USE OF GEOTHERMAL HEAT FOR SUGAR REFINING IN IMPERIAL COUNTY

DOE/ET/27039--T4

DE82 012891

DRILLING AND RESOURCE DEVELOPMENT PLAN

JUNE 1979

DOE Contract No.
DE-AC 03-79 ET 27039

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Prepared for :

U. S. DEPARTMENT OF ENERGY

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TRW

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DRILLING AND RESOURCE DEVELOPMENT PLAN
Holly Sugar 44P and Holly Sugar 35I
June 25, 1979

BACKGROUND

The Imperial Valley of Southern California is within a major rift zone that has been and is under severe geologic tectonic stress. This stress acting on valley fill sediments and subsurface basement rock, at depth, has opened many fractures and resulted in faulting which has permitted the intrusion of magmatic material. The faults and fractures also serve as conduits for the downward percolation of waters which are warmed by conductive heat produced by the magma. The fault and fracture conduits, in conjunction with the permeable valley fill sediments, form an environment conducive to the formation of geothermal convective cells. These cells, normally centered at the intercept of transverse faults with major rift valley faults, are probably the most favorable target for economical geothermal resources of the hydrothermal type. This concept is diagrammatically shown in Figure 1 (after Garfunkel 1971). This geologic structural circumstance occurs in Sections 29 and 30 T14S, R14E SBBM, property owned by the Holly Sugar Company.

If favorable resources are located on the Holly property by exploratory wells drilled into a zone thought to be a convective cell conduit, the available hot water will be used as a partial source of energy for operating the Holly Sugar processing plant located approximately one mile west of the proposed well location. The temperature of the water to be encountered at a well depth of about 8000 feet is expected to be in excess of 350°F. If drill stem tests (DST) conducted in this well, designated Holly Sugar 44P, are successful, a fluid injection well, designated Holly Sugar 35I, will be drilled to a depth of approximately 6000 feet. The surface location of this well will be the same drilling platform as the production well.

Figure 1. (Zvi Garfunkel 1971)

This document describes the project plans and procedures to be used in drilling and completing both the production and injection wells.

I. PRODUCTION WELL, HOLLY SUGAR 44P

The production well, Holly Sugar 44P, will be drilled from a surface location in element 14 (using the Kettleman Hills numbering system) Section 29 T14S, R14E (Figure 2). The bottom hole location will be in element 44 of the same section. Hole deviation to the desired bottom hole location will be achieved by use of 2.5°/100' bent sub and a turbo-drill. This 8000-foot exploratory well will attempt to intersect favorable sand zones encountered in Standard Oil of California's Wilson No. 1 located in Section 20 T14S, R15E. Schlumberger electrical induction logs taken in the Wilson No. 1 indicate two prime zones of geothermal potential and one secondary zone that has promise, depending on the quantity and quality of fracture permeability found on the Holly property. The shallow secondary target was encountered in the Wilson No. 1 at a depth of 6400 feet below the kelly bushing. The 400 feet of section (6000-6400 feet) preceding the silty sand zone is a highly resistive shale zone that appears to be rather dense and may act as a barrier to the upward flow of convective fluids. The hard silty sand zone, between 6400 and 6900 feet, shows some porosity with moderate resistivity, indicating it may be hard and tight. If this zone exists at the proposed location, it may be highly fractured due to its close proximity to the intercept of the Imperial fault with transverse faulting. However, the prime zone, extrapolated from the Wilson No. 1, begins at about 7200 feet and extends to a depth of 8050 feet. This zone, like the previously discussed secondary target, is overlaid by a rather thick dense shale section (6900-7150 feet). This section may act as a barrier to upward moving hot water, forcing lateral water movement, such as found at East Mesa (TRW 1976, LBL 1978) and other hyper-thermal fields. The proximity of the proposed well location to active faults and the indications that the transverse faults are in tension suggests the possibility of encountering geothermal resources capable of satisfying project requirements. A second prime zone was encountered by the Wilson No. 1 well between 12,150 and 13,000 feet. This

Figure 2. Modified Assessor's Map Bk. 40-Pg. 33. County of Imperial, California Showing the Location of the Drilling Production Platform Production Well and Injection Well.

zone, containing thick rather permeable sands interbedded with sandy silts and shale, is thought to correspond to the geothermal resource zone encountered in the McCulloch Mercer 1-28, Section 28, T14S, R14E at about 12,000 plus feet. A generalized east-west geologic section is shown in Figure 3. This section is based on details taken from the induction log from the Wilson well, Figure 4, and additional data obtained from geophysical surveys.

