Hydrodynamic/Kinetic Reactions In Liquid-Dominated Geothermal Systems

Final Report

April 1982

Contract No. 4-X29-9916F-1

Prepared For:
Los Alamos National Laboratory
And The U.S. Department Of Energy

By:
J. P. Nesewich
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**HYDRODYNAMIC/KINETIC REACTIONS IN
LIQUID DOMINATED GEOTHERMAL SYSTEMS**

HYDROSCALE TEST PROGRAM
Mercer 2 Well Site, South Brawley, California
(Tests No. 15-20, 27 October 1980 - 6 February 1981)

Final Report April 1982

Prepared by:

J.P. Nesevich

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FOREWORD

The work described herein was performed by the Aerojet Energy Conversion Company (AECC) under Contract 4-X29-9916F-1 for the U.S. Department of Energy (DOE) under the auspices of the Los Alamos National Laboratory.

The technical period of performance for this study was from April 1979 to April 1981.

The study provided scale, brine and vapor characterization data for flash power-plant systems using both single- and multiple-flash power cycles.

The authors extend their deep appreciation to the following for their valuable contributions to the program:

Dr. R. Feber, Los Alamos National Laboratory, for his technical coordination of the program and for directing the SEM and X-ray analyses;

Mr. J. Kuwadu, Vice-President of Engineering, Geothermal Kinetics Inc., for assisting in the development of the program test plan and providing dedicated well flows to facilitate testing;

Dr. Otto Vetter of Vetter Research, AECC subcontractor, for conducting the chemical analyses and providing valuable equipment design information; and,

Representatives of the DOE for their support, with particular thanks to Anthony J. Adduci, for his management assistance throughout the work effort.

ABSTRACT

The Aerojet Energy Conversion Company, under contract to the Los Alamos National Laboratory, U.S. Department of Energy, has constructed and tested a mobile geothermal well-site test unit at the Mercer 2 well in South Brawley, California (Imperial Valley). The equipment controlled, monitored, and recorded all process conditions of single- and dual-flash power cycles. Single- and two-phase flashed brine effluents were flowed through piping component test sections to provide hydrodynamic/kinetic data for scale formation. The unit operated at flowrates in excess of 200 gpm and is designed to accommodate flowrates up to 300 gpm.

Primary scale formations encountered were those of PbS, Fe₂(OH)₃Cl (iron hydroxychloride), iron chlorides, and non-crystalline forms of SiO₂. The formation of iron hydroxychloride was due to the unusually high concentration of iron in the wellhead brine (5000 mg/l).

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I. SUMMARY	1
II. INTRODUCTION	4
III. EQUIPMENT DESIGN	6
A. Test Equipment Trailer	6
B. Instrumentation and Controls Trailer	13
C. Diesel Generator Trailer	13
IV. TEST PLAN	15
A. Plan Objectives	15
B. Sampling Plan	16
C. Operational Plan and Summary	17
V. SAMPLING AND ANALYTICAL PROCEDURES	24
A. Sample Collection	24
B. Sample Analysis	29
VI. CHECKOUT TESTS	36
A. Site and Equipment	36
B. Single-Flash Checkout Test	36
C. Multiple-Flash Checkout Test	42
VII. RESULTS OF STEAM AND GAS ANALYSIS FOR CHECKOUT & POWER CYCLE TESTS	50
A. Brine Vapor Pressure Analyses	50
B. Determination of Steam and Noncondensable Gas Flows	51
VIII. RESULTS: BRINE AND SCALE ANALYSIS	55
A. Test Objectives	55
B. Scale Analysis	57
C. Power Cycle Test Results (Tests 19 & 20)	69
XI. CONCLUSIONS AND RECOMMENDATIONS	124
X. LITERATURE REFERENCES	128
APPENDIX A: Equipment Design	
APPENDIX B: Process Analysis	
APPENDIX C: System Mass Balances	
APPENDIX D: Scale Data Sheets	
APPENDIX E: Chemistry Data Sheets	

TABLE OF CONTENTS (cont.)

