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GEOPRESSURED^H - GEOTHERMAL DRILLING AND TESTING PLAN:

MAGMA GULF/TECHNADRIL - DEPT. OF ENERGY
MGT-DOE AMOCO FEE NO.1 WELL,
CAMERON PARISH, LOUISIANA

JULY 1980

PREPARED BY THE GEOTHERMAL BRANCH
ENERGY APPLICATIONS DIVISION
DOE/NEVADA OPERATIONS OFFICE

U.S. DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE
MAGMA/GULF TECHNADRIL

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I. INTRODUCTION

A. Background

In 1975, the U.S. Energy Research and Development Administration (now a part of the U.S. Department of Energy) initiated a research, development, and demonstration program to stimulate commercial development of the geopressured resources underlying the Gulf Coast region of the United States. Several investigators (see References 1, 2, and 3, Section XI) had recognized the energy potential and suggested that studies be conducted to assess the energy resource.

As a part of the Department of Energy (DOE) program, the Magma Gulf Company, under Contract No. ET-78-C-08-1561, undertook a comprehensive study of the geopressured resources in the Sweet Lake geopressured-geothermal prospect located in northern Cameron Parish, Louisiana, in T 12 S, R 7 W, and T 12 S, R 8 W, approximately 15 miles south of Lake Charles, Louisiana. The primary objective of the investigation was to select the optimum resource site for extensive studies (i.e., exploratory drilling, production testing, reservoir analysis, and environmental impact evaluation).

The region is characterized by Cenozoic sand and clay deposits of geosynclinal thickness and differentially uplifted salt structures. The primary geopressured-geothermal aquifer is the "Miogyp" sand of the Camerina zone (Upper Frio formation of Oligocene-Miocene age).

The main prospect is located in a basin on the north flank of the Hackberry-Big Lake-Sweet Lake salt ridge. Interpretation of 27 miles of seismic lines and 17 deep well logs localizes the prospect in a basin with north-westerly dip in a graben between east-west faults which converge eastward.

Aquifer depth ranges from 14,000 to 18,000 feet. Net sand thickness exceeds 400 feet, with 22 percent porosity. Temperatures range from 280°F (corrected) at 14,000 feet to 350°F at 18,000 feet. Geopressures occur below 9,000 feet, with mud weight equivalents in the sand from 15.5 to 16.5 pounds per gallon. Net sand volume of one cubic mile is estimated in the area mapped.

In order to conduct these studies, DOE executed a contract with Magma Gulf-Technadril (MGT), a joint venture between Magma Gulf Company and Technadril, Inc., of Houston, Texas, to conduct the drilling, completion, and testing of one geopressured-geothermal well (i.e., MGT-DOE AMOCO Fee No. 1 well) and one disposal well in Cameron Parish, Louisiana.

B. Program Objectives

The objectives of the well drilling and testing program are to determine the following parameters:

1. Reservoir permeability, porosity, thickness, rock material properties, depth, temperature, and pressure.
2. Reservoir fluid content, specific gravity, resistivity, viscosity, and hydrocarbons in solution.
3. Reservoir fluid production rates, pressure, temperature, production decline, and pressure decline.
4. Geopressured well and surface equipment design requirements for high-volume production and possible sand production.
5. Specific equipment design for surface operations, hydrocarbons distribution, and effluent disposal.
6. Possibilities of reservoir compaction and/or surface subsidence.

C. Well Locations

The test well MGT-DOE AMOCO Fee No. 1 and disposal well MGT-DOE AMOCO Fee No. 2 are located on a 5-acre test site approximately 15 miles south of Lake Charles, Louisiana, in the S 1/2, Sec. 13, T 12 S, R 8 W, on AMOCO fee land under geothermal lease to Magma Gulf Company (see Figures 1, 2, 3, and 4).

Figure 1

Topographic map of Sweet Lake Prime Prospect Area modified from Figure 1 of the Environmental Assessment Report by placement of the star to depict the proposed drill site. Note drill site position between the 10-foot and 5-foot contours of surface elevation and over 2 miles from the nearest wetlands to the southwest.

SWEET LAKE GEOTHERMAL WELL

VICINITY MAP AND
GENERAL LOCATION PLAN

Cameron, La.

Figure 3

WELL LOCATION:
MAGMA GULF - TECHNADRIL
Dept. of Energy Amoco No.2 Disposal Well

Commencing at the Southwest corner of Section 13,
T.12 S., R.8 W., go North along the West Line
of Section 1730 feet, thence East at Right
Angles 2815 feet to the Location.
Ground Elevation 8.3'

We hereby certify that we staked the above
Well Location as shown June 16, 1980.
Whitaker & Webb - Civil Engineers.

George F. Webb Jr.
GEORGE F. WEBB, JR., LA. REG. NO. 3870

MAGMA GULF - TECHNADRIL
WELL LOCATION
SECTION 13, T.12 S., R.8 W.
CAMERON PARISH, LA.

SCALE: 1" = 1000'

JUNE 17, 1980

WHITAKER & WEBB
CIVIL ENGINEERS
LAKE CHARLES, LA.

Figure 4

II. GENERALIZED SITE ACTIVITIES

A. Site Preparation

1. The existing road, access road, and well site area will be graded and uniform to a tolerance of ± 0.2 feet. The existing road from Highway 384 to the turnaround will be covered with 6 inches of shell. The turnaround area (approximately 70 feet x 70 feet) will also be covered with 6 inches of shell. This turnaround will be the location for the site manager's office trailer and will be used to control access to the well site.
2. The access road from the turnaround to the well site will be graded and covered with one layer of DUPONT 3401, 4-ounce pervious TYPAR. This material will then be covered with 12 inches of shell prior to placement of the boards. The boards on the access road shall be three ply, with the bottom ply to be 14 feet wide consisting of 17 mud boards. The second ply will be placed on 9-inch centers, and the top ply will be 12 board runners set on vehicle track spacing. The first two plies may be used board lumber. The top ply will be new boards nailed with a minimum of four 60P nails per board.
3. The well site will be approximately 200 feet x 325 feet in area. The site will be graded and covered with one layer of DUPONT 3401, 4-ounce pervious TYPAR. This material will then be covered with three-ply boarding, except in the area of the rig substructure. The bottom ply shall be laid on 12-inch centers with the middle and top plies on 9-inch centers. In the area of the rig substructure, a fourth ply shall also be laid on 9-inch centers. The top layers shall be nailed with a minimum of four 60P nails per board. All boards shall be 3 x 9 scant good hardwood. The bottom two plies may be good used lumber. The top ply, top two plies in the area of the rig substructure, shall be new 3 x 9 scant hardwood lumber.
4. A ring levee shall be constructed around the turnaround area. This levee will not exceed 2 1/2 feet in height with a drainage ditch not to exceed 1 foot in depth. The ring levee will extend along the north side of the access road to the well site and around the entire well site. This levee will be 3 feet in height. The levee is designed to protect the drill site area from possible flooding and to protect the local farming operations from any possible contamination. Culverts will be constructed under the access road and ring levee in order to accommodate the rice farming operation.
5. No reserve pits will be dug. Metal reserve tanks approximately 50 feet x 60 feet x 7.5 feet will be used instead.
6. See Figures 3, 4, 5, and 6 for drill site layout.

SWEET LAKE
GEOTHERMAL WELL

WELL PAD AND
ACCESS ROAD LAYOUT

Figure 5

Figure 6
2-3

B. Trailers

The trailers at the site will be provided by the various firms and agencies involved. These will include the Magma Gulf-Technadril site manager's office trailer, the tool pusher's trailer, the mud logger's trailer, the mud engineer's trailer, and trailers used by personnel involved in research for the project.

C. Communications

A telephone will be installed in the Magma Gulf-Technadril site manager's trailer. This number will be: 318-474-2650.

D. Power

A power line from the Jefferson Davis REA will be provided to the Magma Gulf-Technadril site manager's trailer. Additional power will be provided by the rig generators.

E. Site Cleanup and Restoration

At the completion of the drilling project, the site will be converted to testing operations. The boards will be removed and the well site will be covered with shell. The boards will be removed from the access road and additional shell will be added to the road surface. If the project is to be abandoned completely, the TYPAR will also be removed from the well site and the shell and TYPAR removed from the access road. The well will be plugged and abandoned according to the State of Louisiana regulations. The well site area and access road will be smoothed and returned to its original use. The existing turnaround and road will remain for use by the rice farmer for farming operations.

F. Water Supply

A water supply well will be drilled to supply water for the test well and disposal well.

G. Sanitation

A 500-gallon sheet steel, tar-coated septic tank and PVC pipe for the distribution lines will be installed on the north side of the turnaround and connected to the Magma Gulf-Technadril site manager's trailer.

III. OCUPATIONAL HEALTH AND SAFETY

A. General

All drilling operations and other site activities will be conducted in accordance with standards of the Occupational Safety and Health Act of 1970 (OSHA).

All participating organizations are responsible for the health and safety of their own personnel and for conducting all activities in accordance with procedures that assure:

1. A safe and healthful environment for the employees.
2. Control and minimization of hazards to the public and to personnel of other participants.
3. Minimization of accidental damage or loss of equipment, materials, and property.

B. Site Access

Because of the hazardous nature of geopressured-geothermal well drilling and testing operations, MGT will control access to the test site and will arrange all visits of nonproject personnel.

C. Fire Protection

Hand-operated fire extinguishers for the drill rig and other surface equipment will be provided. Extinguishers will be available for control of Class A, B, and C fires.

D. Industrial Hygiene

Potable water and chemical or standard toilets will be provided at all areas where personnel are stationed on a full-time basis. The chemical toilets will be serviced on a regular basis. Solid wastes will be disposed of appropriately.

E. Safety Hazards

1. Hydrogen Sulfide

None expected. Normal precautions will be taken by placing H₂S detectors in the drilling fluid pit areas and monitoring same with the mud logging unit.

2. Blowouts

- a. Refer to Section IV.

- b. Should a severe "well kick" develop, the Hydril will be closed and the choke line opened. Circulation will continue while slowly increasing the weight of the drilling fluid. After sufficient weight material (barite) has been added, the Hydril will be opened. Circulation will continue for a length of time necessary to completely stabilize the mud at the new weight. The pump will be shut down and the well observed. If the drilling fluid is stable, normal operations will be continued.

During the course of the well killing procedure with the Hydril closed, the drill pipe will periodically be moved to lessen the chance of the drill pipe becoming stuck in the hole. Should the Hydril fail, the upper preventer will be closed and circulation continued with the drill pipe in place.

IV. DRILLING OPERATIONS

A. Test Well

1. General Drilling Summary

Drill and complete a vertical 15,700-foot well for evaluation of geopressured-geothermal "Miogyp" sands. See Figure 7.

- a. Drive 30-inch x 1-inch wall structural casing which will be the conductor string to ± 120 feet.
- b. Drill 24-inch hole and set 20-inch surface casing at ± 800 feet.
- c. Drill 17 1/2-inch hole, log, and set 13 3/8-inch intermediate casing at $\pm 4,000$ feet.
- d. Drill 12 1/4-inch hole, log, and set 9 5/8-inch intermediate casing at $\pm 10,000$ feet.
- e. Drill 8 3/8-inch hole, log, and set 7 5/8-inch intermediate casing at $\pm 14,900$ feet.
- f. Drill 6 1/2-inch hole, core, log, and set 5 1/2-inch production liner through "Miogyp" sands to $\pm 15,700$ feet.
- g. Complete with 5 1/2-inch tubing string.

2. Pressure Summary

Normal pore pressures are expected to approximately 9,800 feet, where pressures increase rapidly to more than 14.5 ppg within 1,000 feet. The 13 3/8-inch casing shoe at $\pm 4,000$ feet should test to approximately 14.7 ppg; however, there is no advantage to penetrating the transition zone beyond 11.0-11.5 ppg pore pressure. An 11.0 ppg pore pressure at 10,000 feet should sustain a ± 17.0 ppg casing seat for the 9 5/8-inch casing.

Pore pressures continue to increase gradually between 11,000 feet and 12,600 feet, where a 15.5 ppg mud would be increased to ± 15.9 ppg. All three offset wells have experienced a sudden increase in pore pressure and brief gas cuts just prior to the top of the "Miogyp" sand. This sudden increase in pressure requiring ± 16.2 mud is anticipated in this well between 14,500 feet and 14,700 feet (assuming this well to be ± 200 feet low relative to Union's Pan Am No. 2). A mud weight of 16.2 ppg should be adequate for drilling to the 7 5/8-inch casing point at $\pm 14,800$ feet to $\pm 14,900$ feet. This casing point is most critical to the program and should be selected with great care. The 7 5/8-inch shoe must be below the ratty sands at

SWEET LAKE PROSPECT PRODUCING WELL DIAGRAM

Figure 7

± 14,400 feet to 14,440 feet in Union's Pan Am No. 2, but above the lesser pressured shaley sands commencing at ± 14,670 feet in Union's Pan Am No. 2. A casing seat at this point should sustain a test of ± 18.4 ppg.

A conventional core is anticipated just prior to the top of the "Miogyp" sand at ± 15,000 feet. Pressures begin declining in the shales just above the sand and once within the "Miogyp" sands, pressures fall to ± 13.5 ppg. A mud weight of ± 14.5 ppg should be adequate for drilling from below the 7 5/8-inch shoe to a TD of ± 15,700 feet.

3. Drilling Procedure

a. Planned Procedure using single string of casing from 14,900 feet to surface. See Figure 7.

- (1) Prepare location for rig.
- (2) Drive 30-inch x 1-inch wall, 309 pounds-per-foot, Grade B structural casing with D-30 hammer. Obtain bearing load capacity of ± 800,000 pounds or approximately 150 blows per foot.
- (3) Cut off 30-inch below rotary and install flow line on 30-inch drive pipe. Pick up 24-inch bit or 24-inch hole opener with 17 1/2-inch bit and wash out to ± 20 feet below 30-inch pipe.
- (4) Drill 17 1/2-inch hole to ± 800 feet. See pages 4-17 through 4-28 for details.
- (5) Open 17 1/2-inch hole to 24 inches with 17 1/2-inch bit and 24-inch hole opener. Displace hole with 50 to 60 viscosity mud prior to pulling out of hole.
- (6) Run 20-inch casing per page 4-28. Center 20-inch in rotary and hold in place while cementing.
- (7) Cement 20-inch casing using stab in equipment on drill pipe and cement slurry on page 4.23. Should cement in annulus fall below ground level, perform top job using cement slurry recommended for top jobs on page 4-25.
- (8) Install 20-inch slip-on x 20-inch, 3,000 psi flanged casing head with base plate. Assure base plate is resting firmly on 30-inch casing. Use shim stock if necessary. It is imperative that the face of the 20-inch flange be as close to horizontal as possible.
- (9) Nipple up 20-inch, 3,000 psi x 20-inch, 2,000 psi double-studded adapter; 20-inch, 2,000 psi spool with two 4-inch

outlets; and 20-inch, 2,000 psi annular preventer. Install two 4-inch, 2,000 psi valves on spool with two 4-inch diverter lines to reserve tanks. See Figure 8.