The drilling operation (Holly Sugar 44P) will consist of the following major activities:

1. Site preparation
2. Rig-up drilling equipment
3. Spud and drill a 24-inch hole to approximately 75 feet
4. Drill an 18-1/2-inch hole to a depth of approximately 2000 feet using mud as a drilling fluid. Log well and cement 13-3/8-inch pipe to the surface
5. Drill ahead from 2000 feet with a 2.5°/100' bent sub and turbodrill combination until a deviation angle of approximately 23° is achieved (vertical depth of about 2900 feet)
6. Drill ahead with conventional 12-1/4-inch system to a depth of 6300 feet measured depth (MD). Log well and cement 9-5/8-inch casing from 1950 feet to 6300 feet
7. Alternately drill ahead and conduct drill stem tests in an 8-5/8-inch hole to a depth of approximately 8000 feet
8. If temperatures and flow data indicate the wellbore has penetrated acceptable hot water resources, log and hang 7-inch slotted liner from 6250 feet to total depth or the depth at which flow tests will be conducted
9. Drill out shoe with water and prepare for flow testing.

Copies of "Notice of Intention to Drill a Geothermal Resources Well for the Division of Oil and Gas" are included in Appendix A.

Figure 3. East-West Diagrammatic Cross Section of Imperial Valley Sedimentary Column, Section 29 and 30 T14S, R14E

Figure 4. Induction Electrical Log

II. GENERAL SITE ACTIVITIES

A. Site Preparation and Maintenance

Well drilling will take place on drill pad covering approximately three (3) acres in element 14, Section 29 T14S, R14S. The basic plot plan is shown in Figure 5. A cooling tower for the drilling mud will be used only if necessary to protect the hole integrity. It is anticipated that the berm shown surrounding the drilling pad will be open, facing the Holly Sugar waste water pond (Figure 6) such that any accidental fluid discharge will be fully contained.

TRW Energy Systems Group will subcontract the necessary site preparations as follows:

1. Prepare an access road to the site, by grading and compacting a dirt road from the nearest existing road that will handle equipment traffic. Finishing road gravel mix may be required
2. Prepare the drill pad by leveling, compacting gravel and finishing with road gravel mix
3. Excavate a mud reserve pit
4. Excavate for a concrete-lined cellar
5. Spud, drill and install 20-inch conductor pipe
6. Arrange for site watering to maintain dust control
7. Drill "rat" and "mouse" holes. (Tool, pipe, Kelly and swivel holding and storage holes)
8. Provide for site maintenance.

B. Housing (Site Specific)

Other than housing (trailers or mobile homes) furnished by the drilling contractor for his use, a combination living and office trailer will be provided by TRW. This trailer will contain cooking facilities, sleeping quarters, office furnishings, sanitary facilities and other accommodations for TRW personnel who will be supervising well site activities. Service personnel, visiting engineers, dignitaries, DoE Personnel or others wishing to observe operations can obtain housing (motel/hotel) in Brawley, Imperial or El Centro. These cities and attendant facilities are sufficiently close to provide adequate housing of all visitors. Maintenance of the TRW trailer will be provided by TRW.

Figure 5. Standard Plot Plan for Drilling in the Imperial Valley

TRACT 65, 71, 177, 178, 189, SEC. 19, 20, 24, 25, 29, 30, T.14S., R.13 & 14E.,
& POR. SEC. 29, 30, T.14S., R.14E

Tax Area Code
69-000

Figure 6. Emergency Fluid Containment Area

C. Communications

Telephone lines to the drill site will not be provided. Radio or radio telephone communications may be available through the drilling contractor, but will not be required. Telephone communication will be arranged or provided by Holly Sugar Company. During daylight or other working hours access to office phones will be available. Afterhours (times when the plant is closed) telephone access will be through the resident TRW well site supervisor. Night communication, using Holly Sugar Company facilities, will be on an "emergency only" basis.

D. Power

Electrical power for site operations will be provided by the drilling contractor during the time the drill rig is in operation. Additional power, as needed, will be provided by a line connecting to the Holly Sugar plant. TRW will arrange for supply and distribution of this power.

E. Fuel

All fuel to operate the drill rig, trailers and all other site-specific equipment will be provided by the drilling contractor. The drilling contractor will also provide all grease, oil, antifreeze, coolants and other expendables associated with normal equipment operations. Any other fuels or lubricants not available from the drilling contractor will be purchased locally, as needed.

F. Vehicles and Transportation

All vehicles and transportation will be provided on an individual basis. The drilling contractor will be required to furnish all transportation associated with rig operations, including rig-up, drilling, rig-down, clean-up, maintenance, and repair. All service companies, providing mud, cement, hardware or other services will be required to provide their own transportation. TRW will provide one (1) vehicle for well site use by TRW personnel. Additional temporary vehicles may be provided on a day-to-day basis as necessary.

G. Operational and Logistics Support

Except for drilling and logistics associated with drilling, TRW will provide general support. This includes:

1. Crafts
2. Clerical
3. Office Supplies.

H. Site Cleanup and Restoration

Upon completion of the production well, including running casing, cementing and testing geothermal reservoirs, the drilling contractor will remove the rig and all rig-associated equipment. The drilling contractor will be required to dispose of all drilling and test related fluids in the manner specified in the Environmental Impact Report. In addition, the drilling contractor will be required to backfill the mud reserve pit and restore the pad. Wellhead equipment will be installed in accordance with State of California regulations for geothermal wells. The installation of this equipment will be the responsibility of TRW.

