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GEOHERMAL LOOP EXPERIMENTAL FACILITY

Quarterly Report, October—December 1978

By

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January 1979

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San Diego Gas & Electric Company
San Diego, California

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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SDG&E - DOE
GEOTHERMAL LOOP EXPERIMENTAL FACILITY
QUARTERLY REPORT
FOR THE PERIOD
OCTOBER - DECEMBER, 1978

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ABSTRACT

Since the Geothermal Loop Experimental Facility (GLEF) Start-Up in May, 1976, a substantial amount of information has been obtained on the operation of the plant, components, brine and steam composition, production and injection wells, and the potential of the Niland Reservoir. The GLEF was modified in April, 1978, from a four stage flash/binary process to a two stage cycle for the extraction of energy from a high temperature, high salinity, liquid-dominated resource.

This Quarterly summarizes the general operations and accomplishments of the GLEF during the period from October 1, 1978 through December 31, 1978.

CONCISE HISTORY AND DESCRIPTION OF THE NILAND GLEF

Early in 1972, the concept of building a Geothermal Loop Experimental Facility (GLEF) at the Niland Known Geothermal Resource Area (KGRA) was originated. This area is located on the southern shore of the Salton Sea near Niland, California. SDG&E, in cooperation with Magma Power Company, drilled and flowed a geothermal test well to demonstrate the ability of the Niland Reservoir to produce a significant amount of hydrothermal fluid capable of being connected to electric power.

In May, 1975, construction of the GLEF began and start-up of plant operations commenced on May 3, 1976. (See Figure 0-1 for the general appearance of the GLEF). This size facility is the first of its kind for testing high temperature (in excess of 500°F downhole) and high salinity (250,000 ppm) geothermal resources.

Magma Power Company, jointly with the New Albion Resource Company (NARCO), supply geothermal fluid (brine) from two production wells, Magmamax No. 1 and Woolsey No. 1. These are located near the test facility which is thought to be near the center of the geothermal anomaly. Magmamax No. 1 produces brine with a typical temperature and pressure at the wellhead of 440°F and 350 psig, respectively, with an average flowrate of approximately 400,000 lbs/hr. Woolsey No. 1 has produced brine with a typical temperature and

pressure at the wellhead of 380°F and 200 psig, respectively, with an average flowrate of approximately 300,000 lbs/hr. The plant has been modified to accept a two-well flowrate of 800,000 lbs/hr. The produced brine is flowed through the plant and then injected into the reservoir approximately one mile away through one of two injection wells, Magmamax No. 2 and No. 3. Magmamax No. 3 has been the primary injection well, but Magmamax No. 2 is now being used as the injection well. A new injection well (IW5) was drilled and will be utilized for injecting treated brine from the clarifier media filter.

In April, 1978 the plant was shut down for cleaning and plant modifications. At this time the plant was converted from a four stage flash/binary system (Figure 0-2) to a two-stage flash/binary system (Figure 0-3). Critical portions of a two stage flash system with two parallel flash "trains" are simulated. Each supply well has a separate set of flash vessels. The steam produced by the flashed brine passes through steam scrubbers to remove entrained brine containing salts and minerals. The scrubbed steam is condensed by three heat exchangers at approximately 200,000 lbs/hr, partially vaporizing the binary fluid, which is now being used only to dissipate the heat energy. The condensed steam is primarily used for cooling water make-up, but can be recombined with the brine and injected into the reservoir

GEOHERMAL LOOP EXPERIMENTAL FACILITY
Niland, California

FIGURE C-1

NAME	DESIGNER	DO	CH	DATE	TITLE
					GLEF TWO STAGE FLASH BINARY PROCESS FLOW DIAGRAM
					CUSTOMER: SAN DIEGO GAS & ELECTRIC CO.
					DESIGNED BY: LB SCALE: DRAWING NO. 7429-09-D-3219 REV. 0
					APPROVED: GFF DATE: 12/18/78

FIGURE 0-3

for test purposes. The noncondensable gases, primarily carbon dioxide with small amounts of other gases including hydrogen sulfide, are exhausted to the atmosphere through a 130 foot high stack.

Construction of an effluent treatment system (clarifier/filter) has begun and is expected to become fully operational by mid-May, 1979.

In addition to testing the critical portions of the two stage flash process, evaluation of the reservoir after the injection of cooled brine and assessing the potential of the Niland geothermal reservoir are underway. San Diego Gas & Electric Company (SDG&E) owns the facility and manages its testing. SDG&E and the United States Department of Energy (DOE) jointly fund the activities of the facility.

INTRODUCTION

This Quarterly Report covers the period from October 1, 1978 through December 31, 1978. Included are the general operations and accomplishments for this period.

The Plant Operations Section discusses the overhaul and cleaning during October and pigging problems which led to a limited shutdown in December. Reservoir assessment, including production and injection wells, are discussed in the Reservoir Operations Sections. Results of tests that were accomplished are contained in the Testing Section. Laboratory data obtained for steam, brine, binary and cooling water, and scale are indicated in the Systems Chemistry Section. Any equipment that required repairs or modifications to equipment is discussed in the Maintenance Section. The clarifier/media filter is discussed in Section 6.0. The "Other Activities Section" discusses the status of the feasibility and surge studies.

1.0 PLANT OPERATIONS

The GLEF operated this quarter for a total of 1063 hours. During the month of October, 1978, the GLEF shutdown for a planned overhaul and cleaning. The plant has operated a total of 9882 hours since start-up. The plant availability, excluding scheduled outages for the quarter, was 53.3%. The plant capacity factor with all outages included was 48.1%. The overall capacity factor since start-up has been 60.6% or 42.4% if all outages are included. (See Table 1-1 and Figure 1-1)

The planned shutdown for inspection and cleaning in October, 1978, was the first since the facility modification from a four stage flash to a two stage flash cycle. Results of the inspection are included in the Maintenance Section. The scale produced using the two stage flash cycle is softer than the scale formed in the original four stage flash-binary cycle and acid soaking is not required for any portion of the plant brine line prior to hydroblasting, thus reducing cost and downtime required for scale removal. Several safety items including an overflow protection device on the atmospheric flash tank were installed during this cleaning.

The GLEF was started on November 9, 1978 utilizing Magmamax No. 1 for the supply well and Magmamax No. 2 for the injection well. On December 19, 1978 after 856 hours of non-continuous operation (due to leaks, power failures, and miscellaneous, see Table 1-2), the plant was forced to shutdown. The following is a sequence of events leading to this shutdown.

GLEF AVAILABILITY 1978

MONTH	FOR MONTH					SINCE START-UP				
	TOTAL GLEF OPERATING HOURS	TOTAL HOURS IN THE MONTH	POSSIBLE HOURS (EXCLUDING SCHEDULED OUTAGES)	% AVAILABILITY BASED ON TOTAL HOURS	% AVAILABILITY (EXCLUDING SCHEDULED OUTAGES)	CUMULATIVE TOTAL GLEF OPERATING HOURS	CUMULATIVE TOTAL MONTH HOURS	CUMULATIVE POSSIBLE HOURS (EXCLUDING SCHEDULED OUTAGES)	% AVAILABILITY BASED ON TOTAL MONTH HOURS	% AVAILABILITY (EXCLUDING SCHEDULED OUTAGES)
JANUARY	315	744	315	42.3	100	6146	15296	11084	40.2	55.4
FEBRUARY	238	672	672	35.4	35.4	6384	15968	11756	40.0	54.3
MARCH	731	744	731	98.3	100	7115	16712	12487	42.6	57.0
APRIL	304	720	304	42.2	100	7419	17432	12791	42.6	58.0
MAY	0	744	0	—	—	7419	18176	12791	40.8	58.0
JUNE	0	720	0	—	—	7419	18896	12791	39.3	58.0
JULY	221	744	221	29.7	100	221 7640	744 19640	221 13012	29.7 38.9	100 58.7
AUGUST	642	744	730	86.3	87.9	863 8282	1488 20384	951 13742	58.0 40.6	90.7 60.3
SEPTEMBER	537	720	570	74.6	94.2	1400 8819	2208 21104	1521 14312	63.4 41.8	92.0 61.6
OCTOBER	0	744	744	—	—	1400 8819	2952 21848	2265 15056	47.4 40.4	61.8 58.6
NOVEMBER	415	720	508	57.6	81.7	1815 9234	3672 22568	2773 15564	49.4 40.9	65.4 59.3
DECEMBER	648	744	744	87.0	87.0	2463 9882	4416 23312	3517 16308	55.8 42.4	70.0 60.6

NILAND GEOTHERMAL LOOP EXPERIMENTAL FACILITY **1976, 1977 & 1978 AVAILABILITY BY MONTHS**

- Availability = No. of Hours of Plant Operation/Total No. of Hours in the Month.
- ◇ Availability = No. of Hours of Plant Operation/(Total No. of Hours in the Month - Hours of Scheduled Outages).
- Plant Shutdown for Major Overhaul

FIGURE 1-1

OUTAGES

<u>DATE</u>	<u>CAUSE OF SHUTDOWN</u>	<u>OUTAGE TIME</u>	<u>CORRECTIVE ACTION TAKEN</u>
10-1-78	Overhaul (S)	956 hrs.	
11-13-78	Teflon spool leakage (U)	48 hrs.	Repaired
11-20-78	PCV 303 Failure (U)	5 1/2 hrs.	Repaired
11-24-78	Power Failure (U)	2 hrs.	Restored
11-29-78	P-2 Failure (U)	52 1/2 hrs.	Replaced
12-1-78	P-8 Failure (U)	1 hr.	Repaired
12-19-78	Pigs Stuck in Injection Line (U)	73 1/2 hrs.	Cleared/Repair Metal Strap
12-26-78	P-2 Electrical Failure (U)	7 hrs.	Switch Repaired

(S) denotes scheduled outages
(U) denotes unscheduled outages

Girard poly pigs, used to facilitate freshly deposited scale removal, were being launched and run down the injection line on a daily basis. The poly pigs were being damaged on each run. The cause of the damage was unknown. In order to evaluate whether faulty pigs were causing the problem, a mechanical pig was run down the line on October 20, 1978. The mechanical pig was also damaged, leading to the conclusion that an obstruction in the pipe line was causing the damage, possibly a metal bar installed in the test coupons or tee's to keep the pigs from running into a by-pass or blind section of pipe.

On December 8, 1978 a harder poly pig with carborundum straps instead of wire brush straps was sent down the line in order to evaluate the location and severity of the obstruction. This pig executed the run in good shape. Additional poly pigs launched also came out undamaged. Apparently the obstruction had shifted positions and the pigs were now unobstructed. It appeared that the obstruction allowed scale to build up. The mechanical pig from T. D. Williamson was rebuilt with new cups and wire brushes and injected into the injection line in an attempt to further evaluate the problem and clean the line. After 30 minutes (the normal time to run a pig down the line) the brine turned very black going into the Baker tanks. This indicates that the pig was removing large amounts of scale. The water cleared up after another 30 minutes but no pig was received. A swab was then injected into the line in an

attempt to dislodge the pig. The swab came out in pieces without the mechanical pig. A poly pig was then injected into the line to force the mechanical pig out, but only part of the poly pig came out. Another poly pig was injected into the line and nothing came out. Further efforts were suspended since there was no problem pumping the fluid down the line from the plant (approximately 100 PSIG back pressure on the injection line at the plant boundary). The problem was then compounded by Magma's diesel driven injection pump not operating and the plant was shutdown.

After an extensive search, the pigs were located at the elbow at the 2nd test coupon near LLL. One of the metal straps had come loose and caught the mechanical pig. This is apparently the same strap that was damaging the poly pigs before.

The pigs were removed from the injection line, the line was closed, and plant was started up on December 22, 1978.

The plant continued operating through the end of this Quarter. Daily Status Sheets are included in Appendix A.

2.0 RESERVOIR OPERATION

2.1 Production Wells

Magmamax No. 1 was used the entire period as the only production well. During this period, its well head pressure ranged from 250 to 300 psig. The temperatures at plant boundary ranged from 408°F to 432°F. Flow rates varied from 200 to 800 GPM. (Refer to Appendix A)

2.2 Injection Wells

Magmamax No. 2 is being used as the primary injection well. Because Magmamax No. 3 injection back pressure has been unacceptably high, all injection has been diverted to Magmamax No. 2. The wellhead pressure for Magmamax No. 2 ranged from 40 to 230 psig during this period. The increased pressure indicates a plugging of this well. The clarifier installation should reduce this pressure and extend this well's life.

A case study of Magmamax No. 3 is in Appendix B.

2.3 Reservoir Assessment Activities

The 1 1/4" tubing and instruments were removed from Magmamax No. 1. The tubing was badly corroded, and in many areas the tubing was deeply pitted and many holes were formed by corrosion. The tubing had heavy black sulfide scale from the surface to the 1,100 foot level.

The location for a shallow injection well was indicated. It is expected to be operational about the same time as the clarifier is installed.

3.0 TESTING

3.1 1976-1977 GLEF Test Program

The original program of tests to be performed at the GLEF primarily addressed the performance of the major plant components associated with the binary cycle such as heat exchangers, steam scrubbers, and etc. However, Phase I of the Feasibility study (Refer to Quarterly Report, April 1978) has redefined the critical areas to be tested. A report of the results of the original program is being prepared by Bechtel National, Incorporated.

3.2 1978-1979 GLEF Test Program

A feasibility study completed by SDG&E, Bechtel National, Incorporated and The Ben Holt Company in late 1977 and early 1978 showed that a direct flash cycle power plant would be the best choice for the first geothermal power plant at the Niland reservoir. Critical areas of risk were identified. As a result, the GLEF was modified to simulate the critical areas of a two stage flash cycle.

The primary objective of the 1978-1979 GLEF Test Program is to reduce significant risks and costs of constructing and operating a flash-cycle power plant at Niland. This test program consists of several different tests that will be performed separately by SDG&E, Lawrence Livermore Laboratory and Imperial Magma under the overall direction of

SDG&E. The statement of objective and year-end status of each test is given below.

Two new tests (14.0 Well Test Data Reduction and 15.0 Scale Control-Inhibitors) have been added to the test program this Quarter. The reason for these additions was to allow for analysis of data obtained by Lawrence Livermore Laboratory on the Niland reservoir and to study the potential of commercially-available scale inhibitors on the components of the GLEF.

TEST NO. 1.0

Title: SCALE REMOVAL

Responsible Organization: SDG&E

Priority: 1

OBJECTIVES

The objective of this test is to quantitatively evaluate the cost effectiveness of various techniques (in terms of cost of power), for removing scale from brine piping and flash vessels so that the best may be selected for use in the proposed 50 MWe power plant at the reservoir. These techniques are:

1. Piping (on-line);
2. high-velocity water flush (on-line);
3. cavitation/hydroblast (on-line and off-line);
4. acidizing/hydroblast (off-line).

The cost effectiveness will be evaluated by establishing the cost per Kwhr of each technique (including capital and operating expenses and plant down-time required) for a nominal 50 MWe power plant. A qualitative judgment will also be made of the suitability of each technique for use in an operating power plant. (e.g. The ability of the method to clean effectively around elbows, through valves, etc., will be assessed.)

The type and amount of scale formed in the plant varies greatly throughout the plant, depending on the brine conditions. Each of the above techniques will be evaluated in some or all of the following locations in the GLEF:

1. Production line piping;
2. 1st to 2nd stage piping;
3. 2nd stage to atmospheric flash drum piping;
4. injection line piping;
5. flash vessels (cavitation/hydroblast only).

TEST STATUS

This test has not yet been formally initiated. However, much of the test results will be compiled from existing data from Southwest Chemical Company (hydroblasting), and Daedalean Associates, Incorporated (cavitation cleaning) and present experience with pigging in the plant.

TEST NO. 2.0

Title: SCALE PROPERTIES

Responsible Organization: LLL

Priority: 1

OBJECTIVES

The objective of this test is to develop the ability to predict the amount of scale that forms in various sections of the plant and to predict the properties of that scale which affect the effort required to remove it. This information will be used to help size piping, vessels, etc., and to design a descaling system for the 50 MWe power plant proposed for the Niland reservoir.

Scaling rates will be determined at the approximate conditions present in each of the following area:

1. Production line piping;
2. 1st and 2nd stage piping
3. 2nd stage to atmospheric flash drum piping;
4. Atmospheric receiver drain line;
5. injection line piping.