	<u>Page</u>
<u>FIGURES</u>	
III-1	Test Equipment Trailer en Route to the Imperial Valley
III-2	Views of Test Equipment at the Mercer 2 Well Site
III-3	Flow Schematic - Staged Flash - Pumped Brine
III-4	Flash Tank Drawing
III-5	Hydroscale P&ID
IV-1	Flash Tank Coupon Locations and Details
IV-2	Flash Tank Coupons
IV-3	Typical Test Section Configurations
V-1	Flash Tank Sampling Probe
V-2	Cooling Coil Assembly and Details
V-3	Sample Preparation and Analysis Flow Chart
VI-1	Hydroscale Equipment and Well Site Piping Layout
VI-2	Simplified P&ID for Single-Flash Checkout Test No. 15
VI-3	Wellhead Pressure, Temperature and Injection Flow Rates vs. Time (Test No. 15, 10/27/80 thru 10/28/80)
VI-4	Simplified P&ID for Dual-Flash Checkout Tests 16, 17 and 18
VI-5	12 Inch Steam Muffler Discharging into Baker Tank
VI-6	Flash Tank A Steam Valve - PCV 12A
VI-7	Wellhead Pressure, Temperature and Injector Flow Rate vs. Time (Test Nos. 16, 17 & 18, 12/8/80 thru 12/12/80)
VII-1	Brine Saturation Curves
VIII-1	Test Section 400-SP-50-3 (Upstream of 3/4-inch Orifice)
VIII-2	Test Section 400-SP-50-7 (Downstream of 3/4-inch Orifice)
VIII-3	Test Section 400-SU-50-3 (a & b) Upstream of 3/4-inch Orifice Plate and 400-SU-50-7 (c) Downstream of 3/4-inch Orifice Plate
VIII-4	Test Section 400-DU-100-3 (Upstream of 3/4-inch Orifice Plate)
VIII-5	Test Section 400-DU-100-7 (Downstream of 3/4-inch Orifice Plate)
VIII-6	Test Section 300-DU-200-3 (Upstream of 3/4-inch Orifice Plate)
VIII-7	Test Section 300-DU-200-7 (Downstream of 3/4-inch Orifice Plate)
VIII-8	Flash Tank A Block Valve Insert (V-21A)
VIII-9	Flow Diagram for Test 19-1 (Pumped)
VIII-10	Test Section Configuration for Test 19-1 (Pumped)
VIII-11	Test Section 200-SP-50 (Straight Pipe)
VIII-11a	Straight Pipe Sections (200-SP-50)
VIII-12	Test Section 300-SP-50 (Expansion/Contraction)
VIII-12a	Expansion/Contraction Sections (300-SP-50)
VIII-13	Test Section 400-SP-50 (3/4-inch Orifice)
VIII-14	Test Section 400-SP-50 (1-inch Orifice)
VIII-15	Flow Diagram for Test 19-2 (Unpumped)
VIII-16	Test Section Configuration for Test 19-2 (Unpumped)
VIII-17	Test Section 200-SU-50 (Straight Pipe)
VIII-18	Test Section 300-SU-50 (Expansion/Contraction)
VIII-19	Test Section 400-SU-50 (3/4-inch Orifice)
VIII-20	Test Section 500-SU-50 (1-inch Orifice)
VIII-21	Flash Tank A Brine Flow and Scale Analysis (Tests 19-1 & 19-2)

TABLE OF CONTENTS (cont.)

Page

FIGURES

VIII-22	Wellhead Pressure, Temperature and Flow vs Time (Tests 19-1 & 19-2)	94
VIII-23	Injection Line RTD (TE85) Thermo Well	97
VIII-24	Flow Diagram for Test 20-1 (100 psig)	99
VIII-25	Test Section Configuration for Test 20-1 (100 psig)	100
VIII-26	Test Section 100-DU-100 (Straight Pipe)	102
VIII-27	Test Section 300-DU-100 (Expansion/Contraction)	103
VIII-27a	Test Section 300-DU-100 (Expansion/Contraction)	104
VIII-28	Test Section 400-DU-100 (3/4-inch Orifice)	105
VIII-29	Test Section 500-DU-100 (1-inch Orifice)	106
VIII-30	Flow Diagram for Test 20-2 (200 psig)	108
VIII-31	Test Section Configuration for Test 20-2 (200 psig)	109
VIII-32	Test Section 100-DU-200 (Straight Pipe)	111
VIII-33	Test Section 200-DU-200 (Expansion/Contraction)	112
VIII-33a	Test Section 200-DU-200 (Expansion/Contraction)	113
VIII-34	Test Section 300-DU-200 (3/4-inch Orifice)	114
VIII-34a	Microphoto of Scale Build-up on Inlet Edge of 3/4-inch Orifice (300-DU-200)	115
VIII-35	Test Section 400-DU-200 (1-inch Orifice)	116
VIII-35a	Microphoto of Scale Build-up on Inlet Edge of 1-inch Orifice (400-DU-200)	117
VIII-36	Flash Tank A Brine Flow and Scale Analysis (Tests 20-1 & 20-2)	119
VIII-37	Flash Tank B Brine Flow and Scale Analysis (Tests 20-1 & 20-2)	121
VIII-38	Wellhead Pressure, Temperature and Flow vs Time (Tests 20-1 & 20-2)	123

TABLES

I-1	Wellhead Brine Composition for Single-Flash Tests 19-1 & 19-2	2
IV-1	Test Series Summary	23
IV-2	Piping Section Tests (2" Pipe)	23
V-1	Sample Analysis Summary	28
V-2	Number of Liquid and Gas Samples Collected	30
V-3	Number of Solid Samples Collected for Analysis	31
VII-1	Discharge Steam/Noncondensable Gas Concentrations	54
VIII-1	Wellhead Brine Chemistry Test 19 and 20	56
VIII-2	Test Section Brine Chemistry Analysis - Pumped	76
VIII-3	Test Section Brine Chemistry Analysis - Unpumped	86
VIII-4	Flash Tank A Brine/Vapor Chemistry Analysis (Tests 19-1 & 19-3)	93
VIII-5	Test Section Brine Chemistry Analysis for Test 20-1 (100 psig)	101
VIII-6	Test Section Brine Chemistry Analysis for Test 20-2 (200 psig)	110
VIII-7	Flash Tank A (200 psig) Brine/Vapor Chemistry Analysis (Tests 20-1 & 20-2)	120
VIII-8	Flash Tank B (100 psig) Brine/Vapor Chemistry Analysis (Tests 20-1 & 20-2)	122

I SUMMARY

This report presents the results of flashed power cycle-tests conducted with mobile test equipment at the Mercer 2 well site in South Brawley, California. The test equipment operated at single- and dual-flash pressures at flowrates of approximately 200 gpm. Objectives of the tests were to:

- (1) Measure and characterize scale depositions in flash tanks and test sections;
- (2) Monitor (qualitatively and quantitatively) gas and brine chemistries throughout the process; and
- (3) Provide accurate thermo-physical measurements at each step of the energy conversion process (power cycle).