III. OCCUPATIONAL 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. Each individual contractor and service company participating in the project will be required to observe and provide safe operations in accordance with the rules and regulations applicable to each participating organization.

All participants will be responsible for the health and safety of their own personnel. These responsibilities will include:

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

B. First Aid

TRW will locate local medical facilities and physicians in the area for use in the event of accident or illness. The location of the medical facilities and the physician's name, address and emergency telephone number will be posted at conspicuous locations at the project site.

The TRW site vehicle will be available for use as emergency transport for injured persons of all participating organizations.

First aid supplies will be provided by TRW and will be available in the office trailer at the drilling location (project site). TRW personnel assigned to site activities will be briefed on first aid procedures by the TRW Emergency Assistance Team. First aid services will be available to all site personnel.

Additional first aid supplies and trained personnel may be available at the Holly Sugar plant, one mile west of the drill site.

C. Fire Protection

Hand-operated fire extinguishers for the drill rig and associated equipment will be provided by the drilling contractor. TRW will provide additional extinguishers at the office trailer. Extinguishers of various types will be on location at all times. These will be suitable for class A, B or C fires, as appropriate.

In addition, TRW will notify the County Fire Department of the well site location and when operations will start.

D. Sanitation

Portable water will be supplied at the drill site by the drilling contractor. In addition, potable water for drinking, cooking and sanitary purposes will be available at the TRW office trailer.

Chemical toilets will be supplied and serviced by the drilling contractor. The TRW office trailer will have a self-contained toilet facility that will be serviced at appropriate intervals. Solid waste disposal will be in accord with county and State of California regulations.

IV. DRILLING OPERATIONS

A. General

The site will be prepared prior to moving the rig on location. Site preparation includes implacement of a concrete cellar, and setting and cementing 20-inch conductor pipe to a depth of approximately 75 feet.

An 18-1/2-inch hole will be drilled in valley fill sediments, using bentonite based drilling mud (Figure 7). A set of open hole logs will be run prior to setting and cementing 18-3/8-inch casing from 2000 feet to the surface.

After drilling out the cement and cleaning the hole, drilling will resume with a 7-1/4-inch, 60-stage, integral turbodrill with a 2.5° bent sub and a 12-1/4-inch bit. Drilling S85°E will continue with this combination until a cumulative deviation angle of 23° is achieved. This is estimated to occur near 2900 feet. The hole will then be drilled with a conventional 12-1/4-inch centralized and stabilized system, maintaining the 23° off vertical deviation angle. Drilling will continue to a depth of 6300 feet measured depth. At this point, open hole logging will be accomplished prior to setting and cementing 9-5/8-inch casing from 1950 feet (50 feet of insertion into the 13-3/8-inch casing).

Drilling will be resumed with 8-5/8-inch bits. Drilling and testing (drill stem) will continue to a total depth (T.D.) of approximately 8000 feet vertical depth. Open hole logging will be from 6300 to T.D. prior to hanging 7-inch slotted casing from 6250 feet to T.D. (assuming potential production is encountered).

Minimum annular drilling fluid velocities, after drilling the conductor pipe portion of the hole, will be between 75 and 90 fpm, depending on formation and drilling mud conditions. Fluid velocities may be different during operations using the turbodrill system. In any event, the drilling fluid program will attempt to obtain optimum hydraulics to maintain clean hole conditions without causing excessive hole erosion.

Figure 7. Holly Sugar Exploratory Hole 44P

B. Estimated Production Zones

All drilling, casing and other drilling related measurements will be referenced to the Kelly bushing (KB) logging; formation tops and lithology will be referenced to ground level (GL). The following lithological descriptions and well depths are extrapolated from the Wilson et. al. # 1 drilled approximately 6 miles east of the subject site (Figure 8).

<u>Lithology</u>	<u>Vertical Depth (Feet)</u>	<u>Elevation (Sea Level)</u>
1. Alluvium of loose silty clay formed from mixed sources. Generally re-worked flood plain and lakebed deposits. (In Imperial Silty Clay.)	Surface	- 105
2. Interbedded gray mudstone, sandy siltstones, reddish brown siltstones and gray fine grained sandstones. Some thin beds of gravel and occasional conglomerates.	60	- 165
3. Gray shale with thin beds of siltstone and gray calcareous mudstone.	6100	-6205
4. Thick sandy siltstones with thin beds of gray silty shale. May encounter Imperial fault zone in this interval.	6400	-6505
5. Gray calcareous shale with occasional thin beds of silty mudstone.	6900	-7005
6. Thick beds of gray sandstone and silty sandstone with thin beds of gray shale and silty mudstone.	7100	-7205

