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Energy

GEOTHERMAL

USE OF GEOTHERMAL HEAT FOR SUGAR REFINING IN IMPERIAL
COUNTY

Pilot Plant Implementation

September 1984

Work Performed Under Contract No. AC03-80SF10814

Holly Sugar Corporation
Colorado Springs, Colorado

Technical Information Center
Office of Scientific and Technical Information
United States Department of Energy

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USE OF GEOTHERMAL HEAT FOR SUGAR REFINING IN IMPERIAL COUNTY

PILOT PLANT IMPLEMENTATION

Prepared for:
U.S. DEPARTMENT OF ENERGY

Contract No.
DE-AC-03-80-SF-10814

September 1984

HOLLY SUGAR CORPORATION

P.O. Box 1052
Colorado Springs, Colorado

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SUMMARY

A program aimed at replacing fossil fuels with geothermal energy for the processing of sugar beets was conducted under Department of Energy (DOE) Program Opportunity Notice (PON) No. ET-78-N-03-2047. The program was to be carried out in three phases: this report documents activities during the second phase.

The first phase was performed by TRW Energy Systems Group with the Holly Sugar Corporation as industrial participant. That phase, Contract No. DE-AC-03-79-ET-27039, involved the preliminary evaluation of the design and potential benefits of a geothermal industrial process heat system at Holly's plant in Brawley, California. During that contract TRW:

- o conducted an analysis of the prospective geothermal resource using the data base existing at that time,
- o developed a preliminary design of an industrial process heat system for the plant using geothermal energy,
- o published an environmental effects analysis and monitoring report,
- o carried out an economic analysis of the project,
- o disseminated project-related information, and
- o proposed a plan for subsequent phases.

The second phase of the program, to which this report is addressed, was entitled "Pilot Plan Implementation". During this phase, Holly Sugar Corporation under Contract No. DE-AC-03-80-SF-10814, acted as lead organization with TRW Energy Systems Group as integration contractor. The objective of the phase was to develop a successful geothermal resource and use it in conjunction with a geothermal process heat pilot plant to demonstrate the adequacy of a system which could provide technically sound, economical, and environmentally acceptable process heat.

The third phase of the program was planned to carry the pilot plant design to full scale and replace fossil fuel use in accordance with the design projections of the first phase.

The tasks of the second phase were to include the following:

- o drilling and evaluation of an exploratory production geothermal well,
- o completion of a pilot plant design based upon the exploratory well characteristics,
- o completion of a geofluid reinjection well,

- o procurement and construction of all pilot plant facilities,
- o checkout and test of the pilot plant system,
- o sustained operation of the pilot plant,
- o public dissemination of pilot plant test results, and
- o development of further plans for the third phase and preparation of program reports.

During the second phase drilling of an exploratory production well was carried out. The well reached a total depth of about 10,000 feet. Static bottom hole temperatures as high as 393 degrees F were calculated. However, the well did not produce a free flow of more than 2-3 barrels of brine per hour. Attempts were made to stimulate the well by gas lift and circulation. These procedures were unsuccessful in promoting flow, and the well was shut in. At that point the DOE decided to terminate the project.

This report summarizes the activities carried out during the second phase of the program up to the termination of work. More detailed discussions may be found in the monthly progress reports submitted to DOE during the course of the second phase, in the appendix to this report and in the referenced material. Portions of the well logs and other data were furnished to the DOE prior to and as part of the stop work action. Master copies of logs and reports generated during the work and discussed within this report will be retained at Holly Sugar Company' offices in Colorado Springs, Colorado. The Tour Report, including the driller's daily log, is located at Republic Drilling Company, Santa Fe Springs, California.

1.0 INTRODUCTION

1.1 Background

In 1976 TRW Energy Systems Group completed a study to develop information about the potential of geothermal energy and the technology required for its use by utilities (1).^{*} This work was followed by a study for ERDA (2) on the direct application of geothermal energy to sugar refining. From these programs TRW and Holly Sugar Corporation under Department of Energy sponsorship (Program Opportunity Notice ET- 78-N-03-2047) embarked upon a three-phase program to use geothermal energy in the processing of sugar beets.

In response to the PON, TRW and Holly Sugar proposed a program to replace fossil fuels with geothermal energy for sugar beet processing at the Holly Sugar plant at Brawley, California. The proposed geothermal well complex was to be located on the Holly Sugar property and would, if successful, replace more than two-thirds of the plant's energy consumption, or 225,000 barrels of fuel oil per year.

Meeting the objectives of the project would satisfy the DOE's goal of near-term commercialization of direct utilization of geothermal resources by the private sector through:

- o demonstration of the technical, economic, and environmental benefits of geothermal energy in replacing fossil fuels for commercial industrial process heat,
- o demonstration that geothermal systems could provide reliable, cost-effective operations,
- o determination of the economic, conservation, and environmental attributes of geothermal systems for various process heat applications both individually and in cascaded systems,
- o identification of a specific set of commercial users and demonstration of how their processes could be integrated into the Brawley complex to the economic advantage of all participants,
- o dissemination of data which would demonstrate that geothermal systems are practical and profitable in the Brawley area and other known geothermal resource areas (KGRA's), and,

^{*} numbers in parentheses refer to the references

- o promotion of public and industrial awareness of the attributes of geothermal systems.

These objectives were to be met through implementing the PON, and would consist of the following phases:

- (1) design and analysis,
- (2) pilot plant implementation, and
- (3) pilot plant scaleup and retrofit of the industrial user's installation for full scale geothermal process heating.

The first phase of the program, conducted by TRW under Contract No. DE-AC-03-79 ET 27039 and reported in (3), analyzed existing geotechnical data for the Imperial Valley and Brawley areas of California and defined a conceptual design for an industrial process heat system at the Holly Sugar plant site. Economic estimates and fossil fuel savings projections were carried out. During this phase the Energy Systems Group of TRW acted as prime contractor with Holly Sugar as industrial participant.

The second phase, to which this report is directed, was conducted under Contract No. DE-AC-03-80-SF 10814, between Holly Sugar and the DOE. TRW acted as systems designer and project integrator for Holly Sugar. The objectives of this phase were to prove out the geothermal resource on Holly's property and to demonstrate the technical and economic viability of geothermal industrial process heat in a pilot plant.

This report covers the second phase of the program during the period from September 1980 through June 1981. In that time period an exploratory geothermal production well was drilled. The poor production characteristics of that well led to a decision by the DOE to terminate further effort, and in June of 1981, work was stopped at the convenience of the government.

1.2 The Holly Sugar Corporation Sugar Beet Plant

The Holly Sugar Corporation sugar beet processing plant is located in Brawley, California, north of El Centro, California in the Imperial Valley. Figure 1-1 shows the position of Brawley in the Imperial Valley and its relationship to other geothermal activities.

The primary function of the plant is to produce refined sugar and sugar products from sugar beets. Dried beet pulp by-product is sold as livestock feed. The Holly Sugar factory uses a system of oil-fired steam boilers to supply noncondensing turbines to produce electricity and mechanical power. Turbine exhaust steam is used for some of the process steam needed for sugar refining. The remainder of plant steam requirements is produced by a separate oil-fired boiler. Air for the beet pulp

dryers is heated directly with oil burners.

The first phase of the program addressed the design of a pilot plant to demonstrate the feasibility of converting the makeup steam supply and the pulp dryers from fuel oil to a geothermal heat source. Makeup steam and pulp dryers are responsible for 71.7% of the plant's fuel oil demand and could be converted to geothermal energy without affecting the remainder of the plant's energy processes.

The plant was found to be readily adaptable to conversion to geothermal energy. The energy demands of the portion of the Holly plant that could be retrofitted are approximately 75,000 lb/hr of process steam at 268 degrees F (25 psig), and 250 MM Btu/hr into the flow of air which is heated to 275 degrees F for pulp drying. It was found that these two demands could be satisfied by a thermally cascaded system using a series of heat exchangers which would drop the temperature of 3600 GPM of geothermal fluid from 350 to 140 degrees F. The geothermal fluid could be supplied from production wells and returned to injection wells on the Holly property if geothermal fluids of the correct temperature and flow rate were obtained.