The tests included two preliminary checkout tests and two series of flashed power-cycle tests (single and dual flash).

The single-flash power-cycle tests were operated at average pressures of 48 and 26 psig (Tests 19-1 and 19-2). The multiple-flash (dual-flash) tests were operated at average pressures of 178 and 89 psig, respectively (Tests 20-2 and 20-1). Brine flows from each of the four flashing pressures were routed through four 2-inch pipe component test sections for scale deposition data. The flows from the 48 psig single-flash test were pumped to the test sections to ensure single-phase flow. All other brine flows from the flash tanks were unpumped.

Brine/gas chemistry samples were taken and analyzed for each step of the energy conversion cycle. Scale samples from flash tanks and test sections were collected and analyzed for each test. Brine flow from the wellhead was two-phase at an average pressure and temperature of 450 psig and 436°F, respectively. Dissolved solids in the brine ranged from 280,000 to 320,000 mg/L. The pH of the brine ranged from 4.5 to 5.5. Table I-1 shows the average wellhead brine composition for the single-flash tests. Qualitative analysis indicates brine to be corrosive to carbon steel.

I. (continued)

Table I-1. Wellhead Brine Composition for Single-Flash Tests 19-1 and 19-2

Mercer 2 Well

Constituent	Concentration (mg/l) *
Na	71,500
K	9,560
Li	266
Ca	23,300
Mg	441
Ba	2,460
Sr	1,905
B	272
Al	<3
Fe	4,940
Mn	1,190
Pb	255
Zn	1,282
SiO ₂	627
SO ₄	1.
CO ₂	456
HCO ₃	210
CO ₃	1.1
Cl	171,000
TDS	286,000
pH	5.32

The following elements were found to be less than the established detection limit: Ag <0.3; As <10; Au <0.9; Be <0.1; Cd <0.7; Ce <13.0; Co <0.9; Cr <1.1; Cu <0.2; Ga <6.5; Ge <7.5; Hg <3; La <0.3; Mo <7.5; Ni <3.5; PO₄ <10; Sb <4; Se <14; Sn <10; Ti <0.2; V <0.3; Zr <0.5;

*These concentrations are average values based upon the chemical analyses of 17 well-head brine samples taken 1/7/81 through 1/11/81.

L (continued)

Steam and Noncondensable Gases

- o Inlet brine flows were two-phase. Calculations indicate that the vapor phase is approximately 5 to 8% of the total flow by weight.
- o Noncondensable gas content of incoming brine was approximately 4 to 5% of the total flow by weight.
- o Gas Composition analyses of vapor derived from flashing process is as follows (1):

Constituent (% wt)	Single-Flash Tests		Multiple-Flash Tests	
	19-1	19-2	20-1	20-2
H ₂ O (steam)	73.3	65.3	65.2	65.6
CO ₂	22.9	32.9	32.4	33.6
N ₂	2.8	1.1	1.6	0.3
CH ₄	0.1	0.2	0.3	0.3
Ar+O ₂ (2)	0.8	0.5	0.5	0.2
H ₂ S	---	---	0.005	0.002

Notes:

- (1) Enthalpy values used for the calculation of gas flows were extrapolated from Geological Survey Bulletin 1421-B, Ref. 1.
- (2) Laboratory analysis did not distinguish between Ar and O₂. However, due to the reducing nature of the fluid, it is doubtful that O₂ is present.

Scale Formation

- o Scale formation types are as follows:

Test No.	Avg. Pressure (psig)	Type of Scale	Degree of Scale Formation
20-2	178	PbS	Light
20-1	89	Fe ₂ (OH) ₃ Cl	Heavy
19-1	48	Fe ₂ (OH) ₃ Cl & Silica	Heavy
19-2	26	SiO ₂	Extremely heavy

- o The unusual formation of iron hydroxychloride (Fe₂(OH)₃Cl) scale occurred at flash pressures of 89 and 48 psig. Iron sulfides were found at the 178 psig flash pressure along with the major constituent lead sulfide.
- o Primary scaling mechanism is the impingement of suspended solids on walls and obstructions.
- o All scale depositions have a rippled or waved surface. Spacing or period varied for each test condition.

II. INTRODUCTION

The Hydrodynamics/Kinetics Reaction Study was performed by Aerojet Energy Conversion Company (AECC) under contract to the Los Alamos National Laboratory. Los Alamos conducted the program for the U.S. Department of Energy, San Francisco Operations Office (DOE/SAN).

This report covers testing activities performed at the Mercer 2 well in South Brawley, California, from October 1980 to February 1981. The Mercer well is one of the deepest in the Imperial County (approximately 13,500 feet total depth). Wellhead temperatures and pressures experienced while test equipment was operating were in excess of 436°F and 450 psig, respectively.