- (10) Check 30-inch x 20-inch annulus and perform second top job if necessary to fill up annulus to top of 20-inch.
- (11) Pick up 17 1/2-inch bit and bottom-hole assembly without stabilizers. Tag cement and test casing, annular preventer, and spool to 1,000 psi.
- (12) Drill out collar, cement joint, 20-inch shoe, and ± 10 feet of new formation with 9.2 ppg mud. Circulate for one-half hour. Check for mud loss. Do not test casing seat. Should mud loss occur, drill ahead slowly ± 200 feet with 50 to 60 viscosity mud. If mud loss continues, spot 50-barrel, 100-viscosity mud pill at bottom of casing and pull up in casing. Let hole heal. Repeat if necessary.
- (13) Continue drilling 17 1/2-inch hole to $\pm 1,200$ feet.
- (14) Pull out of hole and pick up bottom-hole assembly consisting of three welded blade stabilizers, six 9-inch O.D. and two 7 3/4-inch O.D. steel drill collars, and one 9-inch monel drill collar. Stabilizers should be placed at 30, 90, and 120 feet above bit. Approximate weight of bottom-hole assembly in air should be $\pm 60,000$ pounds.
- (15) Drill ahead to $\pm 4,000$ feet. Take inclination survey every 500 feet or nearest dull bit. Do not exceed 1,000 feet between surveys. Maximum deviation should not exceed $1\frac{1}{2}^\circ$ above 4,000 feet. Drop multishot survey prior to pulling out of hole to log at $\pm 4,000$ feet.
- (16) Run logs per page 4-22.
- (17) Lay down monel collar. Run in hole with remainder of bottom-hole assembly. Condition mud to 9.0 to 9.2 ppg and a maximum funnel viscosity of 30. Use methyl blue test to determine gel content. Check alignment of 20-inch head so that the hole is exactly centered in rotary and the plane of flange face is as near to horizontal as possible. Set plug in 20 inches and realign head if necessary.
- (18) Pull out of hole and run 13 3/8-inch casing to $\pm 4,000$ feet per pages 4-19 through 4-29. Cement 13 3/8-inch using volumes calculated from caliper log and the cementing procedure. Do not tack weld float equipment.
- (19) Check cement level in 13 3/8-inch x 20-inch annulus prior to setting 13 3/8-inch slips. Should top of cement be any distance below top of 20-inch casing, perform top job using recommended high-temperature slurry on page 4-25.

SWEET LAKE PROSPECT

LOW PRESSURE SERVICE

2000 PSI.
MINIMUM REQUIREMENTS

Figure 8

- (20) See pages 4-28 and 4-29 for 13 3/8-inch casing running procedure. Set slips. Cut off casing and nipple down blowout preventers.
- (21) Install 20-inch, 3,000 psi x 13 5/8-inch, 5,000 psi casing spool and test to one-half collapse of 13 3/8-inch, 72-pound, N-80 casing or 1,350 psi.
- (22) Nipple up blowout preventers and choke manifold per attached Figures 9 and 10 and recommended BOP practices.
- (23) Use plug-type test tool and test annular preventer to 3,500 psi. Test rams, casing spool, valves, HCR valve, check valve, choke line, kill line, choke manifold valves, upper and lower kelly cocks, swivel, hose, and standpipe to 5,000 psi.
- (24) Pick up 12 1/4-inch bit and 9-inch drill collars without stabilizers. Drill out float collar and cement joint to within 20 feet of casing shoe. If cement is firm, test casing to 1,500 psi using 500 psi increments. Allow 10 minutes between increments.
- (25) Drill remainder of cement and shoe and $\pm$ 10 feet of new hole below casing. Close annular preventer and pressure up on shoe to a 14.0 ppg equivalent using 9.2 ppg mud. Surface pressure should be $\pm$ 1,000 psi.
- (26) Should casing shoe fail to hold test, determine what mud weight shoe is holding. Pull out of hole and pick up 13 3/8-inch, 72-pound squeeze tool and set in second joint from shoe. Squeeze shoe with 200 sacks of high-temperature squeeze cement recommended on page 4-25.
- (27) Drill out, retest, and squeeze until a successful test is obtained.
- (28) Drill sufficient hole to bury bottom-hole assembly.
- (29) Pick up 12 1/4-inch drilling assembly consisting of six 9-inch collars and ten 7 3/4-inch collars with three stabilizers. Weight in air approximately 75,000 pounds. Run welded blade stabilizers at 60, 90, and 150 feet above bit.
- (30) Drill 12 1/4-inch hole taking inclination surveys every 500 feet or nearest dull bit. Maximum permissible deviation is 2° between surveys or a maximum angle of 5° .

Drilling breaks to be circulated according to page 4-27. Record all kick control information on the kick control information form. Have mud logger provide current and

BNORMAL PRESSURE
SERVICE

5000 psi

BLOWOUT PREVENTER

STACK

Figure 9
4-7

MAGMA GULF-TECHNADRIL SWEET LAKE PROSPECT

ABNORMAL PRESSURE
SERVICE
10000 psi
BLOWOUT PREVENTER
STACK

Figure 10
4-8

written summary of all drilling parameters prior to making a trip. Maintain a continuous chronological log of changes in pit volume and flow line temperatures. Obtain ditch samples per page 4-23. Pick up monel collar on last bit trip before reaching total depth of 12 1/4-inch hole. Maintain minimum mud weight required for safe drilling and tripping based on hole conditions and mud logger's data.

- (31) Upon reaching a total depth of 10,000 feet or a pore pressure of 12 ppg above 10,000 feet, condition hole for logging and drop multishot survey.
- (32) Log hole per page 4-22.
- (33) Pick up stabilized bottom-hole assembly, less monel collar, and condition hole to run 9 5/8-inch casing. Pull up in casing and install 9 5/8-inch rams in top ram preventer.
- (34) Run, cement, and hang 9 5/8-inch casing per pages 4-19. through 4-31.
- (35) Cut off casing, pick up blowout preventers, and install 13 5/8-inch, 5,000 psi by 11-inch, 10,000 psi spool. Test to one-half collapse pressure of 9 5/8-inch casing or 4,000 psi.
- (36) Test blowout preventers and all lines as per Step 23.
- (37) Pick up 8 3/8-inch bit and twenty-one 6 1/2-inch spiral collars without stabilizers and drill out float collar and cement joint to within 20 feet of float shoe, if cement is hard. Test casing to 1,500 psi. Should casing leak, locate leak with retrievable squeeze tool and squeeze with high-temperature cement per page 4-25. Check pump efficiency prior to drilling out 9 5/8-inch shoe.
- (38) Drill out remainder of cement, casing shoe, and 10 feet of new formation. Test casing seat to an equivalent of 16.8 ppg using 12.5 ppg mud in casing. Use procedure as stated in Steps 24 and 25. Surface pressure should be 2,240 psi.
- (39) Should squeeze fail to hold a test, resqueeze, drill out, and retest until test is successful.
- (40) Drill sufficient 8 3/8-inch hole below 9 5/8-inch casing to bury 700 feet of bottom-hole assembly.
- (41) Drill 8 3/8-inch hole to $\pm$ 14,900 feet. Run twenty-one 6 1/2-inch spiral collars with integral blade stabilizers at 60, 90, and 120 feet above bit. Run shock sub with insert bits. Pick up monel collar on last bit run. Bottom-hole assembly weight in air should be 65,000 pounds. Maximum allowable increase in deviation between 500-foot surveys is 2°. Maximum deviation should not exceed 7°.

- (42) Condition hole for logging and make short trip over last normal bit run prior to running multishot while pulling out of hole. Ensure solids in mud are minimum, HT-HP water loss is 10 cc or less, and other rheological properties are as per mud program. Catch mud sample and run 72-, 48-, and 24-hour aging cells at bottom-hole temperature ($\pm 300^{\circ}\text{F}$).
- (43) Log hole per page 4-22.
- (44) Lay down monel collar and run stabilized bottom-hole assembly to condition hole to run 7 5/8-inch casing. Lay down BHA.
- (45) Run, land, and cement casing per page 4-29.
- (46) Nipple down BOP and install 11-inch, 10,000 psi x 9-inch, 10,000 psi tubing spool test to one-half collapse pressure of 7 5/8-inch casing or 5,300 psi.
- (47) Nipple up and test BOP per Step 23.
- (48) Lay down drill pipe in mouse hole and pick up 6 1/2-inch bit, thirty 4 1/2-inch x 2 1/4-inch spiral drill collars, 8,800 feet 3 1/2-inch, 13.3-pound IF X-95, 5,000 feet 3 1/2-inch, 13.3-pound IF S-135 drill pipe. This design based on Used Premium Drill Pipe.
- (49) Trip in hole. Drill out float collar and ± 100 feet of cement below collar, if cement is hard. Test casing to a 17 ppg equivalent with 15.5 ppg mud in hole. Surface pressure should be ± 750 psi. Should casing not test, run 7 5/8-inch retrievable test tool, locate leak, squeeze, drill out, and retest. Hold 500 psi on annulus and monitor, while squeezing, for pressure increase that would indicate tool leakage.
- (50) Drill out remainder of cement and shoe plus 10 feet of new formation. Test shoe to a minimum acceptable leak-off of 16.5 ppg equivalent. Minimum acceptable surface pressure is ± 770 psi with 15.5 ppg mud in hole.
- (51) Should shoe not test, set 7 5/8-inch retrievable test tool in second joint above shoe and squeeze. Hold 1,500 psi on annulus while squeezing. Monitor annulus for pressure increase that would indicate tool leakage or channeling of cement behind the liner.
- (52) Drill out, test, and repeat squeeze until shoe test is satisfactory.

- (53) Drill 6 1/2-inch hole to the proposed coring depth of $\pm 15,000$ feet (depending on correlation with Union's Pan Am No. 2). Hold mud weight at 15.0 to 15.5 ppg while coring through top of "Miogyp" sand. Monitor mud rheology closely and hold solids to a minimum. The remainder of the coring program will be developed according to log correlation. It is planned to core ± 300 feet of the "Miogyp."
- (54) Drill and core 6 1/2-inch hole to $\pm 15,700$ feet or the equivalent of $\pm 15,500$ feet in Union's Pan Am No. 2. Reduce mud weight to ± 14.5 when drilling the "Miogyp." Monitor returns closely for excess shale. Maintain minimum solids to total depth.
- (55) Circulate out and make short trip up in 7 5/8-inch casing; condition hole to log.
- (56) Log 6 1/2-inch hole per page 4-22.
- (57) Condition hole. Run and cement 5 1/2-inch liner per page 4-33.
- (58) Clean out 7 5/8-inch liner to within 100 feet of top of 5 1/2-inch liner. Wait on cement until it is hard. Clean out to top of 5 1/2-inch liner.
- (59) Test top of liner to 18.3 ppg equivalent. Surface pressure will be $\pm 2,700$ psi with ± 14.5 ppg in hole. Should liner leak, squeeze with 7 5/8-inch retrievable squeeze tool and high-temperature squeeze cement per page 4-25.
- (60) Clean out 5 1/2-inch liner to within 40 feet of shoe. Test liner to 18.3 equivalent at top of liner as in Step 59.
- (61) Clean out 5 1/2-inch liner to top of cement.
- (62) Run on drill pipe and set 7 5/8-inch packer with 4-inch bore, ± 25 feet of packer bore extension, locator sub, ± 6 feet of seals for polish bore on top of liner hanger.
- (63) Pressure up on drill pipe to 2,000 psi to test below packer. Pressure up on annulus to 2,000 psi to test above packer.
- (64) Release running tool and pull out of hole laying down drill pipe and bottom-hole assembly. Nipple down BOP.
- (65) Install 11-inch, 10,000 psi x 9-inch, 10,000 psi tubing spool.

- (66) Nipple up BOP and test.
- (67) Pick up seal assembly for packer on 5 1/2-inch, 23-pound, AR-95 SFJ-P tubing. Run 5 1/2-inch tubing in hole. Set seals in packer and test to 1,000 psi on annulus. Pick up and displace 14.5 ppg mud with preheated (130° to 150°) 12.0 ppg solids-free packer fluid.
- (68) It is estimated that the total elongation of the tubing will be ± 115 inches. After displacing with preheated brine water, recheck spacing leaving 8 to 10 feet of seals below top of packer and ± 12 feet of seals above the packer.
- (69) Pick up and displace packer fluid in tubing with field brine water. Land tubing. Test seals with 1,000 psi on annulus.
- (70) Nipple down blowout preventers and install tree. Test to rated working pressure.
- (71) Release rig.
- (72) Rig up wire line service mast with ± 60 feet of 7,500 psi lubricator and run blind box sinker bar to deepest zone to be perforated.
- (73) Perforate deepest zone four shots per foot with 2 7/8-inch hyperdome jet gun. A maximum surface pressure of ± 4,000 psi can be expected after first perforation.
- (74) Unload and test well, restricting surface drawdown to 10 percent of shut-in tubing pressure.
- (75) Repeat procedure and test remainder of zones of interest.
- (76) Set blank plug in no-go nipple at bottom of 5 1/2-inch tubing and shut in well, leaving 50 percent of tubing pressure on well.

b. Optional: 7 5/8-inch Casing Program. See Figure 11.

Should hole conditions be such that it is deemed in the best interest of the program, consideration will be given to running and cementing 7 5/8-inch casing liner from 14,900 feet to 9,800 feet with a 7 5/8-inch tieback string from 9,800 feet to the surface.

The casing weights, grade, and type connections will remain the same, but a liner hanger and tieback equipment will be required in lieu of the crossover joint between the SFJ and ExLine connections.

SWEET LAKE PROSPECT PRODUCING WELL OPTIONAL TIEBACK DIAGRAM

Figure 11
4-13

Subsequent to Step 41 in the drilling program, the following steps will be followed should the 7 5/8-inch casing be cemented up to 9,800 feet with a tieback string above that.

