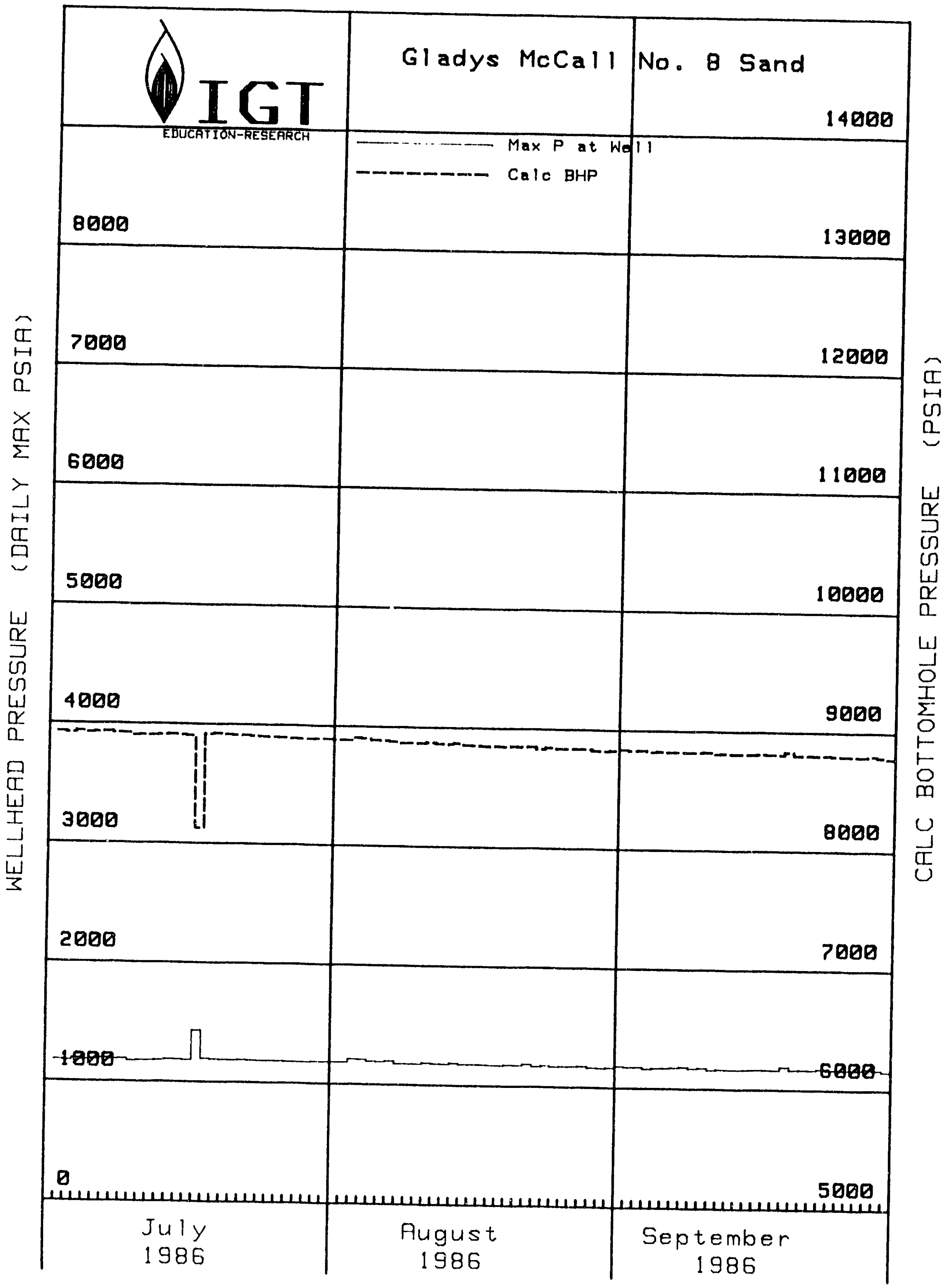

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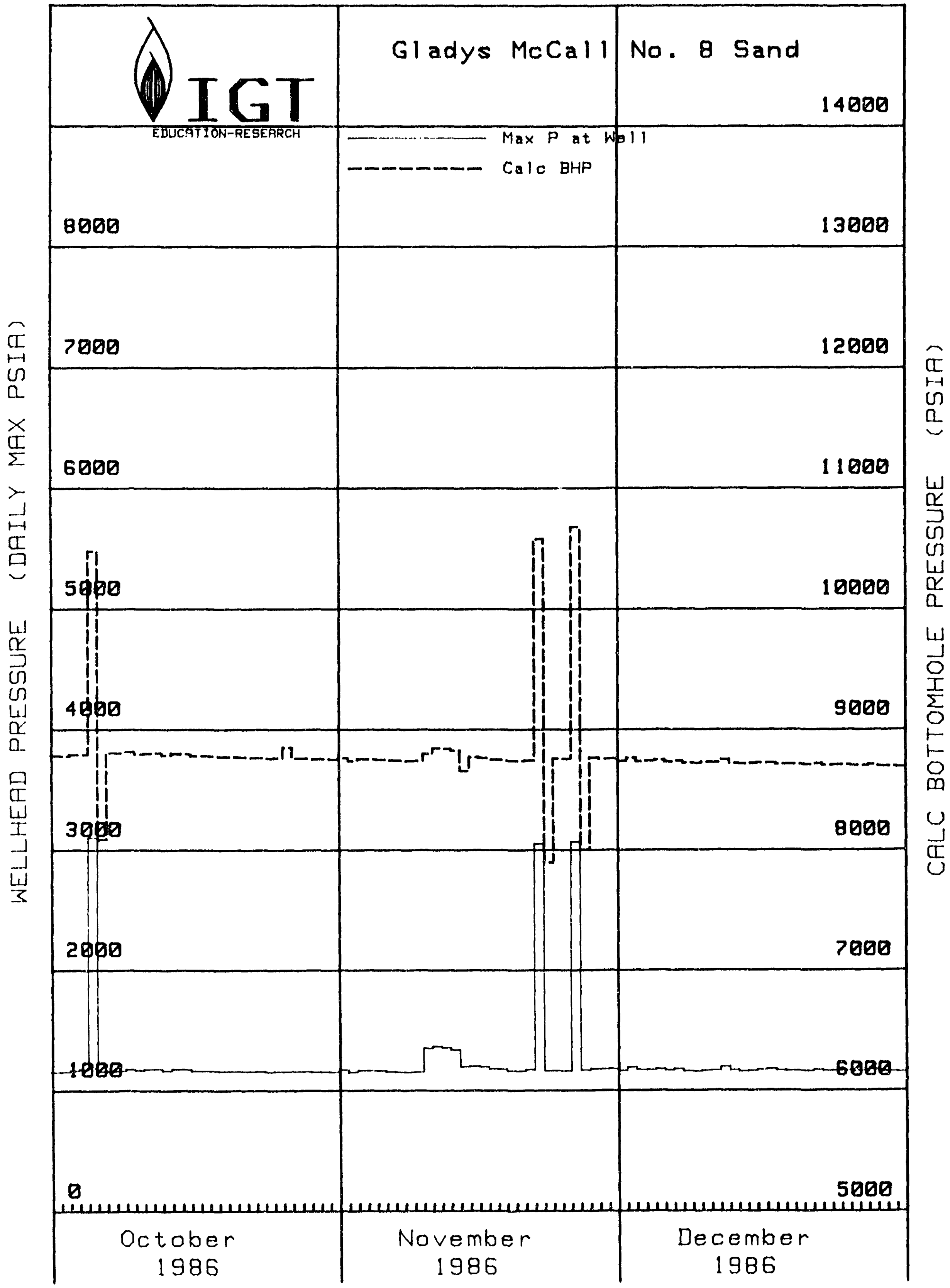
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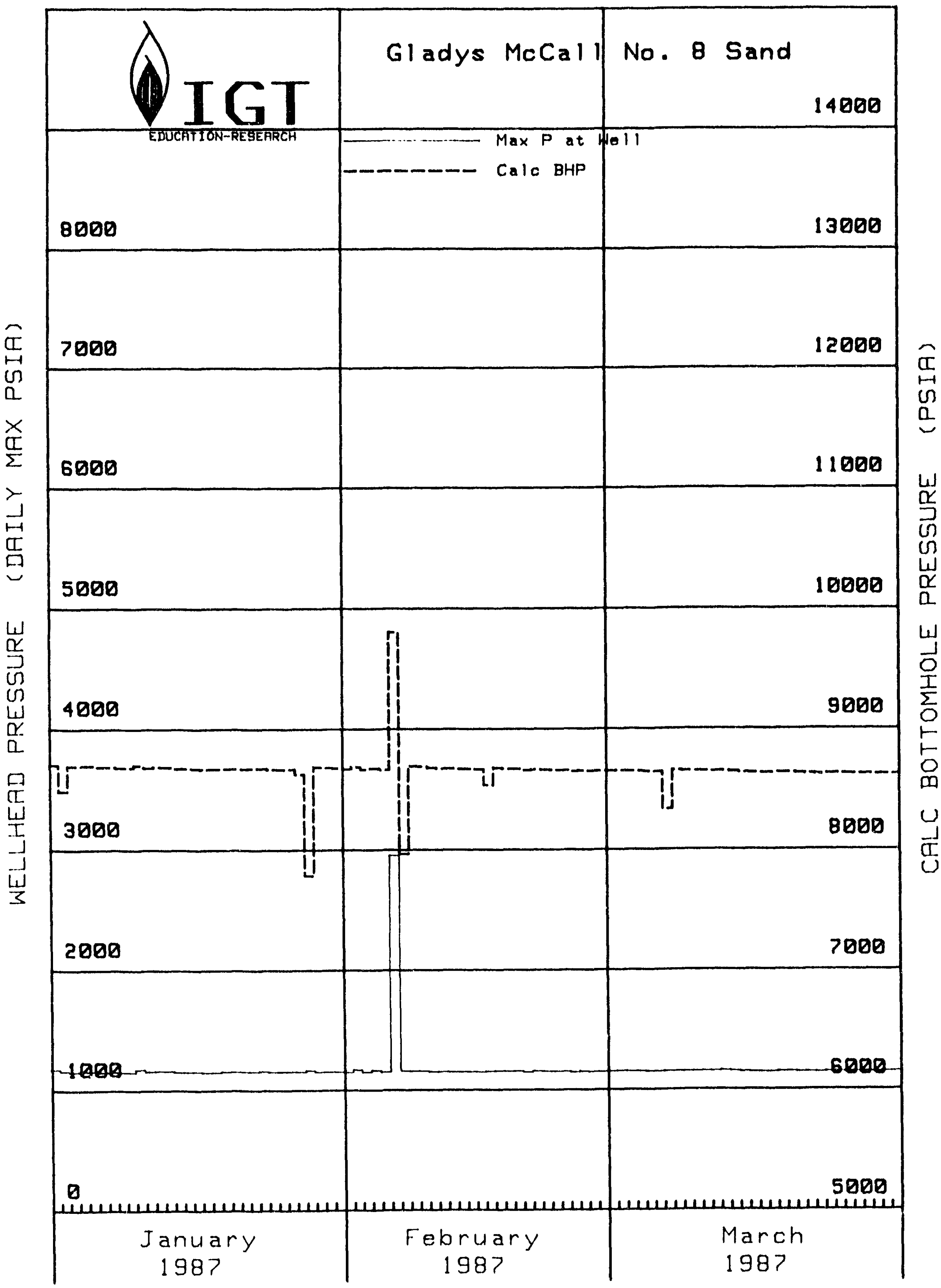
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WELLHEAD PRESSURE (DAILY MAX PSIA)
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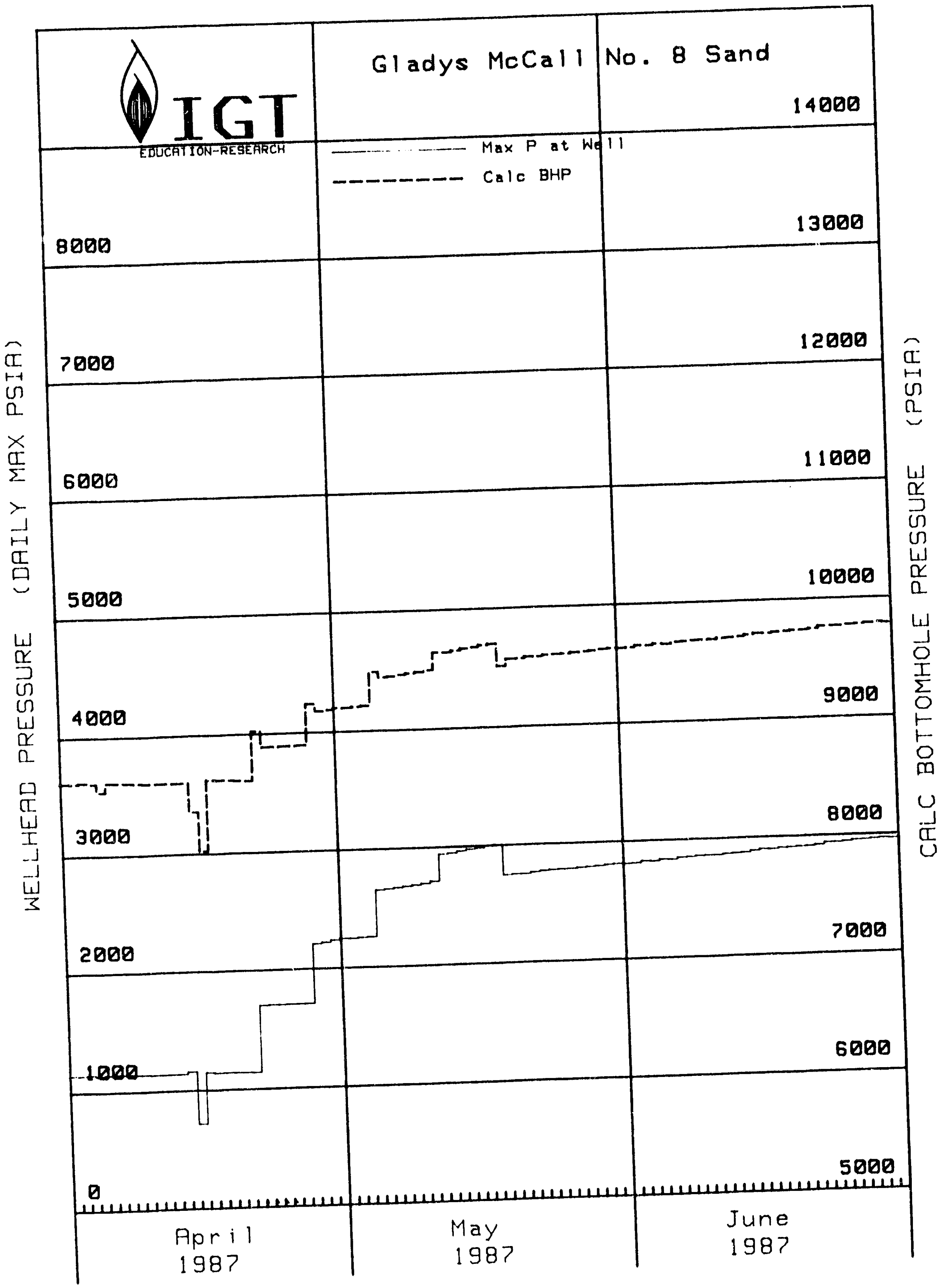
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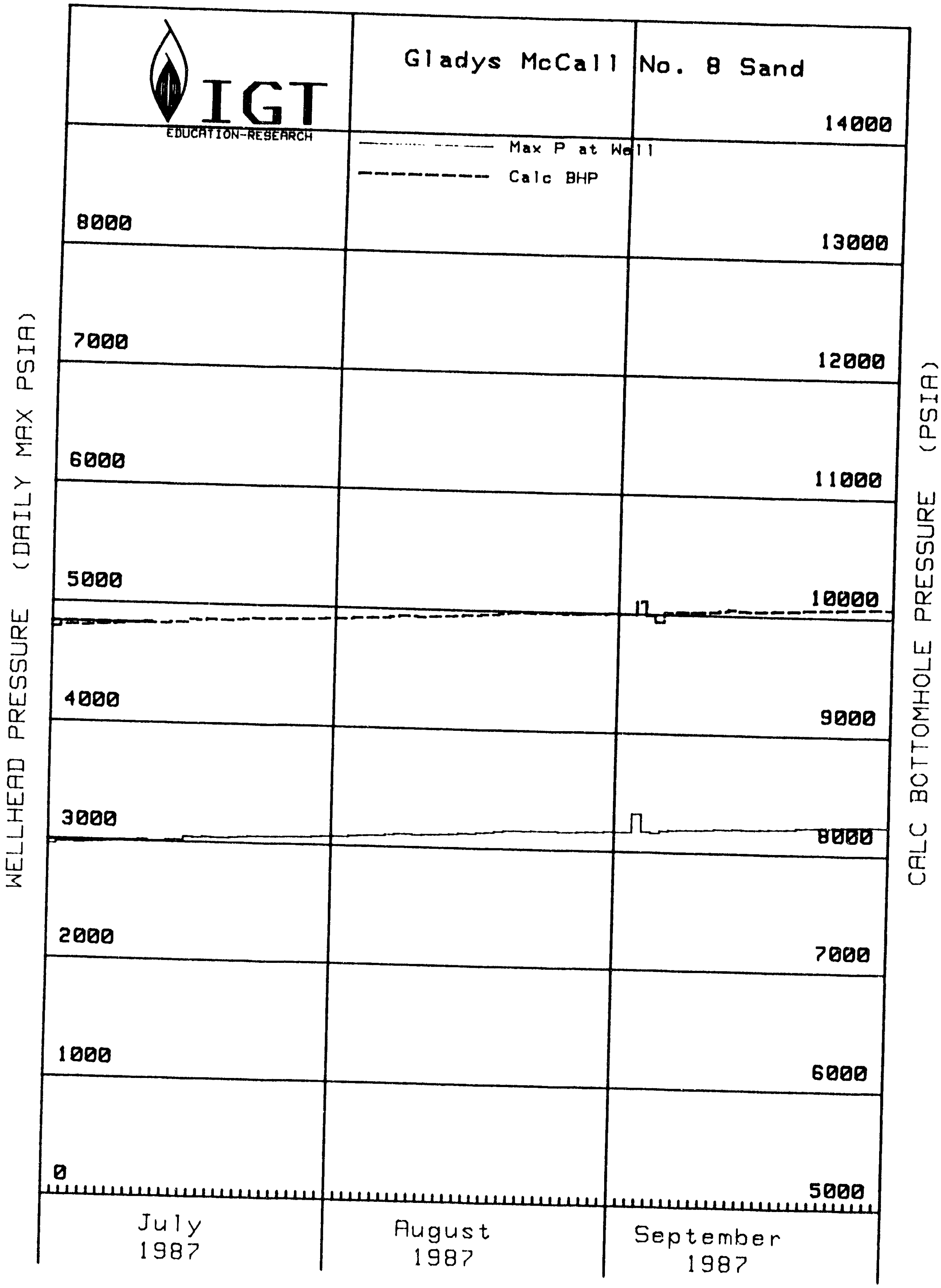
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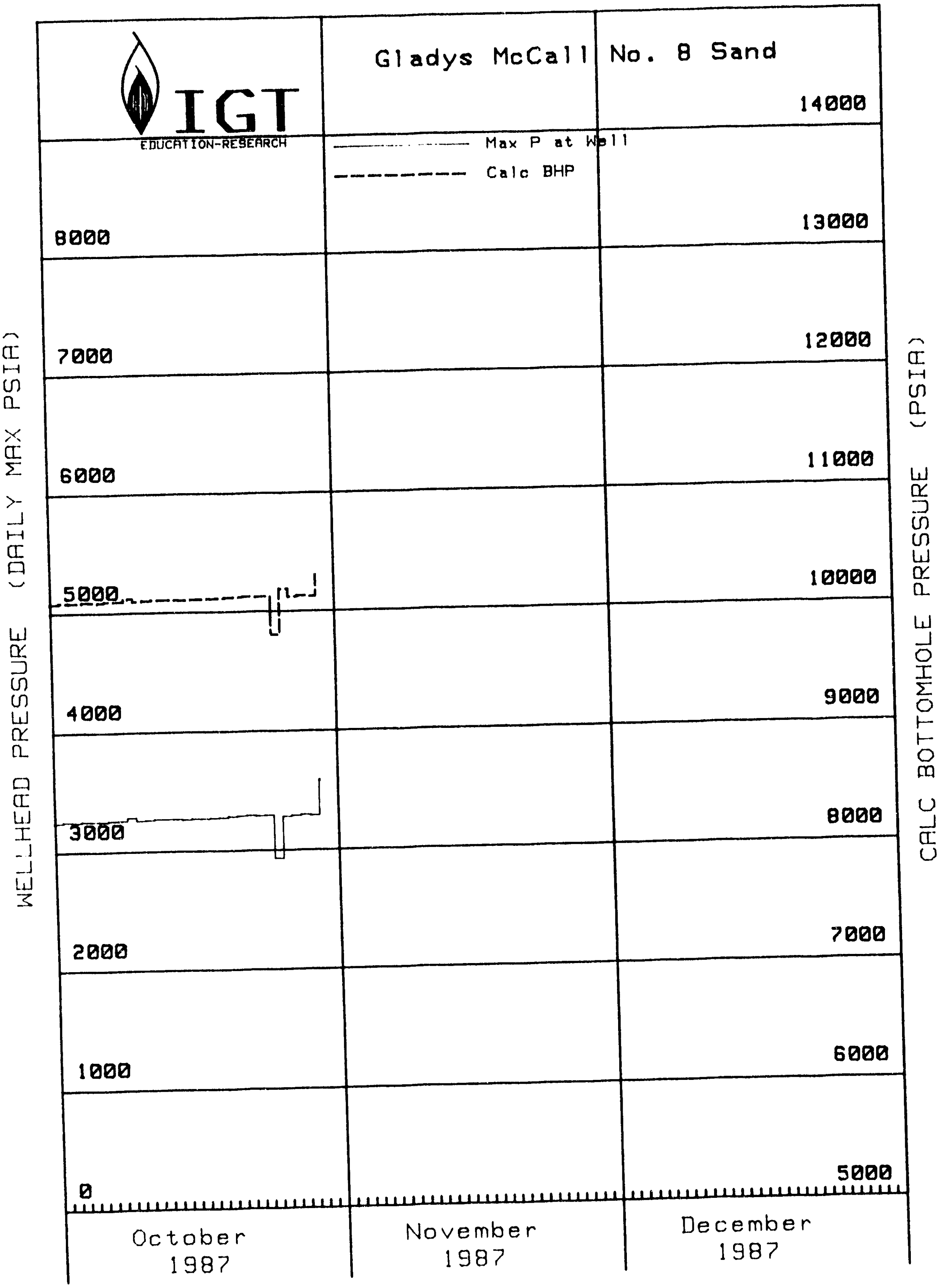
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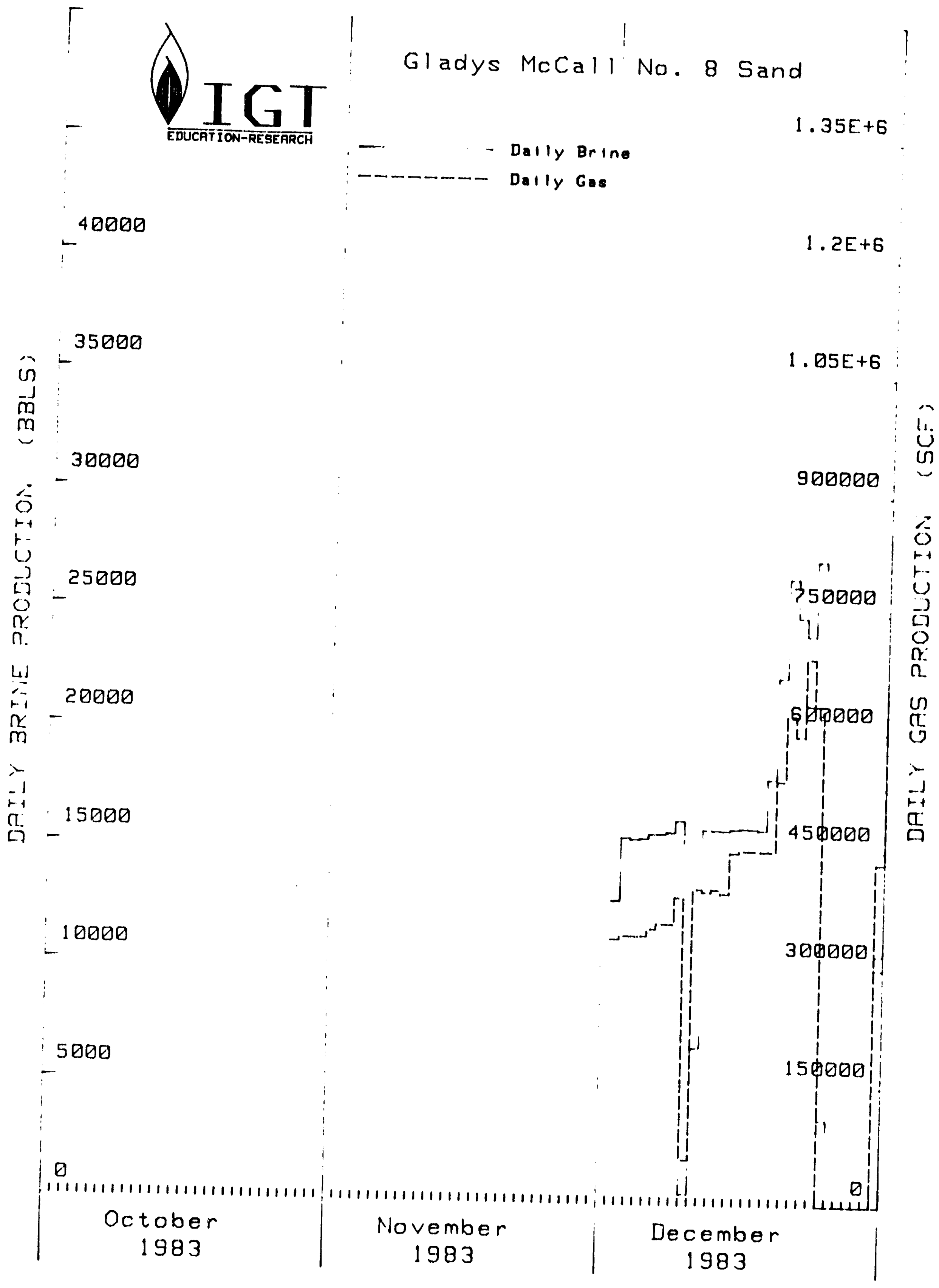
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EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
Daily Brine
Daily Gas
DAILY BRINE PRODUCTION (BBLS)
DAILY GAS PRODUCTION (SCF)
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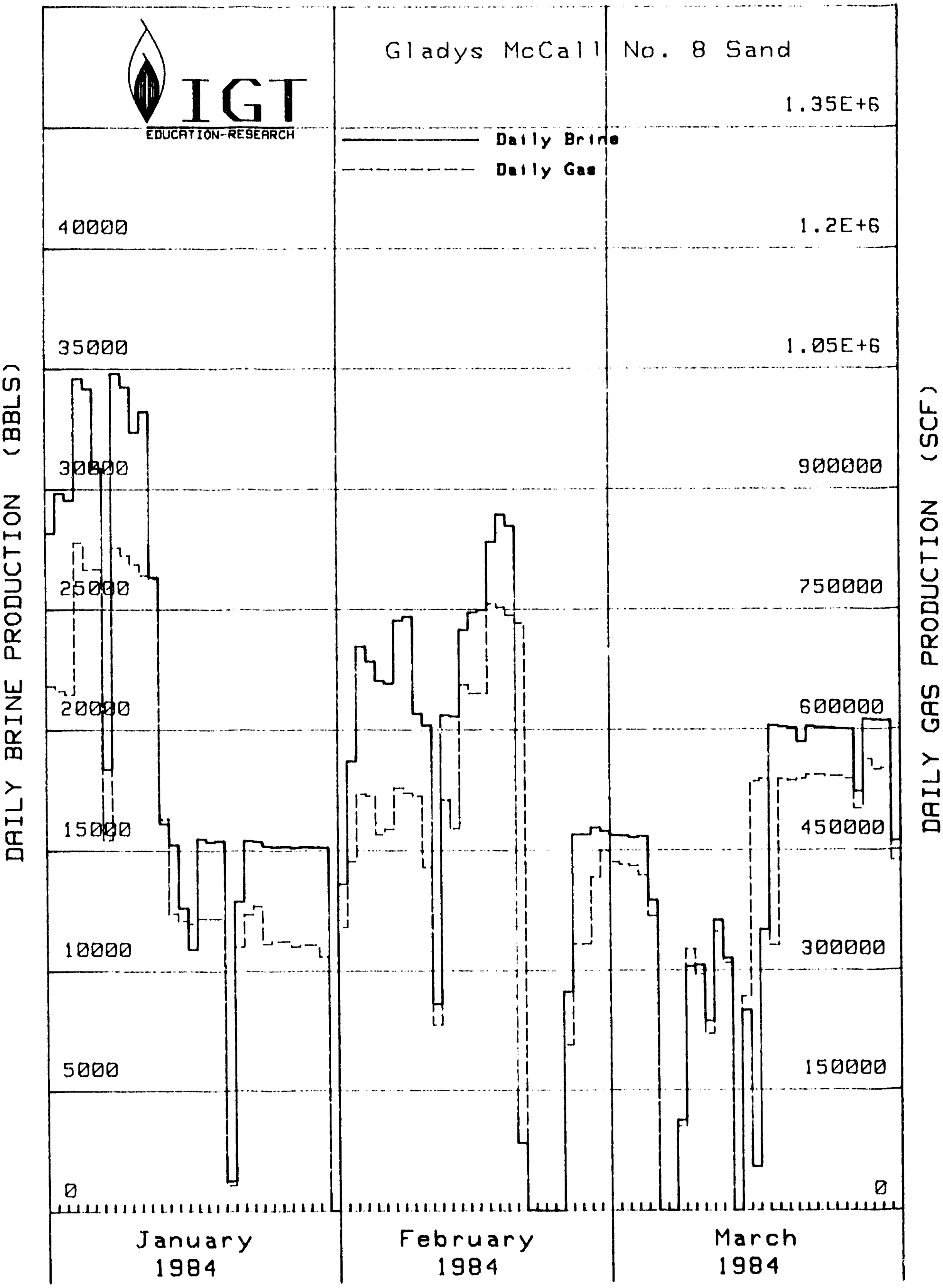
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EDUCATION-RESEARCH
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Daily Brine
Daily Gas
DAILY BRINE PRODUCTION (BBLS)
DAILY GAS PRODUCTION (SCF)
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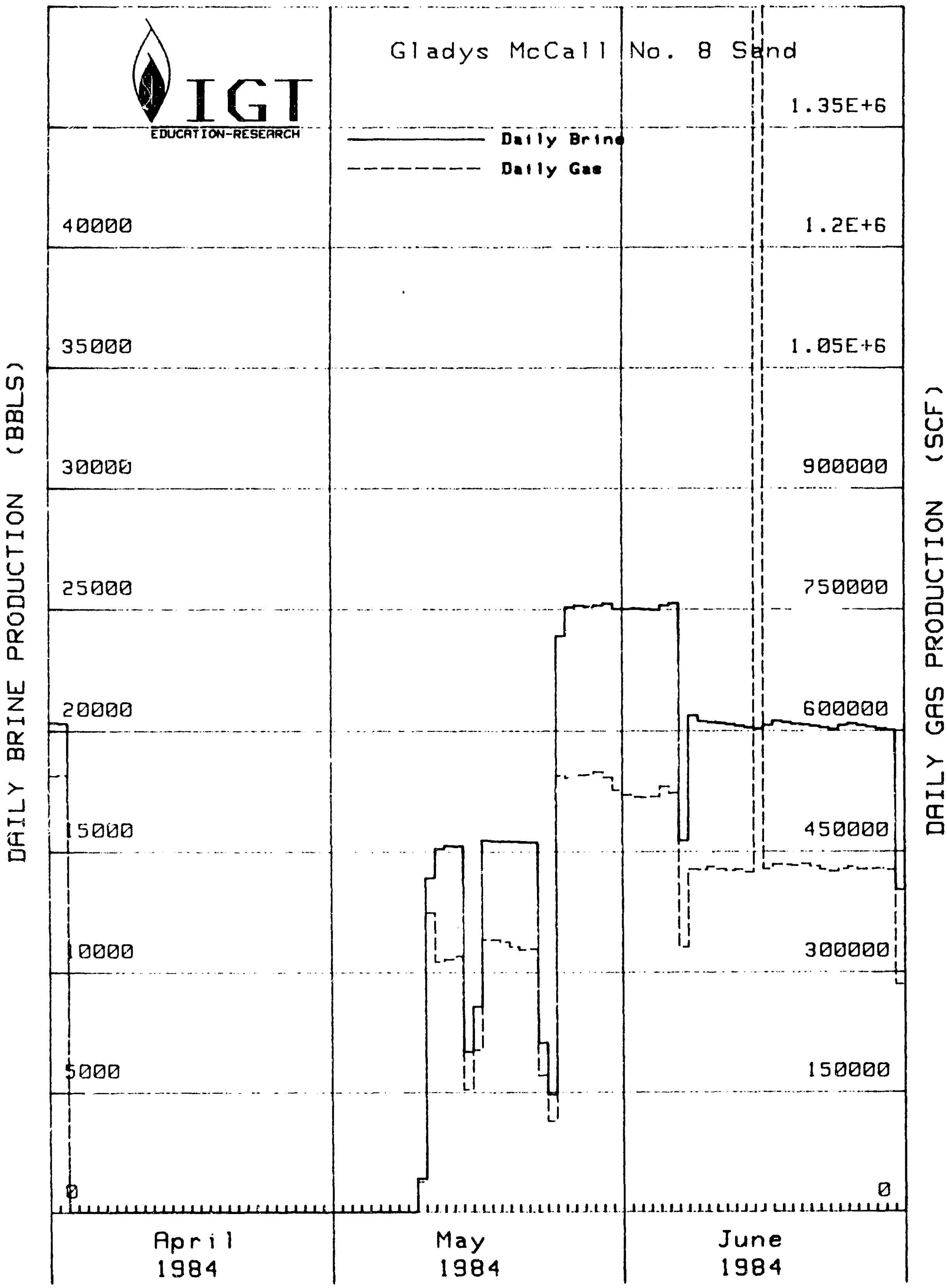
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EDUCATION-RESEARCH
Daily Brine
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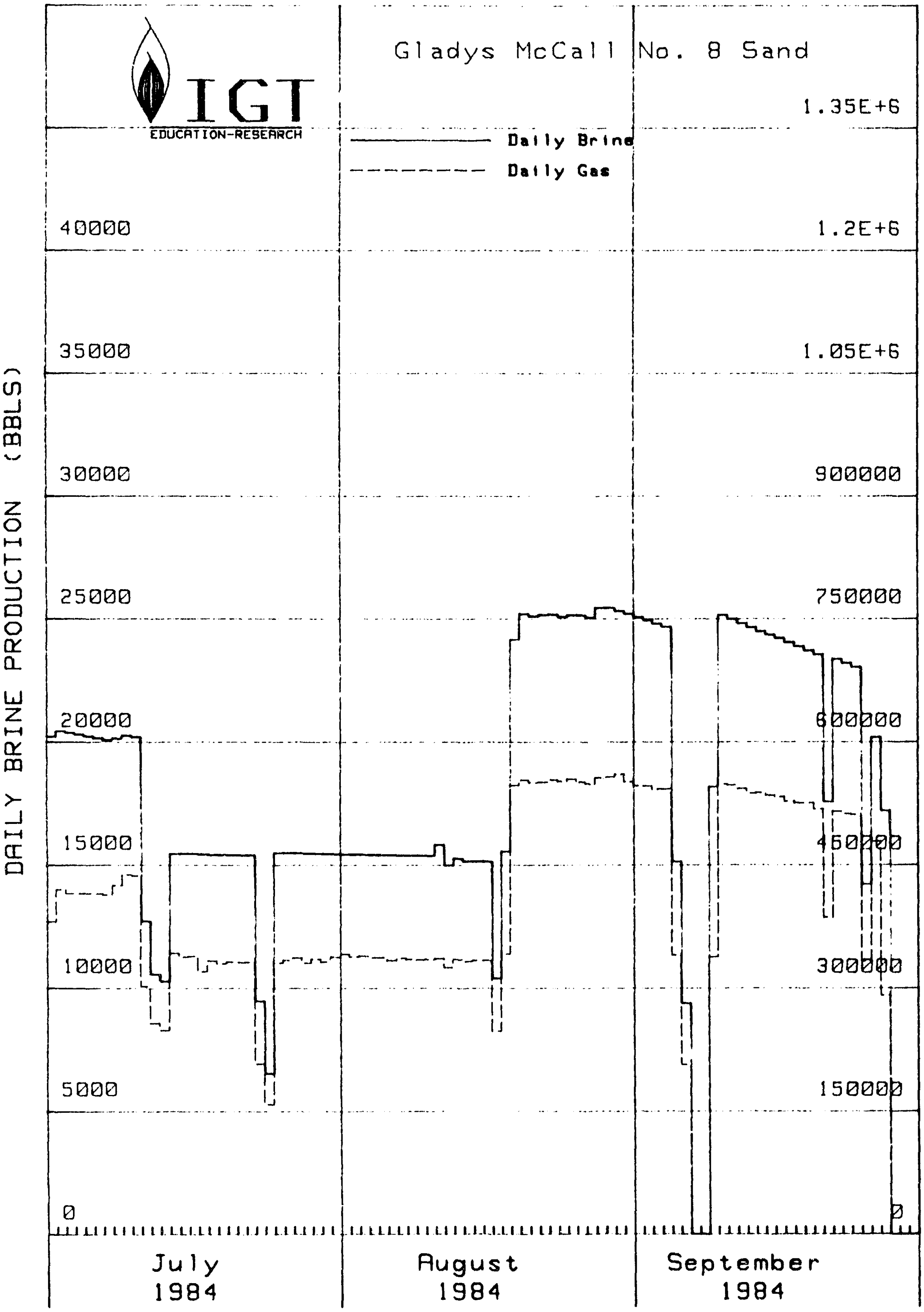
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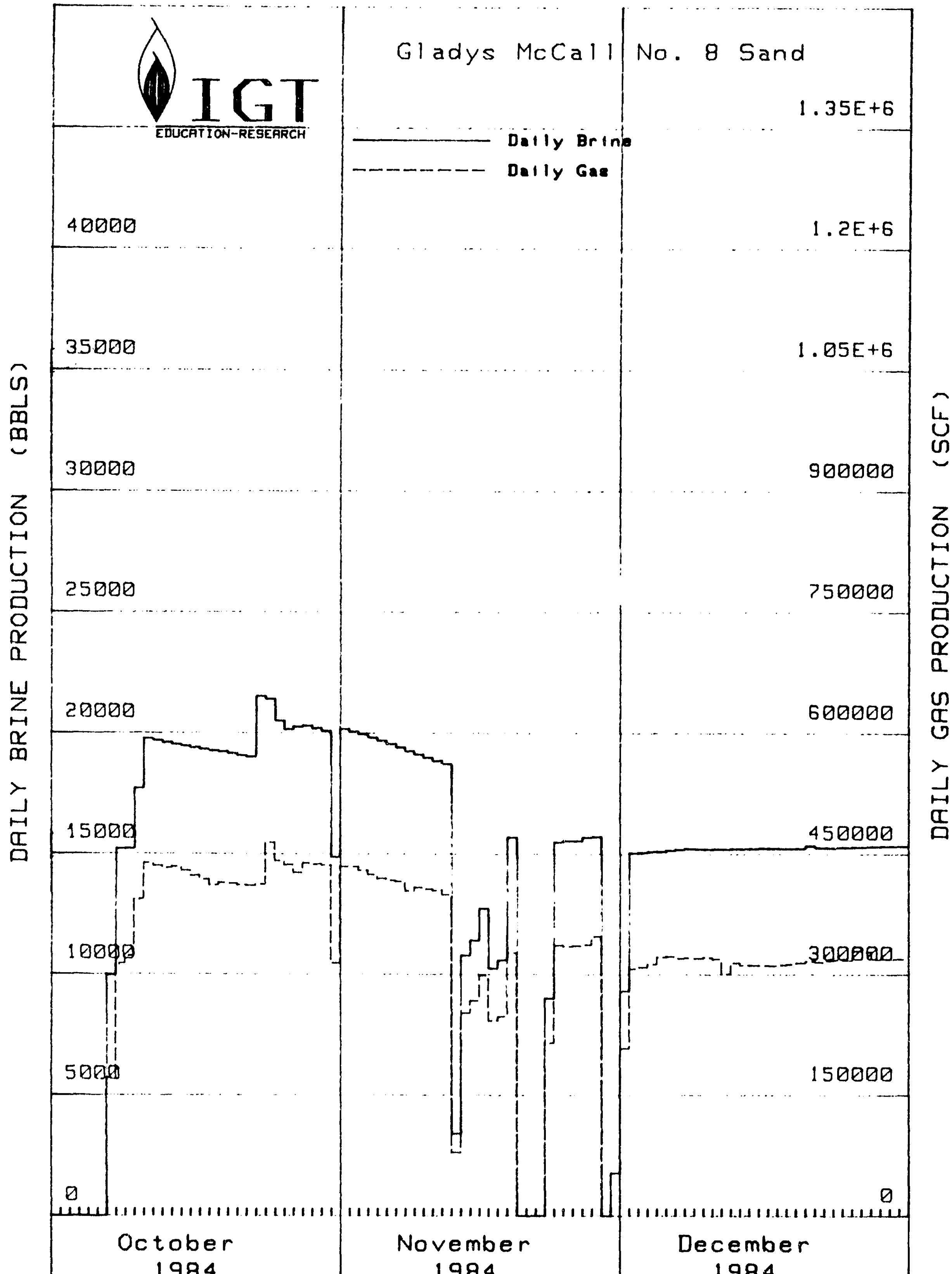
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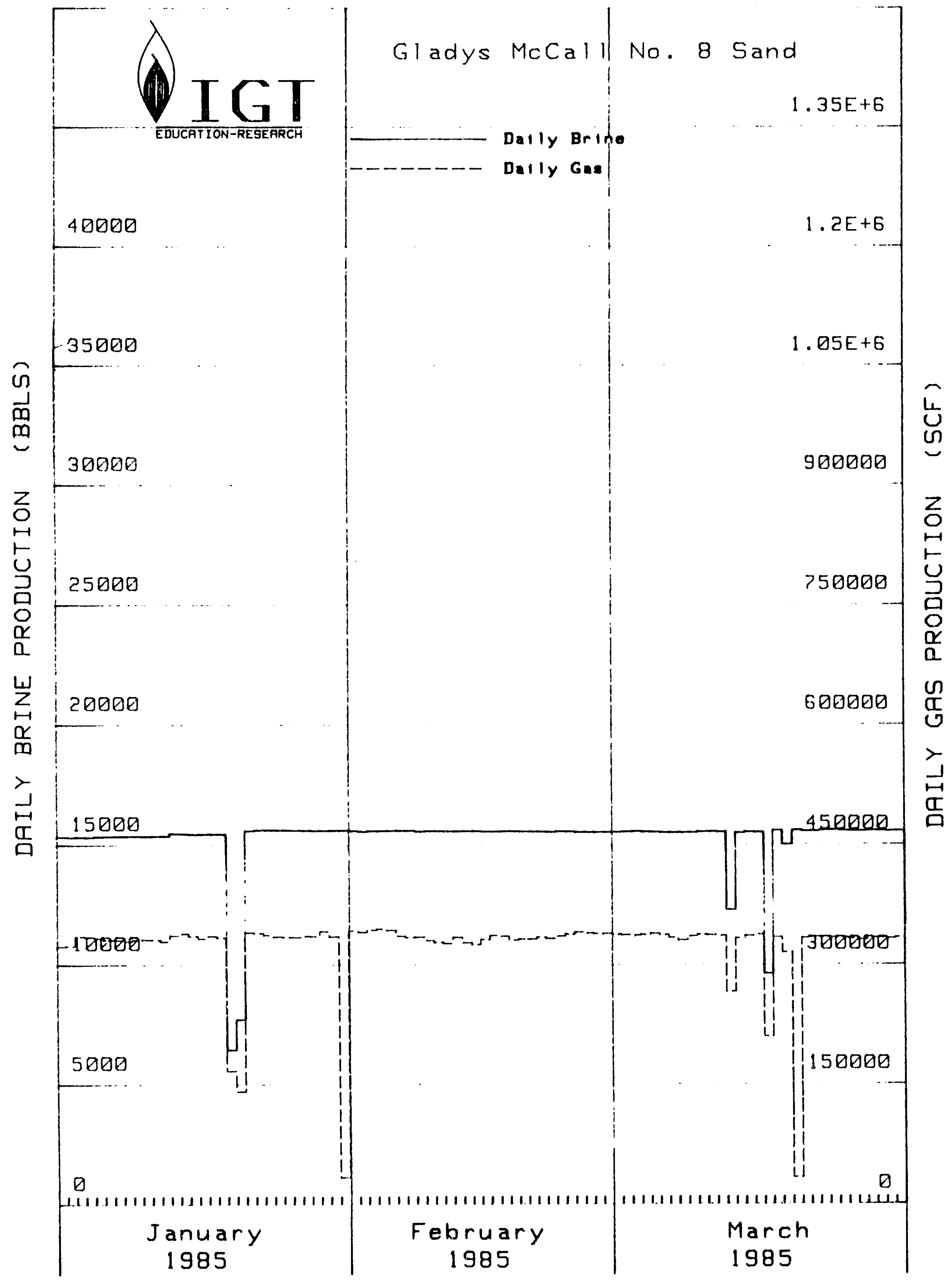
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Daily Brine
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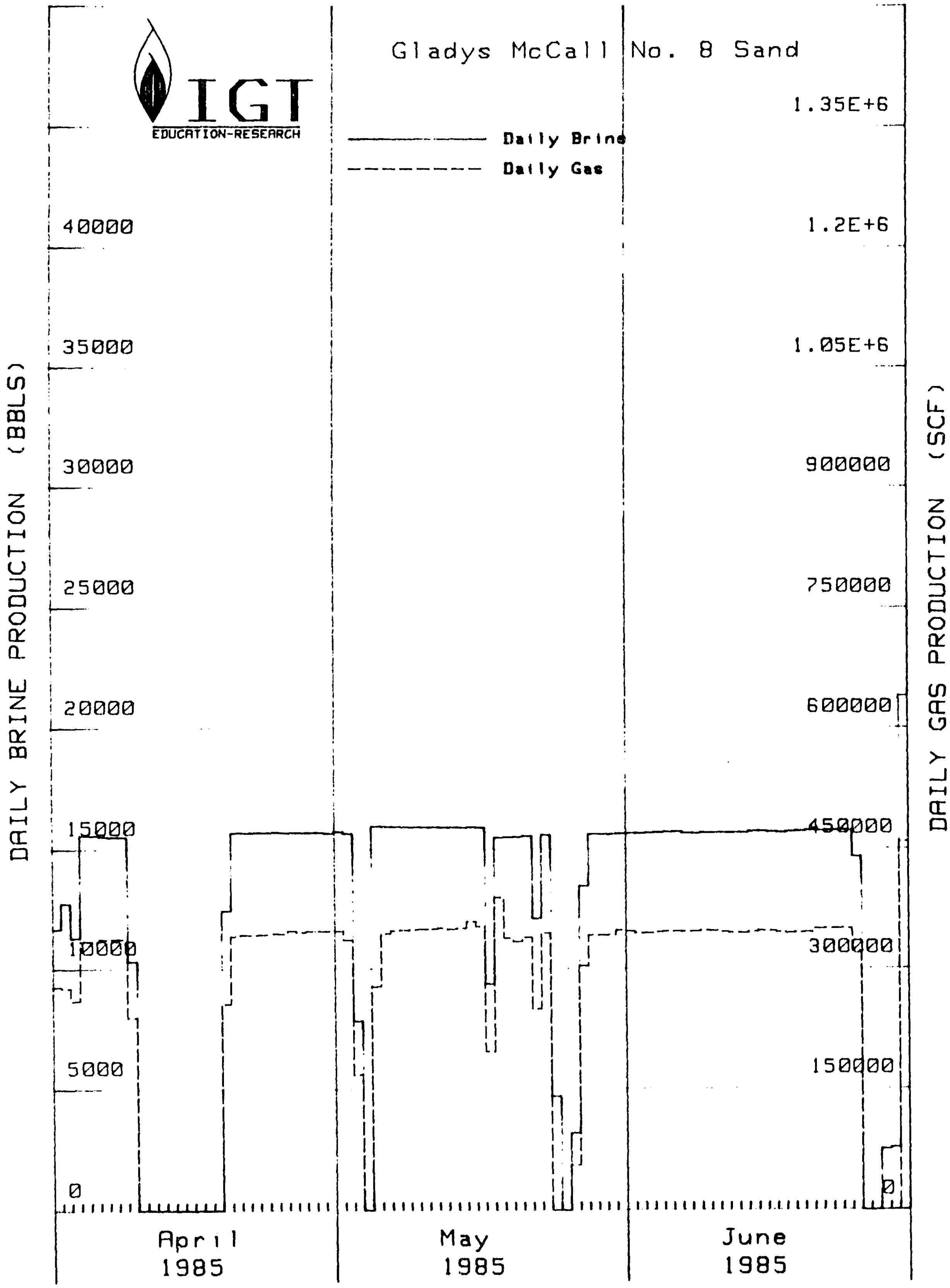
Gladys McCall No. 8 Sand
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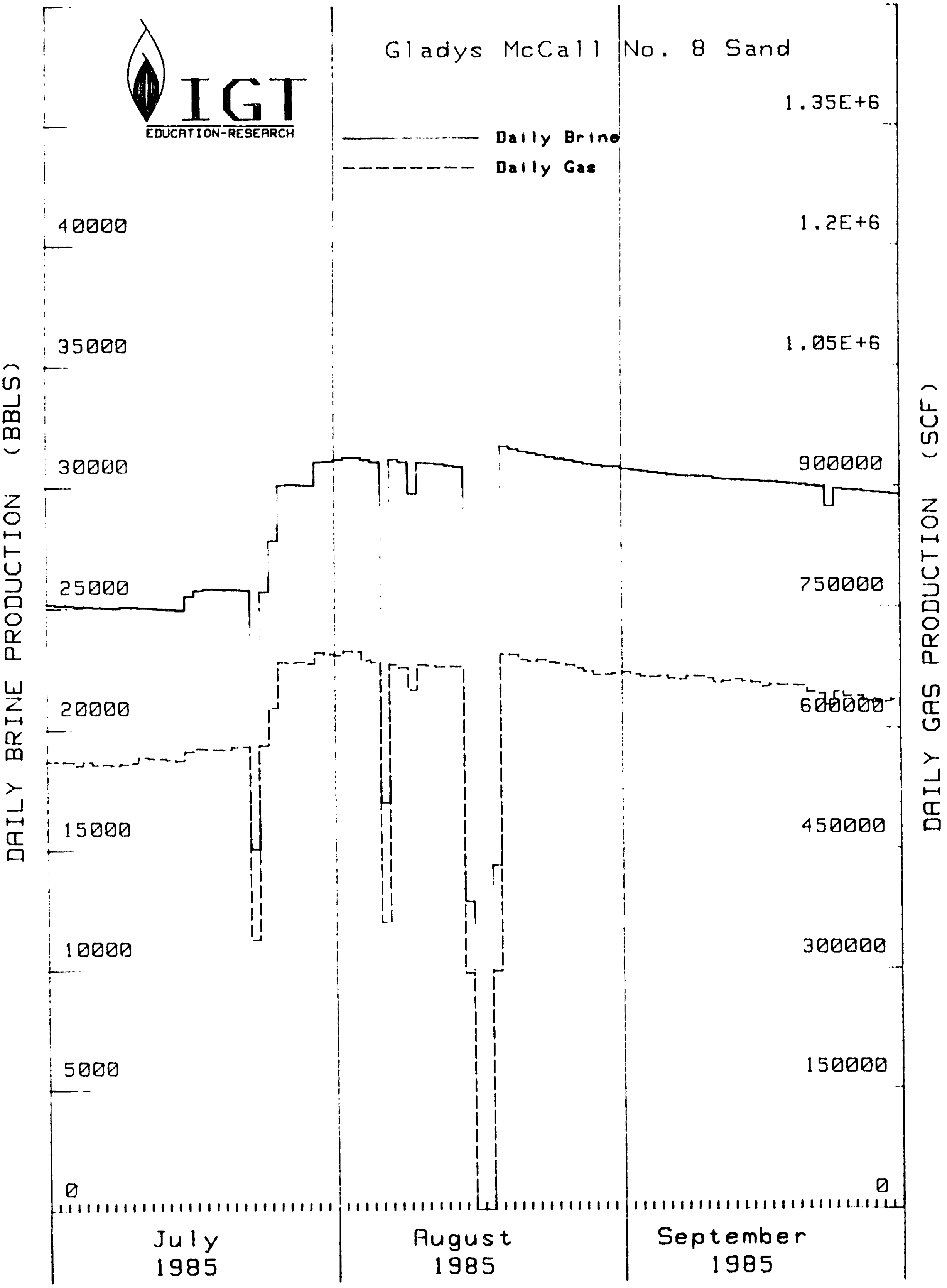

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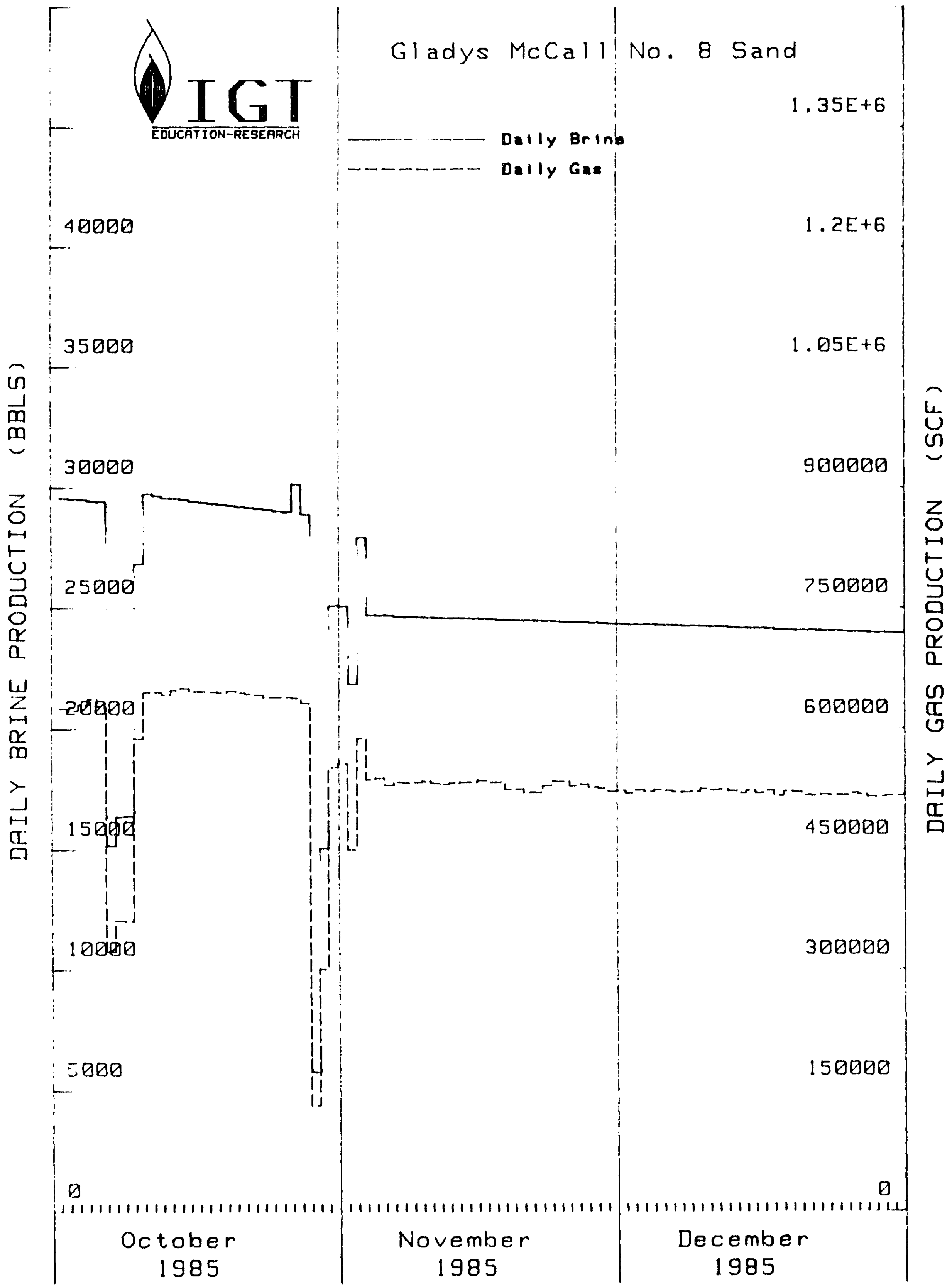
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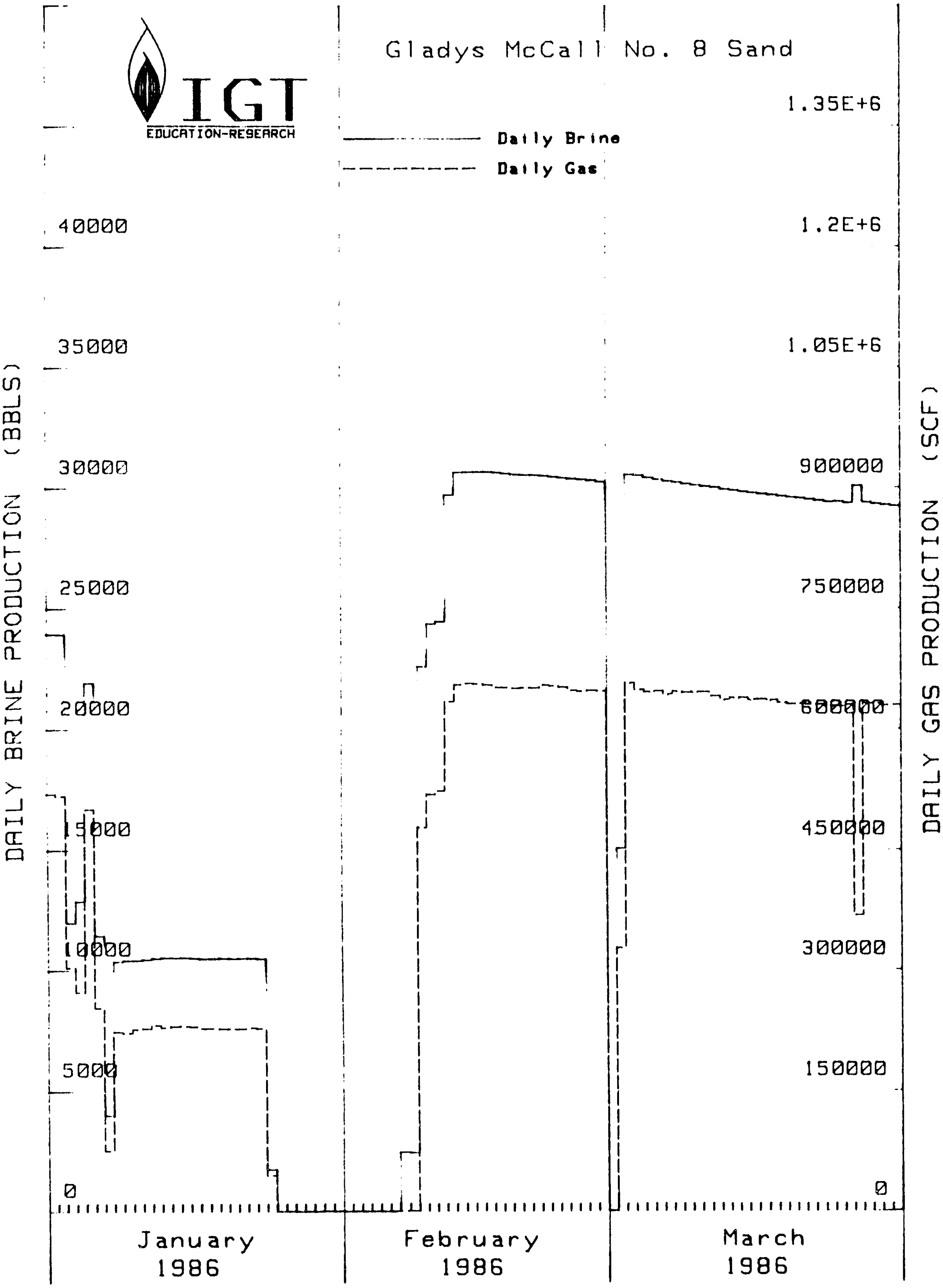
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EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
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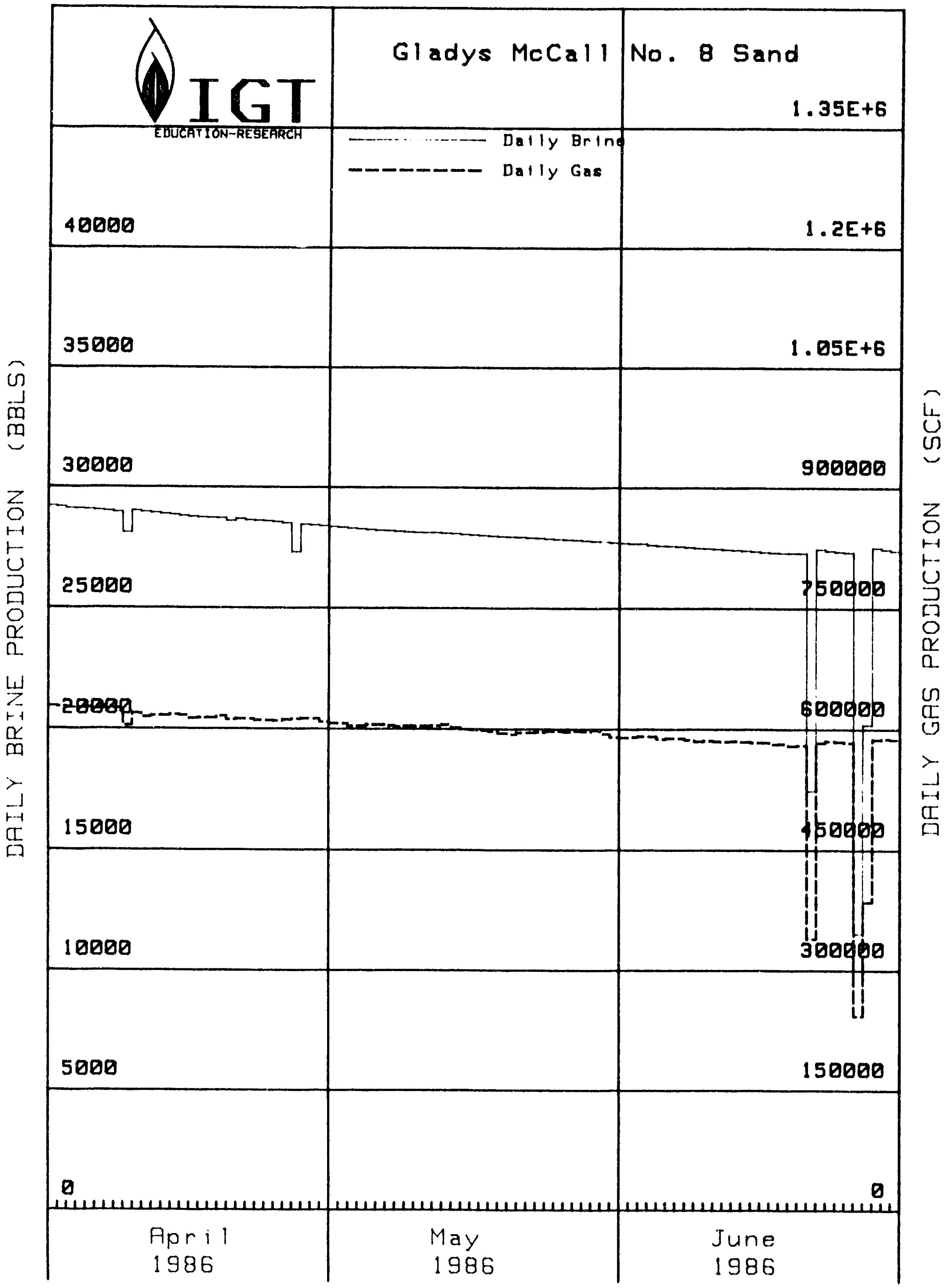
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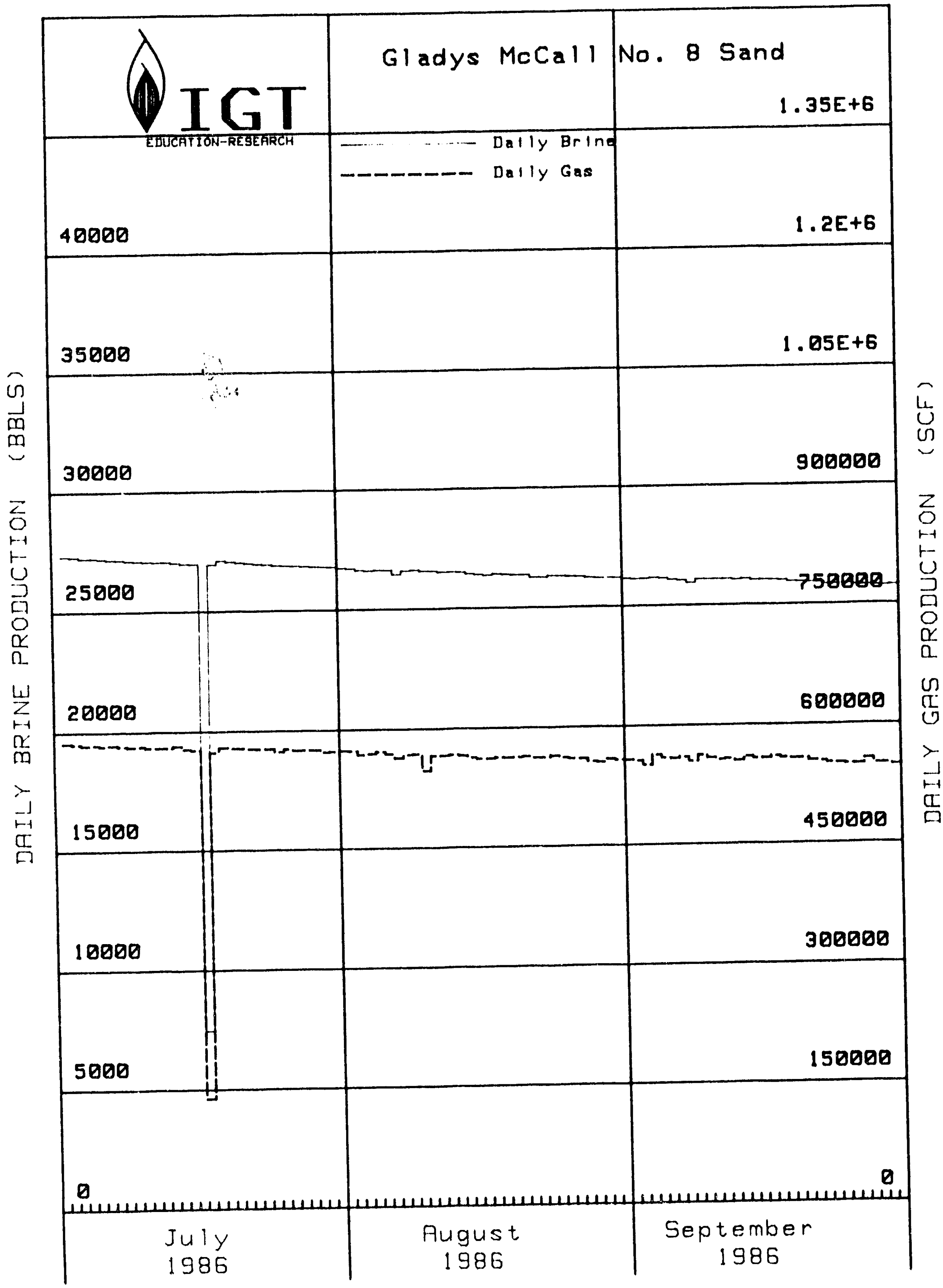

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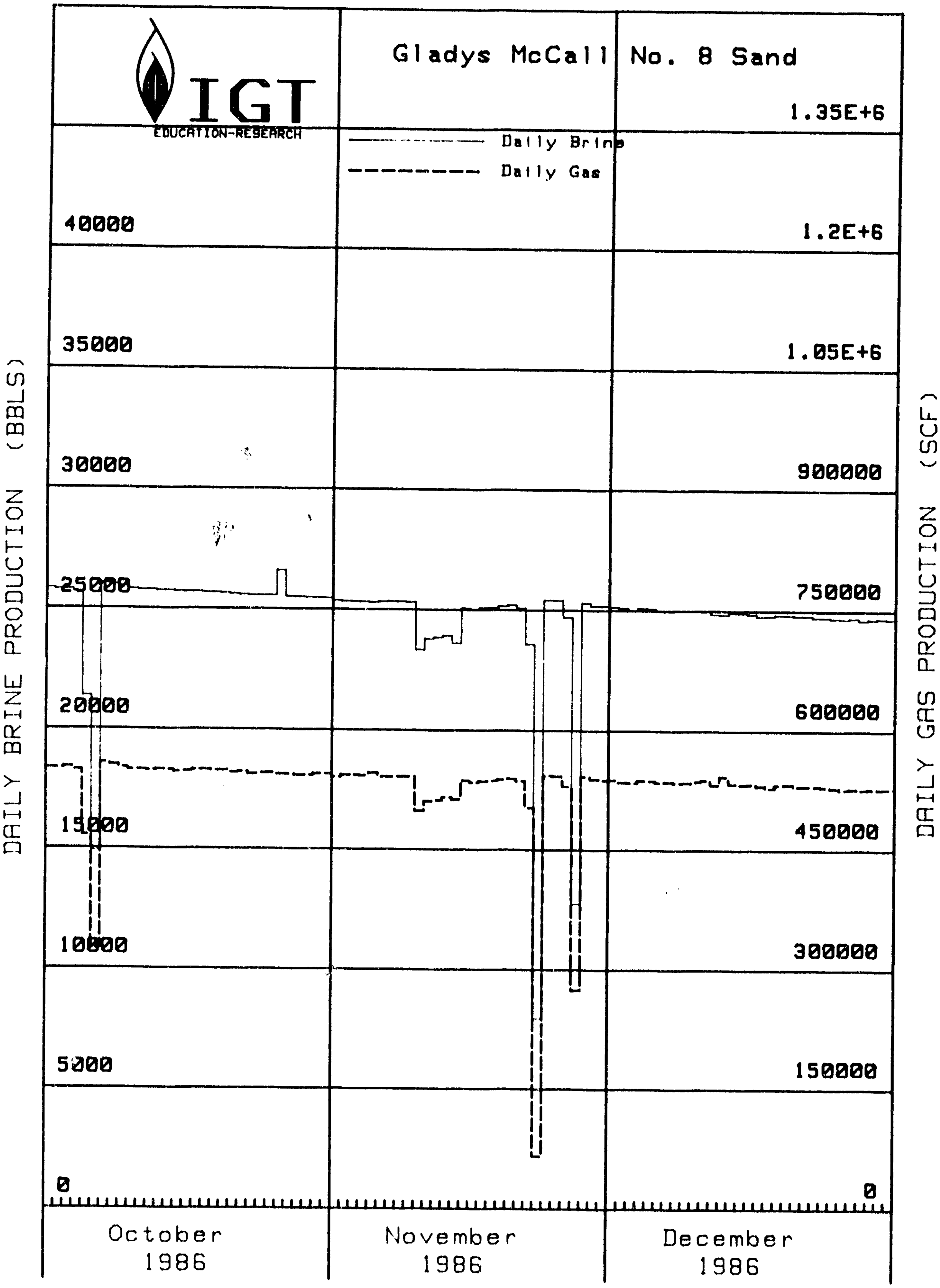