Scale samples from each of these areas will be analyzed for chemical and mineralogical properties, as well as for mechanical properties such as hardness, adherence to wall etc. The effect of temperature, Reynolds Number, etc., on the scaling rate and the scale properties will also be investigated.

Various chemical solvents will be evaluated as a means of enhancing scale removal with possible on-line application.

TEST STATUS

Tests have been completed on effect of 8 candidate solvents on scale from 7 locations at the GLEF. Samples were collected in September-October, 1978, following Magma-max No. 1 operation. Contact times of 1 hr. at 23°C (73.4°F) and 80°C (176°F), and 24 hr. at 23°C (73.4°F) were investigated. The solubility of the scales in the various solutions

have been determined. X-ray diffraction analysis of the Magmamax No. 1 scales have been completed. Mechanical properties were not measurable because of poor sample condition. Attempts will be made at the next opportunity at the GLEF. Instrument problems and backlog has delayed completion of x-ray fluorescence analysis of scale and scale liquor filtrates. Scale samples have been collected from 5 locations at the GLEF following Woolsey No. 1 operation for analysis and dissolution studies.

TEST NO. 3.0

Title: SCALE CONTROL ADDITIVES

Responsible Organization: LLL

Priority: 1

OBJECTIVES

The objective of this test is to determine the possibility of retarding or eliminating scale formation in a two-stage flash system through the addition of scale inhibiting chemicals or sludge particles to the brine. If these techniques are shown to have a beneficial effect, the cost per unit mass of brine treated will be estimated. This technique, if successful, may greatly reduce the cost of power from the 50 MWe power plant proposed for the reservoir.

In addition, the consequences of successful scale inhibition on corrosion and erosion of plant components, effluent treatment, injection well lifetime, etc., will be addressed qualitatively through observations and analysis of the treated brine.

TEST STATUS

Eight proprietary additives (Refer to Table 3-1) were tested (additives added to separated brine at 210°C, 410°F) for periods between 64 and 69 hours in the LLL dual train 2 stage system (Refer to Figure 3-1). A control test in each train was also carried out to establish baseline scaling rates. Chemical analysis of deposited scale is continuing. A 23-hour seeding test was completed. Sludge (20% by weight solids) was obtained from Magma and injected into high temperature brine in the LLL test system. Rate of injection corresponded to addition of .43% by weight solids or 4300 ppm to the brine. Preliminary results on additives will be reported in February 1979.

Proprietary Additives Tested in November-December, 1978 Test Series

<u>Product Name</u>	<u>Company, Address</u>	<u>Chemical Type</u>	<u>Concentration Tested, ppm</u>
Geomate 256	Dearborn Chemical Corp., Lake Zurich, IL	Phosphonate + Polymer	35
CL-165	Calgon Corp., Pittsburgh, PA	Polymer mixture	18
Drewperse 747	Drew Chemical Corp., Boonton, NJ	Phosphonate + Polymer	15
Betz 419	Betz Laboratories, Trevose, PA	Phosphonate + acrylic Polymer	20
Thermosol APS	Far-Best Corporation, Los Angeles, CA	Polyalkylphosphonate	20
S-404	C-E Natco, Bakersfield, CA	Organic Polymer	18
SC-210	Southwest Specialty Chemicals, Houston, TX	Low molecular weight carboxylic acid	10
Cortron R-16	Champion Chemicals, Anaheim, CA	Filming amine	120, 20

SCALE-CONTROL TEST SYSTEM

-168-

FIGURE 3-1

TEST SPOOLS — TEST NO. 4.0

NOTE:
SPOOLS ARE INSULATED WITH
J-M 77, GASKETS & SLEEVES

-16C-

FIGURE 3-2

TEST NO. 4.0

Title: Corrosion/Erosion

Responsible Organization: SDG&E

Priority: 1

OBJECTIVES

The objective of this test is to measure the rates and types of corrosion/erosion of various materials of construction exposed to the brine and steam conditions that will be experienced in a 50 MWe power plant. This information will be used to determine the cost effectiveness of these materials of construction for a 50 MWe power plant with a 30 year design life. Metals, metal cladding, and corrosion-resistant coatings will be tested in the following environments:

1. Production line piping;
2. 1st stage flash vessel (liquid, vapor, and liquid/vapor interface regions);
3. 1st to 2nd stage piping;
4. 2nd stage flash vessel (liquid, vapor, and liquid/vapor interface regions);
5. Injection line piping;
6. Combined steam condensate.

The test will consist of coupon exposure tests to vessels and observation of short pipe spools in the brine piping of the selected materials for qualitative information on the type and amount of corrosion/erosion experienced.

TEST STATUS

Test spools have been installed in order to examine corrosion/erosion. Refer to Table 3-2 and Figure 3-2 for locations and materials being tested. To prevent electrolytic action, each pipe spool was isolated from adjacent pieces by insulating gaskets of Viton A fluorocarbon elastomer. All bolts passing through the flanges were insulated by Teflon FEP sleeves and washers.

Ultrasonic thickness measurements will be made to determine corrosion rates on pipe spools. Due to early problems with the operational reliability of the ultrasonic thickness meter, readings taken prior to January 1979 are invalid. These difficulties will be circumvented in the future by the use of a different meter.

In addition to the pipe spools, test coupons will be installed in the B Train (Refer to Table 3-3 and Figures 3-3 and 3-4). Prior to installation, each coupon will be weighed to 0.1 gram and the thickness will be determined to 0.0005 inches at 16 locations. Photographs will be taken prior to installation and again as installed. It is anticipated that photos will also be taken at each shutdown to document scaling and corrosion tendencies.

TEST SPOOLS - TEST NO. 4.0

Production Lines

Woolsey

Hastelloy C-276
Inconel 625
Incoloy 825
Carbon Steel 1018

Magmamax No. 1

Hastelloy C-276
Inconel 625
Incoloy 825
Carbon Steel 1018
Polymeric Concrete Lined Carbon Steel
29 Cr/4 Mo

Interstage
(1st to 2nd)

A Train

SS 317 LM
Carbon Steel 1018

B Train

SS 317 LM
Carbon Steel 1018

Steam Services
(1st Stage Scrubber Outlet)

Carbon Steel 1018

Combine Condensate

FRP Vinyl Ester

Injection Line
(Magmamax No. 2 and No. 3)

Polymeric Concrete Lined Carbon Steel

COUPONS - TEST NO. 4.0

B Train

1st Stage (V-4)

Hastelloy C-276
Hastelloy G
29 Cr/4 Mo
Ti-CP 50
Carpenter 20CB3
Inconel 625
Incoloy 825
Carbon Steel 1018/1020
Indusco Ceramic
Polyurethane

2nd Stage (V-11)

Inconel 625
Indusco Ceramic
Carbon Steel

COUPONS — TEST NO. 4.0

B TRAIN

FIRST STAGE (V-4)

NO.	MATERIAL
1.	HASTELLOY C-276
2.	HASTELLOY G
3.	29 Cr - 4 Mo
4.	Ti - CP50
5.	CARPENTER 20 CB 3
6.	INCONEL 625
7.	INCOLOY 825
8.	CARBON STEEL
9.	INDUSCO CERAMIC
10.	POLYURETHANE

- NOTES: 1. PANELS (1 THRU 8) ARE ~3" W X 12" L
 2. NUMBERS ON PANELS TO FACE BRINE & UP
 3. 1' INTERVAL BETWEEN PANELS

COUPONS — TEST NO. 4.0 B TRAIN SECOND STAGE (V-II)

TEST NO. 5.0

Title: CORROSION/EROSION PARAMETERIZATION

Responsible Organization: LLL

Priority: 2

OBJECTIVES

The objective of this test is to determine the expected lifetime of carbon steel and other alternate materials of construction in brine, steam and condensate as a function of pH, temperature, oxygen content and any other parameters that may vary within the reservoir or over the life of the wells. This test will be primarily a paper study, utilizing existing data from the Bureau of Mines (as it becomes available) and LLL's data on corrosion rates on modified brine (low pH). The effects of standby oxygen corrosion during plant shutdown will also be evaluated in a test designed to simulate shutdown conditions.

TEST STATUS

The corrosion penetration rate and attack morphology of some 30 commercial metals and alloys in the completed 30 day test have been determined and reported in ATHS/ISP-17, Sept. 1978. Analysis of stress corrosion and weldment coupons is also complete. Report is in preparation.

Evaluation of coupons exposed in downwell test (MagmaMax No. 1) during February, 1978 has been completed. Large differences in corrosion behavior, attributable to composition and microstructure differences were found. Severely corroded sections from a J55 string exposed in February, 1978 are currently being evaluated. Preliminary results were reported in the Lawrence Livermore Laboratory quarterly progress report, UCID-18074-79-1.

TEST NO. 6.0

Title: PLANT COMPONENTS AND INSTRUMENTATION

Responsible Organization: SDG&E

Priority: 1

OBJECTIVES

The objective of this test is to monitor the performance (operating life, failure history, etc.,) of plant components exposed to the brine and geothermal steam. This includes various types of control valves, line block valves, pumps, thermocouples, flow meters, etc. The failure history of these components will be monitored using a "Failure Mode Analysis" program. The effectiveness of various types of equipment operating in the different brine and steam environments will be recorded and analyzed. Engineered changes will be implemented and their effects monitored to improve component performance and lifetime. This data will be used as a basis for selecting components and instrumentation for the 50 MWe flash cycle power plant to be built at the Niland reservoir.

Certain components that are required for safe operation of the plant and will also be evaluated for reliable performance. Relief valves, wellheads, shutoff valves, etc. are among the components to be so evaluated.

TEST STATUS

This test plan has not yet been finalized. A schematic detailing location of components and instruments being tested is currently being prepared.

TEST NO. 7.0

Title: BRINE CHEMISTRY

Responsible Organization: SDG&E

Priority: 1

OBJECTIVES

The objective of this test is to completely characterize the chemistry of the Niland brine. Analyses will be performed on samples of liquid brine, steam, condensate, and non-condensable gases under varying well flow conditions and a correlation drawn between well flow, plant operations, and fluid composition.

TEST STATUS

Sampling of GLEF fluids during this quarter are described in Section 4.0 Systems Chemistry.

TEST NO. 8.0

Title: H₂S ABATEMENT

Responsible Organization: LLL

Priority: 2

OBJECTIVES

The objective of this test is to evaluate the technical feasibility and costs of stripping H₂S from GLEF noncondensable vent gas stream with brine effluent. In addition, the impact on the reactor-clarifier of this H₂S addition to the brine effluent will be considered. Technical advantages, disadvantages and costs of this technique will be compared with the Stretford process.

TEST STATUS

The first continuous scrubbing test using small scale single stage unit completed. Results show up to 82% of H₂S is removed (volumetric ratio of gas flow to brine flow was 0.6). Preliminary report of results included in the Lawrence Livermore Laboratory first quarterly report, UCID-18074-79-1.

TEST NO. 9.0

Title: STEAM SEPARATION

Preparation of this test has been delayed pending an evaluation of its necessity.

TEST NO. 10.0

Title: INJECTION EFFLUENT PROCESSING

Responsible Organization: Magma

Priority: 1

OBJECTIVES

The objective of the 10 MW brine injection processing facility is to demonstrate the viability of a complete treatment system. This will include precipitation and clarification, filtration, sludge handling and dewatering, and sludge disposal.

TEST STATUS

No work on this test was accomplished during this quarter. Beginning operation is planned for the second quarter of 1979.

TEST NO. 11.0

Title: MAKEUP WATER INJECTION COMPATIBILITY

Responsible Organization: Magma

Priority: 1

OBJECTIVES

The objective of this test is to establish the technical and economic feasibility of mixing Salton Sea water with geothermal brine in the Elmco pilot plant reactor clarifier.

Status

This test has been completed by Imperial Magma. The final report will be included in the 1978-1979 GLEF Test Program Final Report. A summary of the findings is as follows:

1. A stable, saturated effluent is produced by reactor clarifier.
2. At least twice the amount of solids are produced when Salton Sea is added to the brine versus brine alone.
3. A scaling problem exists in the clarifier at the point where Salton Sea and brine are mixed.

TEST NO. 12.0

Title: WELL-CASING MATERIALS

Responsible Organization: LLL

Priority: 1

OBJECTIVES

The objective of this test is to assess the rates of corrosion and the types of corrosion with different standard well casing materials, and to establish the expected service life of well casing materials.

TEST STATUS

A 1800 ft test string consisting of API steels J55, N80 and C75 will be introduced into Woolsey No. 1 well next quarter. These samples will be exposed for 3 1/2 months and then analyzed for corrosion.

TEST NO. 13.0

Title: INJECTION STUDIES

Responsible Organization: LLL

Priority: 1

OBJECTIVES

The objectives of this test are to: 1) study the technical and economic feasibility of using Salton Sea water mixed with brine for injection; 2) to determine what additives are necessary to reduce the sulfate concentration; 3) to establish by computer modeling, the effect on the reservoir of injection of Salton Sea water; 4) to determine by core flushing, the injectivity of clarifier effluent from brine and Salton Sea brine mixtures.

TEST STATUS

Chemical stability tests of clarified processed effluents from Magma's pilot facility, evaluation of core and membrane filter test data, and low pH brine adjustment tests have been completed and reported (LLL Geothermal ISP 1st Quarter Technical Progress Report for 1979, UCID-18074-79-1). Additional evaluation tests are dependent on 10 MW sized clarifier startup.

Results of brine/makeup water (Salton Sea, New River, and Alamo River) incubation tests with and without sludge contact at 90°C (194°F) for periods ranging from 15 minutes to 30 days have also been reported in the Lawrence Livermore Laboratory 1st quarterly report, UCID-18074-79-1.

TEST NO. 14.0

Title: Well Test Data Reduction

Responsible Organization:

Priority:

OBJECTIVES

This test has been deleted due to lack of funding.

TEST NO. 15.0

Title: Scale Control-Inhibitors

Responsible Organization: SDG&E

Priority:

OBJECTIVES

The objective of this test is to determine if commercially available chemicals could be used to inhibit the precipitation of silica from the brine. This is the major source of scale formation at the GLEF. If successful, both technically and economically, such a treatment may result in substantial cost savings in the 50 MW plant proposed for Niland.

TEST STATUS

This test has not yet been formally initiated. A test plan is presently being prepared.

4.0 SYSTEMS CHEMISTRY

The sampling of the GLEF fluids (as described in Test No. 7.0 - Brine Chemistry) during this quarter were taken from November 13, 1978 to December 28, 1978 and are described in the following four (4) subsections: steam, brine, binary and cooling water, and scale. Sampling began on November 13, but dilutions of the samples between the 13th and 18th were found to be in error due to the failure of the mechanical pipets. This data is excluded from this report. After November 18 all dilutions were made with manual pipets and the dilution error was eliminated. Not all constituents listed are monitored because to date an accurate test procedure has not been set up yet. The GLEF facility continued to operate with the two stage flash system.

4.1 Steam

Daily and weekly monitored constituents of the GLEF steam are included in Appendix D. Sodium (Na) and calcium (Ca) concentrations for the quarter are graphed in Figures 4-1 through 4-4. The sampling lines for the steam entering the first and second stage scrubbers and the combined condensate were changed from carbon steel to stainless steel, to reduce sample contamination. The sampling points remained unchanged. The sample points for the steam exiting the first and second stage scrubbers were changed from a grab sample at the scrubbers to a more representative sample

1ST STAGE STEAM

-30A-

FIGURE 4-1

2ND STAGE STEAM

-30B-

FIGURE 4-2

1ST STAGE STEAM

D.N.

 1-79

-30C-

FIGURE 4-3

2ND STAGE STEAM

D.N.
SDG
1-79

-30D-

FIGURE 4-4

at the heat exchangers. A flushing system using the water from the spray pond was incorporated in the sample lines, so the lines could be flushed after each sample was drawn to prevent scale buildup. This flushing system appeared to be very effective in preventing scale deposition in the sample lines.