Crucial to the whole implementation of this program was the development of an adequate geothermal resource, and the primary effort of the second phase was directed to the successful development of that resource.

FIGURE 1-1 LOCATION OF BRAWLEY, CALIFORNIA

2.0 HOLLY 44P GEOTHERMAL WELL

2.1 Well Site Selection and Justification

During the initial resource assessment phase of the program, emphasis was placed on drilling and evaluating an exploratory production well. A report entitled "Drill Site Selection and Justification Report" (4) was submitted in November 1979 to the DOE under Contract No. DE-AC-03-79 ET 27039. The Drill Site Selection and Justification Report was submitted to the DOE and returned to TRW in February 1980 with comments. A response to the comments was delivered to the DOE at the end of February 1980.

2.1.1 Basis for Well Site Selection

Reference 4 and its comments describe the rationale for drill site selection. The major conclusions of those documents are:

- o Tectonic Activity: The proposed site is within a tectonically active area between the Imperial and Brawley Faults where spreading is occurring due to east-west tension. Similar areas of spreading within the Imperial Valley have proved heat sources, for example, the Brawley and Heber KGRA's.

The northerly to northeasterly trend of earthquake epicenters in the general area of the site south of Brawley occurs east of the surface trace of the Imperial Fault, suggesting an east dip and a component of normal or tensional faulting.

- o Low Resistivity: The drill site location fell near the middle of a large region of low resistivity (about 1.4 ohm-meters at 4 Km depth) mapped in previous resistivity studies.

The cause of the low resistivity was interpreted to be a large, relatively deep mass of hot water, and it was the basis for drilling a successful exploratory well nearby in Section 28 (Mercer 1-28).

- o Highly Fractured Area: Extensive fracture permeability was postulated at the drill site due to a bottom hole to be located at the intersection of the Imperial Fault and its branches. Highly fractured rocks would allow good flow of geothermal fluids.

The geophysical survey conducted for this project and described in Reference 4 confirmed the presence of previously mapped faults at depth and indicated the presence of faults having no surface expressions. The presence of

the unmapped faults was confirmed by the October 1979 earthquake in El Centro, California.

- o Geographic Location Near Wells of Geothermal Potential: The Holly Sugar property is favorably located relative to the Mercer 1-28 and the Wilson, et. al, wells, which indicated a potential geothermal resource exists at depth.
- o Location of the Holly Well Up the Geologic Structure: The location of the proposed site was closer to the eastward dipping Imperial Fault than is the geothermal discovery well (Mercer 1-28) located one mile to the east. This should have placed the exploratory well up structure and should have allowed the well to penetrate fractured reservoir rocks.
- o The location of the drill site was closer to a basin margin and source of clastics than to the central axis. This suggested that the stratigraphic section at the Holly site would contain more coarse and porous sands.

In the initial drill plan the exploratory well's objective was to reach a viable resource at a depth of 8000 feet. This objective was based on the data and documentation presented or reviewed in reference 4. The impact of going to greater depths on drilling costs and well design, the added operational problems at the plant due to poorer geofluid properties at greater depths, and the impact on the surface geothermal plant were all identified and discussed in the reference and subsequent commentaries.

Throughout this phase of the program, all parties were aware that the Holly well might not produce in commercially acceptable quantities, in terms of temperature or fluid flow, or both. For example the brine flow from the Mercer well "reportedly" was not significant until the well reached a depth of approximately 13,000 feet. At that depth the logged temperatures also increased dramatically indicative of penetration into the top of an active hydro-geothermal cell.

2.2 Drill Plan

Reference 4 presented the drill plan which was developed during the first phase. The California Department of Conservation, Division of Oil and Gas (DOG) was notified of the drill plan and approval to drill a production well (No. PG279-44) and a reinjection well (No. PG279-43) were obtained. The permit identified TRW as operator: the well was designated as Holly 44P.

Figure 2-1 shows the location of the well on the Holly property. Figure 2-2 indicates the offset profile of the well, while Figure 2-3 presents the planned well configuration.

FIGURE 2-1 LOCATION OF HOLLY 44P ON HOLLY PROPERTY

FIGURE 2-2 PROPOSED OFFSET PROFILE

FIGURE 2-3 HOLLY 44P CONFIGURATION

2.3 Pre-Drilling Activities

In addition to the drill plan approvals, the following permits were obtained. During the first phase permits were obtained for the temporary discharge of geothermal "pre-test" fluids (from the California Regional Water Quality Control Board - order No. 81-17) and for the discharge of waste (California Regional Water Quality Control Board - Order No. 79-101). Other permits and licenses included: an Individual Geothermal Resources Well Indemnity Bond (unto the State of California - Bond No. 215 33 71 for the injection well and 215 33 72 for the production well); an "Authority to Construct" (from the Imperial County Air Pollution Control District - Permit No. 1417); a Geothermal Exploration Permit (County of Imperial Permit No. 104-80); a Notice of Intention to Drill a Geothermal Resources Well to the Division of Oil and Gas, State of California; and an Application Environmental Information Form to the Imperial County Planning Commission. A Bond (No. BND-327391) was posted with Imperial County.

In October of 1980 a Management Plan, Milestone Schedule and Status Report, Cost Plan, and Notice of Energy R&D Project were filed with the DOE.

Identification of potential drilling and support contractors was carried out, requests for quotation issued in accordance with the drilling plan requirements, and subcontract negotiations and placement of orders were carried out. Table 2-1 presents the subcontractors and vendors who were selected at that time or participated later in the drilling project.

Prior to well spudding, the site was prepared with an access road, drill pad and berm, mud sump, and well cellar. The well was spudded in in November 1980. The Republic Drilling rig was moved in and drilling began in December of 1980.

TABLE 2-1 SUBCONTRACTORS AND VENDORS TO HOLLY 44P WELL

SUPPLIER	DESCRIPTION	SUPPLIER	DESCRIPTION
Republic Drilling	Drilling Contractor	Rain for Rent	Baker Tank Rentals
WKM	Relief Valve Kit	Rain for Rent	Waterline Services
WKM	Wellhead	Midway Fishing	Fishing Services
WKM	Wellhead Installation	Bakerline	Centralizers, etc.
Oilwell, Keenan, Grant Sooner, and Carbon Steel	Casing		
		H & H Casing	Casing Tool
Halliburton	Cement & Services & Casing Equipment	Valley Supply	Pipe Couplings, etc.
Professional Drilling Fluid	Mud		
Ry-Nel Transit	Crane Rental	Totco	Recorder - Rental
Exlog Smith	Mud Logging		
Schlumberger	Geophysical Logging		
MAPCO	Baker Tank - Rentals	N.L. Acme Tool	Subs - Spool Rings
Vetter Research	Sample Analysis	Core Labs	Sample Analysis
Halliburton	Drill Stem Test	Geolograph	De-Sander
Roy Jones	Mechanical Services and Welding	Wendell	Fluid Hauling
PDF Equipment	Solids Control	GHT	Testing Drill Pipe (Analyze Corrosion Ring)
N L Mc Cullough	Impression Block	Smith Emery	Test Drill Pipe
GB Welding	Pipe Welding	Bucks Straightening	Drill Pipe Straighten- ing
International Directional Drilling	Directional Drilling		
Servco	Tools	B & B Pipe	Slotting 7"
Stabilizer Co.	Stabilizers, Collars		
West Coast Oil Tool	Reed Rock Bits	Insurance	Special
Valley Supply	Drill Bits	Imperial County	Fees for Water Disp.
Smith Tool	Drill Bits	Dick Howell	Hole Drilling
Ryerson	Concrete	AMF Tuboscope	Drill Pipe Inspection
Ryerson	Bulldozer, Haul Tank	Baker Service Tools	Casing Scraper, Down- hole Drilling Motor
Ryerson	Fluid Hauling	Patterson Truck Line	Movement and Loading of Casing
Ry-Nel Transit	Fluid Hauling		
Otis Eng.	Nitrogen Supplies	Oilfield Sales	Pipe Protectors
NOWSCO	Nitrogen Service		

2.4 Well History

2.4.1 Documentation

The following logs were generated during the course of the second phase. Reproducible masters are located at Holly Sugar's offices in Colorado Springs, Colorado.