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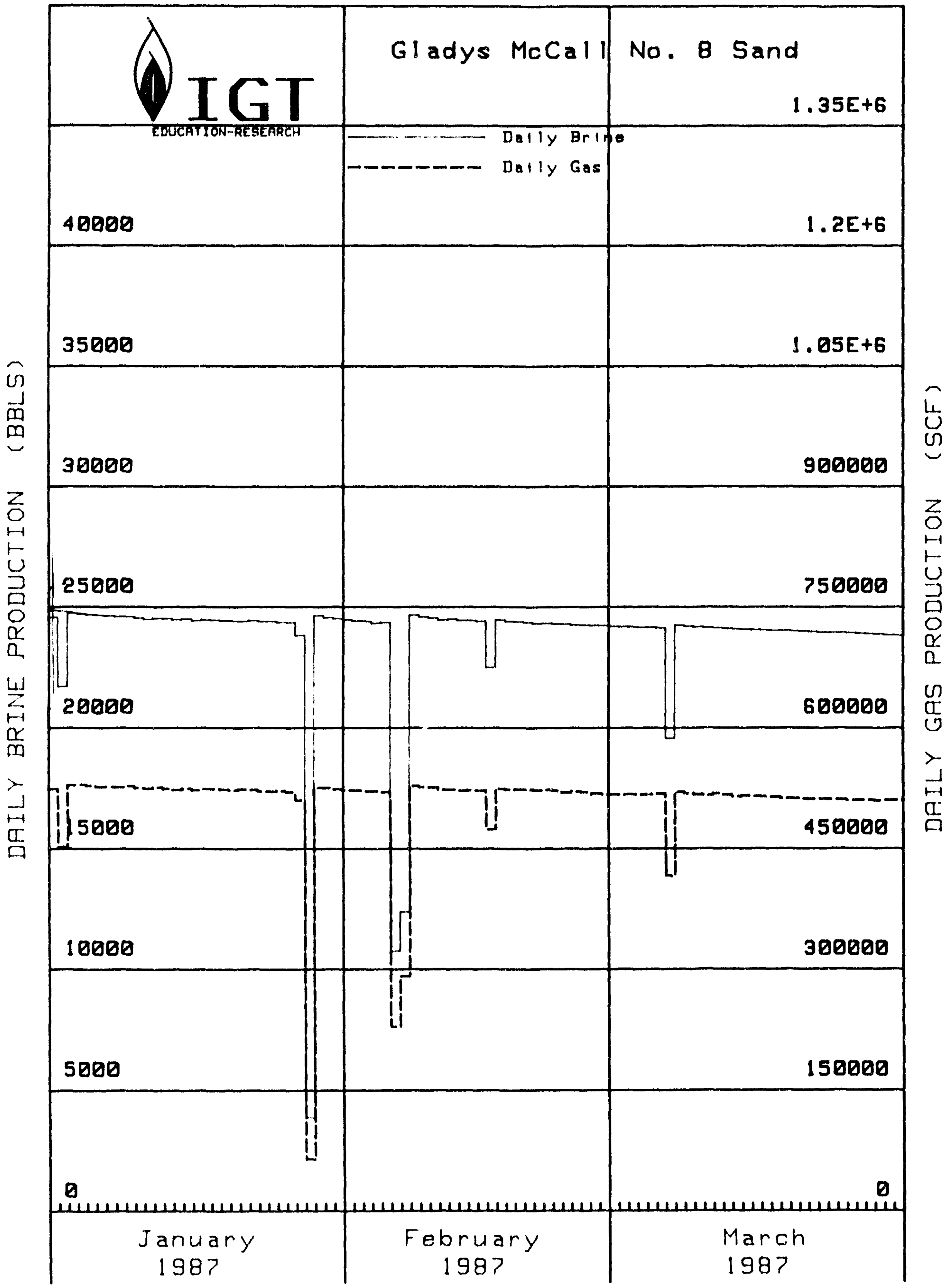
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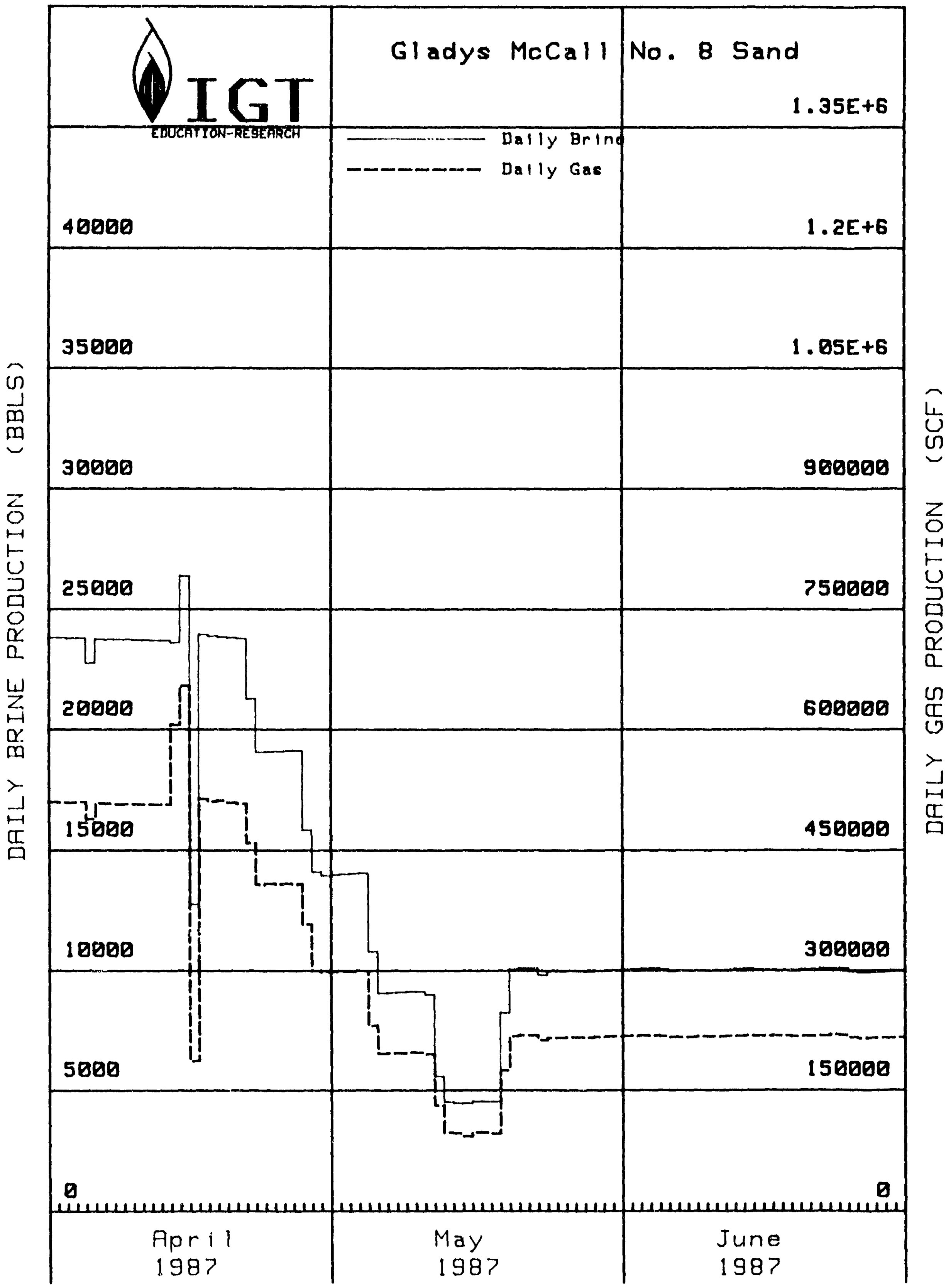
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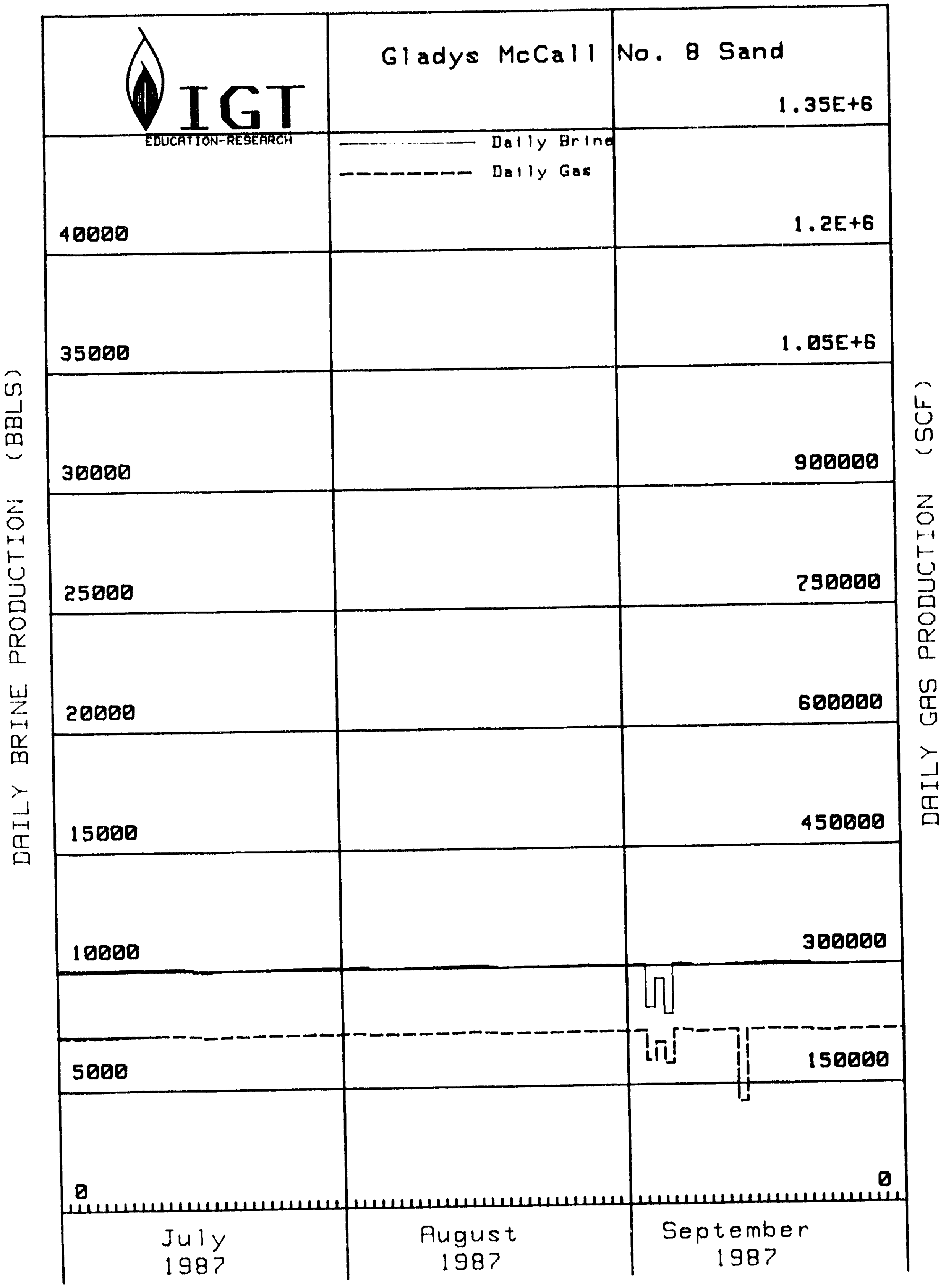
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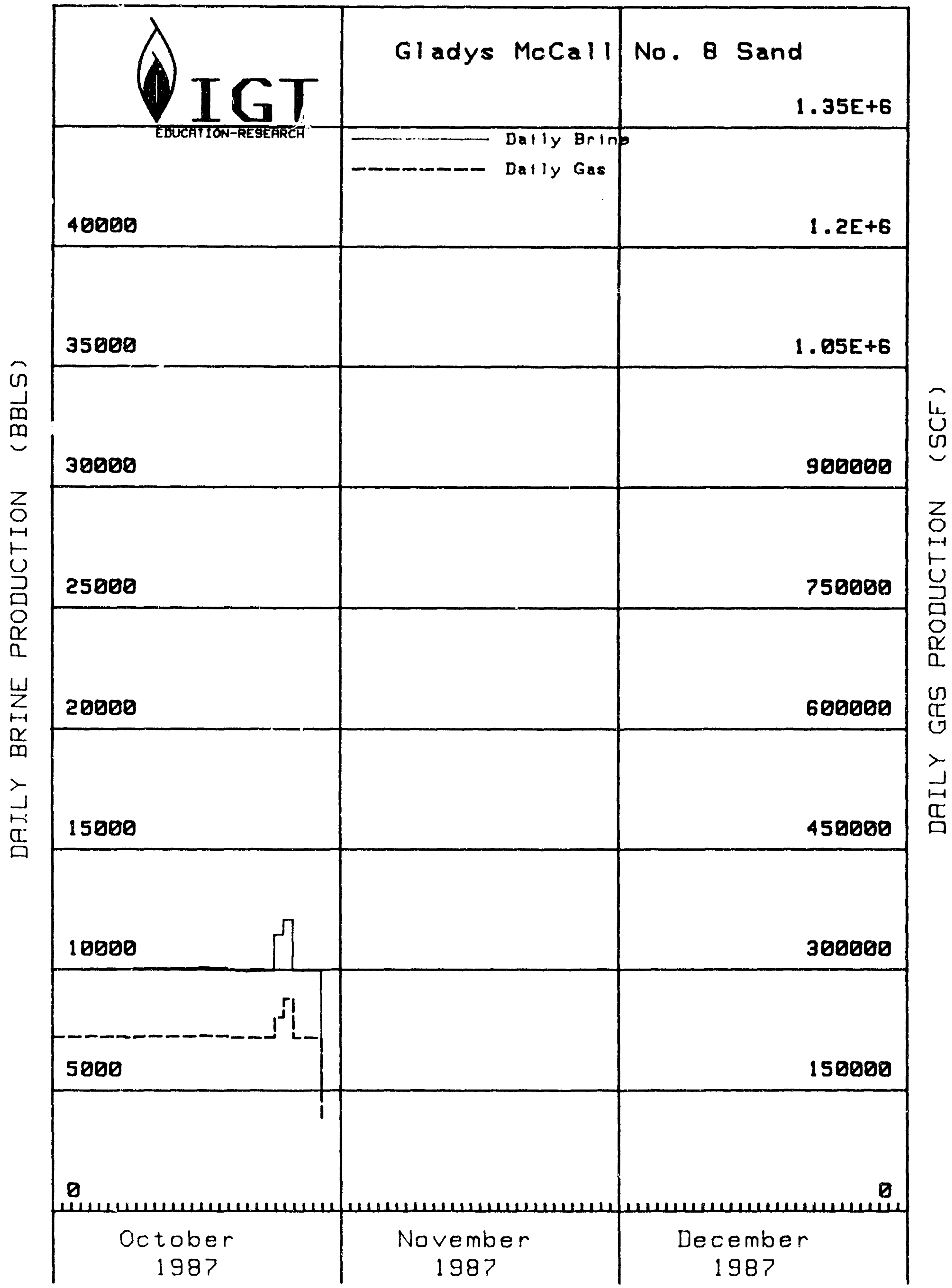
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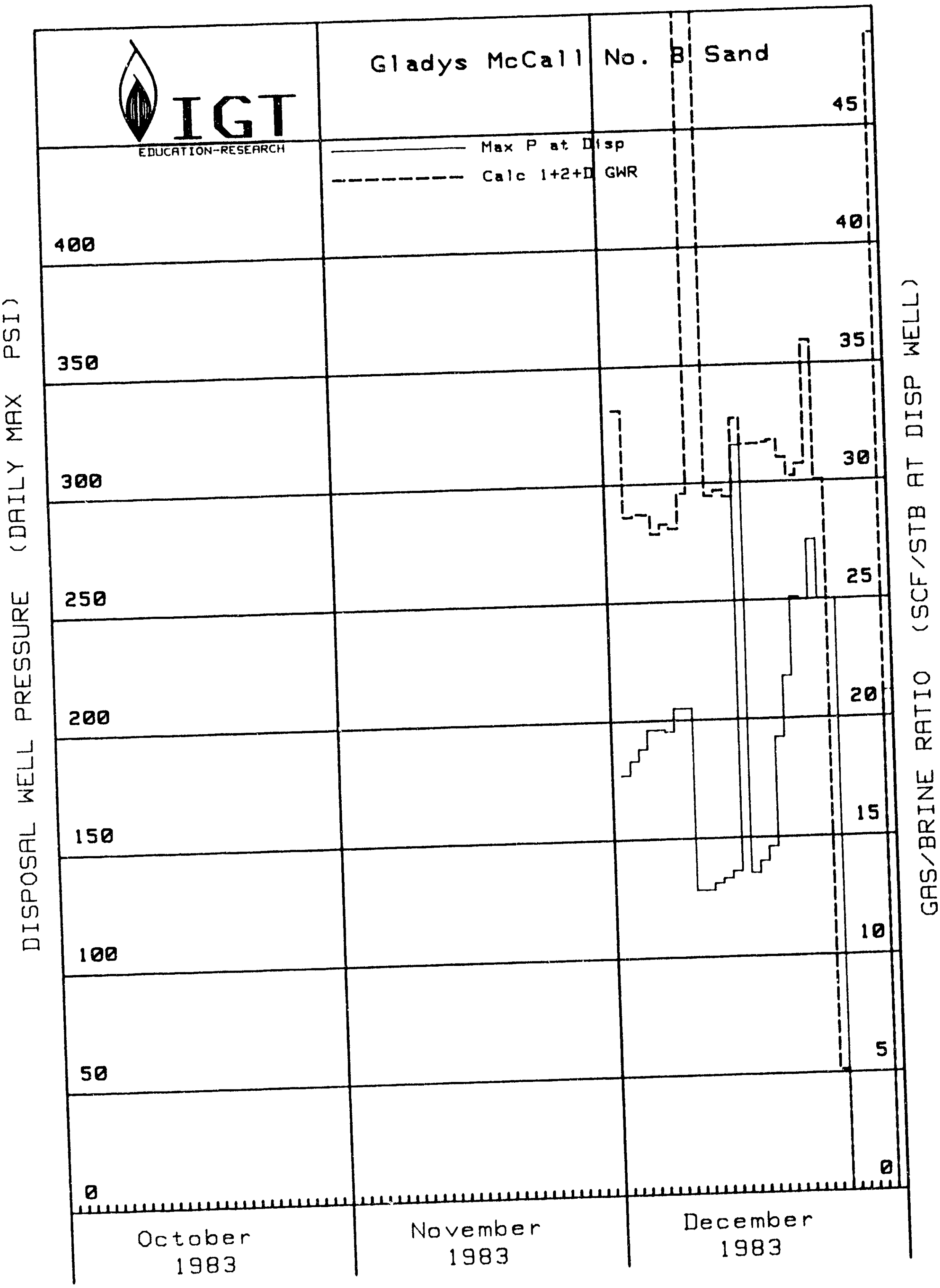
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EDUCATION-RESEARCH
Gladys McCall No. 8 Sand
Max P at Disp
Calc 1+2+D GWR
DISPOSAL WELL PRESSURE (DAILY MAX PSI)
GAS/BRINE RATIO (SCF/STB AT DISP WELL)
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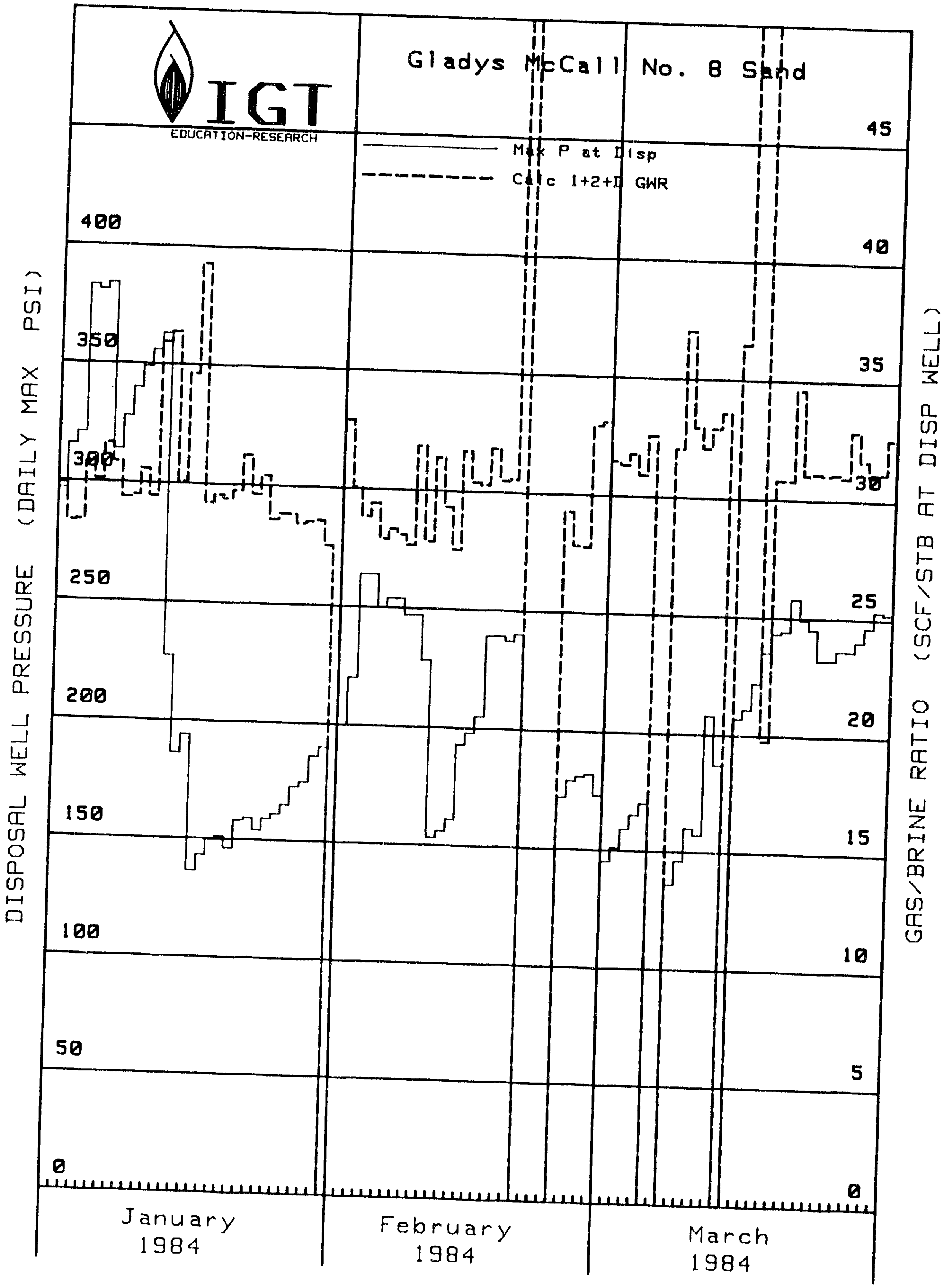
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Max P at Disp
Calc 1+2+D GWR
DISPOSAL WELL PRESSURE (DAILY MAX PSI)
GAS/BRINE RATIO (SCF/STB AT DISP WELL)
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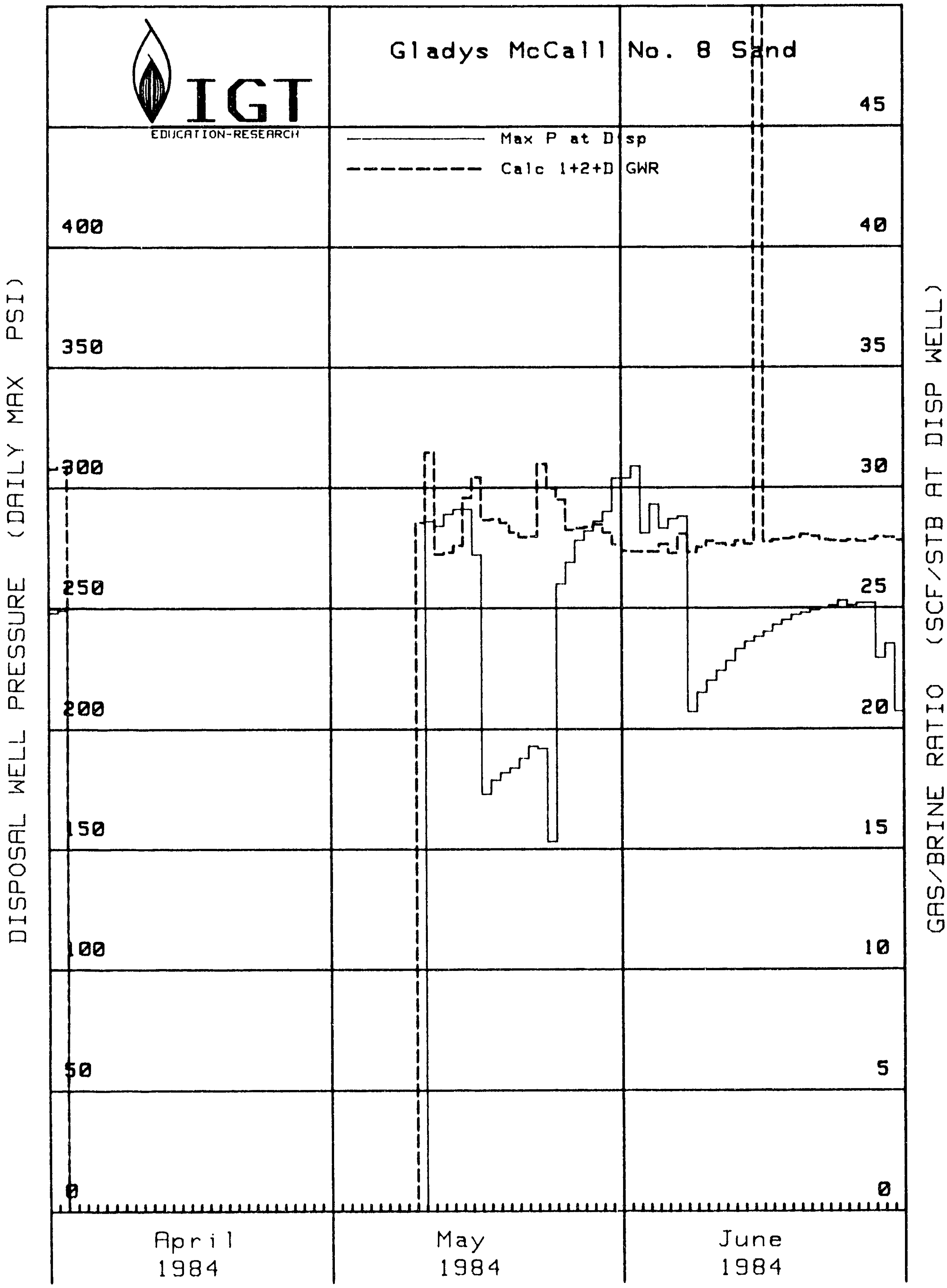
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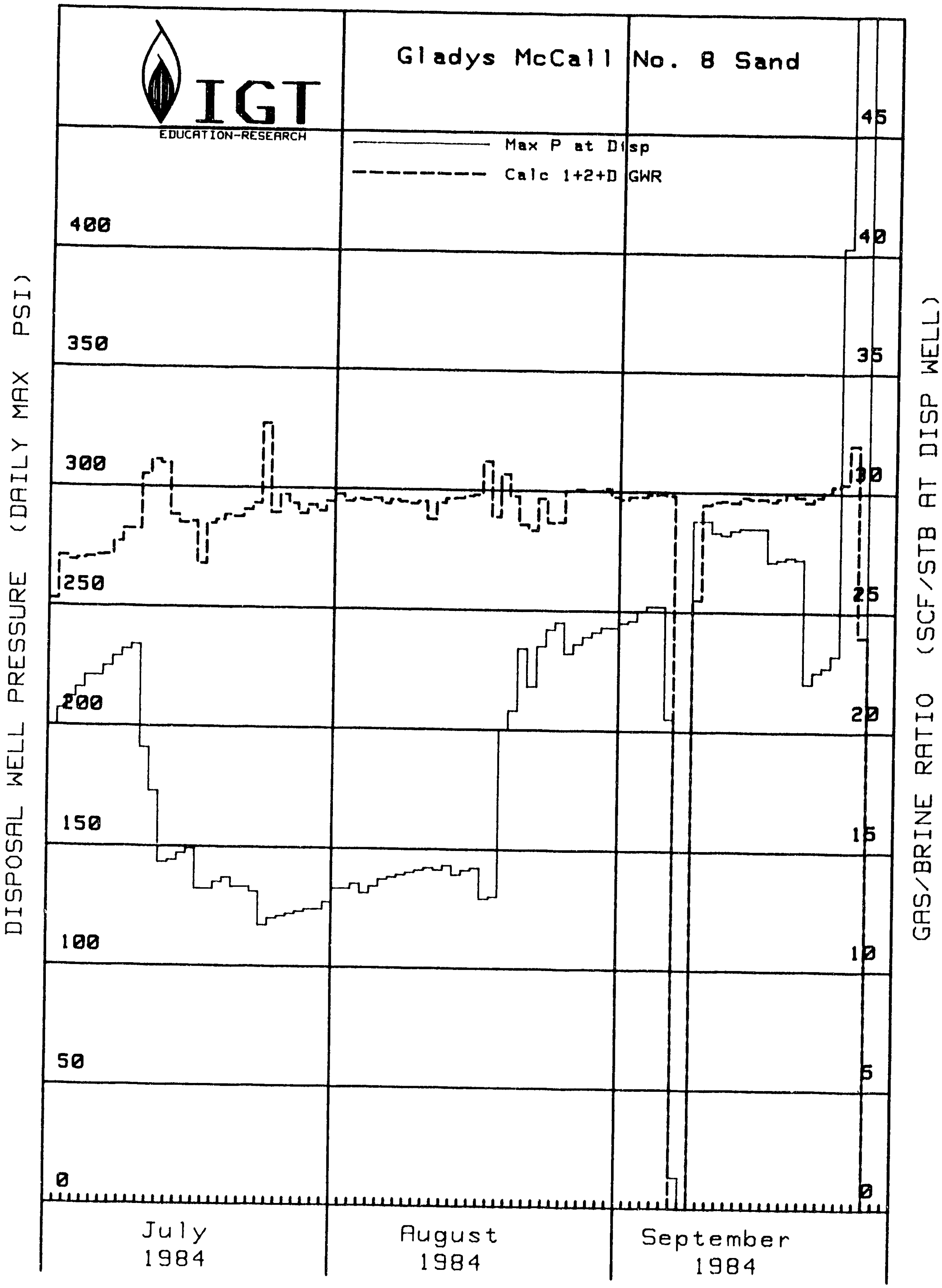
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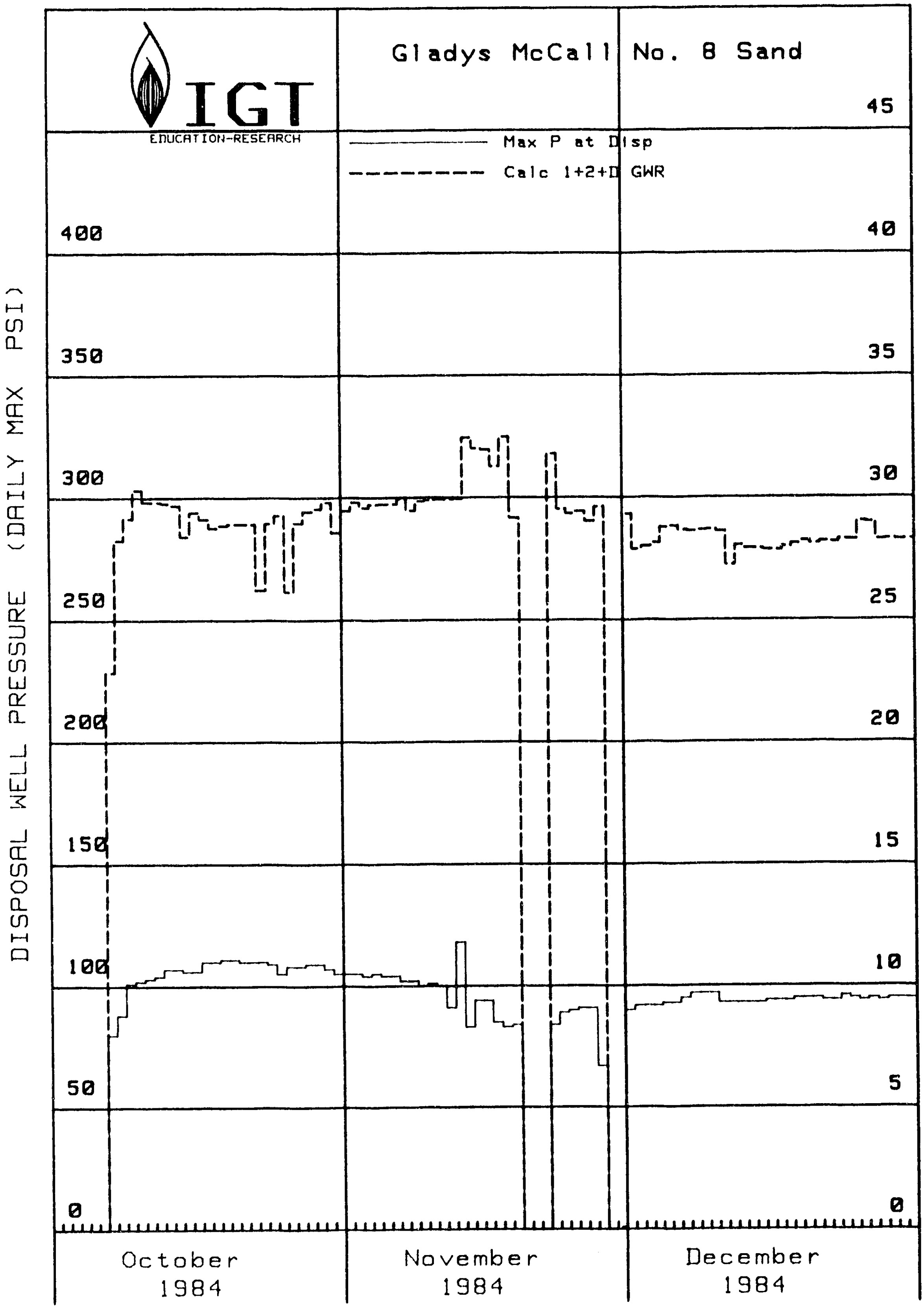

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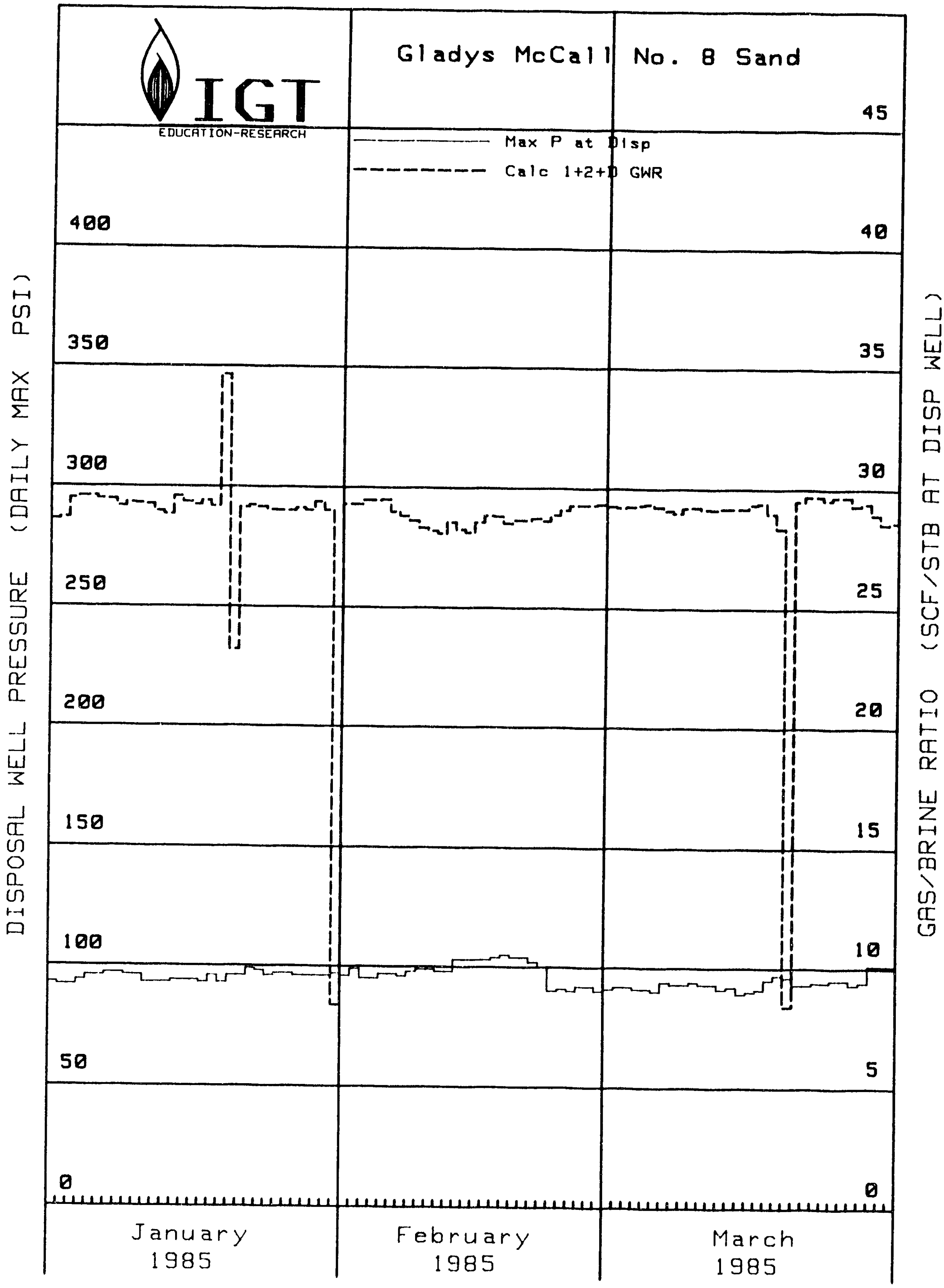
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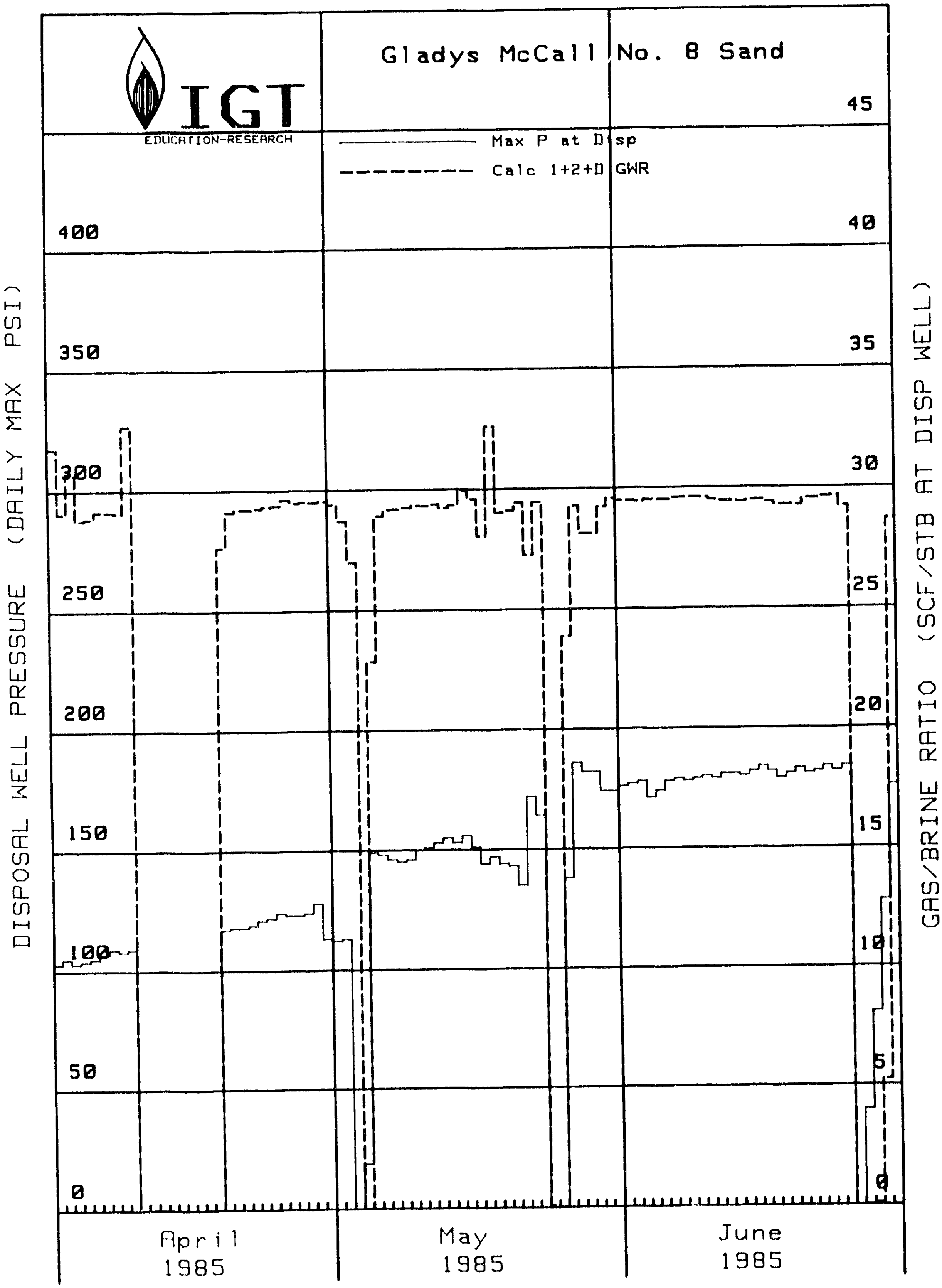
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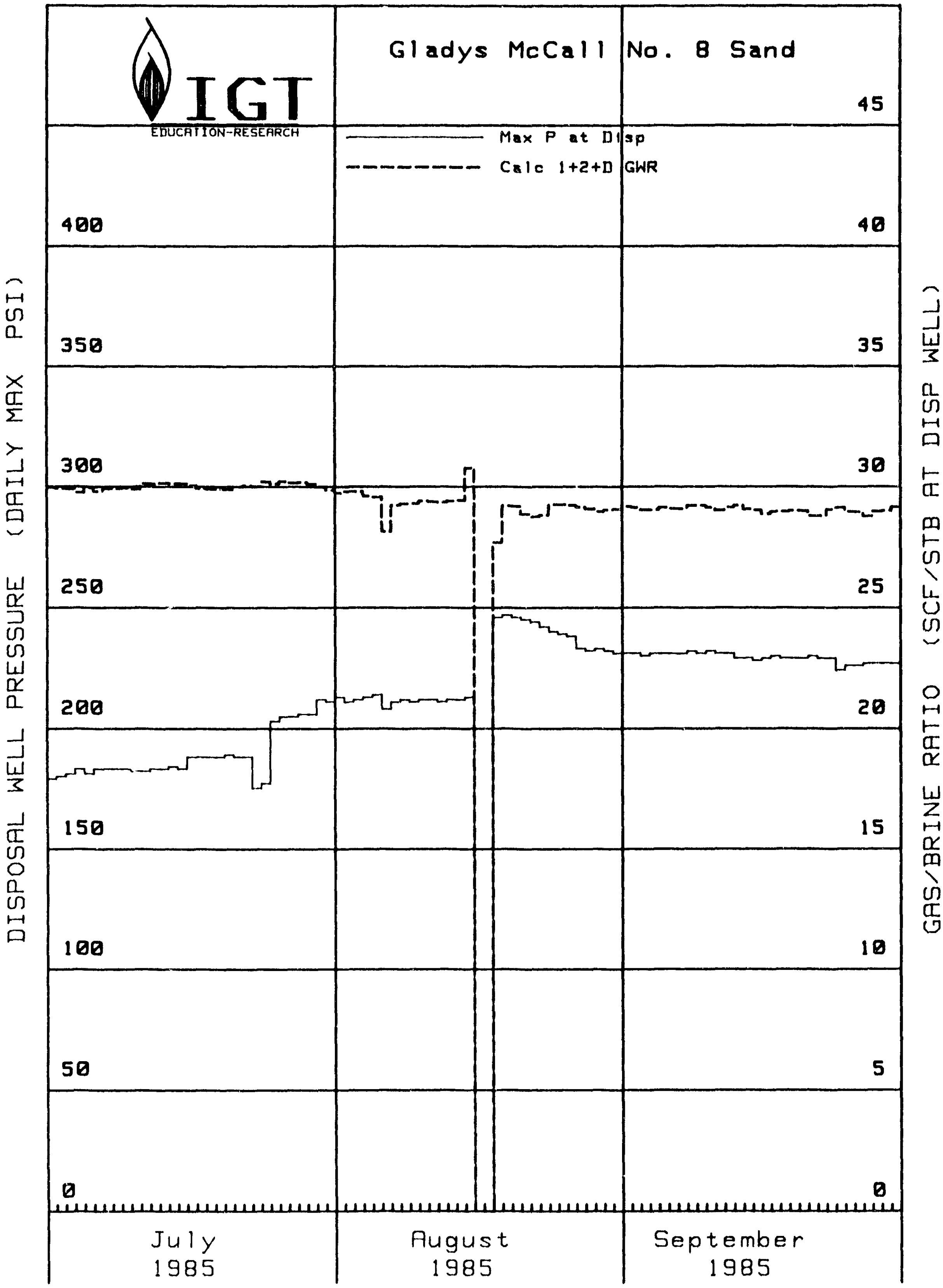

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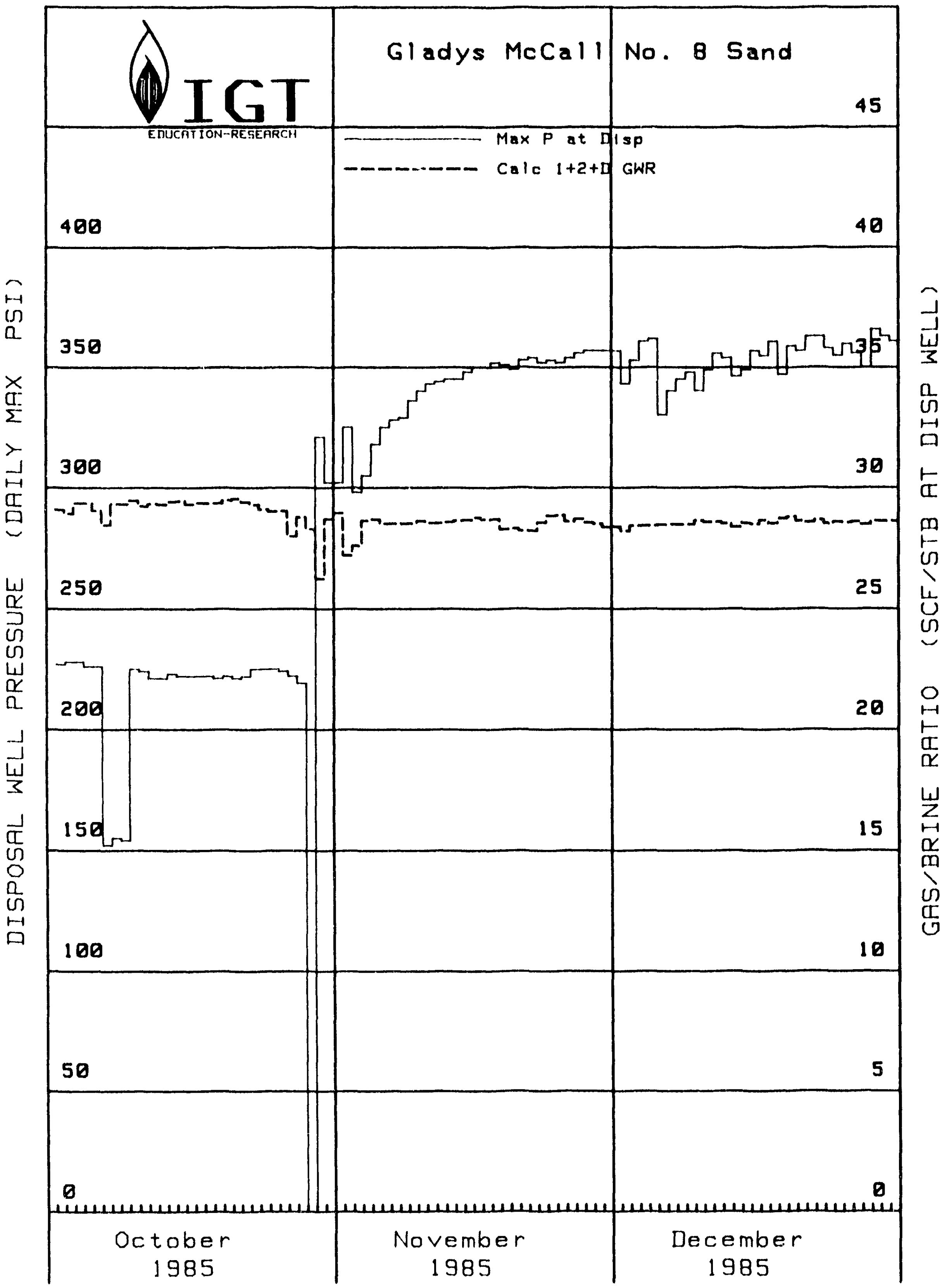
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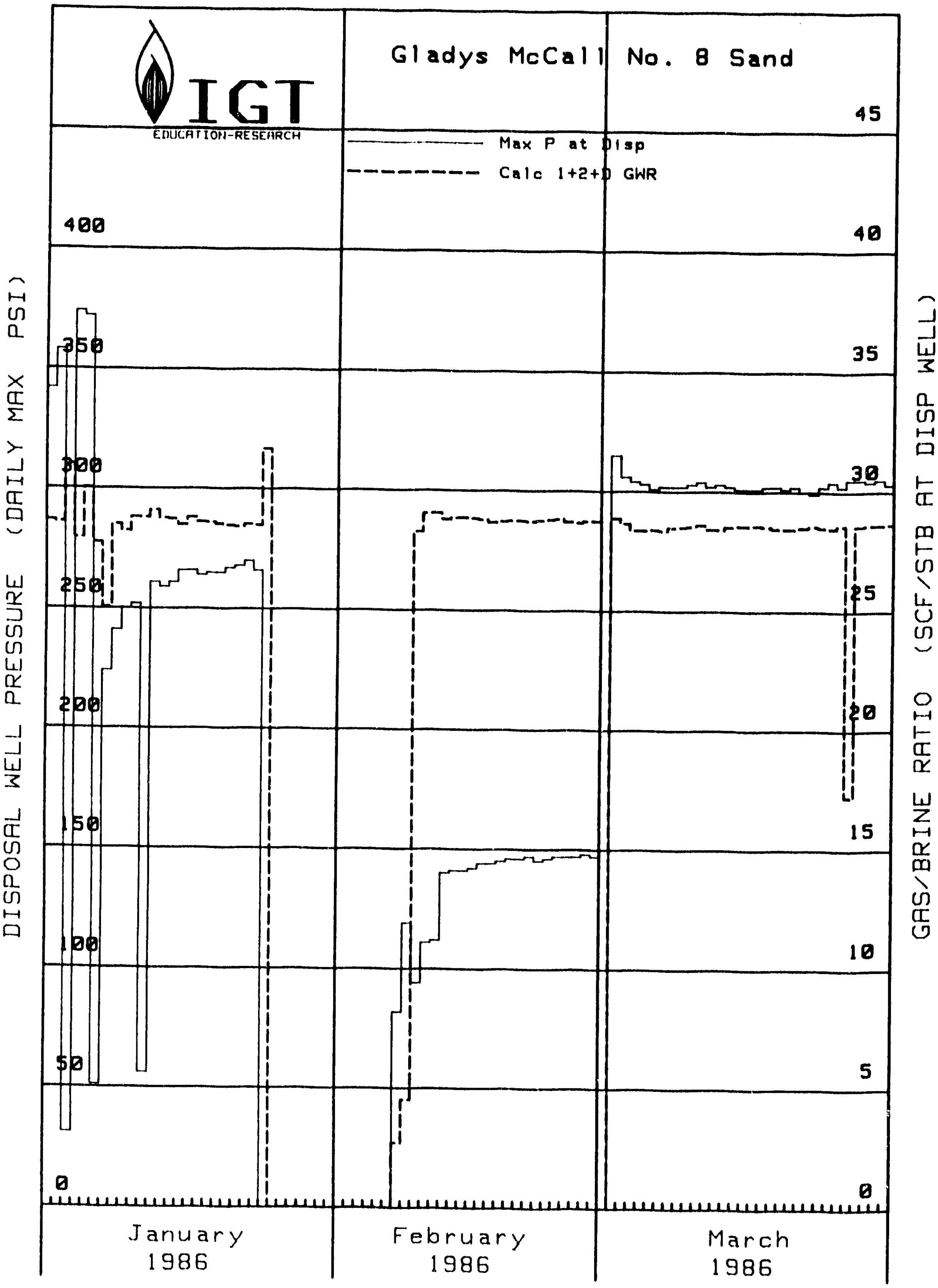
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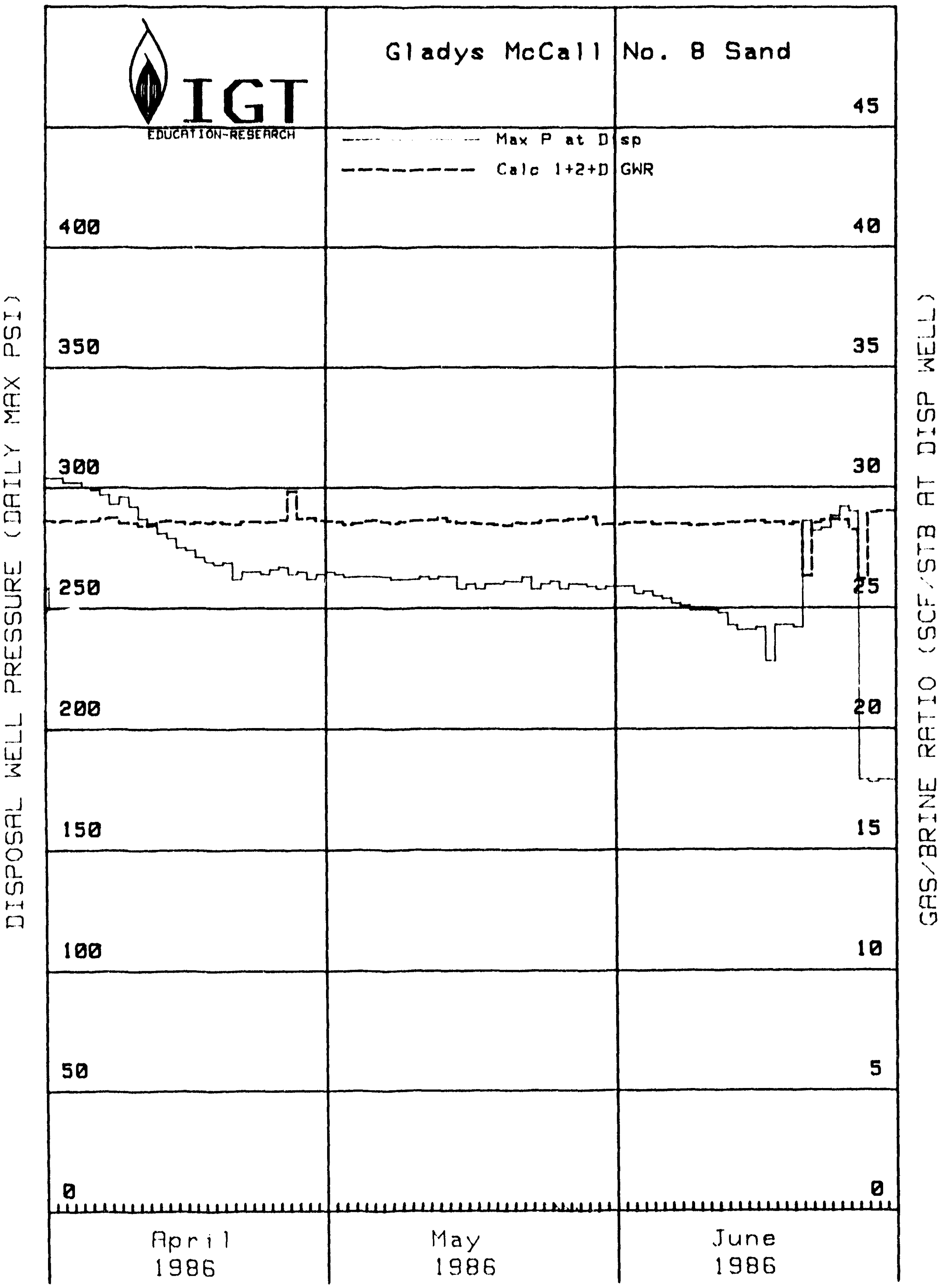
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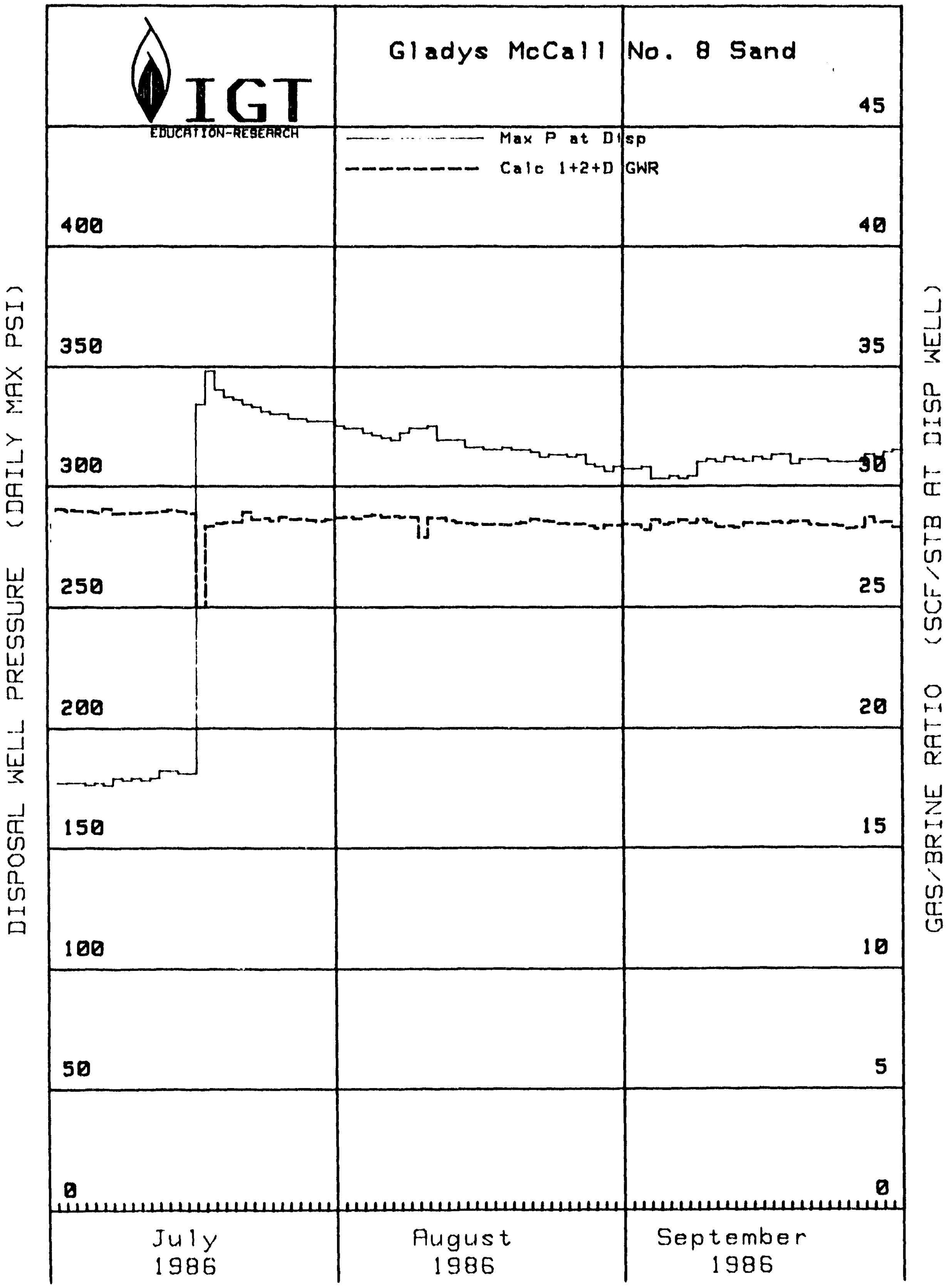
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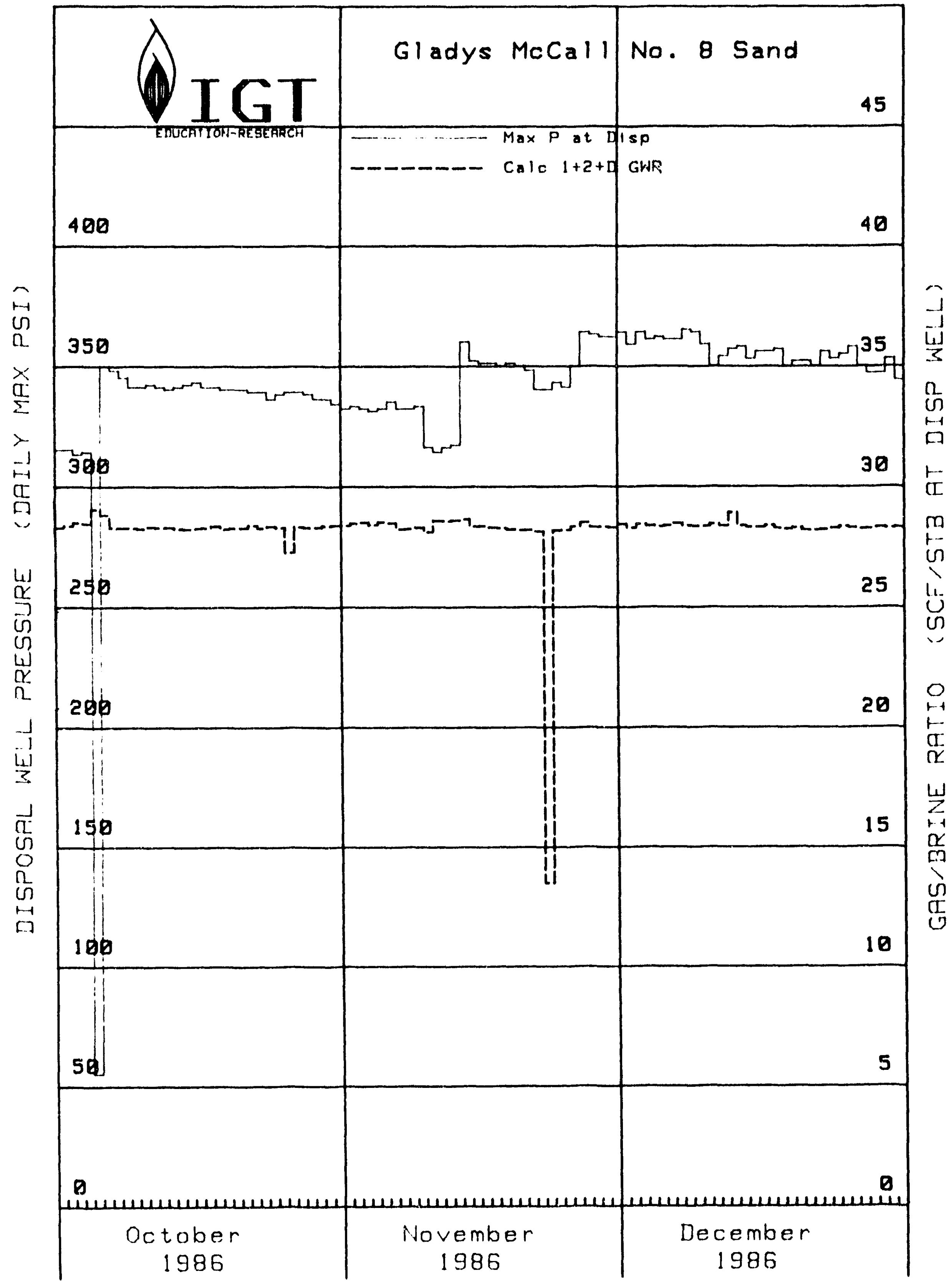
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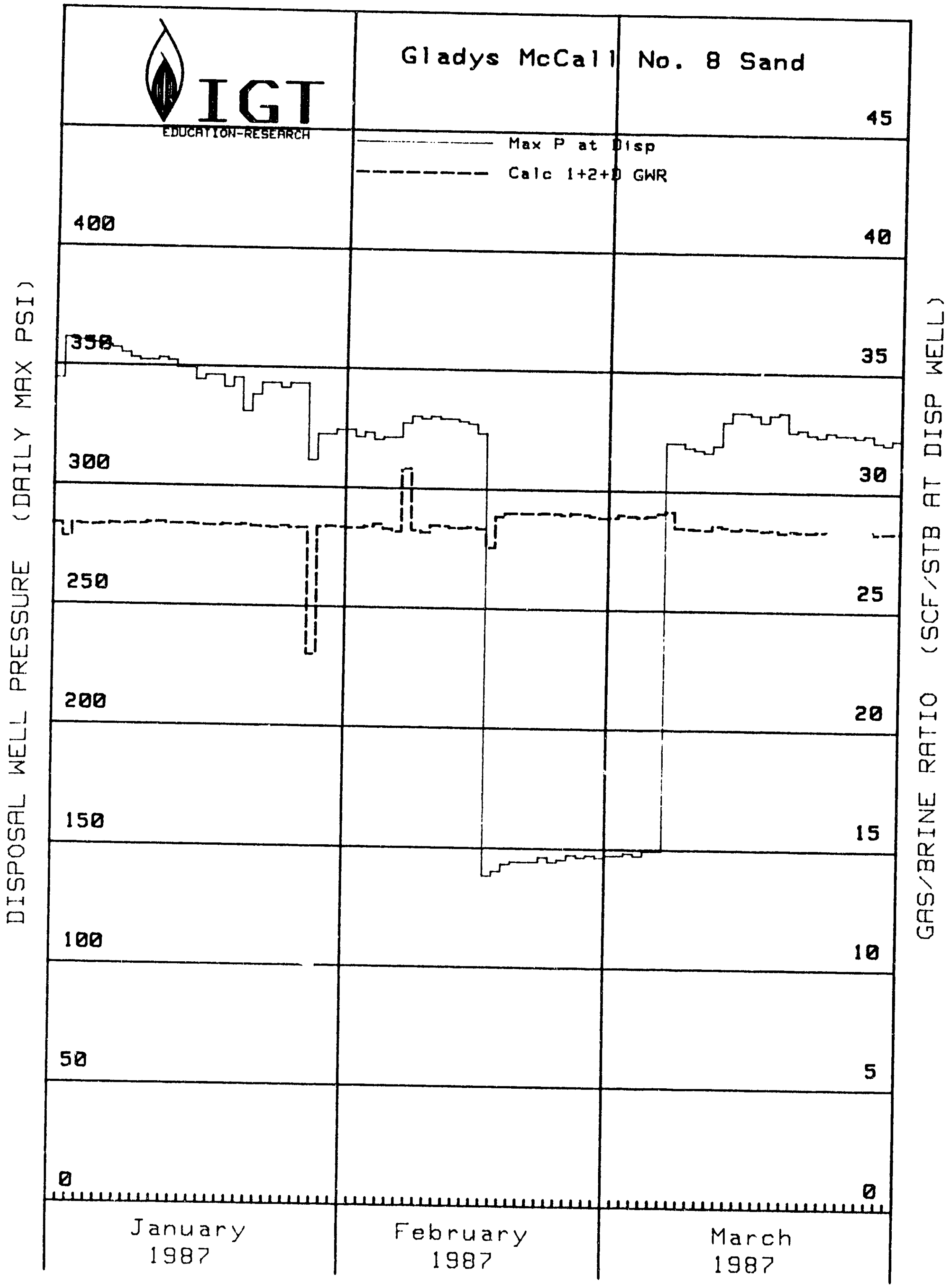

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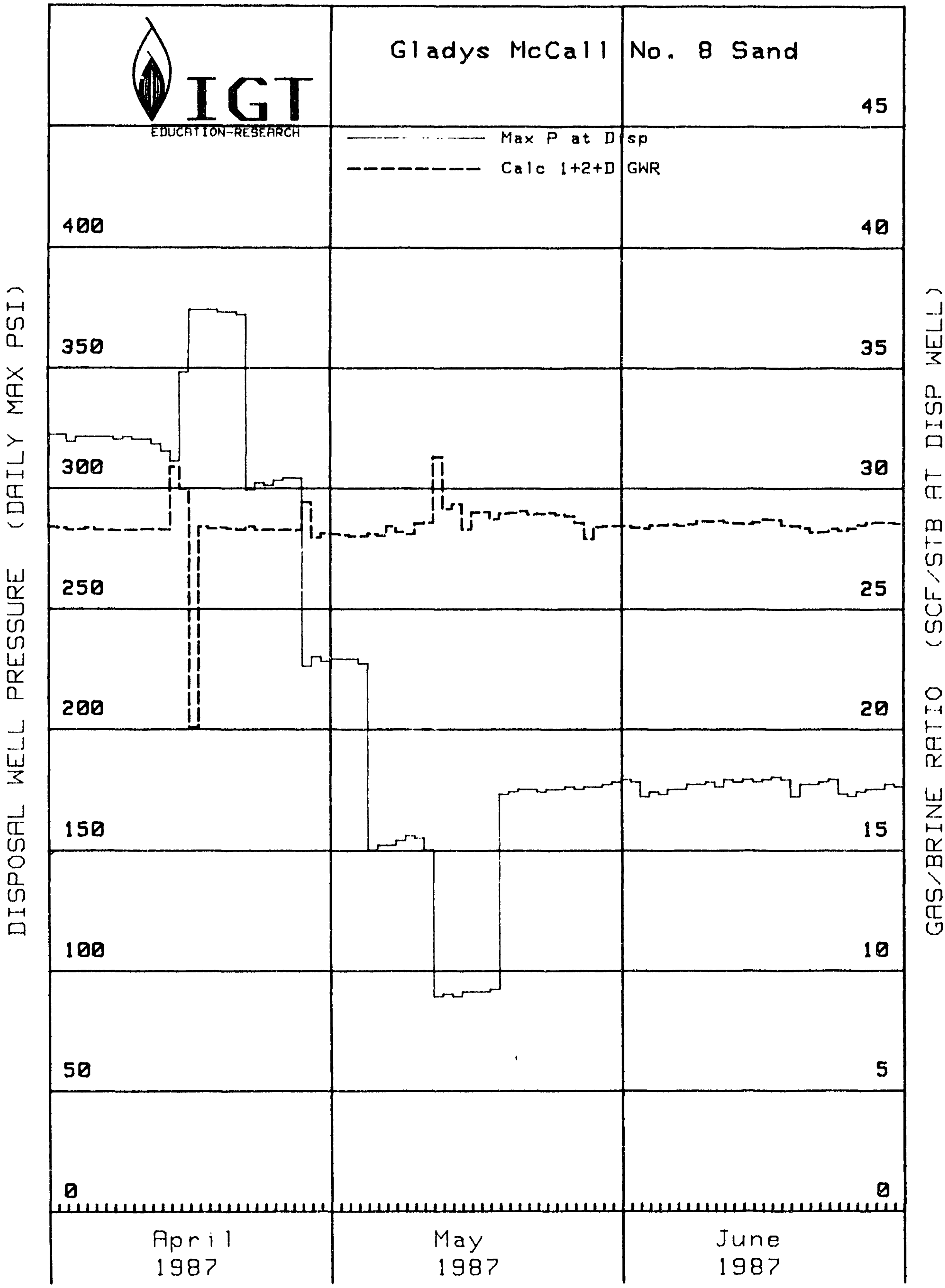
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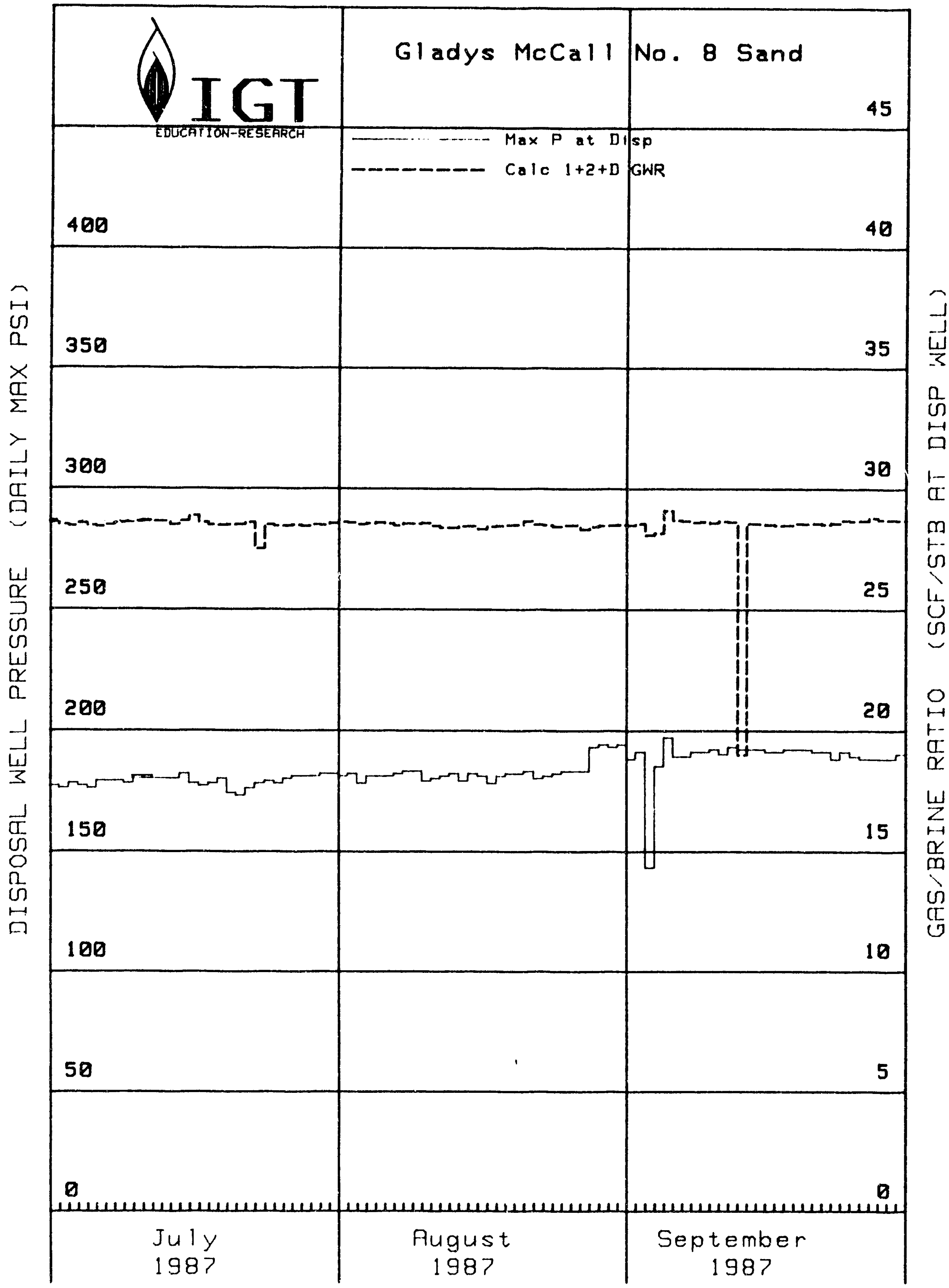
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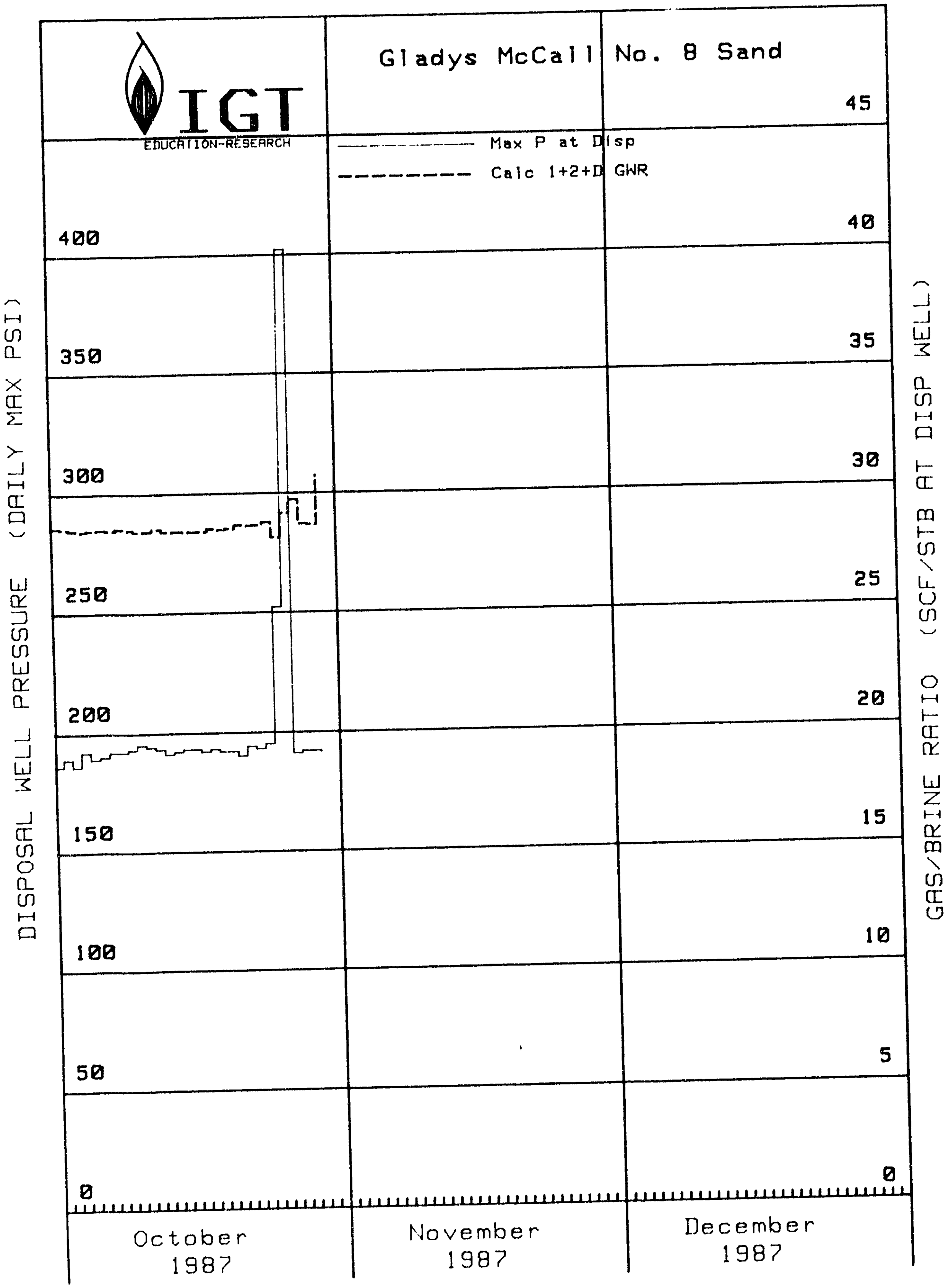
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APPENDIX E

Sand 8 Gas Rate Measurements

There were several inconsistencies in the gas rate calculations reported from the site. Some, although not all, of the sources of error were eliminated and gas rates were recalculated for this report. The field procedure for calculating gas production assumed that the only variables in the orifice equation were the pressure, differential pressure, and temperature. It ignored the effects of the water-vapor content of the gas and changing gas composition, both of which had a significant effect on the reported flow rates. The following subsections document these problems and the corrections made.