Figure 8. East-West Diagrammatic Cross Section Showing Correlation of Favorable Sand Zones Between Deep Wells

C. Drilling Materials

TRW will be responsible for providing the following materials at the drill site:

1. Casing

- a. 75 feet of H-14 20-inch casing
- b. 2000 feet of K-55BTC 13-3/8-inch casing
- c. 4400 feet of N-80BTC 9-5/8-inch casing
- d. 1750 feet of N-80BTC (slotted) 7-inch casing

2. Wellhead Assembly (See Figure 9)

- a. Wellhead anchor assembly
- b. One (1) double-flanged spool for 13-3/8-inch casing
flange to production gate valve. 4-inch flanged side outlet
for blow-down and sampling gate valve
- c. One (1) 4-inch gate valve
- d. One (1) production gate valve
- e. One (1) production block
- f. One (1) pressure gauge
- g. One (1) pressure gauge gate valve
- h. One (1) production block to flow line gate valve.

All other materials required for well drilling and completion will be provided by the drilling contractor.

D. Drilling Procedure

1. Use a dry hole digger to drill a 24-inch hole for 20-inch conductor pipe. Cement the conductor pipe from 75 feet to the surface with approximately 110 cubic feet of cement (approximately 150 percent of calculated cement volume).
2. Prepare a concrete-lined cellar, approximately 8 feet wide, 10 feet long and 6 feet deep. Anchor system should be included in the cellar walls for later use as part of the wellhead anchor assembly.

Figure 9. Wellhead Production Assembly

3. Move in drilling rig and rig-up
4. Drill 18-1/2-inch hole to 2000 feet. Condition hole to run 13-3/8-inch casing. Notify all necessary groups and agencies of scheduled blowout preventer (BOP) pressure tests.
4. Run the following down-hole logs:
 - a. Integrated caliper survey for 2000 feet to 75 feet (4-arm type)
 - b. Induction electric log from 2000 feet to 75 feet
6. Run 2000 + feet of 13-3/8-inch K-55BTC 75 lb/ft casing with guide shoe, float collar and centralizers. Centralizer placement should be checked against caliper log to avoid washouts.
7. Cement to the surface with about 3500 cubic feet of cement (approximately 100 percent excess). Wait 24 hours for cement to set. Run cement bonding log.
8. Install BOP equipment. Install 13-3/8-inch casing head, 13-3/8-inch drilling spool with kill line and blow-down line outlets, pipe rams, blind rams, control station (50 feet from hole), mud fill-up line and mud return line. IADC designator 3M - 13-5/8 - SRRA.
9. Pressure test BOP's and casing with 500-psig surface pressure.
10. Drill out cement, guide shoe and float collar with 12-1/4-inch bit. Continue to drill an additional 90 feet of open hole to accommodate turbodrill
11. Assemble slant drill equipment (Figure 10) with 1° bent sub (2.5°/100'). Condition well bore and prepare to kick-off slant drill procedure. Direction of kick S85°E. (Detail of slant drill geometry in Figure 11).
12. Drill ahead with turbodrill (12-1/4-inch bit) to a measured depth (MD) of 2920 feet (vertical depth 2891). Obtain drift direction data and angle each 30 feet during slant drilling operation. (Once per connection).

Integral Turbodrill				
		3 1/2" Directional 60 Stage		
Item No.	Description	Part No.	Req'd.	Wt./Lbs.
1	Top Sub	D83-21	1	84.8
2	Shaft Cap	D83-3	1	8.6
3	Lockwasher-Turbine Section			
4	Stator Spacer			
5	Shaft Key-Turbine Section			
6	Intermediate Bearing Body	D80-07	3	8.0
7	Intermediate Bearing Sleeve	D80-8	3	2.0
8	Stator - Assembly	U77-01	59	2.3
9	Rotor - Assembly			
10	Turbine Housing	D83-4	1	253.0
11	Turbine Shaft	D83-5	1	85.6
19	Spacer-Bearing Section	D83-6	1	4.5
21	Thrust Bearing Sleeve	D80-22	8	0.5
22	Thrust Bearing Body	D80-084	8	1.4
23	Thrust Disc	D80-21	9	0.8
25	Lower Bearing Body	D80-025	1	7.0
26	Lower Bearing Sleeve	D80-24	1	6.3
29	Lower Sub Lock Ring	D80-30	1	3.0
30	Lower Sub	D80-27	1	15.5
31	Bearing Shaft	D83-9	1	77.0
32	Lower Bearing Spacer	D83-8	1	0.6
33	Retaining Ring	D80-57	1	0.1
34	Catch Ring	D80-56	1	0.3
40	Float Retainer Ring			
41	Shaft Coupling	D83-7	1	8.5
43	Stator Screen Assembly	D83-013	1	2.3
45	Shaft Cap Lock Screw	D83-11	1	0.1
46	Elastico Float	D83-12	1	4.5
	Turbodrill Complete	D83-01	1	750.0