1. Simultaneous Compensated Neutron-Formation Density Logs, 12/12/80, 1/16/81 and 1/30/81, 2"/100 ft and 5"/100 ft scales, 1408 to 10,017 feet.
2. Borehole Geometry, 1/15/81, 2"/100 ft and 5"/100 ft scales, 6242 to 8750 feet
3. Temperature, 12/12/80, 1"/100 ft scale, 1200 to 6300 feet
4. Temperature, 1/15/81, 1"/100 ft scale, 6242 to 8730 feet
5. Temperature, 1/27/81, 1/30/81, 1"/100 ft scale, 6242 to 10,019 feet
6. Temperature, 2/6/81, 1"/100 ft scale, 390 to 10,010 feet
7. Temperature, 5/8/81, 1"/100 ft scale, 150 to 9350 feet
8. Borehole Compensated Sonic, 12/13/80, 2"/100 ft scale, 1407 to 6296 feet
9. Caliper, 12/3/80, 12/13/80, 1/28/81, 1/30/81, 2"/100 ft and 5"/100 ft scales, 91 to 9550 feet
10. Continuous Dipmeter, 12/14/80, 1/28/81, 5"/100 ft scale, 1410 to 9707 feet
11. Dual Induction - Laterolog with Linear Correlation Log, 12/3/80, 12/13/80, 1/15/81, 1/28/81, 2"/100 ft scale, 91 to 10,012 feet
12. Cement Bond - Variable Density, 12/27/80, 2/6/81, 5"/100 ft scale, 234 to 10,013 feet
13. Borehole Geometry, 1/15/81, 2"/100 ft and 5"/100 ft scales, 6242 to 8750 feet
14. Electromagnetic Thickness Gauge, 12/27/80, 5"/100 ft scale, 2946 to 4542 feet
15. Dipmeter Arrow Plot, 12/14/80, 1/28/81, 2"/100 ft scale, 1427 to 9437 feet
16. Coriband, 12/12/80, 1/16/81, 1/28/81, 2"/100 ft scale, 1414 to 10,000 feet

17. Dual Induction Laterolog, 12/3/80, 12/13/80, 1/15/81, 1/28/81, 2"/100 ft and 5"/100 ft scales, 1412 to 10,012 feet

The following vellums are also located in the Holly Sugar offices:

1. Directional Survey
2. Coriband (3)
3. Dip Angle and Direction

Other documents generated in the project and on file at Holly Sugar are:

1. "Completion Report - Holly Sugar 44-P", International Directional Consultants
2. "Reservior Analysis and Recommendations of the Holly Sugar 44-P Well, Production Well Testing", Well Production Testing Company
3. "Petrophysical Evaluation, Well # 44-P, Holly Sugar Field, Imperial County, California", Pacific Resources Management, Incorporated

Additional documents delivered to the DOE during the second phase are listed below.

28 October 1980	Transmittal of Management Plan Milestone Schedule and Status Report Cost Plan, and Notice of Energy R&D Proj.
12 November 1980	First Monthly Report
05 December 1980	Second Monthly Report
12 January 1981	Third Monthly Report
06 February 1981	Fourth Monthly Report
27 January 1981	Final Draft of Testing Plan
13 March 1981	Fifth Monthly Report
15 April 1981	Sixth Monthly Report
30 April 1981	Transmittal of Coriband from 8700-10000'
14 May 1981	Delivery at a meeting with the DOE of: 1) Pacific Resources Management Report

- 2) copy of temperature logs
- 3) copy of pressure measurements

19 May 1981

Seventh Monthly Report

08 June 1981

Transmittal of detailed plans, cost and schedules for:

- 1) acid foam and nitrogen lift
- 2) big rig milling,
- 3) side track drilling
- 4) pumping
- 5) abandoning the well

04 September 1981

Transmittal of "Petrophysical Evaluation" Well 44P, Holly Sugar Field", dated May 4, 1981 prepared by Pacific Resources Management, Inc., and Final Environmental Report, October 1979, "Use of Geothermal Heat for Sugar Refining in Imperial County"

2.4.2 Summary of Well History

The well was spudded in during November 1980. Drilling was conducted to a depth of slightly over 8000 feet following the original drill plan. The formations at that depth showed low to moderate permeability in the sandstones, with favorable temperature gradients. There was only an indication of potential for high permeability at some fault and fracture zones. The target intersection of the Imperial Fault and its branches did not materialize to the projected leve. Approval to extend the hole to 10,000 was granted by DOE.

Drilling continued to a well depth of 10,023 feet at which time the revised drill plan required that drilling stop and well production testing begin. Perforated casing was set in the region between 8997 and 10,023 feet.

Initial flow rates of the well were extremely low and attempts were made to stimulate the well by circulating East Mesa water and nitrogen lifting. During the latter, a portion of the nitrogen coiled tubing was lost in the well. Attempts to fish the tubing were only partially successful. Additional attempts to stimulate the well by gas lift were unsuccessful and on February 18, 1981, the well was shut-in and the drill rig was released.

Table 2-2 presents a concise history of Holly 44P during the period from the start of drilling to the final removal of equipment and shut-in of the well. The table entries were taken from the log of the drill operator, Republic Drilling.

Figure 2-4 (in the rear of this report) presents the logging geologists log. The log shows information relative to the drill rig operation, mud conditions, and formations and lithologies of the well.

TABLE 2-2 HOLLY 44P WELL LOG

- 12-2: Drilled out cement at 75'. (G.L., 20" conductor casing point). Drilled ahead with a 17 1/2" bit to 725'. Ran directional surveys at 238', 450' and 633'. Lined sump with gel to meet Regional Water Quality Control Board requirements.
- 12-3: Drilled ahead from 725' to 1415'. Ran directional surveys at 850', 1128, and 1409. Circulated. Ran Schlumberger DIL and 4 arm caliper logs.
- 12-4: Ran 34 joints of 13 3/8", K-55, 54.5#, Range 3, BTC. Set casing at 1408'. Circulated. Cemented. W.O.C. 24 hrs.
- Landed and tested WKM well head to 1500 psi for 30 minutes.
- 12-5: Installed B.O.P.E. and tested at 1000 psi. D.O.G. witnessed and approved test.
- 12-6: Drilled out float at 1369'. Drilled out shoe at 1408'. Drilled ahead with 12 1/4" bit to 2400'. Ran directinal surveys at 1653', 1934', 2150' and 2375'.
- 12-7: Drilled ahead from 2400' to 2802'. Ran directional surveys at 2448', 2480', 2510', 2541°, 2572', 2603', 2634', 2664' and 2695'.
- 12-8: Drilled ahead from 2802' to 3674'. Ran directional surveys at 2757', 2819', 2862', 2955', 3048, 3138', 3296', 3479', and 3635'.
- 12-9: Drilled ahead from 3674' to 4633'. Ran directional surveys at 3882', 4158', and 4407'.
- 12-10: Drilled ahead from 4633' to 5293'. Ran directional surveys at 4593', 4841, and 5088'. P.O.H. for washout at 4573'.
- 12-11: Drilled ahead from 5293' to 5800'. Ran directional surveys at 5336', and 5585'.
- 12-12: Drilled ahead from 5800' to 6272'. Ran directional surveys at 5833' and 6081'.
- 12-13: Drilled ahead from 6272' to 6316'. Ran directional survey at 6276'. Circulated. Ran Schlumberger DIL, FDC, CNL, Sonic, dipmeter and temperature logs.
- 12-14: Continued logging. Reamed bridge. 6190' - 6267'. Circulated.