The steam's physical characteristics in the first stage remained consistent with those reported in the previous quarter, namely, low pH, low ammonium concentration, high conductivity, high hydrogen sulfide concentration and low brine carryover. The iron, calcium and sodium concentrations varied, but not too severely. The concentrations for these elements entering the scrubber were less than 0.2 ppm for iron, 5.0 ppm for calcium and 11.5 ppm for sodium. The concentrations exiting the scrubber were less than 0.3 ppm for iron, 2.0 ppm for calcium and 4.5 ppm for sodium.

The steam entering the second stage scrubber was extremely impure due to large amounts of brine carryover. This carryover was probably caused by a modification in the second stage separator. Although the pH remained constant, the concentrations of sodium, calcium and potassium were high and traces of other elements, such as silica, were found. These other elements were not detected during previous plant operations. The pH of the steam leaving the second stage scrubber varied considerably, ranging from an acidic pH of 6.19 to a basic pH of 8.70. This trend may have been

due to recirculating the condensed steam out of the second stage scrubber and using it as purge water for the same scrubber. The concentrations of the elements were still high, but the scrubber was most effective in reducing the amount entering the heat exchanger.

The characteristics of the combined condensate were relatively stable throughout this period. There was good correlation for the values between the first and second stage steam scrubbers and the combined condensate, namely, the concentrations of the chemical species were about half of the sum of the same species leaving the first and second stage steam scrubbers.

4.2 Brine

Appendix E lists the daily and weekly monitored constituents of the geothermal brine through the two stage flash system. Sodium (Na), calcium (Ca), and silicon (Si) concentrations for the quarter are graphed in Figures 4-5 through 4-7. During the first two weeks of plant operation, the concentrations of the elements followed the expected trend, that is, the concentrations increased as the brine flowed through the plant. However, this behavior changed during the latter part of the plant operation, but only for the relationship between the second stage and injection, where the concentrations reversed, that is, the concentrations for the injection brine were less than the concentrations for the second stage brine. This trend was probably due to a scale build-up between the second stage separator and the point of injection, thus preventing representative sampling.

BRINE

D.N.
SDGE
1-79

-32A-

FIGURE 4-5

BRINE

D.N.
SDGE
1-79

-32B-

FIGURE 4-6

BRINE

-32C-

FIGURE 4-7

The concentrations of the elements taken from the flush mounted sample point for the incoming brine remained relatively constant during this test period. The following table illustrates the elements measured on the Atomic Absorption Spectrophotometer with the highest, lowest, and average concentrations:

<u>Element</u>	<u>High</u>	<u>Low</u>	<u>Average</u>
K	8130	6500	7350
Na	46500	39000	41700
Ca	21400	16300	19400
Li	175	146	156
Mg	106	88.2	96.7
Mn	563	462	520
Ba	154	111	130
Sr	403	370	393
Zn	229	184	203
Si	243	159	213
Fe	145	117	126
Pb	38.7	8.0	21.0

All measurements are in ppm.

During the first half of the plant operation, a retractable probe was used to try and obtain a more representative sample. The probe was very successful initially, however, during the later part of the run, the retractable probe samples were not as good as the flush

mounted port samples. This was evident in the cation-anion balancing. This reverse trend may have been caused by a scale deposition in the retractable probe, thereby inhibiting a representative sample.

During the last quarter, the lab underwent an extensive program to determine the reliability of the analytical procedures. Some of these procedures were modified or changed completely and now the lab is using what it considers are the best of these procedures. The confidence level for all measurements is within the 95% range.

4.3 Binary and Cooling Water

Appendix F lists the daily and weekly monitored constituents of the binary and cooling water systems. These systems were put into circulation on November 12, 1978, after being cleaned and repaired.

The binary system was monitored for pH, conductivity, sodium, calcium, and iron. The pH of the binary fluid was relatively constant around 9.1, but it dropped to a pH of 6.91 after two weeks of operation. This was due to a leak around a mechanical seal at the binary pump. The leak allowed oxygen to get into the system thereby lowering the pH. The pH rose again on December 4 to 9.1 and remained stable for the rest of the operation. The conductivity, sodium, calcium and iron was constant throughout this period except for the time the pump was shut down.

The cooling water was stable with respect to all measurements. The pH remained between 7.5 and 8.0 and the elements increased slightly due to the addition of the combined condensate.

The cooling water condensers were extremely stable. The dP (differential pressure) was 8 psi at the start up and rose slightly to 11 psi towards the end of the plant operation. The corrosion rate, as measured by the Petrolite cell, has remained between 1.5 and 2.5 mils per year during this period. All of these factors can be attributed to the extensive cleaning of the piping feeding the condensers, condenser tubes, and the addition of Betz chemicals. The Betz chemicals were very effective in controlling the corrosion rate and keeping the condensers operating.

4.4 Scale

During this operating period, the plant was shut down on November 29, 1978 due to the plugging of (P-2) injection pump and again on December 19, 1978 due to the mechanical pigs getting stuck in the injection line. At the time of both shut downs scale samples were collected and analyzed. Refer to 5.0 Maintenance for scale description and removal. The scales were analyzed on the Atomic Absorption Spectrophotometer. Appendix G lists the compounds that are assumed to be there by both qualitative and quantitative analysis. The same trend is observed during the last

period, that is, the Silica (SiO_2) concentration increases as the brine travels through the plant, while the concentrations of the other elements decrease.

4.5 Future Projects

During the next operating period, the laboratory will incorporate density along with the parameters already being measured. Woolsey No. 1 will be flowed during the next period instead of Magmamax No. 1 and all measurements will be conducted on this well.

5.0 MAINTENANCE

On September 24, 1978, the GLEF was shut down for overhaul and cleaning.

5.1 Injection Pump P-2

On November 9, 1978, the GLEF was started and continued operation until November 28, 1978 when the injection pump was removed and returned to the SDG&E Machine Shop because of low discharge pressure. The time of operation was approximately 415 hours. Upon disassembly rubber material was found in the first and second stages. Origin of this material is unknown. Most of the bearings in the pump showed wear.

Approximately one and one half inches of scale build-up was found in the pump can. This amount of scale is not enough to restrict the brine flow through the injection pump but was more than expected.

During the plant operation, the pump was flushed with brine from the pump discharge once every shift. This was done in an attempt to keep the pump can passage open. It was decided that flushing with cooling water once a week was more beneficial than flushing with the brine once a shift, because the cooling water seemed to do a better job.

The scale was also removed in the suction line from separator V-15 to pump and the discharge line from the pump to the first elbow. Scale varied in thickness in this suction line from one inch in the upper portion of the line to three inches on the bottom. The discharge line had approximately one and one half inches of scale equally distributed.

5.2 First Stage Scrubber B

This scrubber was opened and inspected after the 1400 hour run mentioned in the last Quarter Report. The top and bottom manholes were opened and because the overall condition looked better than previous inspections, the internals were not inspected. The bottom had loose scale accumulation of approximately two inches. Samples of the scale were gathered and the scrubber cleaned. Scale composition was presented in the previous quarterly report.

5.3 Second Stage Scrubber B

This scrubber was also opened and inspected after the 1400 hour run mentioned in the last Quarterly Report. The top section had one to two inches of loose scale accumulated while the bottom section had two to three inches. The internals were removed in this scrubber and loose scale was found in all five trays. The overall condition of this

scrubber showed evidence of carryover. Scale samples (composition reported in previous quarterly report) were also gathered from this scrubber and the scrubber cleaned.

5.4 First Stage Separator B

The vessel was ventilated prior to inspection after 1400 hours of operation. The overall appearance of the vessel was relative clean compared to previous inspections. There was approximately one quarter inch of brittle black scale on the sides below the water line. The bottom had about three inches of loose scale covering the entire length of the vessel. The vortex had approximately three eighths to one half inch of scale. Samples of the scale were sent to the lab and the vessel was cleaned by hydroblasting. Cleaning took approximately four hours. Scale composition was reported in the previous quarterly report.

5.5 Second Stage Separator B

This vessel was ventilated prior to inspection after 1,400 hours of operation. Inspection revealed approximately 18" of soft sludge (scale) build-up on the bottom of the entire length of the vessel. One half inch of hard scale was observed above the water line extending throughout one half of the vessel from the inlet end. The remaining portion had no scale at all. Scale samples (composition was presented in previous quarterly report) were sent to the lab

and the vessel was cleaned by Southwest Chemical. The inlet line was modified to direct the flow down instead of splashing on the side of the vessel. The cooling water line, installed on top of the Vortex breaker in the vessel during the last shutdown, became plugged. This line was modified so the cooling water went directly into the vortex for flushing. The cooling water is used for flushing the drain line in an attempt to keep it clear during operation.

5.6 First Stage Separator B Drain

The outlet drain pipe was opened at several locations for inspection and samples. Scale composition was presented in the previous quarterly report. A 90° elbow and test spool was sent to the Corrosion Research Company in Camas Valley, Oregon, during the last overhaul to be lined with a material which was expected to prevent scale build-up. When the elbow and test spool were inspected approximately three eights inch of black brittle scale was found. This was the same amount of build-up on the unlined pipe. The drain line (140 feet of 10 inch pipe) was cleaned by hydroblasting and required 75 hours of disassembly and 12 hours of cleaning.

5.7 Second Stage Separator B Drain

The drain out of the second stage separator had approximately 2 1/2" to 3" of scale build-up. Scale composition was presented in the previous quarterly report.

After the elbow, scale was reduced to approximately one inch. In an attempt to reduce the scale build-up, the first and second 90° elbows were replaced with long radius elbows. The maintenance took approximately 40 hours.

5.8 Pinch Valve "Red Valve"

On September 24, 1978, this pinch valve, used as a control valve located between the second stage B separator (V-11) and the atmospheric flash vessel (V-15), was removed for inspection after 1,400 hours of operation.

The liner (EPDM) showed signs of deterioration on the outlet side. 1/32 in. of scale was found adhering to the liner. Even though the liner was operational, a replacement liner made of viton was purchased and installed for evaluation.

5.9 Pressure Control Valve

The pressure control valve 510 controls the vent gas flow from the gas separator to the vent stack allowing noncondensable gases to escape. This valve has been modified to a two inch equivalent valve. However, this valve is apparently oversized, since it stays closed most of the time until enough pressure builds for the valve to open. The valve then immediately closes. A one inch Fisher valve, designated PCV 110, was installed. This valve should give better control of the vent gas.

5.10 Chlorinator

When the GLEF was constructed, an automatic chlorinator manufactured by Capital Controls Company was installed to chlorinate the spray pond. This instrument has required minimal maintenance but occasionally has been disassembled and cleaned. It was apparent at its last servicing that it would need replacing at the next major plant overhaul.

In October, a factory rebuilt regulator and ejector were received from California Environmental Controls, a distributor of Capital Controls Company under their exchange program. After the new equipment was installed the old equipment was returned.

5.11 Instrument Air Compressor

The original instrument air compressor (M-3A) had a capacity of 35.6 CFM. In September, 1977, this compressor was replaced with a model with a capacity of 43.6 CFM. This air compressor has given reliable service for one year. On September 19, 1978, an interstage relief valve started leaking. The compressor was disassembled and two internal valves were found stuck. The valves were cleaned and lapped on site but leakage continued. A contractor cleaned the head and cooler, renewed the diaphragms in the unloader, and rebuilt the valves. The compressor was reassembled and was restored to service.

5.12 Cavitation Nozzles/Modified Gate Valve

Daedalean Associates had installed nozzles on flanges in the test spools last quarter. This was done to determine if nozzles would plug up by running high pressure clarified brine through a hydro pump and to determine how often this had to be done before the nozzles would plug. Also, Daedalean installed a 10" x 150" gate valve with nozzles installed for testing. This was to determine if the seats could be kept clean of scale while in operation. When the valve was removed for inspection on September 26, the seat had a large amount of scale buildup indicating a failure of the test, although the valve had not been hydroblasted in the last two weeks of operation. Daedalean Associates is preparing a report on their findings of the nozzles and valves.

6.0 GLEF REACTOR CLARIFIER/MEDIA FILTER INSTALLATION

6.1 Purpose

The Reactor Clarifier/Media Filter Installation at the GLEF is intended to demonstrate that suspended solids in the brine can be removed prior to injection into the reservoir and that silica concentrations in the brine can be reduced to saturation values or below. This will result in prolonged injection well life. The treated brine is expected to extend the useful life of the injection wells significantly.

6.2 Description of Project Organization

SDG&E and Doe are jointly funding engineering and construction of the facility. The Ben Holt Company is performing the detailed engineering. SDG&E is constructing and starting up the facility and Imperial Magma will operate and maintain the facility and monitor performance of the new injection well (IW-5) that has been drilled to accept the treated effluent.

6.3 Technical Description of Facility

A schematic of the system is shown in the process flow diagram (Figure 6-1). 625,000 lbs/hr of brine is pumped from the existing atmospheric flash drums by the clarifier feed pump, P-16, to the reactor clarifier, V-17. A flow control valve is manipulated by the existing level

controller on the atmospheric flash drum. The existing system maintains flow out of the flash drum in the same manner; consequently, this method of controlling flow to the system will not alter the operation of the existing plant.

The reactor clarifier, V-17, provides residence time for formation and settling of solids. The effluent brine flows by gravity to the sand and anthracite media filter, V-18B, and thence, to the brine surge tank, V-19, from where it is pumped by the injection pump to a pressure of approximately 500 psig for injection.

The 3,710 lbs/hr of sludge from the reactor clarifier, V-17, flows by gravity to the thickener, V-22, where the sludge is concentrated to 10 percent solids by weight. The sludge from the thickener is pumped to the plate and frame filter, F-1. A cake is produced at the rate of 257 lbs/hr (357 lbs/hr during V-20 drain). This filter is operated approximately every three hours for the necessary length of time and automatically shut down. The filter press is then manually opened and the cake, 60% solids by weight, drops into transportable bins, V-21.

The effluent from the thickener, V-22, and the plate filter, F-1, both flow into the backwash holding tank, V-20.

The media filter, V-18B, must be backwashed once every 24 hours. To accomplish this without disrupting flow through the plant, three media filters are provided so that one can be backwashed once each eight hours. The remaining two carry the full flow for the approximate 20 minute backwash operation.

The backwash tank, V-18A, is filled in four hours by 80 gpm of brine effluent from the media filter. This metering is accomplished by a flow orifice/splitter box which is part of the media filter system, V-18. The backwash operation consists of a seven minute drain, followed by an air blowdown and then a 5-1/2 minute backwash time. The backwash fluid flows by gravity from the backwash tank (V-18) up through the media filter cell (V-18B) to be backwashed, and thence, by gravity flows into the backwash holding tank, V-20. A rising level in V-20 activates the return pump, P-19, which pumps the backwash brine containing 1.14 weight percent suspended solids to the clarifier (V-17) influent line. This drains the holdup tank in four hours. Consequently, at this drain flow rate, the backwash cycle can be reduced to four hours. Furthermore, the pump, P-19, and associated lines are sized for 160 gpm so that the cycle time can be further reduced to two hours, if necessary, subject to maximum total flow rate of 1,600 plus five percent gpm into the reactor clarifier, V-18.

During the four hour drain period, 56.7 lbs/hr of suspended solids are added to the clarifier by the backwash brine to the 204.3 lbs/hr suspended solids entering the clarifier in the influent brine. Consequently, during the four hours drain period, the cake produced contains 232 lbs/hr suspended solids, compared with 167 lbs/hr otherwise. That is, of the 204.3 (or 261 during V-20 drain) lbs/hr suspended solids entering the clarifier, 27.3 (or 29.3) lbs/hr leave in the effluent brine and 167 (or 232) lbs/hr leave in the sludge. The solids leaving in the clarifier effluent brine are removed in the media filter and subsequently backwashed to the holding tank, V-20, and then to the clarifier, V-17, during the drain period as described.¹

6.4 Current Project Status

The GLEF Clarifier/Filter Installation is presently scheduled for construction completion in April, 1979. Approximately one to two months will be required to start up the facility. However, some of the start-up will be conducted during the final stages of construction. The facility is expected to be fully operational by mid-May, 1979.

1. The Ben Holt Co., "GLEF Reactor Clarifier/Media Filter Installation, System Design Package", Nov. 17, 1978, pp 1-4.

As of December 31, 1978 the construction of the clarifier facility was underway, with the major vessel foundation construction approximately 20% complete. Most of the major mechanical and electrical equipment items have been purchased, except for the controls and instrumentation, which are scheduled for purchase in early January.