Program objectives were initially based upon the need for data which could provide insight to the mechanisms and control of scale formation of actual geothermal fluids. The test plan was designed to measure the effects of the hydrodynamics on the rate (kinetics) and type of scale deposition. This was to be accomplished by varying flow rates (Reynolds Number 10^4 – 10^7) of pumped effluent (flashed) brines through various piping component configurations. Initially, carbonate and heavy metal sulfide type fluids were to be examined in this study. However, due to well availability, program changes and costs, full-scale testing was limited to only one heavy metal sulfide type well, i.e., Mercer 2 in South Brawley.

The mobile test equipment was designed and constructed to process flowrates up to 300 gallons per minute (gpm) and to provide multiple flashing capability. The resultant effluent (flashed) brines are pumped (single-phase flow) or flowed (two-phase flow) through piping component test sections on which scale is deposited. While brines are flowed through the test sections at controlled rates, the thermodynamic data are recorded and inlet/outlet brine samples for chemical analysis are taken.

After the test equipment had been fabricated, the program was redirected to perform tests only at typical power plant pressures and flows. Under this revised mode of operation, flash tank scale and vapor evaluations, along with system mass/energy balances, were added to the scope. The hydrodynamic/kinetic interaction (scale formation) data were therefore limited to typical power plant flow velocities for both single- and two-phase flows.

The test equipment was initially checked out at the DOE facility at East Mesa before the test program at the Mercer 2 well was initiated. These tests included two

II. (continued)

preliminary checkout tests and two series of flashed power-cycle tests (single and double flash). The single-flash tests were operated at a nominal 50 psig flashing pressure. Effluent (flashed) brines were flowed through two sets of test sections, one with the aid of a pump. The dual-flash tests were operated at nominal flashing pressures of 200 and 100 psig. Effluent brines from both dual-flash tests were flowed through respective test sections without the aid of a pump.

Resulting scale and chemistry data are essentially those which would be expected in a full-sized single- or multiple-flashed brine power plant, i.e., power plant design data. The following chapters are organized to discuss equipment design, test planning, sampling/analytical procedures, checkout operating experience, results (steam/gas analysis, brine and scale analysis), and conclusions.

III. EQUIPMENT DESIGN

The mobile field-test equipment consists of a Test Equipment Trailer, an Instrumentation and Controls Trailer, and a Diesel Generator Trailer. This equipment, illustrated in Figures III-1 and III-2, is designed to handle and condition brine from both artesian-type wells and wells equipped with down hole pumps.

Because flashing brine from geothermal wells typically produces both steam and noncondensable gases, the conditions of the flash must be controlled in order to optimize the economics of a flashed steam power plant. The field equipment, as designed, provides the means to test brines at various flashing pressures and flows up to 300 gallons per minute (gpm). The Test Equipment Trailer, which processes the incoming brine, is designed to operate as a single-flash system or as a staged group of two or three, depending upon requirements of the resource. The effluent brines (flashed brines) are flowed through piping component test sections for scale deposition studies. Test sections may be inserted to handle either flow between flash tanks or the effluent brine from final flash tank. Either inter-tank brines or final tank effluents may be pumped if desired. This option maintains single-phase flow throughout a test section when pressure drop devices or orifice plates are installed.

The Instrumentation and Controls Trailer and the Diesel Generator provide the required support systems for the Test Equipment Trailer. All three trailers can be moved to remote well sites and operated as a self-contained facility (except for injection).

A. TEST EQUIPMENT TRAILER

1. Operation: Figure III-3 is a simplified flow schematic for a typical test setup. All of the flow operations indicated, including the test sections, are located on the Test Equipment Trailer. This particular example utilizes Flash Tank A and Flash Tank B in series to condition the brine. The inter-tank brine is passed through a pump, which raises the pressure sufficiently to ensure single-phase flow in the test sections. In this case, the six test circuits on the right side of the trailer are being tested. The spent brine pressure is reduced in Flash Tank C prior to the brine's return to the well operator for processing and injection. The brine level in Tank A is controlled by a pneumatically operated valve at the entrance to Tank B. The level in Tank B is controlled by a valve at Tank C, and the level in Tank C is controlled by the valve in the effluent brine line.

Figure III-1. Test Equipment Trailer en Route to Imperial Valley

Figure III-2. Views of Test Equipment at the Mercer 2 Well Site

Figure III-3. Flow Schematic - Staged Flash - Pumped Brine

III. (continued)

The system is designed so that one, two, or all three flash tanks can be operated at the same time or substituted, as required, during a given test. The flashed brine exiting from the bottom of any of the three flash tanks can be routed to the test circuits. Level within the flash tanks is controlled by valving action either upstream or downstream of the flash tank. The flow system is designed so that steady-state flow conditions can be achieved through the flash tanks prior to flow delivery to the test circuits. Either constant flow or pressure can be maintained in each test circuit.

The sizing of lines, valves, and pumps is based on a wellhead brine inlet flow of 300 gpm at a temperature of 400°F and a pressure of 300 psig.