- 12-15: Ran 148 joints (6237') of 9 5/8" OD, 43.5#, N-80, Range 3, BTC casing. Casing point at 6234' with float at 6189' and D.V. collar at 3436'. Circulated and then cemented to 6237'.
- 12-16: W.O.C.
- 12-17: Installed WKM expansion spool and packing elements. Drilled out D.V. collar and float collar. Circulated. Closed pipe rams. Shut down rig for Christmas.
- 12-18: Rig shut down.
- 12-25: Circulated hole.
- 12-26: Pressure tested casing. No test. Ran Halliburton RTTS packer. Tested D.V. collar above 3337' and below 3521'. No test below 3521'. Ran in hole to 6186', tested at 6186, 6065', 6003' and 5817' with no test. Packing rubber leaked at 5817'.
- Ran in hole to 4623' and tested every 90' until the leak was isolated between 4375' and 4407'.
- 12-27: Ran Schlumberger ETT and CBL-VDL. ETT results did not indicate casing fractures.
- 12-28: Drilled out shoe at 6234'. Reamed hole between 6234' and 6320' with 8 1/2" bit. Drilled from 6320' to 6667'. Circulated and conditioned hole for survey. Ran directional survey at 6544'.
- 12-29: Drilled ahead from 6667' to 7008'. Ran directional surveys at 6793', 6855' and at 6983'.
- 12-30: Drilled ahead from 7008' to 7107'. Circulated and ran a directional survey at 7008'. Pulled out of hole for wash out. Drilled ahead 7102' to 7252'. Circulated and surveyed at 7227'. Drilled ahead to 7276'. Pulled out of hole with twist off at 2901'.
- 12-31: Fished. Latched on to fish at 2901' and pulled out of hole. Drilled ahead from 7340' to 7503'. Ran directional survey at 7393'.

1981

- 1-01: Ran AMF sonoscope standard inspection.
- 1-02: Ran AMF sonoscope standard inspection.
- 1-03: Ran AMF sonoscope standard inspection. Drilled ahead from 7340' to 7503'. Ran directional survey at 7393'.

- 1-04: Drilled ahead from 7503' to 7900'. Circulated and ran directional surveys at 7485' and at 7733'.
- 1-05: Drilled ahead from 7900' to 8088'. Circulated and ran directional surveys at 7945' and 8063'. Rotary bearings went out, chained out of hole.
- 1-06: Changed out rotary table. Drilled ahead from 8088' to 8302'. Ran directional survey at 8202'.
- 1-07: Drilled ahead from 8302' to 8344'. P.O.H. for wash out on 50 1/3 stand. Drilled ahead from 8344' to 8359'. P.O.H. for twist off. Top of fish, tagged at 4456'. Fished.
- 1-08: Fished. Laid down bent drill pipe. Straightened bent pipe.
- 1-09: Laid down and straightened bent drill pipe. AMF Tuboscope, inspected pipe.
- 1-10: Straightened and inspected drill pipe.
- 1-10: Straightened and inspected drill pipe.
- 1-12: Inspected drill pipe. Ran in hole with inspected pipe. Circulated and conditioned mud. Wash out on 27th stand. Reamed to 7973'.
- 1-13: Reamed to 8359'. Drilled ahead from 8359' to 8531'. Circulated and then ran directional survey at 8413' and 8506'.
- 1-14: Drilled ahead from 8531' to 8686'. Wash out on 27 1/3 stand. Ran directional surveys at 8506' and at 8659'.
- 1-15: Drilled ahead from 8686' to 8764'. Circulated. Ran Schlumberger DIL FDC, CNL, Sonic, temperature and four arm caliper logs.
- 1-16: Continued to run Schlumberger logs. Changed out rotary table.
- 1-17: Drilled ahead from 8764' to 8868'. Inserted corrosion rings between cross over and heavy drill pipe. Inserted pipe saver rubbers.
- 1-18: Drilled ahead from 8868' to 8984'. Circulated and then ran a directional survey at 8879'.
- 1-19: Drilled ahead from 8984' to 9116'. Circulated and then ran directional survey at 9096'.
- 1-20: Retrieved corrosion ring and saver sub. Drilled ahead from 9116' to 9223'.

- 1-21: Drilled ahead from 9223' to 9421'. Circulated and surveyed at 9251'.
- 1-22: Drilled ahead from 9421' to 9551'. Circulated and surveyed at 9494'.
- 1-23: Drilled ahead from 9551' to 9737'. Circulated and surveyed at 9697'.
- 1-24: Drilled ahead from 9737' to 9834'. Changed over to East Mesa water on evening hour.
- 1-25: Drilled ahead from 9834' to 9808'. Wash out on 25th stand.
- 1-26: Drilled ahead from 9908' to 10,019. Circulated then reamed 30' of fill. Circulated then reamed 20' of fill. Ran directional survey at 9988'.
- 1-27: Circulated for logs. Strapped out of hole, then corrected depth to strap measurement (10,001'). Attempted to log with Schlumberger had to circulate and condition hole. Drilled ahead from 10,001' to 10,023'.
- 1-28: Circulated and ran Schlumberger DIL, CNL, FDC, Sonic, dipmeter, and temperature logs. Had to condition hole and clean out fill intermittently.
- 1-29: Continued to condition hole and run Schlumberger logs.
- 1-30: Continued to condition hole and run Schlumberger logs.
- 1-31: Continued to log with Schlumberger. Circulated and conditioned hole for casing job.
- 2-01: Circulated and conditioned hole for casing job. Ran casing. Tagged bottom at 10,023'. Set liner at 10,023'. Top of liner at 4255'. Circulated and conditioned hole for cement job.
- 2-02: Cemented liner. Blanked off port collar set at 7877' and D.V. collar set at 6130'. Cemented in two stages. W.O.C. 12 hours between stages and 24 hours after second stage.
- 2-03: W.O.C. Tested casing hanger seal at 1000 psi for 30 minutes. Started to drill D.V. collar at 6130'.
- 2-04: Drilled out D.V. collar at 6131'. Ran 6 1/8" casing scraper. Worked scraper in D.V. collar.
- 2-05: Ran RTTS packer at 6151'. Tested casing above packer at 1000 psi. Bled to 900 psi. Tested casing below packer with 1000 psi. Bled to 650 psi. Set packer at 7820'. Tested at 1000 psi above packer which bled to 900 psi.

Tested below packer and it bled to 650 psi.

- 2-06: Drilled out float collar at 7832' and port collar at 7877'. Drilled out shoe at 10,023'. Circulated hole clean and conditioned mud. Ran Schlumberger CBL-VDL with temperature survey.
- 2-07: Finished wireline logging. Opened hole to 10,039'. Circulated hole clean and conditioned mud.
- 2-08: Circulated and conditioned hole. Displaced hole with East Mesa water until clear water returns observed. Shut in and observed well.
- 2-09: Tore down blow out prevention equipment and rigged up flow test equipment.
- 2-10: Tested hole with NOWSCO.
- 2-11: Tested hole with NOWSCO. Lost 1" coiled tubing in hole. Nippled up blow out prevention equipment.
- 2-12: Tagged fish at 57'. Picked up fish. Layed down fish in 100' sections. Nippled down blow out prevention equipment.
- 2-13: Rigged up test equipment. Ran OTIS tubing to T.D. Displaced fluid continuously while running down hole.
- 2-14: Ran in hole with OTIS tubing and nitrogen to 5000'. Displaced fluid continuously while running down hole.
- 2-15: Waited on DOE decision.
- 2-16: Waited on DOE decision.
- 2-17: Waited on DOE decision.
- 2-18: Released rig. Began to tear down.
- 2-19: Tore down and moved out equipment.

2.4.3 Well Completion

Figure 2-5, taken from the Well Production Testing Report, shows schematically the final arrangement of Holly Sugar 44-P. Figure 2-6, taken from data tabulated in the Completion Report, shows the as-drilled alignment of the well.

2.5 Evaluation of Formations

Reference 5 presents a detailed evaluation of the formations which the Holly Well penetrated in the region between 8000 and 10,000 feet, and an interpretation of why the well was unproductive. The conclusions, drawn from that report are as follows:

1. The formations from 8950 to 9990 feet show predominantly low permeability, with variations to moderate permeability in some sandstones and with some potential for high permeability at some fault and fracture zones.
2. Faults or other tectonic disturbances are seen around 9100 feet and 9730 feet.
3. Static bottom hole temperatures are 359 to 393 F.
4. The faulted zone at 9100 feet may be in communication with deeper, hotter formations.
5. Tectonically disturbed areas with higher than normal pore pressures are likely at depths greater than 10,000 feet.
6. Porosities in the best sandstones are about 20%, which would allow for good water storage.
7. Thermal alteration of the rock is lacking.
8. Water salinities derived from the logs were abnormally low for the areas, reaching as low as 10,000 to 15,000 ppm.