- (42) Condition hole for logging and make short trip over last normal bit run prior to running multishot while pulling out of hole.
- (43) Log hole per page 4-22.
- (44) Lay down monel collar and run stabilized bottom-hole assembly to condition hole to run 7 5/8-inch liner.
- (45) Run and cement 7 5/8-inch liner per page 4-32.
- (46) Pick up 8 3/8-inch bottom-hole assembly, less stabilizers, and tag-cement in minimum of 12 hours after bumping plug. Break circulation and wash out any green cement to within 100 feet of top of liner. Drill out only hard cement to top of liner. Circulate out. Test top of liner to 17 ppg equivalent with 16.2 ppg mud in hole. Surface pressure should be $\pm$ 400 psi.
- (47) Should liner top not test, run 9 5/8-inch, 72-pound retrievable test tool to $\pm$ 9,700 feet. Squeeze, drill out, and retest until test is satisfactory using high-temperature squeeze cement per page 4-25.
- (48) Lay down bottom-hole assembly. Pick up 6 1/2-inch bit, thirty 4 1/2-inch x 2 1/4-inch spiral drill collars, 5,100 feet of 3 1/2-inch, 13.30 IF Grade E drill pipe. Complete string with top 2,000 feet being 4 1/2-inch, 16.6-pound XH Grade G and the middle section 7,700 feet of 4 1/2-inch, 16.6-pound XH Grade E.
- (49) Drill out baffle collar and cement to within 20 feet of float shoe, if cement is hard. Test liner to a 17 ppg equivalent at liner top with 15.5 ppg mud in hole. Surface pressure should be $\pm$ 750 psi. Should liner not test, run 7 5/8-inch retrievable test tool, locate leak, squeeze, drill out, and retest. Hold 500 psi on annulus and monitor while squeezing for pressure increase that would indicate tool leakage or channeling of cement behind liner.
- (50) Drill out remainder of cement and shoe plus 10 feet of new formation. Test shoe to a minimum acceptable leak-off of 16.5 ppg equivalent. Minimum acceptable surface pressure is $\pm$ 770 psi with 15.5 ppg mud in hole.
- (51) Should shoe not test, set 7 5/8-inch retrievable test tool in second joint above shoe and squeeze. Hold 1,500 psi on annulus while squeezing. Monitor annulus for pressure

increase that would indicate tool leakage or channeling of cement behind liner.

- (52) Drill out, test, and repeat squeeze until shoe test is satisfactory.
- (53) Drill 6 1/2-inch hole to the proposed coring depth of $\pm 15,000$ feet (depending on correlation with Union of California Pan Am No. 2). Hold mud weight at 15.0 to 15.5 ppg while coring through top of "Miogyp" sand. Monitor mud rheology closely and hold solids to a minimum. The remainder of the coring program will be developed according to log correlation. It is planned to core ± 300 feet of the "Miogyp."
- (54) Drill and core 6 1/2-inch hole to $\pm 15,700$ or the equivalent of $\pm 15,500$ feet in Union's Pan Am No. 2. Reduce mud weight to ± 14.5 when drilling the "Miogyp." Monitor returns closely for excess shale. Maintain minimum solids to total depth.
- (55) Circulate out and make short trip up in 7 5/8-inch casing; condition hole to log.
- (56) Log 6 1/2-inch hole per page 4-22.
- (57) Condition hole. Run and cement 5 1/2-inch liner per page 4-33.
- (58) Clean out 7 5/8-inch liner to within 100 feet of top of 5 1/2-inch liner. Wait on cement until it is hard. Clean out to top of 5 1/2-inch liner.
- (59) Test top of liner to 18.3 ppg equivalent. Surface pressure will be $\pm 2,700$ psi with ± 14.5 ppg in hole. Should liner leak, squeeze with 7 5/8-inch retrievable squeeze tool and high-temperature squeeze cement per page 4-25.
- (60) Clean out 5 1/2-inch liner to within 40 feet of shoe. Test liner to 18.3 ppg equivalent at top of liner as in Step 59.
- (61) Run and cement 7 5/8-inch tieback string per page 4-33.
- (62) Drill out and test 7 5/8-inch liner tieback to 17 ppg equivalent at 9,800 feet. Surface pressure will be $\pm 1,300$ psi with 14.5 ppg in hole.
- (63) Clean out 5 1/2-inch liner to top of cement.
- (64) Run on drill pipe and set 7 5/8-inch packer with 4-inch bore, ± 25 feet of packer bore extension, locator sub, ± 6 feet of seals for polish bore on top of liner hanger.

- (65) Pressure up on drill pipe to 2,000 psi to test below packer. Pressure up on annulus to 2,000 psi to test above packer.
- (66) Release running tool and pull out of hole laying down drill pipe and bottom-hole assembly. Nipple down BOP.
- (67) Install 11-inch, 10,000 psi x 9-inch, 10,000 psi tubing spool.
- (68) Nipple up BOP and test.
- (69) Pick up seal assembly for packer on 5 1/2-inch, 23-pound, C-95 ExLine tubing. Run 5 1/2-inch tubing in hole. Set seals in packer and test to 1,000 psi on annulus. Pick up and displace 14.5 ppg mud with preheated (130° to 150°) 12.0 ppg solids-free packer fluid.
- (70) It is estimated that the total elongation of the tubing will be ± 115 inches. After displacing with preheated brine water, recheck spacing leaving 8 to 10 feet of seals below top of packer and ± 12 feet of seals above the packer.
- (71) Pick up and displace packer fluid in tubing with field brine water. Land tubing. Test seals with 1,000 psi on annulus.
- (72) Nipple down blowout preventers and install tree. Test to rated working pressure.
- (73) Release rig.
- (74) Rig up wire line service mast with ± 60 feet of 7,500 psi lubricator and run blind box sinker bar to deepest zone to be perforated.
- (75) Perforate deepest zone four shots per foot with 2 7/8-inch hyperdome jet gun. A maximum surface pressure of ± 4,000 psi can be expected after first perforation.
- (76) Unload and test well, restricting surface drawdown to 10 percent of shut-in tubing pressure.
- (77) Repeat procedure and test remainder of zones of interest.
- (78) Set blank plug in no-go nipple at bottom of 5 1/2-inch tubing and shut in well, leaving 50 percent of tubing pressure on well.

4. Surface Equipment and Service

a. Wellhead (See Figure 12)

The wellhead assembly will be rated at 10,000 pounds working pressure at 300°F maximum. The head will be a C-29-L with 20-inch O.D. slip-on x 13 3/8-inch x 9 5/8-inch x 7 5/8-inch x 5 1/2-inch O.D., 23-pound, C-95 EX LINE-CB thread, with OCT valves and two 2-inch LP 45° outlets.

b. Blowout Prevention Equipment (See Figures 8, 9, and 10)

The blowout preventers will be 2,000 psi WP, 5,000 psi WP, and 10,000 psi WP, ram-type, hydraulic-controlled equipment. An annular-type preventer will be above the ram preventer, and it will be 2,000, 5,000, or 10,000 psi WP.

c. Drill Rig (See Figure 6)

The rig will have a traveling block and hook, swivel, and rotary rated at 500 tons. The mast should be capable of 1,000,000 A.P.I. static hook load and the substructure must have 1,600,000-pound capacity.

d. Drilling Recording Instruments

Drilling recording instruments consisting of pump stroke counters, continuous mud weight recorders, pit volume totalers, pit level floats, rate of penetration gauges, etc., will be utilized on the drilling rig and by the mud loggers.

e. Other Equipment

Desilters, desanders, degassers, shale shakers, and all normal plus abnormal rig equipment may be utilized.

5. Downhole Equipment and Services

a. Casing Program

- (1) Conductor Casing: 30-inch O.D. x 1-inch wall 309 pounds-per-foot, Grade B drive with D-30 diesel hammer, utilizing pile driving analyzer to a depth capable of supporting bearing load of $\pm 800,000$ pounds. This load should require approximately 150 blows per foot.

SWEET LAKE PROSPECT

Wellhead Assembly

FMC

WELLHEAD EQUIPMENT DIVISION
HOUSTON

X-3995-REV. 1

DATE 2-20-80

FILE NO.

(2) Surface Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
0-400	20"	169	K-55	Butt.	2500/13	3400/6.8	2427 x 10 ³ /20
400-800	20"	133	K-55	Butt.	1500/3.9	3060/6.1	2133 x 10 ³ /40

Float Equipment--Inner string stab in float collar and conventional guide shoe run two joints apart. Thread lok shoe, collar, and top of first joint. See page 4-28 for 20-inch running procedure.

(3) Intermediate Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
0-2500	13 3/8"	72	N-80	Butt.	2670/2.2	5380/2.0	1661 x 10 ³ /1.7
2500-4000	13 3/8"	72	L-80	Butt.	2850/1.5	3450/1.9	1069 x 10 ³ /1.3

Float Equipment--Down jet float shoe with float collar run two joints apart. Thread lok shoe, collar, and top of first joint. See page 4-28 for 13 3/8-inch running procedure.

(4) Intermediate Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
0-10000	9 5/8"	53.5	C-95	ExLine	8850/2.3	9410/1.1	1477 x 10 ³ /1.8

Float Equipment--Down jet float shoe and float collar run two joints apart. Thread lok shoe, collar, and top of first joint. See page 4-29 for 9 5/8-inch casing running procedure.

(5) Production Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
0-9000	7 5/8"	39	C-95	ExLine	10600/1.4	10900/1.1	1063 x 10 ³ /1.9
9000-9040	7 5/8"	39	C-95	ExLine	10600/1.4	10900/1.4	1063 x 10 ³ /4.6
				Box by SFJ Pin			
9040- 14900	7 5/8"	39	S-95	SFJ	10600/1.3	10900/1.7	1063 x 10 ³ /4.6

Float Equipment--Down jet float shoe and float collar run three joints apart. Thread lok shoe; top of first, second,

and third joints; and top of float collar. See page 4-31 for 7 5/8-inch casing running procedure.

(6) Production Liner

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
14700- 15700	5 1/2"	22.54	AR-95	SFJ-P	12450/1.1	12540/1.3	456 x 10 ³ /22

Liner Hanger--5 1/2-inch, 22.54-pound, AR-95 SFJ pin x 7 5/8-inch, 38.05-pound mechanical set multicone hanger with polish bore receptacle for 5 1/2-inch, 22.54-pound, AR-95 tieback stem for H₂S service and $\pm 300^{\circ}\text{F}$.

Float Equipment--Baffle collar run three joints above float shoe. Thread lok shoe, first and second joint, and top and bottom of baffle collar. See page 4-33 for 5 1/2-inch liner running procedure.

(7) Optional 7 5/8-inch Drilling Liner

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
9800- 14900	7 5/8"	39	AR-95	SFJ-P	10600/1.3	10900/1.3	699 x 10 ³ /3.4

Liner Hanger--7 5/8-inch, 39-pound, SFJ pin x 9 5/8-inch, 53.5-pound multicone hanger with polish bore receptacle for 7 5/8-inch, 39-pound, C-95 tieback stem. For H₂S service and temperature of $\pm 300^{\circ}\text{F}$.

Float Equipment--Baffle collar run three joints above float shoe. Thread lok shoe, first and second joint, and baffle collar top and bottom. See page 4-32 for optional 7 5/8-inch drilling liner running procedure.

(8) Optional 7 5/8-inch Tieback Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate/SF</u>
0-9800	7 5/8"	39	C-95	ExLine	10600/1.7	10900/1.1	1063 x 10 ³ /1.9

Run with 7 5/8-inch, 39-pound, C-95 ExLine tieback stem that is compatible with liner hanger. See page 4-33 for optional 7 5/8-inch tieback running procedure.

b. Bit Program

<u>Depth</u>	<u>Hole Size</u>	<u>Recommended Bit Type</u>
0-800	24"	IADC 1-1-1 jet bit or 24-inch hole opener with 17 1/2-inch bit on bottom.
800-4000	17 1/2"	IADC 1-1-1 jet bit.
4000-8000	12 1/4"	IADC 1-1-1 jet bit.
8000-10000	12 1/4"	IADC 5-1-7 carbide jet bit with gauge inserts.
10000-12000	8 3/8"	IADC 5-1-7 or 2-4 jet bit.
12000-13000	8 3/8"	IADC 5-1-7 or 3-7 carbide jet bit with gauge inserts.
13000-14900	8 3/8"	IADC 5-1-7 or 6-1-7 carbide jet bit with gauge inserts.
14900-15700	6 1/2"	IADC 5-1-7 or 6-1-7 carbide jet bit with gauge inserts.

RECOMMENDED STABILIZER SIZES

<u>Bit Size</u>	<u>Stabilizer O.D.</u>
17 1/2"	17 15/32"
12 1/4"	12 7/32"
8 3/8"	8 11/32"
6 1/2"	6 15/32"

c. Drilling Fluid Program

<u>Depth</u>	<u>Mud Type</u>	<u>Weight</u>	<u>Visc.</u>	<u>Percent Solids</u>	<u>Water Loss</u>	<u>PV</u>	<u>YP</u>
0-4000	Gel, caustic lignite	8.8-9.0	40-45	5-6	NC-30	5	10
4000-9000	Gel, caustic lignite	9.0-9.5	36-40	6-10	25-15	8	15
9000-10000	Lignosulfonate	9.5-12.5	38-42	10-17	10-6	14-20	7-8
10000-11000	Lignosulfonate	12.5-14.5	40-44	17-25	6-5	32	10
11000-12500	Lignosulfonate	14.8-15.6	42-46	25-28	12*	28-36	5-12
12500-13000	Lignosulfonate	15.6-15.9	42-48	28-29	12*	32-38	5-12
13000-14500	Lignosulfonate	15.9-16.0	44-48	29-30	12*	33-38	5-12
14500-14900	Lignosulfonate	16.0-16.2	44-48	30-31	12*	33-39	5-12
14900-15700	Lignosulfonate	± 14.5	40-44	25	12*	27-32	5-11

*Maximum HP-HT water loss

- (1) A low-solids, nondispersed system can be used to $\pm$ 9,000 feet. Use desander, desilter until the first addition of barite. Maintain low surface volume to $\pm$ 2,000 feet and start displacing hole with clean mud at this depth. While drilling, start water loss control and operation of fine screen shaker at $\pm$ 2,000 feet.
- (2) Begin converting to inhibited system at 9,000 feet with addition of chromlignosulfonate and lignite to lower water loss and control rheology. Begin addition of sodium chromate at 10,000 feet for thermal stability.
- (3) Have centrifuge operable on first addition of barite.
- (4) Particular care should be taken when coring the shale section above the "Miogyp" sand. The reduced mud weight through this section may induce heaving shale.
- (5) Differential sticking will be a problem in the "Miogyp" section if mud weights are excessive or if rheology of mud is not closely controlled.

d. Logging Program

<u>Depth</u>	<u>Required Logs</u>
0-800	None
800-4000	Induction electric. Multishot directional. Caliper.
4000-10000	Dual induction laterolog. Borehole compensated formation density. High-resolution dipmeter. Compensated sonic log. Temperature log. Compensated gamma ray-neutron.
10000-14900	Same as used in 4000- to 10000-foot interval.
14900-15700	Same as used in 4000- to 10000-foot interval plus: saraband and mechanical properties log in zones of interest.
Production Logs	Gamma ray-neutron. Collar, variable density-CBL. 5 1/2-inch casing caliper.

e. Mud Logging Program

A mud logging system will be installed and operational at the 6,000-foot depth. This will include drilling rates, lithology interpretation and description, total gas content of the drilling fluid--continuously recorded, dual-column chromatograph, trip gas notation, connection gas notation, pump strokes monitored, drilling mud properties, and pit volume and flow rate monitored.