Figure 10. Slant Drill Assembly

Figure 11. Deviation Graph for Production Well

13. Drill ahead with conventional 12-1/4-inch using 4 stabilizers to maintain 23° kick angle (1 near-bit stabilizer and 3 string stabilizers). Drill to a vertical depth of 6000 feet (measured depth approximately 6300 feet).
14. Condition hole and run the following logs:
 - Integrated four-arm caliper survey from 6300 Measured Depth (MD) to 2000 feet
 - Dual induction log from 6300 feet MD to 2000 feet
 - Temperature survey 6300 feet to 2000 feet
15. Run 4350 feet of 9-5/8-inch N-80BTC 53.3 lb/ft casing with guide shoe, float collar and centralizers. Centralizer placement should ensure centralizing pipe in slant hole. 13-5/8-inch casing will overlap 9-5/8-inch casing for 50 feet (permanent hanger at 1950 feet).
16. Cement intermediate casing from 6300 feet (measured) to 1950 feet with 1830 cubic feet of cement (150 percent calculated volume, or 50 percent excess). Wait on cement for 24 hours. Run cement bounding log, if necessary.
17. Drill out excess cement, guide shoe and float collar with 8-5/8-inch bit. Drill ahead (water may be used as drilling mud) running DST's intermittently as determined by estimates of geothermal potential. Continue drilling and testing to approximately 8465 feet MD.
18. Condition hole and run the following logs for 8465 feet MD to 6300 feet MD.
 - Four-arm caliper survey
 - Dual induction laterolog
 - Compensate neutron-formation density log
 - Compensate sonic log
 - High resolution temperature log
19. Hang 7-inch slotted liner, N-80BTC (slotted) 26 lbs/ft from 6250 feet MD as appropriate for testing well.

20. Run tests suggested by onsite log analysis.
21. Release rig and begin clean-up operations.
22. Prepare drill site pad for drilling injection well for full production well test.

E. Surface Equipment and Services

1. Wellhead

(as described in Section C-2 and shown in Figure 9)

2. Blowout Preventer (BOP) Equipment

The listed equipment will make up a total blowout prevention stack that will meet all appropriate regulations, in addition to providing complete safety protection for personnel. Included are the "inside" BOP equipment that meet California "in-string" regulations. The equipments (Figure 12) are as follows:

- a. 13-3/8-inch landing head (weld type), approximately 18 inches above cellar floor
- b. 13-3/8-inch double flange spool (3M) with 3-inch side outlets for kill line and blow-down line
- c. 13-3/8-inch Hydril double ram with manual locking, hydraulically operated (pipe ram with blind ram)
- d. 13-3/8-inch Hydril GK annular BOP with high temperature packing unit
- e. 13-3/8-inch bell nipple with 4-inch fill-up and 10-inch mud return lines
- f. 3-station, remote controlled driller panel (Hydril GKHE manifold)
- g. 80-gallon Hydril accumulator
- h. 3 bottles nitrogen (324 cubic feet per cylinder)
- i. Upper and lower Kellyguard (Kelly and drill pipe safety valve)
- j. Standby drill pipe safety valve with optional thread profile
- k. Inside BOP, flapper type

3. Drilling Recorder

A three-pen driller's log (to record penetration rate, bit weight, string weight and pump pressure) will be used. The driller log equipment, operation and maintenance will be provided by the drilling contractor.

**GEOHERMAL BOPE CLASS 2M (MUD)
1,000 PSI RATING FIRST OPTIONAL CONFIGURATION**

Figure 12. Blow Out Prevention System for the Holly Sugar Geothermal Wells

4. Mud Logging

A mud logging unit will be used from 2000 feet to T.D. to record the following:

- In and out mud temperature
- Lithologic character (lithology above 2000 feet will be visual analysis of cuttings. This up-hole analysis will be provided by TRW)
- Hydrogen sulfide and hydrocarbon gas volume (with alarms).

5. Mud Pit Level Monitoring

This mud pit level will be recorded at the end of each shift. If significant mud losses or gains are recognized at any time, periodic monitoring, depending on volume losses or gains, will be instituted by the drilling contractor and recorded as part of the drilling record.

F. Down-Hole Cement (Casing)

The geothermal gradients found in the Imperial Valley require special considerations for cement. The following combinations have been found effective in the North Brawley Field:

- Conductor Pipe — a slurry composed of Class G and pozzolana cement in ratios of two (2) to one (1) with 30 percent silica flour and 0.6 retarder. Tail-end slurry is Class G with silica flour.
- Surface Casing (13-3/8) — same as conductor pipe.
- Intermediate String (9-5/8-inch) — One to one mixture of Class G and pozzolana cement with 2 percent bentonite, 30 percent silica flour, 1 percent retarder, and 10 percent salt by weight of water. Tail-end slurry is composed of Class G and silica flour without friction reducer. Pozzolana is added to reduce the slurry density. Cement volumes for conductor and surface pipe are 100 percent excess to ensure complete string coverages. Intermediate string has 50 percent excess — slurry weights should be 95 lbs/cubic ft $\pm$ 5%.