2.6 Well Productivity

At a depth of 10,023 feet drilling was stopped, the well was conditioned by circulation, Schlumberger logs run, and perforated casing set in the interval from the bottom of the well to 8997 feet.

Initial flow rates from the well amounted to a few barrels of fluid per hour. Whether this flow was attributable to artesian flow or well expansion is unknown.

Circulation of the well with East Mesa water was continued until clear water was returned at which time the well was shut in

Note: Depths referenced
Kelly Bushing at 16'
above ground level.

FIGURE 2-5 FINAL ARRANGEMENT OF HOLLY SUGAR 44-P

to allow for stabilization. The well's flow was not observed to increase as a result of this effort.

Three attempts to stimulate the well by nitrogen lift were made. The first lift was accomplished but failed to produce flow. During the second attempt, the lift tubing parted. Fishing failed to remove all of the tubing, and a final attempt at stimulation at 5000 feet was unsuccessful.

According to the interpretation of the logs, fractured and faulted zones were intercepted at 9000 - 9100 feet, and around 9700 feet. The fact that these zones were not productive could have been attributable to formation damage during drilling, a tight formation, poor completion, or inappropriate well design.

It is our consensus that drilling damage was minimized by the application of established procedures. Cost considerations did not permit conditioning and testing on a zone-by-zone basis as the drilling proceeded. Recognizing that limitation, procedures were used which should not have impaired flow from the formations.

Well design was partially dictated by the early decision to target for an 8000 foot well, which set the casing program to that level. Upon electing to extend the well to 10,000 feet, the maximum hole diameter was set at 7 inches. The setting of the perforated liner in the lower 1025 feet of the well was based upon early log data indicating the presence of the potential production zones noted above.

Well completion procedures were, as discussed above, compromised by cost constraints and the lack of strongly positive indications of productive zones. As outlined in reference 5, an alternative approach could have been to attempt hydraulic fracturing after the simpler techniques of circulation and nitrogen lift had been attempted. As the reference points out, however, hydraulic fracturing over the 1025 foot length would have been difficult and potentially produce only marginal results.

The final reason for lack of success must be attributed therefore to: a failure of the well to reach a productive zone in terms of permeability, lack of connection to a significant aquifer, and too low a resource temperature. As discussed in the May 1981 meeting, and in the June 1981 plan, cost and schedule, it is expected that the well had failed to penetrate the upper level of a strong hydrothermal zone, and would not do so until it reached a depth as deep as 13,000 feet.

2.7 Post Shut-In Activities

After well operations were suspended a number of meetings and actions took place.

- o On April 30 Coriband logs (8700-10,000 ft) were transmitted to DOE for its review.
- o Pacific Resources Management, Inc. was retained to provide an independent assessment of the geothermal potential based upon the well logs. Their assessment indicated a good probability of achieving desired temperatures and brines at a depth of about 13,000.
- o A program review meeting was held at the DOE on May 14, 1981 to assess the well data and to define alternative actions.
- o On June 8, 1981 cost and schedule proposals were submitted to the DOE. Five alternative plans were proposed including; further acid washing and gas lifts, big rill milling, side track drilling to greater depths, pumping, and abandonment. The last alternative was accepted.

3.0 CONCLUSIONS

3.1 Site Selection

The selection of the well site according to Reference 4 was based on reasonable geologic analyses. There is reason to believe that if the well were deepened to about 13,000 feet, a productive geothermal fluid zone would be reached.

3.2 Problems

Two twist-offs occurred, one at a drilling depth of 7276 feet, the other at 8359 feet. All of the drill pipe used had been inspected according to accepted standards. These failures were variously attributed to the fact that the pipe was used or the drilling speed was improper. Neither cause was specifically isolated, however a reduced drill speed was adopted after the second event.

The conclusion might be drawn that only new pipe should be used. Experience indicated that the savings in drill pipe was offset readily by the additional costs incurred in drilling operations when twist-offs took place.

4.0 REFERENCES

1. "Utilization of U.S. Geothermal Resources", Electric Power Research Institute, "EPRI ER-382, TPS 76-638, TRW Systems and Energy Group, Inc., December, 1976.
2. "Use of Geothermal Heat for Sugar Refining", Energy Research and Development Administration (ERDA), Division of Geothermal Energy, Contract E(04-3)-1317-3, TRW Systems and Energy, May 1977.
3. "Use of Geothermal Heat for Sugar Refining in Imperial County", Final Report-Phase I, U.S. Department of Energy, DoE Contract NO. DE-AC-03-79 ET 27039, TRW Energy Systems Group, October, 1980.
4. "Drill Site Selection and Justification Report", U.S. Department of Energy, DoE Contract No. DE-AC-03-79 ET 27039, TRW Energy Systems Group. November 1979.
5. "Petrophysical Evaluation - Well #44-P, Holly Sugar Field, Imperial County, California", Pacific Resources Management, Inc., Los Angeles, California, May 4, 1981.
6. "Completion Report - Holly Sugar 44-P", International Directional Drilling Consultants
7. "Reservior Analysis and Recommendations of the Holly Sugar 44-P Well, Production Well Testing", Well Production Testing, Report No. 81-4-20, Costa Mesa, California, April 1981

5.0 PRESENTATIONS

1. "Geothermal Energy for Sugar Beet Processing," presented at Las Vegas Program Review, November 20-21, 1980.
2. "Experiences in Geothermal Well Drilling," presented at the Mexican American Engineering Society Meeting at Fullerton, CA, April 15, 1981.

R. F. SMITH CORP.

GEOTHERMAL DIVISION

COMPANY TEI

WELL HOLLY SUGAR 4-P

FIELD Holly Sugar Plant COUNTY Imperial

LOCATION SEC 29 T 11S R 11E

STATE CALIFORNIA COUNTRY U.S.A.

LOGGING GEOLOGISTS Paul D. Jordan, Andy Smith

PRESSURE INST. TYPE _____ TEMP. TYPE Thermocouple

DEPTH LOGGED FROM 60' TO _____

DATE LOGGED FROM December 12th 1980 TO _____

ELEVATION -113 KB ☒ DF ☐ GR ☐

- LITHOLOGY -

ENGINEERING DATA

HOLE SIZE

17 1/2" to 11.00

to _____

to _____

CASING SIZE

13 3/8" to 11.00

to _____

to _____

DRILLING RATE

FT/HR

MIN/FT

ROCK DENSITY -----

DEPTH

LITHOLOGY

AIR AND MUD DRILLING DATA

TEMPERATURE (°F)

IN -----

OUT -----

CO₂ ppm -----
on Air Drilling

TOTAL MUD
GAIN/LOSS -----

PRESSURE PSIG

IN -----

OUT -----

METHANE ppm

ETHANE ppm

H₂S ppm

Resistivity

REMARKS

DESCRIPTIONS

CORE RESULTS

SURVEYS

FORMATION TESTS

MUD AGITATOR

ELECTRIC ☒

AIR ☐

Clay: gen as above.

34

Clay: lt brn/beige, silt, sticky, prtly soluble, effervesces slightly in HCl.

Sand: unconsolidated, fn-v coarse, subangular, pred wht qtz.

Wt. 8.8 Vis 38

Gravel: loc abund, multi-colored, pred ign &/or meta origin w/ sm sed frag.

Note: increasing abundance of gravel/coarse sand.

Clay: pred lt brn w/sm gry stringers, com silt, partly soluble.

Sand/Gravel: generally as seen above, w/increased abundance of gravel.