7.0 OTHER ACTIVITIES

7.1 Feasibility Study

A preliminary review of single stage flash vs the two stage flash option for Niland was completed. The feasibility study did not consider the single stage flash option since other studies have consistently shown that the two stage flash cycle is superior to the single flash, all other things being equal.

The initial GLEF data from the two stage flash operation have indicated that all other things are not equal. Examples are (1) scale formation is significantly greater in the second stage, (2) poor steam purity in the second stage, and (3) surging which may cause a dual entry steam turbine not to be as reliable as a single entry steam turbine.

The conclusions of the preliminary review indicated that if a clarifier/filter is required for effluent treatment a two stage flash is still optimum. The clarifier and filter vessels are unpressurized tanks. Although pressurized clarifiers and filters are technically feasible, they are uneconomical. Since the effluent brine must be reduced in pressure (flashed) prior to the clarifier, utilization of this additional steam in a dual flash cycle is indicated.

The next phase of the feasibility study may analyze the single stage option in more detail. GLEF data, as it pertains to this option, will continue to be reviewed.

7.2 Feasibility Study Addendum

An addendum, evaluating the impact of a direct contact heat exchanger on binary cycle options, was completed. This study indicated that an initial stage of flash, using the steam to vaporize the binary working fluid, followed by a direct contact heat exchanger offered potential benefits at Niland. In addition to an efficiency gain, control of scaling may be an additional benefit. Risks of this cycle option were not addressed, since application is unproven.

Although, the addendum indicated potential benefits for this cycle using a direct contact heat exchanger, no change in the basic conclusion of the feasibility study (two stage flash for initial development) is foreseen. However, direct contact heat exchange should be considered for further research and development.

7.3 Surge Study

In order to reduce the oscillations observed in the brine and steam an initial draft report was completed by the Ben Holt Company to define the oscillations and recommend corrective actions. This draft correlated observed GLEF

oscillations with theoretical flow regimes. It was recommended that a small tank be installed prior to the first stage flash vessel to decouple line oscillations. This final report is expected in the next report period.

8.0 SUMMARY

During this quarter the plant operated for a total of 1063 hours. For the quarter, the scheduled plant availability (excluding scheduled outages) based on one well flow using Magmamax No. 1 was 53.3% and the overall capacity factor since start-up was 60.6%.

The plant was down for its major overhaul and cleaning in October. It was started on November 9, 1978, utilizing Magmamax No. 1 as the production well and Magmamax No. 2 as the injection well and operated until an unscheduled shutdown due to pigs becoming lodged in the injection line. After the unclogging of the injection line the plant was still in operation at the end of this quarter.

The 1978-1979 GLEF Test Program consisting of 15 different tests is now underway. Most of the tests have been defined by specific objectives, testing has been initiated, and preliminary results of several tests have been compiled. These findings are in the areas of scale properties (Test No. 2), scale control additives (Test No. 3), corrosion/erosion parameterization (Test No. 5), H₂S abatement (Test No. 8) and injection studies (Test No. 13).

Data is being compiled on sampling of the GLEF fluids. The systems chemistry findings are separated into subsections in the areas of steam, brine, binary and cooling water, and scale. Sampling point and test procedures have been modified to give a more representative sampling of fluids.

During the shutdown in October, following 1,400 hours of operation, several systems in the brine trains were inspected and cleaned. Location of scale accumulation was documented, and scale samples were gathered and sent to the lab for evaluation.

Construction has begun on the reactor clarifier/media filter installation to demonstrate that suspended solids in the brine can be removed prior to injection and that silica concentration can be reduced to saturation values or below. A new injection well (IW-5) has been drilled to accept the treated effluent. Construction completion is presently scheduled in April, 1979 and is expected to be fully operational by mid-May, 1979.

A preliminary review of a single stage flash vs. the two stage flash option for Niland was completed. Initial GLEF data has indicated discrepancies in early studies' findings of two stage flash cycle superiority. The next phase of the feasibility study may analyze the single stage option in more detail.

A feasibility study addendum, evaluating the impact of a direct contact heat exchanger on binary cycle options, was completed and indicated potential benefits at Niland.

APPENDIX A

TIME 2400 DATE 12-15-78 *Jgh*DAILY STATUS REPORTBrine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	<u>280</u>	<u>150</u>
Plant boundary pressure	_____	<u>250</u>	<u>100</u>
Plant boundary temp.	<u>_____</u>	<u>425</u>	<u>176.9</u>
Flow rate			<u>393</u>
Flow rate from	1A Sep. _____	1B Sep. <u>480</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	<u>117</u>	_____	<u>7.5</u>
Temperature	_____	<u>360</u>	_____	<u>212</u>
Flow rate	_____	_____	_____	_____
Water level	_____	<u>23</u>	_____	<u>45</u>

Cooling Water System

Cond.D/P 9-10 Flow rate 11,500 Corrosion rate 2
 Chemical additive, type & feed rate Betz 607 45%

Binary System

Flow rate 2.0 Corrosion rate 5 1st Stage outlet temp. 270
 Machinery out of commission # 1 acid pump

Remarks: (brief daily summary, test, task, special evaluation, problems)

Clarifier test in progress. P-2 is having problems pumping V-15.

0500 Lit off vacuum pump.

0530 Secured vacuum pump.

0730 Secured CHL to cooling water.

1030 Tried launching T. D. Williams pig which never left the launcher before it melted.

1400 Gibbs crew started hydroblasting. P-2 dropped to 25 psi. Discharge with no back pressure and 718A wide open.

1545 Hooked fire hose to flush P-2 again. Closed PCV 301 to 60% from 70%. Tried lowering pressure in 2B heat exchanger to eliminate strain from lower end of plant. Lowered PCV 303 back pressure from 50 to 40 psi. Opened FCV 104 from 1.5 to 2.5 on scale.

1630 Raised PCV 303 back pressure.

1800 Lit off clarifier.

1900 Started reducing brine flow.

2050 PCV 301 open at 50%.

2100 Commenced flushing P-2.

2145 Increased brine flow 30% to 60%.

2155 PCV 301 back to 55%.

Distribution

W. S. Bischoff
F. J. DeLamarter
J. G. Griffith
C. H. Haas
J. G. Hoaglin
W. O. Jacobson
D. G. Newell
F. Schoepflin

TIME 2400 DATE 12-16-78 *Ygh*

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure		<u>275</u>	<u>100</u>
Plant boundary pressure		<u>240</u>	<u>0</u>
Plant boundary temp.		<u>422</u>	<u>173</u>
Flow rate			<u>715</u>
Flow rate from	<u>1A Sep.</u>	<u>1B Sep.</u>	<u>OOC</u>

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure		<u>118</u>		<u>13 PSIA</u>
Temperature		<u>360</u>		<u>175</u>
Flow rate		<u>OOC</u>		
Water level		<u>24</u>		<u>45.5</u>

Cooling Water System

Cond.D/P 9-11 Flow rate 9000 Corrosion rate 1.8
 Chemical additive, type & feed rate Betz 607 45% CHL secured.
 Chlorine residual trace.

Binary System

Flow rate 1.5 Corrosion rate 5.8 1st Stage outlet temp. 270
 Machinery out of commission # 1 acid pump

Remarks: (brief daily summary, test, task, special evaluation, problems)
 0200 P-2 has 10 psi discharge pressure. V-15 going high.

Cut back on PCV 301 to 50%. Backflushed P-2.

Flushed with cooling water. This helped a little, but

not much. V-15 went high. 15 psi on P-2. Cut back

on PCV 301 40%. Genr. level holding high. Continued

flushing with cooling water and alternate back flushes

of P-2 with 718A shut. We continued this until 0700, 12-16-78. At this time with two fire hoses cut in P-2 with 718A wide open and no back pressure and PCV 301 at 60% and hydroblast nozzle wide open 700 psi. V-15 holding operating level. 200 psi. Hydroblast nozzle on P-2 suction was open to full flow. At the beginning of flushing process when first back flush was tried with 718A closed, noted that 550 psi was on flushing line for about one min. This led me to believe that flushing ports in half moon pipe were plugged so cooling water was not flushing in can yesterday. I would recommend flushing P-2 suction line one hour per shift with alternate back flushes of P-2 at the same time to keep suction clear.

0830

Cut in CHL.

1300

Shot wire brush pig.

1340

Pig recovered in good shape. 2B separator holding level high on swing shift. Pressure was brought to 14 psi then dropped to 13. Level holding at 43. P-2 discharge 480. V-15 holding operating level. PCV 301 63% open.

Distribution

W. S. Bischoff
F. J. DeLamarter
J. G. Griffith
C. H. Haas
J. G. Hoaglin
W. O. Jacobson
D. G. Newell
F. Schoepflin

TIME 2400 DATE 12-17-78 *Jgt*

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	<u>265</u>	_____
Plant boundary pressure	_____	<u>230</u>	<u>0</u>
Plant boundary temp.	_____	<u>413</u>	<u>127.6</u>
Flow rate			<u>800</u>
Flow rate from	1A Sep. _____	1B Sep. <u>629</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	<u>114</u>	_____	<u>9.5</u>
Temperature	_____	<u>358</u>	_____	<u>238</u>
Flow rate	_____	<u>619</u>	_____	_____
Water level	_____	<u>24</u>	_____	<u>40</u>

Cooling Water System

Cond.D/P 9-11 Flow rate 10,000 Corrosion rate 2
 Chemical additive, type & feed rate Betz 607 45% flow rate.

Binary System

Flow rate 2.1 Corrosion rate 1 1st Stage outlet temp. 270
 Machinery out of commission # 1 acid pump.

Remarks: (brief daily summary, test, task, special evaluation, problems)
Clarifier test.

0800 Power tripped off. Computer was deprogramed when
 power tripped off .
1300 Air supply nipple to 718A from regulator broke.
 718A was put in hand and nipple was repaired. 2B
 discharge line is plugging. High level in V-15.

Wire on probe messed up. Instr. Tech. repaired pressure on 2B separator - was increased. Vortex flushing water line was cut in. Opened red valve. Completely cut cooling water in to 2B discharge line. Opened red valve all the way. For 30 min. Closed PCV 301 to 40%. Flushed P-2 suction line until P-2 discharge came from 175 to 300. Back flushed P-2 until pressure went to 375. Secured all flushing water except 2B vortex. Decreased 2B pressure. Commenced opening PCV 301.

2200

PCV 301 85%. Well head pressure 365. 2B separator holding 39" at 8 psig at approximately baseline conditions. No Mag. # 2 readings taken, roads too muddy. No pig launched, same reason.

Distribution

W. S. Bischoff
F. J. DeLamarter
J. G. Griffith
C. H. Haas
J. G. Hoaglin
W. O. Jacobson
D. G. Newell
F. Schoepflin

TIME 2400 DATE 12-18-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	<u>260</u>	_____
Plant boundary pressure	_____	<u>220</u>	<u>120</u>
Plant boundary temp.	_____	<u>410</u>	<u>168.1</u>
Flow rate	_____	_____	<u>819</u>
Flow rate from	<u>1A Sep.</u>	<u>1B Sep.</u>	<u>OUT</u>

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	<u>118</u>	_____	<u>6</u>
Temperature	_____	<u>348</u>	_____	<u>210</u>
Flow rate	_____	<u>43.5</u>	_____	_____
Water level	_____	<u>24</u>	_____	<u>39</u>

Cooling Water System

Cond.D/P 9-11 Flow rate OUT Corrosion rate _____
Chemical additive, type & feed rate Betz 607 45%

Binary System

Flow rate 500 gpm Corrosion rate 2MPY 1st Stage outlet temp. 280
Machinery out of commission Purge acid system. Drill press.

Remarks: (brief daily summary, test, task, special evaluation, problems)

1420 A T. D. Williamson pig was launched but not recovered. A
swab was launched to chase pig. Only a small chunk came out.
Two poly pigs were then launched but only a piece of skin
came out. Ten inch valve was left open. Purge acid system
was secured because of an acid leak at P-7 suction. ✓

cc: W.S.Bischoff, F.J.DeLamarter, J.G.Griffith, C.H.Haas, J.G.Hoaglin,

W. O. Jacobson, D.G.Newell, F. Schoepflin

MEMORANDUM

TO: W. O. Jacobson DATE: December 18, 1978
VIA: W. S. Bischoff, F. J. DeLamarter, C. H. Haas,
G. J. Hoaglin, D. G. Newell, F. Schoepflin
FROM: J. G. Griffith
SUBJECT: Plant Status 12-14-78

Plant is operating at baseline conditions. Flowing
brine from Magmamax # 1 to Magmamax # 2. Adding chlorine,
sodium hypochlorite, and Betz 607 to spray pond.
Adding HCL to purge water.

0100 Secured chlorine.

1045-1120 Pigged. Sixth use of carborundum pig. Good shape.

1315 Pin vibrated out of LCV-718A automatic operating
mechanism. Took manual control of V-15 level. Repaired
LCV-718A.

1445 Returned LCV-718A to automatic.

1530 Magma flow check on reinjection 400 gpm.

1600 Started to bring brine flow to 625 gpm by "B" train
clampitron.

2000 Reached 625 gpm brine flow.

Steamed 24 hours.

Lab Ran confidence levels on analyses.
Input

TIME 2400DATE 12-19-78 *Jgh*DAILY STATUS REPORTBrine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	_____	<u>0</u>
Plant boundary pressure	_____	_____	<u>0</u>
Plant boundary temp.	_____	_____	<u>0</u>
Flow rate			<u>0</u>
Flow rate from	1A Sep. _____	1B Sep. _____	<u>0</u>

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	<u>0</u>	_____	<u>0</u>
Temperature	_____	<u>0</u>	_____	<u>0</u>
Flow rate	_____	<u>0</u>	_____	<u>0</u>
Water level	_____	<u>0</u>	_____	<u>0</u>

Cooling Water System

Cond.D/P 9-11 Flow rate 11,000 Corrosion rate Not Avail.
 Chemical additive, type & feed rate None

Binary System

Flow rate 650 Corrosion rate 40 MPY 1st Stage outlet temp. _____
 Machinery out of commission _____

Remarks: (brief daily summary, test, task, special evaluation, problems)

0900 Tried to flush pigs out of reinjection line.

1000 Had to cease this method because Magma pumps cannot handle flow.

1215 Shut down plant because Magma's pumps are out. We cannot
 shift to the well because there are three pigs stuck in the
 reinjection line.

1730-1830 Removed the 6" valve to the Baker tank. This valve was

leaking through. Did not see pigs in the line. Blanked off 6" valve and started P-2 in attempt to flush pigs into Baker tanks. This failed. Removed 6" blank and inserted a swab in 10" line to determine if pigs were in the last section of 10" pipe. Swab came out proving that the pigs are down stream of the 6" valve.

Distribution

W. S. Bischoff
F. J. DeLamarter
J. G. Griffith
C. H. Haas
J. G. Hoaglin
W. O. Jacobson
D. G. Newell
F. Schoepflin

TIME 2400 DATE 12-20-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	_____	_____
Plant boundary pressure	_____	_____	_____
Plant boundary temp.	_____	_____	_____
Flow rate			_____
Flow rate from	1A Sep. _____	1B Sep. _____	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	_____	_____	_____
Temperature	_____	_____	_____	_____
Flow rate	_____	_____	_____	_____
Water level	_____	_____	_____	_____

Cooling Water System

Cond.D/P 9-11 Flow rate 11,500 Corrosion rate _____
Chemical additive, type & feed rate Betz 607 45%

Binary System

Flow rate 650 Corrosion rate 1.8 MPY 1st Stage outlet temp. _____
Machinery out of commission Acid system reinjection piping

Remarks: (brief daily summary, test, task, special evaluation, problems)

Plant is shut down due to pigs in reinjection line.

Removed last blank at elbow before the reinjection line

goes under the road at Magma and placed a swab inside.

1315 Started P-2 (1325). secured P-2. Received swab in good shape.

1400 Placed men at designated spots along the reinjection line

to watch for pressure drops. This would indicate the

section of line in which pigs were stuck.
1441 Started P-2.
1451 Secured P-2. Pressure drop 190-40 PSIG between LLL
section of line and down stream indicates pigs are
stuck in this section.
1500 Started P-2.
1522 Secured P-2. Loud noise and turbulence at 1st test
spool, so this seems to be the spot. Test spool and
valve were removed. Pigs are there.