G. Drilling Fluid

The composition of the drilling mud may vary depending on lithology and formation chemistry (water). Also, it may be effective to drill into the expected production zones with water. Keeping in mind that "mud" composition may change rather drastically, the following is typical for the Imperial Valley:

Drilling Mud (recirculated back into wellbore)

<u>Components</u>	<u>Amounts</u>	
Magogel (bentonite)	30,000 lbs	(13,600 kg)
Tannathin (lignite)	5,600 lbs	(2,540 kg)
Caustic soda	3,700 lbs	(1,680 kg)
Brite (barium sulfate)	1,000 lbs	(450 kg)
Bicarbonate of soda	500 lbs	(225 kg)
Soda phosphate	1,600 lbs	(725 kg)
Soda ash	1,500 lbs	(680 kg)
Geo-Gel (sepiolite)	69,200 lbs	(31,400 kg)
W1-100 (sodium polyacrylate)	175 gal	(662 liters)
Drilling detergent (soap)	15 gal	(56.8 liters)
Water	24,000 ft ³	(180,000 gal or 680,000 liters)

Total volume of
drilling mud is approximately 25,000 ft³ (708 m³)

H. Drill Cuttings (Lithology Samples)

Samples of cuttings will be taken at 10 feet intervals (geology). These samples will be taken from the most recent material crossing the shale shaker and desander, if a desander is used. The samples will be washed and placed in sample bags that are carefully labeled as to location and depth. These samples, in part, will be used to prepare a continuous lithologic log. The samples will be turned over to the proper county or state agency at the completion of drilling operations.

I. Coring

Coring will be done only as necessary. Core recovery has been so poor in the Imperial Valley that the likelihood of obtaining significant information does not justify the expense.

J. Drill Stem Test (DST's)

No fewer than five (5) or more than ten (10) drill stem tests will be conducted. An attempt will be made to conduct all tests as additional hole is made. Straddle pack tests will be avoided where possible because of the dangers of "stuck" pipe. It may be desirable to "squeeze" and test specific zones after the 7-inch liner is hung. However, this will be decided only after a rather complete examination of the well logs.

K. Well Logging

(Previously discussed)

L. Directional Surveys

Magnetic single-shot surveys will be run every trip for the first 1500 feet, after which single-shot surveys will be conducted every 90 feet or every trip, whichever occurs first. During turbodrill operations, a directional survey will be made, by Eastman, at every connection (30 feet). This will continue until a stable 23° S85 $^{\circ}$ E, is obtained. Thereafter, a directional survey, of the single-shot type, will be made every 120 feet or every trip, whichever occurs first. A "bottom hole" location log and graph will be maintained by TRW at the drill site. This graph will be maintained below the 2000 feet depth.

M. Adandonment

If abandonment of the well is deemed advisable because of the inability to locate a sufficient geothermal resource, or any other reason, development of abandonment procedures will be the responsibility of TRW and Holly Sugar. TRW will coordinate all activities and procedures with the appropriate parties.

Abandonment procedures will be based on the following criteria:

- Lack of a sufficient resource
- Prevent contamination of freshwaters
- Protection of natural resources
- Damage to geothermal reservoirs
- Prevent loss of reservoir energy
- Protection of life, health, environment and property

In general, abandonment will follow the applicable State of California regulations:

- A notice of "Intention to Abandon a Geothermal Resource well" will be filed with the State of California Division of Oil and Gas
- A history of the Geothermal Resource Well will be filed with the Division of Oil and Gas within 60 days after completion of abandonment. (This may be extended to six months, if designated a "prospect well")
- All casing will be cut off at least 2 meters below the ground surface. All concrete cellars and other installed materials will be removed. The surface location will be restored to its natural state, as near as practical
- Good quality heavy drilling mud will replace any water in the hole, in addition to filling all portions of the hole not filled with cement
- All geothermal zones in the uncased portion of the hole will be covered with cement plugs. The plugs will extend from the bottom of the zone to 30 meters above the zone
- All casing stubs and laps will be straddled with a 30-meter plug, 15 meters below and 15 meters above the top of the casing
- All shoe plugs, including the conductor pipe, will be straddled with at least 30 meters of cement

- A minimum of 30 meters of cement straddling the interface or transition zone at the base of fresh water will be emplaced. This will be accomplished whether behind casing or not
- A surface cement plug of at least 15 meters will be emplaced
- A metal plate covering the casing stub will be welded in place prior to covering the wellbore with native soil, at least 6 feet deep.

V. PERMITS

All permits, county, state and federal, will be obtained by TRW for the Holly Sugar Company. Holly Sugar owns all the surrounding land in fee; therefore, property owner permits will not be required.

VI. ENVIRONMENTAL REPORT

TRW has prepared an Environment Report that meets the requirements of the County of Imperial, the State of California, and the National Environmental Protection Act.