Loss of Accuracy at Lower Flow Rates

The measurements of gas production rates from the two separators and of the commingled gas to sales were made with orifice meters. Each separator was equipped with separate orifice plates for gas flow to sales and for gas flow to flare. Portions of gas from each separator could be simultaneously sold and flared. The orifices were not equipped with block valves and bypasses. Thus, shut-in of production was required to change orifice plates. In practice, rather than shut in the production, the sensitivity of the differential-pressure transmitter was changed, with the inherent degrading of resolution, temperature sensitivity, and accuracy during periods of low flow rates.

Water-Vapor Content of Measured Gas

Gas rates reported herein are corrected for the water-vapor content of the gas. Correction of metered gas rates for water vapor was particularly significant for the meter runs on the low-pressure separator. At a temperature of 260°F, the vapor pressure of water is 35.4 psia. The water-vapor content of the gas was 35.4/400 psia at a separator pressure of 400 psia. In this representative case, roughly 9% of the gas passing through the orifice plate was water vapor that was condensed and removed from the stream before the gas was sold. Field gas rate calculations treated this water vapor as produced gas.

Factors Used in Gas Rate Calculations

The gas production rates reported from the Gladys McCall location were calculated manually by the operators using orifice factor conversion tables for each meter run. The orifice factors were tabulated for various pressures and temperatures such that multiplying the value obtained by interpolation of the tables by the square root of the differential pressure yielded the gas flow rate. These tables were provided to the operator by a consultant during 1984. Although the details on how these orifice factors were derived were not included in the records, notations on the tables revealed a few of the values listed in Exhibit E-1 that were used to calculate them.

Exhibit E-1. APPARENT FACTORS FOR MANUAL GAS RATE CALCULATIONS

	HP Sep	LP Sep	Sales
Pipe ID, in.	2.626	2.626	2.067
Orifice bore, in.	0.75	0.375	0.625
Molecular Weight	18.957	22.832	19.407
Specific Heat Ratio	1.3	1.3	1.3
Viscosity, cP	0.015	0.015	0.015

Back-calculation by IGT to obtain the dry gas gravity from the above parameters and orifice factors gave the values 0.6545, 0.7883, and 0.6701, respectively, for the three orifice meters. When IGT installed the computer data acquisition system on the Gladys McCall site in 1986, the real dry gas gravities selected in an effort to match operator-reported rates were 0.6562, 0.727, and 0.670 for the high-pressure separator, low-pressure separator, and sales-gas meter runs, respectively. Subsequent resolution of differences (up to a few percent) between operator-reported rates and rates from the digital system was not practicable because of the lack of details on the calculations used to produce the tables used by the operators.

The gas rates presented herein were not corrected for changes in gas composition and the associated change in gas gravity. The actual dry gas gravity depended primarily on the pressure of the separators. The higher the separator pressure, the lower the gas gravity. This function is clearly shown in Exhibits E-2 and E-3, which present the gas gravity calculated from analyses of gas samples collected at the orifice meters on the high- and low-pressure separators (Locations 4 and 7) at various times over the life of the test.

The dry gas gravity was also affected by the brine temperature and, for the low-pressure separator, by the operating pressure of the high-pressure separator. During normal operation these are secondary effects because these values were essentially constant for most of the test. On April 13-14, 1987, when the high-pressure separator was at 515 psia and the low-pressure separator was at 400 to 450 psia, the low-pressure separator gas gravity was lower than would be expected at that pressure. These data points are blackened in Exhibit E-2 to differentiate them from the remaining samples. The extent to which the lower gravities are caused by undocumented transfers of gas from the high-pressure separator to the low-pressure separator through a bypass line is not clear. These gas transfers were occasionally needed to maintain control of the brine level in the low-pressure separator.

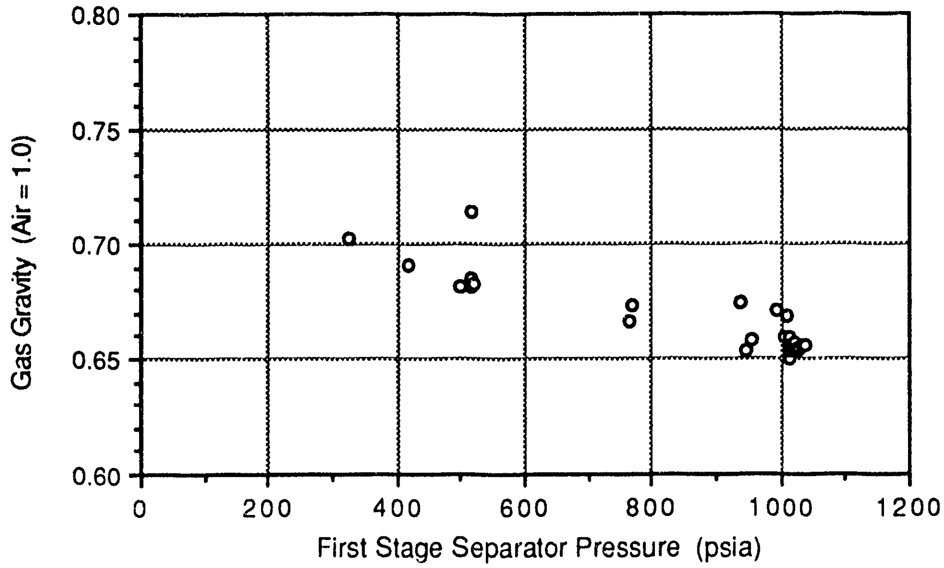

Exhibit E-2. GAS GRAVITY VERSUS FIRST-STAGE SEPARATOR PRESSURE

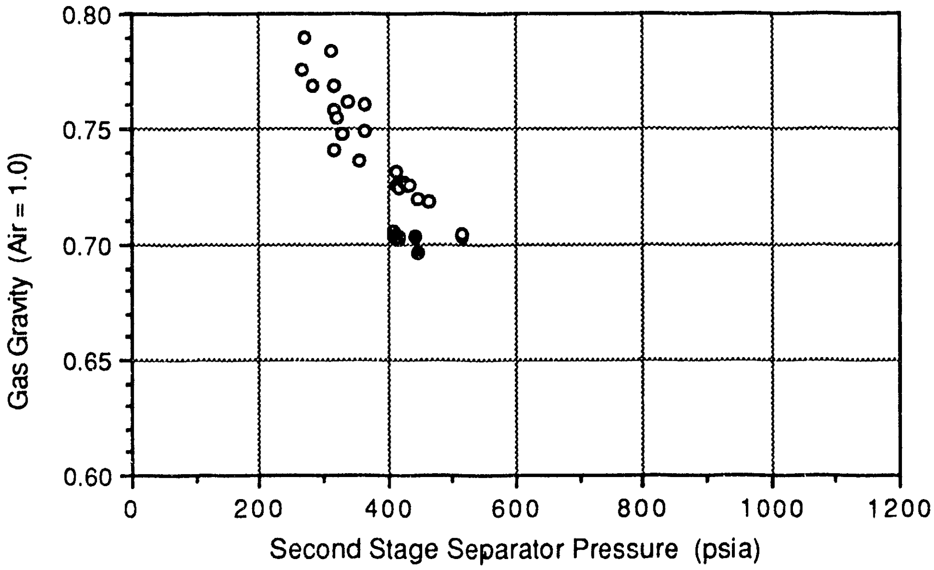

Exhibit E-3. GAS GRAVITY VERSUS SECOND-STAGE SEPARATOR PRESSURE

With the actual gas gravities differing from the assumed gas gravity, the calculated gas flow rates were slightly in error. The gravities would be correct only if the high-pressure separator was operated at 1000 psia and the low-pressure separator was kept at 420 psia. Exhibit E-4 shows how much the reported gas rates are in error at several operating pressures.

Exhibit E-4. ERROR IN GAS RATE CALCULATIONS BASED ON THE DIFFERENT GAS GRAVITIES AT VARIOUS PRESSURES

Pressure	Gas Gravity	Error in Calculated Gas Rate
High-Pressure Separator		
750 psia	0.669	1.0
1015 psia	0.656	0.0
Low-Pressure Separator (HP Sep at 1000 psi)		
300 psia	0.775	3.2
400 psia	0.732	0.3
500 psia	0.708	-1.0

Corrections for Gas Remaining in Brine After the Separator

IGT developed a correlation to deduce the quantity of gas remaining in the brine. This correlation was based on the solubility of methane in brine. A comparison of the calculated values versus actual measurements of the gas content of brine after the separator were made in Exhibit 7.1.2-1 of this report. The algorithm accurately calculates the hydrocarbon gas content of this dissolved gas. The hydrocarbon content of the gas remaining in the brine after the separator is much lower than the hydrocarbon content of the separator gas, with carbon dioxide making up the difference. The carbon dioxide content of this gas remaining in the brine was 40%±10%.

The IGT algorithm is therefore low compared to the total gas content of gas remaining in the brine after the separator. During operation with the second-stage separator pressure at 420 psia, the measured total gas value averaged 2.8 SCF/STB while the IGT algorithm calculated a value of 2.2 SCF/STB. The perforation gas rate reported in Appendix C during this time would be low by about 0.6 SCF/STB. This algorithm more nearly represents the marketable gas and ignores the large quantity of carbon dioxide that flashes off the brine as the pressure is lowered to atmospheric.

APPENDIX F

Long-Term Horner Plot

The Horner plot provides a mechanism to predict the final pressure that the reservoir will build up to following the production. This value is found where the extrapolation of the buildup curve intersects the $(T+\Delta t)/\Delta t = 1$ axis.

The final pressure was calculated from the material-balance equation --

$$C_T V_o [P_o - P_f] = V_p B$$

where -- C_T = Brine + Reservoir Compressibility = 6.27×10^{-6} [1/psi]
V_o = Initial Reservoir Volume [bbls]
P_o = Initial Reservoir Pressure = 12,811 psi, at 15,150 ft
P_f = Final Reservoir Pressure [psi, at time = ∞]
V_p = Volume of Produced Brine = 25.54×10^6 [bbls]
B = Formation Volume Factor = 0.984 [bbl/bbl]

Values for C_T and B are those used by S-Cubed. The point marked P_f in Exhibit 6.3.2-1 is the end point that should be reached for the S-Cubed model with 7.8 billion barrels in the reservoir.

The Horner plots of the bottomhole pressure versus $\Delta t/(T+\Delta t)$, where T is the flow time before shut-in and Δt is the time increment since shut-in. The early-time part of the plot reflects the transients of shutting in the well. Following the transient period is the semi-steady-state period characterized by a straight-line segment in the plot. This portion of the plot is useful for determining the flow capacity, or transmissibility (kh = permeability times thickness) of the reservoir. The last part of the plot is the final adjustment phase of the reservoir seeking its new equilibrium and is characterized by the plot curving away from the straight line of the semi-steady-state stage. Where the extrapolated plot intersects the $\Delta t/(T+\Delta t) = 1$ axis (when $\Delta t = \infty$) is the new equilibrium pressure that will be reached with the remaining brine left in the reservoir. The exact curvature of the final segment of the plot depends on the shape of the reservoir and where the well is located in the reservoir. For a circular reservoir with the well in the center, the plot simply bends downward as it extends to the $\Delta t/(T+\Delta t) = 1$ axis. When the reservoir is long and skinny, and has the well way off center, the plot takes on an "S" shape as it is extrapolated to the $\Delta t/(T+\Delta t) = 1$ axis. (For examples, see Reference 15.)

The common assumption for geopressured reservoirs is that they are hydraulically sealed and not in communication with adjacent reservoirs. The wisdom being that, if they were not sealed, their pressures would be hydrostatic rather than geopressured. This is the theoretical mathematical case of a reservoir with no-flow boundaries that is fully saturated with a slightly compressible fluid. For sealed reservoirs, the late-time portion of the Horner buildup plot will roll over to a final pressure lower than the initial pressure at the $\Delta t/(T+\Delta t) = 1$ axis as the result of removing the fluid from a sealed system. This is shown in Exhibit 6.3.2-1 by the dotted line extrapolation to the value P_f on the $\Delta t/(T+\Delta t) = 1$ axis.

Visual examination of Exhibit 6.3.2-1 reveals that the pressure buildup of the McCall reservoir has an upward curvature, indicating the buildup has passed the initial semi-steady-state stage and is in the phase characterized by an "S"-shaped curvature to the plot. The plot is still on the upward curvature and has not yet turned over as expected to a downward curvature so that the extrapolation of the plot will intersect the $\Delta t/(T+\Delta t) = 1$ axis at a point below the initial pressure. Straight-line extrapolation of the data intersects the $\Delta t/(T+\Delta t) = 1$ axis close to the initial pressure. This extrapolation would indicate that the reservoir is either infinite in size, has water influx, pore-volume creep, or some other mechanism adequate to reestablish the original pressure. The steep slope of the late-time buildup data (1900 psi/cycle) may be indicative of a huge low-permeability region away from the well.

APPENDIX G

Gas Sampling and Analysis

APPENDIX G

Gas Sampling and Analysis

The gas analyses were performed by IGT, Weatherly Laboratories, or Petroleum Analyst, Inc. Petroleum Analyst, Inc., was the laboratory used by the gas buyer (Louisiana Resources, Inc.). The natural gas liquids content, gravity, and heating value for all samples were recalculated on a common basis because the basis for calculating the heating values used by different laboratories was not consistent. Note that heating value is tabulated for a base pressure of 14.73 psia, whereas the natural gas liquids are reported on the Louisiana pressure base of 15.025 psia. The following table shows the Sand 8 gas analyses performed for each sample location. Each sample location described below is identified by its location number on Exhibit 4.0-1.

Location 1 is a gas sampling point at the top of the high-pressure separator. This gas is sampled at the high-pressure separator pressure and brine temperature. This gas is at equilibrium with the brine. This gas is most representative of what is being produced at a given moment from the well, because most of the gas produced is first available at that sample point.

Location 2 is a gas sampling point in the gas line between the high-pressure separator and the gas cooler. Gas from this location is almost indistinguishable from gas sampled at Location 1 in that some cooling of the gas has occurred in the piping, resulting in associated condensation of water vapor and natural gas liquids. This location is where the University of Southwest Louisiana (Keeley and Meriwether) collected "cryocondensate" samples from the gas stream.

Location 3 is a gas sampling point just ahead of the gas cooler. Gas from this location is almost indistinguishable from Location 2.

Location 4 is a gas sampling point at the first separator orifice meter run after the gas has been cooled to near-ambient conditions and condensed liquids have been removed. These gas analyses should be used in the flow-rate calculation for that orifice meter. Gas samples obtained from the high-pressure separator H_2S sample point is indistinguishable from gas obtained at the meter run.

Location 5 is a sampling point in the brine flow line on the high-pressure separator immediately ahead of the dump valves. Brine with its dissolved gas is collected at the high-pressure separator pressure and temperature in steel cylinders. The brine sample cylinder is cooled and the pressure reduced to atmospheric pressure in a volumetric cylinder. The gas exsolved from the brine is then analyzed. The gas remaining in the brine at this point is carried to the low-pressure separator.

Location 6 is a sampling point located on top of the low-pressure separator. Gas from this location is almost indistinguishable from Location 7.

Location 7 is a gas sample point in the line between the low-pressure separator and the sales orifice meter. This gas is at the low pressure and at a temperature usually near that of the brine. Analyses of this gas should be used in the flow-rate calculations for that orifice meter. Gas samples obtained at the low-pressure separator H_2S sample point are similar to gas obtained at the orifice plate.

Location 8 is a brine sampling point in the brine flow line from the low-pressure separator temperature and pressure measurement locations. Brine with its dissolved gas is collected at the low-pressure separator pressure and temperature in steel cylinders. The brine sample cylinder is cooled and the pressure reduced to atmospheric pressure in a volumetric cylinder. The gas exsolved from the brine is then analyzed. The gas remaining in the brine at this point is carried down the disposal well with the brine.

Location 9 is a gas sampling point in the gas line after the high-pressure and low-pressure gases have been cooled, had the water removed with a glycol unit, and brought to sales-line pressure. The sample location is near the sales-gas orifice meter.

Location 10 is a gas sampling point at the custody transfer point near Highway 82, roughly 2.4 miles from the Gladys McCall location. This gas should be the same as gas at Location 9, but analyses of samples from this point by the buyer, Louisiana Resources, Inc., are used for custody transfer considerations. These include verification that the gas meets contract specifications (such as water, hydrogen sulfide, and carbon dioxide content) and determination of its heating value.

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	Calculated Values: Liquids GAL/MCF	Calculated Values: Gravity (Air=1.0)	Calculated Values: Heat Value (BTU/SCF)
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1	I.G.T.	9-Feb-86	2:45 PM	285	1024	7.75	0.20	88.78	2.41	0.55	0.09	0.08	0.02	0.00	0.12	0.92	0.654	969
1	I.G.T.	9-Feb-86	7:15 PM	285	1025	7.68	0.24	88.84	2.39	0.55	0.08	0.08	0.02	0.00	0.12	0.92	0.653	969
1	I.G.T.	10-Feb-86	1:05 PM	294	1015	7.74	0.24	88.64	2.41	0.56	0.09	0.08	0.02	0.01	0.21	0.97	0.656	973
1	I.G.T.	11-Feb-86	10:31 AM	306	1020	7.78	0.23	88.52	2.42	0.56	0.09	0.07	0.02	0.01	0.30	1.01	0.659	976
1	I.G.T.	11-Feb-86	11:11 AM	289	1022	8.00	0.22	88.07	2.54	0.63	0.12	0.10	0.03	0.01	0.28	1.07	0.663	977
1	I.G.T.	11-Feb-86	11:32 AM	291	1019	8.01	0.23	88.12	2.46	0.61	0.11	0.10	0.04	0.01	0.31	1.06	0.663	977
1	I.G.T.	11-Feb-86	12:21 PM	294	1020	7.91	0.22	88.37	2.48	0.60	0.11	0.09	0.03	0.01	0.18	1.00	0.658	972
1	I.G.T.	11-Feb-86	2:25 PM	302	1018	7.81	0.22	88.74	2.40	0.54	0.09	0.07	0.02	0.01	0.10	0.91	0.654	968
1	I.G.T.	13-Apr-87	8:43 AM	284	1013	8.07	0.24	88.50	2.42	0.53	0.08	0.07	0.02	0.02	0.05	0.89	0.655	963
1	I.G.T.	13-Apr-87	4:00 PM	284	515	11.31	0.23	85.43	2.31	0.49	0.07	0.05	0.02	0.01	0.08	0.85	0.686	929
1	I.G.T.	14-Apr-87	7:50 AM	280	515	10.99	0.27	85.77	2.26	0.47	0.07	0.06	0.02	0.02	0.07	0.83	0.682	931
1	I.G.T.	14-Apr-87	12:30 PM	280	515	11.05	0.25	85.52	2.34	0.52	0.09	0.08	0.02	0.02	0.11	0.90	0.685	935
1	I.G.T.	14-Apr-87	12:40 PM	280	515	10.97	0.25	85.73	2.28	0.50	0.08	0.07	0.03	0.02	0.07	0.86	0.683	933
1	I.G.T.	14-Apr-87	1:35 PM	280	516	11.19	0.23	85.49	2.30	0.49	0.07	0.07	0.03	0.02	0.11	0.88	0.686	932
2	I.G.T.	17-Dec-85	5:10 PM	91	1019	7.88	0.25	88.60	2.42	0.55	0.09	0.07	0.01	0.02	0.11	0.92	0.655	967
2	I.G.T.	18-Dec-85	9:30 AM	90	1018	8.00	0.17	88.59	2.43	0.54	0.09	0.07	0.02	0.01	0.08	0.91	0.655	966
2	I.G.T.	15-Jan-86	7:00 AM	225	1015	7.86	0.31	88.47	2.44	0.61	0.09	0.08	0.02	0.01	0.11	0.95	0.656	968
2	I.G.T.	7-Feb-86	9:15 PM	208	518	9.11	0.26	87.68	2.23	0.47	0.07	0.06	0.02	0.01	0.09	0.83	0.664	951
2	I.G.T.	7-Feb-86	9:15 PM	208	518	9.14	0.20	87.66	2.24	0.49	0.07	0.06	0.01	0.02	0.11	0.85	0.665	952
2	I.G.T.	8-Feb-86	8:45 AM	260	1024	7.39	0.23	89.16	2.38	0.53	0.08	0.07	0.02	0.01	0.13	0.91	0.650	972
2	I.G.T.	8-Feb-86	12:44 PM	280	1021	7.79	0.23	88.69	2.41	0.54	0.09	0.08	0.02	0.00	0.15	0.93	0.655	970
2	I.G.T.	10-Feb-86	1:10 PM	294	1015	7.75	0.21	88.84	2.39	0.53	0.09	0.07	0.02	0.02	0.08	0.90	0.653	968
2	I.G.T.	12-Feb-86	3:05 PM	297	1020	7.88	0.25	88.59	2.42	0.53	0.09	0.08	0.02	0.01	0.13	0.93	0.655	968
2	I.G.T.	12-Feb-86	7:00 PM	298	1024	7.77	0.25	88.74	2.43	0.53	0.09	0.07	0.02	0.01	0.09	0.91	0.653	968
4	Weatherly	8-Oct-83	12:00 PM	97	500	10.63	0.25	85.96	2.34	0.52	0.09	0.07	0.02	0.01	0.11	0.89	0.681	938
4	Weatherly	28-Oct-83	12:00 PM	275	515	10.31	0.24	84.85	2.31	0.51	0.09	0.08	0.02	0.01	1.58	1.50	0.714	997
4	Weatherly	14-Jan-84	12:00 PM	227	769	9.09	0.25	87.14	2.41	0.55	0.10	0.08	0.02	0.01	0.35	1.03	0.673	965
4	Weatherly	18-Jan-84	2:00 PM	100	765	6.80	0.26	88.76	2.44	0.55	0.10	0.08	0.03	0.02	0.96	1.30	0.666	1012
4	Weatherly	24-Jan-84	12:00 PM	110	1015	7.89	0.26	88.35	2.48	0.57	0.10	0.09	0.02	0.01	0.23	1.01	0.659	973
4	Weatherly	26-Jan-84	12:00 PM	100	1021	7.81	0.26	88.52	2.48	0.57	0.10	0.09	0.03	0.01	0.13	0.97	0.656	970
4	Weatherly	27-Jan-84	12:00 PM	245	1016	7.83	0.27	88.51	2.47	0.56	0.10	0.08	0.02	0.01	0.15	0.96	0.656	970
4	Weatherly	7-Feb-84	12:00 PM	88	1015	7.77	0.28	88.54	2.47	0.56	0.10	0.08	0.02	0.01	0.17	0.97	0.656	971
4	Weatherly	9-Feb-84	12:00 PM	93	1015	7.29	0.27	88.95	2.48	0.57	0.10	0.08	0.02	0.02	0.22	1.00	0.653	979
4	Weatherly	29-Feb-84	11:00 AM	88	324	12.74	0.24	83.92	2.25	0.49	0.08	0.07	0.02	0.01	0.18	0.89	0.702	918

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test (Cont.)

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	Calculated Values: Liquids GAL/MCF	Calculated Values: Gravity (Air=1.0)	Calculated Values: Heat Value (BTU/SCF)
4	Weatherly	3-Mar-84	10:00 AM	92	419	11.61	0.24	85.03	2.27	0.50	0.08	0.07	0.02	0.01	0.17	0.89	0.691	930
4	Weatherly	4-Jun-84	12:00 PM	102	1005	8.15	0.27	88.20	2.44	0.56	0.10	0.08	0.03	0.02	0.15	0.96	0.659	967
4	Weatherly	29-Jun-84	12:00 PM	78	945	7.82	0.26	88.66	2.45	0.56	0.10	0.08	0.02	0.01	0.04	0.91	0.653	966
4	Weatherly	4-Jun-84	12:00 PM	105	957	8.14	0.27	88.23	2.46	0.57	0.10	0.08	0.02	0.01	0.12	0.95	0.658	966
4	Weatherly	18-Jul-84	2:00 PM	97	1015	7.80	0.25	88.59	2.46	0.56	0.10	0.08	0.02	0.01	0.13	0.95	0.655	970
4	Weatherly	20-Jul-84	12:00 PM	95	1015	7.83	0.26	88.57	2.46	0.56	0.10	0.08	0.02	0.01	0.11	0.94	0.655	969
4	Weatherly	22-Jul-84	12:00 PM	101	995	9.31	0.69	86.70	2.45	0.53	0.09	0.07	0.02	0.01	0.13	0.93	0.671	949
4	Weatherly	24-Jul-84	12:00 PM	94	1018	7.82	0.27	88.53	2.46	0.56	0.10	0.08	0.02	0.01	0.15	0.96	0.656	970
4	Weatherly	26-Jul-84	12:00 PM	82	1020	7.88	0.26	88.50	2.46	0.56	0.10	0.08	0.02	0.01	0.13	0.95	0.656	969
4	Weatherly	22-Aug-84	12:00 PM	87	940	9.99	0.30	86.56	2.33	0.52	0.09	0.07	0.02	0.01	0.11	0.89	0.675	944
4	Weatherly	12-Oct-84	12:10 PM	87	1039	7.89	0.31	88.44	2.47	0.56	0.10	0.08	0.02	0.01	0.12	0.95	0.656	968
4	Weatherly	6-Dec-84	12:00 PM	210	1031	7.54	0.28	88.71	2.48	0.57	0.10	0.08	0.02	0.01	0.21	0.99	0.655	976
4	Weatherly	6-Dec-84	12:00 PM	72	1010	9.24	0.27	87.34	2.28	0.51	0.08	0.07	0.03	0.02	0.16	0.90	0.669	954
4	Weatherly	28-Feb-85	12:00 PM	80	1024	7.81	0.27	88.46	2.49	0.59	0.11	0.09	0.02	0.02	0.14	0.98	0.657	971
4	I.G.T.	15-Jan-86	6:00 AM	88	1015	7.42	0.27	89.07	2.41	0.55	0.09	0.07	0.01	0.01	0.10	0.91	0.650	971
4	I.G.T.	9-Feb-86	2:50 PM	285	1025	7.70	0.21	88.84	2.40	0.54	0.10	0.08	0.00	0.00	0.13	0.92	0.653	970
4	I.G.T.	9-Feb-86	7:21 PM	285	1025	7.73	0.24	88.70	2.42	0.57	0.10	0.08	0.01	0.00	0.15	0.95	0.655	971
4	I.G.T.	10-Feb-86	1:18 PM	293	1016	7.80	0.23	88.52	2.47	0.60	0.11	0.09	0.03	0.02	0.13	0.98	0.656	972
4	I.G.T.	12-Feb-86	11:10 AM	295	1035	7.88	0.26	88.55	2.43	0.55	0.09	0.08	0.02	0.01	0.13	0.94	0.656	968
4	I.G.T.	19-Feb-87	10:50 AM	90	1015	7.91	0.25	88.57	2.40	0.53	0.08	0.07	0.02	0.02	0.15	0.93	0.656	968
4	I.G.T.	13-Apr-87	12:30 PM	95	1013	8.17	0.25	88.36	2.44	0.54	0.08	0.07	0.02	0.01	0.06	0.90	0.656	962
4	I.G.T.	13-Apr-87	5:10 PM	83	514	11.06	0.23	85.75	2.26	0.48	0.07	0.06	0.01	0.02	0.06	0.83	0.682	930
4	I.G.T.	13-Apr-87	6:20 PM	79	515	11.11	0.23	85.69	2.28	0.49	0.07	0.03	0.02	0.01	0.07	0.83	0.683	930
4	I.G.T.	14-Apr-87	7:25 AM	80	515	10.87	0.22	85.95	2.23	0.47	0.07	0.08	0.02	0.01	0.08	0.83	0.681	933
4	I.G.T.	14-Apr-87	2:50 PM	91	517	11.17	0.23	85.55	2.30	0.49	0.07	0.07	0.02	0.01	0.09	0.86	0.685	931
4	I.G.T.	14-Apr-87	10:00 PM	85	519	11.01	0.25	85.75	2.27	0.48	0.07	0.06	0.02	0.02	0.07	0.84	0.683	932
4	I.G.T.	15-Apr-87	6:25 AM	73	515	11.09	0.22	85.70	2.29	0.49	0.07	0.06	0.00	0.00	0.08	0.84	0.683	931
4	I.G.T.	20-Apr-87	4:50 PM	78	1015	8.07	0.25	88.47	2.42	0.54	0.08	0.08	0.02	0.02	0.05	0.90	0.655	963
4	I.G.T.	27-Apr-87	9:45 AM	100	1020	8.09	0.24	88.42	2.44	0.55	0.08	0.07	0.02	0.02	0.07	0.91	0.656	964
5	Weatherly	8-Oct-83	12:00 PM	97	500	39.89	0.00	57.73	1.39	0.19	0.02	0.02	0.00	0.00	0.76	0.76	0.969	653
5	Weatherly	28-Oct-83	12:00 PM	275	515	40.74	0.00	57.21	1.35	0.19	0.02	0.02	0.00	0.00	0.47	0.63	0.970	633
5	Weatherly	14-Jan-84	12:00 PM	227	769	34.05	0.00	63.44	1.62	0.46	0.07	0.03	0.04	0.00	0.29	0.74	0.906	703
5	Weatherly	18-Jan-84	2:00 PM	275	765	32.79	0.00	65.18	1.51	0.29	0.04	0.03	0.01	0.01	0.14	0.58	0.887	705
5	Weatherly	24-Jan-84	12:00 PM	275	1015	25.53	0.00	72.62	1.52	0.19	0.02	0.02	0.00	0.00	0.10	0.52	0.814	775

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test (Cont.)

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	------ Calculated Values ------ Liquids GAL/MCF	Gravity (Air=1.0)	Heat Value (BTU/SCF)
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5	Weatherly	26-Jan-84	12:00 PM	276	1021	30.95	0.00	66.95	1.56	0.36	0.05	0.02	0.00	0.00	0.11	0.60	0.869	724
5	Weatherly	27-Jan-84	12:00 PM	276	1016	30.87	0.00	67.36	1.41	0.19	0.02	0.02	0.00	0.00	0.13	0.51	0.866	721
5	Weatherly	7-Feb-84	10:30 AM	282	1015	34.30	0.00	63.94	1.36	0.19	0.02	0.02	0.00	0.00	0.17	0.51	0.900	687
5	Weatherly	28-Feb-84	12:00 PM	277	324	30.59	0.00	67.53	1.49	0.22	0.03	0.03	0.02	0.01	0.08	0.53	0.864	724
5	Weatherly	3-Mar-84	10:00 AM	277	419	25.47	0.00	72.58	1.59	0.23	0.02	0.02	0.00	0.00	0.09	0.55	0.814	776
5	Weatherly	18-Jul-84	12:00 PM	97	1015	33.88	0.00	65.78	0.22	0.02	0.00	0.00	0.00	0.08	0.02	0.10	0.886	676
5	Weatherly	20-Jul-84	12:00 PM	95	1015	32.97	0.00	65.25	1.55	0.18	0.01	0.01	0.00	0.00	0.03	0.49	0.884	696
5	Weatherly	24-Jul-84	12:00 PM	94	1018	34.76	0.00	63.66	1.29	0.16	0.01	0.02	0.00	0.01	0.09	0.45	0.902	679
5	Weatherly	26-Jul-84	12:00 PM	82	1020	32.53	0.00	65.60	1.39	0.20	0.02	0.02	0.03	0.01	0.20	0.55	0.885	708
5	I.G.T.	7-Feb-86	9:10 PM	208	518	29.99	0.00	68.37	1.36	0.17	0.01	0.01	0.01	0.00	0.08	0.46	0.856	727
5	I.G.T.	8-Feb-86	8:54 AM	264	1031	28.47	0.00	69.85	1.38	0.18	0.02	0.01	0.00	0.00	0.09	0.47	0.842	743
5	I.G.T.	8-Feb-86	12:40 PM	280	1023	28.99	0.00	69.31	1.38	0.18	0.02	0.02	0.00	0.00	0.10	0.48	0.847	738
5	I.G.T.	10-Feb-86	1:25 PM	295	1017	23.50	0.00	74.69	1.49	0.20	0.02	0.02	0.01	0.00	0.07	0.51	0.794	794
5	I.G.T.	10-Feb-86	4:00 PM	298	1014	25.00	0.00	73.20	1.47	0.20	0.02	0.02	0.00	0.00	0.09	0.51	0.809	779
5	I.G.T.	11-Feb-86	10:34 AM	306	1020	27.98	0.00	70.27	1.40	0.19	0.02	0.02	0.00	0.00	0.12	0.50	0.838	750
5	I.G.T.	11-Feb-86	11:14 AM	289	1022	25.98	0.00	72.25	1.43	0.19	0.02	0.02	0.00	0.00	0.11	0.50	0.818	770
5	I.G.T.	11-Feb-86	11:38 AM	291	1019	25.87	0.00	72.36	1.43	0.19	0.02	0.02	0.00	0.00	0.11	0.50	0.817	771
5	I.G.T.	11-Feb-86	12:24 PM	294	1020	26.04	0.00	72.19	1.43	0.19	0.02	0.02	0.00	0.00	0.11	0.50	0.819	769
5	I.G.T.	11-Feb-86	2:30 PM	302	1018	27.31	0.00	70.92	1.41	0.20	0.02	0.02	0.00	0.00	0.12	0.50	0.832	757
5	I.G.T.	14-Apr-87	10:30 AM	280	515	30.46	1.02	66.72	1.45	0.21	0.02	0.02	0.00	0.00	0.10	0.51	0.866	714
5	I.G.T.	14-Apr-87	3:20 PM	280	516	28.90	0.66	68.58	1.49	0.22	0.02	0.02	0.00	0.00	0.11	0.53	0.850	734
5	I.G.T.	14-Apr-87	10:30 PM	285	519	28.36	0.50	69.36	1.46	0.20	0.02	0.02	0.00	0.00	0.08	0.50	0.843	740
5	I.G.T.	15-Apr-87	7:10 AM	285	515	29.34	0.70	68.20	1.43	0.19	0.02	0.02	0.00	0.00	0.10	0.50	0.854	728
5	I.G.T.	20-Apr-87	5:40 PM	284	1015	31.01	0.50	66.79	1.38	0.22	0.01	0.01	0.00	0.00	0.08	0.48	0.868	712
7	Weatherly	14-Jan-84	4:00 PM	226	340	18.89	0.16	78.33	1.81	0.28	0.03	0.03	0.03	0.01	0.43	0.79	0.762	858
7	Weatherly	24-Jan-84	12:00 PM	220	515	13.54	0.19	83.74	1.94	0.31	0.04	0.03	0.00	0.00	0.21	0.73	0.705	904
7	Weatherly	26-Jan-84	12:00 PM	230	425	15.73	0.18	81.61	1.85	0.28	0.03	0.03	0.00	0.01	0.28	0.72	0.727	884
7	Weatherly	27-Jan-84	12:00 PM	250	319	18.95	0.16	78.55	1.75	0.26	0.03	0.02	0.01	0.00	0.27	0.68	0.758	849
7	Weatherly	7-Feb-84	12:30 PM	166	418	15.67	0.12	81.88	1.78	0.28	0.03	0.03	0.00	0.00	0.21	0.67	0.724	881
7	Weatherly	9-Feb-84	12:00 PM	252	315	17.26	0.18	80.23	1.74	0.26	0.03	0.02	0.00	0.00	0.28	0.68	0.741	866
7	Weatherly	18-Jul-84	2:00 PM	223	515	13.40	0.19	83.93	1.91	0.31	0.03	0.03	0.00	0.02	0.18	0.71	0.703	905
7	Weatherly	20-Jul-84	12:00 PM	225	415	15.98	0.17	81.54	1.83	0.28	0.03	0.03	0.00	0.00	0.14	0.66	0.726	875
7	Weatherly	24-Jul-84	1:00 PM	225	318	19.63	0.32	77.60	1.68	0.25	0.03	0.03	0.01	0.01	0.44	0.74	0.769	847
7	Weatherly	26-Jul-84	12:00 PM	267	269	22.24	0.29	75.30	1.63	0.23	0.02	0.02	0.01	0.00	0.26	0.63	0.789	813

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test (Cont.)

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	Calculated Values: Liquids GAL/MCF	Calculated Values: Gravity (Air=1.0)	Calculated Values: Heat Value (BTU/SCF)
7	Weatherly	12-Oct-84	11:46 AM	265	314	21.47	0.17	76.00	1.69	0.25	0.03	0.02	0.00	0.00	0.37	0.70	0.784	827
7	Weatherly	6-Dec-84	12:00 PM	238	363	17.46	0.19	79.29	1.74	0.27	0.03	0.03	0.02	0.03	0.94	0.98	0.761	891
7	Weatherly	28-Feb-85	12:00 PM	245	365	18.25	0.18	79.26	1.78	0.27	0.03	0.03	0.00	0.00	0.20	0.66	0.749	854
7	I.G.T.	17-Dec-85	5:20 PM	270	430	16.00	0.17	81.55	1.81	0.28	0.03	0.03	0.00	0.00	0.13	0.65	0.726	875
7	I.G.T.	18-Dec-85	9:44 AM	270	435	16.04	0.10	81.57	1.81	0.27	0.03	0.03	0.00	0.02	0.13	0.65	0.726	875
7	I.G.T.	15-Jan-86	8:15 AM	245	356	17.10	0.27	80.45	1.68	0.34	0.02	0.02	0.00	0.00	0.12	0.62	0.736	862
7	I.G.T.	10-Feb-86	4:30 PM	293	268	21.18	0.11	76.64	1.60	0.23	0.02	0.02	0.01	0.00	0.19	0.60	0.776	823
7	I.G.T.	11-Feb-86	10:22 AM	303	323	19.02	0.15	78.66	1.71	0.26	0.03	0.03	0.00	0.00	0.14	0.62	0.755	844
7	I.G.T.	12-Feb-86	12:05 PM	295	329	18.44	0.17	79.28	1.70	0.24	0.03	0.02	0.00	0.00	0.12	0.60	0.748	848
7	I.G.T.	19-Feb-87	9:40 AM	280	285	20.52	0.16	77.22	1.64	0.24	0.02	0.02	0.01	0.00	0.17	0.60	0.769	828
7	I.G.T.	13-Apr-87	9:30 AM	276	415	16.71	0.22	80.90	1.81	0.26	0.02	0.01	0.00	0.00	0.07	0.61	0.731	864
7	I.G.T.	13-Apr-87	4:30 PM	260	409	13.60	0.18	83.73	2.01	0.35	0.04	0.03	0.01	0.00	0.05	0.69	0.703	899
7	I.G.T.	13-Apr-87	5:40 PM	250	410	13.89	0.19	83.35	2.06	0.36	0.04	0.04	0.00	0.00	0.07	0.72	0.706	897
7	I.G.T.	14-Apr-87	6:50 AM	270	420	13.30	0.21	83.84	2.08	0.38	0.04	0.05	0.01	0.01	0.08	0.74	0.702	905
7	I.G.T.	14-Apr-87	8:30 AM	280	420	13.43	0.19	83.71	2.08	0.38	0.05	0.05	0.01	0.00	0.10	0.75	0.704	904
7	I.G.T.	14-Apr-87	2:00 PM	270	442	13.44	0.19	83.66	2.13	0.39	0.04	0.04	0.01	0.01	0.09	0.76	0.704	904
7	I.G.T.	14-Apr-87	9:00 PM	280	449	12.70	0.20	84.35	2.15	0.41	0.05	0.05	0.00	0.00	0.09	0.77	0.697	912
7	I.G.T.	20-Apr-87	5:20 PM	280	450	15.38	0.17	82.16	1.84	0.30	0.03	0.03	0.03	0.00	0.08	0.65	0.720	881
7	I.G.T.	27-Apr-87	10:14 AM	274	463	15.41	0.17	82.15	1.86	0.28	0.02	0.02	0.00	0.00	0.09	0.64	0.719	879
8	Weatherly	14-Jan-84	4:00 PM	226	320	42.66	0.00	55.89	1.09	0.12	0.01	0.01	0.02	0.04	0.16	0.43	0.980	600
8	Weatherly	24-Jan-84	12:00 PM	267	515	40.25	0.00	58.41	1.10	0.11	0.01	0.01	0.02	0.00	0.09	0.38	0.954	621
8	Weatherly	26-Jan-84	12:00 PM	276	425	39.40	0.00	59.29	1.09	0.10	0.01	0.01	0.00	0.00	0.10	0.37	0.946	629
8	Weatherly	27-Jan-84	12:00 PM	267	319	45.73	0.00	53.03	1.00	0.10	0.01	0.01	0.00	0.00	0.12	0.36	1.007	565
8	Weatherly	7-Feb-84	12:30 PM	275	418	43.76	0.00	55.11	0.96	0.09	0.01	0.01	0.00	0.00	0.06	0.32	0.986	582
8	Weatherly	9-Feb-84	12:00 PM	272	315	44.25	0.00	54.52	1.00	0.10	0.01	0.01	0.00	0.00	0.11	0.35	0.992	580
8	Weatherly	18-Jul-84	12:00 PM	223	515	40.95	0.00	57.81	1.03	0.10	0.01	0.01	0.00	0.00	0.09	0.35	0.960	612
8	Weatherly	20-Jul-84	12:00 PM	225	415	42.74	0.00	55.94	1.08	0.11	0.01	0.01	0.00	0.00	0.11	0.38	0.978	596
8	Weatherly	24-Jul-84	12:00 PM	225	318	44.60	0.00	54.21	0.99	0.11	0.01	0.01	0.00	0.00	0.07	0.34	0.995	575
8	Weatherly	26-Jul-84	12:00 PM	267	269	46.50	0.00	52.31	0.88	0.08	0.01	0.01	0.01	0.00	0.20	0.36	1.016	559
8	I.G.T.	17-Dec-85	10:15 PM	273	430	26.11	0.00	72.38	1.30	0.13	0.01	0.01	0.00	0.00	0.06	0.42	0.817	764
8	I.G.T.	18-Dec-85	9:15 AM	274	435	33.59	0.00	65.01	1.17	0.12	0.01	0.01	0.00	0.00	0.09	0.40	0.890	688
8	I.G.T.	15-Jan-86	9:30 AM	245	356	36.33	0.00	62.37	1.06	0.10	0.00	0.01	0.00	0.00	0.13	0.37	0.916	661
8	I.G.T.	19-Feb-87	11:00 AM	280	285	37.39	0.81	60.25	1.05	0.10	0.01	0.00	0.00	0.00	0.08	0.35	0.927	637
8	I.G.T.	13-Apr-87	10:50 AM	276	416	38.97	0.97	58.81	1.06	0.10	0.01	0.01	0.00	0.00	0.07	0.35	0.944	622

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test (Cont.)

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	------ Calculated Values ------ Liquids GAL/MCF	Gravity (Air=1.0)	Heat Value (BTU/SCF)
8	I.G.T.	13-Apr-87	7:00 PM	253	418	33.59	0.96	63.95	1.26	0.15	0.01	0.01	0.00	0.00	0.07	0.42	0.894	679
8	I.G.T.	14-Apr-87	9:00 AM	280	420	32.70	1.03	64.68	1.31	0.16	0.01	0.01	0.00	0.00	0.10	0.45	0.886	689
8	I.G.T.	14-Apr-87	4:00 PM	275	445	28.56	0.61	69.12	1.43	0.18	0.01	0.03	0.00	0.00	0.06	0.48	0.845	735
8	I.G.T.	14-Apr-87	9:15 PM	280	449	27.01	0.78	70.52	1.43	0.18	0.01	0.01	0.00	0.00	0.06	0.47	0.830	749
8	I.G.T.	27-Apr-87	10:00 AM	274	463	38.17	0.70	59.88	1.08	0.11	0.01	0.00	0.00	0.00	0.05	0.35	0.935	632
9	Weatherly	12-Oct-84	12:42 PM	98	1015	10.15	0.26	86.52	2.32	0.50	0.08	0.07	0.02	0.01	0.07	0.86	0.675	941
9	Weatherly	28-Feb-85	12:00 PM	67	1024	9.15	0.27	87.32	2.39	0.54	0.10	0.08	0.02	0.02	0.11	0.92	0.668	955
9	Weatherly	28-Feb-85	12:00 PM	62	995	9.10	0.26	87.36	2.39	0.53	0.09	0.09	0.02	0.01	0.15	0.93	0.668	956
9	I.G.T.	15-Jan-86	8:55 AM	79	1019	8.93	0.14	87.95	2.29	0.51	0.08	0.06	0.00	0.00	0.04	0.83	0.661	952
9	I.G.T.	10-Feb-86	4:15 PM	54	1015	9.96	0.21	86.88	2.26	0.49	0.08	0.07	0.01	0.00	0.04	0.82	0.671	941
9	I.G.T.	11-Feb-86	9:50 AM	65	1019	9.45	0.23	87.31	2.29	0.49	0.08	0.07	0.02	0.01	0.05	0.84	0.667	947
9	I.G.T.	11-Feb-86	11:33 PM	62	1020	9.36	0.24	87.34	2.31	0.51	0.08	0.07	0.02	0.01	0.06	0.86	0.667	949
9	I.G.T.	12-Feb-86	10:55 AM	72	1040	9.49	0.23	87.26	2.31	0.49	0.08	0.07	0.01	0.00	0.06	0.85	0.668	947
9	I.G.T.	19-Feb-87	9:15 AM	69	985	9.88	0.24	86.91	2.28	0.48	0.07	0.06	0.02	0.01	0.05	0.83	0.671	942
9	I.G.T.	19-Feb-87	11:10 AM	72	990	9.81	0.25	86.94	2.29	0.50	0.07	0.06	0.02	0.01	0.04	0.84	0.670	943
9	I.G.T.	13-Apr-87	10:15 AM	88	1005	9.14	0.23	87.64	2.34	0.49	0.07	0.07	0.00	0.01	0.01	0.83	0.663	948
9	I.G.T.	27-Apr-87	11:35 AM	92	1010	8.91	0.23	87.85	2.35	0.50	0.07	0.05	0.02	0.01	0.01	0.84	0.661	951
10	La. Res.	29-May-84	12:00 PM	76	927	9.04	0.25	87.55	2.33	0.55	0.09	0.08	0.02	0.01	0.08	0.89	0.665	954
10	La. Res.	29-Jun-84	12:00 PM	78	935	8.49	0.27	88.15	2.33	0.55	0.09	0.07	0.01	0.01	0.03	0.86	0.658	957
10	La. Res.	25-Jul-84	12:00 PM	85	825	8.42	0.25	88.10	2.38	0.56	0.09	0.08	0.02	0.01	0.09	0.91	0.660	961
10	La. Res.	24-Aug-84	12:00 PM	81	970	8.06	0.26	88.43	2.40	0.55	0.09	0.07	0.02	0.01	0.11	0.92	0.657	965
10	La. Res.	24-Sep-84	12:00 PM	84	215	7.83	0.32	88.64	2.38	0.56	0.10	0.08	0.02	0.01	0.06	0.90	0.654	965
10	La. Res.	22-Oct-84	12:00 PM	78	930	9.70	0.25	87.09	2.21	0.51	0.08	0.07	0.01	0.01	0.07	0.83	0.670	945
10	La. Res.	22-Oct-84	12:00 PM	78	215	7.90	0.24	88.75	2.25	0.57	0.11	0.09	0.02	0.01	0.06	0.88	0.654	965
10	La. Res.	28-Nov-84	12:00 PM	60	250	9.76	0.26	86.92	2.37	0.47	0.07	0.06	0.01	0.01	0.07	0.86	0.670	944
10	La. Res.	21-Dec-84	12:00 PM	68	170	9.64	0.36	87.02	2.27	0.52	0.08	0.07	0.01	0.00	0.03	0.83	0.669	943
10	La. Res.	22-Jan-85	12:00 PM		235	9.62	0.25	87.02	2.23	0.53	0.09	0.07	0.02	0.01	0.16	0.89	0.672	950
10	La. Res.	22-Jan-85	12:00 PM	30	975	9.60	0.27	86.92	2.40	0.49	0.09	0.07	0.02	0.01	0.13	0.91	0.671	949
10	La. Res.	21-Feb-85	12:00 PM	67	970	9.56	0.25	87.18	2.24	0.53	0.09	0.07	0.02	0.01	0.05	0.84	0.669	946
10	La. Res.	21-Feb-85	12:00 PM		210	9.50	0.26	87.01	2.25	0.54	0.10	0.08	0.06	0.02	0.18	0.93	0.673	954
10	La. Res.	22-Mar-85	12:00 PM	66	960	10.39	0.25	86.42	2.17	0.52	0.09	0.08	0.02	0.01	0.05	0.83	0.676	938
10	La. Res.	22-Mar-85	12:00 PM		205	9.71	0.24	87.14	2.18	0.52	0.08	0.07	0.01	0.01	0.04	0.81	0.669	943

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test (Cont.)

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	Calculated Values: Liquids GAL/MCF	Calculated Values: Gravity (Air=1.0)	Calculated Values: Heat Value (BTU/SCF)
10	La. Res.	22-Apr-85	12:00 PM	72	225	9.33	0.20	87.46	2.25	0.53	0.10	0.08	0.02	0.01	0.02	0.84	0.666	949
10	La. Res.	22-Apr-85	12:00 PM	72	965	9.44	0.26	87.08	2.38	0.55	0.09	0.08	0.02	0.01	0.09	0.91	0.670	951
10	La. Res.	23-May-85	12:00 PM			10.64	0.25	86.11	2.25	0.51	0.09	0.07	0.01	0.01	0.06	0.84	0.679	935
10	La. Res.	28-May-85	12:00 PM	78	970	10.64	0.25	86.13	2.24	0.50	0.08	0.07	0.01	0.01	0.07	0.84	0.679	935
10	La. Res.	21-Jun-85	12:00 PM	78	210	10.00	0.25	86.81	2.25	0.50	0.08	0.06	0.01	0.01	0.03	0.82	0.672	940
10	La. Res.	21-Jun-85	12:00 PM	78	965	9.94	0.82	86.23	2.24	0.50	0.08	0.07	0.01	0.01	0.10	0.85	0.675	938
10	La. Res.	19-Jul-85	12:00 PM	78	965	10.27	0.24	86.40	2.28	0.51	0.08	0.07	0.02	0.01	0.12	0.88	0.677	942
10	La. Res.	19-Jul-85	12:00 PM	78	205	10.34	0.25	86.42	2.27	0.50	0.08	0.06	0.01	0.01	0.06	0.84	0.676	938
10	La. Res.	22-Aug-85	12:00 PM	87	225	9.80	0.25	86.77	2.35	0.54	0.09	0.08	0.02	0.02	0.08	0.90	0.673	947
10	Weatherly	22-Aug-85	12:00 PM	87	225	9.81	0.29	86.66	2.38	0.55	0.10	0.08	0.02	0.01	0.10	0.92	0.674	947
10	La. Res.	22-Aug-85	12:00 PM	87	925	9.99	0.30	86.56	2.33	0.52	0.09	0.07	0.02	0.01	0.11	0.89	0.675	944
10	La. Res.	19-Sep-85	12:00 PM	83	990	10.15	0.25	86.52	2.26	0.51	0.08	0.06	0.01	0.01	0.15	0.88	0.676	943
10	La. Res.	19-Sep-85	12:00 PM	83	200	10.18	0.27	86.57	2.26	0.50	0.09	0.07	0.01	0.00	0.05	0.83	0.674	939
10	Weatherly	25-Sep-85	12:00 PM	83	990	10.11	0.30	86.35	2.32	0.52	0.09	0.08	0.02	0.01	0.20	0.93	0.678	947
10	La. Res.	22-Oct-85	12:00 PM	80	205	9.96	0.26	86.70	2.29	0.51	0.08	0.07	0.00	0.00	0.13	0.87	0.674	944
10	Weatherly	26-Oct-85	12:00 PM	85	985	10.00	0.29	86.55	2.32	0.52	0.08	0.07	0.02	0.01	0.14	0.90	0.675	945
10	Weatherly	21-Nov-85	12:00 PM		965	7.33	0.26	89.22	2.41	0.53	0.09	0.07	0.02	0.01	0.06	0.89	0.648	971
10	La. Res.	21-Nov-85	12:00 PM		200	9.90	0.25	86.84	2.26	0.51	0.08	0.07	0.01	0.01	0.07	0.85	0.672	943
10	Weatherly	23-Dec-85	12:00 PM		975	8.67	0.26	87.89	2.39	0.52	0.09	0.07	0.02	0.01	0.08	0.89	0.661	957
10	La. Res.	24-Jan-86	12:00 PM	63	205	9.51	0.27	87.18	2.29	0.50	0.08	0.06	0.01	0.01	0.09	0.86	0.669	947
10	I.G.T.	12-Feb-86	10:46 AM	72	1052	9.41	0.23	87.28	2.32	0.50	0.08	0.07	0.03	0.01	0.07	0.87	0.668	949
10	La. Res.	24-Mar-86	12:00 PM	66	195	9.72	0.26	86.98	2.28	0.50	0.08	0.07	0.01	0.01	0.09	0.86	0.671	946
10	La. Res.	19-Jun-86	12:00 PM	81	985	10.02	0.27	86.74	2.24	0.48	0.08	0.07	0.01	0.01	0.08	0.84	0.673	941
10	La. Res.	22-Jul-86	12:00 PM	80	900	10.21	0.26	86.56	2.23	0.48	0.08	0.06	0.01	0.01	0.10	0.84	0.675	940
10	La. Res.	21-Aug-86	12:00 PM	84	995	9.72	0.28	87.00	2.26	0.49	0.08	0.06	0.01	0.01	0.09	0.84	0.671	945
10	La. Res.	5-Sep-86	12:00 PM	86	1020	9.60	0.31	87.11	2.26	0.49	0.08	0.06	0.01	0.01	0.07	0.84	0.669	945
10	La. Res.	23-Sep-86	12:00 PM	85	800	9.66	0.27	87.00	2.31	0.49	0.08	0.06	0.01	0.01	0.11	0.87	0.671	947
10	La. Res.	21-Oct-86	12:00 PM	85	750	9.77	0.25	86.94	2.27	0.49	0.09	0.07	0.01	0.01	0.10	0.86	0.671	945
10	La. Res.	21-Nov-86	12:00 PM	70	900	9.45	0.23	87.31	2.26	0.49	0.07	0.06	0.01	0.01	0.11	0.85	0.668	949
10	La. Res.	17-Dec-86	12:00 PM	59	1030	9.42	0.29	87.22	2.27	0.53	0.07	0.06	0.01	0.01	0.12	0.87	0.669	949
10	La. Res.	16-Jan-87	12:00 PM	51	1025	9.56	0.23	87.19	2.27	0.51	0.07	0.06	0.01	0.01	0.09	0.85	0.669	947
10	La. Res.	23-Feb-87	12:00 PM	60	650	10.02	0.24	86.78	2.23	0.50	0.07	0.06	0.01	0.01	0.08	0.83	0.673	941
10	La. Res.	24-Mar-87	12:00 PM	85	645	9.94	0.23	86.84	2.24	0.49	0.07	0.06	0.01	0.01	0.11	0.84	0.673	943
10	La. Res.	21-Apr-87	12:00 PM	90	780	9.62	0.24	87.14	2.25	0.49	0.07	0.06	0.01	0.01	0.11	0.85	0.670	947

DOE Gladys McCall Well No. 1 Well -- Sand 8
Analysis of Gas Samples Taken During Flow Test (Cont.)

Sample Point	Analysis Lab	Sample Date	Sample Time	Temp (°F)	Press. (psig)	CO2 (Mol %)	N2 (Mol %)	C1 (Mol %)	C2 (Mol %)	C3 (Mol %)	iC4 (Mol %)	nC4 (Mol %)	iC5 (Mol %)	nC5 (Mol %)	C6+ (Mol %)	------ Calculated Values ------ Liquids GAL/MCF	Gravity (Air=1.0)	Heat Value (BTU/SCF)
10	La. Res.	27-May-87	12:00 PM	85	950	9.29	0.24	87.45	2.26	0.50	0.07	0.06	0.01	0.01	0.11	0.85	0.667	950
10	La. Res.	24-Jun-87	12:00 PM	85	750	9.30	0.23	87.49	2.27	0.50	0.07	0.06	0.01	0.01	0.06	0.83	0.665	948
10	La. Res.	21-Jul-87	12:00 PM	85	751	9.27	0.23	87.53	2.27	0.50	0.07	0.06	0.01	0.01	0.05	0.83	0.665	948
10	La. Res.	13-Aug-87	12:00 PM	80	990	9.21	0.23	87.55	2.28	0.51	0.08	0.06	0.01	0.01	0.06	0.84	0.665	950
10	La. Res.	28-Sep-87	12:00 PM	85	810	9.06	0.26	87.59	2.34	0.53	0.10	0.03	0.03	0.02	0.04	0.86	0.664	952
10	La. Res.	21-Oct-87	12:00 PM	85	850	9.39	0.27	87.32	2.30	0.50	0.09	0.07	0.01	0.01	0.04	0.84	0.667	947

APPENDIX H

Calculation of Total Produced Gas

The separator gas combination and the amount of gas recovered from the separators was found to be a function of the separator pressure. Hayden and Randolph (Reference 7 in text) showed that, in the range of separator pressures typically encountered, the hydrocarbon gas solubilities obeyed simple Henry's Law relationships. The Henry's Law constants, however, are different for each hydrocarbon species. The end result is that the concentration of ethane, propane, butanes, etc., to methane in the dissolved gas and with the gas in equilibrium with the brine changes with pressure. The solubility behavior of carbon dioxide is even more complex due to the carbonic acid and bicarbonate ions in solution. Because the quantity and composition of recovered gas varies with separator pressure, a sampling and analysis methodology to quantify total produced gas was followed.

The method of measuring total gas composition used in this study was to mathematically combine the separator gases and gas left in the brine after the separator, using the gas/brine ratio to appropriately weight each fraction. For instance, a typical value for the high-pressure separator gas/brine ratio was 24 SCF/STB. The gas/brine ratio from the low-pressure separator was 3 SCF/STB, and the amount of gas left in the brine after the low-pressure separator was also about 3 SCF/STB. The total gas composition for this hypothetical case would be 80% of the high-pressure separator gas composition and 10% each of the low-pressure gas composition and of the composition of gas left in the brine after the low-pressure separator. In cases where the quantity and composition of gas left in the brine after the large separator was determined directly, the composition and quantity of the low-pressure separator gas would not be needed to calculate a total gas composition. It should be noted that the recombination method used herein and described by Hayden and Randolph does not include carbon dioxide remaining in the brine after flashing to atmospheric pressure. There is about 1 SCF/STB of carbon dioxide that is left out of this calculation. This value was determined on numerous samples by the acid liberation-nitrogen purge technique and an alkalinity titration to determine the quantity of carbon dioxide tied up as bicarbonate.

Sample locations are designated by a sample-point code that is explained on the last page of the table. A default time of 12:00 was entered if no time was recorded. The composition of the total gas is about 84% methane, 13% carbon dioxide, 2.2% ethane, 0.46% propane, and lesser amounts of nitrogen and heavier hydrocarbons.

Gladys McCall Sand 8 Total Gas Study

Date	Time	Sample Point	Temp (F)	Pres (psia)	GWR (scf/bbl)	CO2 (Mol%)	N2 (Mol%)	C1 (Mol%)	C2 (Mol%)	C3 (Mol%)	iC4 (Mol%)	nC4 (Mol%)	iC5 (Mol%)	nC5 (Mol%)	C6+ (Mol%)	Gas Gravity (Air=1)	Liquids (Gal/mcf)	Heat (BTU/scf)
8-Oct-83	12:00	4	97	500	26.50	10.63	0.25	85.96	2.34	0.52	0.09	0.07	0.02	0.01	0.11	0.681	0.89	938
8-Oct-83	12:00	5	97	500	3.75	39.89	0.00	57.73	1.39	0.19	0.02	0.02	0.00	0.00	0.76	0.969	0.76	653
	Calculated Total Gas				30.25	14.26	0.22	82.46	2.22	0.48	0.08	0.06	0.02	0.01	0.19	0.717	0.88	903
28-Oct-83	12:00	4	275	515	26.50	10.31	0.24	84.85	2.31	0.51	0.09	0.08	0.02	0.01	1.58	0.714	1.50	997
28-Oct-83	12:00	5	275	515	3.85	40.74	0.00	57.21	1.35	0.19	0.02	0.02	0.00	0.00	0.47	0.970	0.63	633
	Calculated Total Gas				30.35	14.17	0.21	81.34	2.19	0.47	0.08	0.07	0.02	0.01	1.44	0.746	1.39	951
14-Jan-84	12:00	4	227	769	24.96	9.09	0.25	87.14	2.41	0.55	0.10	0.08	0.02	0.01	0.35	0.673	1.03	965
14-Jan-84	16:00	7	226	340	3.05	18.89	0.16	78.33	1.81	0.28	0.03	0.03	0.03	0.01	0.43	0.762	0.79	858
14-Jan-84	16:00	8	226	320	2.33	42.66	0.00	55.89	1.09	0.12	0.01	0.01	0.02	0.04	0.16	0.980	0.43	600
	Calculated Total Gas				30.34	12.65	0.22	83.85	2.25	0.49	0.09	0.07	0.02	0.01	0.34	0.705	0.96	926
18-Jan-84	14:00	4	100	765	25.20	6.80	0.26	88.76	2.44	0.55	0.10	0.08	0.03	0.02	0.96	0.666	1.30	1012
18-Jan-84	14:00	5	275	765	6.03	32.79	0.00	65.18	1.51	0.29	0.04	0.03	0.01	0.01	0.14	0.887	0.58	705
	Calculated Total Gas				31.23	11.82	0.21	84.21	2.26	0.50	0.09	0.07	0.03	0.02	0.80	0.709	1.16	952
24-Jan-84	12:00	4	110	1015	22.90	7.89	0.26	88.35	2.48	0.57	0.10	0.09	0.02	0.01	0.23	0.659	1.01	973
24-Jan-84	12:00	7	220	515	2.49	13.54	0.19	83.74	1.94	0.31	0.04	0.03	0.00	0.00	0.21	0.705	0.73	904
24-Jan-84	12:00	8	267	515	4.22	40.25	0.00	58.41	1.10	0.11	0.01	0.01	0.02	0.00	0.09	0.954	0.38	621
	Calculated Total Gas				29.61	12.98	0.22	83.70	2.24	0.48	0.08	0.07	0.02	0.01	0.21	0.705	0.89	917
26-Jan-84	12:00	4	100	1021	22.36	7.81	0.26	88.52	2.48	0.57	0.10	0.09	0.03	0.01	0.13	0.656	0.97	970
26-Jan-84	12:00	7	230	425	3.20	15.73	0.18	81.61	1.85	0.28	0.03	0.03	0.00	0.01	0.28	0.727	0.72	884
26-Jan-84	12:00	8	276	425	3.19	39.40	0.00	59.29	1.09	0.10	0.01	0.01	0.00	0.00	0.10	0.946	0.37	629
	Calculated Total Gas				28.75	12.20	0.22	84.51	2.26	0.49	0.08	0.07	0.02	0.01	0.14	0.696	0.87	923
27-Jan-84	12:00	4	245	1016	22.55	7.83	0.27	88.51	2.47	0.56	0.10	0.08	0.02	0.01	0.15	0.656	0.96	970
27-Jan-84	12:00	7	250	319	4.79	18.95	0.16	78.55	1.75	0.26	0.03	0.02	0.01	0.00	0.27	0.758	0.68	849
27-Jan-84	12:00	8	267	319	2.60	45.73	0.00	53.03	1.00	0.10	0.01	0.01	0.00	0.00	0.12	1.007	0.36	565
	Calculated Total Gas				29.94	12.90	0.23	83.84	2.23	0.47	0.08	0.06	0.02	0.01	0.17	0.703	0.87	916
7-Feb-84	12:00	4	88	1015	22.80	7.77	0.28	88.54	2.47	0.56	0.10	0.08	0.02	0.01	0.17	0.656	0.97	971
7-Feb-84	12:30	7	166	418	1.68	15.67	0.12	81.88	1.78	0.28	0.03	0.03	0.00	0.00	0.21	0.724	0.67	881
7-Feb-84	12:30	8	275	418	3.34	43.76	0.00	55.11	0.96	0.09	0.01	0.01	0.00	0.00	0.06	0.986	0.32	582
	Calculated Total Gas				27.82	12.57	0.24	84.12	2.25	0.49	0.08	0.07	0.02	0.01	0.16	0.700	0.88	919

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Date	Time	Sample Point	Temp (F)	Pres (psia)	GWR (scf/ bbl)	CO2 (Mol%)	N2 (Mol%)	C1 (Mol%)	C2 (Mol%)	C3 (Mol%)	iC4 (Mol%)	nC4 (Mol%)	iC5 (Mol%)	nC5 (Mol%)	C6+ (Mol%)	Gas Gravity (Air=1)	Liquids (Gal/ mcf)	Heat (BTU/ scf)
9-Feb-84	12:00	4	93	1015	22.80	7.29	0.27	88.95	2.48	0.57	0.10	0.08	0.02	0.02	0.22	0.653	1.00	979
9-Feb-84	12:00	7	252	315	4.20	17.26	0.18	80.23	1.74	0.26	0.03	0.02	0.00	0.00	0.28	0.741	0.68	866
9-Feb-84	12:00	8	272	315	2.60	44.25	0.00	54.52	1.00	0.10	0.01	0.01	0.00	0.00	0.11	0.992	0.35	580
	Calculated Total Gas				29.60	11.95	0.23	84.69	2.25	0.48	0.08	0.07	0.02	0.02	0.22	0.695	0.90	928
29-Feb-84	11:00	4	88	324	28.30	12.74	0.24	83.92	2.25	0.49	0.08	0.07	0.02	0.01	0.18	0.702	0.89	918
29-Feb-84	12:00	5	277	324	2.31	30.59	0.00	67.53	1.49	0.22	0.03	0.03	0.02	0.01	0.08	0.864	0.53	724
	Calculated Total Gas				30.61	14.09	0.22	82.68	2.19	0.47	0.08	0.07	0.02	0.01	0.17	0.714	0.86	904
3-Mar-84	10:00	4	92	419	28.10	11.61	0.24	85.03	2.27	0.50	0.08	0.07	0.02	0.01	0.174	0.691	0.89	930
3-Mar-84	10:00	5	277	419	2.62	25.47	0.00	72.58	1.59	0.23	0.02	0.02	0.00	0.00	0.09	0.814	0.55	776
	Calculated Total Gas				30.72	12.79	0.22	83.97	2.21	0.48	0.07	0.07	0.02	0.01	0.16	0.702	0.86	917
18-Jul-84	12:00	8	223	515	4.42	40.95	0.00	57.81	1.03	0.10	0.01	0.01	0.00	0.00	0.09	0.960	0.35	612
18-Jul-84	14:00	4	97	1015	22.30	7.80	0.25	88.59	2.46	0.56	0.10	0.08	0.02	0.01	0.13	0.655	0.95	970
18-Jul-84	14:00	7	223	515	3.30	13.40	0.19	83.93	1.91	0.31	0.03	0.03	0.00	0.02	0.18	0.703	0.71	905
	Calculated Total Gas				30.02	13.30	0.21	83.55	2.19	0.46	0.08	0.06	0.01	0.01	0.13	0.705	0.84	910
20-Jul-84	12:00	4	95	1015	23.10	7.83	0.26	88.57	2.46	0.56	0.10	0.08	0.02	0.01	0.11	0.655	0.94	969
20-Jul-84	12:00	7	225	415	3.60	15.98	0.17	81.54	1.83	0.28	0.03	0.03	0.00	0.00	0.14	0.726	0.66	875
20-Jul-84	12:00	8	225	415	3.76	42.74	0.00	55.94	1.08	0.11	0.01	0.01	0.00	0.00	0.11	0.978	0.38	596
	Calculated Total Gas				30.46	13.10	0.22	83.71	2.22	0.47	0.08	0.07	0.02	0.01	0.11	0.703	0.84	912
24-Jul-84	12:00	4	94	1018	23.00	7.82	0.27	88.53	2.46	0.56	0.10	0.08	0.02	0.01	0.15	0.656	0.96	970
24-Jul-84	12:00	8	225	318	2.80	44.60	0.00	54.21	0.99	0.11	0.01	0.01	0.00	0.00	0.07	0.995	0.34	575
24-Jul-84	13:00	7	225	318	4.80	19.63	0.32	77.60	1.68	0.25	0.03	0.03	0.01	0.01	0.44	0.769	0.74	847
	Calculated Total Gas				30.60	13.04	0.25	83.68	2.20	0.47	0.08	0.07	0.02	0.01	0.19	0.705	0.87	915
26-Jul-84	12:00	4	82	1020	23.40	7.88	0.26	88.50	2.46	0.56	0.10	0.08	0.02	0.01	0.13	0.656	0.95	969
26-Jul-84	12:00	7	267	269	4.67	22.24	0.29	75.30	1.63	0.23	0.02	0.02	0.01	0.00	0.26	0.789	0.63	813
26-Jul-84	12:00	8	267	269	2.31	46.50	0.00	52.31	0.88	0.08	0.01	0.01	0.01	0.00	0.20	1.016	0.36	559
	Calculated Total Gas				30.38	13.02	0.24	83.72	2.21	0.47	0.08	0.07	0.02	0.01	0.16	0.704	0.86	914
17-Dec-85	17:10	2	91	1019	23.41	7.88	0.25	88.60	2.42	0.55	0.09	0.07	0.01	0.02	0.11	0.655	0.92	967
17-Dec-85	17:20	7	270	430	3.33	16.00	0.17	81.55	1.81	0.28	0.03	0.03	0.00	0.00	0.13	0.726	0.65	875
17-Dec-85	22:15	8	273	430	2.85	26.11	0.00	72.38	1.30	0.13	0.01	0.01	0.00	0.00	0.06	0.817	0.42	764
	Calculated Total Gas				29.59	10.55	0.22	86.24	2.24	0.48	0.08	0.06	0.01	0.02	0.11	0.679	0.84	937