Distribution

W. S. Bischoff
F. J. DeLamarter
J. G. Griffith
C. H. Haas
J. G. Hoaglin ✓
W. O. Jacobson
D. G. Newell
F. Schoepflin

TIME 2400

DATE 12-21-78

DAILY STATUS REPORTBrine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	_____	_____
Plant boundary pressure	_____	_____	_____
Plant boundary temp.	_____	_____	_____
Flow rate			_____
Flow rate from	1A Sep. _____	1B Sep. _____	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	_____	_____	_____
Temperature	_____	_____	_____	_____
Flow rate	_____	_____	_____	_____
Water level	_____	_____	_____	_____

Cooling Water System

Cond.D/P 9-11 Flow rate 8,500 Corrosion rate _____
 Chemical additive, type & feed rate Betz 607

Binary System

Flow rate _____ Corrosion rate _____ 1st Stage outlet temp. _____
 Machinery out of commission _____

Remarks: (brief daily summary, test, task, special evaluation, problems)

Plant is shut down. 303 went closed. Secured P-8. Removed pigs
 from reinjection line. Commenced closing up the reinjection line.

Distribution: W. S. Bischoff, F. J. DeLamarter, J. G. Griffith,
 C. H. Haas, J. G. Hoaglin, W. O. Jacobson, D. G. Newell, F. Schoepflin

TIME 2400 DATE 12-22-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	<u> </u>	<u>260</u>	<u>210</u>
Plant boundary pressure	<u> </u>	<u>215</u>	<u>125</u>
Plant boundary temp.	<u> </u>	<u>411</u>	<u>186</u>
Flow rate			<u>874 gpm</u>
Flow rate from	1A Sep. <u> </u>	1B Sep. <u>678</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	<u> </u>	<u>118</u>	<u> </u>	<u>10</u>
Temperature	<u> </u>	<u>360</u>	<u> </u>	<u>239</u>
Flow rate	<u> </u>	<u>678</u>	<u> </u>	<u>690</u>
Water level	<u> </u>	<u>24.5</u>	<u> </u>	<u>39</u>

Cooling Water System

Cond.D/P 9-10 Flow rate Corrosion rate 20 MPY
 Chemical additive, type & feed rate sodium hypochlorite @ 20%,
Betz 607 @ 40%

Binary System

Flow rate 445 gpm Corrosion rate 3MPY 1st Stage outlet temp. 275
 Machinery out of commission Acid system

Remarks: (brief daily summary, test, task, special evaluation, problems)

1350 opened 301

1440 launched swab to clean out reinjection line

1630 swab did not reach the other end

1830 sump pump float froze. Repaired float.

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas, JGHoaglin,

WOJacobson, DGNewell, FSchoepflin

TIME 2400 DATE 12-23-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	<u> </u>	<u>260</u>	<u>200</u>
Plant boundary pressure	<u> </u>	<u>225</u>	<u>110</u>
Plant boundary temp.	<u> </u>	<u>415</u>	<u>215</u>
Flow rate			<u>955 gpm</u>
Flow rate from	1A Sep. <u> </u>	1B Sep. <u>641</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	<u> </u>	<u>118</u>	<u> </u>	<u>10</u>
Temperature	<u> </u>	<u>360</u>	<u> </u>	<u>240</u>
Flow rate	<u> </u>	<u>641</u>	<u> </u>	<u>680</u>
Water level	<u> </u>	<u>235</u>	<u> </u>	<u>51</u>

Cooling Water System

Cond.D/P 9-10 Flow rate Corrosion rate 20 MPY

Chemical additive, type & feed rate acid @ approx. 50%, sodium hypro-
chlorite @ approx. 20%, Cl @ 500 lbs/day, Betz 607 @ 40%

Binary System

Flow rate 500 gpm Corrosion rate 3-4 MPY 1st Stage outlet temp. 275

Machinery out of commission None

Remarks: (brief daily summary, test, task, special evaluation, problems)

1030 launched wire brush pig

1045 closed PCV-301 due to misalignment of reinjection line valve
 at the polymeer test spool valve 3/4 closed. Pig stopped
 at valve thus stopping reinjection flow

1055 opened PCV-301

1140 received wire brush pig along w/bits & pieces of the swab.

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas, JGHoaglin,
 WJJacobson. DGNewell. FSchoepflin Use Other Side

TIME 2400 DATE 12-24-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	<u> </u>	<u>265</u>	<u>110</u>
Plant boundary pressure	<u> </u>	<u>225</u>	<u>10</u>
Plant boundary temp.	<u> </u>	<u>415</u>	<u>204</u>
Flow rate			<u>934</u>
Flow rate from	1A Sep. <u> </u>	1B Sep. <u>623</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	<u> </u>	<u>115</u>	<u> </u>	<u>9</u>
Temperature	<u> </u>	<u>360</u>	<u> </u>	<u>235</u>
Flow rate	<u> </u>	<u>623</u>	<u> </u>	<u>--</u>
Water level	<u> </u>	<u>24</u>	<u> </u>	<u>39</u>

Cooling Water System

Cond.D/P 9-10 Flow rate Corrosion rate 20 MPY
 Chemical additive, type & feed rate acid @ approx. 50%, Sodium Hypochlorite
@ approx. 20%, Cl @ 500 lbs/day, Betz 607 @ 40%

Binary System

Flow rate 500 gpm Corrosion rate 3 MPY 1st Stage outlet temp. 276
 Machinery out of commission

Remarks: (brief daily summary, test, task, special evaluation, problems)

1030 launched wire brush pig.

1105 received pig intact

*0230 started getting steam out of vac. pump & low end drain.

Increased 104 flow to eliminate problem

1400 opened PCV 301 100%

Distribution: W. S. Bischoff, F. J. DeLamarter, J. G. Griffith,

C. H. Haas, J. G. Hoaglin, W. O. Jacobson, D. G. Newell, F. Schoepflin

TIME 2400 DATE 12-25-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	<u> </u>	<u>265</u>	<u>120</u>
Plant boundary pressure	<u> </u>	<u>225</u>	<u>10</u>
Plant boundary temp.	<u> </u>	<u>415</u>	<u>198</u>
Flow rate			<u>916</u>
Flow rate from	1A Sep. <u> </u>	1B Sep. <u>641</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	<u> </u>	<u>114</u>	<u> </u>	<u>9</u>
Temperature	<u> </u>	<u>360</u>	<u> </u>	<u>232</u>
Flow rate	<u> </u>	<u>641</u>	<u> </u>	<u>--</u>
Water level	<u> </u>	<u>23.5</u>	<u> </u>	<u>39.5</u>

Cooling Water System

Cond.D/P 9-10 Flow rate -- Corrosion rate 20 MPY
Chemical additive, type & feed rate acid @ approx. 50%, Betz 607 40%
sodium hypochlorite @ 20%, Cl @ 500 lbs/day.

Binary System

Flow rate 500 gpm Corrosion rate 2 MPY 1st Stage outlet temp. 276
Machinery out of commission

Remarks: (brief daily summary, test, task, special evaluation, problems)

No significant changes worth mentioning.

Distribution: W. S. Bischoff, F. J. DeLamarter, J. G. Griffith,

C. H. Haas, J. G. Hoaglin, W. O. Jacobson, D. G. Newell, F. Schoepflin

TIME 2400 DATE 12-26-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	<u> </u>	<u>270</u>	<u>140</u>
Plant boundary pressure	<u> </u>	<u>230</u>	<u>10</u>
Plant boundary temp.	<u> </u>	<u>417</u>	<u>193</u>
Flow rate			<u>996</u>
Flow rate from	1A Sep. <u> </u>	1B Sep. <u>653</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	<u> </u>	<u>114</u>	<u> </u>	<u>10</u>
Temperature	<u> </u>	<u>360</u>	<u> </u>	<u>232</u>
Flow rate	<u> </u>	<u>653</u>	<u> </u>	<u>--</u>
Water level	<u> </u>	<u>25</u>	<u> </u>	<u>39</u>

Cooling Water System

Cond.D/P 9-10 Flow rate -- Corrosion rate 20 MPY
Chemical additive, type & feed rate Acid @ 50%, Sod. Hypo. @ 20%,
Betz 607 @ 40%, Betz 35A @ 40%

Binary System

Flow rate 450gpm Corrosion rate 1-2 MPY 1st Stage outlet temp. 277
Machinery out of commission

Remarks: (brief daily summary, test, task, special evaluation, problems)

0900 Secured P-2. Secured the plant. Found that the maintaining
circuit from P-2 local switch was broken. Open wire.

1550 Open wire in P-2 controls was replaced and PCV 301 reopened.

2000 Baseline conditions were met.

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas, JGHoaglin,

WOJacobson, DGNewell, FSchoepflin

TIME 2400 DATE 12-27-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	<u>255</u>	<u>150</u>
Plant boundary pressure	_____	<u>210</u>	<u>190</u>
Plant boundary temp.	_____	<u>410</u>	<u>184</u>
Flow rate			<u>993</u> Not correct
Flow rate from	1A Sep. _____	1B Sep. _____	<u>612</u>

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	<u>120</u>	_____	<u>10</u>
Temperature	_____	<u>362</u>	_____	<u>231</u>
Flow rate	_____	<u>44.4</u>	_____	<u>--</u>
Water level	_____	<u>25</u>	_____	<u>39.5</u>

Cooling Water System

Cond.D/P 9-11 Flow rate -- Corrosion rate 0
 Chemical additive, type & feed rate Acid @ 50%, Betz 607 @ 40%,
Betz 35A @ 40%, Cl @ 500 lbs/day, Sod. Hypro. @ 20%

Binary System

Flow rate 425 gpm Corrosion rate 20 1st Stage outlet temp. 278
 Machinery out of commission _____

Remarks: (brief daily summary, test, task, special evaluation, problems)

0220 Closed PCV 301 70%-65% (Magma's pump couldn't keep up).

0915 Gibbs started hydroblasting P-2 & flushing with CW & back
 flush from P-2 dis.

0930 Started flushing 2B separator outlet piping.

1040 Secured hydroblasting & flushing 2B sep. outlet.

1220 Launched wire brush pig.

1245

Received pig intact.

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas,
JGHdaglin, WOJacobson, DGNewell, FSchoepflin

TIME 2400 DATE 12-28-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure	_____	<u>260 psig</u>	<u>160 psig</u>
Plant boundary pressure	_____	<u>210 psig</u>	<u>40 psig</u>
Plant boundary temp.	_____	<u>410°F</u>	<u>180°F</u>
Flow rate			<u>1,021</u> Not Correct
Flow rate from	1A Sep. _____	1B Sep. <u>655 gpm</u>	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure	_____	<u>122 psig</u>	_____	<u>10 psig</u>
Temperature	_____	<u>362°F</u>	_____	<u>233°F</u>
Flow rate	_____	<u>42,100 lb/hr</u>	_____	<u>--</u>
Water level	_____	<u>25"</u>	_____	<u>39"</u>

Cooling Water System

Cond.D/P 10-11 Flow rate -- Corrosion rate 4 mpy
 Chemical additive, type & feed rate Acid @ 55%, Betz 607 @ 40%,
Sod. Hypo. @ 1 barrel/day, Cl @ 400 lbs/day.

Binary System

Flow rate 500 gpm Corrosion rate 20 mpy 1st Stage outlet temp. 275°F
 Machinery out of commission _____

Remarks: (brief daily summary, test, task, special evaluation, problems)

1000 secured Betz 35A to cooling water.
1100 LLL started their core flooding test on clarifier.
1245 launched used carborundum pig.
1315 received pig intact.
1448 launched used wire brush pig.
1520 received pig intact.

2400

P-2 discharge is not as high as it should be.
P-2 dis. = 250# w/718A 3/4 closed.

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas,
JGHoaglin, WOJacobson, DGNewell, FSchoepflin

Jch

TIME 2400 DATE 12-29-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure-PSIG	_____.	<u>250</u>	<u>180</u>
Plant boundary pressure-PSIG	_____.	<u>210</u>	<u>170</u> to Baker Tan
Plant boundary temp.-°F	_____.	<u>408</u>	<u>185.3</u>
Flow rate-GPM			<u>472</u> from Magma Baker Tanks
Flow rate from 1A Sep. _____ GPM		1B Sep. <u>665</u> GPM	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure-PSIG	_____	<u>119</u>	_____	<u>7.5</u>
Temperature-°F	_____	<u>357.9</u>	_____	<u>215</u>
Flow rate-1000 lb/hr	_____	<u>45.5</u>	_____	<u>OOO</u>
Water level-inches	_____	<u>24"</u>	_____	<u>40</u>

Cooling Water System

Cond.D/P A-11/B-10 PSID Flow rate OOO GPM Corrosion rate 4 MI

Chemical additive, type & feed rate Betz 607 @ 40%, Sod. Hypo. @ 20%

Binary System

Flow rate 500 GPM Corrosion rate N/A MPY 1st Stage outlet Temp. 346.6 °F

Machinery out of commission None

Remarks: (brief daily summary, test, task, special evaluation, problems)

No special test or evaluations.

1130 launched new wire brush pig

1200 received pig, badly damaged

1205 launched old used carborundum pig

1245 received pig, intact.

1300

LLL secured core test

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas,
JGHoaglin, WOJacobson, DGNewell, FSchoepflin

JG H

TIME 2400 DATE 12-30-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure-PSIG	_____.	<u>265</u>	<u>230</u>
Plant boundary pressure-PSIG	_____.	<u>240</u>	<u>1046</u> (not correct line scale)
Plant boundary temp.-°F	_____.	<u>420</u>	<u>170</u>
Flow rate-GPM			_____
Flow rate from 1A Sep. _____ GPM		1B Sep. <u>583</u> GPM	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure-PSIG	_____	<u>116</u>	_____	<u>9</u>
Temperature-°F	_____	<u>360</u>	_____	<u>230</u>
Flow rate-1000 lb/hr	_____	<u>46.0</u>	_____	_____
Water level-inches	_____	<u>24</u>	_____	<u>55</u>

Cooling Water System

Cond.D/P 11 PSID Flow rate 00C GPM Corrosion rate 4 MI

Chemical additive, type & feed rate ~~1000~~, Sod. Hypro. one barrel per day, Betz 607 40%, Chlorine 400# per day

Binary System

Flow rate 500 GPM Corrosion rate N/A MPY 1st Stage outlet Temp. 308 °F

Machinery out of commission None

Remarks: (brief daily summary, test, task, special evaluation, problems)

1100 flushed P-2 can & suction line with C.W.

1130 launched wire brush pig

1205 received pig

1220 launched pig

1315 received pig

2100 back flushed P-2 and suction line.
2345 secured flushing P-2
* P-2 pump capacity is dropped about 10%

Distribution: WSBischoff, FJDeLamarter, JGGriffith, CHHaas,
JGHoaglin, WOJacobson, DGNewell, FSchoepflin

2h

TIME 2400 DATE 12-31-78

DAILY STATUS REPORT

Brine System

<u>Wells in use</u>	<u>Woolsey</u>	<u>Mag. 1</u>	<u>Mag. 2</u>
Wellhead pressure-PSIG	<u> </u>	<u>283</u>	<u>200</u>
Plant boundary pressure-PSIG	<u> </u>	<u>260</u>	<u>0</u>
Plant boundary temp.-OF	<u> </u>	<u>425</u>	<u>182</u>
Flow rate-GPM			<u>1064 (incorrect)</u>
Flow rate from 1A Sep. <u> </u> GPM		1B Sep. <u> </u> GPM	

Steam System

<u>Stage</u>	<u>1A</u>	<u>1B</u>	<u>2A</u>	<u>2B</u>
Pressure-PSIG	<u> </u>	<u>114</u>	<u> </u>	<u>9</u>
Temperature-OF	<u> </u>	<u>360</u>	<u> </u>	<u>220</u>
Flow rate-1000 lb/hr	<u> </u>	<u>45.1</u>	<u> </u>	<u> </u>
Water level-inches	<u> </u>	<u>24</u>	<u> </u>	<u>55</u>

Cooling Water System

Cond.D/P 11 PSID Flow rate 00C GPM Corrosion rate 4 MI

Chemical additive, type & feed rate Sod. Hypro. @ 1 barrel/day, Betz 607

@ 40%, Chlorine @ 450# per day

Binary System

Flow rate 425 GPM Corrosion rate N/A MPY 1st Stage outlet Temp. 308 °F

Machinery out of commission None

Remarks: (brief daily summary, test, task, special evaluation, problems)

0400 decreased brine flow due to high V-15 level

0400-0600 flushed P-2

0615 decreased brine flow. P-2 could not pump down V-15.