A computerized logging unit will also be installed at the 6,000-foot depth. This unit will monitor formation porosity, formation pore pressure, rate of penetration, weight on bit, rotary rpm, accumulative drilling hours, and bearing condition of drill bit. Calculations of equivalent circulating density, fracture gradient, corrected "d" exponent, swab-surge pressures, and a hydraulics analysis will be furnished by the logging unit personnel.

f. Well Cuttings Sample Collection

Three sets of sample cuttings at 30-foot intervals will be taken beginning at the surface and continuing to total depth. These will be analyzed at the well site, and washed samples will then be distributed to authorized parties for further interpretation. These samples are to include canned samples taken at 60-foot intervals for geochemical analysis. Sample collection and distribution will be coordinated by Magma Gulf-Technadril personnel.

g. Cement Program

(1) 20-Inch Surface Casing at 800 Feet

Type Cement

Lead Slurry--Lightweight cement plus 35 percent silica flour plus 3 percent sodium chloride mixed 13.4 ppg. Slurry yield is 2.12 cubic feet per sack.

Tail Slurry--Class "H" plus 40 percent silica flour mixed at 15.8 ppg. Slurry yield is 1.55 cubic feet per sack.

Quantity

Lead Slurry--460 sacks.

Tail Slurry--500 sacks.

The combined yield of the lead and tail slurries should equal the volume of the annulus plus 100 percent.

(2) 13 3/8-Inch Intermediate Casing at 4,000 Feet

Type Cement

Lead Slurry--High-temperature/low-density cement plus 1.7 percent water loss control agent and 1/4 pound per sack of Kwik Seal mixed at 13.2 ppg. Slurry yield is 1.52 cubic feet per sack.

Tail Slurry--Class "H" plus 40 percent silica flour and 0.75 percent friction reducer and water loss control agent mixed at 16.28 ppg. Slurry yield is 1.47 cubic feet per sack.

Use 100-barrel low water loss flush ahead of lead slurry.

Quantity

Lead Slurry--Quantity sufficient to fill 2,700 feet of open-hole annulus (from caliper log) with 25 percent excess plus 800 feet of 20-inch casing annulus.

Tail Slurry--Sufficient to fill 500 feet of hole from caliper log or approximately 300 sx.

Note

Both cements should test zero free water.

The tail in slurry should have 500 psi compressive strength within 6 hours.

Run lab test at bottom-hole circulating temperature to determine free water and compressive strength prior to cementing casing.

Lead slurry should have in excess of 12 hours of pumping time. Determine amount of retarder for this pumping time prior to cementing casing.

(3) 9 5/8-Inch Intermediate Casing at 10,000 Feet

Type Cement--Class "H" plus 40 percent silica flour, 0.75 percent friction reducer, and approximately 0.2 percent retarder. Slurry weight is 16.28 ppg. Exact amount of retarder to be determined by lab test prior to mixing cement. Slurry yield is 1.47 cubic feet per sack.

Run 50-barrel low water loss spacer weighted to 13.0 ppg ahead of cement.

Quantity--Sufficient quantity to fill 3,000 feet of annulus based on caliper log.

(4) 7 5/8-Inch Production Casing at 14,900 Feet

Type Cement--Class "H" plus 40 percent silica flour, 3 percent potassium chloride, 0.4 percent low water loss additive, 1.0 percent friction reducer, 0.25 percent defoamer, and retarder as necessary for pumping time. Slurry weight is 17.0 ppg. Slurry yield is 1.33 cubic feet per sack. Quantity of retarder required will be determined by lab test prior to cementing casing.

Run 20-barrel low water loss spacer weighted to 16.5 ppg ahead of cement.

Quantity--Based on open-hole caliper log, use 150 percent of open-hole annular volume plus 1,000 feet of annular volume between 9 5/8-inch casing and 7 5/8-inch casing.

(5) 5 1/2-Inch Production Liner at 15,700 Feet

Type Cement--Class "H" plus 40 percent silica flour, 3 percent potassium chloride, 0.4 percent low water loss additive, 0.75 percent friction reducer, 0.25 percent defoamer, and retarder as necessary. Slurry weight is 16.28 ppg. Slurry yield is 1.47 cubic feet per sack. Quantity of retarder required will be determined by lab test prior to cementing liner.

Run 10-barrel low water loss spacer ahead of cement.

Quantity--Sufficient volume (based on caliper) to fill annulus plus 25 percent excess.

(6) High-Temperature "Top Job" and Squeeze* Cement

Type Cement--Class "H" plus 40 percent silica flour and 10 percent sodium chloride. Slurry weight is 16.2 ppg. Slurry volume is 1.47 cubic feet per sack.

*Retarder will be required when using for squeeze cement. Amount determined by depth and temperature. Delete sodium chloride for squeeze cement.

Quantity--As needed.

(7) Optional 7 5/8-Inch Drilling Liner at 14,900 Feet

Type Cement--Class "H" plus 40 percent silica flour, 3 percent potassium chloride, 0.4 percent low water loss additive, 1.0 percent friction reducer, 0.25 percent

defoamer, and retarder as necessary for pumping time. Slurry weight is 17.0 ppg. Slurry yield is 1.33 cubic feet per sack. Quantity of retarder required will be determined by lab test prior to cementing liner.

Run 20-barrel low water loss spacer weighted to 16.5 ppg ahead of cement.

Quantity--Sufficient volume based on hole caliper to fill annulus plus 100 percent excess.

(8) Optional 7 5/8-Inch Tieback at 9,800 Feet

Type Cement--Class "H" plus 40 percent silica flour, 0.75 percent friction reducer, and approximately 0.2 percent retarder. Slurry weight is 16.28 ppg. Slurry yield is 1.47 cubic feet per sack. Lab test cement prior to cementing casing.

Quantity--260 sacks.

h. Hydraulics Program

<u>Depth</u>	<u>Hole Size</u>	<u>Mud Wt.</u>	<u>AVDP</u>	<u>GPM</u>	<u>Jet</u>	<u>JV</u>	<u>P_b</u>	<u>S.P.</u>
4000	17 1/2	9.2	66	768	3-18	332	886	2000
6000	12 1/4	9.2	116	615	2-13	486	1941	3000
					1-14			
8000	12 1/4	9.5	100	531	2-12	478	1941	3000
					1-13			
10000	12 1/4	12.5	80	424	3-12	411	1889	3000
11000	8 3/8	14.8	130	275	1-8	383	1942	3000
					2-13			
12000	8 3/8	15.6	126	268	1-8	380	1911	3000
					2-13			
13000	8 3/8	15.9	122	259	1-8	366	1857	3000
					2-13			
14000	8 3/8	16.0	118	251	1-8	355	1799	3000
					2-13			
14900	8 3/8	16.2	116	246	1-8	349	1760	3000
					2-13			
15700	6 1/2	± 14.5	170	205	1-8	290	1088	3000
					2-13			

Note

Where 2-13 and 1-8 jets are recommended, 3-10 may be used, unless there is a possibility of plugging jets due to hole conditions.

This program is designed for a rig similar to Resource Drilling, Inc., Rig No. 9.

The pumps are assumed parallel using 1,000 H.P. each to 10,000 feet.

i. Recommended BOP Procedures

- (1) Test entire BOP system each 7 days using fresh water.
- (2) Maintain full working pressure on accumulator system.
- (3) Use no screwed valves and/or fittings in BOP or manifold system.
- (4) Do not use kill line for routine fill-up on trips.
- (5) Pump through choke and kill lines each trip.
- (6) Open and close rams and kelly cocks on each trip.
- (7) Maintain kelly cock wrench and inside BOP at driller's console.
- (8) All choke and kill valves adjacent to spool or casing head should be kept in open position and only used in emergencies. Do not throttle flow with inside valve; they should always be full open or completely closed.
- (9) Install casing rams in top position prior to running 9 5/8-inch or smaller casing.
- (10) Casing and pipe rams should be installed prior to running liners.
- (11) Maintain drill pipe box by drill collar pin sub on floor while making trips.
- (12) Maintain extra set of pipe rams on rig at all times.
- (13) Do not hook up kill line to casing head valves except in emergency. Use kill line off spool above lower pipe rams.

j. Drilling Break Procedure

- (1) Stop drilling upon encountering a drilling break.
- (2) Check well for flow. If no flow, drill 5 feet more of break and check for flow again.
- (3) Circulate break one-half way to surface, check for flow. If no flow, circulate two-thirds of way to surface and check for flow.

- (4) If no flow, circulate all of break to surface. If no flow, nor an attempt to flow, continue drilling, maintaining constant weight on bit.
- (5) If drilling rate in break continues to increase, check for flow each 5 feet (or 1/2 hour drilling time), whichever is first. Check plot of D-exponent in mud logger's trailer.

k. Running and Cementing Procedure--20-Inch Casing String

- (1) Pick up and run 20-inch casing as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
0-400	± 400 feet	20-inch, 169-pound, K-55 buttress
400-760	± 360 feet	20-inch, 133-pound, K-55 buttress
± 720	1 each	20-inch, 133-pound, K-55 stab in float collar
720-800	80 feet	20-inch, 133-pound, K-55 buttress
800	1 each	20-inch, 133-pound, K-55 guide shoe

Bow spring centralizers--run two per joint on bottom two joints.

- (2) Do not tag bottom of hole.
- (3) Run in hole with stab-in-sub on drill pipe and circulate and condition mud to ± 30 viscosity.
- (4) Cement casing per page 4-23. Catch two samples each of lead and tail slurry.
- (5) Under displace cement in drill pipe one barrel, pick up stinger and check for back flow from collar, dropping one barrel of cement on top of collar.
- (6) Lay down cementing string.
- (7) After surface sample of tail cement sets, cut off 20-inch casing and proceed to nipple up.

Note--Before cementing, it is imperative the 20-inch casing be centered in the rotary and held in place during the cementing operation.

1. Running and Cementing Procedure--13 3/8-Inch Casing String

- (1) Sandblast bottom 500 feet of casing and let rust prior to running.
- (2) Obtain caliper log on hole prior to the cleanup trip.

- (3) Pick up and run 13 3/8-inch casing as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
0-2500	2,500 feet	13 3/8-inch, 72-pound, N-80 butt. casing
2500-3920	1,420 feet	13 3/8-inch, 72-pound, L-80 butt. casing
3920	1 each	Float collar
3920-4000	80 feet	13 3/8-inch, 72-pound, L-80 butt. casing
± 4000	1 each	Float shoe

Bow spring flow diverter centralizers--run two per joint on bottom two joints. One each 200 feet up to 800 feet.

Rigid centralizers, ± 17 1/4-inch O.D.--run, one at 750 feet then every 200 feet to 150 feet and one at 50 feet.

- (4) Do not tag bottom of hole. Circulate long enough to bring bottoms-up twice. Viscosity of mud should be reduced to a maximum of 30. Reciprocate casing, making 10- to 15-foot strokes if possible without exceeding 750,000 pounds pull over the weight of the blocks.
- (5) Reciprocate casing, if possible, while mixing and pumping cement. See page 4-24 for type and volume of cement. Discontinue reciprocation when plug bumps or when required pull above weight of blocks exceeds 750,000 pounds. Do not allow plug to bump with more than 500 psi pressure surge. Release pressure if no flow back.
- (6) Use 100-barrel low water loss mud flush ahead of cement.
- (7) Hook load should be approximately 200,000 pounds above weight of blocks.
- (8) Hang casing in tension.

m. Running and Cementing Procedure--9 5/8-Inch Casing String

- (1) Sandblast bottom 3,000 feet of casing and let rust prior to running.
- (2) Calculate hole capacity using caliper from sonic log.
- (3) Pick up and run 9 5/8-inch casing as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
0-9920	9920 feet	9 5/8-inch, 53.5-pound, C-95 ExLine
± 9920	1 each	Float collar
9920-10,000	80 feet	9 5/8-inch, 53.5-pound, C-95 ExLine
± 10,000	1 each	Down jet float shoe

Bow spring flow diverter centralizers:

Run two per joint on bottom three joints.
Run one per joint next five joints.

Rigid centralizers $\pm$ 12 1/4-inch O.D.--run one per joint on two joints above 100 feet.

- (4) Do not tag bottom. Break circulation immediately. Reciprocate casing, making 10- to 15-foot strokes if possible without exceeding 650,000 pounds.
- (5) Circulate long enough to bring bottoms to surface. Casing should weigh $\pm$ 440,000 pounds in 12.5 ppg mud.
- (6) Cement with quantity and type of cement per page 4-24.
- (7) Discontinue reciprocation when plug bumps or pull above weight of blocks exceeds 650,000 pounds. Do not allow plug to bump with more than 500 psi.
- (8) Displace cement with 12.5 ppg mud. Bump plug, and then increase pressure on top of plug to 3,000 psi, then release pressure. Hang casing in tension.
- (9) Hook load should be approximately 433,000 pounds over the weight of blocks when plug bumps. If not, pick up to 433,000 pounds.
- (10) Wait on cement to set 12 hours or as necessary by cementing company test data.
- (11) Place a mark on casing at rig floor.
- (12) Pick up another 100,000 pounds making the hook load now 533,000 pounds over the weight of the blocks. Mark on casing should now indicate a stretch of less than 19 inches.
 - (a) If stretch is greater than 22 to 24 inches (do not slack off), allow cement to set up another 6 hours, then pull tension to 767,000 pounds over the weight of the blocks. This should result in approximately 60 inches of stretch since string was at 433,000 pounds.
 - (b) If stretch is less than 15 inches and weight indicator is 533,000 pounds above weight of blocks, continue to pick up until weight above blocks is 767,000 pounds. Total stretch from 433,000 to 767,000 pounds should be approximately 60 inches.