2. Flash Tanks: There are three identical flash tanks (steam/brine separators) which are used to condition the brine flows. These are mounted on a flat bed trailer. The primary requirements of these tanks are as follows:
 - a. Efficiently remove steam and noncondensable gases from incoming brine.
 - b. Lower the brine pressure and temperature in controlled stages to simulate a power plant operating mode.
 - c. Provide single-phase brine effluents to test sections.
 - d. Provide test coupons inside the flash tank for scale deposition studies.

Two basic types of flash tanks are currently in use:

- a. Vertical cylindrical cyclones which utilize inertial (centrifugal) forces to separate the steam from the brine.
- b. Horizontal or vertical cylinders in which brine is directed against splash plates and separated from the steam by gravity.

Either type can be equipped with internal baffles to further dry the steam.

The Webre-type design, which is a vertical cylindrical cyclone flash tank, was selected because of a good performance record and trailer installation advantages. Figure III-4 shows flash tank elevations and details.

III. (continued)

Steam is exhausted from the top of the tank to simplify steam and flash tank drain lines. A bottom steam outlet with standpipe and baffles would have yielded a drier steam (higher quality); however, the intent of the test program was not to optimize flash tank vapor but to ensure a single-phase brine effluent.

Flash tank design data were obtained from a review of existing operational flash tank designs. A comparison of the basic and derived parametric data with those of the selected design is shown in Appendix A, Table A.1. As shown therein, the difference between marginal operation and fully functional operation could not be explained by a relation between volume or surface area and flowrates. However, all of the tanks with satisfactory performance did have length-to-diameter ratios of approximately 3.4. Consequently, this ratio was selected as the basic design parameter. The tank dimensions were then derived from a highway transportation height constraint of 14 feet. The flowrate of 300 gpm was determined to be adequate for the planned experimental studies.

Our flash tanks were designed and constructed with two brine inlets for the following reasons:

- a. Some modes of operation might require mixing of brine in the tanks.
- b. The second inlet could be used if excessive erosion were encountered at the first inlet.
- c. Since the optimum location for the brine inlet is not known precisely, the provision of two inlets allows this to be found experimentally.

The brine inlets for the tanks reviewed were located 1 to 2 tank diameters from the tank tops. The two brine inlet locations selected for the Test Equipment Trailer tanks allowed satisfactory tank operation while maintaining maximum inlet head to the pump. Other tank dimensions selected conform to those of existing functional units, as shown in Appendix A.1.

Materials considered for the flash tanks included both carbon and alloy steels. Comparative dimensional, weight, and cost data are shown in Appendix A, Table A.2. These data indicate that the use of alloy steels rather than carbon steels does not offer any substantial advantages.

III (continued)

3. Flat Bed Trailer: The trailer is a Feree M/N CT-25. It has a capacity of 50,000 lb and was designed to accommodate the mounting supports for the three flash tanks. The total weight of the equipment, including flash tanks, pumps, control valves, inlet and outlet test manifolds, electrical power panel, and required piping, is approximately 37,000 lb. The trailer (when operating in the field) is supported in a fixed position by screw jacks.

B. INSTRUMENTATION AND CONTROLS TRAILER

All of the recording and control instrumentation is housed in a conventional air-conditioned travel trailer. The relation between this instrumentation and the piping and instrumentation throughout the rest of the system is diagramed in Figure III-5. The trailer plan view and control console are shown in Appendices A.3 and A.4, respectively. The trailer, a Casa Real M/N 35C, was factory-modified to accommodate a three-section instrument control console. All electrical signal and pneumatic control lines from the test equipment trailer connect to this unit. The output signals from pressure, temperature, and flow devices were recorded on a 100-channel data logger. The data logger is a Monitor Lab M/N 9302, equipped with a paper tape printer and a cassette tape output. Flash tank and test section temperatures are visually displayed with panel meters located near the top of the console. All pneumatic controllers provide both visual and chart readings. An instrumentation list, summarizing the type of readout and instrument accuracy, is presented in Appendix A.5.

All instruments or measuring equipment used for data acquisition were calibrated periodically, utilizing an ALRC documented calibration program. All standards used for calibration are traceable to the National Bureau of Standards.

C. DIESEL GENERATOR TRAILER

A 100-kW diesel generator trailer with an auxiliary 200-gallon fuel tank was rented to provide electrical power.

Figure III-5. Hydroscale P&ID

IV. TEST PLAN

The well-site test program was designed to obtain the maximum amount of data over a relatively short period of time. Through an agreement with the site operator, Vetter Research (also a program subcontractor), and the site developers, Geothermal Kinetics, Inc. (GKI) and McCulloch Geothermal Corp. (MCR), permission was given to operate the AECC equipment at the Mercer 2 well-site in South Brawley, California. The site developers (GKI/MCR) had planned to begin a 30-day flow test in October 1981 as part of a DOE loan guarantee program. Under terms of the initial agreement, the AECC test equipment would operate in parallel and obtain test data within the 30-day period, preferably during the first half or two-thirds of that period. However, since the parallel operating plan proved unfeasible, a period of dedicated flow at the end of the loan guarantee test period was adopted instead.