1150 launched pig

1225 received pig

1850

secured clarifier

P-2 pump capacity is down about 25 to 30%

Distribution: WSBischoff, FJDeLamar,ter, JGGriffith, CHHaas,
JGHoaglin, WOJacobson, DGNewell, FSchoepflin

APPENDIX B

A CASE STUDY OF A SALTON SEA GEOTHERMAL BRINE DISPOSAL WELL

By

John G. Morse
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An injection pressure history was compiled for the Magmamax #3 (MM3) well located in the Salton Sea Geothermal Field. MM3 is used for the disposal of spent brine from a geothermal test facility operated by SDG&E. During two years of operation from 5/3/76 to 4/13/78, $9.0 \times 10^5 \text{ m}^3$ of cooled hypersaline (210,000 ppm TDS) brine was injected into the well. The well was operated intermittently over the two-year period with a cumulative operating time of 7886 hours. The operating time is composed of 33 flow periods with four periods greater than 700 hours and one in excess of 1000 hours. The wellhead injection pressure required for an average flow rate of $3 \times 10^{-2} \text{ m}^3/\text{sec}$ varied from 0.7 to 3.45 MPa during the two years of operation.

MM3 is completed to a depth of 933 meters with a slotted liner from 793 to 933 meters. Temperature logs taken after shut-in show fluid to be entering the formation over a 61 meter interval from 793 to 854 meters. Several spinner surveys run toward the end of the first year show fluid leaving the well bore over only a 1 to 2 meter interval of the slotted liner indicating that most of the liner had been plugged. The injection interval had been underreamed prior to setting the slotted liner creating an annulus around the well casing. This annulus appears to permit continued injection over a 61 m interval of the formation with only a 1 to 2 meter open interval in the well casing.

Three injection pressure fall-off surveys were conducted on the well. The first two surveys were conducted on 5/14/76 and 3/2/77 respectively with a relatively low resolution logging tool. The third survey was conducted on 4/13/78 with a high resolution HP logging tool. All surveys reached the end of well bore storage effects at approximately 100 minutes following shut in. The third survey showed the permeability of the injection interval to be $9.9 \times 10^{-13} \text{ m}^2$ with strong evidence that the reservoir is naturally fractured with both fracture and matrix flow. The three surveys show successively increasing well impairment or dimensionless "skin" factors of +110, +153, and +163 respectively.

During the first year of operation, the spent brine was untreated prior to injection. During this period, the injection temperature was between 93-99°C. and the well head injection pressure increased from 0.7 to 3.45 MPa. During the second year several workovers were conducted on the well and the brine was partially treated using settling tanks (2-3 hours residence time) prior to injection. During this period, the injection temperature was between 77-82°C with an injection pressure that ranged from 1.72 to 2.76 MPa. The net effect of the partial treatment and workovers was to reduce the rate of increase in injection pressure and to maintain the pressure within an acceptable operating range. The effect of these remedial measures is also seen in the smaller increase in measured skin damage between the second and third fall-off surveys described above.

In this study, the lifetime of a well is defined as the operating time until the injection pressure exceeds on-site pumping capability (3.45 MPa). Data from MM3 indicates that with no brine treatment, well lifetime is about 150 days and with settling tanks about two years. This estimate is in close agreement with results of membrane filter tests conducted using Salton Sea brine (Owen, et al., 1977). Recently, Magma Power and Lawrence Livermore Laboratory have shown that a reaction clarifier used in conjunction with pressure filters can significantly improve injectability of Salton Sea brine (Tewhey, et al., 1978). Using this treatment process dissolved silica is reduced to below saturation and suspended solids ($1\text{ }\mu\text{m}$ in diameter) are reduced to less than 5 ppm (Quong, et al., 1978). With this type of pre-injection brine processing Salton Sea injection well lifetime could be increased by an order of magnitude to between 20 and 30 years.

References

- Owen, L. B., P. W. Kasameyer, R. Netherton, and L. Thorson, "Predicting the Rate at Which Suspended Solids Plug Geothermal Injection Wells," Third Workshop on Geothermal Reservoir Engineering, Stanford University, 1977
- Tewhey, J. D., M. A. Chan, P. W. Kasameyer, and L. B. Owen, "Development of Injection Criteria for Geothermal Resources," Geothermal Resources Council Transactions, Vol. 2, 1978
- Quong, R., N. D. Schoepflin, G. E. Tardiff, and F. R. McLain, "Processing of Geothermal Brine Effluents for Injection," Geothermal Resources Council Transactions, Vol. 2, 1978

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APPENDIX C

Date: 11-18-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	6.12	6.09	9.24	6.49	6.10
Cond	1790	1700	2420	990	1410
NH ₃ -N	225	199	116	112	184
Cl ⁻	11.5	7.7	656	13.4	N.D
HCO ₃ ⁻	977	977	91.4	533	787
Total Alkalinity as CaCO ₃	801	801	74.9	437	645
SO ₄ ⁼					
S ⁼	15	5	0.3	N.D	2.2
CO ₃ ⁼			100		
Al					
B					
Ba					
Ca	4.26	1.60	69.1	8.51	5.32
Co					
Cu					
Fe	0.06	0.30	3.69	0.72	0.42
Pb					
Li					
Mg					
Mn					
K	1.67	0.56	42.2	0.56	0.56
Si					
Na	7.69	0.82	261	2.47	1.65
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-20-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	6.11	6.14	9.45	6.29	6.01
Cond	1840	1800	1750	1150	1500
NH ₃ -N	219	219	103	110	165
Cl ⁻	18.2	8.6	383	57	128
HCO ₃ ⁻	1133	1120	205	593	883
Total Alkalinity as CaCO ₃	929	918	168	486	724
SO ₄ ⁼					
S ⁼	12	2	0.1	N.D	2
CO ₃ ⁼					
Al	N.D	N.D	N.D	N.D	N.D
B					
Ba	N.D	N.D	N.D	N.D	N.D
Ca	3.13	0.63	75.0	23.1	11.3
Co					
Cu					
Fe	0.03	0.08	3.78	1.20	0.49
Pb	N.D	N.D	N.D	N.D	N.D
Li					
Mg	0.35	N.D	11.4	N.D	N.D
Mn					
K	2.16	0.54	40.5	2.70	1.62
Si	N.D	N.D	1.55	N.D	N.D
Na	8.62	2.30	159	15.8	9.48
Sr					
Zn	N.D	N.D	0.25	0.16	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-22-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	6.16	6.10	9.35	8.36	6.14
Cond	1910	1820	2680	970	1500
NH ₃ -N	219	219	84.6	117	176
Cl ⁻	12.0	12.0	565	65	67
HCO ₃ ⁻	1120	1120	210	540	856
Total Alkalinity as CaCO ₃	918	918	172	443	702
SO ₄ ⁼					
S ⁼	2.5	1.5	N.D	N.D	2.0
CO ₃ ⁼			103		
Al					
B					
Ba					
Ca	3.57	0.59	113	5.95	3.57
Co					
Cu					
Fe	0.11	0.11	3.71	0.11	0.13
Pb					
Li					
Mg					
Mn					
K	2.70	1.08	54.1	2.70	1.08
Si					
Na	6.73	1.28	263	18.6	8.33
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-27-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.98	6.02	8.97	8.07	5.95
Cond	1620	1560	1500	828	960
NH ₃ -N	240	234	96.7	113	160
Cl ⁻	31.6	26.8	258	70.8	160
HCO ₃ ⁻	1107	1107	232	527	830
Total Alkalinity as CaCO ₃	907	907	190	432	670
SO ₄ ⁼					
S ⁼	3.0	2.0	N.D	N.D	N.D
CO ₃ ⁼			129		
Al					
B					
Ba	N.D	N.D	N.D	N.D	N.D
Ca	4.17	0.60	77.4	7.14	2.98
Co					
Cu					
Fe	0.17	0.08	3.34	0.06	0.08
Pb	N.D	N.D	0.12	N.D	N.D
Li	0.02	N.D	0.15	0.07	0.03
Mg	0.56	N.D	29.9	N.D	N.D
Mn	0.05	0.05	0.68	0.12	0.03
K	1.62	1.08	37.8	4.32	3.78
Si	N.D	N.D	4.50	N.D	N.D
Na	7.56	1.74	180	19.8	10.8
Sr					
Zn	0.17	N.D	0.26	N.D	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-29-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.88	5.79	8.73	8.24	5.85
Cond	1770	1730	2050	1040	1350
NH ₃ -N	212	228	105	117	162
Cl ⁻	53.9	18.9	294	114	73
HCO ₃ ⁻	1107	1113	279	488	791
Total Alkalinity as CaCO ₃	907	929	229	399	648
SO ₄ ⁼					
S ⁼	2.5	2.0	N.D	N.D	1.5
CO ₃ ⁼			93		
Al					
B					
Ba					
Ca	3.49	0.23	75.6	11.0	5.81
Co					
Cu					
Fe	0.14	0.14	5.74	0.05	0.08
Pb					
Li					
Mg					
Mn					
K	0.78	0.10	16.7	7.22	3.11
Si					
Na	8.43	0.90	205	49.2	24.7
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-4-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	6.00	5.97	8.98	6.19	5.96
Cond	1720	1690	2000	2780	2200
NH ₃ -N	219	204	89.7	118	171
Cl ⁻	44.5	18.1	357	672	300
HCO ₃ ⁻	1094	1080	216	448	804
Total Alkalinity as CaCO ₃	896	886	177	367	659
SO ₄ ⁼					
S ⁼	4.0	2.0	N.D	0.3	0.8
CO ₃ ⁼			93		
Al	N.D	N.D	N.D	N.D	N.D
B					
Ba	N.D	N.D	N.D	N.D	N.D
Ca	3.41	0.23	73.9	90.9	45.5
Co					
Cu					
Fe	0.16	0.08	4.04	1.58	0.60
Pb	N.D	N.D	N.D	N.D	N.D
Li	N.D	N.D	0.21	0.97	0.42
Mg	0.26	N.D	0.47	0.44	0.15
Mn	N.D	N.D	0.63	1.88	0.86
K	0.67	N.D	33.3	50.0	20.7
Si	N.D	N.D	N.D	N.D	N.D
Na	7.07	2.17	196	255	111
Sr	N.D	N.D	0.97	1.89	0.79
Zn	N.D	N.D	N.D	0.18	0.09

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-6-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.97	5.94	9.07	6.39	6.01
Cond	1800	1700	1830	1160	1495
NH ₃ -N	243	225	113	106	180
Cl ⁻	59	15	278	86	48
HCO ₃ ⁻	1093	1093	237	553	856
Total Alkalinity as CaCO ₃	896	896	194	453	702
SO ₄ ⁼					
S ⁼	3.0	2.5	N.D	N.D	1.5
CO ₃ ⁼			134		
Al					
B					
Ba					
Ca	3.13	0.13	56.3	13.1	6.3
Co					
Cu					
Fe	0.08	0.03	4.03	0.83	0.25
Pb					
Li					
Mg					
Mn					
K	1.1	0.13	40.0	6.7	3.3
Si					
Na	2.01	1.44	155	29.0	16.1
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-8-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.90	6.15	9.08	8.60	6.07
Cond	1640	1600	1220	615	1450
NH ₃ -N					
Cl ⁻	58	15	163	61	34
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼					
S ⁼	4.5	3.5	N.D	N.D	2.5
CO ₃ ⁼					
Al					
B					
Ba					
Ca	3.21	0.24	23.8	5.95	4.17
Co					
Cu					
Fe	0.03	N.D	3.35	0.03	0.03
Pb					
Li					
Mg					
Mn					
K	0.57	N.D	19.0	4.76	2.86
Si					
Na	11.2	2.16	81.9	22.8	9.91
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-11-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.94	5.95	9.04	8.52	6.35
Cond	1850	1750	1460	760	1470
NH ₃ -N	225	240	214	119	169
Cl ⁻	51	17	223	75	42
HCO ₃ ⁻	1094	1094	269	92	817
Total Alkalinity as CaCO ₃	896	896	220	76	670
SO ₄ ⁼					
S ⁼	5.0	3.0	N.D	N.D	0.8
CO ₃ ⁼			119	194	
Al					
B					
Ba	N.D	N.D	N.D	N.D	N.D
Ca	4.65	1.74	34.9	5.23	4.65
Co					
Cu					
Fe	0.08	0.04	0.94	0.04	0.04
Pb	N.D	N.D	N.D	N.D	N.D
Li	N.D	N.D	0.25	0.09	0.04
Mg	N.D	N.D	6.64	0.08	0.04
Mn	N.D	N.D	0.13	N.D	N.D
K	0.73	N.D	2.42	3.64	1.82
Si	N.D	N.D	N.D	N.D	N.D
Na	10.3	4.31	125	38.8	15.9
Sr	N.D	N.D	0.40	0.09	0.05
Zn	N.D	N.D	N.D	N.D	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-13-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.90	6.11		6.70	6.22
Cond	1750	1740		940	1390
NH ₃ -N					
Cl ⁻	60	19		17	17
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼					
S ⁼	9.0	3.5		N.D	0.4
CO ₃ ⁼					
Al					
B					
Ba					
Ca	2.79	0.47		5.58	2.90
Co					
Cu					
Fe	0.06	0.03		0.28	0.09
Pb					
Li					
Mg					
Mn					
K					
Si					
Na	9.46	1.69		5.41	4.39
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-15-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.93	6.00		8.60	6.16
Cond	1650	1700		550	1500
NH ₃ -N					
Cl ⁻	44	18		36	23
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼					
S ⁼	7.0	3.5		N.D	0.2
CO ₃ ⁼					
Al					
B					
Ba					
Ca	2.81	0.31		3.44	1.77
Co					
Cu					
Fe	0.03	0.03		0.03	0.03
Pb					
Li					
Mg					
Mn					
K					
Si					
Na	10.8	1.85		12.7	7.10
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-18-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	6.02	6.63		6.68	6.00
Cond	1750	1750		2700	2200
NH ₃ -N	214	212		136	167
Cl ⁻	36	12		571	248
HCO ₃ ⁻	1080	1067		532	830
Total Alkalinity as CaCO ₃	886	875		436	680
SO ₄ ⁼	N.D	N.D		N.D	N.D
S ⁼	1.5	1.0		N.D	1.0
CO ₃ ⁼					
Al	N.D	N.D		N.D	N.D
B					
Ba	N.D	N.D		N.D	N.D
Ca	2.07	0.22		109	38.0
Co					
Cu	N.D	N.D		N.D	N.D
Fe	0.14	0.09		1.02	0.34
Pb	N.D	N.D		N.D	N.D
Li	N.D	N.D		0.84	0.37
Mg	N.D	N.D		0.34	0.14
Mn	0.04	0.03		2.11	0.94
K	1.20	N.D		43.3	23.3
Si	N.D	N.D		N.D	N.D
Na	7.41	2.16		222	92.6
Sr	0.09	N.D		1.94	0.79
Zn	N.D	N.D		0.66	0.25