- (13) Hang 767,000 pounds on casing slips without slacking off any appreciable weight.

n. Running and Cementing Procedure--7 5/8-Inch Casing

- (1) Sandblast bottom 3,000 feet of casing and let rust prior to running.
- (2) Calculate hole capacity using caliper from sonic log.
- (3) Run full string of 7 5/8-inch casing as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
0-9800	9800 feet	7 5/8-inch, 39-pound, C-95 ExLine
9800-9840	40 feet	7 5/8-inch, 39-pound, C-95 ExLine box x SFJ pin
9840-14780	4940 feet	7 5/8-inch, 39-pound, C-95 SFJ
± 14780	1 each	7 5/8-inch, 39-pound, C-95 float collar
14780-14900	120 feet	7 5/8-inch, 39-pound, C-95 SFJ
± 14900	1 each	7 5/8-inch, 39-pound, C-95 float shoe

(4) Centralizers

Bow spring with stop rings
 Two each on bottom joints
 One each 600 feet apart up to 10,000 feet
 Two each for two joint 10,000-9,920
 One each 500 feet apart to 8,920

- (5) Run casing to within ± 5 feet of bottom. Circulate hole clean. Reciprocate casing if possible with 10- to 15-foot strokes. Casing should weigh approximately 430,000 pounds in 16.2 ppg mud.
- (6) Cement casing per page 4-25.
- (7) Wait on cement for 18 hours and mark casing at rotary table.
- (8) Pick up 50,000 pounds or 15 inches. Should 15 inches of stretch be obtained before 50,000-pound pickup, slack off to original mark and wait an additional 6 hours and repeat procedure. Should the 15 inches of stretch be obtained at about the same time as the 50,000-pound pickup, then cement is set at ± 9,000.
- (9) Continue to pick up until hook load (weight above blocks) is 685,000 pounds. Total stretch should be 79 inches.
- (10) Hang full 685,000 pounds on slips.

o. Running and cementing Procedure--Optional 7 5/8-Inch Drilling Liner

- (1) Sandblast bottom 3,000 feet of liner and let rust prior to running.
- (2) Calculate hole capacity using caliper from sonic log.
- (3) Rabbit all drill pipe, subs, and crossovers used in running string.
- (4) Install 7 5/8-inch rams in top position of BOP stack. Obtain and locate at drillers console a swedge from 7 5/8-inch SF J-P back to drill pipe connection.
- (5) Pick up and run 7 5/8-inch liner as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
± 9,800	1 ea	Tie-Back sleeve
± 9,800	1 ea	Multicone Hanger
9,800 ± 14,780	4,980 ft	7 5/8", 39#, AR-95, SFJ-P
± 14,780	1 ea	Shear nut sub landing collar
14,780 ± 14,900	120 ft	7 5/8", 39#, AR-95, SFJ-P
± 14,900	1 ea	Baffle Collar
± 14,900	1 ea	Float Shoe

Bow spring centralizers: Run 2 per joint on bottom 3 joints, and 1 every other joint back to hanger.

- (6) Do not tag bottom of hole. Circulate long enough to bring bottom up to surface. Reciprocate liner, making 10 to 15-foot strokes while circulating.
- (7) Drop actuating ball, pressure up, set and release from hanger.
- (8) Increase pressure and shear pin in catch sub.
- (9) Perform cement job using a quantity of slurry equivalent to 2 times the calculated hole volume. See page 4-25.
- (10) Pull out of hanger, do not attempt to reverse or circulate out excess cement.
- (11) Pull 15 stands above hanger and pump 5 barrels of mud down drill pipe.
- (12) Pull drill pipe to ±8,000 feet and pump another 5 barrels through drill pipe. Shut down and WOC for 8 hours prior to pulling out of hole.

p. Running and Cementing Procedure--Optional 7 5/8-Inch Tieback

(1) Sandblast bottom 3,000 feet of casing and let rust prior to running.

(2) Pick up and run 7 5/8-inch casing as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
0-9800	± 9800 feet	7 5/8-inch, 39-pound, C-95 ExLine
± 9,800	1 each	7 5/8-inch tieback

(3) Run in hole, tag up, pick up, and circulate hole clean. Reciprocate casing making 10- to 15-foot strokes.

(4) Casing should weigh approximately 306,000 pounds in 14.5 ppg mud.

(5) Cement casing with quantity and type cement per page 4-26.

(6) Casing should weigh approximately 294,000 pounds after cement job. Slack off approximately 15,000 pounds.

(7) Wait on cement for 18 hours.

(8) Place mark on casing at rig floor.

(9) Pick 50,000 pounds or 12 inches of stretch. If 12 inches of stretch is obtained before getting over 40,000 pounds, slack off; wait another 6 hours on cement to set and repeat procedure.

(10) If 12 inches of stretch is obtained about same time 50,000-pound pull is applied, this means casing is only stretching down to ± 7,000 feet and the cement is set below that depth.

(11) Continue pickup until hook load (above weight of blocks) is 548,000 pounds. Total stretch should be approximately 63 inches.

(12) Hang full 548,000 pounds on slips; do not slack off any weight.

q. Running and Cementing Procedures--5 1/2-Inch Liner

(1) Sandblast entire length of liner and let rust prior to running.

(2) Calculate hole capacity using caliper from sonic log.

- (3) Rabbit all drill pipe, subs, and crossovers used in running string.
- (4) Install 5 1/2-inch rams in top position of BOP stack. Obtain and locate at driller's console a swedge from 5 1/2-inch SFJ-P back to drill pipe connection.
- (5) Pick up and run 5 1/2-inch liner as follows:

<u>Depth</u>	<u>Quantity</u>	<u>Description</u>
± 14,700	1 each	Polish bore receptacle
± 14,700	1 each	Mechanical set, multicore hanger
14,700-15,580	880 feet	5 1/2-inch, 22.54-pound, AR-95 SFJ-P
± 15,580	1 each	Landing collar
15,580-	120 feet	5 1/2-inch, 22.54-pound, AR-95 SFJ-P
± 15,700		
± 15,700	1 each	Cementing set shoe

Bow spring centralizers--run two per joint on bottom three joints and two 100 feet apart below hanger.

- (6) Do not tag bottom of hole. Circulate long enough to bring bottom up to surface. Reciprocate liner, making 10- to 15-foot strokes while circulating.
- (7) Set hanger and back out setting tool.
- (8) Perform cement job using a quantity and type of cement per page 4-25.
- (9) Pull out of hanger; do not attempt to reverse or circulate out excess cement.
- (10) Pull 15 stands above hanger and pump 5 barrels of mud down drill pipe.
- (11) Pull out of hole with drill pipe. Shut down and wait on cement for 8 hours prior to starting in hole.

B. Disposal Well

1. Drilling Procedure (See Figure 13)
 - a. Prepare location for rig.
 - b. Move in rig and rig up.
 - c. Drive 20-inch x 1/2-inch wall pipe per page 4-40.
 - d. Cut off drive pipe below rotary. Install flow line and fill-up line on 20-inch pipe.

SWEET LAKE PROSPECT

DISPOSAL WELL DIAGRAM

- e. Pick up 17 1/2-inch bit and bottom-hole assembly (BHA) and drill to 1,350 feet. Run deviation survey at less than 200-foot intervals. Allowable deviation is one-half degree per 100 feet with a maximum deviation of 2 degrees.
- f. Condition hole for logging SLM out of hole. Run open-hole logs 0-1,350 feet per page 4-44.
- g. Make cleanup trip. Circulate and condition hole to run casing. Check rig-hole alignment prior to running casing.
- h. Run and cement 13 3/8-inch casing per pages 4-40 and 4-42. Center 13 3/8-inch casing in rotary and hold while cement sets. Should cement not circulate, top out with recommended cement.
- i. Cut off 13 3/8-inch casing and 20-inch conductor. Install 13 3/8-inch slip-on type 3,000 WP wellhead with base plate (see Figure 14). Level base plate on 20-inch drive pipe and weld head onto 13 3/8-inch surface casing.
- j. Nipple up 12-inch, 3,000 psi blowout preventers (BOPs). See Figure 15.
- k. Test BOP assembly, including valves on choke and kill line plus circulating system to standpipe to 2,000 psi. Test casing to 2,000 psi. (Notify Louisiana Conservation representative for witness of casing test.)
- l. Pick up 12 1/4-inch bit and BHA and GIH. Drill out float collar, cement, and float shoe plus 10 feet of formation. Circulate for 30 minutes to check for mud loss. Should the formation take fluid, add sufficient gel to mud system to sustain full returns and drill ahead.
- m. Drill sufficient depth to bury BHA, then pull out of hole. Pick up 12 7/32-inch O.D. welded blade stabilizers at 60, 90, and 150 feet above bit. Pick up monel drill collar on last bit run prior to reaching total depth (approximately 7,440 feet).
- n. Drill 12 1/4-inch hole to depth equivalent to $\pm$ 7,440 feet in UOC Pan Am Fee No. 1. SLM out of hole on next to last bit run.
- o. Condition hole to log. POH running multishot directional survey.
- p. Run open-hole logs per page 4-44.
- q. Lay down monel drill collar. GIH with stabilized BHA. Condition hole to run 9 5/8-inch casing.
- r. Run 9 5/8-inch casing per page 4-40 and cement per page 4-43. Should cement not circulate, top out with recommended cement.

ADDITIONAL EQUIPMENT

Figure 14
4-37

WELLHEAD EQUIPMENT DIVISION HOUSTON		FILE NO.	
		DATE 7-11-80	PART NO.
MAGMA GULF - TECHNADRIL		GEN. A.A.	
		QTY.	PRICE
X-3995-A-REV. 3		SPEC.	

SWEET LAKE PROSPECT

Figure 15
4-38

- s. Install 13 5/8-inch, 3,000 WP x 11-inch, 5,000 WP casing head spool ("B" section, Figure 14).
- t. Nipple up blowout preventers and test to 3,000 psi as outlined in Step k.
- u. Pick up bit and scraper and BHA without stabilizers and clean out inside of casing to float collar. Displace mud with 9.5 ppg brine. POH. Lay down DP and DC.
- v. Run logs inside 9 5/8-inch casing per page 4-44.
- w. Rig up and run 7-inch casing to approximately 6,400 feet with injection packer. Space out with 60,000 pounds of weight-set injection packer applied just as casing hanger "shoulders-up" in "B" section head. See page 4-41.
- x. Nipple up tree and test seals as recommended by manufacturer.
- y. Release rig.
- z. Rig up nitrogen truck and coil tubing unit. Displace water from well down to above 2,000 feet.
- aa. Rig up wire line lubricator and perforate proposed injection interval with a casing gun.
- bb. If well will flow, clean out perforations by a limited flow test being careful to limit sand production.
- cc. Treat perforations and injection zone with HCl and HF1 to clean perforations and well bore damaged zone.
- dd. If well will not flow, rig up nitrogen truck and coil tubing unit. Clean out perforations by a limited "backflow" test. NOTE: Injection efficiency contingent upon "backflow" rates and quantities.
- ee. Perform injection test.
- ff. SI for future operations.

2. Surface Equipment and Services

- a. Wellhead (See Figure 14)

The Christmas tree assembly will be rated at 5,000 psi WP.

- b. Blowout Prevention Equipment (See Figure 15)

The blowout preventer will be 3,000 psi WP, ram-type, hydraulic-controlled equipment. An annular-type preventer will be above the ram preventer which will be 3,000 psi WP also.

c. Drill Rig

The rig will be capable of drilling to 8,000 feet with 4 1/2-inch drill pipe and capable of running 9 5/8-inch casing to 7,440 feet. The mast should be capable of 750,000 pounds API static hook load and the substructure must have 750,000-pound capacity.

d. Drilling Recording Instruments

Drilling recording instruments consisting of a pit level device and three-pen recorder for measuring rate of penetration, pump pressure, and hook load.

3. Downhole Equipment and Services

a. Casing Program

(1) Conductor Casing

20-inch O.D., 1/2-inch wall, 104-pound, A-234 Grade B welded. Drive to $\pm$ 100 feet with D-30 hammer. Required bearing load is $\pm$ 540,000 pounds including safety factor.

(2) Surface Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate 1,000/SF</u>
0-1350	13 3/8"	72	N-80 and K-55	Butt.	2670/4+	5380/6+	1661/20+

(a) Run float shoe and float collar two joints apart. Thread lok shoe, top of first joint, and collar.

(b) Run two bow spring centralizers on bottom two joints.

(c) Land casing in tension.

(d) Set base plate flush and level on 20-inch pipe.

(3) Production String Casing

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate 1,000/SF</u>
0-1700	9 5/8"	47	C-75	Butt.	4630/11.8	6440/5.3	1018/3.1
1700-7440	9 5/8"	43.5	N-80	Butt.	3810/2.4	6330/6.3	1005/5.7

(a) Run float shoe and float collar two joints apart. Thread lok shoe, top of first joint, and collar.

- (b) Run two flow diverter type centralizers on each of first two joints. Run one flow diverter type centralizer every second joint for the next 10 joints.
- (c) Reciprocate pipe $\pm$ 15 feet while cementing. Hold 2,500 psi on plug, after plug bumps, for $\pm$ 4 hours or until the tail cement attains 250 psi compressive strength.
- (d) Land casing in tension.

(4) Injection String

<u>Depth</u>	<u>Size</u>	<u>Wt.</u>	<u>Grade</u>	<u>Conn.</u>	<u>Colps Rate/SF</u>	<u>Burst Rate/SF</u>	<u>Tension Rate 1,000/SF</u>
0-6,400	7"	23#	K-55	LTC w/ ABC Mod. coupling	3270/1.1	4360/1.2	366/2.5

- (a) Make up one joint of 7-inch casing below injection packer and 7-inch casing above.
- (b) Run in hole to approximately 6,400 feet and set injection packer.
- (c) Space out so that 60,000 pounds of casing weight is set down on packer at the same time the hanger "shoulders up" in tree. Back out landing joint.
- (d) Nipple down BOPs.

b. Drilling Fluid Program

<u>Depth</u>	<u>Type Mud</u>	<u>Weight</u>	<u>Visc.</u>	<u>Percent Solids</u>	<u>Water Loss</u>	<u>PV/YP</u>
0-1350	Gel-water	9.0-9.2	40-50	6-7	30	8/12
1350-5000	Gel-water Lignite	9.0-9.2	35-40	3-5	20	7/12
5000-6400	Gel-water Lignite	9.0-9.2	35-38	3-5	15	5/10
6400-7400	Gel-water Lignite	9.0-9.2	40-45	3-5	2-4	14/7

- (1) Have water loss below 4 cc at $\pm$ 6,400.

(2) After reaching total depth, wash mud tanks that will be used to circulate 9.5 ppg brine water.

(3) It is estimated to require $\pm$ 1,000 barrels to complete job.

(4) Do not mix mud with brine.

c. Deviation Program

Single Shot

0-1,350 feet

Run Totco at least every 200 feet. Maximum allowable deviation is 2 degrees.

1,350-6,400 feet

Run Totco at least every 500 feet. Maximum allowable deviation is 5 degrees.

6,400-7,400 feet

Run Totco every 200 feet. Maximum allowable deviation is 5 degrees.