The test plan scope of work included both geothermal power plant simulation and data gathering for the study of hydrodynamic/kinetic interactions. The proposed plan provided for the evaluation of flash tank vapors at predetermined power-cycle conditions, scale characterization, rates of scaling, brine chemistries, mass flows, brine carryover, and required parameters for mass and heat balances around the flash tanks. The plan also provided for passing both pumped and unpumped flash-tank effluents through four to six test sections. These sections included a variety of piping and pressure-reducing components which simulated brine effluent pipeline conditions. Finally, the thermodynamic and hydrodynamic data, when combined with brine and scale analysis, were intended to provide the baseline hydrodynamic/kinetic reaction data.

A. PLAN OBJECTIVES

The proposed test plan was made up of two parts -- a single-flash test and a dual-flash test. The single-flash test (4-5 days) and the longer dual-flash tests (8-12 days) would provide flash tank, rates of scaling (pumped and unpumped), and hydrodynamic/kinetic interaction data. Specifically, the required data provided are:

1. Verification of the predetermined operating conditions;
2. Flash-tank scale deposition rates;
3. Flash-tank performance, gas separation efficiency/carryover, and operational limits;

IV. (continued)

4. Scale deposition rates on surface piping for both pumped and unpumped conditions;
5. Composition of scale samples taken from test sections and flash tanks;
6. Complete brine chemistry throughout the energy conversion process;
7. Complete thermodynamic and hydrodynamic data for a total system;
8. Noncondensable and entrained gas content;
9. System mass and energy balances;
10. A data base for the hydrodynamic/kinetic modeling study (pumped single-phase brines).

Data Base: The following engineering and process design requirements bounded the data base for Item 10 above:

1. Temperature not to exceed 572°F (300°C).
2. Brine flow velocities not to exceed those producing pressure drops of 1 to 2 psi per 100 ft of 2-inch diameter pipe.
3. Brine flow Reynold's number (Re) to be maintained within a range of 10^4 to 10^7 .
4. Piping component test sections to provide the following information:
 - a. The effects of fluid momentum/viscous forces and chemical diffusion at the laminar sublayer in the turbulent flow regime for single-phase flow through a tube (amount and distribution of scale deposition as a function of flow velocity-boundary layer thickness)
 - b. Scale deposition in stepped pipes at or near steps with single- and two-phase brine flows (cavitation pressure drop studies).
 - c. Scale deposition with single-phase flow around bends and through orifices (initial separation and induced precipitation studies).

Volumetric flows to meet requirements 2 and 3 ranged from 30 to 80 gpm (3 to 8 ft/sec - 2-inch pipe).

B. SAMPLING PLAN

Liquid, gaseous and solid samples were to be collected at all key points of the test configuration. Analytical data from samples would be used to calculate mass balances, identify process changes, and provide a data base for hydrodynamic/kinetic integration.

IV. (continued)

Sampling stations for liquid and gaseous samples are shown on the previous hydroscale P&ID (Figure III-5). Generally, the liquid sample collection points are taken from the wellhead, the flash tanks, the inlet test section manifold, from each test section outlet, and the brine effluent (injection) line. The gas and steam condensate samples are collected from sample points located in the upper (vapor) section of each flash tank. Solid scale samples are collected from flash tank sample coupons, as shown in Figures IV-1 and IV-2, and from piping component test sections. Typical test section configurations are shown in Figure IV-3.

The frequency of sample collection was to be sufficient to ensure a definition of process chemistries for a specific flash condition. However, due to the difficulty of the task, samples were taken only during daylight hours.

C. OPERATIONAL PLAN AND SUMMARY

The test plan executed was scaled down to an eight-day program made up of a four-day single-flash test and a four-day dual-flash test. This was necessary because of the change from a parallel flow testing mode to that of a dedicated flow. The original test concept, as mentioned previously, was to operate in parallel with the site developers' 30-day reservoir test. Two attempts were made to operate in this mode. The first, in October of 1980, was halted after 28 hours of operation due to injection well difficulties. The second attempt, in December 1980, was halted after approximately 50 hours of operation due to impact on the liquid/gas flow ratios to the site operator's test equipment. However, both of these truncated test efforts were used to check out equipment and sampling methods and obtain flash tank pressure-temperature data.

After the shutdown in December, the site developers (GKI/MCR) decided to provide a dedicated flow to the hydroscale equipment for a 10-day period in January of 1981. Thus, the 8-day test program was conceived and adopted, allowing 2 days for stabilizing flows and contingencies.

SOLID SAMPLE LOCATIONS IN FLASH TANKS

FLASH TANK COUPON DETAIL

ALL MATERIAL IS CARBON STEEL

Figure IV-1. Flash Tank Coupon Locations & Details

Figure IV-2. Flash Tank Coupons

Figure IV-3. Typical Test Section Configurations

IV. (continued)

The revised or shortened test program was initiated on January 2, 1981, but was terminated after approximately 99 hours of operation due to failure of the electrical generating equipment during a severe rainstorm. However, sufficient data had been obtained to complete the single-flash series of tests.

The site developers provided an additional dedicated well flow period of 4 to 6 days in February. This provided sufficient time to complete the dual-flash test series. Tests were initiated on February 2, 1981 and completed on February 6, 1981.

1. Single-Flash Test: The initial test in January was conducted for 99 hours at single-flash conditions of 50 psig. The flashing pressure of 50 psig was selected as a minimum to avoid excessive low-pressure scaling and to overcome effluent brine head and frictional losses to the operator's injection processing equipment.