All aspects of the environment were considered in formulating this Drilling Plan and considered in the decision process.

VII. SCHEDULE

The schedule of significant activities is shown in Figure 13. The numbered events on the schedule parallel previously discussed activities, but are not numbered identically.

VIII. INJECTION WELL, HOLLY SUGAR 35I

The injection well will be drilled from a surface location approximately 20 feet south of the production well (Holly Sugar 44P). Surface facilities such as the mud reserve pit, access roads, pad facilities and parking will be the same as those used for drilling the production well (Holly Sugar 44P). The bottom hole location will be in element 35, as shown in Figure 2. Hole deviation will be achieved by using a 2.5°/100' bent sub and a turbodrill as previously described in Figure 8. The 6000 feet vertical depth injection well will attempt to intercept high

Figure 13. Schedule of Significant Activities Holly Sugar 44P

permeability sands above the primary and secondary geothermal target zones previously discussed in Section I, Production Well, Holly Sugar 44P. A total depth of 6000 feet will leave a 400 feet shale barrier between the lowest injection point and potential geothermal production horizons, if the stratigraphy is as anticipated. The injection well deviation geometry is graphically displayed in Figure 14.

The drilling operations for the Holly Sugar 34I will consist of the following major activities:

- 1) Skid drilling equipment and prepare to drill.
- 2) Spud and drill a 24-inch hole to approximately 75 feet. Cement 20-inch conductor pipe to the surface.
- 3) Drill 18-1/2-inch to 1500' using mud as a drilling fluid. Log the open hole (1500 feet to 75 feet) and cement 16-inch casing to the surface.
- 4) Drill ahead from 1500 feet with a 2.5°/100' bent sub and turbodrill combination until a deviation angle of 22° 50' with a heading of S70°E is achieved.
- 5) Drill ahead at a constant angle of 22° 50' to a measured depth of 6330 feet, 6000 vertical. Log the hole and hang 10-3/4 inch casing (with slots opposite injection zones).
- 6) Squeeze cement above and below injection zones. Run cement bonding logs.
- 7) Pressure test casing above injection zone to pressures 300 psig above formation pressure.
- 8) Rig-up fluid injection head and test fluid acceptance rates.
- 9) Release rig and clean-up site as specified for the production well.

(The above numbers parallel events on the "schedule of activities," shown in Figure 15, but are not identical.)

Figure 14. Deviation Graph for Injection Well

Figure 15. Schedule of Significant Activities Holly Sugar 351

A. Site Preparation and Site Activities

Site preparation, housing, communications, power, fuel, vehicles and site restoration will follow the same plan as discussed previously for the production well, Holly Sugar 44P.

B. Occupational Health and Safety

The standards of OSHA (1970) for a safe environment, first aid, fire protection and sanitation will be maintained as discussed earlier under Section III.

C. Drilling Operations

Drilling operations will proceed as discussed earlier. Only hole dimensions, depths and final completion will change significantly. These were discussed under Section IV, Part D. The fundamental changes are discussed in the above.

BOP equipment will be changed to accomodate 16-inch surface casing.

On-site recording equipment, drilling mud, cement, and well logging will be the same as that used on the production well where appropriate. Changes in the original production well drilling program that result in greater efficiencies will be instituted for the injection well (Holly Sugar 34I).

APPENDIX A

NOTICE OF INTENTION TO DRILL

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

Notice of Intention to Drill a Geothermal Resources Well

(SUBMIT IN DUPLICATE)

Operator TRW Energy Systems Group		Well Designation Holly Sugar 44P			
Field South Brawley	County Imperial	Sec. 29	T. 14S	R. 14E	B.&M. SB
Name (Person submitting report - print or type) TRW Energy Systems Group		Street Address One Space Park, Redondo Beach, CA			
Title (Agent or officer of company) Norton R. Wahl, Business Manager	City Redondo Beach	State California		Zip Code 90278	

Signature _____ Date June 12 Telephone Number (213)536-2358

The appropriate drilling fee, an indemnity or cash bond, a complete drilling program, and a parcel map showing the operator's surface rights, mineral rights, and the location of the proposed well must accompany this notice.

Location of well: 701.04 meters South along section/Property line, and 50.3 meters East at right angles to said line from the Northwest corner of section 29 XX

Elevation of prepared site about below sea level: 31.39 meters.

Is the surface location or intended productive interval within 100 feet of property boundary? ☐ yes ☒ no

If well is to be directionally drilled, show proposed coordinates (from surface location) at total depth:

653.8 meters East and 3.048 meters South

PROPOSED CASING PROGRAM

All depth measurements taken from top of Kelly Bushing that is Approx. 6.70 meters above ground.