Multishot Directional

Run multishot from total depth to surface.

d. Cementing Program

(1) Surface Casing

Type Cement

Lead Slurry--Lightweight cement plus 35 percent silica flour and 3 percent salt mixed at 13.4 ppg yields 2.12 cubic feet per sack.

Tail Slurry--Class "H" plus 40 percent silica flour mixed at 15.8 ppg yields 1.55 cubic feet per sack.

Quantity

Lead Slurry--Using 100 percent excess should require 567 sacks for 850 feet of fill-up.

Tail Slurry--Using 100 percent excess should require 450 sacks for 500 feet of fill-up.

Top Out--Should cement not circulate, Class "H" plus 40 percent silica flour and 2 percent calcium chloride mixed at 15.8 ppg yields 1.55 cubic feet per sack.

(2) Production String

Type Cement

Lead Slurry--Lightweight cement plus 35 percent silica flour and 3 percent salt mixed at 13.4 ppg yields 2.12 cubic feet per sack.

Tail Slurry--Class "H" plus 40 percent silica flour mixed at 15.8 ppg yields 1.55 cubic feet per sack.

Quantity

Lead Slurry--Using 50 percent excess, 6,400 feet of fill-up should require 1,450 sacks.

Tail Slurry--Using 50 percent excess, 1,000 feet of fill-up should require 300 sacks.

Top Out--Should cement not circulate, Class "H" plus 40 percent silica flour and 2 percent calcium chloride.

e. Hydraulics Program

Assumptions

- (1) 500-foot, 7 3/4-inch O.D. x 12 13/16-inch I.D. drill collars.
- (2) 4 1/2-inch DP.
- (3) GD PZ9 Triplex pump (85% eff.).
- (4) 6 1/2-inch liners.
- (5) 100 SPM

<u>Depth</u>	<u>Hole Size</u>	<u>Mud Wt.</u>	<u>AVDP Ft./Min.</u>	<u>GPM</u>	<u>Jets</u>	<u>J.Vel</u>	<u>Press Drop</u>		<u>Pump Press</u>
							<u>Jets</u>	<u>System</u>	
1850'	17 1/2"	9.0-9.2	60	331	9-9-10	525	2484	148	2632
					9-10-10	490	2159	148	2307
					10-10-10	459	1894	148	2042
					10-10-11	429	1655	148	1803
					10-11-11	403	1458	148	1506
4000'	12 1/4"	9.0-9.2	60	331	9-9-10	525	2484	276	2760*
					9-10-10	490	2159	276	2435
					10-10-10	459	1894	276	2170
					10-10-11	429	1655	276	1931
					10-11-11	403	1458	276	1734

*Exceeds working press of pump which is 2,650 pounds with 6 1/2-inch liners.

<u>Depth</u>	<u>Hole Size</u>	<u>Mud Wt.</u>	<u>AVDP Ft./Min.</u>	<u>GPM</u>	<u>Jets</u>	<u>J.Vel</u>	<u>Press Drop</u>		<u>Pump Press</u>
							<u>Jets</u>	<u>System</u>	
7440'	12 1/4"	9.0-9.2	60	331	9-9-10	525	2484	432	2916*
					9-10-10	490	2159	432	2591
					10-10-10	459	1894	432	2326
					10-10-11	429	1655	432	2087
					10-11-11	403	1458	432	1890

*Exceeds working press of pump which is 2,650 pounds with 6 1/2-inch liners.

f. Logging Program

Open Hole

Run 1--Induction	0-1350'
Run 2--Caliper	0-1350'
Run 3--Dual Induction	1350-7440'
Run 4--FDC-CNL-GR	1350-7440'
Run 5--Sonic with Caliper	1350-7440'
Run 6--Sidewall Cores	Various

Cased Hole--9 5/8-Inch Casing

Run 1--GR-N	0-7360'
Run 2--CBL-VDL	0-7360'
Run 3--Casing Caliper	0-7360'

g. Completion

- (1) Run and set 7-inch, 8 rd x 9 5/8-inch, 40-pound injection packer with 6-foot polish receptacle and locator sub with 7-inch O.D., 8 rd box top connection O-ring. Packoff overshot to seal over 5 1/2-inch polish back off sub. Overshot has 8-inch O.D. guide ring for 9 5/8-inch casing. Polish I.D. of packer is 7 3/8 inches x 12 feet.
- (2) Run hole with 9 5/8-inch retrievable squeeze tool on drill pipe with 900 feet of tail pipe below packer.
- (3) Displace liner with $\pm$ 900 gallons of HCL acid.
- (4) Squeeze acid into formation.
- (5) Overdisplace acid with 50 barrels of clean solids-free 9.5 brine.
- (6) Lay down squeeze tool and tail pipe.
- (7) Complete well.

V. PRODUCTION TESTING

A. Introduction

The initial paragraph of Magma Gulf's proposal to DOE in May 1976 stated:

Economic analyses by Magma Gulf Company indicate that the energy resources of geopressured-geothermal reservoirs cannot be successfully operated unless large volume water production can be sustained (over 1,000 GPM). Yet this possibility has been challenged by knowledgeable engineers and geologists who cite low permeability and geopressured formation collapse as inhibiting factors. However, until sustained high volume production is demonstrated, all other questions are academic.

The production well has an excellent chance to produce such volumes, and the completion and production testing schedules are designed to demonstrate it.

B. Producing Sands

Logs of adjacent wells demonstrate the massive character of the lower 150± feet of the "Miogyp" target sands. This lower sand member is separated from the overlying sands by 30 to 50 plus feet of shale.

Unless wire line log and core analyses suggest modifications, it is proposed to complete the well in the lower sand and to attempt to produce the requisite volume from that sand member alone. Anticipated sand porosity is 22 percent. Permeability is also expected to be high, but no data are available until the sand is cored. Should this producing interval prove inadequate or should any problem develop in the completion in this interval, the additional middle and upper sand members provide the opportunity for additional attempts. Alternative procedures for completion are also possible. If the required volumes are not produced through perforations, the possibility of recompleting by screening and gravel packing is being examined.

C. Completion

Two 50-foot perforation strings containing four shots per foot will be used. It is believed that this conventional perforation technique will achieve the desired flow of 40,000 barrels per day without damaging the formation. This technique will provide an opportunity to perforate the upper "Miogyp" sands in subsequent stages, if necessary.

D. Initial Flow

Following perforation, the well will be flowed into tanks sufficiently for cleanup and then shut in. No testing or sampling is anticipated at

this stage, but the observed flow response will provide sufficient indication to permit the first "decision point" to be determined (whether to proceed with the test loop or to attempt the perforation of overlying sands).

E. Site Layout for Testing

Figures 16 and 17 show schematics of the surface facilities for Phases I and II. They include the wellhead, flow lines, samplers, separators, scrubbers, condensers, compressors, and meter runs.

F. Surface Testing Facilities

Flow characteristics of the well are to be tested initially in a test loop prior to the planning and construction of permanent testing and production facilities. The test loop is designed to conduct flow directly from the production well to the disposal well(s) with a bypass line for securing fluid and gas samples.

Following 60 days of testing with the test loop, this facility will be dismantled. Testing results will be used to design a permanent facility which will then be installed to permit a prolonged period of production. Diagrams of the wellhead and surface testing facilities are shown in Figures 12, 16, and 17.

Facilities of Phase I (test loop) will provide for full stream production directly into a disposal well. Assuming a normal pressured sand at 6,400 feet in the disposal well would have a formation pressure of only $\pm 3,000$ psi, it can be assumed that great quantities of water can be injected with surface flowing pressures derived from the producing well without assistance of pumps.

The producing well will be allowed to establish a stabilized flow rate into the disposal well by regulation of an adjustable choke. After stabilization is established through the 8-inch bypass, air-operated valves will rapidly close off a sample in the 8-inch bypass and divert the full stream through the main 8-inch line to the disposal well. Pressure, temperature, and flow rates will be continuously recorded. The trapped sample (approximately six barrels) in the bypass will be cooled to desired temperature, reduced to desired pressure, and the gas samples withdrawn into evacuated vessels. Liquid samples under pressure will be purged from the bypass by assistance of high-pressured nitrogen.

Should the disposal well fail to take maximum desired flow rate, a booster centrifugal pump or an additional disposal well will be added to the system.

Gas samples will be analyzed for mole percent concentrations of CO_2 , $\text{C}_1\text{-C}_5$, and C_6 by a mass spectrometer. Hydrogen sulfide and other

SWEET LAKE PROSPECT PHASE I SURFACE FACILITY

MAGMA GULF-TECHNADRIL

Figure 16
5-3

SWEET LAKE PROSPECT

PHASE II

SURFACE FACILITY

Figure 17

volatile inorganic or organic sulfur compounds will be determined by gas chromatography and a flame photometric detector.

Corrosion and scale-formation properties of geothermal waters are expected to be different from those of waters having similar chemical composition but produced from oil and gas wells. The high salinities, Cl concentration, and high temperatures increase the corrosivity of geothermal waters by facilitating dissolution of iron at anodic sites. At reduced temperatures and pressures, these waters are expected to precipitate great quantities of oxyhydroxides of iron, carbonates, of Ca, Sr, and Ba, along with some sulfate of barium. Corrosion and scale probes inserted into the produced stream will be continuously monitored. Control and reduction of the fluids' pH may be necessary before injection into the disposal well. Since most geothermal waters are expected to be supersaturated with BaSO_4 and many other compounds above 77°F , it may be desirable in the Phase II process facility to maintain some minimum temperature and pressure prior to injection into the disposal well.

Due to the above uncertainties and anticipated problems, design criteria will be determined in Phase I prior to designing the permanent facilities of Phase II. Figure 17 is a generalized flow diagram for the permanent facility. Alternatives to this flow diagram might include such items as aerial forced draft coolers, filters, chemical injectors, or atmospheric storage tanks. Presently, it appears that the most likely permanent system will maintain the fluids above some minimum temperature ($70\text{--}80^\circ\text{F}$) and never exposed to atmospheric pressure.

G. Test Loop Production

Installation of the test loop, thereby connecting the production well to the disposal well, will permit short-term testing. This is planned for a 60-day period as follows:

<u>Test Period</u>	<u>Test Duration</u>	<u>Cumulative Test Time</u> (End of Period)	<u>Test Rate</u> BPD	<u>Cumulative Fluid Production</u> M Barrel
Initial State	3 days	Day 3	0	0
Dynamic				
Phase 1a	3 days	Day 6	0-10,000	15
Phase 1b	9 days	Day 15	10,000	105
Phase 2a	3 days	Day 18	10,000-20,000	150
Phase 2b	9 days	Day 27	20,000	330

<u>Test Period</u>	<u>Test Duration</u>	<u>Cumulative Test Time</u> (End of Period)	<u>Test Rate</u> BPD	<u>Cumulative Fluid Production</u> M Barrel
Phase 3a	3 days	Day 30	20,000-30,000	405
Phase 3b	9 days	Day 39	30,000	675
Phase 4a	3 days	Day 42	30,000-40,000	780
Phase 4b	9 days	Day 51	40,000	1,140
Final Static	9 days	Day 60	0	1,140

Although the initial three days of each testing phase is allocated to building the flow rate, it is likely that the productive capability of the well will permit a more rapid flow rate buildup. Behavior will be carefully monitored to detect sand production or other problems. In addition, consideration may be given to prolonging or accelerating the testing to attempt greater flow rates than 40,000 BPD, if results warrant. During the testing period, a Hewlett-Packard pressure gauge will provide continuous bottom-hole pressure measurements. This gauge can operate at the expected temperatures of 305°F or slightly higher for a test time of this duration.

Data obtained during these tests will include flow rates (q), stabilized producing pressures (Pw) at those varying flow rates and static pressures (Pws). These data will permit a study of productivity index, reservoir parameters, and other pertinent information. Combined with the petrophysical analyses of the wire line logs and the laboratory analyses of the cores and other samples, a reliable evaluation of the reservoir and its long-term productivity capacity should be available at the termination of this testing interval.

H. Permanent Production

The successful completion of Phase I test loop production will permit the design and construction of permanent testing facilities. These will be designed to produce prolonged maximum flow and the separation of the associated methane. A period of six months' operation is allocated for this plan. The object of this testing is to demonstrate that a production well can be operated for commercial production. Consequently, successful accomplishment should lead to the continuation of this facility and the commercial sale of the gas produced.

During the interval of design and construction of the production facilities, complete analyses of the data accumulated from the test loop results will also permit the design of additional tests during the period of permanent production.

I. Associated Research

Chemical Analyses of Production Fluids

During the period of test loop and permanent production, chemical analyses of the production fluids will be made.

Sampling is scheduled at weekly intervals to occur at the beginning, midpoint, and end of the 60-day test loop production and monthly during the 6-month permanent production period.

Each sampling will yield well site analysis of these parameters:

pH	Conductance
Dissolved solids	Turbidity
Chloride	Suspended solids
Silica	Bicarbonate
Density	Carbonate
Temperature	

Laboratory analyses will be conducted on two of the test loop production samples and two of the permanent production samples for the following:

Water Sample

Viscosity	Potassium	Arsenic
Calcium	Zinc	Mercury
Magnesium	Iron	Lead
Strontium	Cadmium	Barium
Boron	Chromium	Radon
Sodium	Copper	

Gas Sample

CO₂, N₂, C₁-C₅, C₆+, H₂, He, O₂, Rn, H₂S, NH₃

The foregoing tests will be of particular value in association with any problems in mineral precipitation that may impede production or disposal. Such problems must be identified during the test loop production in order to correctly design the permanent facilities.

Two samples collected during the test loop production will also be subjected to recombination and differential liberation studies. These tests will be especially important in predicting the methane potential during long-term production and the designing of the permanent surface facilities.

J. Core Analysis

Core analyses will be performed on both sidewall cores and diamond cores. These will include cores taken in the transition zone just above the "Miogyp" sand and approximately 300 feet of the sand.

Analyses will include:

- Horizontal permeability
- Porosity
- Fluid saturation
- Vertical permeability
- Grain density
- Sieve analysis
- Core-gamma log

K. Paleontological Analysis

Daily examination of well samples for paleontological analysis will be conducted in order to determine:

- Biostratigraphic zones
- Local zones important for correlation purposes
- Environments of deposition

L. Geochemical Analysis

Geochemical analysis of well samples to determine the hydrocarbon source quality, source type (gas, condensate, or oil), and degree of thermal maturity. Tests performed will include:

- C₁-C₇ hydrocarbon analysis
- C₄-C₇ gasoline-range hydrocarbon and organic carbon analysis
- Organic carbon analysis
- C₁₅+ hydrocarbon analysis
- C₁₅+ soxhlet extraction and deasphalting
- C₁₅+ liquid chromatographic separation
- Organic matter (kerogen) type and thermal alteration rank
- Vitrinite reflectance percent Ro
- GC analysis of C₁₅+ paraffin-naphthene hydrocarbon

M. Rock Mechanics

Both nontime-dependent and time-dependent testing of core samples will be conducted. Nontime-dependent test measurements will include radial and axial deformation, ejected pore fluid volumes, permeability, and P and S wave velocities. The data will be used to calculate bulk compressibilities, uniaxial compaction coefficients, shear moduli, and porosities and permeabilities as a function of stress state.