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-26-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.91	6.11	8.96	6.22	5.86
Cond	1780	1770	2500	2070	2000
NH ₃ -N	222	202	120	117	190
Cl ⁻	7.8	34	393	423	182
HCO ₃ ⁻	1126	1140	106	490	918
Total Alkalinity as CaCO ₃	923	935	87	401	752
SO ₄ ⁼					
S ⁼	3.0	1.0	0.2	N.D	1.5
CO ₃ ⁼			166		
Al					
B					
Ba	N.D	N.D	N.D	N.D	N.D
Ca	2.72	1.09	65.2	92.4	32.6
Co	N.D	N.D	N.D	N.D	N.D
Cu					
Fe	0.14	0.05	4.24	0.68	0.19
Pb	N.D	N.D	N.D	N.D	N.D
Li	N.D	N.D	0.45	0.78	0.24
Mg	0.12	N.D	15.7	0.47	0.20
Mn	N.D	N.D	0.71	1.49	0.48
K	0.53	N.D	41.2	37.6	11.8
Si	N.D	N.D	2.94	0.98	N.D
Na	3.41	1.42	170	196	62.5
Sr	N.D	N.D	1.03	1.48	0.40
Zn	N.D	N.D	N.D	N.D	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-28-78	1st Stage Steam In	1st Stage Steam Out	2nd Stage Steam In	2nd Stage Steam Out	Combined Condensate
pH	5.89	5.91	8.97	7.24	5.96
Cond	1650	1950	1010	1300	1820
NH ₃ -N					
Cl ⁻	31	14	198	7.3	
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼					
S ⁼	3.5	3.0	0.1	N.D	0.8
CO ₃ ⁼					
Al					
B					
Ba					
Ca	2.38	0.60	35.7	6.55	2.98
Co					
Cu					
Fe	0.15	0.03	1.15	0.09	0.06
Pb					
Li					
Mg					
Mn					
K					
Si	N.D	N.D	N.D	N.D	N.D
Na	3.57	1.10	79.7	7.14	4.12
Sr					
Zn					

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

APPENDIX D

Date: 11-18-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.97	4.99	5.98	5.94	5.21
Cond	265,000	285,000	310,000	347,500	355,000
NH ₃ -N	307	313	340	347	368
Cl ⁻	107,000	104,000	123,000	135,000	135,000
HCO ₃ ⁻	233	228	71	61	51
Total Alkalinity as CaCO ₃	191	187	58.2	50	41.8
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	111	141	152	163	145
Ca	19,100	20,200	21,300	23,400	24,500
Co					
Cu					
Fe	117	120	132	150	153
Pb	28.2	69.2	89.7	103	100
Li					
Mg	94.6	97.8	108	125	128
Mn					
K	6,670	7,220	7,780	8,330	8,890
Si	159	176	205	248	235
Na	39,000	39,600	43,400	47,800	50,500
Sr					
Zn	229	213	229	263	263

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-20-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.99	5.10	5.68	5.80	5.05
Cond	310,000	310,000	335,000	365,000	370,000
NH ₃ -N	323	309	356	381	347
Cl ⁻	109,000	111,000	123,000	138,000	132,000
HCO ₃ ⁻	232	221	68.5	58.0	58.0
Total Alkalinity as CaCO ₃	190	181	56.1	47.5	47.5
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al	0.51	0.77	0.51	0.51	0.51
B					
Ba	115	183	144	163	170
Ca	16,300	17,500	18,800	23,800	25,000
Co					
Cu					
Fe	125	128	141	155	166
Pb	13.9	34.2	41.8	45.6	46.8
Li					
Mg	97.9	105	115	133	136
Mn					
K	6,500	7,000	7,600	9,200	9,200
Si	211	211	230	250	268
Na	39,700	42,500	46,000	54,600	56,900
Sr					
Zn	205	205	230	250	258

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-22-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.83	4.65	5.64	5.72	4.92
Cond	335,000	350,000	360,000	405,000	390,000
NH ₃ -N	338	311	342	394	386
Cl ⁻	126,000	131,000	138,000	145,000	140,000
HCO ₃ ⁻	237	221	63.2	58.0	100
Total Alkalinity as CaCO ₃	194	181	51.8	47.5	82.0
SO ₄ ⁼ (TDS)	208,000	199,000	224,000	245,000	245,000
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	154	135	141	153	158
Ca	19,000	19,000	20,200	22,600	23,800
Co					
Cu					
Fe	124	129	134	153	158
Pb	38.7	39.8	46.2	51.6	50.5
Li					
Mg	99.3	103	110	129	129
Mn					
K	7,570	7,570	8,110	9,730	10,300
Si	209	209	233	257	268
Na	39,700	39,700	44,200	48,700	51,300
Sr					
Zn	204	225	221	250	246

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-27-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.98	4.82	5.90	5.92	5.32
Cond	305,000	309,000	319,000	390,000	365,000
NH ₃ -N	323	317	361	373	356
Cl ⁻	110,000	113,000	122,000	137,000	129,000
HCO ₃ ⁻	221	227	79	74	90
Total Alkalinity as CaCO ₃	181	186	65	60	73
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	118	114	140	143	157
Ca	19,000	27,400	29,800	32,100	28,600
Co					
Cu					
Fe	124	138	146	213	146
Pb	24.7	30.9	49.4	43.2	50.6
Li	156	171	182	209	181
Mg	104	116	123	149	127
Mn	477	614	682	818	750
K	7,030	8,110	8,650	10,800	8,650
Si	179	208	200	217	225
Na	46,500	50,600	58,700	61,600	52,300
Sr					
Zn	188	205	222	239	244

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-29-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.70	4.75	5.64	5.87	4.86
Cond	300,000	290,000	335,000	350,000	350,000
NH ₃ -N	315	333	384	406	378
Cl ⁻	116,000	114,000	129,000	151,000	139,000
HCO ₃ ⁻	206	227	68.5	81.7	132
Total Alkalinity as CaCO ₃	168	186	56.2	67.0	108
SO ₄ ⁼					
TDS	225,000	225,100	251,300	286,600	275,400
CO ₃ ⁼					
Al					
B					
Ba	112	115	118	179	142
Ca	18,600	18,600	23,300	24,400	23,300
Co					
Cu					
Fe	128	131	150	164	167
Pb	36.8	39.5	48.7	56.6	51.3
Li	148	149	165	185	182
Mg	90.2	94.0	113	124	128
Mn	462	474	551	615	615
K	6,670	6,670	7,780	9,440	8,890
Si	180	200	208	215	204
Na	41,000	41,600	50,600	58,400	54,800
Sr					
Zn	212	208	226	261	243

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-4-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.78	4.78	5.70	5.84	5.04
Cond	305,000	291,000	319,500	370,000	360,000
NH ₃ -N	397	297	354	436	378
Cl ⁻	111,000	109,000	127,000	141,000	141,000
HCO ₃ ⁻	253	253			
Total Alkalinity as CaCO ₃	207	207	61	56	52
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al	1.17	1.17	1.56	1.95	2.34
B					
Ba	112	112	119	119	112
Ca	18,200	20,500	22,700	25,000	22,700
Co					
Cu					
Fe	117	123	139	167	153
Pb	13.6	39.5	46.9	48.1	50.6
Li	146	150	171	189	189
Mg	98.5	106	102	120	120
Mn	500	526	579	684	658
K	7,330	8,000	8,660	9,330	9,330
Si	227	236	250	175	181
Na	40,200	42,400	46,700	54,300	50,000
Sr	370	392	432	481	476
Zn	191	205	227	250	241

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-6-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.51	4.45	5.40	5.65	4.92
Cond	297,500	290,000	310,000	370,000	370,000
NH ₃ -N	323	408	361	403	930
Cl ⁻	111,000	110,000	126,000	141,000	141,000
HCO ₃ ⁻	248	242	69	79	58
Total Alkalinity as CaCO ₃	203	199	56	65	48
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	136	136	160	172	172
Ca	20,000	15,000	22,500	22,500	17,500
Co					
Cu					
Fe	122	125	144	156	161
Pb	14.1	29.4	43.5	45.9	49.4
Li	152	148	169	195	193
Mg	90.9	95.0	112	120	120
Mn	524	524	590	694	668
K	7,330	6,670	9,330	11,300	11,300
Si	207	213	245	133	255
Na	39,100	37,900	42,500	56,300	55,200
Sr	393	379	443	476	474
Zn	188	183	210	232	237

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-8-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.83	4.83	5.85	5.86	5.27
Cond	270,000	270,000	302,500	335,000	330,000
NH ₃ -N					
Cl ⁻	111,000	111,000	126,000	141,000	141,000
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	130	137	143	163	176
Ca	21,400	21,400	23,800	26,200	23,800
Co					
Cu	0.28	0.49	0.89	0.57	0.74
Fe	121	115	138	144	150
Pb	8.0	22.6	41.3	42.7	44.0
Li	150	144	166	179	176
Mg	92.4	88.2	101	122	113
Mn	539	451	553	612	626
K	7,620	7,620	9,520	10,500	9,520
Si	231	242	275	154	298
Na	43,100	43,100	48,300	60,300	51,700
Sr	396	366	433	484	497
Zn	184	186	221	236	236

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-11-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.93	4.93	5.78	5.83	5.24
Cond	309,000	300,000	315,000	345,000	365,000
NH ₃ -N	373	276	394	459	363
Cl ⁻	114,000	111,000	129,000	146,000	141,000
HCO ₃ ⁻	227	227	69	63	58
Total Alkalinity as CaCO ₃	186	186	56	52	48
SO ₄ ⁼	11.0	9.0	20.0	28.0	22.0
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	152	132	157	132	170
Ca	20,900	18,600	23,300	20,900	25,600
Co					
Cu					
Fe	129	117	152	180	168
Pb	37.0	20.5	46.6	32.9	52.1
Li	166	150	195	182	210
Mg	88.2	79.8	105	109	118
Mn	563	476	563	534	606
K	7,880	7,270	9,090	9,090	9,700
Si	235	200	253	64.7	253
Na	43,100	37,900	44,800	43,100	55,200
Sr	387	351	455	425	486
Zn	212	182	227	212	247

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-13-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.62	4.66	5.50	5.80	5.15
Cond	300,000	270,000	315,000	370,000	350,000
NH ₃ -N					
Cl ⁻	116,000	109,000	126,000	146,000	141,000
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼	18	20	18	15	20
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	134	116	152	140	159
Ca	19,800	17,400	22,100	23,300	23,300
Co					
Cu					
Fe	130	98.1	133	184	149
Pb	18.7	34.1	45.3	40.0	48.0
Li	154	128	162	179	174
Mg	100	82.6	109	126	122
Mn	520	371	550	624	579
K	7,140	5,710	7,860	8,570	8,570
Si	243	194	264	76.4	257
Na	43,900	35,100	48,600	49,300	46,600
Sr	403	314	428	483	459
Zn	211	163	226	253	253

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-15-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.63		5.56	5.63	5.04
Cond	270,000		310,000	340,000	340,000
NH ₃ -N					
Cl ⁻	114,000		129,000	143,000	143,000
HCO ₃ ⁻					
Total Alkalinity as CaCO ₃					
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	140		157	180	198
Ca	19,800		21,900	26,000	24,000
Co					
Cu					
Fe	145		157	160	148
Pb	16.0		42.7	46.7	49.3
Li	175		166	203	192
Mg	92.4		105	130	113
Mn	531		560	718	675
K	8,130		8,750	10,600	10,000
Si	232		247	103	273
Na	42,600		45,700	55,600	53,100
Sr	403		427	535	488
Zn	197		244	263	250

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-18-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	5.00		5.86	5.86	5.40
Cond	310,000		350,000	385,000	375,000
NH ₃ -N	311		378	358	386
Cl ⁻	114,000		127,000	143,000	141,000
HCO ₃ ⁻	237		74	63	63
Total Alkalinity as CaCO ₃	194		60	52	52
SO ₄ ⁼	29.7		20.3	21.8	25.0
S ⁼					
CO ₃ ⁼					
Al	2.19		2.55	2.92	1.82
B					
Ba	151		162	162	167
Ca	19,600		20,700	21,700	22,800
Co					
Cu	0.39		0.98	1.00	0.84
Fe	130		144	164	164
Pb	10.5		40.8	46.1	44.7
Li	153		167	191	185
Mg	103		117	131	131
Mn	552		619	700	686
K	8,000		9,330	10,700	11,300
Si	228		248	277	277
Na	42,000		45,800	51,900	49,400
Sr	394		440	509	486
Zn	223		256	285	260

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-26-78	Magma Max No. 1	Magma Max No. 1 (RP)	1st Stage Out	2nd Stage Out	Injection
pH	4.80		5.74	5.68	5.53
Cond	310,000		350,000	380,000	380,000
NH ₃ -N	283		331	386	381
Cl ⁻	108,000		122,000	139,000	139,000
HCO ₃ ⁻	267		72	72	61
Total Alkalinity as CaCO ₃	219		59	59	50
SO ₄ ⁼					
S ⁼					
CO ₃ ⁼					
Al					
B					
Ba	122		142	161	161
Ca	20,700		23,900	26,100	25,000
Co	1.96		2.45	2.94	2.45
Cu					
Fe	130		160	160	168
Pb	12.2		43.9	50.0	45.1
Li	163		190	193	194
Mg	106		126	126	130
Mn	533		627	640	653
K	7,650		9,410	10,000	10,600
Si	230		245	275	225
Na	42,600		47,700	51,100	49,400
Sr	397		460	475	477
Zn	195		229	243	229

RP - Retractable Probe

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

APPENDIX E

Date: 11-18-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.31	7.68	7.71
Cond	940	1940	2000
NH ₃ -N	132	37.2	37.4
Cl ⁻	13.4	283	283
HCO ₃ ⁻	178	249	249
Total Alkalinity as CaCO ₃	146	204	204
SO ₄ ⁼			
Total PO ₄ ⁼		9.4	9.4
Ortho PO ₄ ⁼		7.2	9.8
Organic PO ₄ ⁼			
CO ₃ ⁼	275		
Al			
B			
Ba			
Ca	0.53	85.1	85.1
Co			
Cu			
Fe	0.90	2.60	2.63
Pb			
Li			
Mg		4.05	4.05
Mn			
P	0.56	28.9	26.7
Si		15.8	15.8
Na	6.32	187	187
Sr			
Zn			

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-20-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.15	7.80	7.69
Cond	920	2150	2150
NH ₃ -N	134	48.2	48.0
Cl ⁻	49.3	259	259
HCO ₃ ⁻	527	316	316
Total Alkalinity as CaCO ₃	432	259	259
SO ₄ ⁼			
Total PO ₄ ⁼		11.2	11.0
Ortho PO ₄ ⁼		10.4	10.0
Organic PO ₄ ⁼			
CO ₃ ⁼	130		
Al	N.D	N.D	N.D
B			
Ba	N.D	N.D	N.D
Ca	1.25	100	106
Co			
Cu			
Fe	0.54	2.61	2.58
Pb	N.D	N.D	N.D
Li			
Mg	N.D	38.5	40.2
Mn			
P	2.16	37.8	37.8
Si	N.D	15.4	16.5
Na	4.31	227	241
Sr			
Zn	N.D	0.08	0.08

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-22-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	6.91	7.81	7.81
Cond	1370	2300	2300
NH ₃ ⁻ N	123	55.6	54.6
Cl ⁻	33.5	330	321
HCO ₃ ⁻	1383	342	337
Total Alkalinity as CaCO ₃	1134	280	276
SO ₄ ⁼			
Total PO ₄ ⁼			
Ortho PO ₄ ⁼			
Organic PO ₄ ⁼			
CO ₃ ⁼			
Al			
B			
Ba			
Ca	4.76	89.3	89.3
Co			
Cu			
Fe	7.63	2.61	2.63
Pb			
Li			
Mg			
Mn			
P	1.62	35.1	35.1
Si	N.D	16.7	16.7
Na	11.9	212	208
Sr			
Zn		0.08	0.08