The test plan called for two days of pumped brine tests followed by two days of unpumped brine tests. In each test series, brine effluent from the flash tank was flowed (either pumped or unpumped) through four test sections. The flow through each section was set at typical design flow velocities ranging from 3.4 to 7.1 ft/sec. In each series, the four test sections were made up of one straight 2-inch pipe section, one 4-inch expansion/2-inch contraction section, one 3/4-inch orifice plate section, and one 1-inch orifice plate section. Each of the sections had a short radius elbow inlet and a blind tee or short radius elbow exit as illustrated in previous test section Figure IV-3.

The flash-tank pressure was held constant for the entire test series. The effluent from the tank was pumped through four parallel test sections for two days. The pump was then turned off, and the flow was diverted to four other sections. Flow continued through the unpumped test sections until a rainstorm forced shutdown 25 hours into the test.

The single-flash tests described above provided eight test sections with documented thermodynamic and hydrodynamic history for scale analysis. Brine, steam, and gas samples for chemical analysis were taken at regular intervals at critical points in the system.

IV. (continued)

2. Dual-Flash Test: The dual-flash tests commenced on February 2, 1981 and ended on February 6, 1981 after 103 hours of testing. Test flashing pressures were set at 200 psig and 100 psig. The third flash tank, Tank C, was operated at 50 psig, but was not included as part of the test. The purpose of Tank C was to reduce the brine outlet pressure and thereby avoid any potential damage to the site operator's downstream injection equipment. The flashing pressures were chosen somewhat arbitrarily to provide a good overall cross section or range of data along with the single-flash series data.

The test plan was to operate two days with unpumped brine at 100 psig, to be followed by two days with pumped brine at 200 psig. Again, brines were flowed in each case through four test sections similar to those used in the single-flash tests. However, after completion of the initial 100-psig test series, the brine pump shaft was locked in position due to scale buildup and could not be restarted. Therefore, the 200-psig test series was operated in an unpumped mode.

Flash-test pressures were held constant throughout the testing periods, and test section flow velocities were set in a range from 3.2 to 7.8 ft/sec. Testing provided eight test sections for scale analysis whose thermodynamic and hydrodynamic history was known. Brine, steam, and gas samples for chemical analysis were taken at regular intervals at critical points in the system.

3. Test Summary: The detailed flow schematics and results for the single- and dual-flash tests are shown in Sections VII and VIII, respectively. A total of 16 circuits were tested at flowrates ranging from 3.2 to 7.8 ft/sec. The completed test summary is shown in Tables IV-1 and IV-2.

IV. (continued)

TABLE IV-1
Test Series Summary

Date	Test Series	Test Descriptions	Pipe Test Sections	Flash Tank Coupons	Brine/ Gas Samples	Hrs
10/80	15	Checkout test for single-flashed brine	0	2	14	28
12/80	16, 17, 18	Checkout test for dual-flashed brine	0	9	33	39
1/81	19	Single-flash tests	8	3	119	99
2/81	20	Dual-flash tests	8	6	140	103
Totals			16	20	306	269

TABLE IV-2
Piping Section Tests (2" Pipe)

Test Section Configuration	Flowrates (GPM)			
	Single-Flash (50 psig)		Dual-Flash (100 psig) (200 psig)	
	Pumped	Unpumped	Unpumped	Unpumped
2" elbow, 1" dia. orifice, 2" elbow	45.3	40.2	58.9	69.8
2" elbow, 3/4" dia. orifice, 2" elbow	33.0	36.1	37.0	31.7
2" elbow, 4" expansion/contraction, 2" blank tee	69.4	45.8	76.1	55.1
2" elbow, 2" straight pipe, 2" blank tee	69.1	44.9	65.4	65.1

V. SAMPLING AND ANALYTICAL PROCEDURES

The objective of the sampling and analytical program was to provide sufficient liquid, gas, and solid samples for the characterization of the chemistry/scale deposition process.

Analysis was performed on liquid brines, steam condensate, and noncondensable gases under both single- and dual-flash power-cycle configurations. Scale deposits taken from critical locations in flash tanks and test sections were also analyzed.

In order to design and operate a geothermal power plant, it is necessary to define the properties of the geothermal brine throughout the energy conversion process. As brine flowed through test equipment, heat was extracted and the brine properties were altered. These changes, plus the characterization of resulting steam, condensate, and noncondensable gases, were monitored throughout each flashed steam cycle tested. Scale deposits were collected, analyzed, and measured at the end of each test series.

A. SAMPLE COLLECTION

The test unit was constructed with sampling stations located such that brine chemistry changes for any desired power flash cycle could be monitored.

1. Sampling Stations: There are 26 sample points located on the equipment trailer, and two additional points are located on the inlet piping to the trailer. The locations are shown on the System P&ID (previous Figure III-5). Each sampling station was equipped with 1/2-inch Whitey ball valves. The upper (vapor) section of the flash tanks and the steam lines are equipped with a removable-type probe which projects into the process stream to avoid any boundary-layer effects at the walls. Figure V-1 shows details of a sample probe for flash tanks and steam lines. An armored stainless-steel flex hose was connected to the sample station valve/probe and was run to a stainless-steel cooling coil assembly for sample cooling prior to collection. Figure V-2 shows a typical assembly with a filter (0.5 μ m) attached for filtered acidified (FA) or filtered untreated (FU) sampling.