Gladys McCall Sand 8 Total Gas Study

Date	Time	Sample Point	Temp (F)	Pres (psia)	GWR (scf/ bbl)	CO2 (Mol%)	N2 (Mol%)	C1 (Mol%)	C2 (Mol%)	C3 (Mol%)	iC4 (Mol%)	nC4 (Mol%)	iC5 (Mol%)	nC5 (Mol%)	C6+ (Mol%)	Gas Gravity (Air=1)	Liquids (Gal/ mcf)	Heat (BTU/ scf)
18-Dec-85	9:15	8	274	435	2.66	33.59	0.00	65.01	1.17	0.12	0.01	0.01	0.00	0.00	0.09	0.890	0.40	688
18-Dec-85	9:30	2	90	1018	23.24	8.00	0.17	88.59	2.43	0.54	0.09	0.07	0.02	0.01	0.08	0.655	0.91	966
18-Dec-85	9:44	7	270	435	3.49	16.04	0.10	81.57	1.81	0.27	0.03	0.03	0.00	0.02	0.13	0.726	0.65	875
	Calculated Total Gas				29.39	11.27	0.15	85.62	2.24	0.47	0.08	0.06	0.02	0.01	0.09	0.685	0.83	930
15-Jan-86	7:00	2	225	1015	21.70	7.86	0.31	88.47	2.44	0.61	0.09	0.08	0.02	0.01	0.11	0.656	0.95	968
15-Jan-86	8:15	7	245	356	3.00	17.10	0.27	80.45	1.68	0.34	0.02	0.02	0.00	0.00	0.12	0.736	0.62	862
15-Jan-86	9:30	8	245	356	2.33	36.33	0.00	62.37	1.06	0.10	0.00	0.01	0.00	0.00	0.13	0.916	0.37	661
	Calculated Total Gas				27.03	11.34	0.28	85.33	2.24	0.54	0.07	0.07	0.02	0.01	0.11	0.687	0.86	930
8-Feb-86	8:45	2	260	1024	23.50	7.39	0.23	89.06	2.38	0.53	0.08	0.07	0.02	0.01	0.13	0.650	0.91	972
8-Feb-86	8:54	5	264	1031	6.60	28.47	0.00	69.85	1.38	0.18	0.02	0.01	0.00	0.00	0.09	0.842	0.47	743
	Calculated Total Gas				30.10	12.01	0.18	84.93	2.16	0.45	0.07	0.06	0.02	0.01	0.12	0.692	0.82	922
8-Feb-86	12:40	5	280	1023	7.25	28.99	0.00	69.31	1.38	0.18	0.02	0.02	0.00	0.00	0.10	0.847	0.48	738
8-Feb-86	12:44	2	280	1021	22.50	7.79	0.23	88.69	2.41	0.54	0.09	0.08	0.02	0.00	0.15	0.655	0.93	970
	Calculated Total Gas				29.75	12.96	0.17	83.97	2.16	0.45	0.07	0.07	0.02	0.00	0.14	0.702	0.82	913
10-Feb-86	13:05	1	294	1015	22.10	7.74	0.24	88.64	2.41	0.56	0.09	0.08	0.02	0.01	0.21	0.656	0.97	973
10-Feb-86	13:25	5	295	1017	6.58	23.50	0.00	74.69	1.49	0.20	0.02	0.02	0.01	0.60	0.07	0.794	0.51	794
	Calculated Total Gas				28.68	11.36	0.18	85.44	2.20	0.48	0.07	0.07	0.02	0.01	0.18	0.688	0.86	932
11-Feb-86	10:31	1	306	1020	23.50	7.78	0.23	88.52	2.42	0.56	0.09	0.07	0.02	0.01	0.30	0.659	1.01	976
11-Feb-86	10:34	5	306	1020	7.12	27.98	0.00	70.27	1.40	0.19	0.02	0.02	0.00	0.00	0.12	0.838	0.50	750
	Calculated Total Gas				30.62	12.48	0.18	84.28	2.18	0.47	0.07	0.06	0.02	0.01	0.26	0.700	0.89	923
11-Feb-86	11:11	1	289	1022	23.10	8.00	0.22	88.07	2.54	0.63	0.12	0.10	0.03	0.01	0.28	0.663	1.07	977
11-Feb-86	11:14	5	289	1022	6.52	25.98	0.00	72.25	1.43	0.19	0.02	0.02	0.00	0.00	0.11	0.818	0.50	770
	Calculated Total Gas				29.62	11.96	0.17	84.59	2.30	0.53	0.10	0.08	0.02	0.01	0.24	0.697	0.95	931
11-Feb-86	11:32	1	291	1019	23.20	8.01	0.23	88.12	2.46	0.61	0.11	0.10	0.04	0.01	0.31	0.663	1.06	977
11-Feb-86	11:38	5	291	1019	7.03	25.87	0.00	72.36	1.43	0.19	0.02	0.02	0.00	0.00	0.11	0.817	0.50	771
	Calculated Total Gas				30.23	12.16	0.18	84.46	2.22	0.51	0.09	0.08	0.03	0.01	0.26	0.699	0.93	929
11-Feb-86	12:21	1	294	1020	22.70	7.91	0.22	88.37	2.48	0.60	0.11	0.09	0.03	0.01	0.18	0.658	1.00	972
11-Feb-86	12:24	5	294	1020	6.69	26.04	0.00	72.19	1.43	0.19	0.02	0.02	0.00	0.00	0.11	0.819	0.50	769
	Calculated Total Gas				29.39	12.04	0.17	84.69	2.24	0.51	0.09	0.07	0.02	0.01	0.16	0.695	0.89	926

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Date	Time	Sample Point	Temp (F)	Pres (psia)	GWR (scf/ bbl)	CO2 (Mol%)	N2 (Mol%)	C1 (Mol%)	C2 (Mol%)	C3 (Mol%)	iC4 (Mol%)	nC4 (Mol%)	iC5 (Mol%)	nC5 (Mol%)	C6+ (Mol%)	Gas Gravity (Air=1)	Liquids (Gal/ mcf)	Heat (BTU/ scf)
11-Feb-86	14:25	1	302	1018	23.10	7.81	0.22	88.74	2.40	0.54	0.09	0.07	0.02	0.01	0.10	0.654	0.91	968
11-Feb-86	14:30	5	302	1018	6.81	27.31	0.00	70.92	1.41	0.20	0.02	0.02	0.00	0.00	0.12	0.832	0.50	757
	Calculated Total Gas				29.91	12.25	0.17	84.68	2.17	0.46	0.07	0.06	0.02	0.01	0.10	0.694	0.82	920
19-Feb-87	9:40	7	280	285	4.44	20.52	0.16	77.22	1.64	0.24	0.02	0.02	0.01	0.00	0.17	0.769	0.60	828
19-Feb-87	10:50	4	90	1015	22.86	7.91	0.25	88.57	2.40	0.53	0.08	0.07	0.02	0.02	0.15	0.656	0.93	968
19-Feb-87	11:00	8	280	285	1.75	37.39	0.81	60.25	1.05	0.10	0.01	0.00	0.00	0.00	0.08	0.927	0.35	637
	Calculated Total Gas				29.05	11.61	0.27	85.13	2.20	0.46	0.07	0.06	0.02	0.02	0.15	0.690	0.85	927
13-Apr-87	9:30	7	276	415	3.34	16.71	0.22	80.90	1.81	0.26	0.02	0.01	0.00	0.00	0.07	0.731	0.61	864
13-Apr-87	10:50	8	276	416	3.07	38.97	0.97	58.81	1.06	0.10	0.01	0.01	0.00	0.00	0.07	0.944	0.35	622
13-Apr-87	12:30	4	95	1013	22.32	8.17	0.25	88.36	2.44	0.54	0.08	0.07	0.02	0.01	0.06	0.656	0.90	962
	Calculated Total Gas				28.73	12.45	0.32	84.34	2.22	0.46	0.07	0.06	0.02	0.01	0.06	0.696	0.81	914
13-Apr-87	17:40	7	250	410	1.20	13.89	0.19	83.35	2.06	0.36	0.04	0.04	0.00	0.00	0.07	0.706	0.72	897
13-Apr-87	18:20	4	79	515	27.27	11.11	0.23	85.69	2.28	0.49	0.07	0.03	0.02	0.01	0.07	0.683	0.83	930
13-Apr-87	19:00	8	253	418	2.91	33.59	0.96	63.95	1.26	0.15	0.01	0.01	0.00	0.00	0.07	0.894	0.42	679
	Calculated Total Gas				31.38	13.30	0.30	83.58	2.18	0.45	0.06	0.03	0.02	0.01	0.07	0.703	0.79	905
14-Apr-87	7:25	4	80	515	27.21	10.87	0.22	85.95	2.23	0.47	0.07	0.08	0.02	0.01	0.08	0.681	0.83	933
14-Apr-87	8:30	7	280	420	1.18	13.43	0.19	83.71	2.08	0.38	0.05	0.05	0.01	0.00	0.10	0.704	0.75	904
14-Apr-87	9:00	8	280	420	2.88	32.70	1.03	64.68	1.31	0.16	0.01	0.01	0.00	0.00	0.10	0.886	0.45	689
	Calculated Total Gas				31.27	12.98	0.29	83.91	2.14	0.44	0.06	0.07	0.02	0.01	0.08	0.701	0.80	910
14-Apr-87	7:50	1	280	515	27.21	10.99	0.27	85.77	2.26	0.47	0.07	0.06	0.02	0.02	0.07	0.682	0.83	931
14-Apr-87	10:30	5	280	515	4.31	30.46	1.02	66.72	1.45	0.21	0.02	0.02	0.00	0.00	0.10	0.866	0.51	714
	Calculated Total Gas				31.52	13.65	0.37	83.17	2.15	0.43	0.06	0.05	0.02	0.02	0.07	0.707	0.79	902
14-Apr-87	14:50	4	91	517	27.47	11.17	0.23	85.55	2.30	0.49	0.07	0.07	0.02	0.01	0.09	0.685	0.86	931
14-Apr-87	15:20	5	280	516	3.90	28.90	0.66	68.58	1.49	0.22	0.02	0.02	0.00	0.00	0.11	0.850	0.53	734
	Calculated Total Gas				31.37	13.37	0.28	83.44	2.20	0.46	0.06	0.06	0.02	0.01	0.09	0.705	0.82	907
14-Apr-87	14:50	4	91	517	27.47	11.17	0.23	85.55	2.30	0.49	0.07	0.07	0.02	0.01	0.09	0.685	0.86	931
14-Apr-87	14:00	7	270	442	1.07	13.44	0.19	83.66	2.13	0.39	0.04	0.04	0.01	0.01	0.09	0.704	0.76	904
14-Apr-87	16:00	8	275	445	2.82	28.56	0.61	69.12	1.43	0.18	0.01	0.03	0.00	0.00	0.06	0.845	0.48	735
	Calculated Total Gas				31.36	12.81	0.26	84.01	2.22	0.46	0.06	0.07	0.02	0.01	0.09	0.700	0.82	913

Gladys McCall Sand 8 Total Gas Study

Date	Time	Sample Point	Temp (F)	Pres (psia)	GWR (scf/ bbl)	CO2 (Mol%)	N2 (Mol%)	C1 (Mol%)	C2 (Mol%)	C3 (Mol%)	iC4 (Mol%)	nC4 (Mol%)	iC5 (Mol%)	nC5 (Mol%)	C6+ (Mol%)	Gas Gravity (Air=1)	Liquids (Gal/ mcf)	Heat (BTU/ scf)
14-Apr-87	22:00	4	85	519	27.73	11.01	0.25	85.75	2.27	0.48	0.07	0.06	0.02	0.02	0.07	0.683	0.84	932
14-Apr-87	22:30	5	285	519	3.48	28.36	0.50	69.36	1.46	0.20	0.02	0.02	0.00	0.00	0.08	0.843	0.50	740
	Calculated Total Gas				31.21	12.94	0.28	83.92	2.18	0.45	0.06	0.06	0.02	0.02	0.07	0.700	0.80	910
14-Apr-87	22:00	4	85	519	27.73	11.01	0.25	85.75	2.27	0.48	0.07	0.06	0.02	0.02	0.07	0.683	0.84	932
14-Apr-87	21:00	7	280	449	1.02	12.70	0.20	84.35	2.15	0.41	0.05	0.05	0.00	0.00	0.09	0.697	0.77	912
14-Apr-87	21:15	8	280	449	2.70	27.01	0.78	70.52	1.43	0.18	0.01	0.01	0.00	0.00	0.06	0.830	0.47	749
	Calculated Total Gas				31.45	12.44	0.29	84.40	2.19	0.45	0.06	0.06	0.02	0.02	0.07	0.696	0.81	915
15-Apr-87	6:25	4	73	515	27.68	11.09	0.22	85.70	2.29	0.49	0.07	0.06	0.00	0.00	0.08	0.683	0.84	931
15-Apr-87	7:10	5	285	515	3.53	29.34	0.70	68.20	1.43	0.19	0.02	0.02	0.00	0.00	0.10	0.854	0.50	728
	Calculated Total Gas				31.21	13.15	0.27	83.72	2.19	0.46	0.06	0.06	0.00	0.00	0.08	0.702	0.80	908
21-Apr-87	16:50	4	78	1015	21.66	8.07	0.25	88.47	2.42	0.54	0.08	0.08	0.02	0.02	0.05	0.655	0.90	963
21-Apr-87	17:40	5	284	1015	8.97	30.95	0.71	66.64	1.38	0.22	0.01	0.01	0.00	0.00	0.08	0.868	0.48	712
	Calculated Total Gas				30.63	14.77	0.38	82.08	2.12	0.45	0.06	0.06	0.01	0.01	0.06	0.718	0.78	890
27-Apr-87	9:45	4	100	1020	22.64	8.09	0.24	88.42	2.44	0.55	0.08	0.07	0.02	0.02	0.07	0.656	0.91	964
27-Apr-87	10:00	8	274	463	3.36	38.17	0.70	59.88	1.08	0.11	0.01	0.00	0.00	0.00	0.05	0.935	0.35	632
27-Apr-87	10:14	7	274	463	4.24	15.41	0.17	82.15	1.86	0.28	0.02	0.02	0.00	0.00	0.09	0.719	0.64	879
	Calculated Total Gas				30.24	1[illegible].46	0.28	84.37	2.21	0.46	0.06	0.06	0.01	0.01	0.07	0.696	0.81	915
4-May-87	9:45	4	79	1006	22.78	7.97	0.24	88.62	2.41	0.53	0.08	0.06	0.02	0.02	0.05	0.654	0.89	964
4-May-87	8:00	7	266	423	3.77	16.14	0.16	81.53	1.76	0.27	0.02	0.02	0.01	0.00	0.09	0.726	0.61	871
4-May-87	8:15	8	266	423	3.18	43.05	0.40	55.34	0.99	0.10	0.01	0.00	0.00	0.00	0.11	0.982	0.35	587
	Calculated Total Gas				29.73	12.76	0.25	84.16	2.18	0.45	0.06	0.05	0.02	0.02	0.06	0.698	0.79	912
11-May-87	7:15	4	80	1010	23.16	7.84	0.40	88.63	2.40	0.53	0.08	0.05	0.02	0.01	0.04	0.653	0.87	962
11-May-87	7:55	7	258	418	3.23	15.93	0.38	81.57	1.76	0.26	0.02	0.02	0.00	0.00	0.06	0.724	0.59	869
11-May-87	9:10	8	258	418	3.07	44.50	0.50	53.86	0.94	0.09	0.01	0.00	0.00	0.00	0.10	0.996	0.33	571
	Calculated Total Gas				29.46	12.55	0.41	84.23	2.18	0.45	0.07	0.04	0.02	0.01	0.05	0.696	0.79	911
18-May-87	10:55	4	93	1017	22.76	7.74	0.22	88.88	2.43	0.55	0.08	0.06	0.01	0.00	0.03	0.651	0.88	965
18-May-87	11:55	7	231	408	3.77	15.68	0.14	82.04	1.77	0.27	0.02	0.02	0.00	0.00	0.06	0.720	0.60	875
18-May-87	12:00	8	253	408	3.33	44.76	0.50	53.64	0.91	0.09	0.00	0.00	0.00	0.00	0.10	0.998	0.32	568
	Calculated Total Gas				29.86	12.87	0.24	84.09	2.18	0.46	0.06	0.05	0.01	0.00	0.04	0.698	0.78	909

Gladys McCall Sand 8 Total Gas Study

Date	Time	Sample Point	Temp (F)	Pres (psia)	GWR (scf/bbl)	CO2 (Mol%)	N2 (Mol%)	C1 (Mol%)	C2 (Mol%)	C3 (Mol%)	iC4 (Mol%)	nC4 (Mol%)	iC5 (Mol%)	nC5 (Mol%)	C6+ (Mol%)	Gas Gravity (Air=1)	Liquids (Gal/mcf)	Heat (BTU/scf)
16-Jul-87	11:35	7	250	430	2.26	16.09	0.15	81.66	1.79	0.27	0.01	0.01	0.00	0.00	0.02	0.723	0.58	869
16-Jul-87	12:00	8	271	427	3.46	42.89	0.41	55.51	1.05	0.09	0.01	0.01	0.01	0.01	0.01	0.979	0.33	586
	Calculated Total Gas				29.32	12.94	0.20	83.81	2.31	0.51	0.06	0.06	0.03	0.02	0.05	0.701	0.85	912
20-Oct-87	18:30	4	92	1015	24.84	7.92	0.16	88.62	2.48	0.58	0.09	0.06	0.01	0.01	0.07	0.654	0.92	967
20-Oct-87	19:05	7	261	416	2.66	15.60	0.13	82.03	1.81	0.28	0.03	0.02	0.01	0.01	0.08	0.721	0.63	878
20-Oct-87	19:20	8	261	416	3.34	41.51	0.40	56.80	1.03	0.11	0.01	0.01	0.01	0.01	0.11	0.968	0.37	604
	Calculated Total Gas				30.84	12.22	0.18	84.61	2.27	0.50	0.08	0.05	0.01	0.01	0.08	0.694	0.84	920
21-Oct-87	10:20	5	263	1013	7.22	30.26	0.40	67.56	1.43	0.20	0.02	0.02	0.01	0.01	0.09	0.862	0.50	722
21-Oct-87	8:50	4	82	1014	25.85	7.98	0.12	88.49	2.53	0.58	0.09	0.08	0.03	0.01	0.09	0.656	0.96	969
	Calculated Total Gas				33.07	12.84	0.18	83.92	2.29	0.50	0.07	0.07	0.03	0.01	0.09	0.701	0.86	915
21-Oct-87	8:50	4	82	1014	25.85	7.98	0.12	88.49	2.53	0.58	0.09	0.08	0.03	0.01	0.09	0.656	0.96	969
21-Oct-87	9:25	7	263	417	2.22	15.63	0.12	81.98	1.81	0.28	0.03	0.01	0.01	0.01	0.12	0.722	0.64	879
21-Oct-87	9:35	8	263	417	3.03	39.11	0.41	59.16	1.08	0.10	0.01	0.01	0.01	0.01	0.10	0.945	0.38	628
	Calculated Total Gas				31.10	11.56	0.15	85.17	2.34	0.51	0.08	0.07	0.03	0.01	0.09	0.689	0.88	929

SAMPLE POINT	LOCATION:
1	Directly from top of first separator.
2	From tubing connected to horizontal run between first stage separator and gas cooler.
4	From either the Drager sample point or the meter run after the gas cooler.
5	Gas released from brine taken from first stage separator. Pressure reduced to atmospheric pressure.
7	From Drager sample point on top of second separator.
8	Gas released from brine taken from second separator. Pressure reduced to atmospheric pressure.

APPENDIX I

Liquid Hydrocarbon Production

A few hundred barrels of two distinctly different liquid hydrocarbons, a heavy aliphatic oil and an aromatic condensate, were recovered during the production of over 25 million barrels of brine and 700 million standard cubic feet of gas. The liquid hydrocarbons generated considerable interest because 1) the possibility of the fraction of liquid hydrocarbons increasing to the point where oil sales may become a significant source of revenue was not known, 2) the mechanism of transport of this oil to the wellbore is not understood, and 3) production of heavy oil at the Sweezey well was quickly followed by the well sanding up and loss of the well.

A measurement technique was employed to try to measure the amount of liquid hydrocarbons produced. Concentrations and compositions were monitored by the University of Southwestern Louisiana, who coined the term "cryocondensates" after the method of collecting the samples. This method found a small quantity, roughly 35 ppm, of primarily aromatic hydrocarbons produced with the brine. The separation and recovery of most of these dissolved hydrocarbons was not economically feasible, although a small fraction of this 35 ppm of condensible/extractable hydrocarbons made up the condensate mentioned above.

Compositions of the hydrocarbon fractions and methods of transport to the wellbore are discussed in subsections below.

Heavy Aliphatic Oil -- During January 1985, after production of approximately 6 million barrels of brine, a heavy oil was found floating at the gas/brine interface in the separators. This oil was bled from the separators daily and the volumes were recorded. The quantity of oil recovered versus cumulative brine production is reproduced here as Exhibit I-1. The recovered oil averaged about 7 parts per million in the produced brine.

There was some question about whether heavy oil production began at an earlier date but was not noticed until January 1985. There was an increase in the alkane fraction of the predominantly aromatic cryocondensate that coincided with the onset of production of heavy oil. The increase in alkanes appeared in the cryocondensate sample of December 28, 1 month before the production of heavy oil was noted, but was not observed in earlier samples. This is strong evidence that no heavy oil was produced prior to December 1984.

The composition of the heavy oil was clearly different from the cryocondensate and the condensate that condensed from the gas stream. Several samples of the heavy oil were analyzed by gas chromatography. Only a portion of each sample was recovered from the chromatograph. Very heavy ends, such as asphaltenes and tar, were irreversibly adsorbed onto the chromatographic column and did not reach the detector. The distribution of the eluted portion of the samples is presented versus carbon number in Exhibit I-2. The fraction of each sample that was not recovered

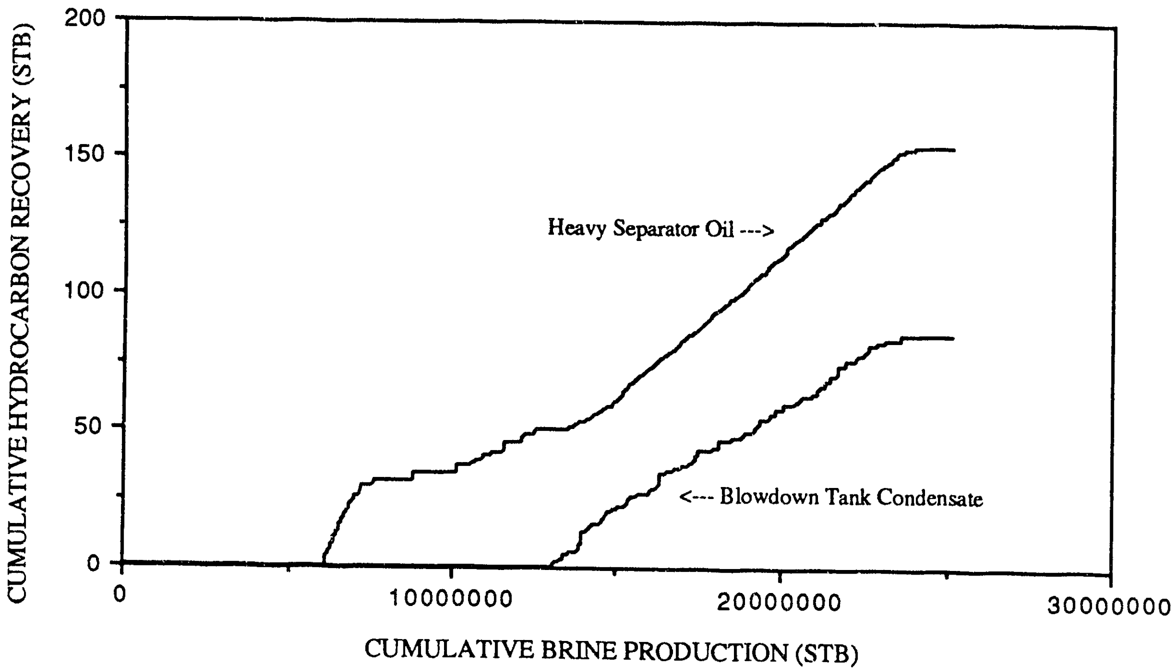


Exhibit I-1. LIQUID HYDROCARBON RECOVERY

was the fraction higher than the highest carbon number in the table. Representative chromatograms are presented in Exhibit I-3 and I-4. The normal alkane backbone, clearly apparent in most samples, is labeled.in Exhibit I-4.

The samples were also analyzed on shorter simulated distillation gas chromatography columns that provide less resolution but greater recovery of the heavy ends. These data are presented in Exhibits I-5 and I-6. The initial boiling point of the heavy oil samples are close to 400°F. It is probable that the lighter ends of this heavy oil were cooked off (distilled) during the time the oil resided in the large separator. The light ends were transported out of the separator in the gas stream, and these lighter hydrocarbons were then observed as an increase in the alkane portion in the condensate samples.

There was some question about how the oil was transported to the well. Conventional theory states that the oil saturation must be above some minimum value, generally 20% to 30% of the pore volume, before oil will flow. There was no evidence of an oil phase in the core or the log interpretations obtained from this well. Alternate hypotheses for transport of oil to the wellbore are 1) that the heavy oil was dissolved in the brine, much like the aromatics that were found in the

Exhibit I-2, Part 1. HIGH-PRESSURE SEPARATOR OIL
CARBON NUMBER DISTRIBUTION

Carbon No.	19 Feb 87	13 Apr 87	14 Apr 87	15 Apr 87	21 Apr 87	27 Apr 87
9	0.04	--	--	--	--	--
o-Xylene	0.06	--	--	--	--	--
10	0.13	<0.01	<0.01	0.18	0.31	0.19
11	0.24	0.44	0.30	0.26	0.23	0.17
12	0.29	0.52	0.37	0.31	0.44	0.38
13	0.63	0.59	0.43	0.54	0.71	0.46
14	1.12	1.11	0.79	1.20	0.71	0.83
15	1.67	1.40	1.13	1.86	1.31	1.18
16	2.06	1.80	1.52	2.35	1.67	1.55
17	2.90	2.75	2.41	3.28	2.51	2.34
18	4.09	3.19	2.83	3.53	1.12	2.75
19	4.73	3.81	3.50	3.91	5.29	3.25
20	5.19	4.24	4.02	4.23	3.93	3.64
21	5.17	4.78	4.56	4.60	4.39	4.13
22	5.17	4.99	4.84	4.96	5.08	4.63
23	4.53	4.63	5.14	4.58	4.55	4.18
24	3.32	4.58	3.75	3.59	3.60	3.39
25	3.29	4.27	4.22	3.87	3.92	3.59
26	2.37	4.19	4.10	3.87	3.93	4.21
27	1.83	4.64	4.57	4.34	4.42	3.59
28	1.24	3.57	3.56	3.38	3.40	3.17
29	0.65	4.38	4.39	4.20	4.24	3.89
30		2.20	1.92	1.84	1.87	1.79
31		2.77	2.72	2.56	2.57	2.43
32		2.99	2.99	2.87	2.88	2.67
33		3.31	3.19	3.08	2.39	2.80
34		1.27	1.28	2.03	1.88	1.61
35		2.14	2.07	1.20	1.64	1.43
36		1.72	1.58	1.34	1.18	1.30
37		1.18	1.18	1.32	1.77	1.20
38		1.17	1.12	1.09	1.09	1.04
39		1.06	1.05	1.01	1.02	0.93
40		0.96	0.93	0.90	0.88	0.85
41		0.86	0.80	0.79	0.82	0.75
42		0.74	0.76	0.73	0.73	0.70
43		0.72	0.69	0.67	0.66	0.63
44		1.31	1.32	1.20	1.29	1.22
% of Sample Recovered	50.90	83.99	80.00	81.64	78.43	72.83

Exhibit I-2, Part 2. HIGH-PRESSURE SEPARATOR OIL CARBON NUMBER DISTRIBUTION

Carbon No.	4 May 87	11 May 87	18 May 87	16 Jul 87	21 Oct 87
9	- -	- -	- -	- -	- -
o-Xylene	- -	- -	- -	- -	- -
10	0.15	0.36	4.78	0.37	- -
11	0.10	0.20	2.53	0.26	0.06
12	0.27	0.43	5.09	0.40	0.19
13	0.51	0.29	7.31	0.47	0.34
14	0.42	0.52	4.66	0.31	0.34
15	0.93	0.62	7.33	0.21	0.52
16	1.24	0.66	6.01	0.35	0.36
17	1.88	0.83	5.64	0.25	0.45
18	2.37	1.08	4.75	0.41	0.29
19	3.03	1.28	3.98	0.27	0.68
20	3.63	1.72	3.49	0.37	0.61
21	4.27	2.35	3.34	0.52	0.73
22	5.15	3.09	3.13	0.49	0.75
23	4.12	3.39	2.65	0.67	1.12
24	4.55	3.60	2.42	0.80	1.31
25	4.34	3.09	1.80	0.79	1.78
26	3.17	3.91	3.00	1.17	2.20
27	3.11	4.66	1.51	1.74	2.81
28	4.06	3.77	1.80	1.70	3.33
29	3.80	4.02	2.34	1.96	4.38
30	3.82	3.44	1.84	3.18	4.57
31	3.65	3.06	1.59	2.90	5.54
32	3.20	3.77	1.35	3.72	3.73
33	2.71	4.04	1.27	2.75	2.20
34	2.31	1.65	0.94	1.34	4.69
35	2.33	1.38	0.78	1.42	3.27
36	2.37	2.03	0.71	1.35	2.47
37	1.96	2.52	0.73	1.66	2.53
38	1.25	1.41	0.68	2.17	3.60
39	1.16	1.32	0.68	1.62	1.66
40	1.04	1.18	0.56	1.19	2.67
41	0.89	1.04	0.59	1.04	1.69
42	0.87	0.97	0.38	0.94	1.10
43	0.75	0.86	0.33	0.83	1.36
44	1.48	1.52	0.25	2.12	0.83
% of Sample Recovered	80.87	70.00	90.23	41.71	64.00

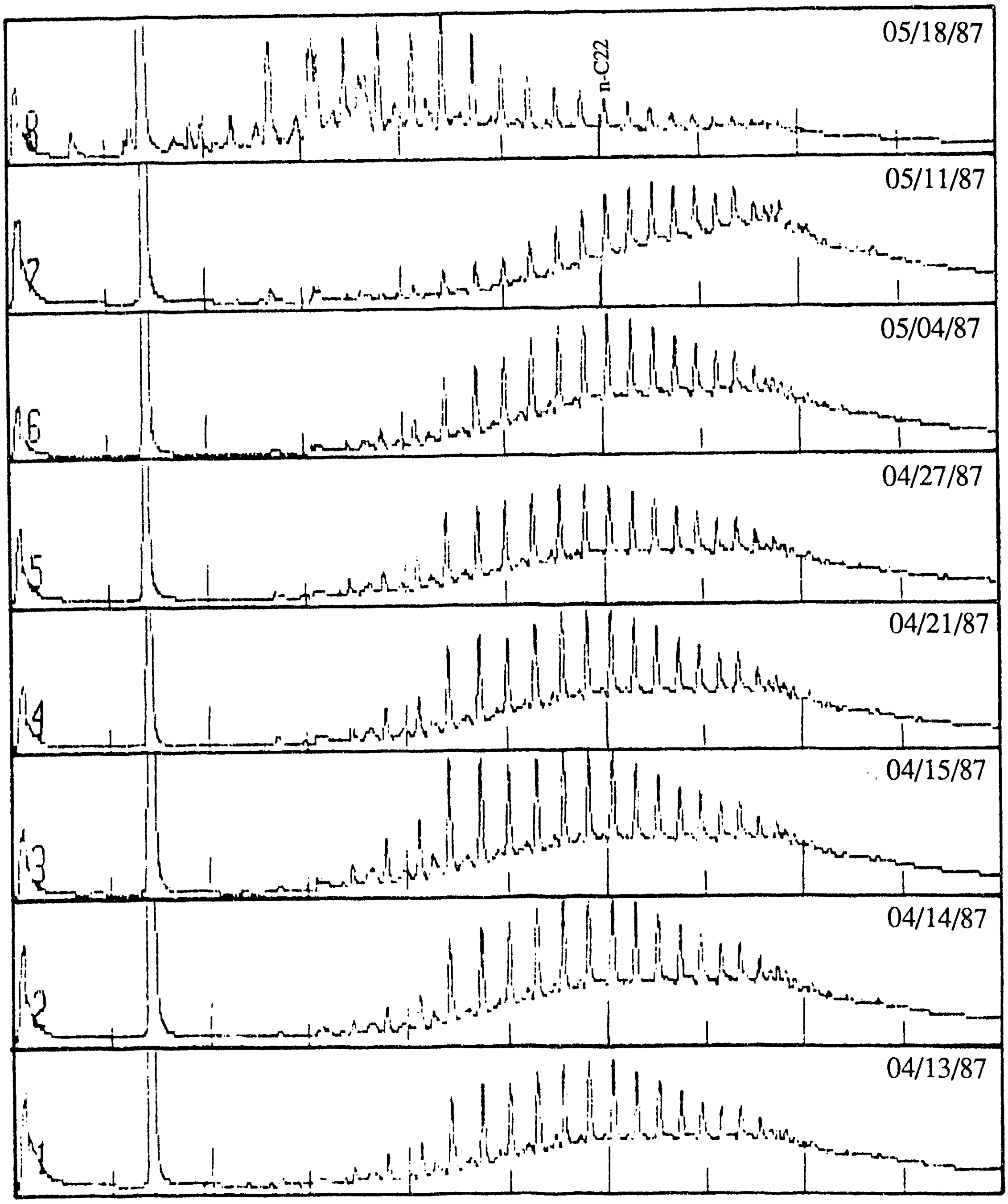


Exhibit I-3. HIGH-PRESSURE SEPARATOR OIL CHROMATOGRAMS

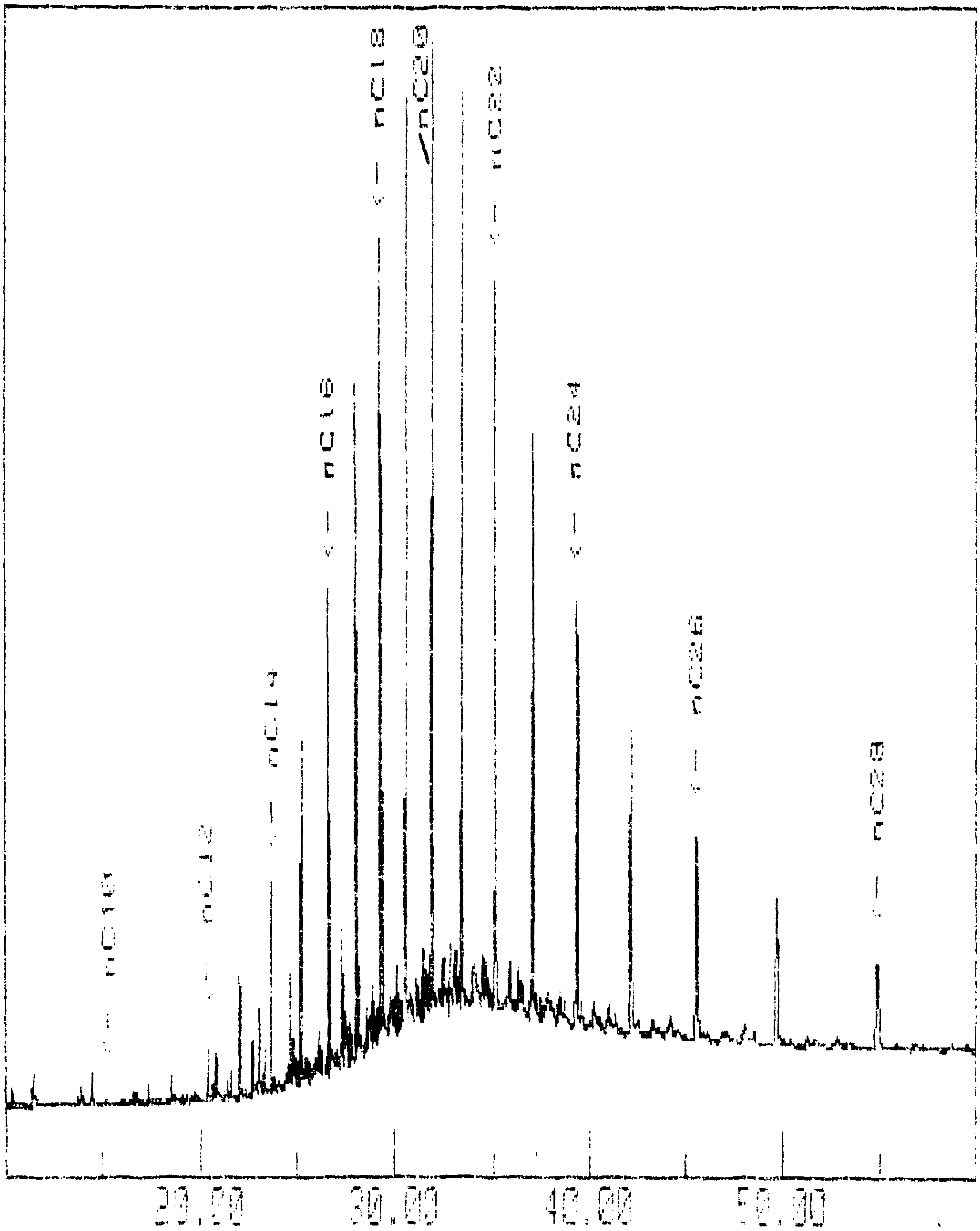


Exhibit I-4. HIGH-PRESSURE SEPARATOR OIL CHROMATOGRAM

Exhibit I-5. HEAVY OIL SIMULATED DISTILLATION BY GAS CHROMATOGRAPHY

% Recovered	Temperature, °F				
	2/19/87	4/13/87	4/14/87	4/15/87	4/21/87
Initial Boiling Point	405	395	420	410	390
5%	540	535	55	530	540
10%	595	590	605	570	590
15%	625	625	640	610	630
20%	655	650	665	640	660
30%	705	695	710	690	710
40%	745	745	755	740	755
50%	790	780	805	785	800
60%	835	830	855	835	860
70%	895	885	915	900	935
80%	990	980	1018	1010	

% Recovered	Temperature, °F				
	4/27/87	5/04/87	5/11/87	5/18/87	7/16/87
Initial Boiling Point	410	420	390	<200	390
5%	550	570	600	350	710
10%	600	620	670	410	795
15%	640	655	710	450	840
20%	670	680	735	470	860
30%	715	725	780	505	920
40%	770	770	830	560	1010
50%	820	805	875	615	
60%	885	860	940	685	
70%	995	920	1018	765	
80%		1018		860	
90%				1018	

cryocondensate; 2) that the oil was dispersed in the reservoir in discrete, immobile accumulations that were transported to the wellbore through a free gas phase; and 3) that a small quantity of oil was being coned in from a nearby pool of oil. Each mechanism is supported by some data, although no proposed method had a clear advantage over the others. Each mechanism is discussed briefly in the following paragraphs.

The quantity of oil that is being produced, 5 to 9 ppm by weight, is consistent with laboratory data on the solubility of oil in water. Exhibit I-7 is reproduced from J. P. Price's "Aqueous Solubility of Crude Oil" (1981). This study involved distilling a crude oil, similar to the

Exhibit I-6. LOW-PRESSURE SEPARATOR SIMULATED DISTILLATION BY GAS CHROMATOGRAPHY

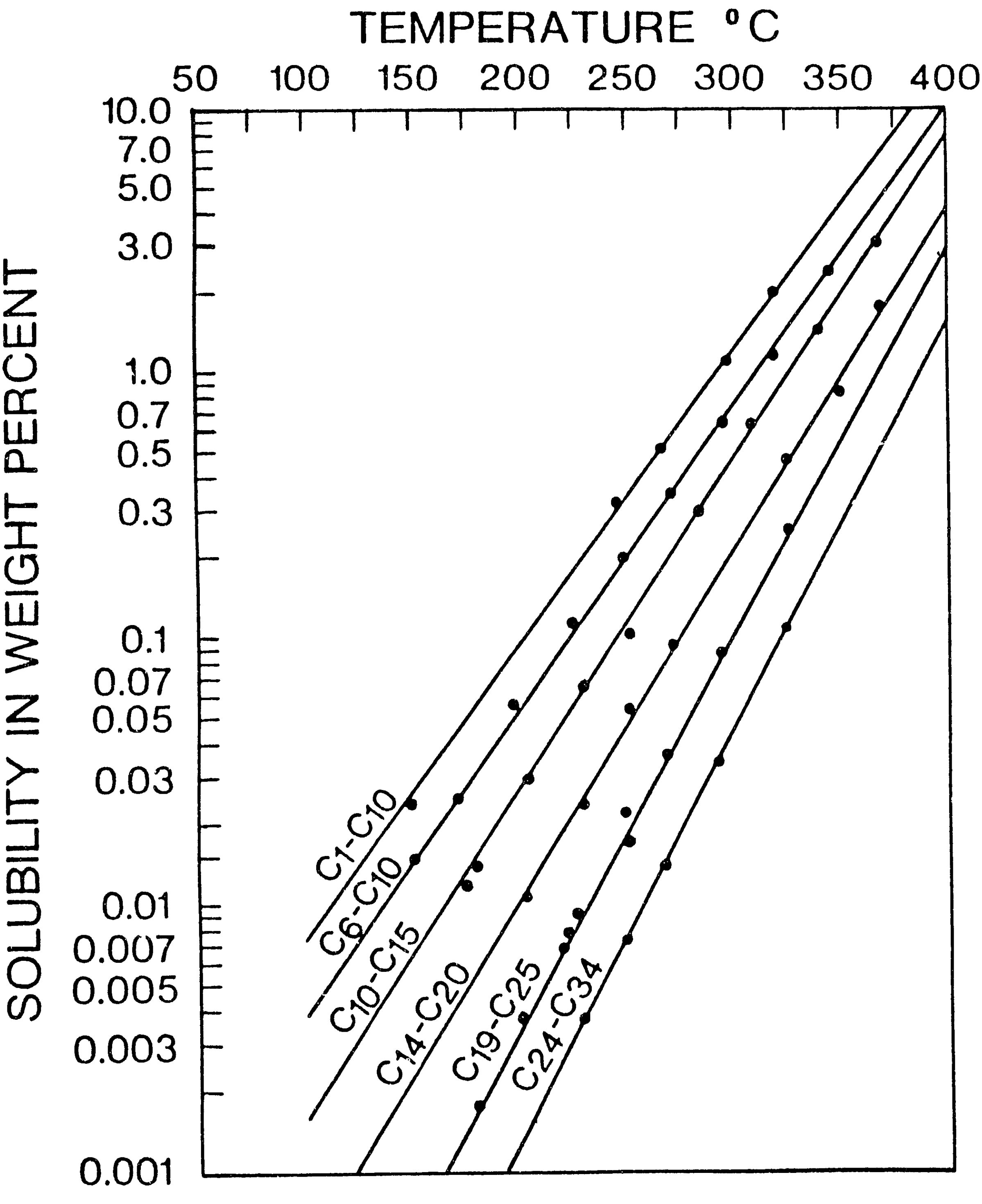
% Recovered	Temperature, °F 2/19/91	4/13/87
Initial Boiling Point	440	360
5%	605	540
10%	645	585
15%	675	615
20%	695	645
30%	745	695
40%	775	735
50%	825	785
60%	875	830
70%	940	895
80%		1010

oil produced at the Gladys McCall well, into carbon-number fractions and determining the solubility of each fraction in water. The pressure was approximately 10,875 psia in this study. At 140°C -- the temperature of the Sand 8 -- the solubility of the oil fractions reported by Price are as follows:

C6 to C10	130 ppm by weight
C12 to C15	55 ppm by weight
C14 to C20	19 ppm by weight
C19 to C25	6 ppm by weight
C24 to C34	2 ppm by weight

Price found that these solubilities were not additive and there was interference between ranges. He also noted that salt, at 10% by weight, decreased the solubility of the C10 to C15 fraction by about 75%. Nevertheless, the data suggest that the 7 parts per million of oil produced could have been dissolved in the brine at reservoir conditions.

Weres (1985) suggested the produced oil was in a gas phase in the reservoir. The scenario calls for an oil phase to exist in the reservoir, but the oil saturation is too small for the oil phase to



Aqueous solubility of six petroleum distillation fractions in ppm (by weight) as a function of temperature at a constant pressure of 750 bars. Carbon number range shown for each curve.

Exhibit I-7. AQUEOUS SOLUBILITY OF CRUDE OIL
[From J. P. Price's "Aqueous Solubility of Crude Oil" (1981)]

migrate as such. The heavy oil produced was dissolved in a gas phase that formed down-hole after reservoir pressure declined in response to production of brine and gas. He cites increases in the C7 to C13 *n*-alkanes production just prior to the onset of heavy oil production to support this hypothesis. A problem with this hypothesis is that the bottomhole pressure at the onset of oil production was over 10,700 psia, whereas a gas phase could not be expected to form until the bubble-point pressure of around 9200 psia was reached.

Finally, there has been a suggestion that oil migrated from the shale during the drawdown, or was present at this interface near the well, and the oil production is largely the coning in of a very thin oil accumulation from the shale/sandstone interface. A problem with this hypothesis is that oil production began while brine rates were below 15,000 STB/d. At this lower rate, particularly following higher rate production, it seems unlikely that a pressure gradient large enough to cause oil coning could be present.

It is unlikely that the quantity of oil produced would become economical with continued production. If the original oil in place was trapped in small immobile pockets in the Number 8 Sand and is being transported to the well in the newly formed gas phase, then production of this oil will be dependent on production of the differentially liberated gas out in the reservoir. In the Gas Section of this report, we explained why this will not occur to any large extent. Oil production from the Gladys McCall Sand 8 will remain only at a nuisance level of a few parts per million in the brine.

Knockout-Pot Condensate -- The knockout-pot condensate is those hydrocarbons that drop out of the gas phase as the gas is cooled from 290°F in the separators to the near-ambient temperature required for gas dehydration and sales. An analysis of a sample of the knockout pot is provided in Exhibit I-8. The accompanying chromatogram is provided in Exhibit I-9 with the normal alkane chain labeled.

The knockout-pot condensate was largely aromatic (contained benzene-like ring structures) and contained less of the aliphatic hydrocarbons than did the heavy separator oil. Because aromatics are much more soluble in water than their straight-chain counterparts, the components making up the knockout-pot condensate were most likely dissolved in the reservoir brine at reservoir conditions.

The knockout-pot condensate was disposed of without measuring volumes for the first half of the test. Volumes were first measured in 1985. The sudden appearance of knockout-pot condensate at 13 million barrels of brine produced should not be construed to mean this hydrocarbon liquid was not being produced before this time, as was the case for the heavy oil production.

Exhibit I-8. GAS COOLER CONDENSATE COMPOSITION

Carbon No.	19 Feb 87	04 May 87	11 May 87	18 May 87	16 Jul 87	21 Oct 87
1	<0.01	- -	- -	- -	- -	0.01
2	0.01	<0.01	<0.01	0.01	0.01	0.02
3	0.07	<0.01	0.05	0.06	0.02	0.08
4	0.17	<0.01	0.13	0.11	0.06	0.15
5	0.19	<0.01	0.13	0.12	0.06	0.13
6	0.27	<0.01	0.34	0.30	0.18	0.20
Benzene	4.01	<0.01	3.05	3.26	2.57	5.10
7	0.60	<0.01	0.56	0.52	0.32	0.29
Toluene	4.07	<0.01	3.16	3.54	2.86	5.24
8	1.26	<0.01	0.31	0.36	0.14	0.56
Ethylbenzene	1.00	<0.01	0.83	0.94	0.80	1.25
m,p-Xylene	1.91	<0.01	1.67	1.94	1.69	2.63
Styrene	- -	- -	- -	- -	- -	0.02
9	1.44	0.01	1.01	1.79	0.95	0.24
o-Xylene	1.66	<0.01	1.12	0.95	0.95	2.37
C3-Benzene	- -	- -	- -	- -	- -	3.56
10	3.97	0.09	3.44	3.61	4.55	0.39
11	6.16	0.39	3.88	3.34	1.94	4.12
12	6.16	2.17	4.76	4.58	1.86	2.77
Naphthalene	- -	0.38	3.08	4.18	6.36	6.79
13	9.85	5.75	6.22	5.34	3.48	1.53
C1-Naphthalene	- -	2.46	5.38	7.81	13.07	12.94
14	11.07	9.63	7.46	5.75	3.57	2.80
C2-Naphthalene	- -	- -	- -	- -	- -	8.78
15	10.49	16.91	11.70	11.81	11.34	4.27
16	7.54	12.47	9.00	8.57	10.21	7.57
C3-Naphthalene	- -	- -	- -	- -	- -	3.94
17	6.99	14.50	10.07	7.89	10.50	1.64
18	6.97	9.24	5.91	6.82	5.25	4.18
19	5.08	8.29	5.20	4.86	3.30	3.54
20	3.36	5.18	3.62	3.27	3.12	2.29
21	2.31	4.14	3.22	2.70	2.89	2.27
22	1.47	2.47	1.92	1.94	2.36	1.91
23	0.89	1.96	1.15	1.46	2.10	1.73
24	0.54	2.87	0.74	1.37	1.69	1.83
25	0.29	1.09	0.89	0.80	1.80	1.17
26	0.14	- -	- -	- -	- -	1.16
27	0.05	- -	- -	- -	- -	0.39
28	<0.01	- -	- -	- -	- -	0.11

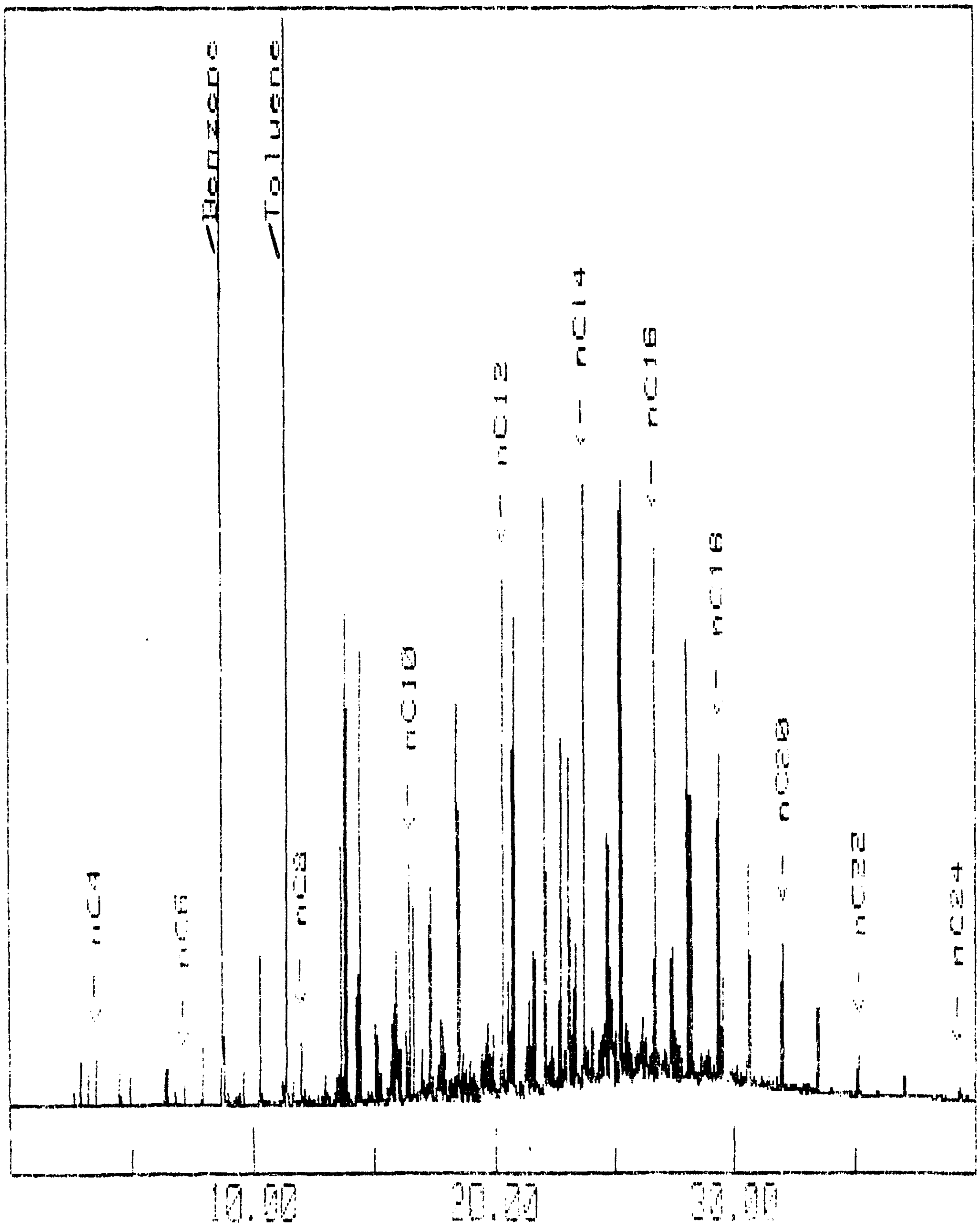


Exhibit I-9. KNOCKOUT-POT CONDENSATE CHROMATOGRAM

Cryocondensates -- The term "cryocondensates" is used to describe most of the heavy, predominantly aromatic, hydrocarbons produced. These hydrocarbons were collected and analyzed by Drs. J. Meriwether and D. Keeley of the University of Southwestern Louisiana, and most of the data incorporated herein is taken from their reports. The cryocondensates include all hydrocarbons that condense from the gas at about -60°F, plus those hydrocarbons that remain in brine that has been cooled to below ambient temperature and flashed to 1 atmosphere pressure. The cryocondensates contain numerous aromatic hydrocarbons, including benzene, naphthalene, indene, phenyl and biphenyl, benzofurans, anthracene, phenanthrene, and their derivatives. There are only minor amounts of alkanes present.

Much like the knockout-pot condensate described above, these hydrocarbons are believed to be dissolved in the brine at reservoir conditions. Because aromatics are much more soluble in water than their straight-chain counterparts, the components making up the knockout-pot condensate were most likely dissolved in the reservoir brine at reservoir conditions. Indeed, almost half of these hydrocarbons remain dissolved in the brine at separator conditions, whereas the remainder flashes into the gas phase.

Changes in the cryocondensate concentrations have been speculated to portend the production of oil. Zarrella et al. (1967) reported that the concentration of benzene decreased with distance from an oil deposit. These observations were based on hydropressured, not geopressured, reservoirs. The brine in hydropressured reservoirs where commercial accumulations of hydrocarbons exist tends to be more mobile over geologic time than the brine trapped in geopressured aquifers. The oil source would constantly replenish the aromatics in the brine as fresh brine is introduced to the system. In geopressured reservoirs, the aquifer is bound by shale and fault barriers. Brine flow into the system is very limited. We therefore would not expect the relationship between the benzene concentration gradients to be as related to an oil deposit in a geopressured reservoir as in a conventionally pressured reservoir.

Zarrella also noted that brines in contact with gas fields did not contain benzene. Again, this is probably not applicable to geopressured-geothermal reservoirs. This lack of benzene is consistent with the above scenario whereby benzene in the brine is continually replenished by an oil phase in the reservoir. Benzene and other aromatics are produced by the diagenesis of kerogen and large organic molecules. Both are stable molecules that do not tend to readily degrade into smaller molecules at the pressure and temperature found in this aquifer. Indeed, methane and benzene have been found in all geopressured-geothermal wells and also in the much hotter geothermal wells.

APPENDIX J

PVT Analysis for Sand 8 by Weatherly Laboratories, Inc.

RESERVOIR FLUID ANALYSIS

FOR

TECHNADRIL-FENIX & SCISSON, INC.

GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD
CAMERON PARISH, LOUISIANA

WEATHERLY LABORATORIES, INC.

WEATHERLY LABORATORIES, INC.

J. E. WEATHERLY, JR.
CHAIRMAN

223 GEORGETTE LAFAYETTE, LA 70506
PHONE (318) 232-4877

JOHN D. NEAL
PRESIDENT
BRYAN SONNIER
VICE PRESIDENT

OCTOBER 24, 1983

TECHNADRIL-FENIX & SCISSON, INC.
3 NORTHPOINT DRIVE
SUITE 200
HOUSTON, TEXAS 77060

ATTENTION: MR. LARRY DURRETT

RE: RESERVOIR FLUID STUDY
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD
CAMERON PARISH, LOUISIANA

GENTLEMEN:

ATTACHED ARE THE RESULTS OF THE ANALYSES OF THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF A RECOMBINED RESERVOIR FLUID SAMPLE FROM THE SUBJECT WELL. SURFACE SEPARATOR SAMPLES WERE COLLECTED FROM THIS WELL BY A REPRESENTATIVE OF WEATHERLY LABORATORIES, INC. ON OCTOBER 8, 1983. THE GAS-WATER RATIO (GWR) MEASURED ON THIS TEST, 25.01 CUBIC FEET OF SEPARATOR GAS PER BARREL OF SEPARATOR LIQUID, WAS USED AS THE BASIS FOR ONE RECOMBINATION. THE RESULTANT RESERVOIR FLUID EXHIBITED A BUBBLE POINT OF 9,200 PSIA AT THE RESERVOIR TEMPERATURE 290 DEGREES FAHRENHEIT.

OTHER RECOMBINATIONS WERE DONE TO DETERMINE A BUBBLE POINT -VS- GWR RELATIONSHIP. A DIFFERENTIAL LIBERATION AND VISCOSITY MEASUREMENTS WERE PERFORMED USING RESERVOIR FLUID RECOMBINED TO THE PRODUCED GWR AT THE TIME OF SAMPLING.

WE WISH TO THANK YOU FOR THIS OPPORTUNITY OF SERVING YOU. SHOULD THERE BE ANY QUESTIONS CONCERNING THIS REPORT, PLEASE CONTACT US.

YOURS VERY TRULY

John Neal

JOHN NEAL

CC: MR. JONNE BERNING
TECHNADRIL-FENIX & SCISSON, INC.
RT. 1, BOX 36-B
GRAND CHENIER, LA 70643

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

GEOPRESSURE/GEOTHERMAL PROJECT SAMPLING AND LABORATORY PROCEDURE

1) WATER VAPOR CONTENT OF SEPARATOR GAS WAS DETERMINED BY FLOWING GAS FROM A METERING VALVE ON THE SEPARATOR GAS METER RUN THROUGH A WEIGHING TUBE (INDICATOR DRIERITE ($CaSO_4$) WEIGHED TO 0.1 MILLIGRAM) TO A RUSKA GASOMETER. SEPARATOR GAS SAMPLES WERE TAKEN FROM THE SAME PLACE INTO 1 GALLON STAINLESS STEEL (S.S.) CYLINDERS AFTER THOROUGH PURGING. SEPARATOR LIQUID SAMPLE CYLINDERS (1000 ML. S.S.) WERE FIRST CHARGED WITH SEPARATOR GAS TO FULL SEPARATOR PRESSURE. THE LIQUID CYLINDERS WERE THEN CONNECTED TO THE SEPARATOR WATER SAMPLING POINT BY A S.S. TUBE LONG ENOUGH TO LOOP THROUGH A COOLING BATH. THE WATER TRANSFER LINE WAS THEN SLOWLY AND THOROUGHLY PURGED AT THE CYLINDER. SEPARATOR WATER WAS LET INTO THE CYLINDER BY SLOWLY BLEEDING GAS FROM THE TOP VALVE. AT NO TIME WAS THE WATER CAUGHT IN THE CYLINDER ALLOWED TO DROP BELOW SEPARATOR PRESSURE.

2) FLASH LIBERATION OF GAS FROM SEPARATOR WATER WAS ACCOMPLISHED BY USING A WEIGHED SEPARATOR FLASK. THIS SEPARATOR FLASK WAS CONNECTED TO THE OUTLET OF A SEPARATOR WATER CYLINDER BY A SHORT CAPILLARY LINE. GAS FROM THE SEPARATOR FLASK PASSED THROUGH A WEIGHED DRYING TUBE THROUGH A GLASS CYLINDER (~ 300 ML.) TO A RUSKA GASOMETER. A VACUUM VALVE AND A MERCURY MANOMETER WAS CONNECTED TO THE GAS MANIFOLD BETWEEN THE DRYING TUBE AND THE GASOMETER. BEFORE COMMENCING THE FLASH, THE ENTIRE FLASH GAS MANIFOLD WAS EVACUATED AND THEN FILLED WITH HELIUM TO ATMOSPHERIC PRESSURE. A KNOWN VOLUME OF SEPARATOR WATER WAS PUSHED OUT OF THE SAMPLE CYLINDER AT A PRESSURE SLIGHTLY ABOVE FIELD SEPARATOR PRESSURE BY USE OF A CALIBRATED MERCURY PUMP. THE VOLUME OF STOCK TANK WATER PRODUCED WAS DETERMINED BY ITS WEIGHT AND DENSITY. THE VOLUME OF DRY GAS EVOLVED WAS DETERMINED WITH THE GASOMETER. THIS GAS VOLUME WAS SUBJECT TO $\pm$ 2 % ERROR DUE TO THE VERY SMALL AMOUNTS MEASURED. THE GAS WAS CHARGED TO A CHROMOTOGRAPH FOR ANALYSIS FROM THE GLASS CYLINDER.

3) PHYSICAL RECOMBINATION OF SEPARATOR EFFLUENTS:
SEPARATOR GAS WAS CHARGED INTO A TEMPERATURE CONTROLLED CELL. THE VOLUME OF THIS WINDOWED CELL IS KNOWN FOR ANY PRESSURE AND TEMPERATURE. THE PRESSURE OF THE GAS IN THE CELL WAS MEASURED WITH A MERCURY MANOMETER AND A BAROMETER. THIS CALCULATED GAS VOLUME WAS SUBJECT TO A $\pm$ 1 % ERROR DUE TO THE SMALL AMOUNT CHARGED TO THE CELL. A VOLUME OF SEPARATOR WATER WAS CHARGED INTO THE WINDOWED CELL BY USE OF A CALIBRATED MERCURY PUMP. THE WATER WAS METERED AND MEASURED AT A PRESSURE SLIGHTLY ABOVE FIELD SEPARATOR PRESSURE. FOUR RECOMBINATIONS WERE DONE IN ORDER TO PRODUCE A SATURATION PRESSURE-VS-GAS WATER RATIO CURVE. RESERVOIR FLUID RESULTING FROM RECOMBINATION OF THE PRODUCED GWR (FIFTH RECOMBINATION) WAS USED TO PERFORM A DIFFERENTIAL LIBERATION AND VISCOSITY MEASUREMENT.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

4) PRESSURE-VOLUME RELATIONS OF RECOMBINED RESERVOIR FLUID AT RESERVOIR TEMPERATURE:
EACH DATUM OF PRESSURE-VOLUME RELATIONS WAS CORRECTED FOR MERCURY PUMP CALIBRATION, MANIFOLD EXPANSION, CELL EXPANSION, MERCURY COMPRESSIBILITY AND MERCURY THERMAL EXPANSION. LIQUID VOLUME PERCENT WAS DETERMINED BY CALIBRATED CATHETOMETER AND BY DATA INTERPRETATION.

5) DIFFERENTIAL LIBERATION OF RESERVOIR FLUID AT RESERVOIR TEMPERATURE:
GAS FROM EACH PRESSURE DECREMENT OF THE DIFFERENTIAL LIBERATION WAS ANALYZED IN THE SAME MANNER AS DESCRIBED IN 2), (FLASH LIBERATION). DIFFERENTIAL LIQUID CHANGES WERE NOTED.

6) VISCOSITY OF RESERVOIR FLUID WAS MEASURED BY MR. J. R. COMEAU OF WEATHERLY LABORATORIES. A DESCRIPTION OF MR. COMEAU'S EXPERIMENTAL PROCEDURES IS GIVEN BELOW:
GEOTHERMAL WATER VISCOSITIES WERE MEASURED USING A RUSKA ROLLING BALL VISCOMETER WITH AN ELECTRONIC DETECTION SYSTEM TO PREVENT ELECTROLYSIS. THE DETECTION SYSTEM CONSISTS OF A SENSITIVE AUDIO AMPLIFIER WITH POSITIVE FEEDBACK ADJUSTED JUST BELOW OSCILLATION. THE BALL IS HELD BY AN ELECTROMAGNET. WHEN CURRENT TO THE MAGNET IS TURNED OFF, A PULSE IS PRODUCTED WHICH STARTS A DIGITAL TIMER. WHEN THE BALL STRIKES THE CONTACT AT THE OTHER END OF THE VISCOMETER THE ELECTRICAL DISTURBANCE PRODUCED IS GENERALY AMPLIFIED AND TURNS THE TIMER OFF. TIMES WERE MEASURED TO 1/100TH OF A SECOND AND AVERAGED. THE VISCOMETER WAS CALIBRATED AT EACH OF TWO ANGLES USING DISTILLED WATER AT SEVERAL TEMPERATURES. THESE RESULTS WERE USED ALONG WITH PREVIOUS RESULTS TO OBTAIN NEW CALIBRATION CURVES. t p VERSUS u WERE PLOTTED TO OBTAIN CALIBRATION.

t = ROLL TIME, (SECONDS)

p = DENSITY DIFFERENCE BETWEEN BALL AND RESERVOIR FLUID, (gm./ml.)

u = VISCOSITY, (CENTIPOISE)

THE VISCOMETER WAS CHARGED WITH RESERVOIR FLUID AND RUN AT 290°F AT 1000 LB. INTERVALS. THE VISCOSITIES HAD A PROBABLE ERROR OF ± 0.01 CENTIPOISE.

NOTE: ALL DATA FOR PRESSURES GREATER THAN 11,000 PSI WERE OBTAINED BY EXTRAPOLATION. THE VISCOSITY DATA ARE ABOUT 0.1 CENTIPOISE LOWER THAN THE PREVIOUS REPORT (N1901 10224 OF APRIL 1983). WE BELIEVE THAT THIS IS DUE TO A FILM BUILDUP IN THE 404 S.S. BARREL OF THE OLD E.L.I. VISCOMETER. THIS FILM DID NOT FORM IN THE 316 S.S. BARREL OF THE RUSKA VISCOMETER.

LAB. NO. N2106-10457

FIELD DATA FOR WEATHERLY LABORATORY INVESTIGATION

WELL RECORD

COMPANY	TECHNADRIL-FENIX & SCISSON, INC.
WELL	GLADYS MCCALL NO. 1
FIELD	EAST CRAB LAKE
PARISH AND STATE	CAMERON, LOUISIANA

FIELD CHARACTERISTICS

FORMATION NAME	
SAND NAME AND DESIGNATION	8
DATE COMPLETED	
ORIGINAL RESERVOIR PRESSURE	

WELL CHARACTERISTICS

ORIGINAL PRODUCED GAS-LIQUID RATIO		
PERFORATIONS		
ELEVATIONS		
TOTAL DEPTH		
LAST RESERVOIR PRESSURE	12,783	PSIA
RESERVOIR TEMPERATURE	290	DEGREES F

SAMPLING CONDITIONS

DATE SAMPLED		10-8-83	
TUBING PRESSURE, FLOWING		12,676	PSIG
PRIMARY SEPARATOR TEMPERATURE	(METER RUN)	97	DEGREES F, (SEP.) 268'F
PRIMARY SEPARATOR PRESSURE		500	PSIG
PRIMARY SEPARATOR GAS RATE	(WET GAS)	349,750	SCF/DAY
SEPARATOR LIQUID RATE		13,987	BBLS./DAY
GAS-LIQUID RATIO (SEPARATOR)		25.01	SCF/BBL.SEP.WATER
SHRINKAGE FACTOR (VOL.S.T.WATER @ 60'F/VOL.SEP.WATER)		0.9437	
GAS-LIQUID RATIO (STOCK TANK)		26.50	SCF/BBL.S.T.WATER
PRESSURE BASE		15.025	PSIA @ 60 DEGREES F

NOTE: FOR DRY GAS, 24.95 SCF/BBL. SEP. WATER @ SEP. CONDITIONS.
26.44 SCF/BBL. S.T. WATER @ 60'F.

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

CALCULATION OF GAS RATE, 10-8-83 TEST

(Factors from GPSA Engineering Data Book)

\/Hw Pf	=	107.5735	Hw	=	22.47 "H20 ,	Pf	=	515 psia
Fb	=	113.9873	D	=	2.626 " ,	d	=	0.750 "
Fpb	=	0.9804			15.025 psia			
Fr	=	1.0004	b	=	0.0470			
Y2	=	1.0003	Hw/Pf	=	0.042 ,	d/D	=	0.286
Fg	=	1.2116	Gravity	=	0.6812 ,	Fg	=	\/1 / 0.6812
Ftf	=	0.9662	Temp.	=	97 degrees F ,	Ftf	=	\/520 / 557
Fpv	=	1.0348	pTr'	=	1.547 ,	pPr'	=	0.751
			Z	=	0.9339 ,	Fpv	=	\/1 / Z
			Epsilon	=	12.5			

Q = \/Hw Pf x Fb x Fpb x Fr x Y2 x Fg x Ftf x Fpv x 24

Q = 349,750 SCF/day @ 15.025 PSIA @ 60 Degrees F (WET)

LAB NO. N2106-10457 PAGE 5 OF 25

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

RESERVOIR FLUID SUMMARY

Reservoir Temperature, Degrees F		290
Saturation Pressure at 290 Degrees, Psia		9200
Compressibility of Reservoir Oil at 290 Degrees F		
Vol. per Vol. per Psi x 10 6		
From 9200 Psia to 10000 Psia		3.00
From 10000 Psia to 11000 Psia		2.81
From 11000 Psia to 12783 Psia		2.76
		DIFF. LIB.
Saturated Oil at 9200 Psia, 290 Degrees F		
Density, Gms. per Ml.		1.01221
Lbs. per Bbl.		354.78
Specific Volume, Cu.Ft. per Lb.		0.015825
Viscosity, Centipoise		0.277
Formation Volume Factor, Bbls. per Bbl.		
"Equivalent Stock Tank Oil" at 60 Degrees F	1.0575 * ,	1.0532
Solution Gas-Oil Ratio, Cu.Ft. per Bbl.	30.38 * ,	33.51 WET
"Equivalent Stock Tank Oil" at 60 Degrees F	30.19 * ,	31.60 DRY
Reservoir Oil at 12783 Psia 290 Degrees F		
Density, Gms. per Ml.		1.02255
Lbs. per Bbl.		358.40
Specfic Volume, Cu.Ft. per Lb.		0.015665
Viscosity, Centipoise		0.310
Formation Volume Factor, Bbl. per Bbl.		
"Equivalent Stock Tank Oil" at 60 Degrees F	1.0468 * ,	1.0426

NOTE: REFERENCES TO 'OIL' ABOVE SHOULD READ 'WATER'.

* BASED ON SEPARATOR WATER FLASH.

LAB NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 290 DEGREES F

RECOMBINATION (1) 20.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME Cu. Ft./Lb.	LIQUID VOLUME PERCENT	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	OIL DENSITY GM/CC	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F WET **
12783 RES.	0.9830	0.015643		1.0444			24.90	25.07
11000	0.9879	0.015721		1.0496			24.90	25.07
10000	0.9907	0.015766		1.0526			24.90	25.07
9000	0.9935	0.015811		1.0556			24.90	25.07
8000	0.9963	0.015855		1.0586			24.90	25.07
7000	0.9993	0.015903		1.0618			24.90	25.07
6730 B.P.	1.0000	0.015914	100.00	1.0625			24.90	25.07
6707	1.0001	0.015916	TINY BUBBLE					
6605	1.0004	0.015920	BUBBLE					
6501	1.0008	0.015927	99.99					
6009	1.0027	0.015957	99.94					
5000	1.0068	0.016022	99.83					
4000	1.0112	0.016092	99.68					
3000	1.0191	0.016218	99.20					
2004	1.0331	0.016441	98.13					
1000	1.0768	0.017136	94.42					
71	4.4075	0.070141	23.13					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60

DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

LAB. NO. N2106-10457 PAGE 7 OF 25

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 290 DEGREES F

RECOMBINATION (2) 18.00 SCF SEP. GAS @ 15.025 PSIA & 60°F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	SPECIFIC VOLUME Cu.Ft./Lb.	LIQUID VOLUME PERCENT	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	OIL DENSITY GM/CC	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60°F DRY **	WET **
12783 RES.	0.9803	0.015635		1.0432			22.78	22.95
11000	0.9852	0.015713		1.0484			22.78	22.95
10000	0.9880	0.015758		1.0514			22.78	22.95
9000	0.9906	0.015802		1.0544			22.78	22.95
8000	0.9937	0.015849		1.0575			22.78	22.95
7000	0.9966	0.015875		1.0606			22.78	22.95
6000	0.9994	0.015939		1.0636			22.78	22.95
5785 B.P.	1.0000	0.015949	100.00	1.0642			22.78	22.95
5522	1.0010	0.015965	99.98					
5000	1.0036	0.016006	99.87					
4013	1.0081	0.016078	99.70					
3000	1.0148	0.016185	99.33					
2000	1.0272	0.016383	98.41					
1000	1.0667	0.017013	95.04					
500	1.1582	0.018472	87.65					
159	1.7489	0.027893	58.11					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 290 DEGREES F

RECOMBINATION (3) 15.00 SCF SEP. GAS @ 15.025 PSIA & 60°F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME Cu.Ft./Lb.	LIQUID VOLUME PERCENT	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	OIL DENSITY GM/CC	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60°F DRY **	WET **
12783 RES.	0.9772	0.015622		1.0422			19.61	19.77
11000	0.9821	0.015700		1.0474			19.61	19.77
10000	0.9849	0.015745		1.0504			19.61	19.77
9000	0.9876	0.015788		1.0533			19.61	19.77
8000	0.9904	0.015833		1.0563			19.61	19.77
7000	0.9931	0.015876		1.0591			19.61	19.77
6000	0.9959	0.015920		1.0621			19.61	19.77
5000	0.9987	0.015965		1.0651			19.61	19.77
4550 B.P.	1.0000	0.015986	100.00	1.0665			19.61	19.77
4500	1.0002	0.015989	BUBBLE					
4000	1.0022	0.016021	99.93					
3500	1.0046	0.016060	99.84					
3000	1.0080	0.016114	99.64					
2000	1.0188	0.016287	98.86					
1000	1.0526	0.016827	95.95					
500	1.1318	0.018093	89.36					
197	1.4605	0.023348	69.31					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 290 DEGREES F

RECOMBINATION (4) 10.00 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. CONDITIONS.