Anelastic, time-dependent testing to determine time dependence of strain, pressure maintenance, and permeability changes will be done to simulate reservoir characteristics. This will be useful in determining reservoir performance and possible subsidence.

N. Clay Mineralogy and Diagenesis

Results of this analytical study will be used to reconstruct the diagenetic history of the sediments penetrated during drilling and to determine ways in which porosity and permeability of the sediments have been altered by burial diagenesis. This study should also indicate if the porosities and permeabilities are typical of the region, and if the pore spaces are primary or secondary. It will also provide data useful in determining the optimum reservoir production program.

O. Reservoir Testing and Analysis

After completion, cleanup, and pressure testing, cased hole logs will be run to record temperatures, bottom-hole pressures, and correlate casing depths. The cased hole logs will be correlated with the open-hole logs and core analysis data. These data will be used to determine the perforation points. It is expected that the lowest sand in the "Miogyp" sand will be perforated first, with the lowest 100 feet being perforated with four holes per foot. After testing of this interval, additional perforations may be opened in the "Miogyp" sand at shallower depths.

After perforating, the well will be flowed sufficiently for cleanup and to open up the perforations. The well will then be shut in with no additional testing scheduled at this point.

After installation of the test loop, the well will then be brought on stream according to the flow test schedule shown on pages 5-5 and 5-6.

The static pressure will be measured during each three-day buildup for comparison with the stabilized producing pressure. From these data and the production rate, the productivity index for the sand may be calculated. The productivity index and pressure buildup will be used to calculate reservoir permeability for comparison with core analysis data.

During the flow testing, continuous bottom-hole pressures, surface pressures, temperatures, and flow volumes will be measured. Water and gas samples will be taken at specified intervals for analysis.

The results of these analyses will be used to determine the reservoir permeability, areal extent, distance to barriers, possible compaction and subsidence, and total reservoir characteristics. Reservoir simulation models will also be developed using these data.

Ultimately, from the reservoir analysis and modeling, the potential of the reservoir to provide kinetic and thermal energy and methane gas sufficient to prove the viability of the geopressured-geothermal resource will be determined.

P. Coordination of Testing Data and Information

Due to the varied tests to be performed and the number of research organizations involved, it is vitally important that all test samples, materials, and data be coordinated by a single entity. Coordination of testing will be done by the Magma Gulf-Technadril project research manager.

VI. ENVIRONMENTAL ASSESSMENT AND MONITORING PLAN

A. Introduction

Louisiana State University (LSU) will undertake management of environmental baseline and monitoring studies for geopressured test well activities in the vicinity of Sweet Lake, Louisiana. Magma Gulf Company, in cooperation with the U.S. Department of Energy (DOE), is currently planning to drill and test a geopressured well near Sweet Lake at the location given in Figure 18. A schedule for the planned drilling and testing program is given in Section X.

The drilling and testing operations associated with the Magma Gulf/DOE Sweet Lake geopressured well will be conducted within the scope of an Environmental Assessment prepared by Coastal Environments, Inc., under contract to Oak Ridge National Laboratory and identified as follows:

Environmental Assessment
Geothermal Energy, Geopressure Subprogram
Sweet Lake No. 1
January 1980
U.S. Department of Energy

In this assessment, the implication of geopressured resource testing is evaluated for activities from well site preparation through site restoration after testing is complete.

B. Environmental Baseline and Monitoring Studies

The purpose of collecting environmental baseline data is to provide a description of selected physical, chemical, and biological conditions against which later environmental monitoring data can be compared. This comparison will provide a basis for determining the net environmental change attributable to test well operations at any subsequent time.

The following data shall be collected to establish the baseline of ambient conditions prior to fluid production:

Air Quality

Existing air quality conditions
Local meteorological characteristics

Water Quality (Surface and Subsurface)

Existing water quality conditions
Water resource usage
Hydrologic patterns, surface and groundwater levels

Sweet Lake Geopressured Prospect. Drill site location depicted with star. Magma Gulf leases are shown as follows: A - Amoco, S and L - Sweet Lake (from Magma Gulf Company).

Figure 18

Subsidence

- Subsidence history
- Leveling surveys

Seismicity

- Microseismic surveys

Ecosystem Quality

- Biological surveys

In order to avoid duplications, information presented in the DOE/Oak Ridge Environmental Assessment for the Sweet Lake well test shall be incorporated where possible in the LSU environmental baseline evaluation. For example, very little additional work may be required to establish existing ecosystem quality.

An environmental monitoring program designed to provide comparative data during drilling and production phases will include the studies listed below. The asterisk indicates the studies that are contingent upon the occurrence of environmental changes (e.g., changes in air quality and/or standards violation in the case of air quality) and are not considered in the base scope work.

Air Quality

- Air quality monitoring
- Pollutant dispersion modeling*
- Continuous wind speed, wind direction, temperature, and precipitation

Seismicity

- Continuous microseismic surveys

Water Quality (Surface and Subsurface)

- Water quality monitoring
- Water level monitoring

Subsidence

- Repeated leveling surveys

Ecosystem Quality

- Biological surveys*
- Bioassays*

Monitoring studies may be increased if environmental conditions, either natural or as a result of test well activities and geopressure fluid

analysis, require such adjustment. However, LSU will be obligated to demonstrate the inadequacy of the existing data collection program when seeking approval for additional studies.

The combined scope of environmental baseline and monitoring studies which are planned during the first year include the air quality, water quality, subsidence, seismic, and ecological studies described below.

1. Air Quality

Air quality baseline studies will be performed to: (a) determine ambient air quality prior to possible disturbance from test well activities, (b) identify any substance potentially derived from the geopressed fluid that may have an adverse effect on the environment and establish baseline concentrations for these substances, (c) collect locally available meteorological data necessary for understanding dispersion and conversion patterns, and (d) provide baseline data compatible with later measurements needed to assure compliance with state and federal air quality standards.

Air quality monitoring will be performed to determine changes in air quality which may be related to well testing activities. Sampling and analysis for hazardous substances will be from a fixed automated monitoring unit located approximately one mile north of the test site (prevailing winds are from the south).

Analyses will include continuous measurement of sulfur dioxide, hydrogen sulfide, total hydrocarbons, and methane. Meteorological data from continuous recorders shall include wind speed, wind direction, temperature, and precipitation. In the event of significant atmospheric pollutant emissions, dispersion characteristics will be determined.

Analytical procedures for air quality monitoring will be consistent with designated Reference or Equivalent Methods published by the U.S. Environmental Protection Agency, Monitoring and Research Laboratory, Research Triangle Park, North Carolina, November 3, 1978. Analyzer performance shall conform to specifications for automated methods as described in 40 CFR, Parts 50 and 53.

2. Water Quality

Water quality baseline studies will be conducted to determine: (a) ambient water quality conditions in local bayous and canals and in shallow groundwater prior to possible disturbance from test well activities, (b) baseline conditions for substances potentially present in the geopressed fluids, and (c) water resource usage and baseline concentrations for substances and physical properties for which state standards have been established.

Water quality monitoring studies will be performed so that changes in chemical and physical properties of surface water and groundwater can be determined. Surface water samples will be collected monthly;

surface water levels will be recorded at the time of sample collection. Laboratory analyses to be conducted for each sample will include Na, K, NH_3 , SO_4 , Cd, Mn, Ca, Cl, Ba, Pb, As, B, Hg, total hardness (calculated), and total organic carbon. Field measurements shall include pH, specific conductance, turbidity, temperature, and dissolved oxygen.

Three observation wells will be drilled approximately 500 feet into the zone of fresh groundwater. Groundwater samples will be collected each month. Field and laboratory analyses to be performed on groundwater samples will be the same as for surface waters. Water level in the observation wells will be reported monthly.

Ground and surface water sample collection, handling, preservation, and analysis will be consistent with methods published by the U.S. Environmental Protection Agency, "Manual of Methods for Chemical Analyzers of Water and Wastes" (1974), and the U.S. Geological Survey, "Recommended Methods for Water Data Acquisition" (1977).

3. Subsidence

Subsidence baseline studies will include an initial leveling survey to establish relative surface elevations and an examination of historic leveling data and topographic maps to determine subsidence history in the vicinity of the test well.

The initial leveling survey shall consist of approximately 20 miles of first-order precise leveling. Leveling profiles will be tied to National Oceanic and Atmospheric Administration (NOAA) elevation benchmarks which are located beyond the area of potential subsidence impact. Procedures to be used in establishing benchmarks in the vicinity of the test well will be in accordance with guidelines provided in the NOAA publication, "Specifications to Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys" (1978).

Subsidence monitoring will consist of first-order releveing surveys which will be conducted at 12-month intervals during production to document the occurrence of land-surface subsidence, if any, near the well site or of differential surface movement along reactivated faults. First-order releveing is planned during the second-year environmental monitoring program and is not considered in the base scope of work.

4. Seismicity

Microseismic surveys will be performed to (a) determine background microseismic activity prior to disturbance from fluid production and (b) monitor microseismic activity during fluid production. Baseline microseismic studies will include an initial reconnaissance survey to determine sources and levels of background microseismic activity.

Data from this survey will be used to identify locations for permanent monitoring installations which will be least influenced by natural and cultural background noise.

Continuous microseismic monitoring will be performed using seismometers emplaced in sealed boreholes at approximately four feet below ground surface. Microseismic monitoring studies will provide the origin time of local seismic events, their estimated locations, and their relative magnitudes. The microseismic monitoring net will be operative for approximately six months prior to fluid production.

5. Ecosystem Quality

Baseline ecological studies will rely on existing published and unpublished data to establish ranges and populations of plant and animal species in the vicinity of the test well. Additional biological surveys will be conducted in the event of significant impact to plant or animal life but are not considered part of the base scope of work.

6. Environmental Program Management

The environmental monitoring program will be managed by Dr. Charles G. Groat, Director of the Louisiana Geological Survey and Professor of Geology, Louisiana State University. The management of environmental monitoring will include ensuring that data collected is compiled, analyzed, and reported to DOE on a quarterly basis, or more frequently if necessary. LSU will provide for contractual arrangements with firms for performance of selected field and laboratory studies. Overall data interpretation and impact assessment will be performed by LSU investigators. LSU will also be responsible for determining if federal, state, and local environmental quality standards are being met and will inform DOE in the event of noncompliance. LSU investigators will also inform DOE when an increase or decrease in baseline monitoring studies are required, justifying such changes in scope as they occur.

This Environmental Monitoring Plan outlines a one-year program of combined environmental monitoring and baseline studies. LSU will prepare quarterly status reports, including data summaries, and an annual report summarizing the results obtained during the first year. Based on analysis of the data; the development of the test well; and federal, state, and local regulations, LSU will propose a second-year plan for continuing air quality, water quality, subsidence, and microseismic monitoring studies. In preparing this plan, LSU will determine whether or not it can be accomplished at a reduced level in any of the monitoring programs (e.g., increasing the interval between water samples, reducing the number of ions analyzed, increased level of air quality monitoring, etc.).

VII. PERMITS

The attached permits are applicable to the drilling of the Magma Gulf-Technadril/DOE AMOCO Fee No. 1 well in Cameron Parish, Louisiana.

State of Louisiana Office of Conservation	GR-10	Application for Permit to Drill or (Renew) for Geothermal Resource (Figure 19)
State of Louisiana Department of Conservation	MD 13-R	Permit to Drill for Minerals (Figure 20)
Louisiana Department of Transportation and Development	LDPW-GW-1	Water-Well Registration (Figure 21)
Louisiana Department of Transportation and Development	LDPW-GW-2	Water-Well Abandonment and Plugging (Figure 22)
State of Louisiana Office of Conservation	GR-4	Geothermal Resource Work Permit (Figure 23)

MAGMA GULF-TECHNADRIL

STATE OF LOUISIANA OFFICE OF CONSERVATION		TYPE ONLY
APPLICATION FOR PERMIT TO DRILL or (RENEW) FOR GEOTHERMAL RESOURCE		
SERIAL No. <u>11-7759</u>	DATE <u>2-28-80</u> (<u>3/12/80</u>)	CORE NUMBERS
PARISH <u>CAMERON</u>		
FIELD <u>WILDCAT</u>		
OPERATOR <u>MAGMA GULF - TECHNADRIL/DOE</u>		
ADDRESS <u>1111 FANNIN, SUITE 1010</u>		
CITY <u>HOUSTON,</u>	STATE <u>TEXAS</u>	ZIP <u>77002</u>
WELL NAME <u>MAGMA GULF-TECHNADRIL-DOE/AMOCO FEE</u>		NO. <u>#1</u>
LOCATION: Sec. <u>13</u> T <u>12S</u> R <u>8W</u> <u>1,650 Ft. N and 2,310 Ft. E</u> of SW corner Sec. 13.		
PROPOSED TOTAL DEPTH <u>± 15,900 Feet</u>		
ZONE or RESERVOIR OF PROPOSED COMPLETION <u>"MIOGYPS SAND, "Camerina Zone (Upper Fr 10)</u>		
APPLICABLE OFFICE OF CONSERVATION ORDERS <u>29B</u>		<u>77002</u>
SEND PERMIT TO <u>Magma Gulf-Technadril, 1111 Fannin, #1010 Houston, Tx</u>		
FOR ADDITIONAL INFORMATION - CONTACT: <u>R. W. Rodgers</u>	PHONE <u>713/757-0579</u>	
BY <u>R. W. Rodgers</u>	APPLICANT'S SIGNATURE	
DISTRICT APPROVAL _____	DATE _____, 19__	
ISSUED BY _____	DATE _____, 19__	
API No. (OC USE ONLY)	Form GR-10 ('79)	

Figure 19

MAGMA GULF-TECHNADRIL

R.T. SUTTON
COMMISSIONER

State of Louisiana

DEPARTMENT OF NATURAL RESOURCES
OFFICE OF CONSERVATION

P.O. BOX 44275
BATON ROUGE, LA. 70804

March 18, 1980

RE: Cameron
Wildcat
Amoco Fee NO.1
Serial #167759

Magma Gulf-Technadrill/DOE
1111 Fannin Dr
Suite 1010
Houston TX 77002

Gentlemen:

We are issuing Permit to Drill for the above referenced well with the understanding that completion of said well must be in compliance with the provisions of the Statewide Order No. 29-P.