WOB 25,000 RPM 125 PP 1800 SPH 150	DRILL RATE 400 300 200 100	BULK DENSITY	WOB 25,000 RPM 125 PP 1800 SPH 150	1700	Vol 401 bbls Dp 2 bbls Add 2 bbls Gain 45 bbls	102/107	Temperature decrease due to long circulation time for survey.	Wt 9.0 Vis 40 Plastic Vis 10 Cl 900ppm Sand: (trace) Sol Cont: 5.5 Yield Pnt: 4 Filtrate: 14.1 Filter Ck: 2 pH: 10.2
				1800	LOSS GAIN Vol 405 bbls Dp 6 bbls Add 26 bbls Loss 16 bbls	103/109	Clay becoming firmer and blocky in part.	Clay: pred lt med brn, soft, structureless, sl-mod solubl; med-dk brn, firm, becoming blocky.
				1900	TEMPERATURE (F) 200 CO ₂ ppm 2,000 Vol 403 bbls Dp 7 bbls Add 40 bbls Loss 0 bbls	103/109	Gain is due to cont- inual washing of the shakers; also less loss of fluid over the shakers.	Clay: incr amts of med-dk brn, firm, blocky, insolub.
				2000	Vol 493 bbls Dp 3 bbls Add 21 bbls Loss 8 bbls			Clay: description gen as above.
TRW Holly Sugar 14-p				Depth	Vol 511 bbls Dp 8 bbls Add 45 bbls Loss 19 bbls			
				LITHOLOGY	TEMPERATURE (F) OUT IN CO ₂ ppm	PRESSURE psi OUT IN METHANE ppm	H ₂ S ppm Resistivity	REMARKS EXLOG/SMITH PAGE 5

Clay: pred lt brn/beige
soft-sl firm, less
massive, structureless,
sl-mod solubl, sl stick-
iness, loc stringers of
lt gry, insolubl, v
sticky, v soft clay.

Wt 9.0 Vis 40
Plastic Vis 10
Cl 900ppm
Sand: (trace)
Sol Cont: 5.5
Yield Pnt: 4
Filtrate: 14.1
Filter Ck: 2
pH: 10.2

Clay: pred lt-med brn,
soft, structureless,
sl-mod solubl; med-dk
brn, firm, becoming
blocky.

Clay: incr amts of
med-dk brn, firm,
blocky, insolub.

Clay: description gen
as above.

DRILL RATE		BULK DENSITY		TEMPERATURE (F)		PRESSURE		REMARKS	
WOB	RRM	WOB	RRM	OUT	IN	OUT	IN	EXLOG/SMITH	PAGE 6
25,000	125	25,000	125	200	20,000	200	20,000	Clay:lt-med brn,soft, structureless,mod calc, sl-mod sol,less than 10% firm and sl sol,	
1800	150	1800	150	200	20,000	200	20,000	Clay:gen as above with less than 10% sand:v fn gr,multi-color, sb-rnd.	
150	150	150	150	200	20,000	200	20,000	Note: microfossils in sample.	
150	150	150	150	200	20,000	200	20,000	Wt 9.0 Vis 38 Plastic Vis 9 Cl- 800ppm Sand-trace Sol Cont:5.5 Yield Point:6 Filtrate:11.6 Filter Ck:2 pH: 2.4	
150	150	150	150	200	20,000	200	20,000	Clay:med brn,soft,mod calc, sl-mod solub,w less than 10% fn sand.	
150	150	150	150	200	20,000	200	20,000	Sand:sm multicolored, sm wht qtz, rnd-ing, unconsolidated.	
150	150	150	150	200	20,000	200	20,000	Sandstone:lt brn-buff, fn-med fn,pred subang, qtz,sm biotite,bronze mica,poss chlorite, SS poss detrital	
150	150	150	150	200	20,000	200	20,000	Remarks

LITHOLOGY	TEMPERATURE (°F) OUT — IN — —		PRESSURE psi OUT — IN — —		METHANE ppm	H ₂ S ppm	Resistivity
	CO ₂ ppm						
Vol 381 bbls Dp 5 bbls Add 80 bbls Loss 20 bbls		97/101					81.1
Vol 445 bbls Dp 20 bbls Add 80 bbls Gain 50 bbls							81.5
LOSS	GAIN				METHANE ppm — 1000		81.5
Vol 451 bbls Dp 10 bbls Add 32 bbls Gain 17 bbls		99/93			Emulsion Secondary Oil Vol 17 in Claystone @ 2500'.		81.5
Vol 461 bbls Dp 17 bbls Add 36 bbls Loss 0 bbls					Temperature Out Decrease Due To Addition of Fresh H ₂ O.		82.0
Vol 457 bbls Dp 25 bbls Add 40 bbls Loss 22 bbls			200		PRESSURE OUT —	H ₂ S — 10	82.0
	TEMPERATURE (°F)		20,000		PRESSURE IN —	Res. —	82.0
Vol 530 bbls Dp 42 bbls Add 42 bbls Gain 15 bbls		93/94			Secondary Oil & Gas Vol 12 in Claystone @ 2000'.		82.0
Vol 566 bbls Dp 32 bbls Add 42 bbls					Temperature Out Increase Due To Decrease in Addition of H ₂ O.		82.0
					Secondary Oil & Gas Vol 12 in Claystone @ 2770'		82.0
Vol 530 bbls Dp 32 bbls Add 0 bbls Loss 0 bbls		96/94					82.0
							82.0

Claystone: buff, soft,
v calc, structureless,
assoc w/ Clay: buff,
solubl, sl sticky, calc.

Siltstone: pred buff,
sm lt gry, soft, calc,
sm grdg to sandy silt-
stone.

Claystone: lt buff, gry-
brn mod brn, occ yel st.
ain, firm-soft, massive,
with Clay: lt gry buff,
soft, massive, sticky, sl
mod solubl, mod calc.

Sandstone: lt gry, vfn-
med gr, fria, sbang-sbr-
nd, pred qtz & multi-
color lithic frags w/
abun clay matrix, calc

Glauconitic buff gray-red, lt brn-gray, massive, bc-
mg firm, com silty &
sandy, calc, occ wht mot-
tling (qtz & calc-sec-
ondary).

Wt 9.0 Vis 39
PV 9 Cl-700
Sand: trace
Sol Con 5.5
YP 5 Filtr 14.5
FC 2 pH 10.2

Claystone: gen as above;
loc lt grn-gry, soft-
sl firm, calc, small
blk lith frag.

Job 11 1/4 hrs
No. 5 Hughes 03630 122

WOB 15,000
RPM 150
PP 1500
SPM 104

DRILL RATE

100 300 200 100

BULK DENSITY

WOB 15,000
RPM 150
PP 1500
SPM 104

TRW Holly Sugar 44-P

Depth	LITHOLOGY	TEMPERATURE (F) OUT — IN — — — CO ₂ ppm	PRESSURE psi OUT — IN — — — METHANE ppm	H ₂ S ppm Resistivity
3700	Vol 4.16 bbls Dp 8 bbls Add 14 bbls Loss 17 bbls LOSS GAIN	99/100	Calc Fracture Fill Limestone found locally	
3800	Vol 4.37 bbls Dp 8 bbls Add 14 bbls Loss 17 bbls LOSS GAIN	104/102	Calc Fracture Fill Chlorite @ 3750	
3900	Vol 4.18 bbls Dp 14 bbls Add 0 bbls Loss 7 bbls LOSS GAIN	107/117	Chloritized Sandstone @ 3920	
4000	Vol 4.39 bbls Dp 14 bbls Add 21 bbls Gain 18 bbls LOSS GAIN	109/115		
	Vol 4.40 bbls Dp 22 bbls Add 50 bbls Gain 27 bbls LOSS GAIN			
	Vol 4.64 bbls Dp 16 bbls Add 21 bbls Gain 19 bbls LOSS GAIN			

Claystone: pred rd-brn, sm rd-brn/lt grn-gry bndg & mott (alteration) soft-sl firm.

Sandstone: argillaceous, rd-brn/buff, v fn-fn gr, rnd qtz & lith frag, fria, calc, sl frm-sl hd.

Siltstone: buff, sm rd-brn to yel-brn, loc lt gry, soft-v firm, calc; interbdd w/ claystn; sm grdg.

Limestone: pred rd-brn, argillaceous, 50% calc, sm mott.

Note: Calc, clr-yel-grn mott fracture fill abundant.