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME Cu.Ft./Lb.	LIQUID VOLUME PERCENT	FORMATION VOLUME FACTOR Bo **	RELATIVE OIL VOLUME	OIL DENSITY GM/CC	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: DRY **	SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F: WET **
12783 RES.	0.9721	0.015592		1.0397			14.32	14.48
11000	0.9769	0.015669		1.0448			14.32	14.48
10000	0.9797	0.015714		1.0478			14.32	14.48
9000	0.9825	0.015759		1.0508			14.32	14.48
8000	0.9853	0.015804		1.0538			14.32	14.48
7000	0.9881	0.015849		1.0568			14.32	14.48
6000	0.9909	0.015894		1.0598			14.32	14.48
5000	0.9938	0.015941		1.0629			14.32	14.48
4000	0.9967	0.015987		1.0660			14.32	14.48
3000	0.9996	0.016034		1.0691			14.32	14.48
2855 B.P.	1.0000	0.016040	100.00	1.0695			14.32	14.48
2500	1.0022	0.016075	99.89					
2000	1.0068	0.016149	99.58					
1000	1.0310	0.016537	97.53					
500	1.0862	0.017432	92.70					
228	1.2608	0.020223	79.93					

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: ** BASED ON SEPARATOR WATER FLASH.
REF. TO 'OIL' ABOVE SHOULD READ 'WATER'.

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

COMPOSITE LABORATORY DATA 290 DEGREES F

RECOMBINATION (5) 25.01 SCF SEP. GAS @ 15.025 PSIA & 60'F/BBL. SEP. WATER @ SEP. COND.- PRODUCED GWR

PRESSURE PSIA	PRESSURE VOLUME RELATIONS: RELATIVE VOLUME V/Vsat Bt	PRESSURE VOLUME RELATIONS: SPECIFIC VOLUME Cu.Ft./Lb.	LIQUID VOLUME PERCENT	FORMATION VOLUME FACTOR Bo **	DIFFERENTIAL LIBERATION: FORMATION VOLUME FACTOR Bo	DIFFERENTIAL LIBERATION: OIL VISCOSITY CENTIPOISE	DIFFERENTIAL LIBERATION: SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F DRY	DIFFERENTIAL LIBERATION: SOLUTION GAS-OIL RATIO PER BARREL STOCK TANK OIL AT 60'F WET
12783 RES.	0.9899	0.015665		1.0468	1.0426	0.310	31.60	33.51
11000	0.9948	0.015743		1.0520	1.0477	0.293	31.60	33.51
10500	0.9962	0.015765		1.0535	1.0492		31.60	33.51
10000	0.9976	0.015787		1.0550	1.0507	0.284	31.60	33.51
9500	0.9991	0.015811		1.0565	1.0523	0.279	31.60	33.51
9200 B.P.	1.0000	0.015825	100.00	1.0575	1.0532	0.277	31.60	33.51
9000	1.0007	0.015836	99.99			0.275		
8500	1.0023	0.015861	99.97					
8000	1.0042	0.015891	99.94			0.267		
7500	1.0058	0.015917	99.90					
7000	1.0078	0.015948	99.86			0.260		
6000	1.0115	0.016007	99.79		1.0613	0.254	27.53	29.36
5000	1.0160	0.016078	99.64			0.249		
4000	1.0219	0.016172	99.35		1.0655	0.249	22.89	24.60
3000	1.0309	0.016314	98.76			0.252		
2000	1.0483	0.016589	97.41		1.0692	0.257	15.80	17.23
1000	1.1022	0.017442	92.91			0.262		
500	1.2238	0.019367	83.80			0.263		
250	1.5178	0.024019	67.61					
105	2.7088	0.042867	37.90					
15								
15*					1.0000		0.00	0.00

NOMENCLATURE:

V/VSAT. IS THE VOLUME OF FLUIDS (OIL AND GAS) AT THE INDICATED TEMPERATURE AND PRESSURE RELATIVE TO THE VOLUME OF SATURATED OIL AT BUBBLE-POINT PRESSURE AND INDICATED TEMPERATURE.

Bo IS THE VOLUME OF OIL AT RESERVOIR TEMPERATURE AND INDICATED PRESSURE RELATIVE TO THE VOLUME OF EQUIVALENT STOCK TANK OIL MEASURED AT 60 DEGREES F.

GAS-OIL RATIO, IS CUBIC FEET OF GAS AT 15.025 PSIA AND 60 DEGREES F, PER BARREL OF STOCK TANK OIL AT 60 DEGREES F.

NOTE: * INDICATES VALUE MEASURED @ 60'F
** BASED ON SEPARATOR WATER FLASH
ALSO BASED ON SEP. WATER FLASH: SOLUTION GAS IN RES. FLD. IS
30.19 SCF DRY GAS/BBL. S.T. WATER @ 60'F
30.38 SCF WET GAS/BBL. S.T. WATER @ 60'F

REF. TO "OIL" ABOVE SHOULD READ "WATER"

LAB. NO. N2106-10457

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

EFFECT OF GAS-WATER RATIO UPON BUBBLE POINT PRESSURES @ 290'F

GAS-WATER RATIO (SCF SEP. GAS @ 15.025 PSIA 7 60'F) / (BBL. SEP. WATER @ 500 PSIG & 268)	BUBBLE POINT (PSIA)
~ 31.9 EXTRAPOLATED	12783 RES. PRESSURE
25.01 (PRODUCED)	9200
20.00	6730
18.00	5785
15.00	4550
10.00	2855

LAB.NO.N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SEPARATOR WATER FLASH TO 0 PSIG & 78'F

SOLUTION GAS-WATER RATIO, DRY = 3.75

, WET = 3.88 SCF GAS @ 15.025 PSIA & 60'F / BBL. WATER @ 0 PSIG & 60 'F

SHRINKAGE = 0.9437 VOL. S.T. WATER @ 60'F / VOL. SEP. H20 @ 500 PSIG & 268'F

STOCK TANK WATER DENSITY = 1.0656 Gm/Ml. @ 60'F

GAS GRAVITY , DRY = 0.9729 (SEE ANALYSIS ON PAGE 15)

, WET = 0.9590

PRODUCED OCTOBER 8, 1983:

GWR = 26.44 + 3.75 = 30.19 SCF TOTAL DRY GAS @ 15.025 PSIA & 60'F / BBL. STOCK TANK WATER @ 60'F

GWR = 26.50 + 3.88 = 30.38 SCF TOTAL WET GAS @ 15.025 PSIA & 60'F / BBL. STOCK TANK WATER @ 60'F

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SEPARATOR GAS SAMPLED:
OCTOBER 8, 1983 @
500 PSIG & 97°F

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		0.22 ± .04
CARBON DIOXIDE	10.63	10.61
NITROGEN	0.25	0.25
METHANE	85.96	85.77
ETHANE	2.34	2.33
PROPANE	0.52	0.52
ISO-BUTANE	0.09	0.09
N-BUTANE	0.07	0.07
ISO-PENTANE	0.02	0.02
N-PENTANE	0.01	0.01
HEXANES	0.00	0.00
HEPTANES PLUS	0.11	0.11
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6813	0.6812

NOTE: WATER VAPOR MEASURED ON SITE, AVERAGE 5 RUNS.

LAB. NO. N2106-10457

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
SEPARATOR WATER FLASH
● ● PSIG & 78'F
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		3.24
CARBON DIOXIDE	39.89	38.60
NITROGEN	-----	-----
METHANE	57.73	55.86
ETHANE	1.39	1.34
PROPANE	0.19	0.18
ISO-BUTANE	0.02	0.02
N-BUTANE	0.02	0.02
ISO-PENTANE	0.00	0.00
N-PENTANE	0.00	0.00
HEXANES	0.00	0.00
HEPTANES PLUS	0.76	0.74
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.9729	0.9590

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
6000 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY	WET
	MOLE %	
WATER		1.86
CARBON DIOXIDE	4.20	4.12
NITROGEN	----	----
METHANE	89.03	87.37
ETHANE	4.34	4.26
PROPANE	1.53	1.50
ISO-BUTANE	0.22	0.22
N-BUTANE	0.18	0.18
ISO-PENTANE	0.08	0.08
N-PENTANE	0.04	0.04
HEXANES	0.00	0.00
HEPTANES PLUS	0.38	0.37
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6513	0.6507

GAS DEVIATION FACTOR (Z) = 1.109 @ 6000 PSIA & 290'F

BBLS. GAS IN RES./MMSCF (Bg) = 713 @ 6000 PSIA & 290'F

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
4000 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		2.53
CARBON DIOXIDE	3.10	3.02
NITROGEN	----	----
METHANE	91.74	89.42
ETHANE	3.50	3.41
PROPANE	0.99	0.96
ISO-BUTANE	0.19	0.19
N-BUTANE	0.13	0.13
ISO-PENTANE	0.04	0.04
N-PENTANE	0.02	0.02
HEXANES	0.00	0.00
HEPTANES PLUS	0.29	0.28
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6260	0.6259

GAS DEVIATION FACTOR (Z) = 0.997 @ 4000 PSIA & 290'F

BBLS. GAS IN RES./MMSCF (Bg) = 962 @ 4000 PSIA & 290'F

LAB. NO. N2106-10457

TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
2000 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY	WET
	MOLE %	
WATER		3.75
CARBON DIOXIDE	3.87	3.72
NITROGEN	----	----
METHANE	92.34	88.87
ETHANE	2.75	2.65
PROPANE	0.63	0.61
ISO-BUTANE	0.10	0.10
N-BUTANE	0.08	0.08
ISO-PENTANE	0.02	0.02
N-PENTANE	0.01	0.01
HEXANES	0.00	0.00
HEPTANES PLUS	0.20	0.19
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.6206	0.6207

GAS DEVIATION FACTOR (Z) = 0.947 @ 2000 PSIA & 270'F

BBLS. GAS IN RES./MMSCF (Bg) = 1828 @ 2000 PSIA & 270'F

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TECHNADRIL-FENIX & SCISSON, INC.
GLADYS MCCALL WELL NO. 1, SAND 8
EAST CRAB LAKE FIELD

SOLUTION GAS FROM
15 PSIA SAMPLE -
DIFFERENITAL LIBERATION
(CALCULATED NITROGEN FREE)

CHROMATOGRAPHIC ANALYSIS

	DRY (MOLE %)	WET (MOLE %)
WATER		8.32
CARBON DIOXIDE	24.79	22.73
NITROGEN	----	----
METHANE	73.93	67.78
ETHANE	1.06	0.97
PROPANE	0.11	0.10
ISO-BUTANE	0.00	0.00
N-BUTANE	0.00	0.00
ISO-PENTANE	0.00	0.00
N-PENTANE	0.00	0.00
HEXANES	0.00	0.00
HEPTANES PLUS	0.11	0.10
TOTAL	100.00	100.00
GRAVITY (AIR = 1.00)	0.8032	0.7881

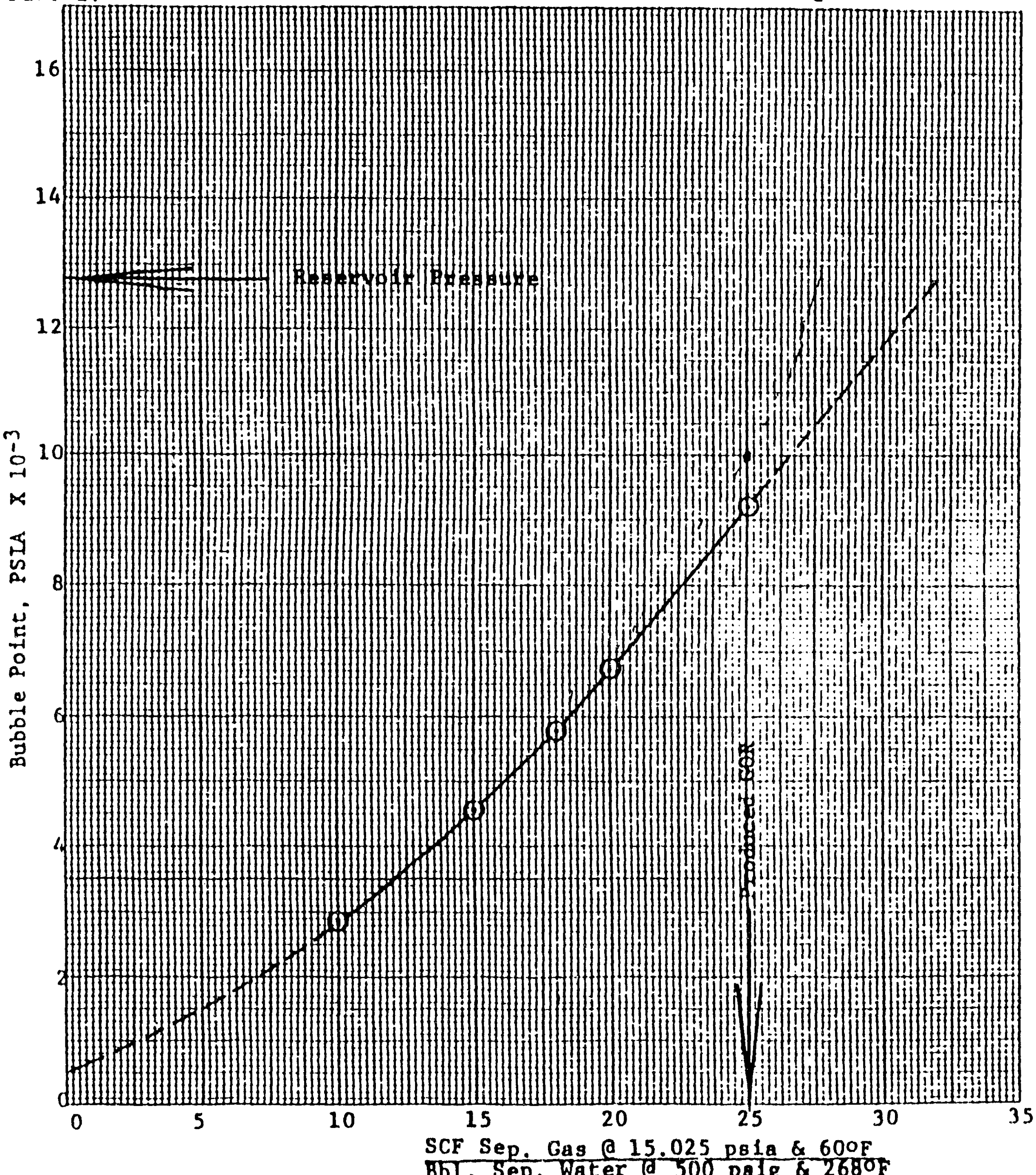
GAS DEVIATION FACTOR (Z) = 1.000 @ 15 PSIA & 290'F

BBLS. GAS IN RES./MMSCF (Bg) = 256,893 @ 15.025 PSIA & 290'F

LAB. NO. N2106-10457

Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Sand 8 Field East Crab Lake

FIG. 1: Effect of Gas-Water Ratio on Bubble Point Pressure @ 290°F



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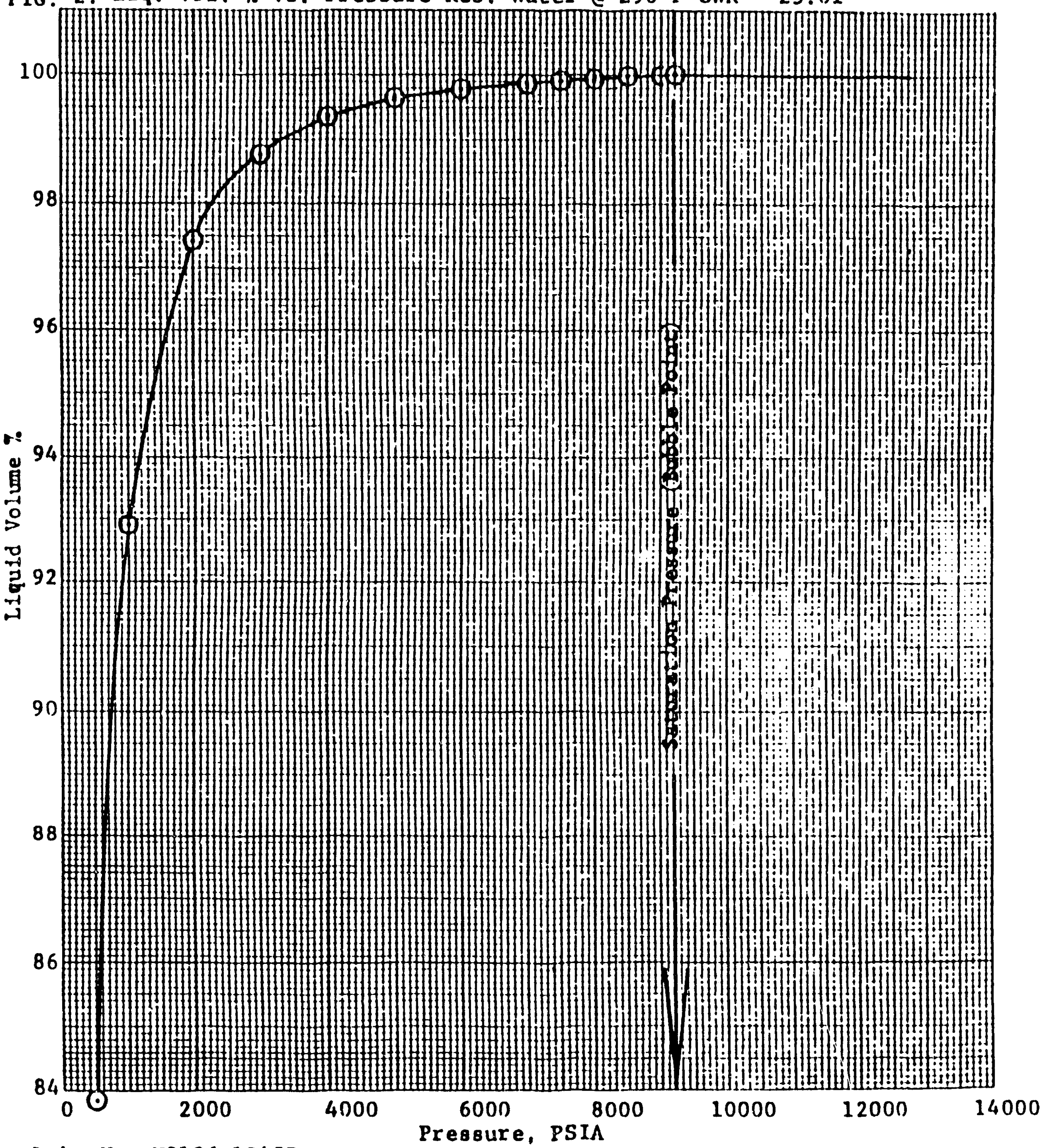
Company Techuadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Sand 8 Field East Crab Lake

FIG. 2: Liq. Vol. % vs. Pressure-Res. Water @ 290°F GWR = 25.01



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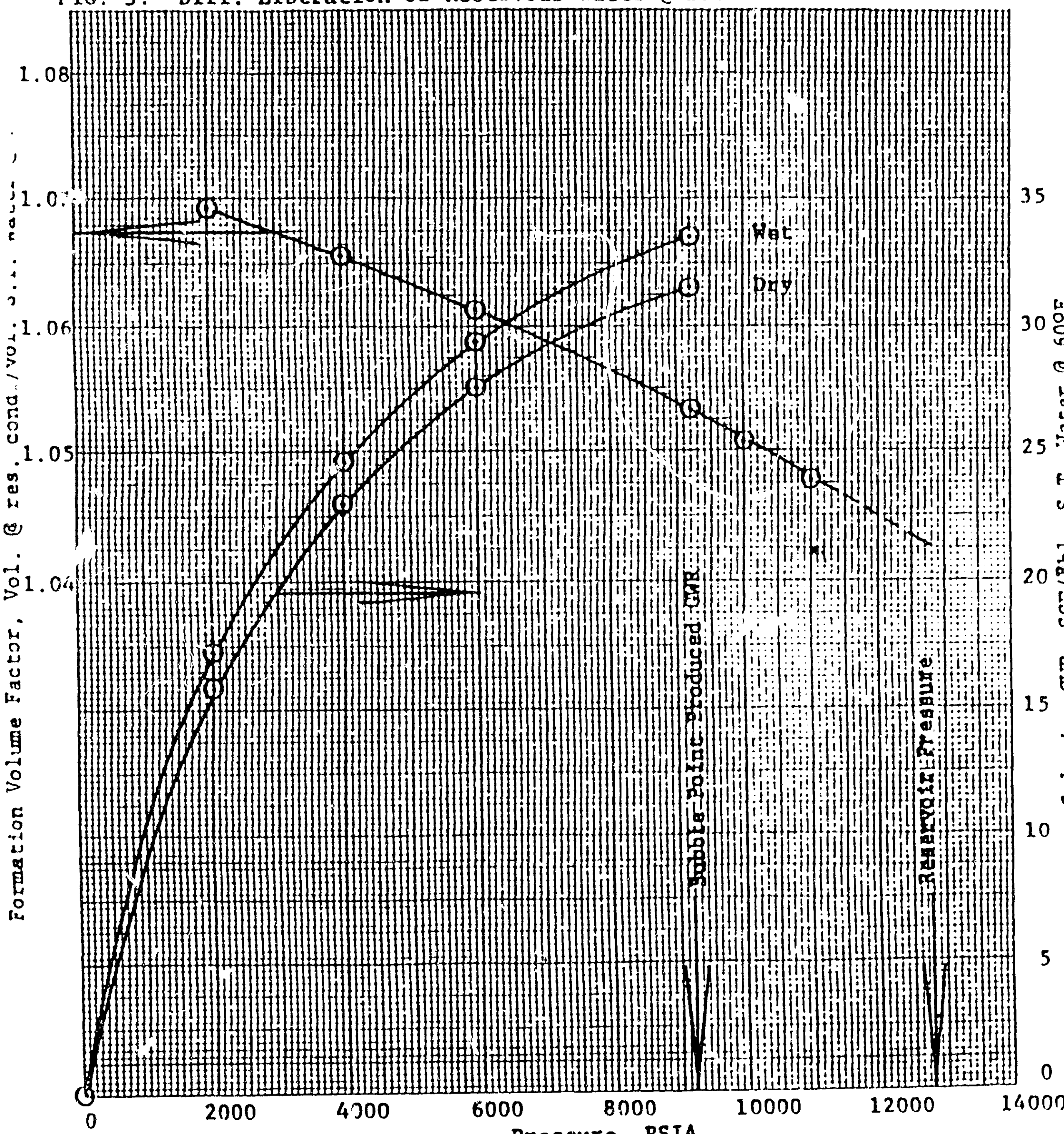
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Field East Crab Lake

FIG: 3: Diff. Liberation of Reservoir Water @ 290°F GWR = 25.01



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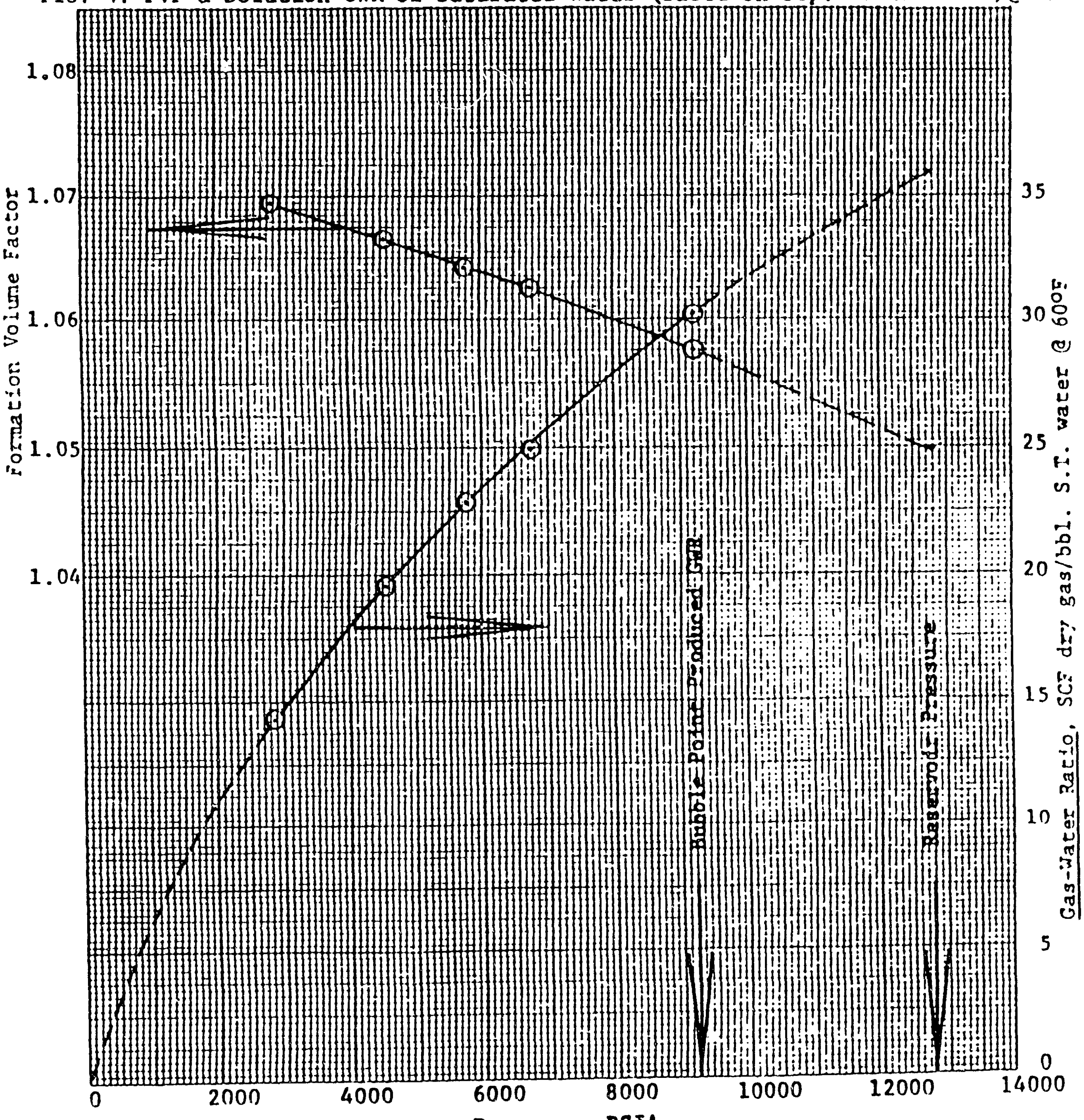
Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Field East Crab Lake

FIG: 4: FVF & Solution GWR of Saturated Water (Based on sep. water flash)@ 290°F



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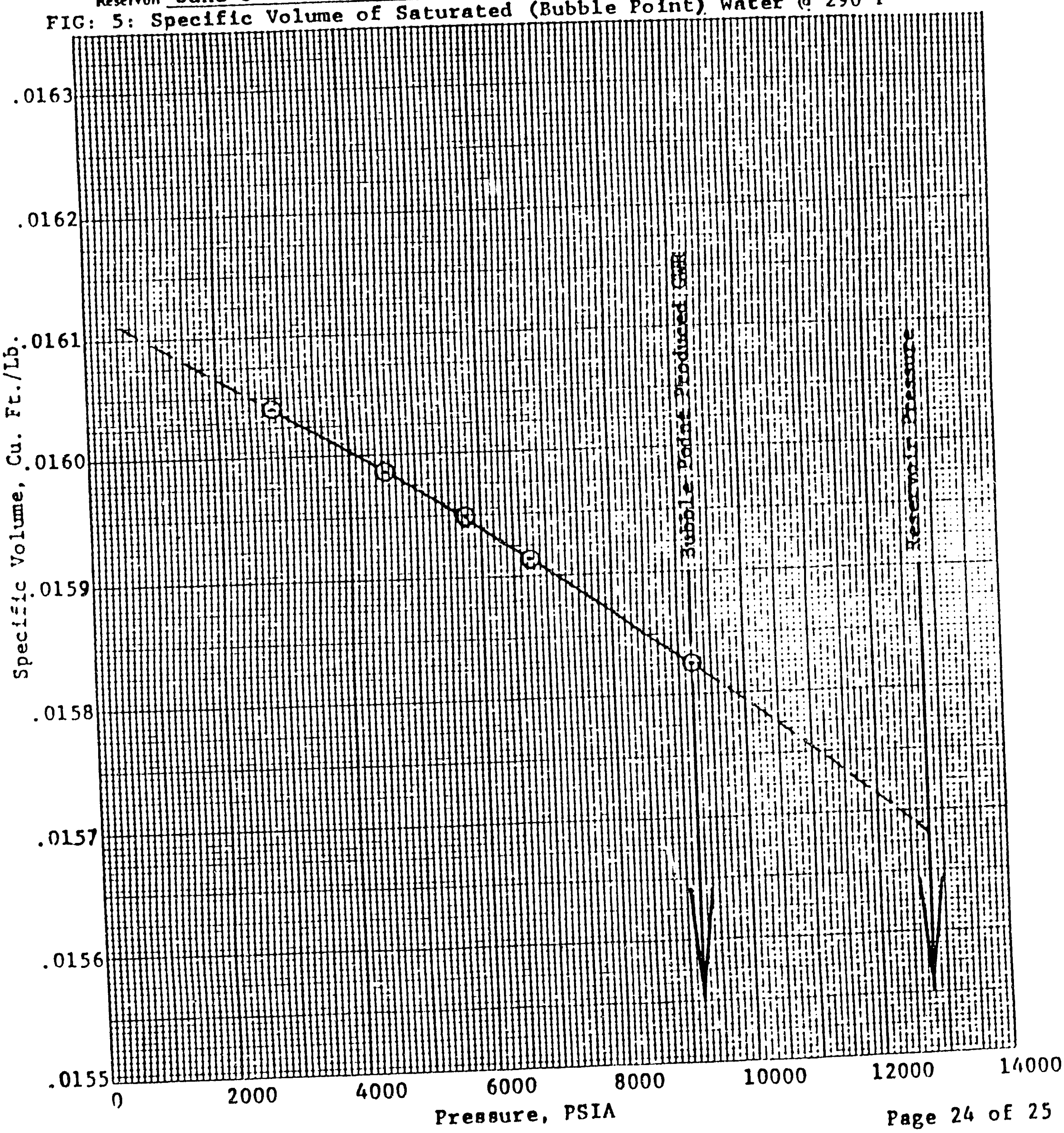
Company Technadril-Fenix & Scisson   Well Gladys McCall No. 1
Reservoir Sand 8   Field East Crab Lake

FIG: 5: Specific Volume of Saturated (Bubble Point) Water @ 290 F



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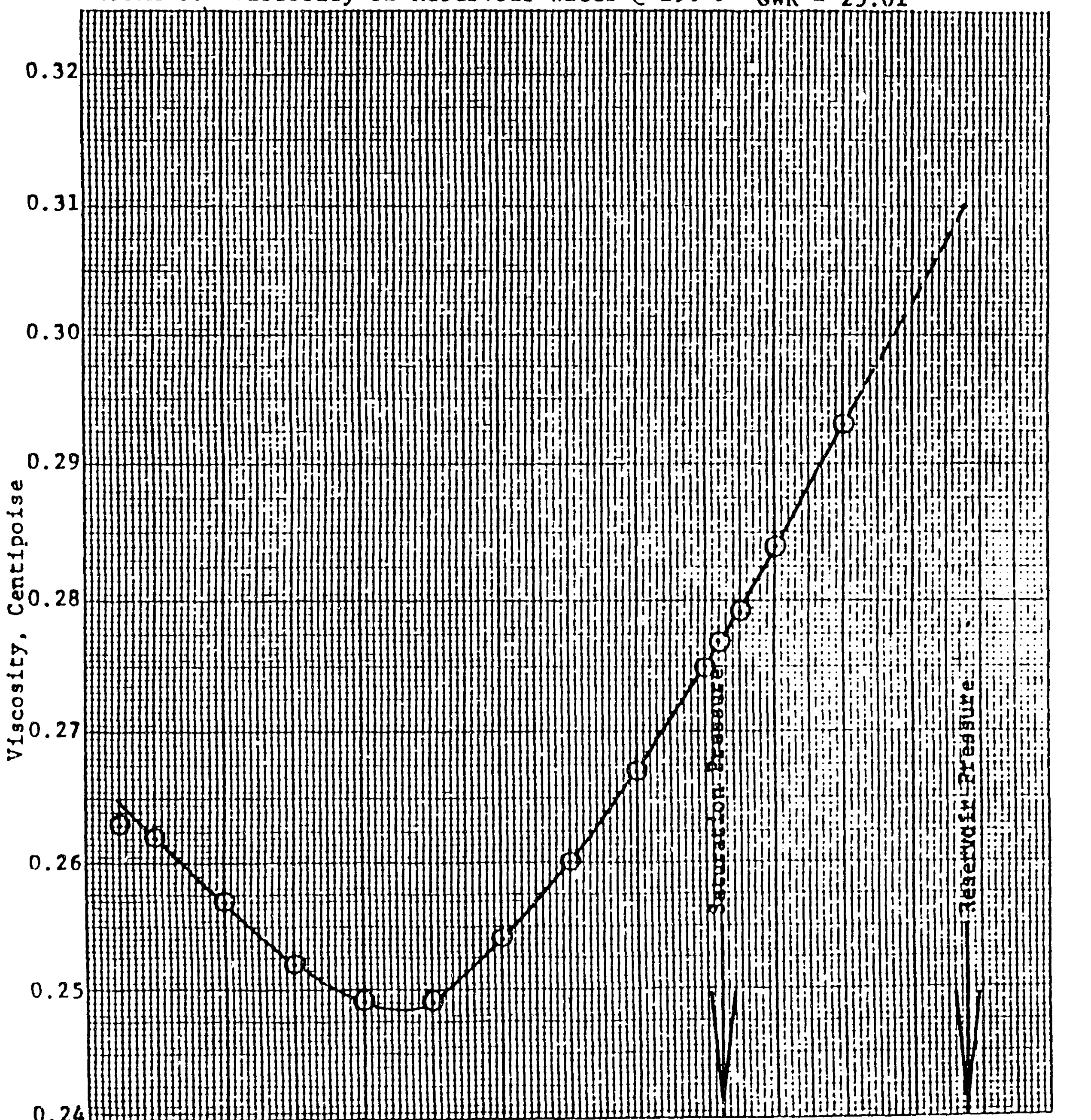
Lab. No. N2016-10457

Company Technadril-Fenix & Scisson Well Gladys McCall No. 1
Reservoir Sand 8 Field East Crab Lake

FIGURE 6: Viscosity of Reservoir Water @ 290°F GWR - 25.01



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APPENDIX K
Reservoir Bubble Tests

During tests of Wells of Opportunity that produced gas-saturated brine (G.M. Koelemay, Riddle-Saldana, and Prairie Canal wells), IGT observed that sudden increases in production rate were accompanied by a transient "bubble" of natural gas having a duration of 10's of minutes. During the "bubble," produced gas/brine ratio was higher, natural gas liquid (NGL) content of the gas was higher, and carbon dioxide content was unchanged relative to steady-state production of gas-saturated brine. Understanding of the bubble was found in the phenomena described below.

IGT adopted the procedure of carefully monitoring gas rates and composition following a step increase in drawdown as a "bubble test" to determine whether the flowing bottomhole pressure was below the bubble-point pressure of reservoir brine -- or, in other words, to determine whether free gas was in pores of the reservoir rock near the wellbore.

As brine pressure in the reservoir drops below the bubble-point pressure, a portion of the gas is exsolved. This gas is much richer in heavy hydrocarbons than the gas remaining in solution. Furthermore, this gas is trapped in the reservoir until the gas phase is continuous. The gas saturation needed to form a continuous gas phase is termed the "critical gas saturation." There is little data available on critical gas saturation, but the value is assumed to be about 3% of the total pore volume (National Petroleum Council, 1980). Data from the PVT study indicate that the Gladys McCall reservoir pressure would have to drop to below 2000 psia before gas would occupy 3% of the pore volume in the entire reservoir. But in the area immediately surrounding the wellbore, brine being produced experiences large differential-pressure gradients associated with brine converging on the wellbore and perforations.

As the bottomhole pressure drops below the bubble-point pressure, gas exsolves near the wellbore. Gas saturation near the wellbore increases as fresh brine sweeps through the high pressure-gradient region, leaving its small gas-phase contribution. The gas saturation will increase until the critical gas saturation is reached. Thereafter, any gas exsolving from solution will raise the saturation above critical and result in an equally small amount of free-gas production up the wellbore. The reservoir volume at the critical gas saturation will increase as the pressure declines, but it will always be a very small fraction of the total reservoir volume under any reasonable production scenario. Production of free gas from the high pressure-gradient region near the wellbore will be hidden by exsolution of gas further out in the reservoir.

One condition wherein production of previously trapped free gas will be noticed is temporary in nature and constitutes IGT's "bubble test." If the well had been flowing at a steady rate and had built up critical gas saturation near the wellbore, a sudden drop in the bottomhole pressure would cause the gas to expand. The amount of expansion will depend on the drop in the bottomhole pressure. For example, if the bottomhole pressure drops from 9500 to 9300 psia, the gas will expand approximately 2%. This small portion of the gas in near wellbore pore space that is at critical gas saturation will become mobile and will be produced.

The amount of mobilized gas will be small, but its composition will be markedly different from the composition of the dissolved gas that is normally produced. Although small gas composition changes over long periods may be attributed to many factors, these same small changes over a period of a few hours needed to perform a bubble test are conclusive. If the ethane/methane and propane/methane ratios increase after "bottoms-up" during a bubble test, free gas is being produced.

Two bubble tests were performed at the Gladys McCall well. The first was on February 12, 1986, and the second was on April 14, 1987.

On February 11, 1986, the brine rate was increased from about 23,000 to about 28,500 STB/d. IGT collected gas samples and analyzed them onsite. Exhibit K-1 presents the relevant data. As the brine rate increased, the bottomhole pressure dropped from 9580 to 9250 psia. The ratios of ethane/methane and propane/methane changed significantly, as shown graphically in Exhibit K-2.

Exhibit K-1. TOTAL GAS HYDROCARBON RATIO CHANGES DURING THE FEBRUARY 11, 1986, BUBBLE TEST

Time In Test	Ethane/Methane	Propane/Methane
Before Rate Increase	0.0257	0.0056
After Rate Increase, Before Bottoms-Up	0.0259	0.0056
About 15 Minutes After Bottoms-Up	0.0271	0.0063
About 30 Minutes After Bottoms-Up	0.0263	0.0061
About 80 Minutes After Bottom-Up	0.0265	0.0060
About 3.5 Hours After Bottoms-Up	0.0257	0.0055
About 8 Days After Bottoms-Up	0.0259	0.0054

The increase in the hydrocarbon ratios after the slow (about 1-hour) increase in brine rate was obvious in Exhibit K-1. But examination of Exhibit K-2 reveals no obvious increase in the gas/brine ratio. The increase, if any, was less than 1 SCF/STB. The gas composition data reveals that the maximum amount of time that free gas may have been produced was 4 hours. This leads us to conclude that free-gas production was less than 5000 SCF.

At bottomhole pressure and temperature, 5000 SCF of gas would occupy less than 12 cubic feet of reservoir pore volume. Adjusting for porosity (16%) and the assumed water saturation (97%), this is equivalent to the gas content of 2500 cubic feet of reservoir rock. As the fraction of gas produced would be proportional to the drop in the bottomhole pressure, which declined from 9580 to 9250 psia (only 3.6% of the free gas could flow), the free-gas phase at the critical gas saturation necessary to produce 5000 SCF of gas should occupy 70,000 cubic feet of reservoir rock. Assuming a pay thickness of 300 feet, this volume would be a cylinder with a radius of 8.6 feet. This is an upper limit because an upper limit for free-gas production (1 SCF/STB for 4 hours) was used in these calculations.

The buildup of free gas to critical gas saturation would have occurred over a time of weeks or months before the "bubble test." Review of the history of calculated flowing bottomhole pressure suggests that this may have occurred during the fourth quarter of 1985 at a pressure of roughly 9500 psi.

During April 1987 the bubble test was repeated. Long-term production had reduced the bottomhole pressure to about 8600 psia. Flow rates had been controlled by the first-stage separator pressure, and the chokes were fully open. It was recognized that increasing the flow rate required lowering the separator pressure. If this occurred during the bubble test, changing inventories of gas in the separator volume would make it difficult to quantize any change in the gas to brine ratio.

On April 13, 1987, the first-stage separator pressure was lowered from 1010 to 515 psia, a minimum pressure needed to maintain control of the levels in the separators and drive brine into the disposal well. At the same time, the chokes were adjusted so that the wellhead pressure remained constant at about 1150 psia and the brine-flow rate remained constant at slightly above 20,000 STB. The well was then allowed to run overnight so that the gas compositions in the separators would equilibrate at the lower separator pressure and good baseline data could be obtained.

The chokes were then opened all the way at 12:00 hours on April 14. The brine rate jumped from 22,050 to 25,300 STB/d, the wellhead pressure dropped from 1150 to 710 psia, and the calculated bottomhole pressure dropped from 8590 to 8395 psia. Exhibit K-3 presents the changes in the gas/brine ratio, the brine flow rate, and the hydrocarbon ratios during the test. Pertinent data is plotted in Exhibit K-4.

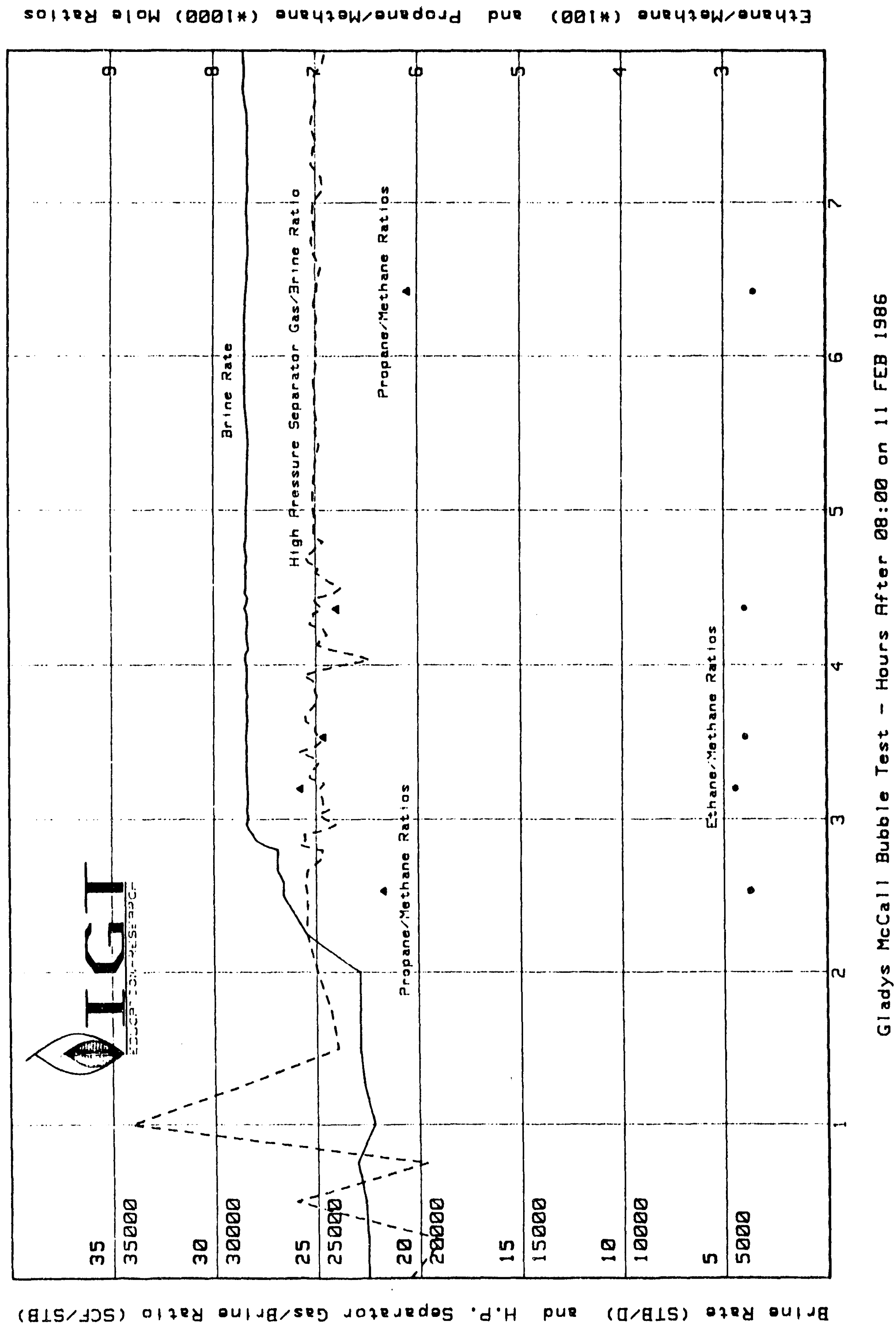

Exhibit K-2. BRINE RATE, FIRST-STAGE SEPARATOR GAS/BRINE RATIO AND HYDROCARBON RATIOS DURING FEBRUARY 11, 1986, RESERVOIR BUBBLE TEST

Although the changes in the hydrocarbon ratios are not as clear during this test as in the February 1986 test, an increase in the hydrocarbon ratios is evident. In Exhibit K-4 it is also clear that the production of free gas was at most trivial. The bubble, if it could be called such, consisted of less than 1000 SCF of gas.

Exhibit K-3. FIRST-STAGE SEPARATOR GAS HYDROCARBON RATIO CHANGES DURING THE APRIL 14, 1987, BUBBLE TEST

Time in Test	Ethane/Methane	Propane/Methane
Before Rate Increase	0.0264	0.0055
About 25 Minutes After Bottoms-Up	0.0266	0.0058
About 80 Minutes After Bottoms-Up	0.0269	0.0057
About 2.5 Hours After Bottoms-Up	0.0269	0.0057
About 10 Hours After Bottoms-Up	0.0265	0.0056
About 18 Hours After Bottoms-Up	0.0267	0.0057

This is only about 2.5 cubic feet of gas at bottomhole pressure and temperature. Adjusting for porosity (16%) and the assumed water saturation (97%), this is equivalent to the gas content of 500 cubic feet of reservoir. The fraction of free gas that would be produced is proportional to the drop in the bottomhole pressure and the resultant gas expansion (about 195 psi/8395 psia, or 2.3%). Thus, 1000 SCF of gas is estimated to have come from a reservoir volume of about 20,000 cubic feet. Assuming a thickness of 300 feet, this volume would be in a cylinder with a radius of 4.5 feet.

This data is not inconsistent with the February 1986 test, which concluded that any free gas production had to come from a cylinder with a radius less than 7.7 feet.

The mathematical model that provides insight consists of examining a right circular cylinder in the reservoir that is concentric with the wellbore and has a radial thickness Δr. Brine that is below its bubble-point pressure and is radially flowing through this cylinder of reservoir rock liberates about 0.002 SCF/STB of gas per psi of pressure drop across the radial thickness Δr. But that flowing pressure drop is related to the dimensions of the cylinder and brine rate by Darcy's Law. Equating the pressure drops from the equations for these two phenomena makes possible solving for the time required to achieve critical gas saturation as a function of radial distance from the wellbore, brine rate, and reservoir parameters. In conventional oil field units, the resultant equation is --

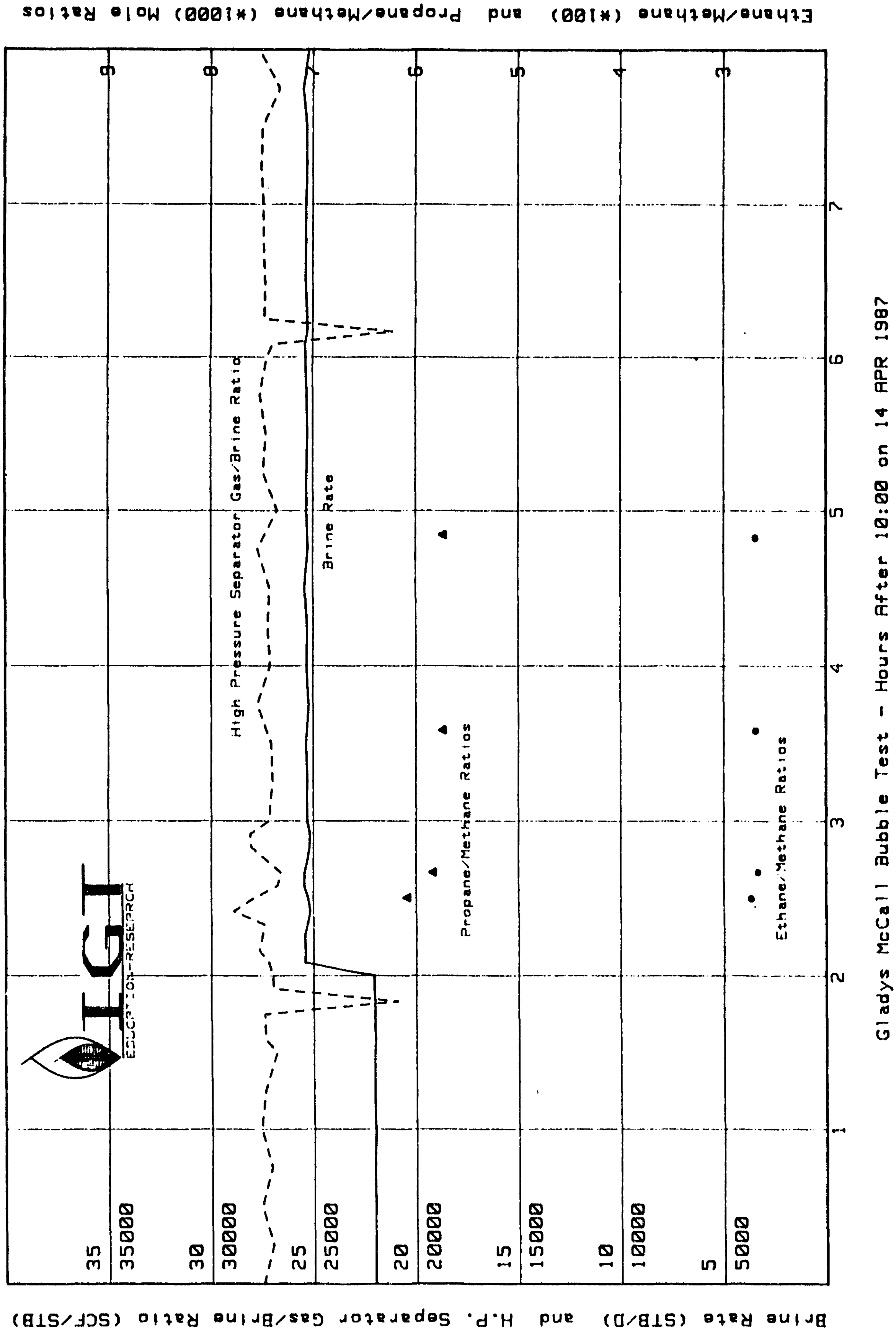

Exhibit K-4. BRINE RATE, FIRST-STAGE SEPARATOR GAS/BRINE RATIO AND HYDROCARBON RATIOS DURING THE APRIL 14, 1987, RESERVOIR BUBBLE TEST

$$t = (4.59\,\pi^2\,P\,T_b\,\varnothing\,S_{gc}\,K\,h^2\,r^2)/(E_x\,P_b\,T\,\mu\,Q^2)$$

Where --
t = Time, days
P = Pressure, psia
T_b = Temperature Base, Deg. K.
$\varnothing$ = Porosity, fraction
S_{gc} = Critical Gas Saturation, fraction
K = Permeability, Darcies
h = Pay Zone Thickness, ft
r = Radius, ft
E_x = Gas Exsolved for a Pressure Drop of 1 psi, = 0.002 SCF/STB
P_b = Pressure Base, psia
T = Temperature, Deg. K.
μ = Brine Viscosity, cP
Q = Brine Rate, STB/d

Solving this equation for the Gladys McCall well for a flow rate of 25,000 STB/d and for a radius of 10 feet reveals that about 277 days or 9 months would be required to achieve critical gas saturation. In contrast, for the Wells of Opportunity where the bubbles were observed, permeability and thickness were both about an order of magnitude smaller than for the Gladys McCall well. For a brine rate of 5000 STB/d, such a well would achieve critical gas saturation 10 feet from the wellbore in the much shorter time of about a week.

This very slow buildup of the critical gas saturation in the reservoir, coupled with not being able to change the bottomhole pressure more than a few percent, led to the conclusion that there is no reasonable engineering basis to support expectations of a large bubble of free gas being produced during April 1987. The bubble test was successful in that it did provide a qualitative indication of whether or not the reservoir was saturated. The second test supports the conclusions reached on the first bubble test; that is, the bottomhole pressure was below the bubble-point pressure of the brine.

The produced gas/brine ratio appeared to start a very slow decline in the third or fourth quarter of 1985. The bottomhole pressure at this time ranged from 9400 to 10,000 psia. These were the lowest bottomhole pressures experienced to date. The decline in the produced gas/brine ratio is assumed to be caused by gas being liberated in the reservoir because of the bottomhole pressure falling below the bubble-point pressure. Small but apparent changes in the produced brine composition and the characteristics of the produced hydrocarbons (oil production was first noticed during January 1985) must be considered. There remains a possibility that the changes in the gas/brine ratio reflect previously isolated brine production.

The produced gas composition changed slightly between April and December 1985. The change, a slight reduction in the ethane/methane and propane/methane ratios, is consistent with gas being liberated from the brine in the reservoir. The bottomhole pressure ranged from 9400 to 10,800 psia. There were no gas analyses during this period that could narrow the extensive range in pressure. Again, there remains a possibility that a previously isolated brine started being produced during this time frame as discussed above.

The January 11, 1986, bubble test provided conclusive evidence that the bottomhole pressure was below the bubble-point pressure prior to January 1986. The lowest bottomhole pressure experienced before the test was 9400 psia in October 1985. The bubble-point pressure was above 9400 psia.

The April 14, 1986, bubble test provided conclusive evidence that the bubble-point pressure was above 8600 psia. Obviously the result was redundant after the 1986 test, but the 1987 bubble test also provided additional insight into interpretation of the results of a bubble test.

APPENDIX L

Procedures Manual for Geopressured Fluids

STANDARD SAMPLING AND ANALYTICAL METHODS FOR GEOPRESSURED FLUIDS

Prepared For

DEPARTMENT OF ENERGY

by

McNeese State University

Lake Charles, Louisiana 70609

September 1980

B. E. Hankins, Editor

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FOREWORD

This manual was produced in conjunction with a committee formed by the Department of Energy for the expressed purpose of writing a set of standards to be used for sampling and analyzing geopressured fluids. Each procedure is the result of a consensus of the committee. The name of each committee member, together with the mailing address and the telephone number, is listed below for the convenience of the reader. Many of the references listed in the procedures sections were authored by one or more of the committee members. Individual members of the committee will welcome the opportunity to provide additional information to interested parties.

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SAMPLING AND ANALYSIS OF GEOPRESSURED FLUIDS

I. INTRODUCTION

Fluids from most geopressured-geothermal wells contain a high concentration of dissolved solids, principally sodium chloride. The fluids, under several thousand psig pressure and at elevated temperature, also contain large amounts of natural gas. Furthermore, samples from these wells usually are collected at the surface where the pressure is lower than that found in the reservoir; thus, equilibrium conditions between gas and liquid phases have been disturbed. These samples are unique, therefore, and often require special procedures and special conditions for their analyses.

The Department of Energy and the Gas Research Institute recognized that a set of standard sampling and analytical procedures for geopressured-geothermal fluids should be published: DOE established an 11-member board (see Foreword) to study the problem and GRI provided the funds for writing and publishing the material. Members of the DOE-appointed board will be happy to discuss the procedures with others or to provide additional information.

The sampling and analytical procedures outlined in this manual are the result of a consensus of the 11-member board established by DOE; these procedures should be followed when analyzing fluids from geopressured-geothermal wells. Analyses of water samples (Section XIII) and gas samples (Section XIV) are included. **A condensed set of on- site procedures may be found in Appendix B.**

Most commercial laboratories have the equipment necessary to carry out the majority of the determinations listed in this manual; however, some determinations require special equipment which many commercial installations lack. The determinations that require special equipment are listed in Section XI; it may be necessary to contact a university laboratory for these. Also, it may be necessary to subcontract some other determinations to laboratories having special equipment.

References are listed with each determination. Methods for the collection and analysis of surface and ground waters have been published by the U.S. Geological Survey (8). Many of these procedures have been modified for application to oil field and geopressured waters (6). Some of these procedures, and others, have been adapted further by chemists at McNeese State University, Lake Charles, LA (3,4).

A. DETERMINATIONS TO BE PERFORMED ON WATER SAMPLES

pH, T, specific conductance, dissolved solids, suspended solids, Na, K, Ca, Mg, Sr, Ba, HCO_3^-, $CO_3^=$, Cl^-, $SO_4^=$, SiO_2, Mn, Fe, $S^=$, B, Cd, Hg, Zn, As, Cr, Cu, Pb, F^-, NH_3, Ra-226, gross α, gross β, gross γ, identification of metals in dissolved solids by emission spectrography, identification of clays and minerals in suspended solids by x-ray diffractometry (or equivalent method).

B. DETERMINATIONS TO BE PERFORMED ON GAS SAMPLES

Standard hydrocarbon analysis (C_1-C_6 and C_{6+}), H_2S, He, Rn-222, CO_2, N_2, NH_3, O_2, H_2, identification of other gases from Z=1 to Z≅400 by mass spectrometry, the gas/water ratio from recombination-differential liberation studies or zero-flashed bottom-hole samples and the gas/water ratio from surface measurements at the gas/water separator.

II. ON-SITE LABORATORY

The following determinations must be made at an on-site laboratory before precipitation occurs in the sample (within 30 minutes of the time the sample is collected): pH, T, specific conductance, dissolved solids (gravimetric), suspended solids, alkalinity (including organic acid anions), alkalinity ($CO_2^{\cdot}$), Cl^- (filtered, untreated (FU) samples), $S^=$, NH_3, SiO_2 (FU samples not diluted). Other determinations may be made later and in more conventional facilities. Hydrogen and helium must be determined as soon as possible because they diffuse through the sample containers rapidly. If SiO_2 is to be determined later, dilute one FU sample 1:2 with deionized water and dilute another FU sample 1:4 with deionized water Determine SiO_2 on both samples. Collect individual samples for the on-site determination of $S^=$ and NH_3.

III. COLLECTION OF SAMPLES

A. GAS SAMPLES

The on-site equipment must be provided with certain take-off accessories (Figures I and 2) The high-pressure separator must be fitted with a valve at the top of the unit (gas take-off point) so that the flow of the gas can be controlled. The valve must contain a ¼" NPT female connection. Collect gas samples from the gas take-off point of the high-pressure separator in 75 cc. teflon-lined stainless steel containers fitted with Whitey valves containing ¼"ID NPT male connectors.

B. WATER SAMPLES

Collect water samples as close to the well-head as possible. A water take-off point must be installed after the high-pressure choke but before the high-pressure separator (Figures 1 and 2). A valve must be provided to control the flow of fluid. The assembly is completed by attaching a pressure gauge and a 20-foot length of stainless steel tubing (teflon-lined if possible). A section of the tubing should be coiled and placed inside a 55-gallon drum, which has been filled with chilled water. Terminate the tubing with a ¼"NPT stainless steel cross. Attach a valve to one port of the cross and plug the remaining two ports with stainless steel threaded plugs. These plugs can be removed to attach filters.

Small amounts of water samples may be collected and stored in 4 oz. flint glass bottles fitted with polyseal caps. These are available from most chemical supply houses. Larger amounts of water samples may be collected and stored in plastic containers; see Sections VII and VIII for special cleansing instructions. Samples to be used for boron or silicon determinations should not be collected or stored in glass bottles.

C. RECOMBINATION SAMPLES

Gas samples for determining the solubility of natural gas in brine (gas/water ratio) by recombination-differential liberation studies should be collected at the gas sampling port described earlier (Section III-A and Figure 1). Water samples to be used in recombination studies should be collected from a point on the high-pressure separator that represents the low-pressure side such that stock-tank water samples are available. A control valve with ¼"NPT female threads should be installed at the stock-tank water port to control the flow of fluid (Figure 1).

D. BOTTOM—HOLE SAMPLES

Several commercial companies market devices designed to collect bottom-hole samples at **in-situ** temperatures and pressures. The operation is simple in theory but difficult in practice, especially when applied to geopressured wells. None of the geopressured-geothermal wells tested to date have yielded reliable data from bottom-hole samples collected under **in-situ** conditions, when these samples were transferred to high-pressure containers prior to determining the gas/water ratio.

The following procedures for collecting and transferring bottom-hole samples are idealistic in concept. Equipment for performing these operations under ideal conditions does not exist at this time because suitable bottom-hole samplers are not fitted with heating devices and the temperature of the fluid within the samplers cannot be maintained at **in-situ** conditions.

To collect a bottom-hole sample from a geopressured-geothermal well, a teflon-lined sampler containing a heated jacket that is thermostatically controlled should be used. The diameter of this unit is dictated by the diameter of the well-bore and the length of the unit is dictated by the volume of the sample required. Using a wire-line, lower the unit to the depth from which samples are desired. One standard device is a flow-through unit that has both upper and lower valves open when the unit is inserted into the well-bore. When the unit is located at the desired depth, the valves can be closed with a clock-timer mechanism, a shear-pin mechanism, or a pressure-actuated mechanism. Another unit has a chamber with one valve only. In practice, the sample chamber in this unit is evacuated before inserting the sampler into the well-bore. The sampler is lowered to the required depth using a wire-line, the valve is opened mechanically or electrically to admit fluid, then closed, then the entire sampler is retrieved with the wire-line.

A single sampler may be used to collect several samples by transferring the contents of the sampler after each collection to a high-pressure container. The high-pressure containers may be transported to a laboratory where the gas/water ratio can be determined.

Standard "oil patch" technology for transferring geopressured-geothermal samples from bottom-hole devices has relied on the use of a hydraulic device to pressure-up the high-pressure container to **in-situ** conditions; the single-phase fluid then flows from the bottom-hole sampler to the high-pressure container. Commercial hydraulic units have used mercury for the confining liquid but another fluid would be better to

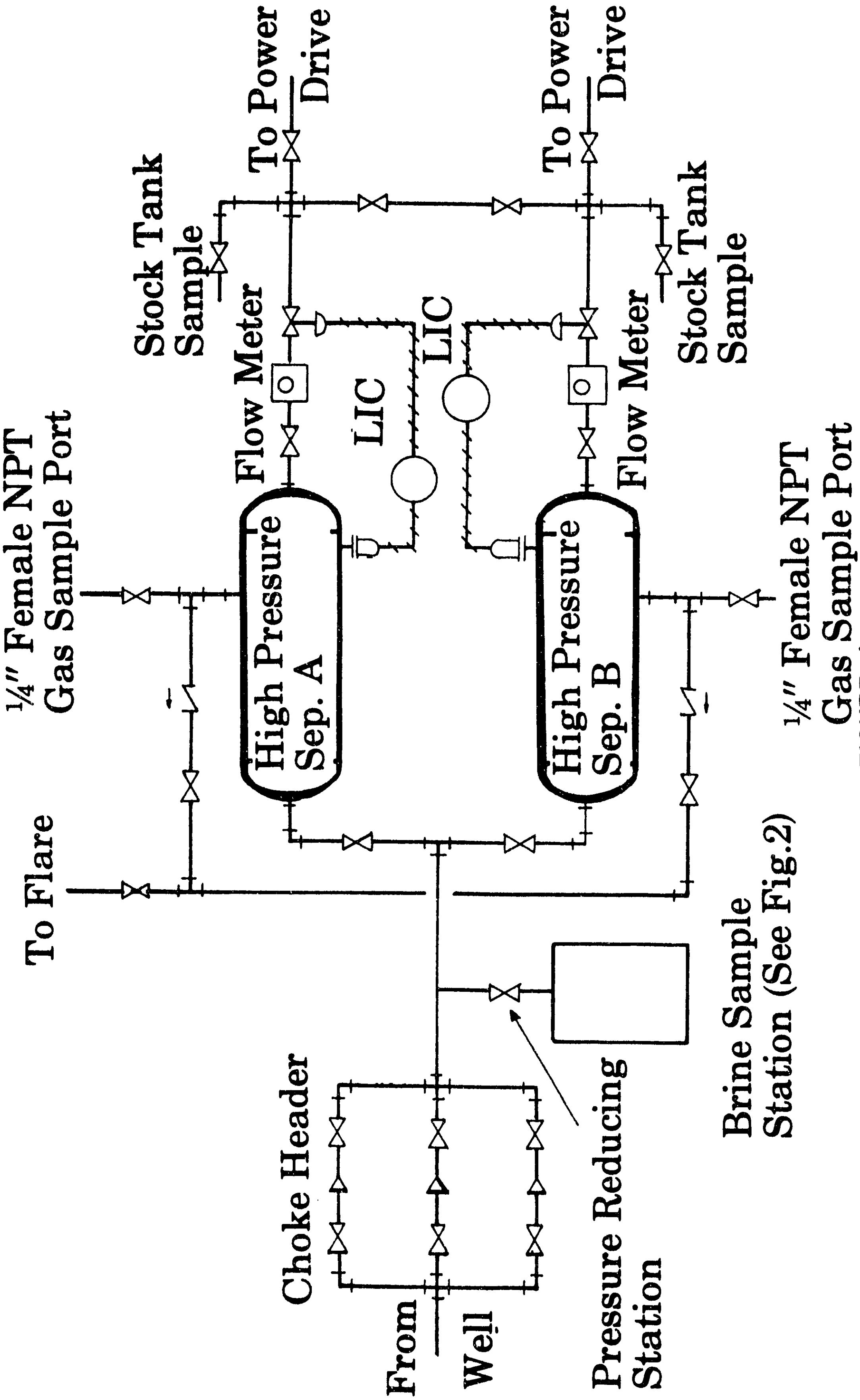

FIGURE 1

LOCATION OF SAMPLING STATIONS

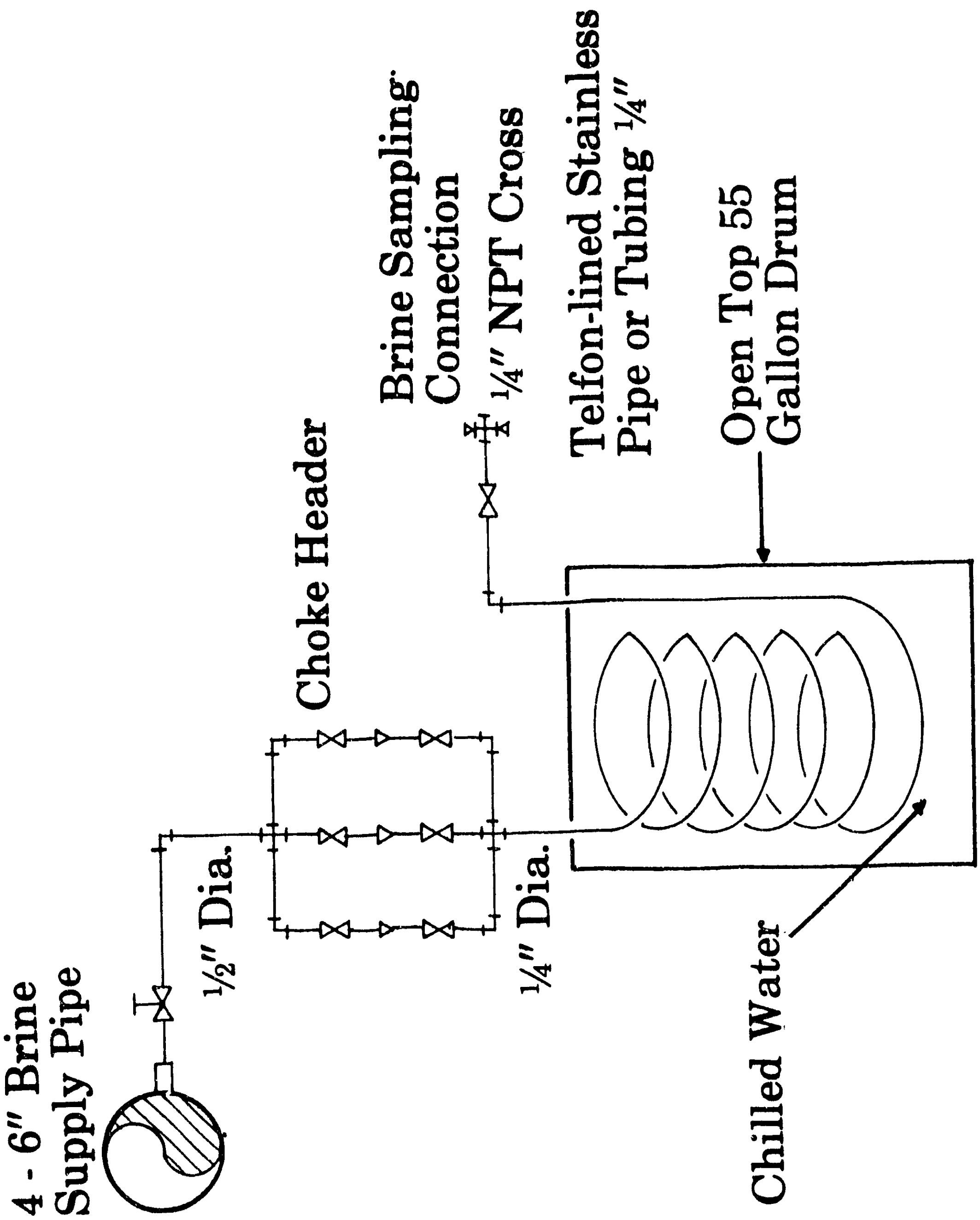

FIGURE 2

GEOPRESSURED BRINE SAMPLING STATION

avoid contaminating the sample with mercury and other metals. Transfer of the single-phase fluid from the bottom-hole sampler to the high-pressure container must be made at pressures no lower than reservoir pressure.

IV. EVALUATION OF GAS/WATER RATIO DATA

A. FROM BOTTOM—HOLE SAMPLES

Commercial bottom-hole sampling devices used to date do not have heaters and the in-situ temperature of the fluid within the sampler cannot be maintained; therefore, the bottom-hole fluid cools as it is brought to the surface, the pressure decreases, and a two-phase system forms. Even though the sample is subjected to the correct in-situ pressure and vigorous agitation later, the operator never can be positive that the system has returned to a single phase. It is best, therefore, to determine the gas/water ratio directly on the sample contained in the bottom-hole device. If the seals of the bottom-hole device hold and if the integrity of the sample is maintained, the gas/water ratio data obtained from zero-flashing the sample directly from the bottom-hole sampler should be reliable.

The problem with gas/water ratio data collected from bottom-hole samples is encountered because bottom-hole samplers are expensive and operators wish to use the same sampler to collect several samples; therefore, the samples usually are transferred to high-pressure containers. If either temperature or pressure falls below reservoir conditions before the sample is transferred, some of the gas dissolved in the brine will be exsolved and a two-phase system will exist.

The standard transfer procedure involves pressuring-up the transfer apparatus and the bottom-hole sampler to in-situ pressure, then agitating the fluids contained in the bottom-hole sampler to return them to a single-phase system. However, experience has shown that it is very difficult, if not impossible, to return the system to a single phase. The gas may be redissolved in the brine only after vigorous and prolonged agitation, conditions that are difficult to achieve in the field. Even then, without a window in the sampler for observing the condition of the fluids, there is uncertainty as to the number of phases present. Furthermore, some operators have transferred the fluids at less than reservoir pressure.

With the hydraulic transfer system currently in use, and for reasons outlined previously, there is some question concerning the complete transfer of gas and brine from the bottom-hole sampler to the high-pressure container; therefore, the gas/water ratio data from these measurements are suspect. If the temperatureof the bottom-hole fluid could be maintained in the sampler (with a heater), a single-phase system would remain and a properly designed transfer system pressured-up to in-situ conditions would allow all of the sample to be transferred from the sampler to the high-pressure containers. Under these conditions, data obtained from the transferred samples would be as reliable as the data obtained from zero-flashing samples directly from the bottom-hole sampler.

Teflon-lined bottom-hole samplers are not necessary to determine the gas/water ratio reliably, however, the use of the teflon-lined equipment would allow fluids uncontaminated with the sampler metal to be collected and the chemical analysis of the brine would be more meaningful. Likewise, chemical analysis of the bottom-hole fluid would be more meaningful if some fluid other than mercury were used for the confining fluid in the hydraulic pump.

B. FROM SURFACE MEASUREMENTS

Gas/water ratio data obtained from surface equipment may be skewed high because the surface equipment measures the steam as well as the natural gas from the flashed fluid. Also, any free gas from gas-pockets in the producing zone will be measured along with the gas from the brine and that will increase the gas/water ratio. Calculations can correct for the amount of additional gas measured as steam (see Appendix A), but no correction can be made for the intrusion of free gas into the producing zone unless reliable gas/water ratios have been obtained from bottom-hole samples and recombination-differential liberation studies.

C. FROM RECOMBINATION—DIFFERENTIAL LIBERATION MEASUREMENTS

The gas/water ratio obtained from recombination-differential liberation measurements is the saturation value of the gas in the brine at reservoir conditions.

D. RELATIONSHIP BETWEEN GAS/WATER RATIO MEASUREMENTS

The gas/water ratio obtained from recombination-differential liberation measurements assumes saturation of the brine with natural gas in the producing zone.

The gas/water ratio obtained from a bottom-hole sample whose integrity has been maintained may be less than the saturation value; this is the best method of measuring the extent to which these geopressured-geothermal fluids approach saturation with natural gas.

The gas/water ratio obtained from surface measurements may be high; i.e., higher than the saturation value, due to free gas entering the well-bore along with the geopressured brine. If there is no gas cap, and if the brine is not saturated with gas, then the ratio obtained from both surface equipment and bottom-hole samples will be less than that obtained from recombination-differential liberation measurements.

V. TREATMENT OF WATER SAMPLES

Note: Water from geopressured-geothermal wells often contains crude petroleum which interferes with various analytical procedures. Most of this oil may be removed by allowing the water sample to flow through a loose plug of glass wool during the collection process.

A. RAW, UNTREATED (RU)

Collect a water sample in a previously cleaned bottle and stopper the bottle tightly. Label the bottle "RU." The following determinations are to be made on RU water: pH, T, specific conductance, suspended solids, alkalinity, and $S^{=}$.

B. RAW, ACIDIFIED (RA)

Collect a water sample in a previously cleaned bottle and add enough 1:1 HNO_3 to make the pH of the solution 1.5 ± 0.5 as measured with pH paper or a pH meter. Mix the contents thoroughly, stopper the bottle tightly, and label the bottle "RA." The following determinations are to be made on RA samples: Ra-226, gross α, gross β, and gross γ.

C. FILTERED, UNTREATED (FU)

Collect a sample of water that has been filtered through a 0.45- m membrane filter. Stopper the container tightly and label it "FU." The following determinations should be made on FU samples: dissolved solids (on-site), Cl^-, (on-site), SiO_2, B, F^-, and NH_3.