SIZE OF CASING CM API	WEIGHT (Kg)	GRADE AND TYPE	NEW OR USED	TOP OF CASING (m)	SIZE OF HOLE (cm)	VOLUME OF CEMENT (m³)	CEMENTING DEPTHS	CALCULATED FILL BEHIND CASING
50.8 (20 in)	143.7/m	H40	New	Surface	63.5	3.76	22.86m	Surface
33.97 (13-3/8 in)	114.7/m	K55 BTC	New	Surface	45.3	93.12	609.6m	Surface
24.45 (9-5/8 in)	81.78/m	N80 BTC	New	579.12	31.12	63.64	1920.24m	579.12
17.78 (7 in)	39.75/m	N80 BTC(Slot)	New	1890	21.91	As Needed	To T.D. (2374m)	None

Intended zone(s) of completion: Pleistocene/Pliocene 400 psi Estimated total depth: 2438.4 meters.

ENVIRONMENTAL INFORMATION (SEE REVERSE SIDE)

If a governmental agency has prepared an environmental document, please submit a copy of the document with this notice or supply the following information:

Government Agency: Imperial County Planning Commission Contact Person: Richard D. Mitchell, Director
Address: Court House, El Centro, CA 92243 Phone: (714) 352-8184
Document title: Use of Geothermal Heat for Sugar Refining S.C.H. No.: (Unassigned)

Submitted in compliance with Section 3724, Division 3, Chapter 4, Public Resources Code.

ENVIRONMENTAL INFORMATION

The California Environmental Quality Act (CEQA) applies to the project described in the information on the front of the notice if the project could have a significant impact on the environment. To approve a project subject to CEQA, the Division of Oil and Gas must consider the need for either a Notice of Exemption, a negative declaration, or a final environmental impact report. If none of these documents exists or if an operator is seeking approval for a project involving six (6) or fewer exploratory wells (including temperature observation wells), the operator shall contact the Division of Oil and Gas CEQA Unit as soon as possible. The phone number is (916) 445-9686. The address is 1416 Ninth Street, Room 1316-35, Sacramento, California 98514.

FOR DIVISION USE ONLY

API WELL NO. _____

MAP	MAP BOOK	CARDS	FEE	BOND	FORMS		GEP # (14 SP)	EXEMPT ☐	NEG. DEC. ☐	E.I.R. ☐
					OGG114	OGG121				
								CLASS _____	SCH. NO _____	

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

Notice of Intention to Drill a Geothermal Resources Well
(SUBMIT IN DUPLICATE)

Operator T.W. Energy Systems Group		Well Designation Holly Sugar 35I				
Field South Brawley		County Imperial	Sec. 29	T. 14S	R. 14E	B.&M. SB
Name (Person submitting report - print or type) TRW Energy Systems Group		Street Address One Space Park, Redondo Beach, CA				
Title (Agent or officer of company) Norton R. Wahl, Business Manager	City Redondo Beach	State California	Zip Code 90278			

Signature _____ Date June 12 Telephone Number (213) 536-2358

The appropriate drilling fee, an indemnity or cash bond, a complete drilling program, and a parcel map showing the operator's surface rights, mineral rights, and the location of the proposed well must accompany this notice.

Location of well: 701 meters South along section XXXXXX line, and 50 meters East at right angles to said line from the Northwest corner of section XXXXXX 29 or _____
(Direction) (Cross out one) (Direction)

Elevation of prepared site above below sea level: 31.39 meters.
(Cross out one)

Is the surface location or intended productive interval within 100 feet of property boundary? ☐ YES ☒ NO

If well is to be directionally drilled, show proposed coordinates (from surface location) at total depth:

452.63 meters East and 201.7 meters South
(Direction) (Direction)

PROPOSED CASING PROGRAM

All depth measurements taken from top of Kelly Bushing that is Approx 6.70 meters above ground.
(Derrick Floor, Rotary Table, or Kelly Bushing)

SIZE OF CASING CM API	WEIGHT (Kg)	GRADE AND TYPE	NEW OR USED	TOP OF CASING (m)	SIZE OF HOLE (cm)	VOLUME OF CEMENT (m ³)	CEMENTING DEPTHS	CALCULATED FILL BEHIND CASING
50.8 (20 in)	143.7/m	H40 ST&C	New	Surface	61.0	3.76	22.86m	To Surface
40.64 (16 in)	114.7/m	N80 BT&C	New	Surface	47.0	36.88	426.7m	To Surface
27.30 (10-3/4 in)	84.81/m	N80 BT&C	New	426.72	37.5	As Needed	Intermit to 1828.8m	To 1402m

Intended zone(s) of completion: Pleistocene/Pliocene 350 psi Estimated total depth: 1828.8 meters.
(Name, depth, and expected pressure)

ENVIRONMENTAL INFORMATION
(SEE REVERSE SIDE)

If a governmental agency has prepared an environmental document, please submit a copy of the document with this notice or supply the following information:

Government Agency: Imperial County Planning Commission Contact Person: Richard D. Mitchell, Director
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					OGG114	OGG121				
								CLASS _____	SCH. NO. _____	