Wt 9.3 Vls 38
FV: 8. VP: 8
Filtrate: 11.5
Solid Cont: 6.0
Filtr Ck: 2.0
Cl: 450 ppm
pH: 10.2

Siltstone: med gry, rd-brn/buff, sl frm-firm, v calc, grdg to sandy siltstn.

Claystone: pred rd-brn, sm alteration to lt grn-gry, sm mott (altrd) colrng, calc, soft-sl firm, incrng blocky.

REMARKS
EXLOG/SMITH PAGE 10

MOB 35/10,000# RPM 120 FF 1200 SPM 118	DRILL RATE 100 300 200 F100	BULK DENSITY	1100	Vol 169 bbls	111/118	METHANE ppm --- 1000	16 3/4 S29W	Claystone:red brn,lt brn,med gry-lt grn-gry,dk drusy brn,bcmg blk,loc slty,v-mod calc,sl fialty,loc limestn,red-brn,v calc.
				Loss 0 bbls				
MOB 10,000# RPM 120 FF 1200 SPM 129			1200	Vol 163 bbls	112/122	Trace of vein quartz & blue-green alteration stain on claystn/siltstn @ 1100'.		Siltstone:lt brn,red-brn,brn-yell,blk,y-mod. calc,weak bedding observable,loc thin qtz-rich stringrs,fa-med gr.
				Loss 27 bbls				
			1300	Vol 156 bbls	112/119	Trace of fibrous Calcite @ 1270'.		Claystone:red brn,salm on pink,sm med brn,sm mottling(wht patches),v calc,blk & sft int-rbddd w/ Siltstone:red-brn,brn-yell,sm mottling,v calc,blk,y.
				Loss 1 bbls				
			1400	Vol 607 bbls	116/125	Trace cryptocrystalline chloritization of claystone and siltstone @ 1370'.	36 3/4 S29W	Sandstone:tr amnts v fn gr qtz grns,thin stringrs,sl calc,salmon pink,red-brn,lt gry brn com silty & abun clay-rich matrix.
				Loss 71 bbls				
			1500	Vol 629 bbls				Claystone:red brn,brn,med gry brn,yell stain,mod-v calc,tr chlrtzd grn clystn,sm blu-grn alteration stains,blk,y.
				Loss 15 bbls				
				Vol 630 bbls				Siltstone:red-brn,gry,blk,y,mod-v calc.
				Loss 10 bbls				
The Holly Sugar W.P.			Depth	LITHOLOGY	TEMPERATURE (F) OUT --- IN --- CO ₂ ppm	PRESSURE psi OUT --- IN --- METHANE ppm	H ₂ S ppm Resistivity	REMARKS EXLOG/SMITH

PAGE 11

WOB 10,000 RPM 120 WT 1500 STN 120	Vol 102 bbls	117/24	Fluid dumped to lower and weight.	METHANE ppm --- 1000
	Dp 17 bbls			
	Add 15 bbls			
	Loss 6 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 304 bbls		Fossil Small (Micro) @ 4500'	118/25
	Dp 290 bbls			
	Add 15 bbls			
	Loss 63 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 553 bbls		Fossil Small (Micro) @ 4500'	119/26
	Dp 25 bbls			
	Add 3 bbls			
	Loss 8 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 421 bbls		Fossil Small (Micro) @ 4500'	119/26
	Dp 25 bbls			
	Add 93 bbls			
	Loss 93 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 580 bbls		Fossil Small (Micro) @ 4500'	119/26
	Dp 8 bbls			
	Add 10 bbls			
	Loss 3 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 577 bbls		Fossil Small (Micro) @ 4500'	119/26
	Dp 16 bbls			
	Add 15 bbls			
	Loss 6 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 585 bbls		Fossil Small (Micro) @ 4500'	119/26
	Dp 12 bbls			
	Add 18 bbls			
	Loss 1 bbls			
WOB 10,000 RPM 120 WT 1500 STN 120	Vol 604 bbls		Fossil Small (Micro) @ 4500'	119/26
	Dp 10 bbls			
	Add 20 bbls			
	Loss 9 bbls			

Claystone: dk red brn,
med brn-ltbrn, blk,
med calc, sl fissil,
intrbedded w/ Siltstone;
red brn, pink, med
calc, blk, qtz-rich,
strng in gr qtz sand

Note: Unconsolidated
Clay still constitutes
15-25% of sample.

Siltstone/Claystone:
dk red brn-med red brn
Blk-sl fissil, med-v
calc, com slty clystr.

NOTE: Rock density
being taken from
4634 to T.D. Previous
to this point rock samples
have been to unstable
in density fluid to obtain
accurate reading.

Clay: lt brn/buff, v
soft, v soluble, loc
to 60% of sample.

Siltstone: med gry,
med gry-brn & sm med
rd-brn, loc pink, v
frm, sandy tex, vis
lith & qtz frag, v
calc, approx density:
2.27

Sandstone: (5%), wht-
lt yel, well artd, w
rnd, fria, hd, qtz, calc
cnt.

REMARKS
EXLOG/SMITH PAGE 12

Wt 9.2 Vis 38
PV 9 YP 8
pH 9.9 Filt Ck 2
Cl- 400ppm Sanditr
Sol Cont:6

Claystone/Siltstone:
med red-brn-lt brn, med
brn, sm med-dk gry, blk,
sl fiss, mod calc, sm
mottling, Density=2.43.

Siltstone: lt gry, sm b
brn, sandy, firm, fria,
calc, sm loc bndg.

Claystone: pred med-dk
rd-brn, firm, calc, sl
fissility, loc show-
ing some fracture fill

Sandstone: cln-wht, sm
other mn colors, pr-
mod strtd, rnd, friable,
unconsolidated-sl frm.

Note: Calcite fract-
ure fill & Marca-
site associated w/
Sandstones @ 5460
& 5530.

Claystone: med red brn,
med gry, blk-mod fiss,
mod calc, sm mottling,
com silty in part, int-
rbdded w/ Sandstone: cln
100% qtz, fn-med gr, w
rnded & wtrtd, uncnsltd
friable in part, sl calc

REMARKS
EXLOG/SMITH PAGE 11

TRW Holly Sugar 44-P

EXLOG/SMITH PAGE 16

Depth	LITHOLOGY	TEMPERATURE (F)		PRESSURE psi		H ₂ S ppm	Resistivity
		OUT	IN	OUT	IN		
130/110	Vol 117 bbls Dp 8 bbls Add 18 bbls Loss 7 bbls						
130/110	Vol 117 bbls Dp 26 bbls Add 47 bbls Loss 21 bbls						
130/110	Vol 512 bbls Dp 31 bbls Add 138 bbls Gain 21 bbls						
130/110	Vol 531 bbls Dp 0 bbls Add 0 bbls Loss 7 bbls						
130/110	Vol 592 bbls Dp 52 bbls Add 124 bbls Loss 10 bbls						
130/135	Vol 615 bbls Dp 58 bbls Add 91 bbls Loss 10 bbls						
130/135	Vol 666 bbls Dp 48 bbls Add 66 bbls Gain 33 bbls						
132/112	Vol 650 bbls Dp 52 bbls Add 41 bbls Gain 4 bbls						

Wt 8.85 Vis 40
PV:12 YP:9
pH:11.8
Filtrate:8.5
Filtr Cake:2
Cl-600
Sand:trace
Sol Cont:2.5

Claystone: med-dk red-brn w/sm med-dk gry, mod hd, fissl.e, mod calc, com slty, tr pyr & calc.

Siltstone: med-dk gry w/sm rd-brn, mod hd, mod calc; Av. Sp 3=2.36

Sandstone: wht-clr, fn-med gn, w rnd, w srtd, vit qtz; sm loc chlor & bronze mica, sm calc cnt.

Wt 8.9 Vis 36
PV:10 YP:4
pH:11.5
Filtrate:8.0
Filtr Cake:1
Cl-575
Sand:trace
Sol Cont:2.5

Claystone: pred med-dk red-brn, sm med brn & med-dk gry, mod hd, fiss mod calc, com silty.