D. FILTERED ACIDIFIED (FA-HNO_3)

Collect a measured amount of water as specified in Section V-C and add 1:1 HNO_3 with a calibrated pipet until the pH is ~1.5(pH meter). Discard the solution. Collect an additional sample of water as specified in Section V-C. Using the information obtained from the pH adjustment of the discarded solution, add an appropriate amount of 1:1 HNO_3 to the new sample to produce a pH of 1.5, mix the contents thoroughly, and label "FA-HNO_3." Test a portion of the acidified solution to confirm that the pH of the new sample is 1.5 ± 0.5, then discard the portion tested. Stopper the container tightly. Make a notation of the amount of acid used in the pH adjustment. The following determinations are to be made on FA-HNO_3 samples: Cu, As, Cr, Pb, Cl^- (not on-site), Mn, Fe, Cd, Hg, and Zn.

E. FILTERED, ACIDIFIED (FA-HCl)

Collect a measured amount of water as specified in Section V-C and add 1:1 HCl with a calibrated pipet until the pH=3.0 (pH meter). Discard the solution. Collect an additional sample of water as specified in Section V-C. Using the information obtained from the pH adjustment of the discarded solution, add an appropriate volume of 1:1 HCl to the new sample to adjust the pH to 3.0, mix the contents thoroughly, and label "FA-HCl." Test a portion of the acidified solution to confirm that the pH of the analytical sample is 3.0 ±0.5, then discard the portion tested. Stopper the container tightly. Make a notation of the amount of acid used in the pH adjustment. The following determinations are to be made on FA-HCl samples: Ba, Sr, Na, K, Ca, Mg, and $SO_4^{=}$.

VI. SPECIAL REAGENTS

All HCl, HNO_3, H_2SO_4, and NH_4OH used must be ultra-pure. Ultrex reagents have been found to be suitable as have the ultra-pure reagents from G.F. Smith Chemical Company, but equivalent grades are available from most commercial chemicall suppliers. Other reagents used for the various determinations should be "analytical" grade.

VII. PREPARATION OF GLASSWARE

The glassware used in procedures for determining trace elements must be cleaned scrupulously. Follow the procedure outlined in Section VIII-B, but adjust the amounts proportionately.

VIII. CONTAINER PREPARATION

A. STAINLESS STEEL CYLINDERS (TEFLON—LINED)

Check the cylinders to see that no grease or loose solid material is present. Remove any grease by rinsing with an organic solvent such as petroleum ether. Be sure to remove the last traces of the organic solvent; passing dry nitrogen through the container usually will remove all of the solvent from the cylinder.

Install valves on the cylinder with teflon tape. Pressure-test each cylinder by filling it with nitrogen to 300 psig and immersing the cylinder in a water bath for 1/2 hour.

B. PLASTIC CONTAINERS

Rinse with two 250-mL portions of 6 *M* HCl. Remove the HCl by rinsing with 300-mL portions of deionized water until the rinse water gives no test with $AgNO_3$, then rinse with a final 300-mL portion of deionized water. The fourth rinse usually is free of chloride when cleaning five-gallon plastic containers and the third rinse usually is free of chloride when cleaning one-gallon containers.

IX. SAMPLING FREQUENCY

Sampling frequency depends upon how long the well flows. Consult the following table to determine how often samples should be collected.

Flow Time	Sampling Time	No. of Samples
1 week	Day 1,3,5	3
2 weeks	Day 12	1 (total of 4)
3 weeks	Day 19	1 (total of 5)
4 weeks	Day 26	1 (total of 6)
>4 weeks	Sample once each month	(1 per month)

X. SAMPLES TO BE ANALYZED

A. WATER SAMPLES

The following determinations should be made on each water sample collected according to the above schedule: pH, T, specific conductance, dissolved solids, suspended solids, Na, K, Ca, Mg, Sr, alkalinity (including organic acid anions), alkalinity (CO_2), Cl^-, F^-, SiO_2, Fe, $S^=$, Cd, Zn, and NH_3.

The following determinations should be made on the water samples collected on day 1, day 12, day 26, and on every third water sample collected monthly after day 26; i.e., quarterly: Ba, $SO_4^=$, Mn, B, Hg, As, Cr, Cu, Pb, Ra-226, gross α, gross β, gross γ, identification of metals in dissolved solids by emission spectrography. These determinations should be repeated on the first and second samples collected monthly after day 26 if the quarterly determinations show trends.

B. GAS SAMPLES

The following determinations should be made on the gas samples collected on day 1, day 12, day 26 and on every third gas sample collected monthly after day 26; i.e., quarterly: standard hydrocarbon analysis (C_1-C_6 and C_{6+}), H_2S, He, Rn-222, CO_2, N_2, NH_3, O_2, H_2. These determinations should be repeated on the first and second samples collected monthly after day 26 if the quarterly determinations show trends.

The identification of gases other than those listed above should be made **on one sample only** using mass spectrometry. Gases from Z = 1 to Z $\approx$400 should be sought. The one sample chosen for this determination should be obtained from the middle of the test period.

The amount of natural gas dissolved in the brine (gas/water ratio) should be determined on at least one set of gas and water samples from the separator and from bottom-hole samples when available.

C. SUSPENDED SOLIDS

The clays and minerals in the suspended solids collected on days 1, 3, 5, and 12 should be determined by x-ray diffractometry (or equivalent method). Save the remaining suspended solids samples for the identification of clays and minerals if that becomes necessary.

XI. DETERMINATIONS THAT REQUIRE SPECIAL EQUIPMENT

A. DETERMINATIONS IN WATER SAMPLES

Special equipment is needed to determine Ra-226, gross α, gross β, gross γ, metals in dissolved solids by emission spectrography and clays and minerals in suspended solids by x-ray diffraction. Many university laboratories have the equipment necessary to make these determinations (3,4).

Some oil service testing companies that perform core analyses have x-ray diffraction equipment and the expertise to identify clays and minerals.

Procedures for determining Ba, Mn, As, Cu, Cr, Pb, and Hg use neutron activation analysis as an analytical tool; thus, a neutron generator or a nuclear reactor is required to perform these determinations by neutron activation analysis. Again, some university laboratories have this equipment (3,4). Alternate procedures for these metals are listed, however, using atomic absorption spectrometry.

B. DETERMINATIONS IN GAS SAMPLES

Special equipment is needed to determine Rn-222 and to identify the components of a gas from $Z=1$ to $Z\cong400$ by mass spectrometry as explained in Section XI-A.

XII. SCALE AND CORROSION INHIBITORS

Records must be kept for any chemical added to the system to inhibit corrosion or scaling. Information should include the following:

> Type and chemical description; molecular weight range and charge density (for polymers); cost; reasons for choice; alternatives; dosage level; point of addition to the system, reasons for this choice, and alternatives; time of addition; dosage versus time curves; method of monitoring the dosage; effectiveness of the chemical; description of the problem; and quantitative information on changes in scaling or corrosion characteristics and locations. In addition, a method of obtaining inhibitor-free water samples should be provided.

XIII. PROCEDURES: DETERMINATIONS IN WATER SAMPLES

ALKALINITY

INCLUDES ORGANIC ACID ANIONS
AN ON-SITE DETERMINATION

INTRODUCTION This procedure determines the total alkalinity, including the portion attributable to organic acid anions.

METHOD Volumetric.

SAMPLING Use a raw, untreated sample. See Section V-A for special instructions.

PROCEDURE Allow the sample to cool somewhat before an aliquot is taken. Pipet 50.00 mL of the cooled sample into a 250-mL beaker. Place the electrodes of a calibrated pH meter into the sample and titrate with 0.02 *N* H_2SO_4. Add the standard acid in increments of 1-2 mL at the beginning of the titration and change the increments to 0.25-0.5 mL at pH=5.0. The incremental volumes should be determined by the actual titration and the speed with which the pH is changing. Titrate the solution until the pH is 2.0. Tabulate values of pH and mL and determine the end point graphically from a plot of pH vs. mL.

RESULTS Report alkalinity as mg HCO_3^-/L.

REFERENCE 6

ALKALINITY

TOTAL CARBON DIOXIDE
AN ON-SITE DETERMINATION

INTRODUCTION This method determines the alkalinity due to the carbonate type species in the sample.

METHOD Gravimetric (loss of carbon dioxide)

SAMPLING Use a raw, untreated sample. See Section V-A for special instructions.

PROCEDURE Loss of carbon dioxide may be obtained by using an alkalimeter (unit-weight model). Allow the sample to cool somewhat before an aliquot is taken. Pipet a portion of the cooled sample into the alkalimeter and fill the reservoir of the alkalimeter with dilute H_2SO_4. The sample and acid are weighed, the stopcock is opened to admit the H_2SO_4 to the sample (slowly), the mixture is heated gently (being careful not to lose water vapor) to expel any dissolved carbon dioxide, and the alkalimeter is weighed again. The loss in weight is the amount of carbon dioxide.

RESULTS Report as mg HCO_3^-/L.

REFERENCE 9

ALTERNATE PROCEDURE The Knorr (CO_2-weight model) type alkalimeter may be used also.

REFERENCE 5

GROSS ALPHA, GROSS BETA, GROSS GAMMA

METHOD Radioassay

SAMPLING Use a raw, acidified sample. See Section V-B for special instructions.

PROCEDURE

Gross Alpha: Evaporate a small amount of the water sample and count the alpha radiation in an evacuated chamber.

Gross Beta: Evaporate a portion of the water sample and count total beta activity with a G-M beta detector.

Gross Gamma: Evaporate a portion of the water sample (or use the portion prepared for the gross beta) and count gross gamma with a Ge (Li) detector.

RESULTS

Report gross alpha as μg U/L.

Report gross beta as pCi ^{137}Cs/L.

Report gross gamma as pCi total gamma radiation.

REFERENCE 3

AMMONIA, FLUORIDE, SULFIDE

METHOD Ion-specific electrode

SAMPLING Ammonia: Collect a **separate** filtered, untreated sample for ammonia. This is an on-site determination.

Sulfide: Collect a **separate** raw, untreated sample for sulfide. If the solution is turbid, filter it through glass wool. This is an on-site determination.

Fluoride: Use a filtered, untreated sample. See Section V-C for special instructions.

PROCEDURE Use the **appropriate** specific ion electrode and follow the manufacturer's instructions. Measure the ammonia, fluoride, or sulfide content.

RESULTS Report ammonia as mg NH_3/L.

Report fluoride as mg F^-/L.

Report sulfide as mg $S^=$/L.

ARSENIC

METHOD Neutron activation analysis

SAMPLING Use a filtered, acidified (HNO_3) sample. See Section V-D for special instructions.

PROCEDURE Prepare arsenic-free HCl by adding 500 mL of benzene to ~1500 mL of concentrated HCl. Shake thoroughly, allow the two layers to separate, and discard the benzene layer. Repeat the extraction with an additional 500 mL of benzene and discard the benzene.

Place 100.00 mL of the sample in a 500-mL separatory funnel, add 10 mL of arsenic-free HCl and 10.00 mL of benzene. Shake for two minutes, remove 5.00 mL of benzene, and place the benzene in a 10-mL rabbit. Evaporate the benzene in a vacuum oven ($<40^0C$), seal the rabbit, and irradiate the contents of the rabbit with $\sim10^{13}n/cm^2$-s for two hours. Count arsenic as As-76 (26.3 hours). The sensitivity is affected by the presence of bromine and the two peaks must not be confused.

RESULTS Report as mg As/L.

REFERENCES Preparation of arsenic-free HCl:7
Activation procedure: 3

ALTERNATE PROCEDURE Arsenic may be determined by atomic absorption spectrometry either directly or after converting the metal to arsine. Care should be exercised to prevent the absorption of radiation by organic vapors (e.g., acetylene) at the arsenic wavelengths.

REFERENCE 8

BARIUM

METHOD Neutron activation analysis

SAMPLING Use a filtered, acidified (HCl) sample. See Section V-E for special instructions.

PROCEDURE Irradiate 2.00 mL of the sample and an appropriate standard for two minutes at $\sim 10^{13}$ n/cm^2-s. Post irradiation chemistry is necessary. Add 20 mg of Ba^{++} and 10 mg of Fe^{+++} to the irradiated water sample and standard. Precipitate Fe^{+++} as the hydroxide with ammonium hydroxide, then precipitate Ba^{++} with $(NH_4)_2CO_3$. Filter, dissolve the precipitate in dilute HCl, reprecipitate Fe^{+++} as the hydroxide and Ba^{++} as the carbonate, filter, dry, weigh for the determination of recovery efficiency, and count Ba-139 (83 min.).

RESULTS Report as mg Ba/L.

REFERENCE 3

ALTERNATE PROCEDURE Barium may be determined in a nitrous oxide-acetylene flame by atomic absorption spectrometry.

REFERENCE 8

BORON

INTRODUCTION Use Teflon or plastic beakers for collection and analysis.

METHOD Carmine-spectrometric.

SAMPLING Use a filtered, untreated sample. See Section V-C for special instructions.

PROCEDURE If precipitation has occurred in the filtered, untreated sample, shake the solution thoroughly and allow it to settle somewhat. Pipet 2.00 mL of the sample into a 30-mL Teflon beaker. Prepare a blank by pipetting 1.8 mL of deionized water into a Teflon beaker. Pipet 1.8 mL of standard boron solutions (0.01 and 0.025 mg B/L) into a Teflon beaker. To blank and standard solutions, add 0.2 mL of silica standard. The concentration of silica in the 2.00 mL volumes of samples, blank, and standards should be the same. Adjust the volume of the standards to 2.00 mL. To blank, standards, and samples, add two drops of concentrated HCl and two drops of concentrated H_2SO_4. Allow to cool, add 10.00 mL of carmine solution (0.5 g of carmine/liter of concentrated H_2SO_4) to blank, standards, and sample. Allow to stand for 1 hour. Set the spectrophotometer to 600 nm and use the blue sensitive phototube. Use a 1-inch cell and read the absorbance of each sample against the blank as a reference. Determine the amount of boron graphically.

RESULTS Report as mg B/L.

REFERENCE 8

CADMIUM, IRON, ZINC

METHOD	Atomic absorption spectrometry.
SAMPLING	Use a filtered, acidified (HNO_3) sample. See Section V-D for special instructions.
PROCEDURE	Determine cadmium, iron, or zinc directly by atomic absorption spectrometry.
RESULTS	Report cadmium as mg Cd/L. Report iron as mg Fe/L. Report zinc as mg Zn/L.
REFERENCE	8

CALCIUM, MAGNESIUM

INTRODUCTION Lanthanum chloride must be added to mask interferences.

METHOD Atomic absorption spectrometry.

SAMPLING Use a filtered, acidified (HCl) sample. See Section V-E for special instructions.

PROCEDURE Determine calcium or magnesium directly by atomic absorption spectrometry. Use 1.00 mL of La_2O_3 solution (29 g of La_2O_3 dissolved in small portions in 250 mL of concentrated HCl (**CAUTION!**) and dilute to 500 mL with deionized water) for each 10.00 mL of sample or standard.

RESULTS Report calcium as mg Ca/L.
Report magnesium as mg Mg/L.

REFERENCE 8

CHLORIDE

INTRODUCTION If this determination is performed on-site, allow the sample to cool somewhat before an aliquot is taken; otherwise, a volume error will be made during the pipetting step.

METHOD Mohr titration.

SAMPLING Use a filtered, untreated sample for on-site analysis or a filtered, acidified (HNO_3) sample for analysis at a later time. See Sections V-C and V-D for special instructions.

PROCEDURE Pipet 1.00 mL of the cooled sample into a 125-mL Erlenmeyer flask and dilute the sample to approximately 50 mL. Add 10 drops of K_2CrO_4 indicator solution (5 g of K_2CrO_4/100 mL of deionized water) and titrate with 0.1 *N* $AgNO_3$ until the end point persists.

RESULTS Report as mg Cl^-/L.

REFERENCE 8

CHROMIUM, COPPER, LEAD

INTRODUCTION

Chromium, copper, or lead may be extracted with ammonium pyrollidine dithiocarbamate in methyl isobutyl ketone. The three metals are extracted simultaneously and each may be determined by subjecting the extract to atomic absorption spectrometry or to neutron activation analysis

METHOD

Atomic absorption spectrometry.

SAMPLING

Use a filtered, acidified (HNO_3) sample. See Section V-D for special instructions.

PROCEDURE

Pipet a 100.00-mL sample into a 250-mL volumetric flask. Prepare a blank and a standard containing 0.1 mg M^{+n}/L in the extracted medium similarly. Add two drops of bromphenol blue solution (0.1 g of bromphenol blue dissolved in 100 mL of 50% ethanol) to each flask. Adjust the pH by adding 2.5 *M* NaOH (10 g of NaOH in 1 L of solution) dropwise until the blue color persists, then add 0.3 *M* HCl (25 mL of concentrated HCl in deionized water diluted to 1 L) until the blue color just disappears. Add 2.00 mL of 0.3*M* HCl in excess. Add 5.00 mL of APDC solution (1 g of ammonium pyrrolidine dithiocarbamate in deionized water diluted to 100 mL. Prepare fresh daily.) and mix. Add 10.00 mL of MIBK (methyl isobutyl ketone) and shake the flask and contents for three minutes. Allow the layers to separate and add deionized water until the MIBK layer is in the neck of the flask. Determine Cu, Cr, or Pb in the MIBK extract by atomic absorption spectrometry.

RESULTS

Report chromium as mg Cr/L.
Report copper as mg Cu/L.
Report lead as mg Pb/L.

REFERENCES

Extraction procedure: 4
Atomic absorption spectrometry. 8

ALTERNATE PROCEDURE

Remove 5.00 mL of the MIBK extract from the neck of the volumetric flask, place the extract in a 10-mL rabbit, evaporate the MIBK in a vacuum oven (<35°C), seal the rabbit, and irradiate with $5 \times 10^{12} n/cm^2 \cdot s$ in a pneumatic system for 10-15 s. Copper is counted as Cu-66 (5.1 minutes). Irradiate for one hour. Chromium is counted as Cr-51 (27.7 days). Irradiate with 14.8 Mev neutrons. Count, using a pneumatic system, the 0.8 s activity of ^{207m}Pb produced from the ^{208}Pb (n, 2n) reaction.

REFERENCE

3

CLAYS AND MINERALS

INTRODUCTION The composition of the suspended solids, with regard to clays and minerals, may be determined by x-ray diffraction.

METHOD X-ray diffractometry.

SAMPLING Use the solid material from the suspended solids determination.

PROCEDURE The suspended solids collected on the filter should be subjected to x-ray diffraction techniques such that clays and minerals will be identified. A semi-quantitative determination of each mineral identified is desirable.

RESULTS Report the identities of the clays or minerals present.

DISSOLVED SOLIDS

AN ON-SITE DETERMINATION

METHOD Gravimetric.

SAMPLING Use a filtered, untreated sample. See Section V-C for special instructions.

PROCEDURE Pipet a volume of sample containing <200mg of dissolved solids into a pre-weighed container. Evaporate the liquid over a steam bath or in an oven(~80°C), then dry at 180°C for two hours or until constant weight is attained. Save the dried material for possible analysis by emission spectrography.

RESULTS Report as mg dissolved solids/L.

REFERENCE 4

ALTERNATE PROCEDURE Alternatively, the dissolved solids content may be calculated by adding the concentrations found for the cations and the anions. Convert (HCO_3^-) to ($CO_3^=$) for this calculation.

REFERENCE 8

MANGANESE

INTRODUCTION

Large amounts of manganese may be determined directly by atomic absorption spectrometry (see CADMIUM, IRON, ZINC). Trace amounts may be determined directly by neutron activation analysis. Alternatively, trace amounts of manganese may be determined by atomic absorption spectrometry following an extraction procedure. Iron and magnesium interfere in the extraction step, however, and the neutron activation procedure is preferred.

METHOD

Neutron activation analysis.

SAMPLING

Use a filtered, acidified (HNO_3) sample. See Section V-D for special instructions.

PROCEDURE

Irradiate 1.00 mL of the sample for 30 minutes at $\sim 10^{13}$ n/cm^2-s. Precipitate the manganese as the hydroxide with ammonium hydroxide, centrifuge, dissolve the precipitate with dilute HCl, then precipitate MnO_2 by adding (carefully!) 100 mg of $KBrO_3$. Count as Mn-56 (2.6 hours).

RESULTS

Report as mg Mn/L.

REFERENCE

3

ALTERNATE PROCEDURE

Pipet a 100.00 mL sample into a 250-mL volumetric flask. Prepare a blank and a standard containing 0.1 mg Mn/L in the extracted medium similarly. Add two drops of bromcresol green solution (0.1 g of bromcresol green dissolved in 100 mL of 20% ethanol) to each flask. Adjust the pH by adding 0.3 *M* HCl (25 mL of concentrated HCl in deionized water diluted to 1 L) dropwise until a light olive-green color is attained. Add 5.00 mL of APDC solution (4 g of ammonium pyrrolidine dithiocarbamate in deionized water diluted to 100 mL. Prepare fresh daily.) and mix Add 5.00mL of MIBK(methyl isobutyl ketone) and shake the flask and contents for two minutes. Allow the layers to separate and add deionized water until the MIBK layer is in the neck of the flask. Determine manganese in the MIBK layer by atomic absorption spectrometry.

REFERENCE

8

MERCURY

INTRODUCTION Special procedures for cleaning the glassware are necessary when determining very low levels of mercury. Soak borosilicate glass bottles with chromic acid overnight, rinse five times with deionized water, and oven dry >200° C for two hours.

METHOD Neutron activation analysis.

SAMPLING Use a filtered, acidified (HNO_3) sample. See Section V-D for special instructions.

PROCEDURE Irradiate 10.00 mL of the sample at $\sim 10^{13} n/cm^2$-s for 14 hours. Allow to decay for ~ two months before counting Hg-203 (46.6 days).

RESULTS Report as mg Hg/L.

REFERENCES Special cleaning procedure: 1
Analytical procedure: 3

ALTERNATE PROCEDURE Alternatively, mercury may be determined by flameless atomic absorption spectrometry.

REFERENCE 8

METALS

QUALITATIVE OR SEMI-QUANTITATIVE

IN SUSPENDED SOLIDS AND DISSOLVED SOLIDS

INTRODUCTION Metals in the suspended solids or metals in the water may be identified quickly and easily by emission spectrography.

METHOD Emission spectrography.

SAMPLING For the identification of metals in solution, use the dried material collected from the dissolved solids determination. Metals in the suspended solids may be identified by removing some of the solid material from the 0.45-μm filter used in the suspended solids determination.

PROCEDURE Use an instrument with a plate factor of at least 3.5 A/mm and photograph the ultraviolet part of the spectrum. Sample dilution with graphite, sample and counter electrodes used, exposure time, current, developing conditions, etc. are left to the discretion of the laboratory involved. An overall good sensitivity for qualitative analysis is required. Examine the plates for the presence of metals not specifically requested in Section I-A. These metals may then be determined by the appropriate analytical procedure.

REFERENCE 3

pH

AN ON-SITE DETERMINATION

METHOD Electrometric.

SAMPLING Use a raw, untreated sample. See Section V-A for special instructions.

PROCEDURE Use a pH meter with automatic temperature compensation. Calibrate the pH meter with buffers of pH=7.0 and pH=4.0 immediately prior to collecting the sample. Measure the pH of the water sample as soon as possible after collection. Do not stir the sample. The readings of some samples drift downscale when the electrodes are inserted in the sample, then drift upscale as the CO_2 is exsolved from solution. Report the lowest reading. A stable pH reading will not be available until all of the CO_2 has been removed from the sample and the stable reading is not the true pH of the original sample.

RESULTS Report acidity in pH units.

ALTERNATE PROCEDURE A more rigorous method for pH measurement is as follows: Calibration of the pH meter with the appropriate buffer should be carried out at the same temperature at which the geopressured fluid was collected. Completely fill a 4 oz. glass bottle (polyseal cap) with a sample collected at the well-head. Stopper the sample bottle immediately and measure the pH as soon as possible. The pH electrodes should be fitted with a plastic sleeve which fits tightly into the mouth of the glass bottle containing the sample to be measured. This procedure is essential to minimize loss of CO_2 during the pH measurement. Record the temperature at which the sample is collected as well as the temperature at which the pH is measured.

REFERENCE 6

POTASSIUM

METHOD Flame emission or atomic absorption spectrometry.

SAMPLING Use a filtered, acidified (HCl) sample. See Section V-E for special instructions.

PROCEDURE Determine potassium directly by flame emission or atomic absorption spectrometry. Sodium interference may be compensated for by preparing potassium standards containing the same concentration of sodium found in the samples.

RESULTS Report as mg K/L.

REFERENCES Flame emission spectrometry: 4
Atomic absorption spectrometry: 6

ALTERNATE PROCEDURE Sodium interference may be masked by adding sodium equivalent to 2000 mg Na/L to the potassium samples and standards aspirated into the flame.

REFERENCE 6

RADIUM

INTRODUCTION This procedure determines Ra-226, Ra-228, and other radium isotopes electroplated on platinum foil. A multi-channel analyzer is useful for separating the energy levels.

METHOD Radioassay.

SAMPLING Use a raw, acidified sample. See Section V-B for special instructions.

PROCEDURE To 100.00 mL of the sample, add 50 mg of Ba^{++} (as $BaCl_2$) and 20 mg of Fe^{+++} (as $FeCl_3$) to act as a carrier. Make the solution basic with NH_4OH, digest at 80-90°C, filter, and discard the $Fe(OH)_3$. Precipitate $Ba(Ra)CO_3$ with $(NH_4)_2CO_3$. Filter and retain the precipitate. Dissolve the precipitate in 6 *M* HNO_3 and precipitate $Ba(Ra)(NO_3)_2$ by adding 20 mL of fuming nitric acid. Filter and retain the precipitate. Add 10 mL of absolute ethanol to the precipitate, cool in an ice bath, add 10 mL of ether, and stir thoroughly. This last step dissolves $Ca(NO_3)_2$. Filter. Dissolve the remaining precipitate in water, make the solution basic with NH_4OH, and precipitate $Ba(Ra)CO_3$ with $(NH_4)_2CO_3$. Filter. Dissolve the precipitate with 0.2 *M* HNO_3 and use the resulting solution to load a Dowex 50×8 ion exchange column.* Separate the Ba and Ra by eluting with 0.32 *M* ammonium citrate solution adjusted to pH=5.6 with dilute ammonium hydroxide or dilute hydrochloric acid. To the Ra fraction (second fraction eluted), add 2 mg of Ba^{++} carrier, adjust the pH to 8.0 with dilute NH_4OH, precipitate $Ba(Ra)CO_3$ with $(NH_4)_2CO_3$. Dissolve the $Ba(Ra)CO_3$ in the minimum amount of 0.5 M HNO_3. Place the nitric acid solution in an electroplating cell and electroplate the metal onto platinum foil at 20 mA for 6 hours. Place the electroplated sample in an alpha chamber to determine Ra-226. Place the electroplated sample in a beta detection system to determine Ra-228.

*Prepare the Dowex ion exchange resin column as follows: Remove organic material by washing the column with several column volumes of 95% ethyl alcohol, followed by two or more column volumes successively of 0.6 *M* ammonium citrate (pH=5.6) and 1.5 *M* NH_4OH.

RESULTS Report as pCi Ra-226 or pCi Ra-228/L.

REFERENCE 3

SILICA

INTRODUCTION Silica may be determined directly in FU samples on-site if the determination is made immediately after sample collection; otherwise, field dilutions will be necessary since some precipitation of silica may occur if too much time elapses between sample collection and analysis. Use Teflon or plastic beakers for collection and analysis.

METHOD Molydenum blue-spectrometric.

SAMPLING Use a filtered, untreated sample for on-site analysis. See Section V-C for special instructions.

PROCEDURE Allow the FU sample to cool somewhat. (1) Pipet 1.00 mL of the sample into a beaker. Add 10.00 mL of deionized water. (2) Pipet 1.00 mL of each standard into separate beakers. Add 10.00 mL of NaCl solution (containing 1/10 the concentration of chloride found in the sample) to each beaker containing standards. (3) Prepare a blank by adding 1.00 mL of deionized water and 10.00 mL of NaCl solution (same concentration as in step 2) to a beaker. (4) Pipet into each of the beakers in steps 1-3: (a)5.00 mL of 1.0 *N* HCl, (b) 5.00 mL of Na_2 EDTA solution (10 g/L), and (c) 5.00 mL of ammonium molybdate solution (52 g of $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$ in deionized water, adjust the pH to 7-8 with 10 *M* NaOH, and dilute to 1 L with deionized water. Filter through 0.45-μm membrane filter if necessary.) (5) Wait 5 minutes and add 5.00 mL of $H_2C_4H_4O_6$ (tartaric acid) solution (100 g/L) to each beaker. Mix. (6) Wait 2 minutes and add 10.00 mL of Na_2SO_3 solution (170 g/L) to each beaker. Mix. (7) Wait 30 minutes. Use 1 cm cells and measure the absorbance of each sample and standard at 700 nm (red filter, red sensitive phototube) against the blank as a reference. Plot the data and graphically determine the SiO_2 concentration.

RESULTS Report as mg SiO_2/L.

REFERENCE 4

ALTERNATE PROCEDURE To prevent the possible precipitation of silica in samples not intended for on-site analysis, collect two FU samples and dilute them 1:2 and 1:4, respectively, with distilled water. The amount of silica should be determined in both dilutions; agreement between the two dilutions is evidence that no precipitation of silica occurred. To determine silica, follow the procedure outlined above. Some volume adjustments must be made for the diluted samples.

REFERENCE 8.

SODIUM

METHOD Flame emission spectrometry

SAMPLING Use a filtered, acidified (HCl) sample. See Section V-E for special instructions.

PROCEDURE Determine sodium directly by flame emission spectrometry. Potassium does not interfere at levels up to 1 mg K/L in the aspirated solution. At 5 mg K/L in the aspirated solution, an enhancement of 4-6% in the measured sodium concentration is observed. Most geopressured-geothermal samples contain high Na/K ratios and the samples must be diluted several thousand-fold in order to place the level of sodium in the proper analytical range. At these dilutions, the potassium concentration rarely exceeds 1 mg K/L.

RESULTS Report as mg Na/L.

REFERENCE 3

ALTERNATE PROCEDURE Determine sodium directly by atomic absorption spectrometry. Mask potassium interference by adding potassium equivalent to 1000 mg K/L to the sodium samples and standards aspirated into the flame.

REFERENCE 6

SPECIFIC CONDUCTANCE

AN ON-SITE DETERMINATION

METHOD Electrometric.

SAMPLING Use a raw, untreated sample. See Section V-A for special instructions.

PROCEDURE To determine specific conductance, use a commercial instrument that has been calibrated with KCl at various temperatures.

RESULTS Report specific conductance in μmhos/cm or μS/cm(microsiemens/cm) at 25^{0}C.

REFERENCE 8

STRONTIUM

METHOD Atomic absorption spectrometry.

SAMPLING Use a filtered, acidified (HCl) sample. See Section V-E for special instructions.

PROCEDURE Use 1.00 mL of a La_2O_3-KCl mixture (Dissolve 117.3 g of La_2O_3 in the minimum amount of dilute HCl+19.1 g of KCl, then add deionized water to 1000 mL) for each 10.00 mL of sample or standard.

RESULTS Report as mg Sr/L.

REFERENCE 8

SULFATE

METHOD Gravimetric.

SAMPLING Use a filtered, acidified (HCl) sample. See Section V-E for special instructions.

PROCEDURE Prepare a chromatographic column as follows: Wash 80-200 mesh chromatographic grade alumina with deionized water. Allow the alumina to settle, decant the supernatant liquid, and repeat the washing procedure until the supernatant liquid is clear. Transfer the alumina to a chromatographic column, wash with 50 mL of 1 *M* ammonium hydroxide, several 5-mL portions of 0.1 *M* ammonium hydroxide, and 50 mL of deionized water. Wash with 10 mL of 1 *M* HCl for the final wash.

Acidify the sample with 30% HCl to pH=0.5-1.0. Introduce the sample onto the previously prepared chromatographic column, wash with 10 mL of 1 *M* HCl followed with a total of 25 mL of deionized water added in several portions. Elute the sulfate from the column by adding 5 mL of 1 *M* ammonium hydroxide followed by 20 mL of 0.1 *M* ammonium hydroxide. Add an additional 20 mL of 0.1 *M* ammonium hydroxide in 5-mL portions. Wash with 25 mL of deionized water. Do not allow the column to become dry.

Neutralize the eluted sample with dilute HCl and add 1 mL of dilute HCl in excess, then dilute to approximately 200 mL with deionized water. Treat with 0.25 *M* $BaCl_2$ solution. Digest the precipitate for two hours at 80- 90°C, cool, filter, wash the paper, and heat the residue in a muffle furnace (~1000°C) until constant weight is attained.

RESULTS Report as mg $SO_4^{=}$/L.

REFERENCES Preparation of chromatographic column: 2
Adsorption of sample on, and elution from, the column: 2
Precipitation of sulfate: any standard text.

ALTERNATE PROCEDURE Alternatively, sulfate may be determined by ion chromatography.

REFERENCE 6

SUSPENDED SOLIDS

AN ON-SITE DETERMINATION

METHOD Gravimetric.

SAMPLING Collect the suspended solids residue during the filtration step for filtered, untreated or filtered, acidified samples.

PROCEDURE Weigh a piece of 0.45-μm membrane filter, then filter a measured volume of sample through the membrane. Remove soluble salts by washing the membrane with deionized water. Remove oil and grease by washing the membrane with petroleum ether. Dry the filter at 110^{0}C and reweigh it. Save the dried material for possible x-ray diffraction or emission spectrographic analysis.

RESULTS Report suspended solids in mg/L.

REFERENCE 3

XIV. PROCEDURES:

DETERMINATIONS IN GAS SAMPLES

AMMONIA, HELIUM, HYDROGEN, HYDROGEN SULFIDE

INTRODUCTION Hydrogen and helium diffuse through most sample containers quickly; therefore, these gases must be determined as soon as possible after collection.

METHOD Gas chromatography.

SAMPLING Use a sample collected from the separator or the sample remaining from previous gas analyses. See Section III-A for special instructions. Save the sample for the possible determination of other gases.

PROCEDURE These gases should be determined by standard gas chromatography. Use the proper column, carrier gas, etc. to obtain the correct determination.

RESULTS Report as mole per-cent of each element or compound.

COMPOSITION OF GASES

QUALITATIVE

INTRODUCTION The composition of gases, as determined by procedures listed in this manual, is reported in mole-percent. This reporting procedure is a method for normalizing the reported components of a gas to 100%; however, other components may be present but go undetected. To guard against this possibility, at least one gas sample should be subjected to a mass spectrometric analysis.

METHOD Mass spectrometry.

PROCEDURE Follow the standard procedure for detecting gases from Z = 1 to Z = 400. A semi-quantitative determination is desirable.

RESULTS Report the identity of the gases present and the semi-quantitative results if possible.

GAS/WATER RATIO

INTRODUCTION

The solubility of natural gas in brine is determined at reservoir conditions of temperature and pressure. Record the bottom-hole temperature and the bottom-hole pressure.

METHOD

Recombination-Differential Liberation.

SAMPLING

Collect a gas sample at the high-pressure separator in a one-gallon teflon-lined stainless steel container after the container has been flushed with at least five volumes of separator gas. Collect the gas under the pressure of the system by closing the exit valve of the sample container before closing the inlet valve.

Collect a sample of water at the low-pressure side of the high-pressure separator in a 500-mL teflon-lined stainless steel container. Collect the water sample under equilibrium conditions as follows: Fill the container with gas from the separator. Attach the container (in a vertical position) to the water collection port and completely open the valve from the separator. Completely open the inlet valve of the sample container, but open the exit valve of the sample container only slightly. Under these conditions, the fluid will displace the gas in the container very slowly, and the equilibrium conditions will be maintained as nearly as possible. The 500-mL container should be filled in about 20 minutes. Close the exit valve, close the inlet valve of the sample container, then close the separator valve. The water and gas samples should be collected as close to the same time as possible.

PROCEDURE

Perform a recombination and differential liberation study on the gas-water system at reservoir temperature and pressure. Use a windowed equilibrium cell such that saturation can be observed visually. The details of this procedure are rather standard in petroleum service testing laboratories. Weatherly Labs (Lafayette, La.), PVT Labs (Houston, Tx.), and Core Labs (Dallas, Tx.) are three such service laboratories in the Louisiana-Texas area.

RESULTS

Report SCF gas (60^{o}F) /Bbl brine (60^{o}F).

ALTERNATE PROCEDURE

The gas/water ratio may be determined from surface measurements at the separator or from bottom-hole samples.

REFERENCE

See Sections III-C and III-D.
See the discussion in Section IV and Appendix A.

HYDROCARBONS

INCLUDES CARBON DIOXIDE, NITROGEN AND OXYGEN

METHOD Gas chromatography.

SAMPLING Use a sample collected from the separator or the sample remaining from previous gas analyses. See Section III-A for special instructions. Save the sample for the possible determination of other gases.

PROCEDURE Use a gas chromatograph to determine C_1-C_6 and C_{6+} . The standard analysis usually determines CO_2, N_2 and O_2 simultaneously.

RESULTS Report as mole per-cent of each element or compound.

RADON-222

INTRODUCTION Record the date and time of sampling.

METHOD Radioassay.

SAMPLING Use a sample collected from the separator or the sample remaining from previous gas analyses. See Section III-A for special instructions. Save the sample for the possible determination of other gases.

PROCEDURE Evacuate the alpha counting chamber and admit a known amount of the gas sample into the chamber. Count the Rn-222.

RESULTS Report as pCi ^{222}Rn/L. Results must be corrected to the time of sampling because of the short half-life (~3 days) of Rn-222.

REFERENCE 3

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APPENDICES

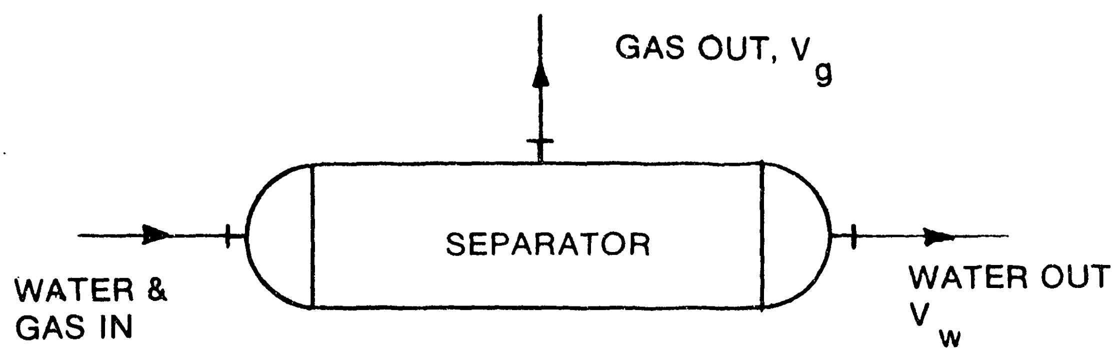
APPENDIX A

CALCULATION OF GAS/WATER RATIO FROM SURFACE MEASUREMENTS

The gas/water ratio can be calculated readily from temperature, pressure, and flow rate data taken at the gas/water separator of the surface equipment immediately downstream of the well-head.

Figure 3 represents the flow conditions at the separator. Symbols are defined below and used in the sample calculations which follow.

Figure 3.



Symbols

V_g = Volume of gas leaving separator, cu.ft./hour @ t_s, P_s.

t_s = Temperature of separator, ^oF.

P_s = Pressure of separatore, psig.

V_w = Volume of water leaving separator, Bbls./hour.

SCF = Standard cubic feet.

SCFH = Standard cubic feet/hour.

Bbls = Barrels.

Standard conditions for the gas = 60^oF, 14.7 psia.

Assumptions

1 Gas and water are in equilibrium as they leave the separator.

2. Gas and water leave the separator at t_s and P_s.

SAMPLE CALCULATION

P_s = 300 psig.

t_s = 250° F.

V_w = 625 Bbls/hour.

V_g = 823,000 cu.ft./hour @ t_s, P_s.

The gas leaving the separator is, therefore, saturated with water vapor (as steam) at t_s, P_s.

1. **The Calculation of Gas/Water Ratio for "Wet" Gas**

Gas volume at standard conditions is:

$$823{,}000 \times \frac{460+60}{460+250} \times \frac{14.7}{300+14.7}$$

$$823{,}000 \times 0.7324 \times 0.0467 = 28{,}156 \text{ SCF}$$

Rate of flow = 28,156 SCFH

$$\text{Gas/Water Ratio} = \frac{28{,}156}{625} = 45.0 \text{ SCF/Bbl (wet)}$$

2. **The Calculation of Gas/Water Ratio for "Dry" Gas**

The partial pressure of water (steam) in the gas is read from any compilation of the properties of water, usually referred to as "Steam Tables." From the table headed "saturation temperatures," observe that the pressure of water at 250°F is 29.8 psia. This value is the partial pressure of steam in the separator of Figure 3. The total pressure is 314.7 psia. The percent of the pressure due to water is 29.8/314.7=0.0947, or 9.47%. Since volume percent is equal to pressure percent, it is apparent that 9.47% of the gas leaving the separator is water. The volume of dry gas leaving the separator is

$$(1-0.0947)\ 28{,}156 = 0.9053 \times 28{,}156 = 25{,}490 \text{ SCF}$$

The gas/water ratio is, therefore, $\frac{25{,}490}{625}$ = 40.8 SCF/Bbl (dry).

APPENDIX B

CONDENSED ON-SITE PROCEDURES AND CHECKLIST

☐ 1. Collect a raw, untreated sample of the water, filter through a loose plug of glass wool and perform the following determinations: pH, T, specific conductance, alkalinity (including organic acid anions), alkalinity (total CO_2) $S^=$

☐ 2. Filter a measured portion (about one gallon) of the water through a 0.45 μm membrane filter and perform the following determinations: suspended solids, dissolved solids, Cl^-, SiO_2, B, F^-, NH_3.

Note: Dissolved solids, Cl^-, B, and F^- need not be determined on-site. Dilute a separate sample 1:2 and another 1:4 with distilled water if SiO_2 is to be determined later and not on-site.

☐ 3. Collect a filtered sample using a 0.45 μm membrane filter, adjust the pH to 1.5±0.5 with 1:1 HNO_3 (Section V-D). No on-site determinations are made using this solution. Section V-D lists the ions to be determined with FA-HNO_3 solution.

☐ 4. Collect a filtered sample using a 0.45 μm membrane filter, adjust the pH to 3.0±0.5 with 1:1 HCl (Section V-E) No on-site determinations are made using this solution. Section V-E lists the ions to be determined with FA-HCl solution.

☐ 5. Collect a raw, untreated sample of the water and adjust the pH to 1.5±0.5 with 1:1 HNO_3 (Section V-B). No on-site determinations are made using this solution. Section V-B lists the determinations to be made with RA solution.

☐ 6. Collect a gas sample in a 75 cc teflon-lined stainless steel container (Section III-A). Note separator gas pressure and temperature.

☐ 7. Collect gas and water samples for recombination-differential liberation studies (Section III-C) as needed.

☐ 8. Collect bottom-hole samples (Section III-D) as needed.

APPENDIX C

ALPHABETICAL LISTING OF PROCEDURES (WATER)

Alkalinity (including organic acid anions) 10

Alkalinity (CO_2) 11

Alpha radiation (Gross alpha) 12

Ammonia 13

Arsenic 14

Barium 15

Beta radiation (Gross beta) 12

Boron 16

Cadmium 17

Calcium 18

Chloride 19

Chromium 20

Clays and Minerals 21

Copper 20

Dissolved Solids 22

Fluoride 13

Gamma radiation (Gross gamma) 12

Iron 17

Lead 20

Magnesium 18

Manganese 23

Mercury 24

Metals (qualitative) 25
pH 26
Potassium 27
Radium-226, Radium-228 28
Silica 29
Sodium 30
Specific Conductance 31
Strontium 32
Sulfate 33
Sulfide 13
Suspended Solids 34
Zinc 17

APPENDIX D

ALPHABETICAL LISTING OF PROCEDURES (GAS)

Ammonia 36

Carbon Dioxide 39

Composition of Gases (qualitative) 37

Gas/Water Ratio 38

Helium 36

Hydrocarbons 39

Hydrogen 36

Hydrogen sulfide 36

Nitrogen 39

Oxygen 39

Radon-222 40

STANDARD SAMPLING AND ANALYTICAL METHODS FOR GEOPRESSURED FLUIDS

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avoid contaminating the sample with mercury and other metals. Transfer of the single-phase fluid from the bottom-hole sampler to the high-pressure container must be made at pressures no lower than reservoir pressure.

IV. EVALUATION OF GAS/WATER RATIO DATA

A. FROM BOTTOM—HOLE SAMPLES

Commercial bottom-hole sampling devices used to date do not have heaters and the in-situ temperature of the fluid within the sampler cannot be maintained; therefore, the bottom-hole fluid cools as it is brought to the surface, the pressure decreases, and a two-phase system forms. Even though the sample is subjected to the correct in-situ pressure and vigorous agitation later, the operator never can be positive that the system has returned to a single phase. It is best, therefore, to determine the gas/water ratio directly on the sample contained in the bottom-hole device. If the seals of the bottom-hole device hold and if the integrity of the sample is maintained, the gas/water ratio data obtained from zero-flashing the sample directly from the bottom-hole sampler should be reliable.

The problem with gas/water ratio data collected from bottom-hole samples is encountered because bottom-hole samplers are expensive and operators wish to use the same sampler to collect several samples; therefore, the samples usually are transferred to high-pressure containers. If either temperature or pressure falls below reservoir conditions before the sample is transferred, some of the gas dissolved in the brine will be exsolved and a two-phase system will exist.

The standard transfer procedure involves pressuring-up the transfer apparatus and the bottom-hole sampler to in-situ pressure, then agitating the fluids contained in the bottom-hole sampler to return them to a single-phase system. However, experience has shown that it is very difficult, if not impossible, to return the system to a single phase. The gas may be redissolved in the brine only after vigorous and prolonged agitation, conditions that are difficult to achieve in the field. Even then, without a window in the sampler for observing the condition of the fluids, there is uncertainty as to the number of phases present. Furthermore, some operators have transferred the fluids at less than reservoir pressure.

With the hydraulic transfer system currently in use, and for reasons outlined previously, there is some question concerning the complete transfer of gas and brine from the bottom-hole sampler to the high-pressure container; therefore, the gas/water ratio data from these measurements are suspect. If the temperatureof the bottom-hole fluid could be maintained in the sampler (with a heater), a single-phase system would remain and a properly designed transfer system pressured-up to in-situ conditions would allow all of the sample to be transferred from the sampler to the high-pressure containers. Under these conditions, data obtained from the transferred samples would be as reliable as the data obtained from zero-flashing samples directly from the bottom-hole sampler.

Teflon-lined bottom-hole samplers are not necessary to determine the gas/water ratio reliably; however, the use of the teflon-lined equipment would allow fluids uncontaminated with the sampler metal to be collected and the chemical analysis of the brine would be more meaningful. Likewise, chemical analysis of the bottom-hole fluid would be more meaningful if some fluid other than mercury were used for the confining fluid in the hydraulic pump.

B. FROM SURFACE MEASUREMENTS

Gas/water ratio data obtained from surface equipment may be skewed high because the surface equipment measures the steam as well as the natural gas from the flashed fluid. Also, any free gas from gas-pockets in the producing zone will be measured along with the gas from the brine and that will increase the gas/water ratio. Calculations can correct for the amount of additional gas measured as steam (see Appendix A), but no correction can be made for the intrusion of free gas into the producing zone unless reliable gas/water ratios have been obtained from bottom-hole samples and recombination-differential liberation studies.

C. FROM RECOMBINATION—DIFFERENTIAL LIBERATION MEASUREMENTS

The gas/water ratio obtained from recombination-differential liberation measurements is the saturation value of the gas in the brine at reservoir conditions.

D. RELATIONSHIP BETWEEN GAS/WATER RATIO MEASUREMENTS

The gas/water ratio obtained from recombination-differential liberation measurements assumes saturation of the brine with natural gas in the producing zone.

The gas/water ratio obtained from a bottom-hole sample whose integrity has been maintained may be less than the saturation value; this is the best method of measuring the extent to which these geopressured-geothermal fluids approach saturation with natural gas.

The gas/water ratio obtained from surface measurements may be high; i.e., higher than the saturation value, due to free gas entering the well-bore along with the geopressured brine. If there is no gas cap, and if the brine is not saturated with gas, then the ratio obtained from both surface equipment and bottom-hole samples will be less than that obtained from recombination-differential liberation measurements.

V. TREATMENT OF WATER SAMPLES

Note: Water from geopressured-geothermal wells often contains crude petroleum which interferes with various analytical procedures. Most of this oil may be removed by allowing the water sample to flow through a loose plug of glass wool during the collection process.

A. RAW, UNTREATED (RU)

Collect a water sample in a previously cleaned bottle and stopper the bottle tightly. Label the bottle "RU." The following determinations are to be made on RU water: pH, T, specific conductance, suspended solids, alkalinity, and $S^{=}$.

B. RAW, ACIDIFIED (RA)

Collect a water sample in a previously cleaned bottle and add enough 1:1 HNO_3 to make the pH of the solution 1.5 ± 0.5 as measured with pH paper or a pH meter. Mix the contents thoroughly, stopper the bottle tightly, and label the bottle "RA." The following determinations are to be made on RA samples: Ra-226, gross α, gross β, and gross γ.

C. FILTERED, UNTREATED (FU)

Collect a sample of water that has been filtered through a 0.45- m membrane filter. Stopper the container tightly and label it "FU." The following determinations should be made on FU samples: dissolved solids (on-site), Cl^-, (on-site), SiO_2, B, F^-, and NH_3.

D. FILTERED ACIDIFIED (FA-HNO_3)

Collect a measured amount of water as specified in Section V-C and add 1:1 HNO_3 with a calibrated pipet until the pH is ~1.5(pH meter). Discard the solution. Collect an additional sample of water as specified in Section V-C. Using the information obtained from the pH adjustment of the discarded solution, add an appropriate amount of 1:1 HNO_3 to the new sample to produce a pH of 1.5, mix the contents thoroughly, and label "FA-HNO_3." Test a portion of the acidified solution to confirm that the pH of the new sample is 1.5±0.5, then discard the portion tested. Stopper the container tightly. Make a notation of the amount of acid used in the pH adjustment. The following determinations are to be made on FA-HNO_3 samples: Cu, As, Cr, Pb, Cl^- (not on-site), Mn, Fe, Cd, Hg, and Zn.

E. FILTERED, ACIDIFIED (FA-HCl)

Collect a measured amount of water as specified in Section V-C and add 1:1 HCl with a calibrated pipet until the pH=3.0 (pH meter). Discard the solution. Collect an additional sample of water as specified in Section V-C. Using the information obtained from the pH adjustment of the discarded solution, add an appropriate volume of 1:1 HCl to the new sample to adjust the pH to 3.0, mix the contents thoroughly, and label "FA-HCl." Test a portion of the acidified solution to confirm that the pH of the analytical sample is 3.0 ±0.5, then discard the portion tested. Stopper the container tightly. Make a notation of the amount of acid used in the pH adjustment. The following determinations are to be made on FA-HCl samples: Ba, Sr, Na, K, Ca, Mg, and $SO_4^{=}$.

VI. SPECIAL REAGENTS

All HCl, HNO_3, H_2SO_4, and NH_4OH used must be ultra-pure. Ultrex reagents have been found to be suitable as have the ultra-pure reagents from G.F. Smith Chemical Company, but equivalent grades are available from most commercial chemicall suppliers. Other reagents used for the various determinations should be "analytical" grade.

VII. PREPARATION OF GLASSWARE

The glassware used in procedures for determining trace elements must be cleaned scrupulously. Follow the procedure outlined in Section VIII-B, but adjust the amounts proportionately.

VIII. CONTAINER PREPARATION

A. STAINLESS STEEL CYLINDERS (TEFLON—LINED)

Check the cylinders to see that no grease or loose solid material is present. Remove any grease by rinsing with an organic solvent such as petroleum ether. Be sure to remove the last traces of the organic solvent; passing dry nitrogen through the container usually will remove all of the solvent from the cylinder.

Install valves on the cylinder with teflon tape. Pressure-test each cylinder by filling it with nitrogen to 300 psig and immersing the cylinder in a water bath for 1/2 hour.

B. PLASTIC CONTAINERS

Rinse with two 250-mL portions of 6 *M* HCl. Remove the HCl by rinsing with 300-mL portions of deionized water until the rinse water gives no test with $AgNO_3$, then rinse with a final 300-mL portion of deionized water. The fourth rinse usually is free of chloride when cleaning five-gallon plastic containers and the third rinse usually is free of chloride when cleaning one-gallon containers.

IX. SAMPLING FREQUENCY

Sampling frequency depends upon how long the well flows. Consult the following table to determine how often samples should be collected.

Flow Time	Sampling Time	No. of Samples
1 week	Day 1,3,5	3
2 weeks	Day 12	1 (total of 4)
3 weeks	Day 19	1 (total of 5)
4 weeks	Day 26	1 (total of 6)
>4 weeks	Sample once each month	(1 per month)

X. SAMPLES TO BE ANALYZED

A. WATER SAMPLES

The following determinations should be made on each water sample collected according to the above schedule: pH, T, specific conductance, dissolved solids, suspended solids, Na, K, Ca, Mg, Sr, alkalinity (including organic acid anions), alkalinity (CO_2), Cl^-, F^-, SiO_2, Fe, $S^=$, Cd, Zn, and NH_3.

The following determinations should be made on the water samples collected on day 1, day 12, day 26, and on every third water sample collected monthly after day 26; i.e., quarterly: Ba, $SO_4^=$, Mn, B, Hg, As, Cr, Cu, Pb, Ra-226, gross α, gross β, gross γ, identification of metals in dissolved solids by emission spectrography. These determinations should be repeated on the first and second samples collected monthly after day 26 if the quarterly determinations show trends.

B. GAS SAMPLES

The following determinations should be made on the gas samples collected on day 1, day 12, day 26 and on every third gas sample collected monthly after day 26; i.e., quarterly: standard hydrocarbon analysis (C_1-C_6 and C_{6+}), H_2S, He, Rn-222, CO_2, N_2, NH_3, O_2, H_2. . These determinations should be repeated on the first and second samples collected monthly after day 26 if the quarterly determinations show trends.

The identification of gases other than those listed above should be made **on one sample only** using mass spectrometry. Gases from $Z=1$ to $Z \cong 400$ should be sought. The one sample chosen for this determination should be obtained from the middle of the test period.

The amount of natural gas dissolved in the brine (gas/water ratio) should be determined on at least one set of gas and water samples from the separator and from bottom-hole samples when available.

C. SUSPENDED SOLIDS

The clays and minerals in the suspended solids collected on days 1, 3, 5, and 12 should be determined by x-ray diffractometry (or equivalent method). Save the remaining suspended solids samples for the identification of clays and minerals if that becomes necessary.

XI. DETERMINATIONS THAT REQUIRE SPECIAL EQUIPMENT

A. DETERMINATIONS IN WATER SAMPLES

Special equipment is needed to determine Ra-226, gross α, gross β, gross γ, metals in dissolved solids by emission spectrography and clays and minerals in suspended solids by x-ray diffraction. Many university laboratories have the equipment necessary to make these determinations (3,4).

Some oil service testing companies that perform core analyses have x-ray diffraction equipment and the expertise to identify clays and minerals.

Procedures for determining Ba, Mn, As, Cu, Cr, Pb, and Hg use neutron activation analysis as an analytical tool; thus, a neutron generator or a nuclear reactor is required to perform these determinations by neutron activation analysis. Again, some university laboratories have this equipment (3,4). Alternate procedures for these metals are listed, however, using atomic absorption spectrometry.

B. DETERMINATIONS IN GAS SAMPLES

Special equipment is needed to determine Rn-222 and to identify the components of a gas from $Z=1$ to $Z\cong400$ by mass spectrometry as explained in Section XI-A.

XII. SCALE AND CORROSION INHIBITORS

Records must be kept for any chemical added to the system to inhibit corrosion or scaling. Information should include the following:

> Type and chemical description; molecular weight range and charge density (for polymers); cost; reasons for choice; alternatives; dosage level; point of addition to the system, reasons for this choice, and alternatives; time of addition; dosage versus time curves; method of monitoring the dosage; effectiveness of the chemical; description of the problem; and quantitative information on changes in scaling or corrosion characteristics and locations. In addition, a method of obtaining inhibitor-free water samples should be provided.

APPENDIX M

Sand 8 Brine Analyses by Rice University

This appendix presents the results of analyses performed on produced brine. The brine contained about 100,000 mg/L of dissolved solids. The composition of the produced brine was typical of oil field brines and contained primarily sodium chloride. The data suggest the brine was getting fresher with time, although that conclusion is tenuous.

There were ten brine analyses performed, with the majority performed by SCAI before 1986. Average analyses are provided in Exhibit M-1. The SCAI data in Exhibit M-1 is the average brine composition for seven samples analyzed by SCAI between 1983 and 1985. Also included are the results of a December 17, 1985, sample analyzed by IGT, a September 4, 1986, sample collected by IGT and analyzed at the University of Texas Bureau of Economic Geology, and an average of four June 5, 1987, samples analyzed by Rice University. Finally, the last column is an average of the four values presented on this page, with no weighting factors such as the number of samples analyzed or the number of duplicate analyses performed on a sample. The individual analyses are presented in Exhibit M-2.

There was also an overall decline in calcium, chloride, and sodium over the life of this test. These three elements constitute 98% of the total dissolved solids present in the brine, so the data suggest the brine was getting less saline as the test proceeded. This change my be interpretted as evidence of shale de-watering or possible communication with a fresher zone. To determine whether this change is statistically significant is difficult, given the small number of brine analyses performed, the number of laboratories involved, and possible differences in sample collection and handling. Some values, such as a 38,400 mg/L sodium reported by SCAI for the August 7, 1984, sample, are believed to be erroneous simply because they are far outside the range of other analyses. Low barium concentrations reported by SCAI for samples collected from 1984 to February 1985 are also believed to be erroneous. Samples from that period that were archived were analyzed by Rice University in 1987 and were found to have close to 500 mg/L barium, rather than the 50 to 100 mg/L reported. Nevertheless, most errors are in the range of a few percent, and the average composition is a fair indication of the composition of the produced brine.

It is clear from the data that the SCAI samples were more saline than the samples collected by IGT and Rice. This is equivalent to stating that the samples analyzed during the first half of the flow test were more saline than samples analyzed during the second half of the flow test. IGT and Rice cool the brine prior to exposing the brine to atmospheric pressure. If the brine is not cooled prior to releasing pressure during sample collection, the water flashing off the 290°F brine will concentrate the remaining salts by about 6%. Whether the observed salinity change is a function of sampling procedures or of the produced brine becoming less saline is not known.

Exhibit M-1. AVERAGE BRINE COMPOSITION

	SCAI[b] 11/83-5/85	IGT 17/12/85	BEG 2/9/86	Rice 5/6/87	Average[c]
Alkalinity (HCO_3)[a]	285	488	306	477	389
Ammonia	118	72	-	-	95
Arsenic	0.007	-	<2.5	-	0.007
Barium	185	576	536	468	441
Boron	40	-	33	39	37
Bromide	-		-	-	25
Cadmium	0.02	0.11	<0.5	0.12	0.1
Calcium	3,872	3,900	3,760	3,574	3,777
Chloride	57,100	55,200	55,770	55,000	55,768
Chromium	0.04	0.06	<0.5	0.03	0.04
Copper	0.03	0.14	<0.5	0.02	0.06
Dissolved Solids	94,000	96,500	-	-	95,250
Fluoride	0.22	-	0.5	-	0.4
Iodide	-	44	-	-	44
Iron	31	27	28	31	29
Lead	0.07	<0.2	-	<1	0.07
Lithium	-	25	25	29	26
Magnesium	329	280	300	256	291
Manganese	2.1	1.9	2.0	2.1	2.0
Mercury	<0.001	<0.005	-	-	<0.05
pH (pH units)	6.6	6.8	-	-	6.7
Potassium	757	788	862	749	789
Silica (SiO_2)	125	149	101	151	132
Sodium	31,700	34,000	31,930	29,560	31,798
Strontium	448	324	336	381	372
Sulfate	1.7	<2	<10	-	<2
Zinc	0.28	0.11	<0.5	0.16	0.2
Spec. Grav.	1.064	-	-	-	1.07
Conductivity, µmho/cm	111,200	-	-	-	111,200

[a] All results in mg/L unless otherwise specified.

[b] SCAI data are mean value of seven analyses. Chloride value for August 7, 1984, sample was deleted from the data set.

[c] Average is mean of the analyses presented in this table. No weighting factors were used to account for the fact the SCAI data are an average of seven samples collected between November 1983 and May 1985. The Rice data was an average of four samples collected on June 5, 1987.

There was an extensive study of the brine chemistry performed by Cuddihee et al. of Rice University in 1987. This included the analysis presented in Exhibit M-1 plus numerous other analyses. Roughly sixty samples were analyzed for pH, alkalinity, hardness, iron, silica, chloride, and some trace metals. Most of the samples analyzed were collected between April 1986 and June and some trace metals. Most of the samples analyzed were collected between April 1986 and June 1986, although some archived samples were also analyzed. Cuddihee found a relationship between brine rates and iron concentration and also noted the decrease in chloride over an 18-month period that suggested the brine was getting fresher. He also noted a fluctuation in chloride concentration that had a range of about 3000 mg/L (5% of the total) with a periodicity of 30 to 60 days. The report is included herewith.

Exhibit M-2. GLADYS McCALL SAND 8 BRINE ANALYSES

Analysis for	Units	Nov 83	07 Feb 84	07 Aug 84	12 Oct 84	01 Dec 84	28 Feb 85	01 May 85	17 Dec 85	04 Sep 86	06 May 87
Alkalinity (HCO3)	mg/l	NA	232	288	285	288	337	281	488	306	477
Alpha (gross)	pCi/l	40	1570	72	68	60	56	35	NA	NA	NA
Ammonia	mg/l	NA	280	135	50	100	60	81	72	NA	NA
Arsenic	mg/l	0.013	0.004	<0.005	<0.005	<0.005	<0.005	0.015	NA	NA	NA
Barium	mg/l	420	60	80	44	125	95	470	576	522	468
Beta(gross)	pCi/l	340	1870	380	345	310	470	510	NA	NA	NA
Boron	mg/l	36	38.5	40.8	40.6	41.5	40.3	40.4	NA	<0.2	39
Cadmium	mg/l	0.015	0.022	0.005	0.020	0.030	0.015	0.015	0.11	NA	NA
Calcium	mg/l	4040	3643	4330	3840	3830	3730	3690	3900	3680	3574
Chloride	mg/l	59290	58700	57750	56300	55200	56600	56100	55200	55770	55000
Chromium	mg/l	0.04	<0.02	<0.02	<0.02	0.11	0.040	0.030	0.06	NA	0.03
Conductivity	µmho/cm	NA	111800	117800	109000	111400	107200	110000	NA	NA	NA
Copper	mg/l	0.015	0.075	0.035	0.020	0.020	0.035	0.035	0.14	NA	0.02
Dissolved Solids	mg/l	97800	94900	95100	93600	91700	93500	91600	96500	93000	NA
Fluoride	mg/l	0.14	0.40	0.17	0.27	0.16	0.20	0.19	NA	NA	NA
Gamma(gross)	pCi/l	1530	1290	180	150	230	180	250	NA	NA	NA
Harness (CaCO3)	mg/l	NA	NA	NA	NA	NA	NA	NA	11200	NA	NA
Iodide	mg/l	NA	NA	NA	NA	NA	NA	NA	44	NA	NA
Iron	mg/l	14.0	18.6	23.6	22.0	89.3	25.6	26.5	26.6	0.20	31.0
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	0.16	<0.05	0.08	<0.20	NA	<1
Lithium	mg/l	NA	NA	NA	NA	NA	NA	NA	24.8	23.7	29.0
Magnesium	mg/l	354	318	370	348	300	305	306	280	299	256
Manganese	mg/l	2.1	1.4	1.6	1.7	3.1	2.4	2.1	1.9	1.9	2.1
Mercury	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	NA	NA
pH	- -	NA	7.2	6.9	6.18	6.34	6.56	6.30	6.8	NA	NA
Potassium	mg/l	430	780	833	825	807	810	817	788	858	749
Radium	pCi/l	17	33	72	41	45	47	53	NA	NA	NA
Radon(gas)	pCi/l	NA	49.3	26	20	30	33	36	NA	NA	NA
Silica(SiO2)	mg/l	100	127	129	130	128	128	132	149	133	151
Sodium	mg/l	29750	30200	38400	33900	32150	31700	32550	34000	31200	29560
Specific Gravity	g/ml	1.0639	1.0637	1.0626	1.0610	1.0632	1.0666	1.0627	NA	NA	NA
Strontium	mg/l	540	473	420	440	427	400	433	324	262	381
Sulfate	mg/l	<1	<1	2.8	<1	2.0	1.1	3.3	<2.0	NA	NA
Sulfide	mg/l	NA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
Zinc	mg/l	0.29	0.26	0.28	0.24	0.21	0.28	0.37	0.11	NA	0.16
Laboratory		SCAI	SCAI	SCAI	SCAI	SCAI	SCAI	SCAI	IGT	MSL	RICE

SCAI = Scientific Consulting and Analysis, Inc.
IGT = Institute of Gas Technology
MSL = Mineral Studies Laboratory, University of Texas, Bureau of Economic Geology
RICE = Rice University

MITIGATION OF ADVERSE BRINE CHEMISTRY ASSOCIATED WITH GEOPRESSURED ENERGY PRODUCTION

by

J. Cuddihee
M. H. Salimi
E. H. Street
M. B. Tomson

FINAL REPORT

to

Institute of Gas Technology

Department of Environmental Science and Engineering
Rice University
Houston, Texas 77251

October, 1987

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ABSTRACT

Geopressured reservoirs in the Gulf Coast area are potential sources of vast quantities of energy in the form of thermal and mechanical energy and dissolved natural gas. As the brine is produced from these reservoirs the pressure reduces. This drop in pressure causes scale formation. In addition, the hot brines are often quite corrosive due to dissolved carbon dioxide.

In order to understand the brine chemistry of these produced fluids and to mitigate the adverse effects of scale and corrosion it was proposed to measure the concentration of brine components as a function of time and flow rate. About sixty different samples were measured for common bulk parameters and for trace metals. Bulk parameters such as pH, alakalinity, hardness, total dissolved solids, silicon, and iron were measured by conventional "wet" methods in the laboratory. Trace elements were measured by inductively coupled plasma arc (ICP) spectroscopy. The ICP results required two runs on each sample, one run for the higher concentration elements and one run for the element present at lower concentrations. Considerable attention was given to sample collection methods and to documenting reproducibility of each measurement procedure; this greatly facilitated intersample comparisons and trend detection.

Samples dating from March, 1983 to July, 1987, were analyzed, with emphases on samples collected during 1987. Most elements showed no statistically significant change in concentration during the study period, when appropriate corrections were made for sampling methods. The concentration of chloride seemed to decrease about 4% from 1985 to 1987 with a secondary periodicity of about sixty days, although these effects are just in the range of the overall confidence of the experiments and collection procedures. Iron exhibited the most striking change with flow rate. The concentration of iron was inversely related to flow rate to the 0.30-power with a correlation coefficient of 0.94. This strongly suggests that the steel pipe is slowly corroding at a constant rate and that as the flow increases the concentration decreases. The concentration of phosphonate remained constant at 0.15 mg/l during the study period. Finally, some scale did form in the surface equipment during the drawdown tests. This scale analyzed to be conventional "oil field" calcite containing about five mole percent iron.

I. BACKGROUND AND SUMMARY OF RESULTS

Vast quantities of recoverable natural gas may exist in deep geopresured formations along the Gulf Coast area. Initial results suggest that the produced brines are probably saturated with methane, natural gas, and carbon dioxide. These brines also contain large quantities of inorganic materials such as calcium, chloride, sodium, and bicarbonate. As the brines are produced, the pressure decreases. As the pressure drops, carbon dioxide and methane escape from solution into the gas phase. The release of carbon dioxide causes the pH to increase which increases the amount of ionic carbonate (CO_3^{2-}) in water. The increased concentration of ionic carbonate causes calcium carbonate (calcite) scale to form. Also, pressure and temperature affect the equilibrium constants of the calcite system; a drop in temperature reduces the calcite scale formation tendency and a drop in pressure increases the scale formation tendency. Generally, scale formation is controlled by the use of threshold inhibitors which interact with growing nuclei to prevent the formation of stable scale crystals. Threshold scale inhibitors include, phosphonates, polyacrylate and polymaleate.

Corrosion is generally expected to be a problem in produced hot brine with substantial carbon dioxide. Less is known about corrosion formation and control than about scale. More needs to be known about corrosion formation and the relationship of scale formation to corrosion control.

The overall objective of this project has been to perform analytical chemistry tests to better understand the constituative nature of produced geopressured fluids from the DOE Gladys McCall well. Several bulk parameters were analyzed by conventional laboratory procedures, whereas, the concentrations of metals and trace elements were determined by the newer procedures of inductively coupled plasma arc (ICP) spectroscopy. Considerable attention was given to sampling procedures and to analytical procedure statistics.

To summarize, the following conclusions have been reached relative to the composition of Gladys McCall brine. Some tests were performed on samples dating back to 31 March 1983.

1. Most elements showed no statistical change in concentration.
2. The concentration of chloride (Cl^-) appears to have decreased about 4% from 1985 to present. In addition, the chloride data shows a 30 to 60 day periodicity. The periodicity swing is about five times larger than the experimental precision.
3. The concentration of iron is inversely related to the flow rate:

$$Fe \propto \frac{1}{Flow^{0.301}}$$

   This is about what would be expected if corrosion were occurring at a mass transport controlled rate, as is probably the case.
4. When appropriate controls and standards are run, there appears to be little systematic variation between the concentration results obtained using conventional laboratory "wet" methods and the newer ICP methods. Note: "wet" methods measure Ca+Sr+Ba+Mg as "hardness" and Ca+Sr+Ba as "calcium."
5. No change in phosphonate concentration (~0.15 mg/l) in the produced brine was detected during the study period.

6. There is a significant concentration of strontium, Sr (~390 mg/l) and barium Ba (~460 mg/l) in the produced brine. Neither element showed any significant variation during the study period.

7. Occasional scale which formed in the surface equipment during the study period had the average composition:

$$Ca_{0.92}Fe_{0.05}Mg_{0.02}Sr_{0.007}Ba_{0.002}CO_3$$

This is a conventional oil or gas well calcite material.

II. BRINE SAMPLING AND ANALYTICAL PRECISION

On June 5, 1987 four consecutive one liter brine samples were collected under CO_2 for the purposes of measuring the reproducibility of the sampling procedure. Wellhead samples #1 - #4 were collected from approximately 1:45 p.m to 2:15 p.m. by the usual procedure of slowly circulating the brine through a coil of stainless steel tubing immersed in an ice bath and bubbling 100% CO_2 through the sample as the sample bottle filled.

One large bag of ice was used in collecting all four samples. The collection temperature of the first sample varied from an initial 20°C to a final temperature of 30°C. The temperature of the second sample was not measured but the final temperature of the third sample was a tepid 48°C. The temperature of the fourth sample was not measured but was assumed to be greater than 48°C. There was no ice remaining in the immersion bath at the conclusion of sampling. Samples 1 - 3 were collected in glass bottles while sample 4 was collected in the usual narrow-necked nalgene bottle.

The results of the wet chemical analyses are included in Table II-1. Table II-2 includes the results of the ICP analyses. The tables also include the results of the 6/5/87 sample collected by well site personnel (E.O.C.) earlier in the day. This sample was also collected in a CO_2 atmosphere while circualting through an ice bath. The reproducibility results are summarized graphically in Figures 1a-f.

For "wet" chemical methods the overall precisions vary from 0.4% for hardness to 5.5% for iron. There is no detectable difference between glass or nalgene collection bottles or between EOC and Rice University staff. In the following paragraphs "wet" chemical methods are compared with ICP analyses.

Comparison of ICP vs. Wet Method

June 5, 1987 Samples

Iron - In general there is excellent agreement between the Hach colorimetric method and the ICP method. Both methods measured the average of all 6/5 samples to be equal to 31.4 mg/l. It was observed that complete color development occasionally would take as long as 10 to 15 minutes. This could account for an occasional low value measured by the wet method.

Silicon - In general the colorimetric Hack method is about 15% lower than the ICP analyses. This could be due to suppressed color development in the Hach method due to "molybdate - unreactive" forms of silica in the brines. However, careful calibration of the sodium metasilicate ICP standard by the technique of known addition is also suggested to assure that emission is truly linear over the range concentrations between the standard and the samples.

Calcium - The Hach method utilizes an EDTA titration method at 13 pH to prevent interference from magnesium. However, barium and strontium are titrated along with calcium. In order to compare the two methods, the equivalent weights as calcium of barium and strontium determined by the ICP must be added to the ICP calcium measurements.

Avg. ICP conc. for all 6/5 samples	x	Calcium equivalent conversion factor	=	Equivalent mg/l calcium
Ba 468		.2916		137
Sr 381		.4568		174
Ca 3524		1		3574
Fe 31		.7168		22
		Total =		3907 mg/l as calcium

The wet method measured 4064 mg/l as calcium which is 3.8% higher than the 3907 mg/l value calculated from ICP analyses.

Hardness - The hardness titration is performed at 10 pH to enable all divalent cations (including magnesium) to be measured. The calcium equivalent of the magnesium concentration is calculated as above:

Avg. ICP conc. for all 6/5 samples	x	Calcium equivalent conversion factor	Equivalent mg/l calcium
Mg 256	x	1.648	422 mg/l as calcium

The wet method measured total hardness equal to 4510 mg/l as calcium which is 4.0% higher than the calculated ICP value of 4329.