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-27-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	7.80	7.68	7.68
Cond	1260	2190	2200
NH ₃ ⁻ N	145	69.4	69.4
Cl ⁻	41.0	402	402
HCO ₃ ⁻	935	369	364
Total Alkalinity as CaCO ₃	767	302	298
SO ₄ ⁼			
Total PO ₄ ⁼		6.0	5.8
Ortho PO ₄ ⁼		3.4	4.0
Organic PO ₄ ⁼		1.2	1.0
CO ₃ ⁼			
Al			
B		1	
Ba	N.D	N.D	N.D
Ca	0.60	137	137
Co			
Cu			
Fe	2.44	3.03	2.87
Pb	N.D	N.D	N.D
Li	N.D	0.23	0.23
Mg	N.D	39.2	39.2
Mn	0.08	0.98	0.98
P	5.41	35.1	29.7
Si	N.D	21.4	21.4
Na	9.59	262	262
Sr			
Zn	N.D	N.D	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 11-29-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	8.69	7.85	7.80
Cond	1280	2300	2300
NH ₃ -N	160	82.2	73.1
Cl ⁻	24.7	425	425
HCO ₃ ⁻	804	379	385
Total Alkalinity as CaCO ₃	659	311	315
SO ₄ ⁼			
Total PO ₄ ⁼		11.2	12.6
Ortho PO ₄ ⁼		5.7	5.9
Organic PO ₄ ⁼		0.6	1.0
CO ₃ ⁼	168		
Al			
B			
Ba			
Ca	0.35	105	105
Co			
Cu			
Fe	1.17	2.81	2.81
Pb			
Li			
Mg		39.5	41.4
Mn			
P	0.89	38.9	38.9
Si		20.6	20.6
Na	12.7	244	262
Sr			
Zn		N.D	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-4-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.15	7.88	7.88
Cond	1560	2700	2700
NH ₃ -N	195	84.0	90.4
Cl ⁻	22.0	495	495
HCO ₃ ⁻	922	401	395
Total Alkalinity as CaCO ₃	756	328	324
SO ₄ ⁼			
Total PO ₄ ⁼		18.5	13.8
Ortho PO ₄ ⁼		8.4	7.4
Organic PO ₄ ⁼		6.2	2.5
CO ₃ ⁼	285		
Al	N.D	N.D	N.D
B			
Ba	N.D	N.D	N.D
Ca	0.91	114	108
Co			
Cu			
Fe	0.93	3.52	3.55
Pb	N.D	N.D	N.D
Li	N.D	0.27	0.27
Mg	N.D	38.3	36.5
Mn	N.D	1.11	1.07
P	0.27	50.0	53.3
Si	N.D	20.6	30.6
Na	7.34	261	258
Sr	N.D	1.13	1.13
Zn	N.D	0.09	0.09

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-6-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.30	8.00	7.98
Cond	1550	2800	2800
NH ₃ ⁻ N	240	95	98
Cl ⁻	23	494	524
HCO ₃ ⁻	777	432	426
Total Alkalinity as CaCO ₃	637	354	350
SO ₄ ⁼			
Total PO ₄ ⁼		13.8	13.8
Ortho PO ₄ ⁼		9.6	8.4
Organic PO ₄ ⁼		2.0	3.0
CO ₃ ⁼	402		
Al			
B			
Ba		N.D	N.D
Ca	0.25	106	119
Co			
Cu			
Fe	0.67	3.78	3.78
Pb		N.D	N.D
Li		0.31	0.31
Mg		37.2	39.3
Mn		1.28	1.27
P	0.13	53.3	56.7
Si		25.0	25.0
Na	4.0	267	287
Sr	N.D	1.19	1.21
Zn		0.09	0.09

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-8-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.15	7.85	7.85
Cond	1570	2750	2750
NH ₃ ⁻ N			
Cl ⁻	23	514	534
HCO ₃ ⁻			
Total Alkalinity as CaCO ₃			
SO ₄ ⁼			
Total PO ₄ ⁼		15.8	15.8
Ortho PO ₄ ⁼		8.6	8.8
Organic PO ₄ ⁼		1.0	0.0
CO ₃ ⁼			
Al			
B			
Ba			
Ca	0.71	119	125
Co			
Cu			
Fe	0.32	2.88	2.91
Pb			
Li			
Mg			
Mn			
P	0.57	61.9	66.7
Si		27.0	27.0
Na	3.88	284	284
Sr			
Zn			

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-11-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.15	7.82	7.80
Cond	1600	3000	3100
NH ₃ -N	243	103	101
Cl ⁻	28	613	613
HCO ₃ ⁻	619	480	480
Total Alkalinity as CaCO ₃	508	393	393
SO ₄ ⁼		473	511
Total PO ₄ ⁼		21.0	22.3
Ortho PO ₄ ⁼		10.4	10.4
Organic PO ₄ ⁼		5.0	4.3
CO ₃ ⁼	505		
Al			
B			
Ba	N.D	N.D	N.D
Ca	0.47	128	128
Co			
Cu			
Fe	0.04	3.05	3.13
Pb	N.D	N.D	N.D
Li	N.D	0.38	0.38
Mg	0.08	42.0	39.9
Mn	0.03	1.23	1.23
P	N.D	51.5	54.5
Si	N.D	28.9	28.9
Na	5.60	474	388
Sr	N.D	1.20	1.20
Zn	N.D	0.20	0.20

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-13-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.30	7.96	8.00
Cond	1680	3100	3100
NH ₃ -N			
Cl ⁻	28	574	574
HCO ₃ ⁻			
Total Alkalinity as CaCO ₃			
SO ₄ ⁼		467	
Total PO ₄ ⁼		14.3	14.3
Ortho PO ₄ ⁼		10.0	9.6
Organic PO ₄ ⁼		3.3	2.5
CO ₃ ⁼			
Al			
B			
Ba			
Ca	0.23	105	105
Co			
Cu			
Fe	0.03	3.77	3.73
Pb			
Li			
Mg			
Mn			
P	N.D	64.3	57.1
Si			
Na	3.72	314	311
Sr			
Zn			

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-15-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.23	7.88	7.86
Cond	1650	3100	3100
NH ₃ ⁻ N			
Cl ⁻	26	633	633
HCO ₃ ⁻			
Total Alkalinity as CaCO ₃			
SO ₄ ⁼			
Total PO ₄ ⁼		13.8	13.5
Ortho PO ₄ ⁼		8.2	8.6
Organic PO ₄ ⁼		3.5	3.2
CO ₃ ⁼			
Al			
B			
Ba			
Ca	0.42	130	130
Co			
Cu			
Fe	0.03	2.77	2.77
Pb			
Li			
Mg			
Mn			
P		65.6	65.6
Si		38.7	28.7
Na	4.63	401	407
Sr			
Zn			

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-18-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.11	7.80	7.80
Cond	1950	3400	3400
NH ₃ -N	288	126	110
Cl ⁻	17	62	62
HCO ₃ ⁻	395	469	469
Total Alkalinity as CaCO ₃	324	384	384
SO ₄ ⁼	N.D	453	453
Total PO ₄ ⁼		19.0	15.1
Ortho PO ₄ ⁼		8.6	8.6
Organic PO ₄ ⁼			
CO ₃ ⁼	609		
Al	N.D	N.D	N.D
B			
Ba	N.D	N.D	N.D
Ca	0.98	136	130
Co			
Cu	N.D	N.D	N.D
Fe	0.17	3.64	3.59
Pb	N.D	N.D	N.D
Li	N.D	0.45	0.45
Mg	0.17	37.9	37.9
Mn	N.D	1.47	1.49
P	0.93	70.0	66.7
Si	N.D	38.1	38.1
Na	9.26	340	340
Sr	N.D	1.57	1.57
Zn	N.D	0.33	0.25

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

Date: 12-26-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	9.00	7.69	7.65
Cond	1880	3500	3500
NH ₃ ⁻ N	247	117	122
Cl ⁻	27	716	716
HCO ₃ ⁻	500	467	467
Total Alkalinity as CaCO ₃	410	383	383
SO ₄ ⁼			
Total PO ₄ ⁼		8.1	9.0
Ortho PO ₄ ⁼		2.4	2.4
Organic PO ₄ ⁼			
CO ₃ ⁼	589		
Al			
B			
Ba	N.D	N.D	N.D
Ca	2.17*	147	141
Co	N.D	N.D	N.D
Cu			
Fe	0.16	4.02	4.05
Pb	N.D	N.D	N.D
Li	N.D	0.49	0.49
Mg	0.16	35.4	39.4
Mn	N.D	1.40	1.39
P	0.47	73.5	73.5
Si	N.D	36.7	36.7
Na	12.2	318	318
Sr	N.D	1.38	1.36
Zn	N.D	N.D	N.D

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.
 *Reading high possibly due to leaks of the cooling water condenser.

Date: 12-28-78	Binary	From Pond To Condensers	To Pond From Condensers
pH	8.86	7.52	7.50
Cond	1800	3500	3600
NH ₃ ⁻ N			
Cl ⁻	28	736	736
HCO ₃ ⁻			
Total Alkalinity as CaCO ₃			
SO ₄ ⁼			
Total PO ₄ ⁼		22.5	22.3
Ortho PO ₄ ⁼		13.1	13.1
Organic PO ₄ ⁼		1.3	1.3
CO ₃ ⁼			
Al			
B			
Ba			
Ca	1.79	119	119
Co			
Cu			
Fe	0.06	4.47	4.38
Pb			
Li			
Mg			
Mn			
P			
Si		36.4	36.4
Na	15.4	330	341
Sr			
Zn			

Note: All of the units in this table are ppm except pH and Cond which are dimensionless and umhos respectively.

APPENDIX F

P-2 SUCTION
Date: 11-30-78

Wt. %	% Fraction	% Total Scale
Ca - 2.58	Water Soluble - 54.6	CaCl ₂ - 14.25
Cu - 0.16	CaCl ₂ - 26.1	PbCl ₂ - 0.11
Fe - 0.81	PbCl ₂ - 0.2	LiCl ₂ - 0.05
Pb - 0.38	LiCl - 0.1	MgCl ₂ - 0.11
Li - 0.02	MgCl ₂ - 0.2	MnCl ₂ - 0.44
Mg - 0.02	MnCl ₂ - 0.8	KCl - 4.04
Mn - 0.12	KCl - 7.4	NaCl - 35.38
K - 0.94	NaCl - 64.8	SrCl ₂ - 0.22
Si - 19.79	SrCl ₂ - 0.4	CaO - 0.57
Na - 6.36		CuS - 0.14
Sr - 0.05		FeS - 0.69
		PbS - 0.30
	Acid Soluble - 2.6	MnO - 0.05
	CaO - 22.1	Na ₂ SiO ₃ - 0.85
	CuS - 5.3	CaSiO ₃ - 0.26
	FeS - 26.5	CuO - 0.13
	PbS - 11.5	Fe ₃ O ₄ - 0.81
	MnO - 1.8	PbO - 0.21
	Na ₂ SiO ₃ - 32.8	MnSiO ₃ - 0.04
		SiO ₂ - 41.35
	Acid Insoluble - 42.8	
	CaSiO ₃ - 0.6	
	CuO - 0.3	
	Fe ₃ O ₄ - 1.9	
	PbO - 0.5	
	MnSiO ₃ - 0.1	
	SiO ₂ - 96.6	

P-2 DISCHARGE
Date: 11-30-78

Wt. %	% Fraction	% Total Scale
Ca - 3.22	Water Soluble - 51.9	CaCl ₂ - 15.93
Cu - 0.22	CaCl ₂ - 30.7	PbCl ₂ - 0.67
Fe - 0.23	PbCl ₂ - 1.3	LiCl - 0.26
Pb - 0.66	LiCl - 0.5	MnCl ₂ - 0.31
Li - 0.02	MnCl ₂ - 0.6	KCl - 3.48
Mg - 0.00	KCl - 6.7	NaCl - 31.09
Mn - 0.08	NaCl - 59.9	SrCl ₂ - 0.16
K - 0.96	SrCl ₂ - 0.3	CaCo ₃ - 0.35
Si - 23.33		CuS - 0.16
Na - 6.56		FeS - 0.13
Sr - 0.05		PbS - 0.10
	Acid Soluble - 1.1	Na ₂ SiO ₃ - 0.36
	CaCo ₃ - 31.4	CaSiO ₃ - 0.05
	CuS - 14.9	CuO - 0.14
	FeS - 11.9	Fe ₃ O ₄ - 0.24
	PbS - 9.0	PbO - 0.33
	Na ₂ SiO ₃ - 32.8	SiO ₂ - 46.24
	Acid Insoluble - 47.0	
	CaSiO ₃ - 0.1	
	CuO - 0.3	
	Fe ₃ O ₄ - 0.5	
	PbO - 0.7	
	SiO ₂ - 98.4	

SPOOL PIECE BETWEEN 1B & 2B SEPARATORS
Date: 12-5-78

Wt. %	% Fraction	% Total Scale
Al - 0.09	Water Soluble - 26.3	BaCl ₂ - 0.03
Ba - 0.01	BaCl ₂ - 0.1	CaCl ₂ - 5.50
Ca - 1.28	CaCl ₂ - 20.9	FeCl ₂ - 0.03
Cu - 0.07	FeCl ₂ - 0.1	PbCl ₂ - 1.21
Fe - 16.34	PbCl ₂ - 4.6	LiCl - 0.13
Pb - 12.34	LiCl - 0.5	MgCl ₂ - 0.32
Li - 0.01	MgCl ₂ - 1.2	MnCl ₂ - 1.52
Mg - 0.47	MnCl ₂ - 5.8	KCl - 0.11
Mn - 0.47	KCl - 0.4	Na ₂ SO ₄ - 4.28
K - 0.03	Na ₂ SO ₄ - 16.3	NaCl - 13.10
Si - 14.04	NaCl - 49.8	SrCl - 0.05
Na - 3.31	SrCl ₂ - 0.2	ZnCl ₂ - 0.03
Sr - 0.02	ZnCl ₂ - 0.1	Al ₂ S ₃ - 0.36
Zn - 0.13		CaO - 0.10
		CuS - 0.05
		FeS - 9.10
		PbS - 6.45
	Acid Soluble - 17.1	MgO - 0.36
	Al ₂ S ₃ - 2.1	MnO - 0.46
	CaO - 0.6	Na ₂ SiO ₃ - 0.12
	CuS - 0.3	ZnS - 0.09
	FeS - 53.2	Al ₂ O ₃ - 1.13
	PbS - 37.8	CaSiO ₃ - 0.62
	MgO - 2.1	Fe ₃ O ₄ - 13.19
	MnO - 2.7	PbSO ₄ - 16.75
	Na ₂ SiO ₃ - 0.7	MgSiO ₃ - 0.91
	ZnS - 0.5	MnSiO ₃ - 0.91
		SiO ₂ - 23.03
		ZnO - 0.06
	Acid Insoluble - 56.6	
	Al ₂ O ₃ - 2.0	
	CaSiO ₃ - 1.1	
	Fe ₃ O ₄ - 23.3	
	PbSO ₄ - 29.6	
	MgSiO ₃ - 1.6	
	MnSiO ₃ - 1.6	
	SiO ₂ - 40.7	
	ZnO - 0.1	

INJECTION LINE
Date: 12-21-78

Wt. %
Al - 0.09
Ba - 0.50
Ca - 0.47
Cu - 0.28
Fe - 1.56
Pb - 2.29
Mg - 0.03
Mn - 0.23
K - 0.11
Si - 38.82
Na - 1.07
Sr - 0.07
Zn - 0.17

% Fraction
Water Soluble - 13.8
BaCl₂ - 0.3
CaCl₂ - 16.2
MgCl₂ - 0.6
MnCl₂ - 0.9
CKl - 6.2
NaCl - 75.4
SrCl₂ - 0.6

Acid Soluble - 10.1
Al₂(SO₄)₃ - 0.9
BaCO₃ - 8.4
CaCO₃ - 5.4
CuO - 5.6
Fe₂O₃ - 24.7
PbO - 42.2
MgCO₃ - 0.2
MnCO₃ - 4.7
Na₂SiO₃ - 3.8
SrCO₃ - 1.6
ZnO - 2.5

Acid Insoluble - 76.1
Al₂O₃ - 0.2
BaSO₄ - 0.4
CaSiO₃ - 0.4
CuO - 0.1
Fe₃O₄ - 1.4
PbSO₄ - 0.9
MgSiO₃ - 0.1
MnSiO₃ - 0.2
SiO₂ - 96.2
ZnO - 0.1

% Total Scale
BaCl₂ - 0.04
CaCl₂ - 2.24
MgCl₂ - 0.08
MnCl₂ - 0.12
KCl - 0.86
NaCl - 10.40
SrCl₂ - 0.08
Al₂(SO₄)₃ - 0.09
BaCO₃ - 0.85
CaCO₃ - 0.55
CuO - 0.57
Fe₂O₃ - 2.49
PbO - 4.26
MgCO₃ - 0.02
MnCO₃ - 0.47
Na₂SiO₂ - 0.38
SrCO₃ - 0.16
ZnO - 0.25
Al₂O₃ - 0.15
BaSO₄ - 0.30
CaSiO₃ - 0.30
CuO - 0.08
Fe₃O₄ - 1.07
PbSO₄ - 0.68
MgSiO₃ - 0.08
MnSiO₃ - 0.15
SiO₂ - 73.20
ZnO - 0.08