Siltstone: med blu-gry, mod hd, blk lith frag, mod calc, sm parallel lineations.

REMARKS
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Siltstone: med-dk red
brn, med-dk gry, mod hd,
mod calc, sm bddng vis-
bl, grdtal w/ claystones
med-dk red brn, med-dk
gry, mnr med grn gry,
mod hd-britt, fiss, mod
calc, mnr-tr vein cal-
cite, tr pyr.

Sandstone: lt gry, wht,
clr, fn gr, w rnd, w srted,
friab-unconsoltd str-
ngs, qtz-rich w/ mn
lith frags, sm calc cmt

Wt 8.8 Wt 10
PV 11 YP 7
pH 11.6 Filt. skl
Cl⁻ 550. Sand:tr
Sol Cont: 2.5

Claystone: med-dk rd-brn, sm med gry, v firm-
mod hd, v calc, fissile,
sm bedding & laminations
loc visible; loc abnt
calc fracture fill.

Siltstone: med-dk red
brn, med-dk gry, sm med
gry grn, mod bd, mod calc
com sdy in part, tr-mn
calcite fract-fill.

Clavstone: med-dk red
brn, med, dk gry-grn gry
mod hd-brittle, fissil,
mod calc, mnr calcite
vein fill, tr pyr.

Sandstone: fn-med gr, un-
cons-friab, w rnd, w srt
pred qts, tr-mnr kaolin
tr pyr, tr chlor.

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Sandstone: wht, clr, lt gry, lt grn, lt brn, v fm med gn, mod srtd, w rnd, com slty, tr pyr, sm calc cmnt, tr chlor, tr bronze mica, pred qtz grns, mnr-abundant kaolin.

Siltstone/Claystone: med gry-med grn gry, med red brn, sm mottling, mod hd, massive-fissil, mod calc, tr pyr, sl chloritization, tr bronze mica, mnr-abundant kaolin, mnr-abundant calcite fracture fill.

Sandstone: clr, wht, v fm med gn, mod-wrtd, wrnd-sbrnd, pred qtz w/ mnr lith frags, calc cmnt, friab, mnr-abundant kaolin, tr pyr, tr chlor, tr bronze mica, vein calc.

At 8.8 Vis 39
PV: 10 YP: 15
pH: 11.5
Filtrate: 8.3
Filtr Cake: 2
Cl: 5.0
Sand: trace
S.L. Cont: 2.5

Sandstone: description same as above.

Siltstone/Claystone: lt med grn gry, sm gry, med brn-red brn, mod hd, sm mottling (gry grn-brn), mod calc, fissil, loc abundant kaolin/vein calcite, tr pyr & chlor.

REMARKS
EXLOG/SMITH PAGE 20

Sandstone: wht, clr, lt
brk, lt gry, med-fn gn,
friabl, calc cont, mod-
w artd, sbrnd-wrmd, pred
qts w/am lith frags, tr
chloritisation, tr pyr,
mar-loc abundant kaolin,
abundant vein calcite.

Claystone/Siltstone, dk
med gry-med grn gry, dk
med red brn-med brn, me
lt gry & red brn, sm m
tting, mod-v calc, bd,
fissil, abundant vein ka
olin & calcite, tr pyr,
tr shlorite, tr bromides.

Note: Sample contains
25% Unconsolidated, lit-
med gry Clay (possibly
fault gouge), 8150-8180'

Wt. 8.85 Via hl
PV:13 YP:7
pH:10.8
Filtr Cake:2
Cl- 500ppm
Sand:trace
Sol Cont:2.5

Sandstone: 2 types:
 -wht, fn gn, well srt,
 mod hd, fria, qts w/
 calc cmt.
 -wht-clr, med gn, rnd,
 mod srt'd, multi-clr,
 lith frag, calc cmt,
 sm chloritization.

Siltstone/Claystone: dk red brn-drusy red brn, med-dk gry, massive-sl fiss, hd-vhd, mod calc, com sndy, vein calcite, mnr vein/dissemin pyrite tr chloritization.

REMARKS
EXLOG/SMITH PAGE 21

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gng, lt brn, v fn-fn, sm
mod gny, mod-well grtd
schrd, mod ht, sm fria,
calc opt, tr-mod abnt
chloritization, tr bron
se mica.

Wt 8.8 Vis 60
PV:15 YP:14
pH:11.2
Filtrate:8.8
Filter Cake:2
oil 400
Sand:trace
Sol. Cont: 2.5

Hardstone: wht-clr, sm
lt rd-brn & lt gry, v
fa-fn, mod-w strd, sub-
rnd-w rnd, pred qtz;
min lith frags & clay
matrix, calc cmt, tr ch-
loritization, tr bronze
mica, tr kaolin, tr pyr.

Claystone:lt-med brn,
lt-med rd-brn,lt-med
gry,sm fissility,hard,
v calc,com vein pyrite
& calc fracture fill.

Siltstone: pred lt gry,
ss wht, sandy, tr chlor-
itization, tr blk lith
frags, tr bronze mica,
hard, v calc; assoc w/
abundant fracture fill

Siltstone:lt-med gry,
nd,calc,w/intbdd Sands
plr,fn gr,pred w srt'd,
shang,sm blk lithfrac
sm calc frac fill,trk

WOB 25,000# RPM 60 PP 1200 GPM 100 1/22/81 DRILL RATE 100 75 50 25 2.8 2.6 2.4 2.2 BULK DENSITY WOB 25,000# RPM 60 PP 1200 GPM 100 1/23/81	9000 9500 9600 Depth	Vol 466 bbls Dp 21 bbls Add 49 bbls Loss 56 bbls	134/149 GAIN 113/146° 128/143° 124/145°	Note: General increase in occurrence of pyrite & vein quartz. Common vein Calcite w/ lesser amount of quartz. METHANE ppm --- 1000 Note: Evald loss of 10-15 bbl/hr to formation.	12° 21°	Claystone/Siltstone: gr, red brn, med gry, hd, brittle, calcareous, common calc frac fill, tr vein quartz. Sandstone: wht-clr, fn gr, wstrd, rnd grs, pred qtz w/mnr lith frags, alt fsp & calc cmt, chngng to Quartzite: wht med gr, mod-wstrd, wrnd, sutured grs, calc cmt; loc abndnt kaolin & vn calcite, tr pyr, chlor, & vn quartz.
		Vol 551 bbls Dp 30 bbls Add 50 bbls Loss 31 bbls LOSS		COOLING TOWER OFF LINE COOLING TOWER ON LINE		Wt 8.8 Vis 52 PV 16 VP 15 pH: 11.3 Filtrate 9.0 Filtr Cake: 2 Cl-1500 Sand: trace Sol. Cont: 2.5
		Vol 495 bbls Dp 47 bbls Add 58 bbls Loss 67 bbls		TEMPERATURE (F) 200 CO ₂ ppm 20,000	H ₂ S --- 10 Res. ---	
		Vol 602 bbls Dp 0 bbls Add 198 bbls Loss 10 bbls		Common chloritization of siltstone/claystone.	11° 12°	Siltstone/Claystone: lt dk gry, mod-dk red brn, hd, brittle, fis: il, mod calc, commonly sndy, loc abundant grn gry claytr com vein calc, tr vein qtz, tr pyr.
		Vol 687 bbls Dp 21 bbls Add 159 bbls Loss 53 bbls		COOLING TOWER OFF LINE. Short trip to move pipe rubbers-Hein 60" 29520" COOLING TOWER ON LINE.		Note: Kaolin Abundant in Assoc w/ Siltstone.
	9600	Vol 704 bbls Dp 0 bbls Add 9 bbls Gain 8 bbls		Fluid gain of 32 bbls w/ temperature high of 11° @ 9565'.		Sandstone: pred wht-clr, sm reddish w/apparent intrstitial clay matrix mod strtd, subrnd qtz, v friable, sl firm, calc cmt, mnr loc chloritization, lith frag, tr hematite.
		Vol 719 bbls Dp 0 bbls Add 83 bbls Loss 68 bbls		COOLING TOWER OFF LINE COOLING TOWER ON LINE		
TRW HOLLY SUGAR 144-P