Table II-1. Gladys McCall Well Head Samples June 5, 1987
Wet Chemical Analysis

	Rice #1	Rice #2	Rice #3	Rice #4	E.O.C.	Average	Std.Dev. (%)
Alkalinity (mg/l HCO_3^-)	491	477	474	463	482	477.4	10.3 (2.2%)
*Calcium (mg/l Ca)	4,000	4,053	4,093	4,120	4,053	4,063.8	45.6 (1.1%)
Total Hardness (mg/l as $CaCO_3$)	11,300	11,316	11,216	11,230	11,316	11,275.6	48.7 (0.4%)
Iron (mg/l)	32	31	31.6	29.4	28	30.4	1.67 (5.5%)
Chloride (mg/l)	54,000	55,000	55,233	55,500	55,200	54,987	579.5 (1.05%)
SiO_2 (mg/l)	125	126.5	126	118	115	122.1	5.2
as Si (mg/l)	(58.3)	(59.0)	(58.8)	55.1	(53.6)	(56.9)	(4.3%)
pH @ 1 atm CO_2	5.1	5.1	5.1	5.1	5.1	5.1	
Turbidity @ time of alk. test (F)	0	0	0	12	25-34		
Temperature of collected sample	20°-30°C	30°-48°C (assumed)	48°C	>50°C	?		
Container	Glass	Glass	Glass	Nalgene	Nalgene		

*Reported calcium values include barium and strontium since these elements titrate as a calcium in the EDTA titration method.

Table II-2. Gladys McCall Well Head Samples June 5, 1987 ICP Analysis (mg/l)

	Rice #1	Rice #2	Rice #3	Rice #4	E.O.C.	Avg.	Std.Dev. mg/l	% RSD
Iron	32.0	31.2	31.1	31.8	31.1	31.44	.43	1%
Boron	39.2	37.7	38.2	39.4	39.6	38.82	.83	2.1%
Silicon	71	80	72	73	57	70.6	8.38	11.8%
Magnesium	257	251	251	258	263	256	5.09	1.99%
Strontium	381	377	380	376	391	381	5.96	1.56%
Calcium	3571	3479	3535	3584	3701	3574	81.83	2.29%
Barium	467	460	458	470	487	468.4	11.50	2.46%
Sodium	29835	28915	28961	29615	30459	29557	644.5	2.18%
Lithium	32.9	28.8	26.2	28.6	27.9	28.88	2.47	8.55%
Potassium	935	705	775	663	669	749.4	112.9	15.1%
Chromium	ND	ND	ND	0.03	0.03	0.03	-0-	-0-
Manganese	2.06	2.20	2.01	2.04	1.94	2.05	0.09	4.65%
Cadmium	0.11	0.15	0.11	0.10	0.14	0.122	0.02	17.7%
Copper	0.02	0.01	0.02	0.02	0.01	0.016	0.0055	34%
Lead	ND	ND	ND	ND	ND	-0-	-0-	-0-
Zinc	0.22	0.13	0.16	0.13	0.14	0.156	0.0378	24%

Figure II-1.a-f. Graphical comparison of sampling procedures and ICP vs. wet analyses.

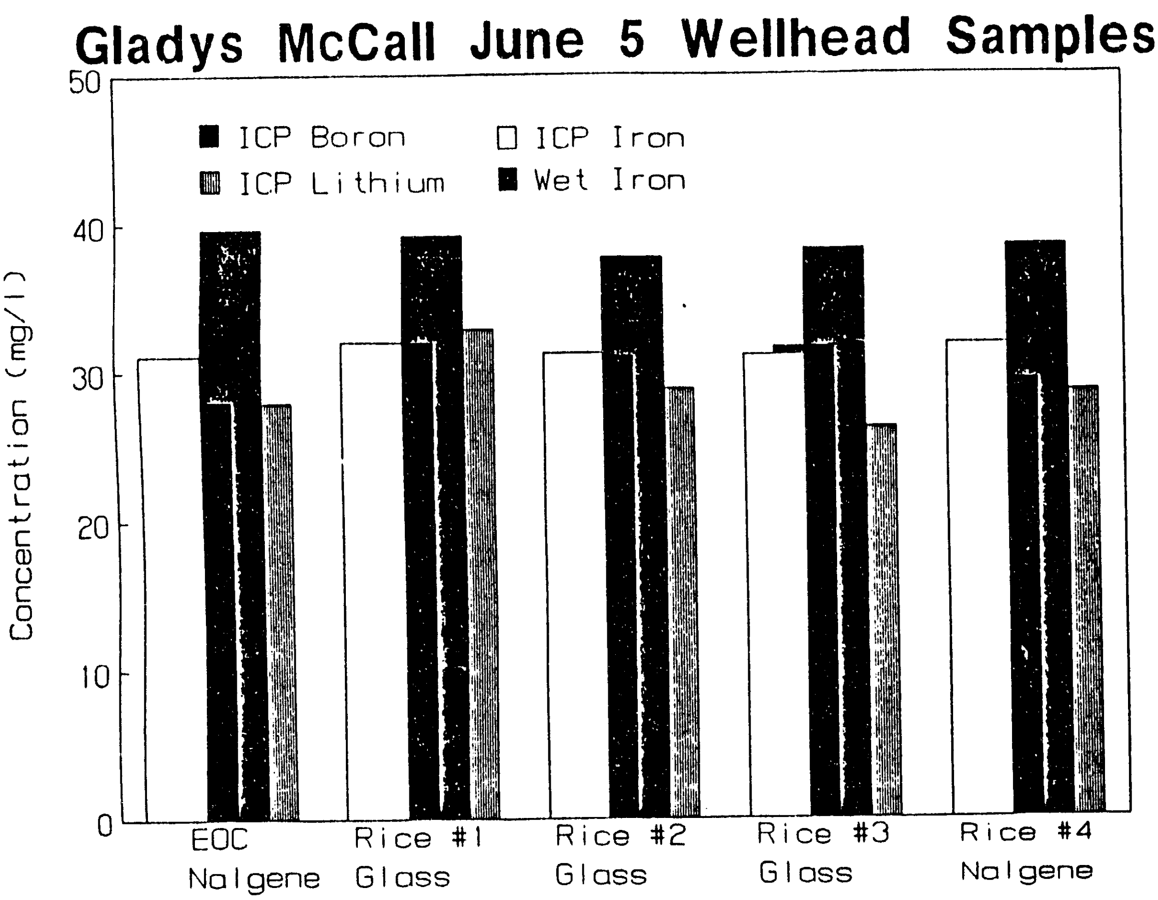

Gladys McCall June 5 Wellhead Samples
ICP Boron
ICP Iron
ICP Lithium
Wet Iron
Concentration (mg/l)
0
10
20
30
40
50
EOC Nalgene
Rice #1 Glass
Rice #2 Glass
Rice #3 Glass
Rice #4 Nalgene

Figure II-1a.

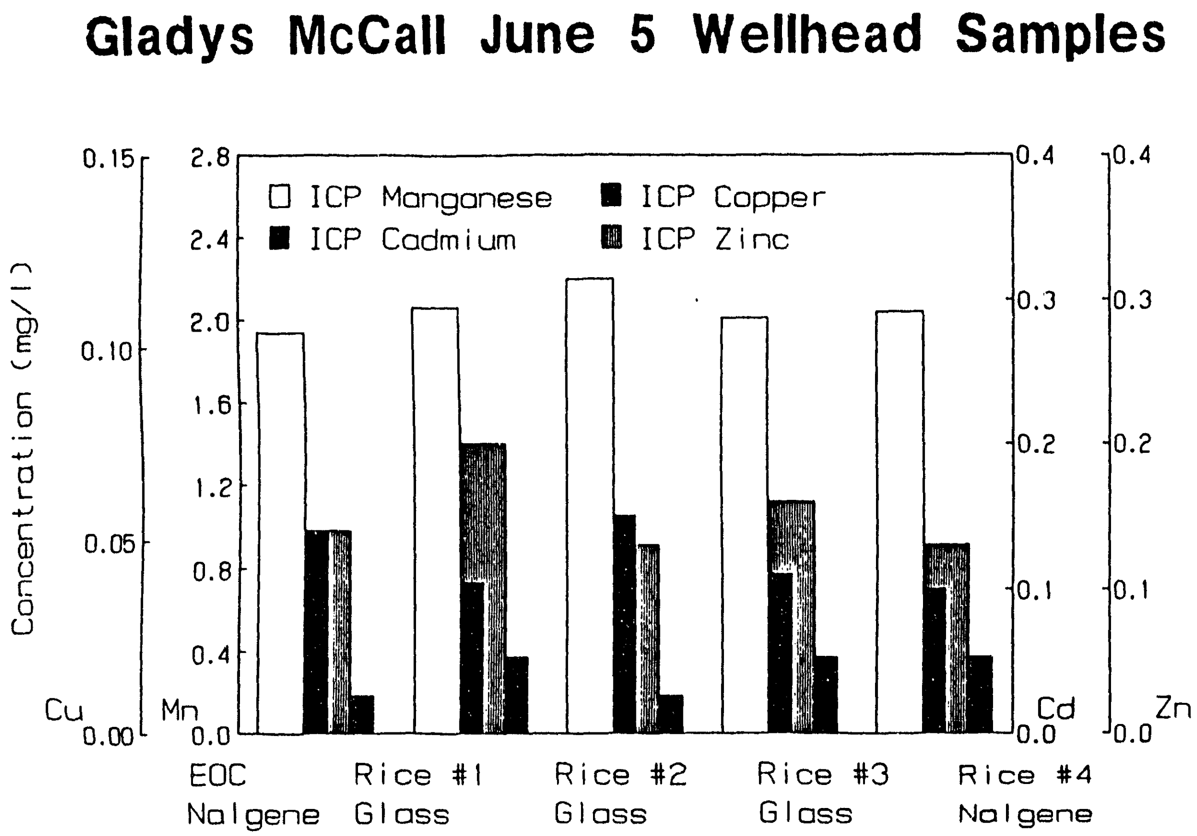

Gladys McCall June 5 Wellhead Samples
ICP Manganese
ICP Copper
ICP Cadmium
ICP Zinc
Concentration (mg/l)
0.15
0.10
0.05
0.00
Cu
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
Mn
0.4
0.3
0.2
0.1
0.0
Cd
0.4
0.3
0.2
0.1
0.0
Zn
EOC Nalgene
Rice #1 Glass
Rice #2 Glass
Rice #3 Glass
Rice #4 Nalgene

Figure II-1b.

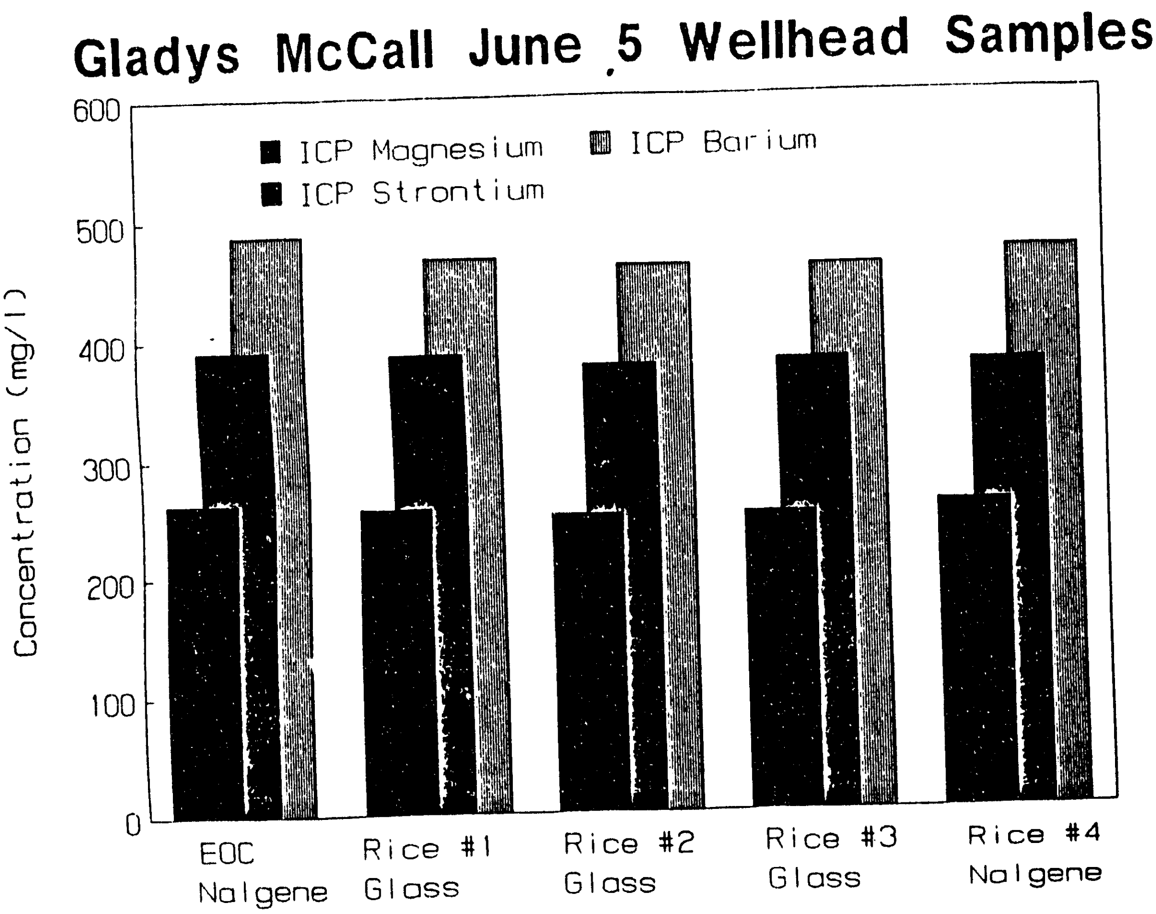

Gladys McCall June 5 Wellhead Samples
ICP Magnesium
ICP Barium
ICP Strontium
Concentration (mg/l)
600
500
400
300
200
100
0
EOC Nalgene
Rice #1 Glass
Rice #2 Glass
Rice #3 Glass
Rice #4 Nalgene

Figure II-1c.

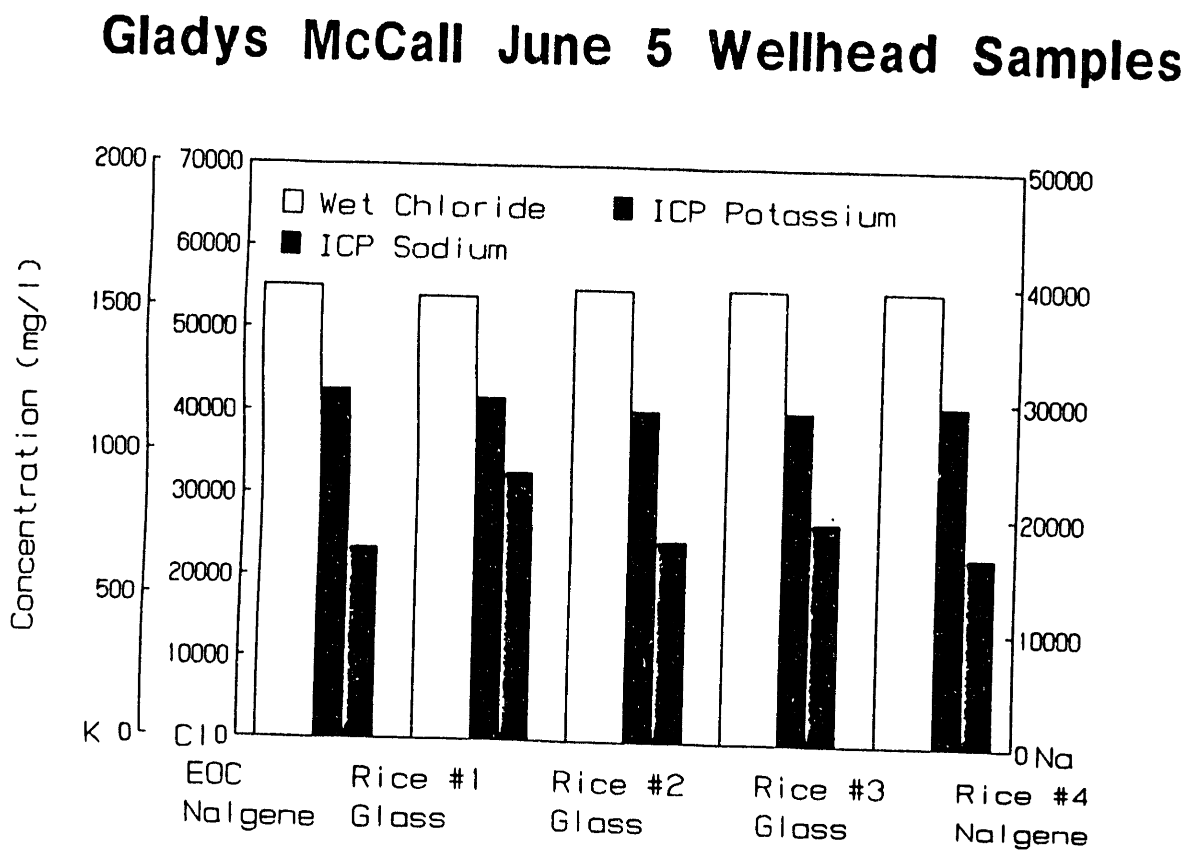

Gladys McCall June 5 Wellhead Samples
Wet Chloride
ICP Potassium
ICP Sodium
Concentration (mg/l)
2000
1500
1000
500
K 0
70000
60000
50000
40000
30000
20000
10000
Cl 0
50000
40000
30000
20000
10000
0 Na
EOC Nalgene
Rice #1 Glass
Rice #2 Glass
Rice #3 Glass
Rice #4 Nalgene

Figure II-1d.

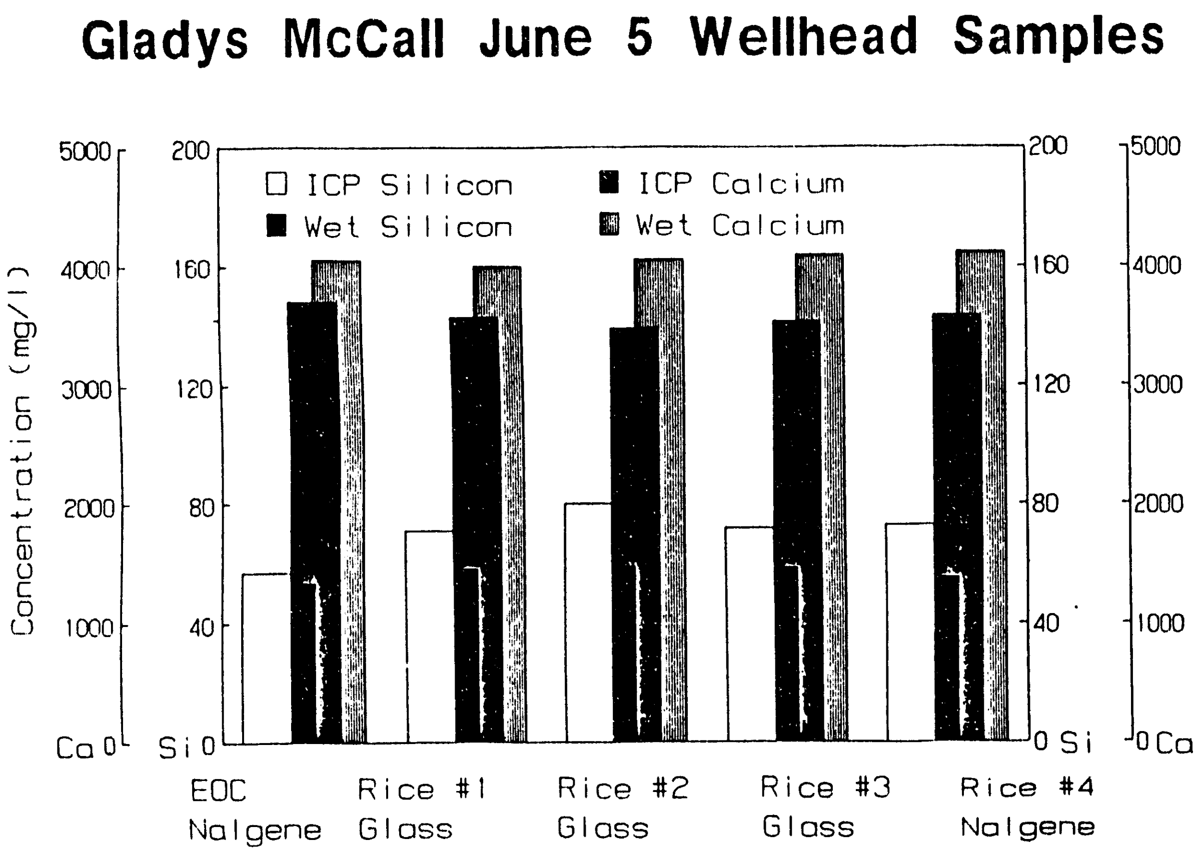

Gladys McCall June 5 Wellhead Samples
ICP Silicon
ICP Calcium
Wet Silicon
Wet Calcium
Concentration (mg/l)
5000
4000
3000
2000
1000
Ca 0
200
160
120
80
40
Si 0
0 Si
0 Ca
EOC Nalgene
Rice #1 Glass
Rice #2 Glass
Rice #3 Glass
Rice #4 Nalgene

Figure II-1e.

Gladys McCall June 5 Wellhead Samples

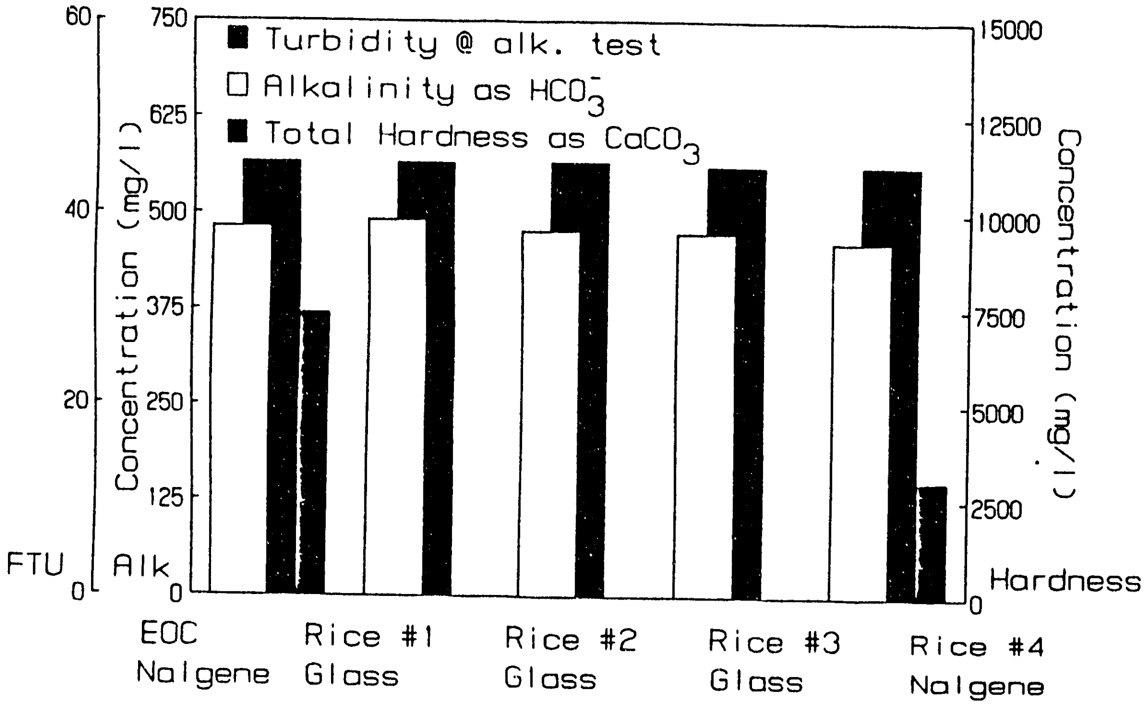


Figure II-1f.

III. BULK PARAMETER ANALYSES

Summary

The results of wet chemical analyses on Gladys McCall brine samples from April 13 through May 11 are presented in Tables III-1 and III-2. There does not appear to be a significant discernable change in the major element composition of the brine over the time period studied. However, the alkalinity does exhibit statistically significant changes in certain samples. The observed decrease in alkalinity (15 mg/l) following the April 13/14 flow test may be interpreted in terms of calcium carbonate scale formation. The weight of scale expected (88 lbs.) from the measured decreased in alkalinity is reasonably consistent with the reported occurrence in the field. (It should also be noted that the associated decrease in Ca^{2+} for this amount of scale would be too small to be detected given the precision of our calcium analysis). The observed location of scale downstream of the choke is also expected from the saturation index equation (Appendix III-1).

However, examination of the data over the entire 4 week period creates a more complicated picture. In the 3 weeks following the initial flow test, flow conditions were not conducive for scaling at the well head, yet two well head samples had appreciably lower alkalinities than had previously been measured (400 mg/l). Also, the variation in alkalinity between daily samples during periods of stabilized flow exceeded the variation previously discussed for the April 13/14 flow test. Therefore, the possibility that the variation in measured alkalinity is not related to scale formation in the well or surface equipment should be considered. One possibility is that the variation is related to the sample collection process. Another possibility is that the alkalinity of the produced formation brine is actually variable due to complex

geochemical or reservoir processes not yet understood. Otherwise, if one adopts the notion that all significantly large changes in alkalinity are the result of $CaCO_3$ scaling, then the data presented here would imply that the scaling process may be episodic.

4/13/87 to 4/14/87 Flow Test

The 4/13/87 12:50 p.m. pre-test samples were taken while the well was producing at an approximate rate of 23,000 barrels per day. Well head pressure was approximately 1140 psia* and the low-pressure separator was at approximately 400 psi. Immediately after sampling at 1:20 p.m. the temperature of the brine was 284°F (with an ambient temperature of 77°F) and the calculated bottom hole pressure was 8590 psia.

At noon on 4/14/87 the choke was opened to reduce well head pressure. By 12:30 p.m. the well head pressure had decreased to 710 psi and the first and second stage separators were at 502 and 432 psi, respectively. The brine production rate was about 27,000 barrels per day. The well flowed for four hours at these conditions until post-test samples were taken from 4:30-5:00 p.m. when the well head, low-pressure separator and disposal well were at approximately 709, 435 and 345 psi, respectively. Prior to the 4:30 p.m. brine sampling, no evidence of scale was detected by wellsite personnel on visual examination of coupons in the surface equipment at approximately 3 p.m. In addition, there was no discernable change in the differential pressure across the disposal well filters. A change in pressure would be expected if calcite nuclei suspended in the brine were large enough to be trapped by the filters.

*Production rates, pressures, and temperatures were taken from J.L.C.'s field notes and do not represent "official" conditions.

The well continued to flow for approximately one day until it was shut-in to repair the surface equipment. While the well was shut-in, a visual examination of the choke showed that scale was indeed present at the choke and immediately downstream of the choke. Scale formation downstream of the choke was expected considering the decrease in pressure of 643 psi across the choke during the flaring operation. At 2:04 p.m. on 4/13/87 a wellhead pressure of 1150 psi was recorded and a first stage separator pressure of 507 psi (The original first stage separator pressure was approximately 950 psi prior to flaring @1:15 p.m.).

The change in the saturation index due to pressure effects from bottomhole to wellhead before the test was $\Delta SI = 1.427$. Following the choke adjustment, ΔSI increased to 1.644 (Appendix). Previous experience with the Gladys McCall #1 well showed that scale formed when ΔSI exceeded 1.30 (GRI Annual Report, 1985 p. 3-9). Therefore, in the absence of inhibitors, downhole scale formation would be expected.

Brine Chemistry

Analyses of subsequent samples are summarized in Table III-2. These data are also displayed in Figures III-1a-i, III-a,b, for the purpose of comparing the changes that were measured in the following four weeks. This discussion will focus on those species related to calcium carbonate scale formation.

The alkalinity was determind by potentiometric titration and reported as mg/l bicarbonate ion (HCO_3^-). Calcium was measured by the Hach method involving an EDTA titration at a pH of 13 to remove magnesium interference. Preliminary ICP analysis of the Gladys McCall brine measured the barium and strontium concentration at approximately 500 and 400 mg/l respectively, indicating that calcium is by far the major divalent cation.

Calcium carbonate scale formation can be thought of as an equal number of calcium cations and bicarbonate anions combining to produce the same number of insoluble calcium carbonate species and hydrogen ions:

$$Ca^{2+} + HCO_3^- \longrightarrow CaCO_{3(s)} + H^+$$

Since the scaling reaction occurs on a molecule for molecule basis, the relative weight loss of Ca^{2+} and HCO_3^- will be proportional to their molecular weights. Therefore, only 40 grams of calcium will react with 61 grams of bicarbonate in the formation of 100 grams of $CaCO_3$. The released proton, H^+, will neutralize one additional bicarbonate ion.

The measured decrease in the system's alkalinity following the flow test of approximately 15 mg/l as bicarbonate would only result in a decrease of 5 mg/l of calcium. The analytical precision of the alkalinity titration is ± 5 mg/l while the precision of the calcium test is ± 50 mg/l. Hence, the formation of small amounts of scale (100 lbs.) could be measured by a decrease is alkalinity (15 mg/l) but would probably not be detected by the calcium method (10 mg/l). The calcium and alkalinity are plotted on the same scale in Figure III-1i.

The decrease in alkalinity <u>can</u> be interpreted in terms of the weight of $CaCO_3$ that would be necessary to produce the observed change in alkalinity. Applying the saturation index equation at various points and times in the flow stream predicts the greatest tendency for scaling would have occurred downstream of the choke during the flaring operation (Appendix III-1). Since these flow conditions continued for 22 hours, a calculated weight of 88 pounds of scale was expected.

The apparent agreement between the measured chemistry and the actual observed scale, lends credence to the notion that alkalinity is a sensitive indicator of scale in the Gladys McCall well. However, the wellhead data from April 20-May 11 show much larger variation in bicarbonate alkalinity than had been measured in the April 13/14 flow test. The question then becomes, are these variations due to a scaling phenomenon or are they related to other processes?

4/20/87 through 5/11/87 Well Head Samples (Table 2)

Figure III-2a shows the production rate and Figure III-2b shows well head pressure through May 11. The flow rate was steadily decreased from 24,000 BPD to 9,000 BPD in three weekly increments of 5,000 BPD. The corresponding well head pressure increased from approximately 1100 psia to 2700 psia over the same time period. It is generally accepted that these flow conditions are not conducive to scaling relative to the 4/14 conditions. Nevertheless, the 4/27 and 5/11 well head samples had significantly lower alkalinities than all other samples. The decrease of 85 mg HCO_3/l between 4/20 and the 4/27 samples could be the result of scaling in either of two places; 1) the formation of about 250 lbs of scale in the downhole production tubing or 2) the precipitation of only 35 milligrams of $CaCO_3$ in the sample collection line during the course of collecting a one liter sample. The most likely location would be that portion of the stainless steel coil tubing between the ice bath and the sampling port. Note that calcium decreased by 180 mg/l when only a 28 mg/l loss would have been expected. Alternatively, this reduction could be due to inherent variation in the produced brine due to reservoir or non-scaling geochemical processes.

Probably the most perplexing aspect of the alkalinity data is the return to "baseline" levels of 475-500 mg/l in the May 4th sample following the low value of April 27th. Significant daily fluctuation can also be seen for the week of May 4 through May 11. If we accept scaling as the operative process to account for this variation, it is logical to conclude that scale formation is intermittent (either in the down-hole tubing, or in the sample collection tubing).

Finally a brief discussion of the remaining measurements is presented:

<u>Chloride</u>	Chloride is clearly the dominant anion present averaging 54,400 mg/l ± 1%.
<u>Total Hardness</u>	The total hardness test is very similar to the calcium test but includes a measurement of magnesium plus strontium, plus barium. The end-point is much sharper than the calcium test and is therefore considered to be more reliable.
<u>Total Iron and Silica</u>	Both measurements are colorimetric and both elements are subject to post-sampling precipitation; silica due to temperature effects and iron due to oxidation. The variation of iron with flow rate will be discussed later.
<u>Sulfate</u>	The Gladys McCall brine contains only 2-4 mg/l sulfate or less. The detection limit is in this range.
<u>pH</u>	The pH was measured prior to the alkalinity titrations when the sample was equilibrated with 1 atmosphere of CO_2 by bubbling CO_2 through

the sample for approximately 30 minutes. The excellent agreement between pH and alkalinity (Figures III-1a and III-1b) would be expected if scaling were taking place either in the system or during sampling. The correlation coefficient between alkalinity and pH is $r = 0.86$, or $r^2 = 0.74$ (i.e., 74% of the variation in pH can be accounted for by a linear variation in alkalinty).

Table III-1. 4-13-87 to 4-14-87 Gladys McCall Flow Test

	Well Head Before Test 4/13/87 12:50 pm	Well Head After Test 4/14/87 4:15 pm	Low Press Separator Before Test 4/13/87 11 am	Low Press Separator After Test 4/14/87 4:30 pm	Disposal Well After Test 4/14/87 4:50 pm	Remarks
Alkalinity mg/1 as HCO_3^- (± 5 mg/1)	497	485	500	485	479	Potentiometric titration under 1 atmosphere CO_2
Calcium mg/1 (± 50 mg/1	4,060*	4,068	4,000	3,987	3,880	EDTA titration at pH 13*
Total Hardness mg/1 as $CaCO_3$ (± 100 mg/1)	11,200	11,325	**	11,025	10,730	EDTA titration at pH 10
Chloride mg/1 (± 300 mg/1)	54,200	54,350	54,300	54,400	54,100	Mercuric Nitrate titration
Iron mg/1 (± 2 mg/1)	28	28	**	26	26	Colorimetric method
S_iO_2 mg/1 (± 2 mg/1)	128	127	**	127	124	Colorimetric method
Sulfate mg/1 (± 1 mg/1)	3	4	3.5	3.5	2.5	Turbidimetric method
Conductance (μmhos/cm) @25°C	111,000					
Phosphonate mg/1	0.13	0.11				Complexametric method utilizing an isobutanol extraction
pH (under 1 atm. CO_2)	5.20 @19°C	5.17 @24°C	5.19 @20°C	5.19 @20°C	5.18 @21°C	Measured under 1 atmosphere CO_2

*Barium and strontium are titrated as calcium by this method
**Sample precipitated before analysis could be completed

Table III-2. Gladys McCall Well Head Samples 4-20-87 through 5-11-87

	4/20	4/27	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11
Alkalinity mg/l as HCO_3^- (± 5 mg/l)	475	390	494	476	464	457	482	457	506	415
Calcium mg/l (± 50 mg/l)	4,120*	3,940	3,960	3,920	3,860	3,850	3,950	3,960	3,890	3,988
Total Hardness mg/l as $CaCO_3$ (± 100 mg/l)	11,375	11,000	11,000	10,950	11,133	11,150	11,067	11,083	10,900	11,083
Chloride mg/l (± 300 mg/l)	54,575	54,300	54,800	53,800	53,900	54,725	54,800	54,500	54,300	55,000
Iron mg/l (± 2 mg/l)	24.5	26	27	30.5	31.8	31.5	32.5	33.3	35.3	31.5
SiO_2 mg/l (± 2 mg/l)	122.5	123.5	112.3	117.3	124.5	115	120.5	122	125	122
Sulfate mg/l (± 1 mg/l)		4			3.5		2.5		2	
pH (under 1 atm CO_2)	5.12 @23°C	5.00 @24°C	5.13 @23°C	5.14 @24°C	5.07 @22°C	5.12 @22°C	5.11 @211°C	5.10 @21°C	5.17 @21°C	4.98 @20°C

*Barium and strontium are titrated as calcium in this method.

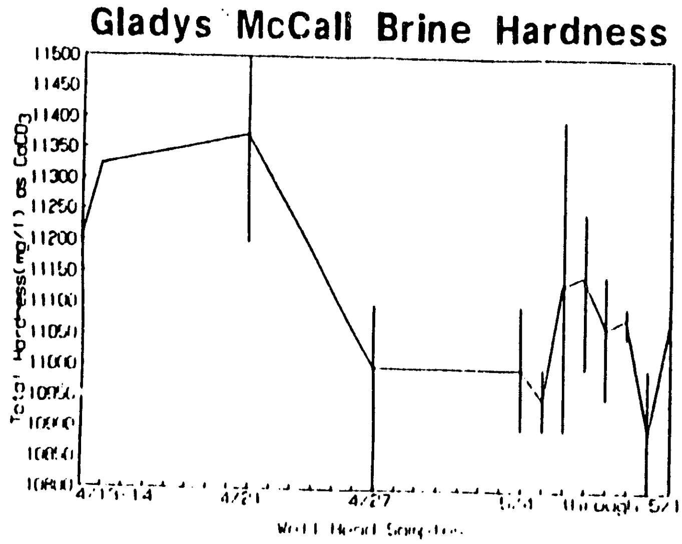


Figure III-1d.

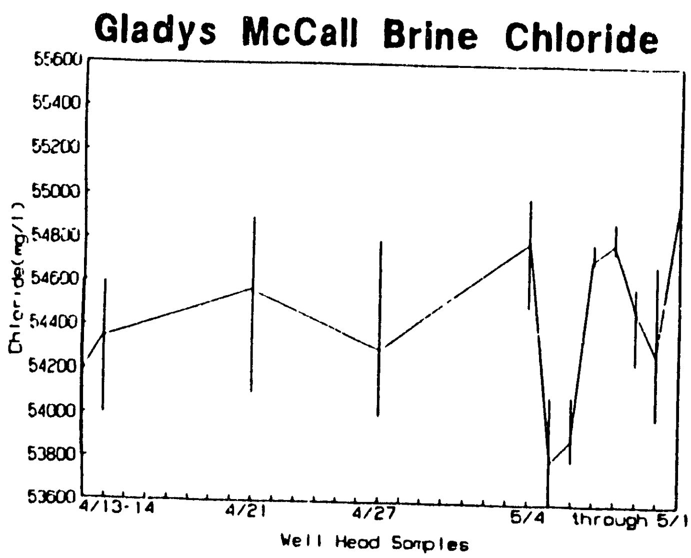


Figure III-1e.

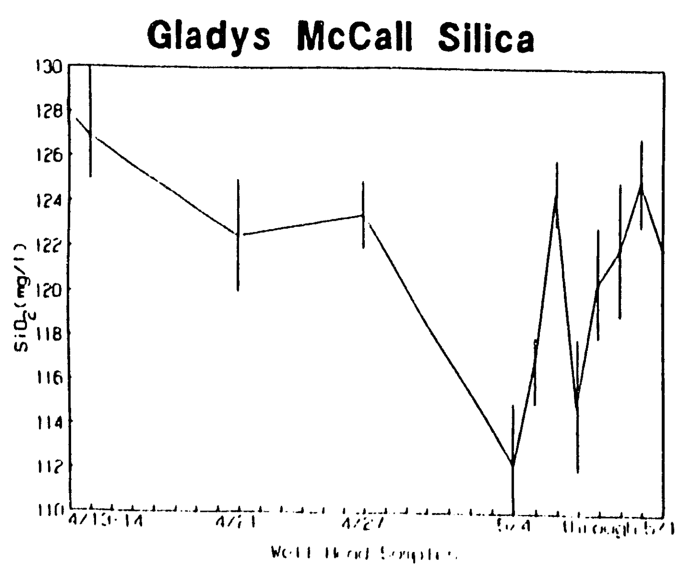


Figure III-1f.

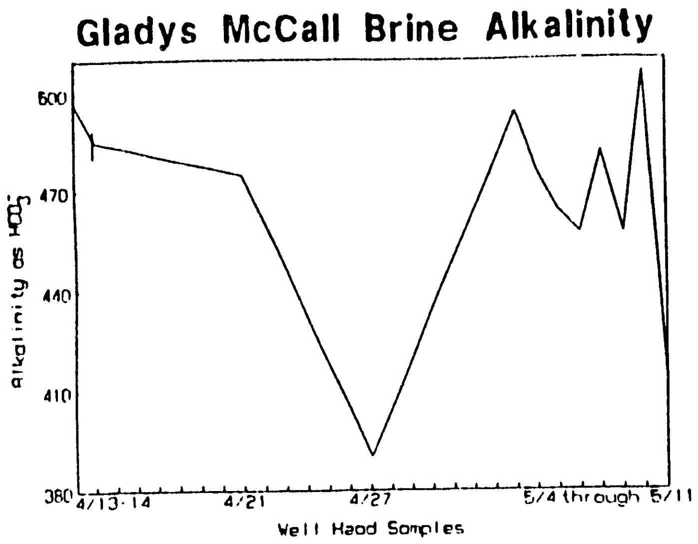


Figure III-1a.

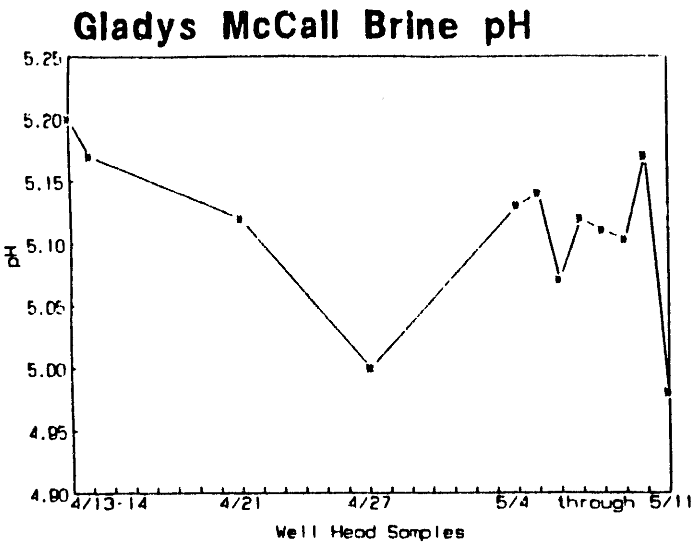
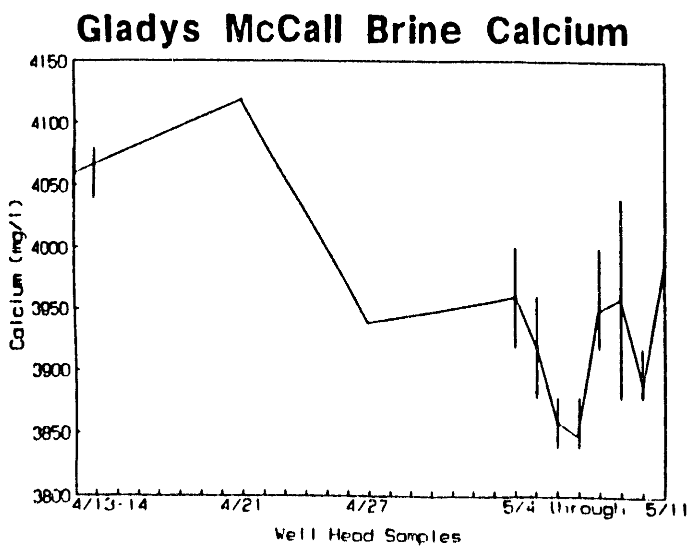


Figure III-1b.



Gladys McCall Brine Iron

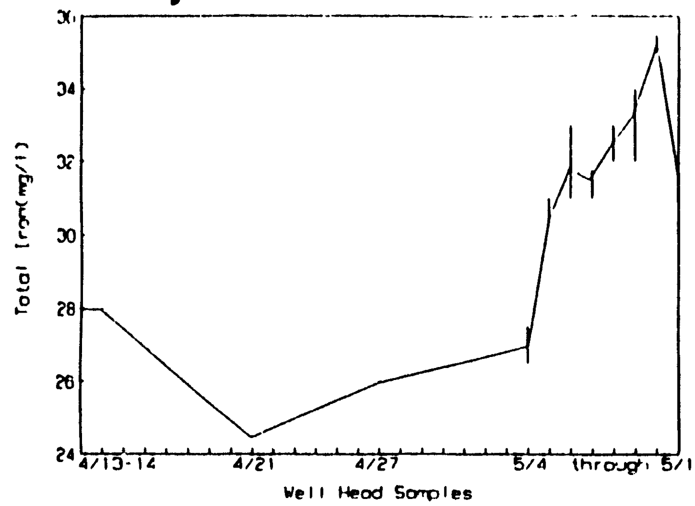


Figure III-1g.

Gladys McCall Sulfate

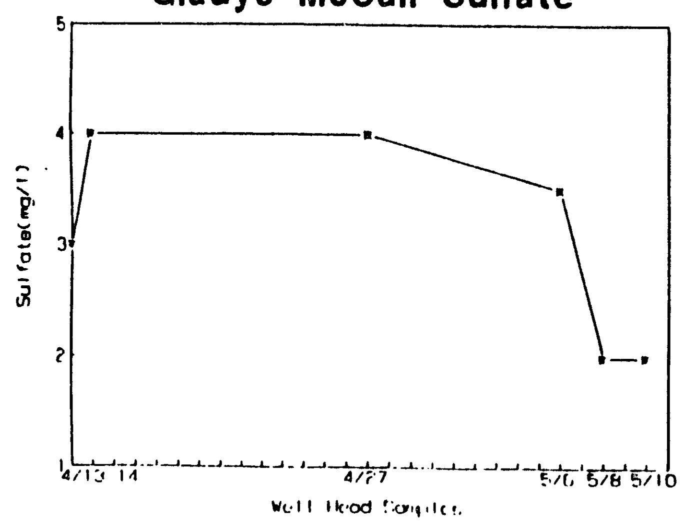


Figure -1h.

Gladys McCall Brine

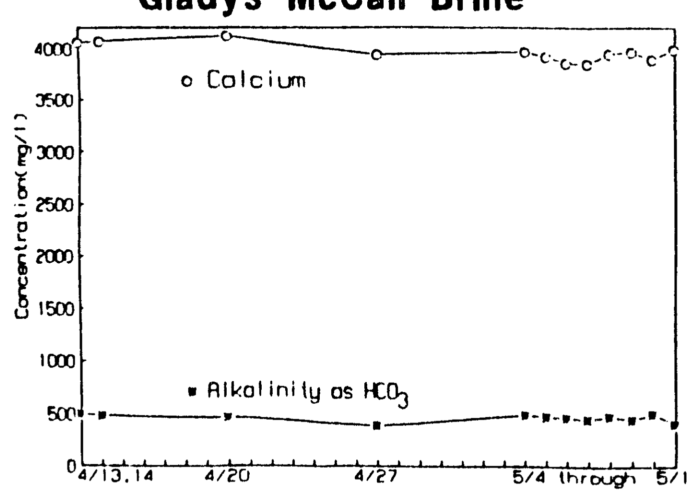


Figure III-1i.

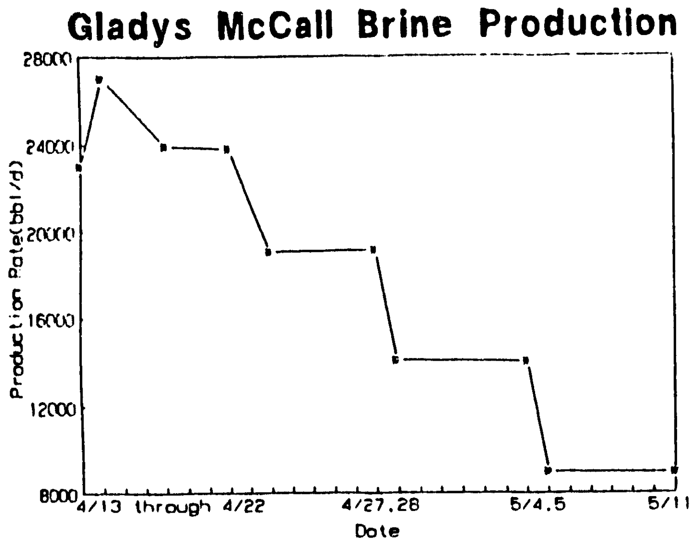


Figure III-2a.

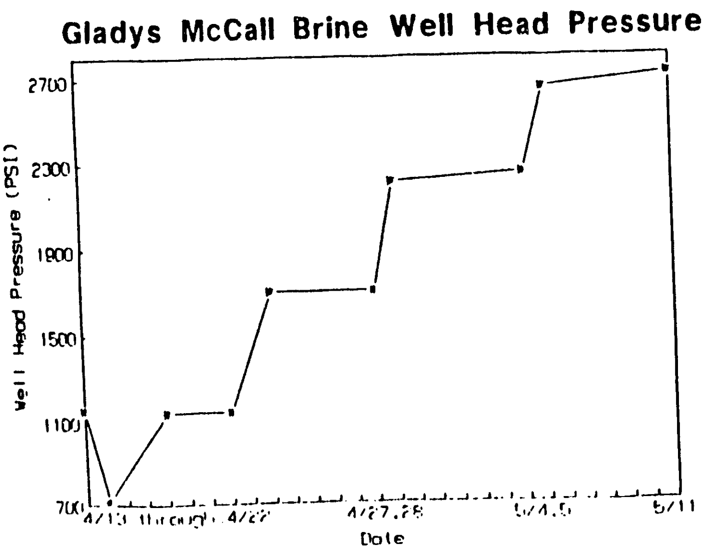


Figure III-2b.

Appendix III-1

Oddo and Tomson's least squares approximation of the saturation index equation takes into account temperature, pressure and ionic strength effects on $CaCO_3$ solubility:

$$SI = \log \frac{T_{Ca} Alk^2}{P X_{CO_2}} + 5.89 + 1.549 \times 10^{-2} T - 4.26 \times 10^{-6} T^2$$

$$- 7.44 \times 10^{-5} P - 2.526\ IS^{1/2} + .920\ IS$$

where TCa(molar) = (mg/l Ca)/40000

Alk (molar) = (mg/l HCO_3)/61000

IS (molar) = Conductance (μmho/cm)/66667

XCO_2 = mole fraction of CO_2 in gas phase

P = pressure in psia

T = temperature in °F

The total change in the saturation index, ΔSI, between any two points in the brine stream is defined as the sums of the changes resulting from P, T, Ca, Alk, P_{CO_2} and IS independently:

$$\Delta SI = SI_2 - SI_1$$

$$= \Delta SI_P + \Delta SI_T + \Delta SI_{Ca} + \Delta SI_{Alk} + \Delta SI\ PCO_2 + \Delta ST_{TDS}$$

The more positive ΔSI becomes, the greater the tendency to scale.

For the purposes of this discussion we will assume that changes in temperature, calcium, alkalinity, partial pressure of CO_2 and ionic strength will be much smaller than the pressure changes experienced during the flow test. Therefore, considering only the pressure terms in the above equation:

$$\Delta SI = SI_{P_2} - SI_{P_1}$$

where SI_{P_2} and SI_{P_1} are the pressure constributions to the saturation indices at points 2 and 1 in the flow stream:

$$= \log \frac{T_{Ca}Alk^2}{P_2X_{CO_2}} - 7.44 \times 10^{-5}P_2 - \log \frac{T_{Ca}Alk^2}{P_1X_{CO_2}} - 7.44 \times 10^{-5}P_1$$

Assuming the following average parameters for sand zone #8:

T_{Ca} (molar) = (4,000 mg/l Ca)/40000 = .1000
Alk (molar) = (485 mg/l HCO_3)/61000 = .0079
IS (molar) = (110,000 μmho/cm)/66667 = 1.6499
X_{CO_2} (molar) = 0.09

We can rewrite the above equation as:

$$\Delta SI = \log \frac{7.024\times10^{-5}}{P_2} - 7.44 \times 10^{-5}P_2 - \log \frac{7.024\times10^{-5}}{P_1} - 7.44 \times 10^{-5}P_1$$

Cancelling and rearranging:

$$= -\log P_2 + \log P_1 + 7.44 \times 10^{-5}(P_1 - P_2)$$

$$\Delta SI = \log \frac{P_1}{P_2} + 7.44 \times 10^{-5}(P_1 - P_2)$$

Note that the resulting equation is independent of brine chemistry.

Applying the same ΔSI equation over the flow stream from the <u>bottom-hole to the well head</u> at various times gives:

1. Before flaring (1 p.m. 4/13/87):

   Bottom-hole (P_1) to well head (P_2)

   P_1 = 8590 psi

   P_2 = 1150 psi

$$\Delta SI_{before\ flare} = \log \frac{8590}{1150} + 7.44 \times 10^{-5}(8590-1150) = \underline{1.427}$$

2. After choke adjustment (noon 4/14/87)

   Bottom-hole (P_1) to wellhead (P_2)

   P_1 = 8395 psi

   P_2 = 710 psi

$$\Delta SI_{after\ choke\ adjustment} = \log \frac{8395}{710} + 7.44 \times 10^{-5}(8395-710) = \underline{1.644}$$

IV. ICP ANALYTICAL RESULTS FOR METALS AND TRACE ELEMENTS

Inductively coupled plasma (ICP) arc spectroscopic results for 16 metals and trace elements are presented in Table IV-1. From preliminary screening the elements in Table IV-1 were grouped into two groups based upon concentration. These two groups were run separately, each along with appropriate standards in a matrix matched solution.

Graphical data comparisons and discussion are presented in Section V.

Table IV-1. ICP Analytical Results for Metals and Trace Elements

Sample: (ppm)	3/31/83	10.27/83 sep/filtered	3/6/85 DI	2/27/87 W	2/27/87 F	4/13/87	4/14/87	4/20/87	4/27/87 A	B	Avg.	
Fe	29.1	18.3	37.0	34.3	23.7	25.5	26.1	25.8	23.9	23.1		
	28.7				24.5	25.2	25.3		24.0	23.2		
B	35.2	60.9	31.5	40.0	40.1	39.5	40.9	42.3	38.9	39.1		
	32.7				39.8	39.9	40.4		40.2	39.8	39.5	
Si	49	49	53	61		61	59	57	51			
	45		68		67	66	55		64	60	58	
Mg	205	288	193	257	255	255	261	259	252	253		
Sr	301	415	284	390	380	389	396	389	382			
Ca	3035	4753	2739	3557	3576	3587	3600	3593	3492	3508		
Ba	355	503	334	468	464	463	474	465	456	461		
Na	21654	32875	21394	29449	29364		29783	30156	302q4	29665	29697	29681
Li	23.8	37.2	21.3	29.5	36.9	31.7	32.5	30.0	31.4	31.7		
K	698	953	557	868	1193	848	882	593	843	760	802	
Cr		0.05	0.07	0.03		0.02	ND	ND	0.03			
Mn		1.93	2.01	1.87		1.84	1.90	1.88	1.77			
Cd		0.15	0.11	0.13		0.14	0.14	0.12	0.13			
Cu		0.03	0.03	0.04		0.03	0.01	0.01	0.02			
Pb		ND	ND	ND		ND	ND	ND	ND			
Zn		1.81	0.15	0.19		0.17	0.09	0.13	0.13			
Alkalinity						497	485	475	390			
pH												
Flow rate						23.5	23.5	24				

Table IV-1 (cont'd)

Sample: (ppm)	5/4/87	5/5/87	5/6/87	5/7/87	5/8/87	5/9/87	5/10/87	5/11/87	5/12/87	5/13/87	5/14/87
Fe	28.4	31.5	31.3	31.5	30.8	33.4	32.6	28.0	41.1	40.6	42.5
				31.4		32.1		27.5			
B	40.5	40.3	39.4	39.7	39.7	42.1	39.7	42.0	40.9	39.6	39.7
				40.4		3/8		39.7			
				40.4		40.9		40.5			
Si	52		60	66		62		60		59	
				68	67		65				
Mg	261	256	259	255	255	255	252	259	259	250	255
Sr	391	380	386	388	374	386	380	390	385	388	380
Ca	3594	3599	3575	3491	3491	3612	3581	3626	3564	3561	3529
Ba	471	469	465	457	456	464	464	477	471	476	465
Na	29452	29668	29842	29765	28606	29874	29122	29581	30096	29667	29281
Li	33.4	30.6	34.0	31.5	37.7	31.9	32.7	32.2	31.6	31.4	30.9
K	928	594	851	824	1164	900	962	952	917	1130	747
Cr	0.05		0.05		2.01		0.01		ND		0.04
Mn	1.88		1.95		2.00		2.01		2.07		2.06
Cd	0.15		0.16		0.13		0.13		0.12		0.17
Cu	0.01		0.02		0.01		0.02		0.01		0.01
Pb	ND		ND		ND		ND		ND		ND
Zn	0.14		0.16		0.12		0.15		0.16		0.13
Alkalinity	494	476	464	457	482	457	506	415	497	458	
pH									5.17		
Flow rate	14	9	9	9	9	9	9	9	4.5	4.5	

Table IV-1 (cont'd)

Sample: (ppm)	5/15/87	5/16/87	5/17/87	5/18/87	5/19/87	5/20/87	5/21/87	5/22/87	5/23/87 Geo	EMVI	Avg
Fe	39.5	43.0	37.4	40.9	30.3	30.4	31.2	32.2	31.0	38.4	
			39.1		30.0		31.3	32.6			
			38.3								
B	39.6	39.5	38.9	38.9	41.8	38.9	39.5	40.8	38.0	38.7	
			4.0		40.0		40.7	40.6			
			39.5		40.9		40.1				
Si		64	63	63	65	63	72	70		66	
			68		67		69	70			
Mg	258	254	255	252	256	252	250	256	249	256	
Sr	385	383	387	385	384	380	385	386	375	378	
Ca	3591	3563	3495	3566	3636	3512	3568	3522	3506	3568	3537
Ba	465	469	461	460	468	469	469	460	451	464	458
Na	29810	29316	29137	29526	29741	29763	28929	29787	29106	29682	29394
Li	29.7	36.7	32.2	30.5	31.5	27.9	30.6	31.6	31.6	29.2	30.4
K	615	835	835	733	911	646	788	900	842	904	873
Cr		0.05	0.03	0.13	0.02	0.03	0.04	0.04		0.11	
Mn		2.14	2.19	2.16	1.98	2.06	2.13	2.08		2.02	
Cd		0.12	0.06	0.05	0.13	0.10	0.11	0.14		0.11	
Cu		0.02	0.02	0.03	0.01	0.02	0.02	0.03		0.02	
Pb		ND	ND	ND	ND	ND	ND	ND		ND	
Zn		0.10	0.09	0.15	0.11	0.15	0.23	0.11		0.09	
Alkalinity		470	503	470		472	505	482			
pH			5.14					5.18			
Flow rate	4.5	4.5	4.5	4.5	10	10	10	10	10		

Table IV-1 (cont'd)

Sample: (ppm)	5/24/87	5/25/87	5/26/87	5/27/87 GEO	Envi	Avg 87	5/28/87	5/29/87	5/30/87	5/31/87	6/1/87
Fe	30.2	31.7	33.3	32.4	31.7		31.6	31.6	32.3	32.3	33.6
			32.9							32.4	
B	38.9	38.9	40.4	40.4	39.1	39.8	39.9	39.4	39.6	40.4	39.1
			39.0							39.6	
			39.7								
Si	67	68	66		68		59	68	72	66	71
			70							69	
Mg	253	253	259	260	255		254	256	256	257	253
Sr	381	378	384	389	382		382	388	380	385	380
Ca	3531	3452	3597	3626	3577	3602	3557	3538	3555	3555	3532
Ba	462	459	463	472	461	467	464	459	459	469	454
Na	29485	29089	29717	29995	29798	29897	29200	29596	29337	39703	30275
Li	26.6	26.5	30.9	33.0	27.1	30.1	29.6	33.5	38.0	30.9	31.1
K	771	1114	770	1165	762	964	1072	1175	1363	822	778
Cr	0.03	0.05	0.07		0.02		0.01	20.01	ND	0.05	20.01
Mn	1.99	2.06	2.03		2.02		2.09	1.98	2.09	2.05	2.06
Cd	0.17	0.13	0.10		0.13		0.11	0.09	0.17	0.12	0.16
Cu	0.01	0.01	0.02		0.01		0.02	0.03	0.01	0.03	0.01
Pb	ND	ND	ND		ND		ND	ND	ND	ND	ND
Zn	0.15	0.12	0.13		0.12		0.14	0.11	0.14	0.15	0.13
Alkalinity		464	494					476		506	
pH			5.19							5.15	
Flow rate	10	10	10	10			10	10	10	10	10

Table IV-1 (cont'd)

Sample: 6/5-1 (ppm)	6/2/87	6/3/87	6/4/87	6/5/87 EOC	6/5-1 GEO	Envi	6/5-2	6/5-3	6/5-4
Fe	31.0	7.88	32.5	31.1	31.1	32.0	31.0	31.1	31.8
		1.77					31.5		
B	38.8	40.6	38.7	39.6	36.7	39.2	37.4	38.2	39.4
		40.6							
Si	66	70	69	57		72	80	72	73
		76				70			
Mg	247	260	255	263	244	257	252	251	258
Sr	371	386	381	391	364	381	375	380	376
Ca	3422	3636	3553	3701	3392	3571	3473	3535	3584
							3484		
Ba	446	469	463	487	444	467	460	458	470
Na	28826	29960	29407	30459	28054	29835	28966	28961	29615
Li	26.1	32.6	30.4	27.9	29.8	32.9	28.8	26.2	28.6
K	724	980	768	669	843	935	819	775	663
Cr	0.08	0.08	0.02	0.03		ND	ND	ND	0.03
Mn	1.99	2.09	2.07	1.94		2.04	2.20	2.01	2.04
Cd	0.12	0.11	0.14	0.14		0.11	0.15	0.11	0.10
								0.10	
Cu	0.02	0.02	0.01	0.01		0.02	0.01	0.02	0.02
Pb	ND	ND	ND	ND		ND	ND	ND	ND
Zn	0.12	0.15	0.12	0.14		0.22	0.13	0.16	0.13
						0.18			
Alkalinity		497		482					
pH		5.18		5.14					
Flow rate	10	10	1010	10					

V. GRAPHICAL DATA PRESENTATION AND DISCUSSION

In order to facilitate examination of various trends in the reported data several plots are included in this section. In Figures V-1a-j, flow rate, Fe, Alk, Mn, Na, Ca, Si, Mg, Ba, Sr, Li, Mg, B, and K are plotted vs. time of sampling. In Figures V-2a-j, 2a-h various parameters are plotted against flow rate. Finally, in Figures V-3a-e, 3a-g various parameters are plotted against each other to discuss potential trends. The scale has been magnified in all cases and as a consequence small percent variations may appear significant.

The most significant correlation appears between iron (Fe) and flow rate in Figures V-1a and V-2b:

$$Fe(mg/l) = 62.92FLOW(tbpd)^{-0.301} \quad R^2 = 0.94$$

Qualitatively, this equation suggests that some process is taking place such that the faster the flow rate the lower the iron concentration. A similar but less pronounced relationship exists between Mn and flow rate, Figure V-2i. Yet, no such a correlation exists between any of the remaining composition variables. It is therefore probably not a property of the production reservoir chemistry. Rather, it is probably a consequence of corrosion of the steel pipe at approximately a mass transport limited rate. Similar exponential dependence follows from an analysis of dimensionless mass transport groups, but more modeling on this well brine is needed to confirm the mechanism.

Few of the remaining parameters vary over sufficient a range to warrant interpreting any trend results.

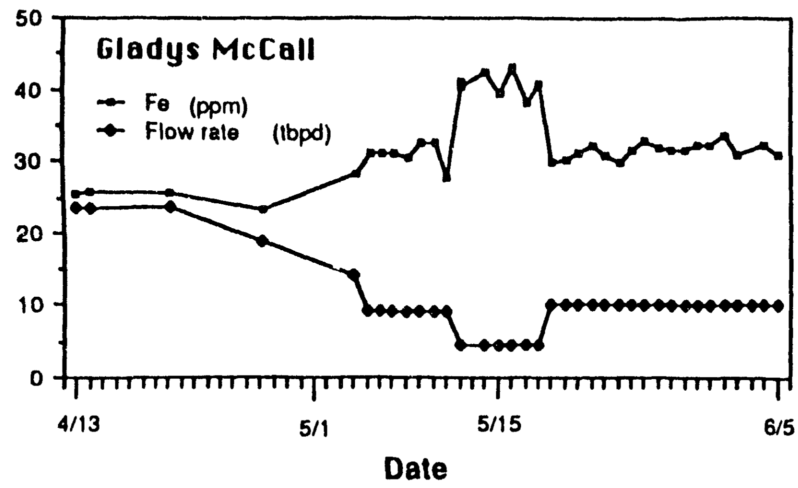


Figure V-1a.

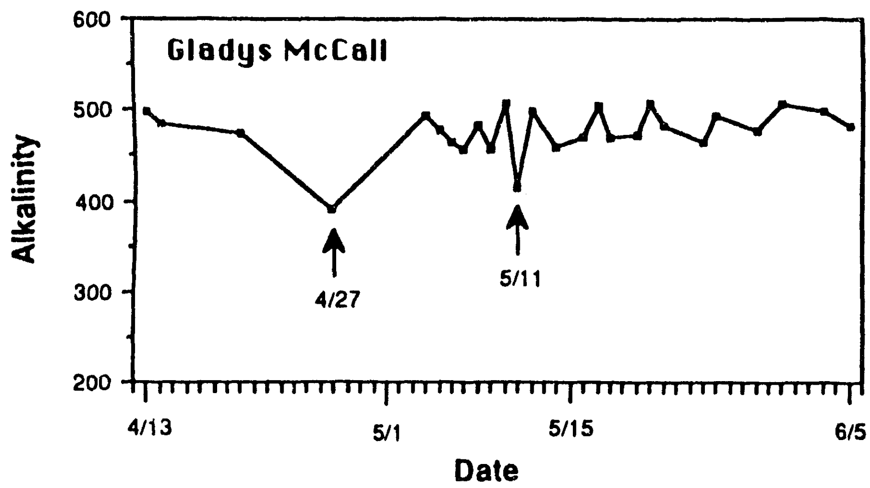


Figure V-1b.

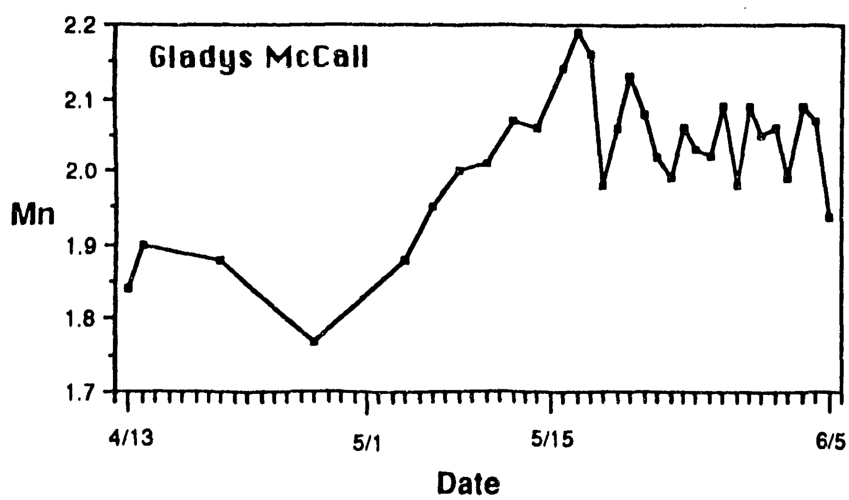


Figure V-1c.

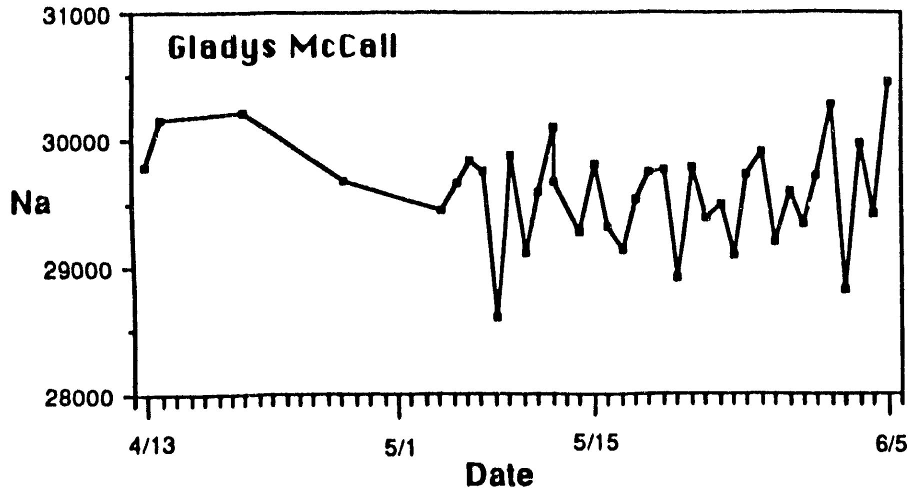


Figure V-1d.

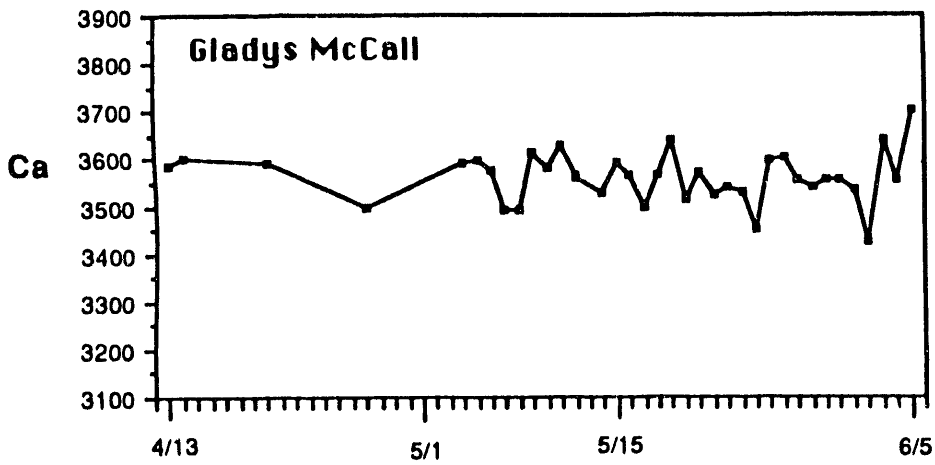


Figure V-1e.

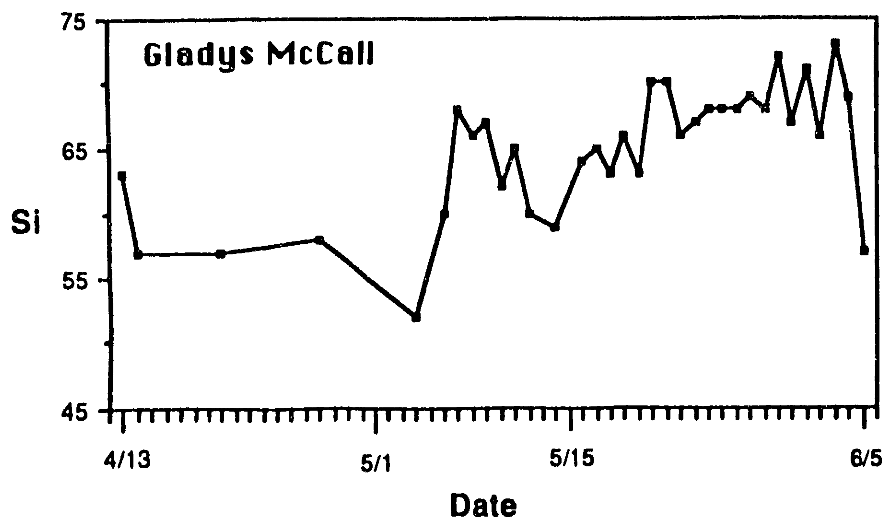


Figure V-1f.

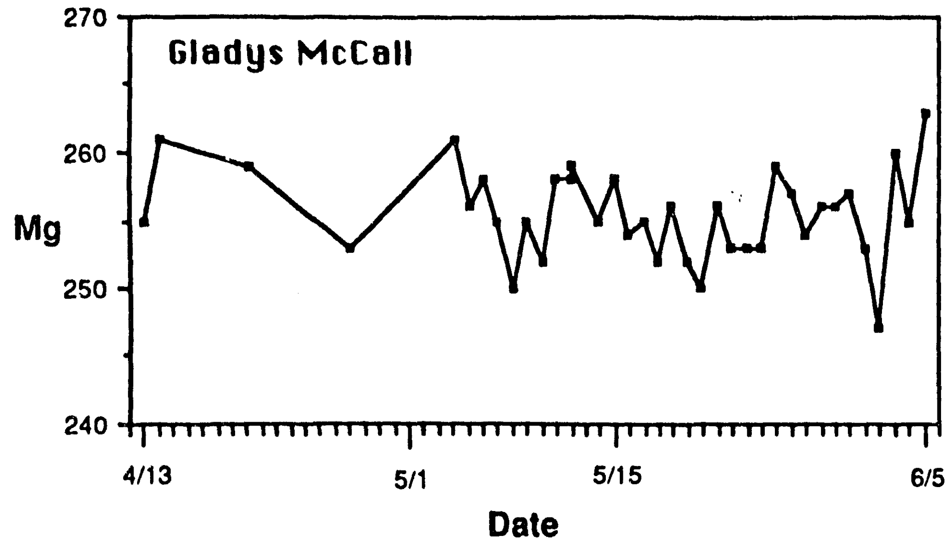


Figure V-1g.

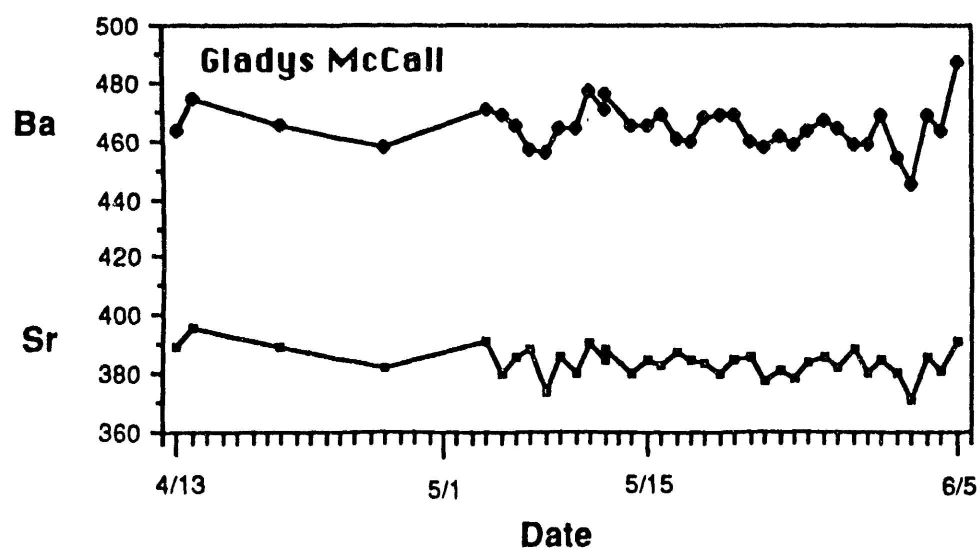


Figure V-1h.