In addition, it is understood that you will furnish the appropriate district manager with Inclination and/or Directional Survey data as proof that the well has been drilled in compliance with the provisions of the Statewide Order NO.29-B, Section XVIII, dated March 1, 1967.

Very truly yours,

R. T. SUTTON, COMMISSIONER
OFFICE OF CONSERVATION

BY

A handwritten signature in dark ink, appearing to read "Joseph W. Hecker".
Joseph W. Hecker
Chief Engineer

cc: W C Wilhite
District Manager
Lake Charles

JWH/JFD/lah

FORM NO. 13-2		ORIGINAL TO OPERATOR	
STATE OF LOUISIANA		PERMIT TO DRILL FOR MINERALS	PERMIT\$100.00
DEPT. OF CONSERVATION			Multiple Zone Processing
Att			
Send To	Lake Charles/13	Date	March 12, 1980
Serial No.	Ser #167759 API #1702321495		
Parish	Cameron 012	Field	Wildcat 9733
Operator Magma Gulf-Technadrill/DOE 9999			
Address 1111 Fannin #1010			
City & State Houston TX 77002			
Well Name Amoco Fee NO.1			
Location Sec. 13, T12S, R8W			
1650' N & 2310' E of SW/C Sec. 13			
PTD 15800			
Zone or Reservoir of Proposed Completion Miogyp/Camerina/Upper Erio			
Applicable Department of Conservation Order 29B
COMMISSIONER		152080	

Figure 20

MAGMA GULF-TECHNADRIL State of Louisiana
Department of Transportation and Development

EDWIN EDWARDS
GOVERNOR

GEORGE A. FISCHER
SECRETARY

Office of Public Works

P.O. Box 44155 Capitol Station Baton Rouge, Louisiana 70804

March 24, 1980

MAGMA GULF- Technadrill/Doe
1111 Fannin, Suite 1010
Houston, Texas 77002

RE: Water Well Rules, Regulations,
and Standards, State of Louisiana

Gentlemen:

It has recently been brought to our attention that your company was issued a permit by the Louisiana Office of Conservation, DNR, to drill an oil or gas well in Louisiana as evidenced by the Permit Serial No.(s) 167759

Because of the rig-supply water wells normally associated with oil and gas drilling activities this letter is written to inform you of your obligation under R.S.38:3091-3097 (State Act 535 of 1972) and the subsequent rules, regulations and standards that were adopted. In accordance with these State Regulations (copy enclosed) all abandoned water wells and holes are required to be properly plugged and sealed and reported to this Office.

Rig-supply water wells are subject to these Regulations and you are being asked to comply accordingly. We all realize that only through your full cooperation can the possibility of contamination of our State's ground water resources be eliminated.

It is necessary that we contact you at this early stage to assure that the water well or hole is plugged and sealed when drilling activities cease at this site. If the rig-supply water well is left in place for the lessee's or land owner's use it must be registered with this Office if it meets one of the two following criteria: (1) public-supply well or (2) capable of producing in excess of 50,000 gallons per day.

A Registration Form (LDPW-GW-1) and an Abandonment Form (LDPW-GW-2) are enclosed for your use. If more forms are needed we will be happy to furnish them upon request. Any questions you have concerning these requirements may be directed to our Water Resources Section at (504) 342-7541.

Yours very truly,

ROY AGUILARD
Assistant Secretary

/jr

FORM: LDPW-GW-2
REV. 1/78

LA, OFFICE OF PUBLIC WORKS

<p>1. WELL OWNER: (If different from owner when drilled, note in item 5) _____</p> <p>ADDRESS: _____</p> <p>OWNERS WELL NUMBER (if any) _____</p> <hr/> <p>2. LOCATION OF WELL: Parish: _____ In SECTION _____</p> <p>TOWNSHIP _____ RANGE: _____ Well is near _____ approximately _____ Miles from _____</p> <p style="text-align: center; font-size: small;">(CROSSROADS, TOWN, RAILROAD, ANY LANDMARK, ETC.)</p> <p style="text-align: center;">(IF POSSIBLE PLEASE ATTACH MAP OR PLAT SHOWING LOCATION)</p> <hr/> <p>3. WELL INFORMATION: Depth of hole, _____ ft., Depth of completed well, _____ ft., Date completed _____ by (Give name and address of water-well contractor who installed well or hole): _____</p>	<p>4. Describe in detail how well or hole was plugged: (materials used, amount of casing and/or screen removed, or left in hole, etc.) _____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <hr/> <p>5. REMARKS: _____</p> <p>_____</p> <p>_____</p> <hr/> <p>I certify that this work was done and completed in accordance with Rules and Regulations of the State on _____, 19____ by (name and address of contractor or owner) _____</p>
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OFFICE USE ONLY															
State		Parish		Local Well No.				Identification Number							
2	2			—							0				
1	2	3	5	6			11	12							26

SEE REVERSE SIDE OF 3RD COPY FOR INSTRUCTIONS

GEOHERMAL RESOURCE WORK PERMIT
STATE OF LOUISIANA OFFICE OF CONSERVATION

Well Name & No. Magma Gulf-Technadril-DOE AMOCO SWD 13 T 12S R 8W
Field Wildcat NO. 1
Parish Cameron
Permit Serial No. 167759 Work Permit No. 659-80

Description of Work Dispose of salt water associated with production and testing of MG-T DOE-AMOCO Fee No. 1, geopressure-geothermal well
Approved as submitted except that 13 7/8
must be set at ± 1350

Sand & Reservoir To Be Tested TD

Operator Magma Gulf-Technadril
Address 1111 Fannin, Suite 1010
City, State & Zip Houston, Texas 77002

Permit Requested By R. W. Rodgers, MG-T Date 6/18/80
Permit Authorized By W. C. Whit District LC Date 6/20/80

See Instructions On Reverse Side

Form GR-4 ('79)

VIII. PROGRAM MANAGEMENT

A. General

This section identifies the organizations and principal personnel participating in the well drilling and testing program and describes basic authorities and responsibilities.

B. Organizations and Personnel

1. Department of Energy, Division of Geothermal Energy (DGE), Washington, D.C.

Geopressure Program Manager (GPM)--Mr. Robert Holliday

2. Department of Energy, Nevada Operations Office (NV), Las Vegas, Nevada

- a. Chief, Geothermal Branch, NV--R. Stearns

- b. NV Project Manager (NVPM)--R. Clarke

- c. Director, Geopressure Projects Office, Houston (DGPO)--K. Westhusing

- d. Testing Project Manager--F. Goldsberry (GPOTPM)

3. Magma Gulf-Technadril, Houston, Texas (MGT)

- a. Contractor Program Manager--R. W. Rodgers

- b. Drilling Manager--C. S. Adkins, Jr.

- c. Business Manager--A. L. Wyand

4. Louisiana Geological Survey

Program Manager--Dr. D. Bebout

C. Authorities and Responsibilities

1. Division of Geothermal Energy (DGE)

Identify overall program objectives, provide funding and authorization, and designate a Geopressure Program Manager (GPM) with the following authorities and responsibilities:

- a. Approve the geopressure well drilling and testing plan.

- b. Approve any major changes to the plan.

- c. Provide an approved Environmental Impact Assessment for the drilling and testing activities.
 - d. Approve any proposed contract modifications which result in increased funding levels.
- 2. Nevada Operations Office (NV)
 - a. Geothermal Branch, Las Vegas, Nevada
 - (1) Provide for implementation of the approved drilling and testing plan through a contractor, Magma Gulf-Technadril.
 - (2) Provide an NV Project Manager (NVPM) to maintain technical and administrative surveillance of the project through receipt of oral and written reports and by on-site monitoring of critical project phases.
 - (3) Provide formal direction to the Contractor as necessary to assure compliance with contract provisions.
 - (4) Report project status to the GPM.
 - (5) Maintain continual cognizance of the well drilling and testing activities.
 - (6) Prepare and coordinate press releases.
 - b. Geopressure Project Office, Houston (GPO)
 - (1) Review and evaluate the well testing progress and make recommendations to the NVPM.
 - (2) Provide the day-to-day interface with industry, states, and educational institutions to maintain effective channels of communications regarding the development of the geopressure energy resource.
 - (3) Maintain a current knowledge of geopressure prospects with a potential for drilling designed wells.
 - (4) Assist in the coordination between the well drilling and testing contractor and the Louisiana Geological Survey scientific studies groups.
- 3. Magma Gulf-Technadril (MGT)
 - a. Prepare a detailed geopressure well drilling and testing plan for approval.
 - b. Conduct the well drilling and testing activities in accordance with the approved plan and the provisions of the Contract.

- c. Coordinate drilling and testing activities with the Louisiana Geological Survey study groups, through the Nevada Operations Office.
- d. Provide logistical and other support to the Louisiana Geological Survey as required, with approval of the Nevada Operations Office.
- e. Prepare and submit reports as specified in Section IX of this plan and maintain a daily project cost status.
- f. Inform NV of any proposed deviation from the approved drilling and testing plan, before the deviation if not an emergency, and immediately afterwards if an emergency.

4. Louisiana Geological Survey

Provide environmental monitoring as required.

See Figure 24 for relationship of primary organizations.

GEOPRESSURE WELL

DRILLING & TESTING PROGRAM ORGANIZATION CHART

Figure 24

IX. REPORTING

All reports (except daily and monthly) will be submitted to DOE/NV by the Contractor for review prior to publication in accordance with specific instructions to be provided by the DOE/NV Technical Information Officer. These instructions will include format, number of copies, and submittal schedules. In summary, the reports will consist of the following:

A. Management Plan

The Contractor's plan to manage the effort described in the statement of work. It will contain management methodologies, control systems, and procedures it will use. It will include milestones and other planning schedules, organizational identifications and descriptions, and special and critical plans, such as test plans and plans for the handling of Government-owned property. Work breakdown structures, key personnel identification, and methods for monitoring progress toward objectives will be required.

B. Milestone Plan and Management Report

The Contractor's milestone schedule for all work breakdown structure items, line items, or deliverables specified in the Contract. To be updated periodically (usually monthly) to show status, progress toward completion, and percent completion of each line item and on the total Contract.

C. Contract Management Summary Report

A single-page graphic presentation of integrated cost, major milestones, and manpower for rapid visual analysis and trend forecasting.

D. Major Milestone Status Plot

A periodic graphic presentation of events, deliverables, or major milestones and associated dates plotted in an expected performance envelope for rapid visual analysis and trend forecasting.

E. Cost Management Report

A periodic report of the status of costs compared to the Cost Plan. Data will be used to report actual and project accrued costs, evaluate performance against plan, identify actual and potential problem areas, construct cost experience for projects and budgeting efforts, and to verify the reasonableness of Contractor's invoices.

F. Technical Progress Report

1. Daily Drilling Report

An informal activity report submitted daily throughout the drilling and testing phase. The daily report will be phoned in directly to

the Nevada Operations Office for subsequent transmittal to other interested parties.

2. Monthly Technical Progress Report

A technical letter report submitted one week after the end of each month describing accomplishments made to date and providing a brief outline of the planned work schedule for the succeeding period. Problems that have occurred will be discussed along with the method of solution. Test measurement results and analytical data will be presented.

G. Final Reports

These written reports will correlate findings of flow tests and analyses and will include a summarization of the operational aspects of well activities. The reports will also include the evaluation of the completion technique and production strategy; the result of sand stability investigations, including the maximum and reasonable rates at which the well and the reservoir will safely operate; the determinations concerning corrosion and scaling properties of the produced fluid and any treating methods that can be used to control corrosion or scaling problems; evaluation of the reservoir deliverability and depletion, including appropriate material-energy balance equations of use; determination of reservoir size as indicated from test data; reservoir fluid characteristics, including salinity, formation compaction related to any detected surface subsidence, and discussion of the heterogeneity of the reservoir if detected.

1. Yearly Technical Report

A technical report will be submitted in draft form upon completion of each contract year. It will describe operational procedures followed, drilling completion and testing methods employed, and it will provide measurement and test information with all necessary illustrations, graphs, and tabulations required to show significant results. Descriptive text will be used to explain all illustrations.

2. Final Technical Report

A report will be submitted at the conclusion of the program presenting a summary of overall program results. It will be a complete report on all significant data obtained and will be a composite of work performed by all investigators directly related to the drilling and testing of the production well, drilling and utilization of the disposal well(s), and operation of the surface facility.

X. SCHEDULE

MAGMA GULF-TECHNADRIL

SWEET LAKE PROSPECT

DE-AC00-80NV10001

MGT-DOE AMOCO FEE NO.1 DRILLING SCHEDULE

Figure 25

XI. REFERENCES

1. Kruger, Paul, and Carl Otte: Geothermal Energy, Stanford University Press, Stanford, California, 1973.
2. Berman, Edward R.: Geothermal Energy, Noyes Data Corp., Park Ridge, New Jersey, 1975.
3. Herrin, E.: "Development of Geothermal Reservoirs From Over-Pressured Areas Beneath the Gulf Coast Plain of Texas," Report AD-766 855, Air Force Office of Scientific Research.
4. Dorfman, M. H., and R. W. Deller: "Proceedings First Geopressured Geothermal Energy Conference," University of Texas at Austin, Center for Energy Research, June 2-4, 1975.
5. Dorfman, M. H., and R. W. Deller: "Summary and Future Projections," Volume I, Proceedings Second Geopressure Geothermal Energy Conference, University of Texas at Austin, February 23-25, 1976.
6. Podio, A. L., et al.: "Reservoir Research and Technology," Volume III, Proceedings Second Geopressure Geothermal Energy Conference, University of Texas at Austin, February 23-25, 1976.
7. Underhill, G. K., et al.: "Surface Technology and Resource Utilization," Volume IV, Proceedings Second Geopressure Geothermal Energy Conference, University of Texas at Austin, February 23-25, 1976.
8. Vanston, J. H., et al.: "Legal Institutional and Environmental," Volume V, Proceedings Second Geopressure Geothermal Energy Conference, University of Texas at Austin, February 23-25, 1976.
9. Whiting, R. L., and H. J. Ramey: "Applications of Material Energy Balances to Geothermal Steam Production," J. Pet. Tech. V21, 1969, pp. 893-900.
10. Cady, G. V.: "Model Studies of Geothermal Fluid Production," Ph.D. Dissertation, Stanford University, 1969.
11. Bebout et al.: Geopressured-Geothermal Fairway Evaluation and Test-Well Site Location--Frio Formation, Texas Gulf Coast, University of Texas, Bureau of Economic Geology Report for the U.S. DOE, Division of Geothermal Energy, 1978.
12. Durham, Jr., C. O.: Analysis of Cameron Parish Geopressured Aquifer Report for the U.S. DOE, Division of Geothermal Energy, 1978.