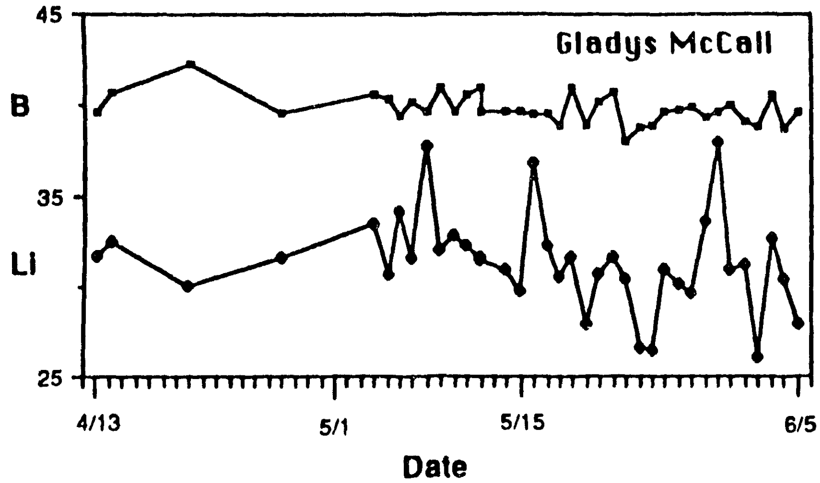


Figure V-1i.

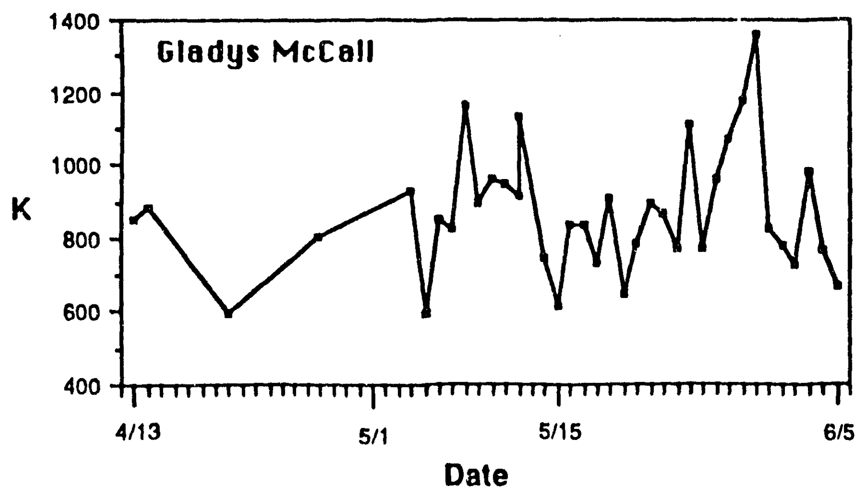


Figure V-1j.

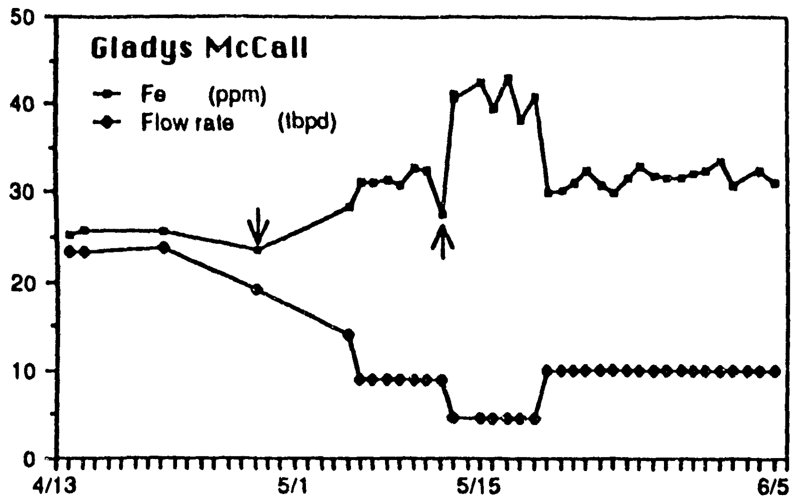


Figure V-2-a.

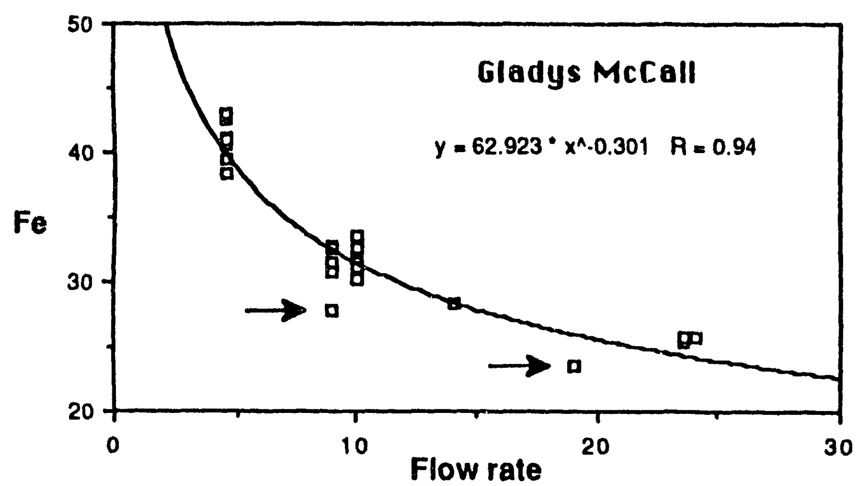


Figure V-2b.

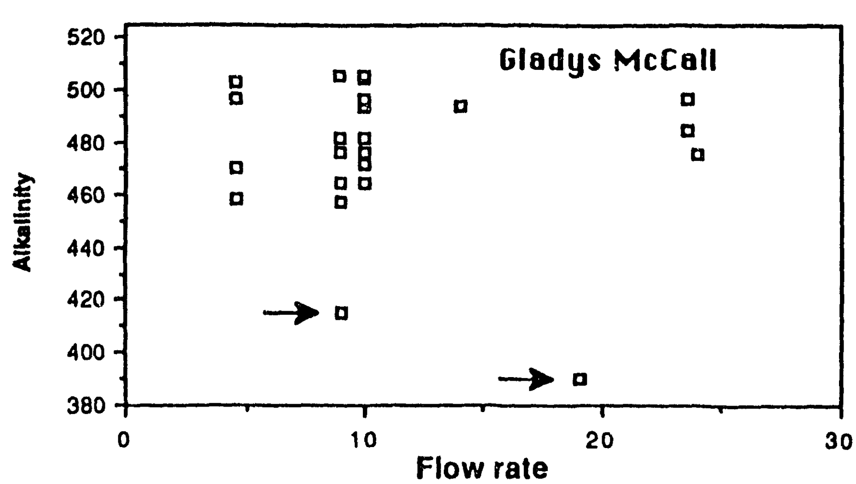


Figure V-2c.

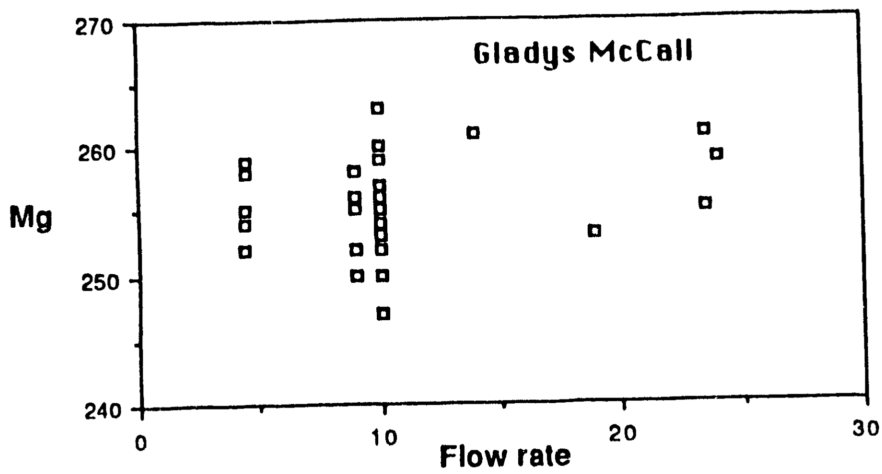


Figure V-2d.

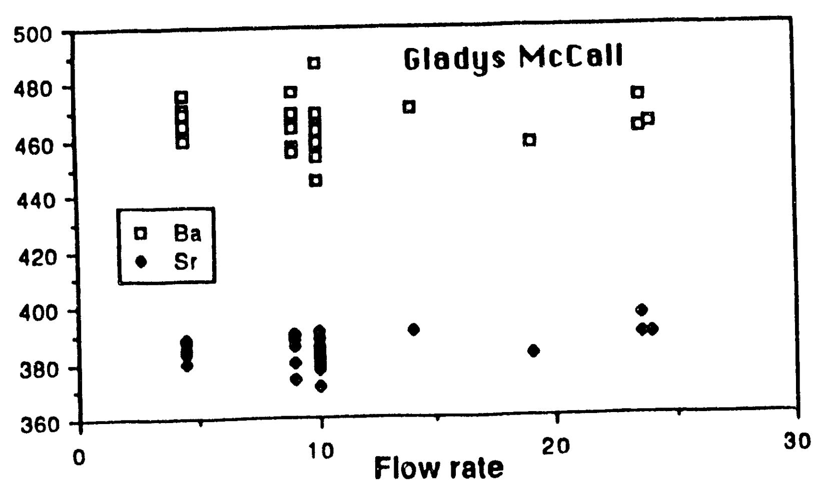


Figure V-2e.

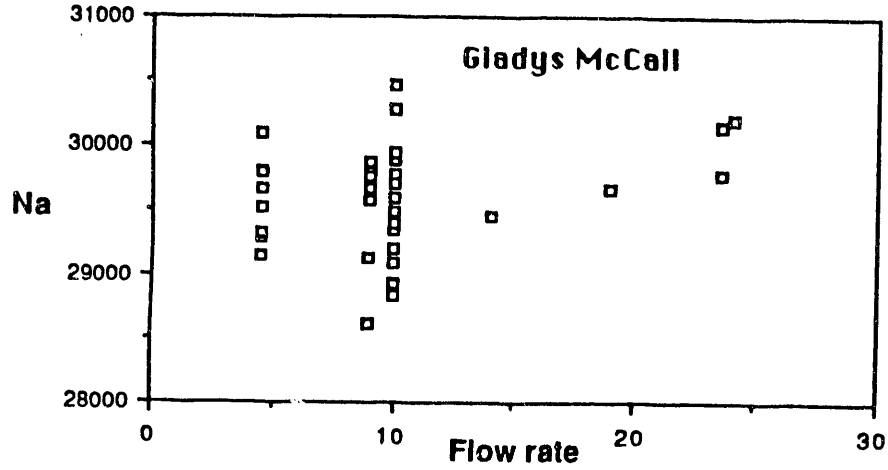


Figure V-2f.

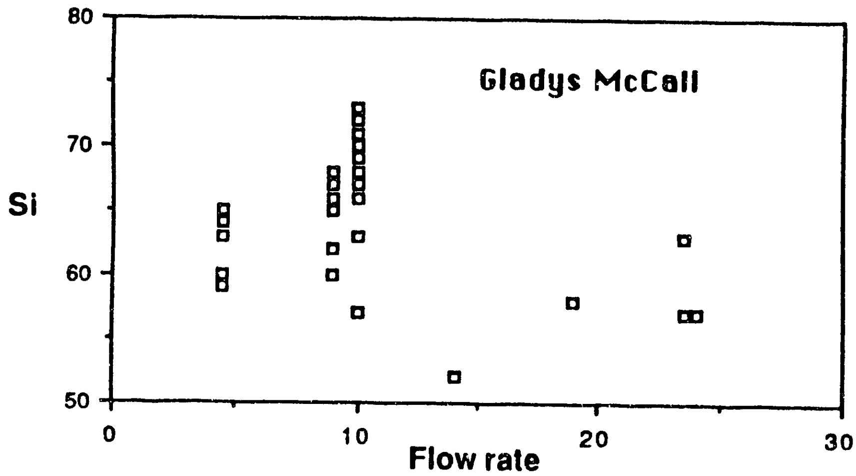


Figure V-2g.

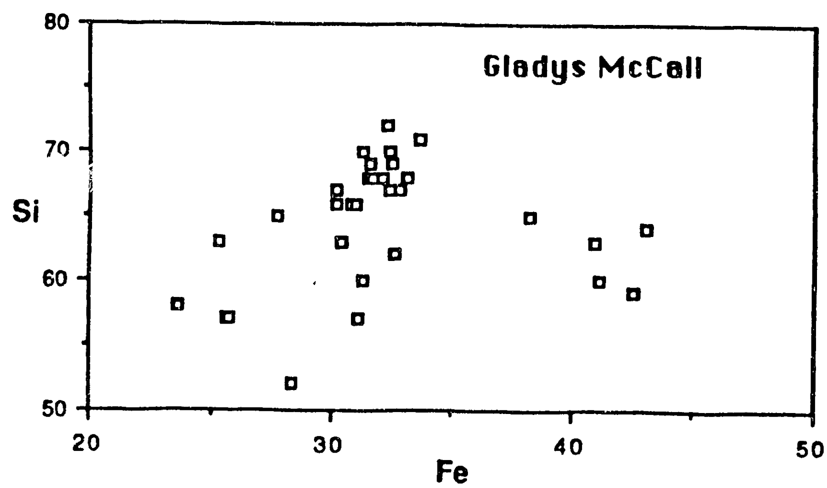


Figure V-2h.

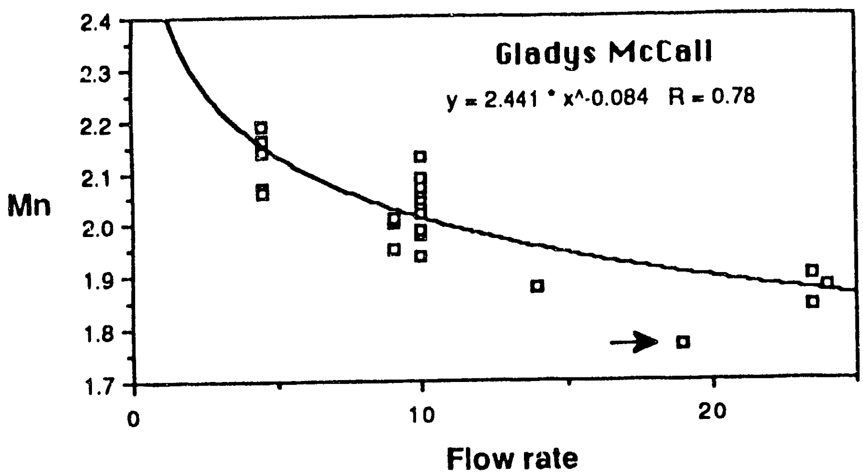


Figure V-2i.

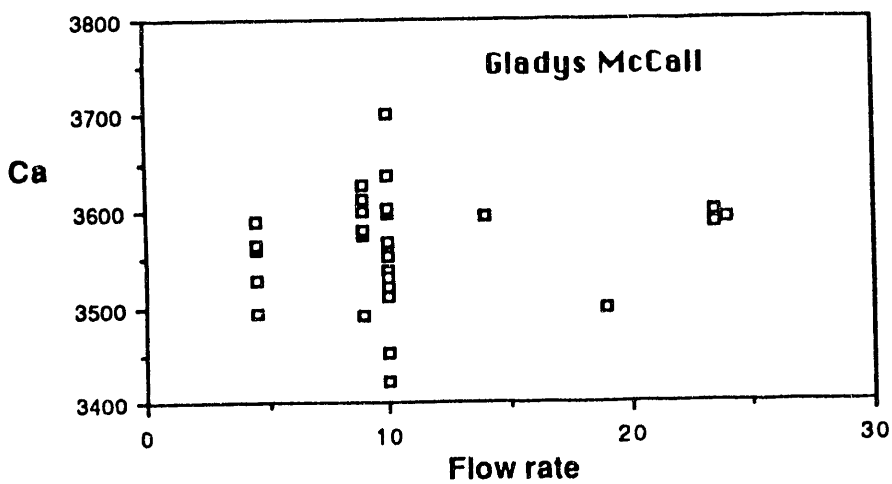


Figure V-2j.

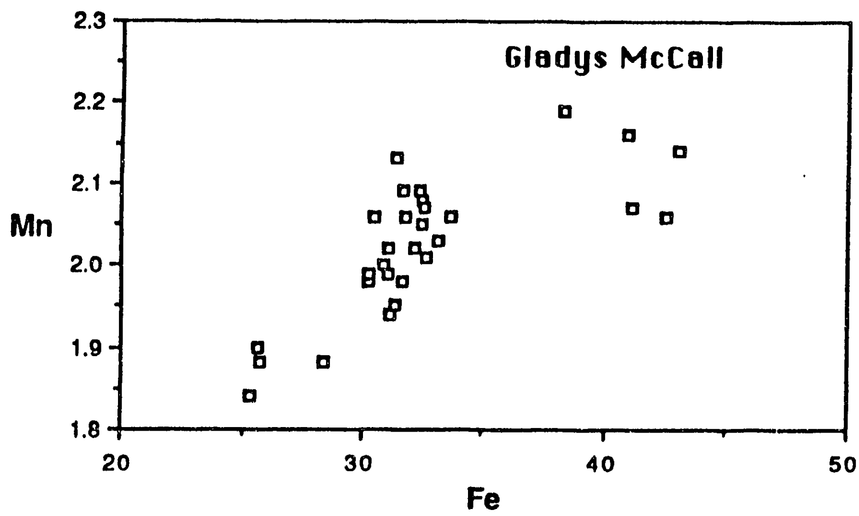


Figure V-3a.

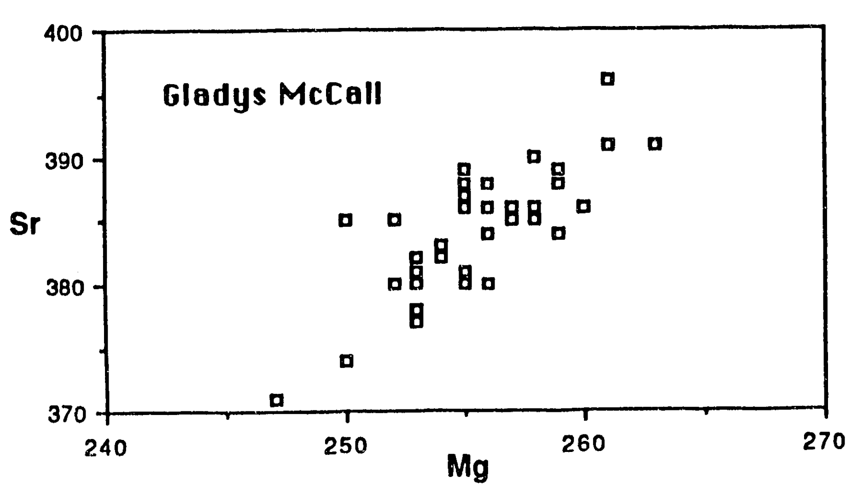


Figure V-3b.

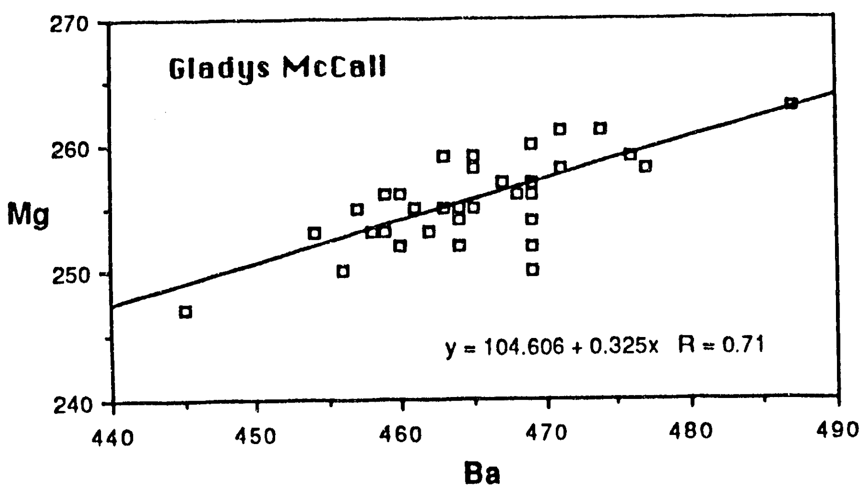


Figure V-3c.

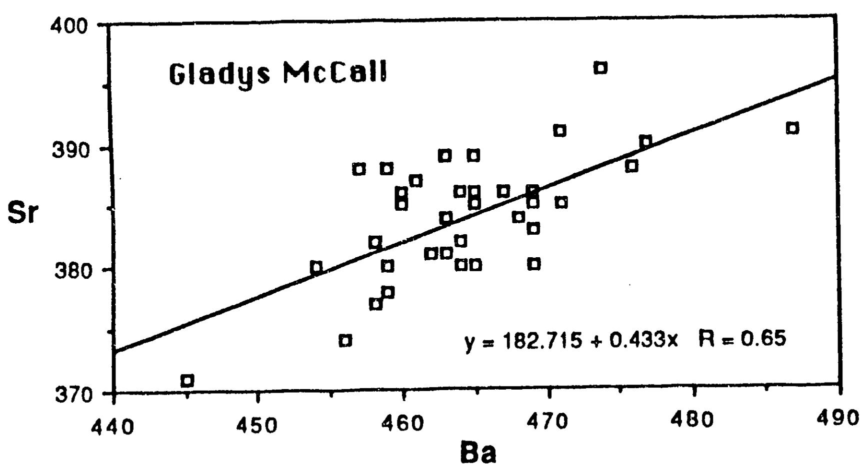


Figure V-3d.

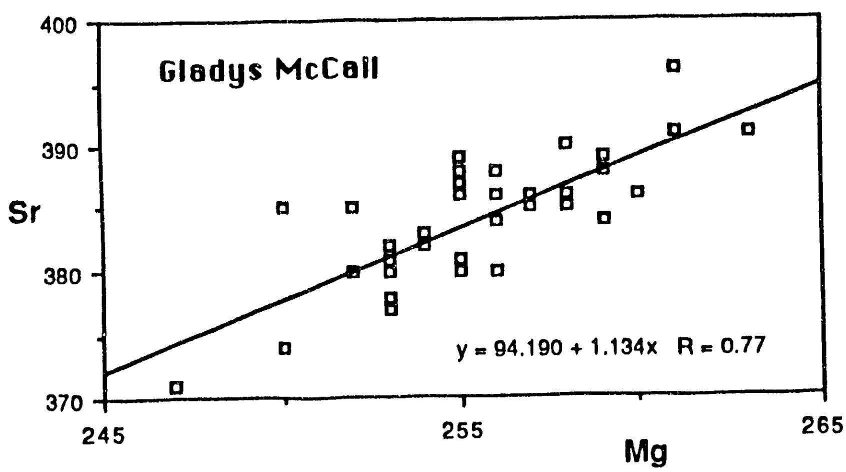


Figure V-3e.

VI. GLADYS MCCALL CHLORIDE RESULTS

The chloride concentration of eighty-three brine samples during the period from July 1985 - January 1987 is plotted in Figure VI-1. The data represent an analysis for approximately every sixth day of flow. The samples were collected in 500 ml Nalgene bottles by wellsite personnel with no attempt to cool the brine prior to exposure to atmospheric pressure during sampling. The samples were analyzed in the laboratory in January 1987 by titration with mercuric nitrate. The plotted values represent an average of three to four measurements per sample with an analytical precision of ± 0.5% (± 300 mg).

Two phenomena are observed in the chloride concentration with time; 1) an overall decrease of 4% in concentration over the 18 month period from approximately 59,500 mg/l to approximately 57,000 mg/l, and 2) an apparent periodicity of thirty to sixty days with an amplitude of 1500-4500 mg/l (2.5-7.5%). The daily brine production rate is also plotted in Figure 1. Several factors could account for the observed overall decrease in salinity with time. There may be an influx of less saline water into the produced zone from adjacent formations as the long term reservoir pressure declines. Sand zone #8 had an initial bottom hole pressure of 12,783 psia when production began in 1983. The flowing bottom hole pressure in early 1987 was approximately 8600 psia when the reservoir had produced nearly 25 million barrels of brine. Considering the impressive volume of produced formation water and the 4200 psia drawdown that has occurred over the four year production history, it seems plausible that an influx of less saline formation water could account for the observed change in brine chemistry.

However, it should be noted that variation in measured brine salinity could arise from both the brine sampling procedure (flashing of the brine on exposure to atmospheric pressure) and the eighteen month lag before analyzing the 1985 samples (potential for water loss through the nalgene bottle). This study clearly points out the need for timely analysis of samples and a sampling procedure designed to eliminate adverse chemical reactions.

The second phenomenon of the apparent periodicity of the fluctuation in chloride content is admittedly more dubious and difficult to explain. Once again, it could simply be an artifact of the sampling process. Alternatively, it may be related to complex reservoir mechanisms not yet understood.

The oscillations are not immediately related to the flow rate. However, it is interesting to note that the brine chemistry is relatively stable during the initial months following the shut-in period for both inhibitor squeezes, and that the oscillations appear to increase in both amplitude and period as time increases. Perhaps a limiting volume of brine must be produced following a shut-in period before the phenomenon is observed. Once again, additional long-term study is needed in other large volume reservoirs to verify the observed trend.

Finally, the measured chloride content of Gladys McCall brines (Table III-2) sampled by slowly circulating the brine through coiled stainless steel tubing immersed in an ice bath, are typically 4-7% less concentrated than samples collected in open bottles without previous cooling of the brine. This is most easily explained by the uncontrolled water loss due to vaporization. The observed change is in excellent agreement with the water loss calculated by Chris Hayden (personal communication 1/16/87).

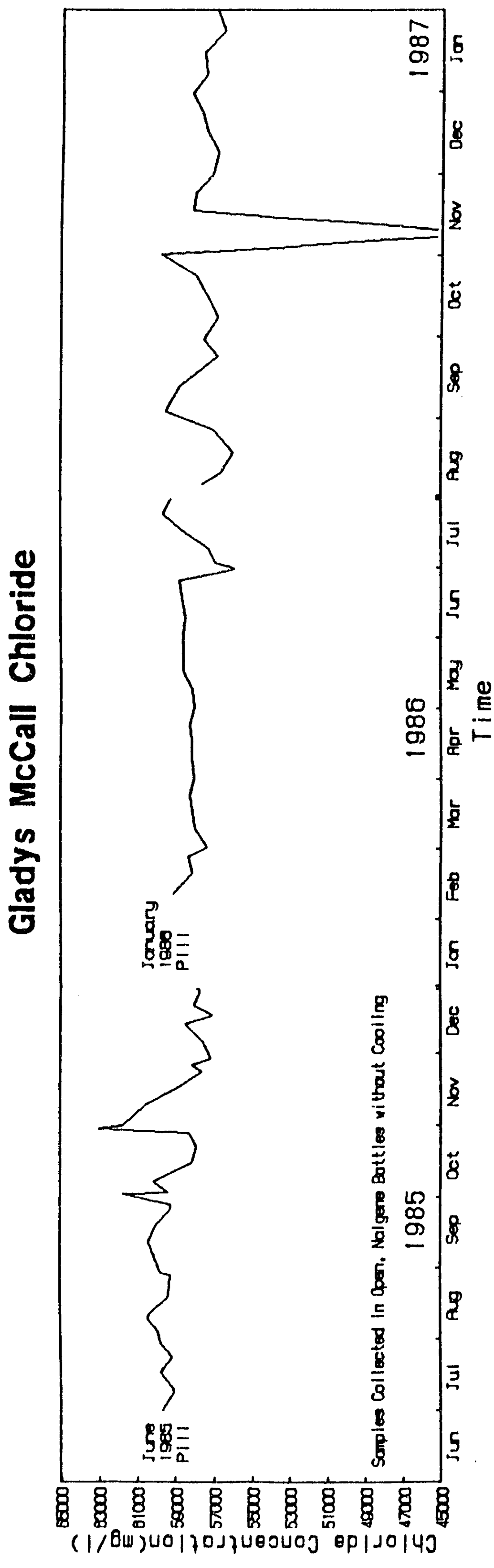

Gladys McCall Chloride
Chloride Concentration(mg/l)
65000
63000
61000
59000
57000
55000
53000
51000
49000
47000
45000
Time
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
1985
1986
1987
June 1985 PI11
January 1986 PI11
Samples Collected in Open, Nalgene Bottles without Cooling

Figure VI-1.

VII. COMPOSITION OF GLADYS MCCALL CARBONATE SCALE SAMPLES COLLECTED APRIL 1987

The flow rate was ≈ 24-27,000 BPD. The Scale 1 and Scale 2 samples are referred to as "soft" scale that was found downstream of the Willis choke but upstream of the surface inhibitor injection point (Table VII-1). Scale 3 is a much "harder" scale that was found at the Willis choke. The scale cyrstals exhibit a very pronounced orientation.

The weighed samples were dissolved in dilute HCl and diluted to a final concentration near that of our major element ICP standard.

From the ICP results in Table VII-1 the composition of the scale was determined to be:

$$[Ca_{.92}Fe_{.05}Mg_{.02}Sr_{.007}Ba_{.002}]CO_3$$

This scale composition is typical of calcite materials from gas and oil field scales. Although the texture was observably different, the chemical analysis is quite similar. This suggests that the texture of scale is related to physical process and not a chemical composition.

Table VII-1. Composition of Scale from Gladys McCall Well, April, 1987

	Scale-1		Scale -2		Scale -3	
Ca	380.0ppm	(90.0%)	373.5	(90.2%)	379.5	(89.9%)
Fe	27.85	(6.6%)	26.8	(6.5%)	27.5	(6.5%)
Mg	6.15	(1.5%)	6.0	(1.4%)	5.8	(1.4%)
Sr	5.6	(1.3%)	5.5	(1.3%)	6.2	(1.5%)
Ba	2.6	(0.6%)	2.5	(0.6%)	3.15	(0.7%)
	422.2	100%	414.3	100%	422.2	100%

Avg Composition of typical Gladys Scale:

	Wt%	Mol%	Relative Mol%
Calcium	90.1	.0094	92.3%
Iron	6.5	.0005	4.9%
Magnesium	6.0	.0002	1.9%
Strontium	5.8	.00007	0.7%
Barium	0.6	.00002	0.2%
		.01018	

APPENDIX N

Corrosion Coupon Data

Corrosion coupons were checked with a frequency of daily to weekly for much of the test. A few coupons were left in place for as long as several months between checking. The corrosion coupon data are presented in Exhibits N-1 through N-6. The entries in this exhibit are in chronological order with the exception that the entries are grouped by step in the testing sequence and by coupon location.

Corrosion in the surface facilities was noted early in the flow test. The October 27, 1983, Daily Testing Report stated that a coupon had lost 2 grams of weight (20% of its total weight) during a 1-week interval. The coupons had an area of about 2.5 square inches exposed to the brine. This weight loss corresponds to a corrosion rate of about 400 mils per year. High corrosion rates for coupons continued to be observed. The November 1, 1984, Daily Testing Report stated that another coupon lost 25% of its weight in 3 days, with an inferred corrosion rate of about 1000 mils per year.

The high coupon corrosion rates were observed in the coupons through much of the flow test. However, the data must be used with caution for several reasons as listed below:

- The coupons were fabricated from 1/8-inch "mild steel" plate in a local machine shop. The metallurgy and coupon fabrication procedures are not known and it is possible that there are metallurgical differences between coupons.
- The coupons were not electrically isolated from the pipe, which leaves open the possibility that corrosion may have been accelerated or inhibited by an electric potential set up between dissimilar metals.
- The corrosion coupon installation and data collection procedures changed over time. Interpretation of corrosion data is difficult without a thorough understanding of corrosion coupon locations and data collection practices.

Some of the important changes in coupon procedure are summarized in the paragraphs below.

The early tests of the well had a first coupon station between the choke and the separator and second coupon station in the brine line between the separator dump valve and the filter skid. After the second separator was installed in series, a new upstream coupon station was built into the brine line between the high-pressure separator dump valve and the inlet to the low-pressure separator. The downstream station remained between the low-pressure separator dump valve and the filter skid.

The initial coupon station between the choke and the first separator differed from the other two in that it involved a small-diameter pipe in parallel with the main flow line. Thus, only a small fraction of the flowing brine passed through the pipe that contained the coupon. In contrast, the full stream passed by the coupons in the other two stations

Initially, there were three coupon holders at each location for daily, weekly, and monthly samples. The extent to which weekly or monthly coupons were used is apparent from the tabulated "Time In" in Exhibits N-1 through N-6.

The most comprehensive coupon data were collected in January 1985. Coupons located in a 6-inch-diameter brine line between the high-pressure separator dump valve and the low-pressure separator were inspected daily. There was considerable variability day by day, but the average weight loss was over 0.5 grams per day. This corresponds to an average corrosion rate of about 700 mils per year. The flow rate during this period was just over 15,000 barrels per day, and the brine velocity in the 6-inch line would have been about 6 feet per second. At the same time, coupons installed in a 6-inch line after the low-pressure separator had a corrosion rate orders of magnitude lower than the coupons located between the separators. It is hypothesized that this was caused by scale formation on the downstream coupons.

The same coupon was often re-installed after being inspected. This is apparent from the numerous entries in Exhibit N-1 wherein the "Weight In" is equal to the "Weight Out" for the prior time interval. This was the case despite recorded weight loss, signifying corrosion, or weight gain, signifying scale deposition. As a result, much of the data, especially after April 1985, are of marginal value. The coupon between the separators was installed on October 9, 1985, and used through the end of the test on October 1987. The coupon was removed every 3 to 7 days during periods when the well was flowing but was not replaced. The original weight of the coupon was 9.14 grams. As shown in the table below, it was higher than the initial value for most of the time. This indicates a coating on the coupon that may well have precluded corrosion.

Date	Weight	Difference From Initial Weight
October 9, 1985	9.14 grams	-
February 15, 1986	9.08 grams	-0.06 grams
March 3, 1986	9.14 grams	0.00 grams
April 8, 1986	9.20 grams	0.06 grams
June 23, 1986	9.454 grams	0.314 grams
June 23, 1986[a]	9.367 grams	0.227 grams
October 8, 1986	9.40 grams	0.26 grams
April 7, 1987	9.381 grams	0.241 grams
July 31, 1987	9.38 grams	0.24 grams
July 31, 1987[a]	9.26 grams	0.12 grams
October 26, 1987	9.328 grams	0.188 grams

[a] Signifies the coupon was washed in acid prior to reinsertion.

Corrosion data for the location after the low-pressure separator had a few valid data points. Corrosion was high enough that coupons were changed with more regularity, generally once every few months. Corrosion rates for new coupons would usually range from 10 to 100 mils per year for a week or so. After a week or two of service, however, the weight of the corrosion coupon would stabilize and usually slowly increase. For instance, a coupon installed on August 19, 1985, had corrosion rates than averaged over 10 mils per year over the next 13 days. Then, weight loss stopped and the average corrosion rate over the following 4 months was a negative value. The coupon was changed on December 27, 1985, and corrosion over the next 12 days averaged over 30 mils per year. Then, the coupon weight changes again showed a negative value over the next few months.

The corrosion data for those periods just after changing coupons was probably the most realistic data available. Large variability in corrosion rates may have been caused by the conflicting processes of scaling and corrosion.

Exhibit N-1. CORROSION COUPON DATA FOR THE 24-DAY FLOW TEST OF SAND 9

Before Separator

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
3/25/83	3/28/83	10.430	10.448	-0.018	3	-6.77
3/28/83	3/29/83	10.465	10.458	0.007	1	7.90
3/29/83	3/30/83	10.244	10.255	-0.011	1	-12.41
3/30/83	4/1/83	10.226	10.243	-0.017	2	-9.59
4/1/83	4/2/83	10.347	10.365	-0.018	1	-20.30
4/2/83	4/3/83	10.449	10.465	-0.016	1	-18.05
4/3/83	4/4/83	10.458	10.460	-0.002	1	-2.26
4/4/83	4/5/83	10.313	10.314	-0.001	1	-1.13
4/5/83	4/6/83	10.227	10.189	0.038	1	42.86
4/6/83	4/7/83	10.282	10.297	-0.015	1	-16.92
4/7/83	4/8/83	10.295	10.314	-0.019	1	-21.43
4/8/83	4/9/83	10.274	10.310	-0.036	1	-40.61
4/9/83	4/10/83	10.347	10.381	-0.034	1	-38.35
4/10/83	4/11/83	10.271	10.283	-0.012	1	-13.54
4/11/83	4/12/83	10.370	10.382	-0.012	1	-13.54
4/12/83	4/13/83	10.197	10.207	-0.010	1	-11.28

Disposal Well Line After Separator

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
3/25/83	3/28/83	10.317	10.330	-0.013	3	-4.89
3/28/83	3/29/83	10.000	10.034	-0.034	1	-38.35
3/29/83	3/30/83	10.220	10.249	-0.029	1	-32.71
3/30/83	4/1/83	10.301	10.323	-0.022	2	-12.41
4/1/83	4/2/83	10.416	10.440	-0.024	1	-27.07
4/2/83	4/3/83	10.400	10.426	-0.026	1	-29.33
4/3/83	4/4/83	10.228	10.239	-0.011	1	-12.41
4/4/83	4/5/83	10.327	10.360	-0.033	1	-37.22
4/5/83	4/6/83	10.458	10.461	-0.003	1	-3.38
4/6/83	4/7/83	10.239	10.245	-0.006	1	-6.77
3/29/83	4/6/83	10.465	10.476	-0.011	8	-1.55
4/7/83	4/8/83	10.019	10.112	-0.093	1	-104.90
4/8/83	4/9/83	10.314	10.231	0.083	1	93.62
4/9/83	4/10/83	10.034	9.998	0.036	1	40.61
4/10/83	4/11/83	9.677	9.696	-0.019	1	-21.43
4/11/83	4/12/83	9.986	9.981	0.005	1	5.64
4/12/83	4/13/83	10.223	10.256	-0.033	1	-37.22
4/6/83	4/13/83	10.281	10.300	-0.019	7	-3.06

Exhibit N-2. CORROSION COUPON DATA FOR THE 21-DAY FLOW TEST OF SAND 8

Before Separator (Flow was 9 Hours on 9/16/83, From 10/7 to 28/83, and Starting 12/2/83)

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time in (Days)	Loss Rate (mils/yr)
9/16/83	10/19/83	10.426	10.558	-0.132	33	-4.51
10/19/83	12/5/83	10.110	10.025	0.085	47	2.04

Disposal Well Line After Separator (Flow was 9 hours on 9/16/83 and From 10/7 to 28/83)

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time in (Days)	Loss Rate (mils/yr)
9/16/83	10/8/83	10.269	10.435	-0.166	22	-8.51
9/16/83	10/8/83	10.216	9.991	0.225	22	11.54
9/16/83	10/8/83	10.463	10.558	-0.095	22	-4.87
10/8/83	10/9/83	10.422	10.391	0.031	1	34.97
10/9/83	10/10/83	10.360	10.365	-0.005	1	-5.64
10/10/83	10/11/83	10.284	10.239	0.045	1	50.76
10/11/83	10/12/83	10.206	10.157	0.049	1	55.27
10/11/83	10/19/83	9.920	9.833	0.087	8	12.27
10/11/83	10/31/83	10.338	10.297	0.041	20	2.31
10/12/83	10/13/83	9.820	9.423	0.397	1	447.82
10/13/83	10/14/83	10.217	9.900	0.317	1	357.58
10/14/83	10/15/83	10.122	9.951	0.171	1	192.89
10/15/83	10/16/83	10.217	10.087	0.130	1	146.64
10/16/83	10/17/83	10.460	10.021	0.439	1	495.19
10/17/83	10/18/83	10.331	10.117	0.214	1	241.39
10/18/83	10/19/83	9.767	9.700	0.067	1	75.58
10/19/83	10/20/83	10.150	10.122	0.028	1	31.58
10/19/83	10/26/83	10.350	8.926	1.424	7	229.47
10/20/83	10/21/83	10.260	9.930	0.330	1	372.24
10/21/83	10/22/83	9.850	9.770	0.080	1	90.24
10/22/83	10/23/83	10.160	9.890	0.270	1	304.56
10/23/83	10/24/83	10.210	9.770	0.440	1	496.32
10/24/83	10/25/83	10.140	9.930	0.210	1	236.88
10/25/83	10/26/83	10.260	10.229	0.031	1	34.97
10/26/83	10/27/83	10.144	10.045	0.099	1	111.67
10/26/83	11/1/83	10.222	10.165	0.057	6	10.72
10/27/83	10/28/83	10.235	10.163	0.072	1	81.22

Exhibit N-3. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- ONE SEPARATOR FROM 12/2/83.THROUGH 1/14/84

Before Separator (Well was Shut in From 10/28/83 Through 12/2/83)

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time in (Days)	Loss Rate (mils/yr)
10/19/83	12/5/83	10.110	10.025	0.085	47	2.04
12/5/83	12/8/83	9.972	9.980	-0.008	3	-3.01

Disposal Well Line After Separator

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time in (Days)	Loss Rate (mils/yr)
12/1/83	12/3/83	10.548	10.470	0.078	2	43.99
12/1/83	12/5/83	10.478	10.540	-0.062	4	-17.48
12/3/83	12/4/83	10.040	9.875	0.165	1	186.12
12/4/83	12/5/83	10.047	9.670	0.377	1	425.26
12/5/83	12/6/83	10.040	10.000	0.040	1	45.12
12/6/83	12/7/83	9.860	9.811	0.049	1	55.27
12/7/83	12/9/83	9.950	9.725	0.225	2	126.90
12/9/83	12/10/83	10.414	10.244	0.170	1	191.76
12/9/83	12/16/83	10.099	9.950	0.149	7	24.01
12/10/83	12/11/83	10.327	10.150	0.177	1	199.66
12/11/83	12/12/83	10.374	10.159	0.215	1	242.52
12/12/83	12/13/83	10.202	9.803	0.399	1	450.07
12/13/83	12/14/83	10.399	10.150	0.249	1	280.87
12/14/83	12/15/83	10.350	10.120	0.230	1	259.44
12/15/83	12/16/83	10.470	10.540	-0.070	1	-78.96
12/16/83	12/17/83	10.430	10.380	0.050	1	56.40
12/17/83	12/18/83	10.190	10.150	0.040	1	45.12
12/18/83	12/19/83	10.990	10.030	0.960	1	1082.88
12/19/83	12/20/83	10.230	9.810	0.420	1	473.76
12/20/83	12/21/83	10.470	10.566	-0.096	1	-108.29
12/21/83	12/22/83	10.385	10.321	0.064	1	72.19
12/22/83	12/29/83	10.088	9.894	0.194	7	31.26
12/29/83	12/31/83	10.328	10.005	0.323	2	182.17
12/31/83	1/1/84	10.267	9.638	0.629	1	709.51
1/1/84	1/2/84	10.320	9.560	0.760	1	857.28
1/2/84	1/3/84	10.183	9.458	0.725	1	817.80
1/3/84	1/4/84	10.578	9.714	0.864	1	974.59
1/4/84	1/5/84	10.203	10.200	0.003	1	3.38
1/5/84	1/7/84	10.317	8.833	1.484	2	836.98
1/7/84	1/8/84	10.169	9.473	0.696	1	785.09
1/8/84	1/10/84	10.153	9.930	0.223	2	125.77
1/10/84	1/11/84	10.490	9.830	0.660	1	744.48
1/11/84	1/12/84	10.400	10.370	0.030	1	33.84
1/12/84	1/13/84	10.300	10.180	0.120	1	135.36
1/13/84	1/14/84	10.140	9.920	0.220	1	248.16

Exhibit N-4, Part 1. CORROSION COUPON DATA FOR THE LONG TERM-FLOW TEST -- TWO SEPARATORS FROM 1/14/84 THROUGH 2/29/84

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
1/14/84	1/16/84	10.102	10.080	0.022	2	12.41
1/16/84	1/17/84	10.220	10.210	0.010	1	11.28
1/17/84	1/20/84	9.974	9.978	-0.004	3	-1.50
1/20/84	1/21/84	10.197	10.200	-0.003	1	-3.38
1/21/84	1/22/84	10.258	10.262	-0.004	1	-4.51
1/22/84	1/23/84	10.484	10.480	0.004	1	4.51
1/23/84	1/24/84	10.311	10.315	-0.004	1	-4.51
1/24/84	1/25/84	10.411	10.450	-0.039	1	-43.99
1/25/84	1/26/84	10.080	10.080	0.000	1	0.00
1/26/84	1/28/84	10.000	10.002	-0.002	2	-1.13
1/28/84	1/29/84	10.419	10.422	-0.003	1	-3.38
1/29/84	2/2/84	10.323	10.115	0.208	4	58.66
2/2/84	2/3/84	10.170	10.170	0.000	1	0.00
2/3/84	2/4/84	10.100	10.091	0.009	1	10.15
2/4/84	2/5/84	10.330	10.300	0.030	1	33.84
2/5/84	2/6/84	10.310	10.300	0.010	1	11.28
2/6/84	2/7/84	10.370	10.340	0.030	1	33.84
2/7/84	2/8/84	10.360	10.353	0.007	1	7.90
2/8/84	2/9/84	10.330	10.310	0.020	1	22.56
2/9/84	2/10/84	10.470	10.430	0.040	1	45.12
2/10/84	2/29/84	10.240	10.220	0.020	19	1.19

Exhibit N-4, Part 2. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 1/14/84 THROUGH 2/29/84

Disposal Well Line After Separator

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
1/14/84	1/15/84	10.280	10.260	0.020	1	22.56
1/15/84	1/16/84	10.620	10.620	0.000	1	0.00
1/16/84	1/17/84	10.360	9.155	1.205	1	1359.24
1/17/84	1/21/84	9.854	9.861	-0.007	4	-1.97
1/21/84	1/22/84	9.894	8.922	0.972	1	1096.42
1/22/84	1/23/84	10.407	9.606	0.801	1	903.53
1/23/84	1/24/84	10.379	9.928	0.451	1	508.73
1/24/84	1/25/84	10.469	9.490	0.979	1	1104.31
1/25/84	1/26/84	10.540	9.574	0.966	1	1089.65
1/26/84	1/28/84	10.230	8.037	2.193	2	1236.85
1/28/84	1/29/84	10.544	9.627	0.917	1	1034.38
1/29/84	2/2/84	10.051	10.322	-0.271	4	-76.42
2/2/84	2/3/84	10.260	10.095	0.165	1	186.12
2/3/84	2/5/84	10.010	9.040	0.970	2	547.08
2/5/84	2/8/84	9.840	9.800	0.040	3	15.04
2/8/84	2/11/84	10.140	9.030	1.110	3	417.36
2/11/84	2/12/84	10.340	9.223	1.117	1	1259.98
2/12/84	2/13/84	10.395	10.090	0.305	1	344.04
2/13/84	2/15/84	10.394	8.518	1.876	2	1058.06
2/15/84	2/18/84	10.303	6.572	3.731	3	1402.86
2/18/84	2/24/84	10.257	7.680	2.577	6	484.48

Exhibit N-5. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- ONE SEPARATOR FROM 2/21/84 THROUGH 7/17/84

Disposal Well Line After Separator

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
2/24/84	2/27/84	10.395	10.319	0.076	3	28.58
2/27/84	2/29/84	10.280	10.220	0.060	2	33.84
2/29/84	3/2/84	10.020	8.508	1.512	2	852.77
3/2/84	3/15/84	10.447	10.087	0.360	13	31.24
3/15/84	3/20/84	10.294	9.592	0.702	5	158.37
3/20/84	3/23/84	10.159	9.692	0.467	3	175.59
3/23/84	3/27/84	10.170	9.646	0.524	4	147.77
3/27/84	3/30/84	10.095	10.078	0.017	3	6.39
3/30/84	5/11/84	10.161	7.373	2.788	42	74.88
5/11/84	5/16/84	10.219	10.185	0.034	5	7.67
5/16/84	5/17/84	10.290	10.280	0.010	1	11.28
5/17/84	5/18/84	10.162	9.376	0.786	1	886.61
5/18/84	5/19/84	10.360	9.890	0.470	1	530.16
5/19/84	5/20/84	10.375	10.080	0.295	1	332.76
5/20/84	5/21/84	10.270	9.580	0.690	1	778.32
5/21/84	5/22/84	10.560	9.785	0.775	1	874.20
5/22/84	5/25/84	10.450	10.016	0.434	3	163.18
5/25/84	5/26/84	10.310	10.280	0.030	1	33.84
5/26/84	5/27/84	10.212	10.185	0.027	1	30.46
5/27/84	5/28/84	10.051	9.803	0.248	1	279.74
5/28/84	5/29/84	10.436	9.705	0.731	1	824.57
5/29/84	6/1/84	9.820	8.630	1.190	3	447.44
6/1/84	6/2/84	10.280	9.260	1.020	1	1150.56
6/2/84	6/3/84	9.380	8.420	0.960	1	1082.88
6/3/84	6/4/84	10.560	10.420	0.140	1	157.92
6/4/84	6/5/84	10.000	9.970	0.030	1	33.84
6/5/84	6/8/84	10.160	10.154	0.006	3	2.26
6/8/84	6/12/84	10.010	9.946	0.064	4	18.05
6/12/84	6/15/84	10.520	7.630	2.890	3	1086.64
6/15/84	6/18/84	10.190	9.380	0.810	3	304.56
6/18/84	6/21/84	10.360	9.529	0.831	3	312.46
6/21/84	6/24/84	9.950	7.941	2.009	3	755.38
6/24/84	6/27/84	10.199	9.960	0.239	3	89.86
6/27/84	6/30/84	10.400	9.990	0.410	3	154.16
6/30/84	7/3/84	10.100	9.800	0.300	3	112.80
7/3/84	7/6/84	9.680	7.860	1.820	3	684.32
7/6/84	7/10/84	10.080	8.230	1.850	4	521.70
7/10/84	7/13/84	9.984	9.994	-0.010	3	-3.76
7/13/84	7/16/84	6.830	6.810	0.020	3	7.52

Exhibit N-6, Part 1. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
7/17/84	7/20/84	10.460	9.550	0.910	3	342.16
7/20/84	7/24/84	10.200	8.876	1.324	4	373.37
7/24/84	7/27/84	11.400	10.950	0.450	3	169.20
7/27/84	7/29/84	10.310	9.620	0.690	2	389.16
7/29/84	8/1/84	9.630	9.850	-0.220	3	-82.72
8/1/84	8/4/84	10.210	8.887	1.323	3	497.45
8/4/84	8/7/84	10.020	9.420	0.600	3	225.60
8/7/84	8/10/84	10.194	8.013	2.181	3	820.06
8/10/84	8/11/84	10.270	9.110	1.160	1	1308.48
8/11/84	8/14/84	10.290	7.900	2.390	3	898.64
8/14/84	8/17/84	10.240	7.701	2.539	3	954.66
8/17/84	8/20/84	10.390	9.280	1.110	3	417.36
8/20/84	8/23/84	10.104	9.890	0.214	3	80.46
8/23/84	8/26/84	9.200	8.850	0.350	3	131.60
8/26/84	8/29/84	10.180	9.020	1.160	3	436.16
8/29/84	9/2/84	10.391	9.065	1.326	4	373.93
9/2/84	9/5/84	10.063	8.293	1.770	3	665.52
9/5/84	9/7/84	10.070	9.762	0.308	2	173.71
9/7/84	9/11/84	10.440	8.706	1.734	4	488.99
9/11/84	9/13/84	10.280	8.061	2.219	2	1251.52
9/13/84	9/16/84	10.053	7.274	2.779	3	1044.90
9/16/84	10/7/84	10.340	9.220	1.120	21	60.16
10/7/84	10/10/84	9.320	7.087	2.233	3	839.61
10/10/84	10/13/84	10.010	7.510	2.500	3	940.00
10/13/84	10/18/84	10.090	9.010	1.080	5	243.65
10/18/84	10/21/84	10.270	10.070	0.200	3	75.20
10/21/84	10/24/84	10.030	9.850	0.180	3	67.68
10/24/84	10/28/84	9.880	7.872	2.008	4	566.26
10/28/84	11/2/84	9.710	7.240	2.470	5	557.23
11/2/84	11/5/84	10.510	10.030	0.480	3	180.48
11/5/84	11/8/84	10.200	9.811	0.389	3	146.26
11/8/84	11/11/84	9.560	8.469	1.091	3	410.22
11/11/84	12/2/84	10.270	9.400	0.870	21	46.73
12/2/84	12/6/84	9.570	9.050	0.520	4	146.64
12/6/84	12/9/84	10.430	8.263	2.167	3	814.79
12/9/84	12/12/84	10.100	9.950	0.150	3	56.40
12/12/84	12/15/84	10.250	9.860	0.390	3	146.64
12/15/84	12/18/84	10.300	9.960	0.340	3	127.84

Exhibit N-6, Part 2. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
12/18/84	12/22/84	10.280	7.077	3.203	4	903.25
12/22/84	12/26/84	10.280	6.056	4.224	4	1191.17
12/26/84	12/30/84	10.440	7.254	3.186	4	898.45
12/30/84	1/3/85	10.250	5.360	4.890	4	1378.98
1/3/85	1/6/85	10.210	6.280	3.930	3	1477.68
1/6/85	1/9/85	9.719	8.210	1.509	3	567.38
1/9/85	1/12/85	9.960	7.990	1.970	3	740.72
1/12/85	1/15/85	10.310	4.020	6.290	3	2365.04
1/15/85	1/18/85	10.490	10.100	0.390	3	146.64
1/18/85	1/22/85	9.860	6.820	3.040	4	857.28
1/22/85	1/25/85	10.200	8.714	1.486	3	558.74
1/25/85	1/28/85	10.310	9.676	0.634	3	238.38
1/28/85	1/31/85	10.240	8.150	2.090	3	785.84
1/31/85	2/4/85	10.070	9.000	1.070	4	301.74
2/4/85	2/7/85	9.000	8.750	0.250	3	94.00
2/7/85	2/13/85	10.090	7.801	2.289	6	430.33
2/13/85	2/17/85	10.410	9.230	1.180	4	332.76
2/17/85	2/21/85	10.140	7.337	2.803	4	790.45
2/21/85	2/25/85	9.760	7.010	2.750	4	775.50
2/25/85	2/28/85	10.360	7.670	2.690	3	1011.44
2/28/85	3/3/85	9.990	8.920	1.070	3	402.32
3/3/85	3/6/85	8.920	7.620	1.300	3	488.80
3/6/85	3/9/85	7.620	7.000	0.620	3	233.12
3/9/85	3/11/85	7.000	6.890	0.110	2	62.04
3/11/85	3/14/85	10.180	10.000	0.180	3	67.68
3/14/85	3/18/85	9.990	9.810	0.180	4	50.76
3/18/85	3/22/85	9.810	9.493	0.317	4	89.39
3/22/85	3/26/85	10.300	6.370	3.930	4	1108.26
3/26/85	3/29/85	6.370	6.213	0.157	3	59.03
3/29/85	4/2/85	6.214	3.850	2.364	4	666.65
4/2/85	4/18/85	7.750	7.692	0.058	16	4.09
4/18/85	4/22/85	7.692	6.270	1.422	4	401.00
4/22/85	4/26/85	8.700	8.382	0.318	4	89.68
4/26/85	4/30/85	8.382	8.324	0.058	4	16.36
4/30/85	5/9/85	8.324	8.375	-0.051	9	-6.39
5/9/85	5/13/85	8.375	8.400	-0.025	4	-7.05
5/13/85	5/18/85	8.400	8.280	0.120	5	27.07
5/18/85	5/28/85	8.280	8.170	0.110	10	12.41
5/28/85	6/7/85	8.170	8.143	0.027	10	3.05
6/7/85	6/13/85	8.143	8.164	-0.021	6	-3.95

Exhibit N-6, Part 3. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
6/13/85	6/17/85	8.164	8.160	0.004	4	1.13
6/17/85	6/21/85	8.160	8.174	-0.014	4	-3.95
6/21/85	7/15/85	8.174	8.052	0.122	24	5.73
7/15/85	7/18/85	8.052	8.050	0.002	3	0.75
7/18/85	7/21/85	8.050	8.033	0.017	3	6.39
7/21/85	7/24/85	8.033	8.023	0.010	3	3.76
7/24/85	7/27/85	8.220	8.030	0.190	3	71.44
7/27/85	7/30/85	8.300	8.320	-0.020	3	-7.52
7/30/85	8/2/85	8.300	8.000	0.300	3	112.80
8/2/85	8/5/85	8.000	7.940	0.060	3	22.56
8/5/85	8/8/85	7.940	7.943	-0.003	3	-1.13
8/8/85	8/22/85	7.943	7.000	0.943	14	75.98
8/22/85	8/30/85	7.000	7.950	-0.950	8	-133.95
8/30/85	9/3/85	7.950	7.950	0.000	4	0.00
9/3/85	9/7/85	7.950	7.960	-0.010	4	-2.82
9/7/85	9/10/85	7.960	7.960	0.000	3	0.00
9/10/85	9/13/85	7.960	7.960	0.000	3	0.00
9/13/85	9/16/85	7.960	7.970	-0.010	3	-3.76
9/16/85	9/19/85	7.970	7.960	0.010	3	3.76
9/19/85	9/22/85	7.960	7.950	0.010	3	3.76
9/22/85	9/25/85	7.950	7.940	0.010	3	3.76
9/25/85	9/30/85	7.940	7.990	-0.050	5	-11.28
9/30/85	10/3/85	7.990	8.000	-0.010	3	-3.76
10/3/85	10/9/85	8.000	7.990	0.010	6	1.88
10/9/85	10/12/85	9.140	9.137	0.003	3	1.13
10/12/85	10/15/85	9.137	9.125	0.012	3	4.51
10/15/85	10/18/85	9.125	9.120	0.005	3	1.88
10/18/85	10/23/85	9.120	9.130	-0.010	5	-2.26
10/23/85	10/27/85	9.130	9.130	0.000	4	0.00
10/27/85	11/3/85	9.130	9.123	0.007	7	1.13
11/3/85	11/6/85	9.123	9.120	0.003	3	1.13
11/6/85	11/9/85	9.120	9.129	-0.009	3	-3.38
11/9/85	11/12/85	9.129	9.130	-0.001	3	-0.38
11/12/85	11/15/85	9.130	9.127	0.003	3	1.13
11/15/85	11/18/85	9.127	9.120	0.007	3	2.63
11/18/85	11/22/85	9.120	9.130	-0.010	4	-2.82
11/22/85	11/25/85	9.130	9.140	-0.010	3	-3.76
11/25/85	11/29/85	9.140	9.137	0.003	4	0.85
11/29/85	12/2/85	9.137	9.135	0.002	3	0.75

Exhibit N-6, Part 4. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
12/2/85	12/5/85	9.135	9.141	-0.006	3	-2.26
12/5/85	12/8/85	9.141	9.138	0.003	3	1.13
12/8/85	12/11/85	9.138	9.136	0.002	3	0.75
12/11/85	12/14/85	9.136	9.139	-0.003	3	-1.13
12/14/85	12/17/85	9.139	9.137	0.002	3	0.75
12/17/85	12/20/85	9.137	9.130	0.007	3	2.63
12/20/85	12/23/85	9.130	9.158	-0.028	3	-10.53
12/23/85	12/27/85	9.158	9.160	-0.002	4	-0.56
12/27/85	12/30/85	9.160	9.160	0.000	3	0.00
12/30/85	1/2/86	9.160	9.151	0.009	3	3.38
1/2/86	1/5/86	9.151	9.146	0.005	3	1.88
1/5/86	1/8/86	9.146	9.140	0.006	3	2.26
1/8/86	1/11/86	9.140	9.146	-0.006	3	-2.26
1/11/86	1/14/86	9.146	9.139	0.007	3	2.63
1/14/86	1/17/86	9.139	9.113	0.026	3	9.78
1/17/86	2/8/86	9.113	9.113	0.000	22	0.00
2/8/86	2/12/86	9.100	9.090	0.010	4	2.82
2/12/86	2/15/86	9.090	9.080	0.010	3	3.76
2/15/86	2/18/86	9.080	9.110	-0.030	3	-11.28
2/18/86	2/21/86	9.110	9.120	-0.010	3	-3.76
2/21/86	2/25/86	9.120	9.130	-0.010	4	-2.82
2/25/86	2/28/86	9.130	9.136	-0.006	3	-2.26
2/28/86	3/3/86	9.136	9.140	-0.004	3	-1.50
3/3/86	3/6/86	9.140	9.143	-0.003	3	-1.13
3/6/86	3/9/86	9.143	9.146	-0.003	3	-1.13
3/9/86	3/12/86	9.146	9.160	-0.014	3	-5.26
3/12/86	3/16/86	9.160	9.162	-0.002	4	-0.56
3/16/86	3/20/86	9.162	9.160	0.002	4	0.56
3/20/86	3/24/86	9.160	9.170	-0.010	4	-2.82
3/24/86	3/27/86	9.170	9.189	-0.019	3	-7.14
3/27/86	3/30/86	9.189	9.190	-0.001	3	-0.38
3/30/86	4/2/86	9.190	9.188	0.002	3	0.75
4/2/86	4/5/86	9.188	9.194	-0.006	3	-2.26
4/5/86	4/11/86	9.194	9.200	-0.006	6	-1.13
4/11/86	4/14/86	9.200	9.230	-0.030	3	-11.28
4/14/86	4/17/86	9.230	9.230	0.000	3	0.00
4/17/86	4/20/86	9.230	9.240	-0.010	3	-3.76
4/20/86	4/23/86	9.240	9.242	-0.002	3	-0.75
4/23/86	4/26/86	9.242	9.248	-0.006	3	-2.26

Exhibit N-6, Part 5. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
4/26/86	4/29/86	9.248	9.245	0.003	3	1.13
4/29/86	5/2/86	9.245	9.246	-0.001	3	-0.38
5/2/86	5/5/86	9.246	9.250	-0.004	3	-1.50
5/5/86	5/8/86	9.250	9.263	-0.013	3	-4.89
5/8/86	5/12/86	9.263	9.271	-0.008	4	-2.26
5/12/86	5/15/86	9.271	9.277	-0.006	3	-2.26
5/15/86	5/18/86	9.277	9.280	-0.003	3	-1.13
5/18/86	5/21/86	9.280	9.290	-0.010	3	-3.76
5/21/86	5/25/86	9.290	9.303	-0.013	4	-3.67
5/25/86	5/28/86	9.303	9.314	-0.011	3	-4.14
5/28/86	5/31/86	9.314	9.326	-0.012	3	-4.51
5/31/86	6/4/86	9.326	9.340	-0.014	4	-3.95
6/4/86	6/8/86	9.340	9.348	-0.008	4	-2.26
6/8/86	6/11/86	9.348	9.343	0.005	3	1.88
6/11/86	6/14/86	9.343	9.340	0.003	3	1.13
6/14/86	6/17/86	9.340	9.346	-0.006	3	-2.26
6/17/86	6/20/86	9.346	9.450	-0.104	3	-39.10
6/20/86	6/23/86	9.450	9.454	-0.004	3	-1.50
6/23/86	6/25/86	9.367	9.373	-0.006	2	-3.38
6/25/86	6/28/86	9.373	9.385	-0.012	3	-4.51
6/28/86	7/2/86	9.385	9.386	-0.001	4	-0.28
7/2/86	7/5/86	9.386	9.380	0.006	3	2.26
7/5/86	7/8/86	9.380	9.392	-0.012	3	-4.51
7/8/86	7/11/86	9.392	9.388	0.004	3	1.50
7/11/86	7/14/86	9.388	9.396	-0.008	3	-3.01
7/14/86	7/17/86	9.396	9.399	-0.003	3	-1.13
7/17/86	7/20/86	9.399	9.410	-0.011	3	-4.14
7/20/86	7/23/86	9.410	9.410	0.000	3	0.00
7/23/86	7/26/86	9.410	9.410	0.000	3	0.00
7/26/86	7/30/86	9.410	9.404	0.006	4	1.69
7/30/86	8/3/86	9.404	9.400	0.004	4	1.13
8/3/86	8/6/86	9.400	9.410	-0.010	3	-3.76
8/6/86	8/15/86	9.410	9.399	0.011	9	1.38
8/15/86	8/18/86	9.399	9.400	-0.001	3	-0.38
8/18/86	8/21/86	9.400	9.411	-0.011	3	-4.14
8/21/86	8/24/86	9.411	9.419	-0.008	3	-3.01
8/24/86	8/28/86	9.419	9.415	0.004	4	1.13
8/28/86	9/1/86	9.415	9.417	-0.002	4	-0.56

Exhibit N-6, Part 6. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
9/1/86	9/4/86	9.417	9.415	0.002	3	0.75
9/4/86	9/7/86	9.415	9.414	0.001	3	0.38
9/7/86	9/10/86	9.414	9.400	0.014	3	5.26
9/10/86	9/13/86	9.400	9.398	0.002	3	0.75
9/13/86	9/17/86	9.398	9.411	-0.013	4	-3.67
9/17/86	9/20/86	9.411	9.417	-0.006	3	-2.26
9/20/86	9/23/86	9.417	9.421	-0.004	3	-1.50
9/23/86	9/26/86	9.421	9.401	0.020	3	7.52
9/26/86	9/29/86	9.401	9.400	0.001	3	0.38
9/29/86	10/2/86	9.400	9.399	0.001	3	0.38
10/2/86	10/5/86	9.399	9.390	0.009	3	3.38
10/5/86	10/8/86	9.390	9.400	-0.010	3	-3.76
10/8/86	10/11/86	9.400	9.425	-0.025	3	-9.40
10/11/86	10/14/86	9.425	9.410	0.015	3	5.64
10/14/86	10/17/86	9.410	9.417	-0.007	3	-2.63

Exhibit N-6, Part 7. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
10/17/86	10/20/86	9.417	9.421	-0.004	3	-1.50
10/20/86	10/23/86	9.421	9.422	-0.001	3	-0.38
10/23/86	10/26/86	9.422	9.437	-0.015	3	-5.64
10/26/86	10/29/86	9.437	9.430	0.007	3	2.63
10/29/86	11/1/86	9.430	9.432	-0.002	3	-0.75
11/1/86	11/4/86	9.432	9.435	-0.003	3	-1.13
11/4/86	11/7/86	9.435	9.433	0.002	3	0.75
11/7/86	11/10/86	9.433	9.440	-0.007	3	-2.63
11/10/86	11/13/86	9.440	9.459	-0.019	3	-7.14
11/13/86	11/16/86	9.459	9.455	0.004	3	1.50
11/16/86	11/19/86	9.455	9.446	0.009	3	3.38
11/19/86	11/24/86	9.446	9.435	0.011	5	2.48
11/24/86	11/27/86	9.435	9.430	0.005	3	1.88
11/27/86	11/30/86	9.430	9.427	0.003	3	1.13
11/30/86	12/3/86	9.427	9.430	-0.003	3	-1.13
12/3/86	12/6/86	9.430	9.452	-0.022	3	-8.27
12/6/86	12/10/86	9.452	9.427	0.025	4	7.05
12/10/86	12/13/86	9.427	9.430	-0.003	3	-1.13
12/13/86	12/17/86	9.430	9.446	-0.016	4	-4.51
12/17/86	12/20/86	9.442	9.440	0.002	3	0.75
12/20/86	12/23/86	9.440	9.441	-0.001	3	-0.38
12/23/86	1/1/87	9.441	9.438	0.003	9	0.38
1/1/87	1/4/87	9.438	9.430	0.008	3	3.01
1/4/87	1/7/87	9.430	9.430	0.000	3	0.00
1/7/87	1/10/87	9.430	9.434	-0.004	3	-1.50
1/10/87	1/13/87	9.434	9.429	0.005	3	1.88
1/13/87	1/16/87	9.429	9.430	-0.001	3	-0.38
1/16/87	1/19/87	9.430	9.434	-0.004	3	-1.50
1/19/87	1/22/87	9.434	9.433	0.001	3	0.38
1/22/87	1/25/87	9.433	9.432	0.001	3	0.38
1/25/87	1/28/87	9.432	9.426	0.006	3	2.26
1/28/87	1/31/87	9.426	9.400	0.026	3	9.78
1/31/87	2/3/87	9.400	9.394	0.006	3	2.26
2/3/87	2/6/87	9.394	9.376	0.018	3	6.77
2/6/87	2/9/87	9.376	9.374	0.002	3	0.75
2/9/87	2/12/87	9.374	9.372	0.002	3	0.75
2/12/87	2/14/87	9.372	9.372	0.000	2	0.00
2/14/87	2/16/87	9.372	9.370	0.002	2	1.13

Exhibit N-6, Part 8. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
2/16/87	2/19/87	9.370	9.369	0.001	3	0.38
2/19/87	2/22/87	9.369	9.360	0.009	3	3.38
2/22/87	2/25/87	9.360	9.345	0.015	3	5.64
2/25/87	2/28/87	9.345	9.374	-0.029	3	-10.90
2/28/87	3/3/87	9.374	9.377	-0.003	3	-1.13
3/3/87	3/6/87	9.377	9.371	0.006	3	2.26
3/6/87	3/9/87	9.371	9.372	-0.001	3	-0.38
3/9/87	3/12/87	9.372	9.378	-0.006	3	-2.26
3/12/87	3/14/87	9.378	9.377	0.001	2	0.56
3/14/87	3/17/87	9.377	9.380	-0.003	3	-1.13
3/17/87	3/20/87	9.378	9.360	0.018	3	6.77
3/20/87	3/23/87	9.360	9.370	-0.010	3	-3.76
3/23/87	3/26/87	9.370	9.370	0.000	3	0.00
3/26/87	3/29/87	9.370	9.377	-0.007	3	-2.63
3/29/87	4/1/87	9.377	9.384	-0.007	3	-2.63
4/1/87	4/4/87	9.384	9.383	0.001	3	0.38
4/4/87	4/7/87	9.383	9.381	0.002	3	0.75
4/7/87	4/10/87	9.381	9.373	0.008	3	3.01
4/10/87	4/12/87	9.373	9.375	-0.002	2	-1.13
4/12/87	4/15/87	9.375	9.379	-0.004	3	-1.50
4/15/87	4/18/87	9.379	9.376	0.003	3	1.13
4/18/87	4/22/87	9.376	9.363	0.013	4	3.67
4/22/87	4/25/87	9.363	9.360	0.003	3	1.13
4/25/87	4/28/87	9.360	9.352	0.008	3	3.01
4/28/87	5/1/87	9.352	9.349	0.003	3	1.13
5/1/87	5/4/87	9.349	9.345	0.004	3	1.50
5/4/87	5/7/87	9.345	9.346	-0.001	3	-0.38
5/7/87	5/10/87	9.346	9.344	0.002	3	0.75
5/10/87	5/13/87	9.344	9.340	0.004	3	1.50
5/13/87	5/16/87	9.340	9.342	-0.002	3	-0.75
5/16/87	5/19/87	9.342	9.340	0.002	3	0.75
5/19/87	5/22/87	9.340	9.350	-0.010	3	-3.76
5/22/87	5/25/87	9.350	9.350	0.000	3	0.00
5/25/87	5/28/87	9.350	9.350	0.000	3	0.00
5/28/87	5/31/87	9.350	9.354	-0.004	3	-1.50
5/31/87	6/4/87	9.354	9.353	0.001	4	0.28

Exhibit N-6, Part 9. CORROSION COUPON DATA FOR THE LONG-TERM FLOW TEST -- TWO SEPARATORS FROM 7/17/84 THROUGH 10/27/87

Between Separators

Date In	Date Out	Weight In (grams)	Weight Out (grams)	Weight Loss (grams)	Time In (Days)	Loss Rate (mils/yr)
6/4/87	6/7/87	9.353	9.353	0.000	3	0.00
6/7/87	6/10/87	9.353	9.353	0.000	3	0.00
6/10/87	6/13/87	9.353	9.350	0.003	3	1.13
6/13/87	6/16/87	9.350	9.344	0.006	3	2.26
6/16/87	6/19/87	9.344	9.379	-0.035	3	-13.16
6/19/87	6/22/87	9.379	9.375	0.004	3	1.50
6/22/87	6/25/87	9.375	9.371	0.004	3	1.50
6/25/87	6/28/87	9.371	9.371	0.000	3	0.00
6/28/87	7/1/87	9.371	9.383	-0.012	3	-4.51
7/1/87	7/4/87	9.383	9.374	0.009	3	3.38
7/4/87	7/7/87	9.374	9.374	0.000	3	0.00
7/7/87	7/10/87	9.374	9.370	0.004	3	1.50
7/10/87	7/13/87	9.370	9.372	-0.002	3	-0.75
7/13/87	7/16/87	9.372	9.383	-0.011	3	-4.14
7/16/87	7/19/87	9.383	9.370	0.013	3	4.89
7/19/87	7/22/87	9.370	9.371	-0.001	3	-0.38
7/22/87	7/25/87	9.371	9.378	-0.007	3	-2.63
7/25/87	7/28/87	9.378	9.375	0.003	3	1.13
7/28/87	7/31/87	9.375	9.380	-0.005	3	-1.88
7/31/87	8/3/87	9.260	9.260	0.000	3	0.00
8/3/87	8/6/87	9.260	9.259	0.001	3	0.38
8/6/87	8/9/87	9.259	9.257	0.002	3	0.75
8/9/87	8/12/87	9.257	9.264	-0.007	3	-2.63
8/12/87	8/15/87	9.264	9.267	-0.003	3	-1.13
8/15/87	8/18/87	9.267	9.270	-0.003	3	-1.13
8/18/87	8/21/87	9.270	9.271	-0.001	3	-0.38
8/21/87	8/24/87	9.271	9.272	-0.001	3	-0.38
8/24/87	8/28/87	9.272	9.282	-0.010	4	-2.82
8/28/87	8/30/87	9.282	9.285	-0.003	2	-1.69
8/30/87	9/2/87	9.285	9.280	0.005	3	1.88
9/2/87	9/5/87	9.280	9.283	-0.003	3	-1.13
9/5/87	9/8/87	9.283	9.286	-0.003	3	-1.13
9/8/87	9/11/87	9.286	9.292	-0.006	3	-2.26
9/11/87	9/14/87	9.292	9.299	-0.007	3	-2.63
9/14/87	9/17/87	9.299	9.299	0.000	3	0.00
9/17/87	9/20/87	9.299	9.303	-0.004	3	-1.50
9/20/87	9/23/87	9.303	9.370	-0.067	3	-25.19
9/23/87	9/27/87	9.370	9.305	0.065	4	18.33