Figure V-1. Flash Tank Sampling Probe

Figure V-2. Cooling Coil Assembly & Details

V. (continued)

2. Sample Types: Eight types of liquid and gaseous samples were collected. Solid scale samples were obtained from flash tank coupons and rings cut from test sections. The liquid and gas samples were designated as raw untreated (RU), filtered untreated (FU), raw acidified (RA), filtered acidified (FA), filtered untreated-diluted (FU-Dil 10X), CO₂, H₂S, and gas for CO₂, H₂, CH₄, and Ar+O₂. Table V-1 summarizes sample types, preparation, and constituents analyzed.
3. Sampling Methods: The most recent sampling methods and procedures were obtained from discussions with Vetter Research (subcontractor responsible for chemical analysis) and with D.W. Shannon and Gene Woodruff of Battelle Pacific Northwest Laboratories. Procedures used for sampling single-phase (either all-liquid or all-steam/gas) geothermal systems are essentially those which are presently recommended in Battelle Report No. PNL-MA-572 (Ref. 2).

All liquid samples were withdrawn through ball valves in stainless steel hoses connected to cooling coils as shown in previous Figures V-1 and V-2. Prior to filling sample bottles (liter), brine was flowed for a 2-3 minute period, long enough to purge the line and flush the sample bottle. Filtered samples typically required more time due to plugging of the filters. Some stations, depending upon test conditions, required as many as 6 to 10 filters for flushing and filling a single sample bottle. Gas samples obtained from flash tank vapor sections and steam lines were obtained from sample stations with a removable-type probe as shown in previous Figure V-1. Vapor was drawn and cooled through similar hoses and cooling coils as used for liquid sampling. Glass bulbs/separators were used to collect gas and steam condensate samples.

H₂S sampling was performed by subcontractor personnel in the final test series (dual-flash tests). Earlier attempts to obtain H₂S analysis by bubbling through zinc acetate were unsuccessful. The H₂S sampling method used is as follows:

ANALYSIS FOR LIQUID SPECIES

	TYPE A1 (RA & FA)*	Type A2 (RU & FU)*	FU-Dil 10X
CONSTITUENT ANALYZED FOR:	CATIONS: Ca, Na, Mg, Mn, Ba, Li, Sr, Pb, Zn, Al, Fe, K, B	Cl, CO ₃ , HCO ₃ , SO ₄ , TDS, pH	SiO ₂
SAMPLE PREPARATION:	5 ml ultrapure conc. HCl to 32 oz. brine sample	None	10 parts deionized water to 1 part brine.

ANALYSIS FOR GASEOUS SPECIES

	GAS	CO ₂	H ₂ S**
CONSTITUENT ANALYZED FOR:	CO ₂ , H ₂ , CH ₄ , Ar+O ₂	CO ₂	H ₂ S
SAMPLE PREPARATION:	Glass sampling bulb	Bubble through NaOH, collect liquid	*Sparge through a CdSO ₄ solution

*Detection limits (Mg/l) for trace elements are as follows: Ag<0.3, As<10.0, Au<0.9, Be<0.1, Cd<0.7, Ce<13.0, Co<0.9, Cr<1.1, Cu<0.2, Ga<6.5, Ge<7.5, Hg<3.0, La<0.3, Mo<7.5, Ni<3.5, Sb<4.0, Se<14.0, Sn<11.0, Ti<0.2, V<0.3, Zr<0.5, PO₄<10.0
Above list does not indicate presence of element; however, if present, quantity would be within limit.

**Performed by subcontractor personnel during dual-flash tests. Attempts to bubble gas through a zinc acetate solution for H₂S in early Tests 15 through 19 were unsuccessful.

TABLE V-1: SAMPLE ANALYSIS SUMMARY

V. (continued)

H₂S Sampling: The samples were collected in 500 ml graduated cylinders which were sealed with neoprene stoppers and fitted with a fritted glass dispersion tube of medium pore size which reached to the bottom of the cylinder. Approximately 250 ml of a cadmium sulfate (140 g/l) solution was poured into the cylinder, and this amount was then read to the nearest ml. Before the samples were collected, the sample ports were opened and flushed. Tygon tubing was used to connect the sample port to the top of the glass dispersion tube, and the sample was bubbled through the CdSO₄ at a moderately slow rate which, even during maximum surges through the system, would not allow escape of any liquid. From 50 to 250 ml of sample condensate were collected, the amount depending on color development in the cadmium sulfate solution and the ratio of gas to condensate exiting the sample ports. After the sample was collected, the cylinder was sealed and the volume it contained was read to the nearest ml. (Ref. 8)

4. **Sampling Frequency:** A minimum requirement for sampling frequency was set at one series of samples for each sample station per day. A minimum sample series from a liquid-phase station is comprised of one each of the following samples: RU, FU, RA, FA, FU-Dil 10X, and FU-NaOH (CO₂). Additional samples were taken whenever possible or when a particular process required more information. Tables V-2 and V-3 summarize sample types and frequency for single- and dual-flash tests.

B. SAMPLE ANALYSIS

Analysis of samples was divided into two parts: field liquid and gas samples and prepared solid samples. The field liquid and gas samples were forwarded immediately to Vetter Research for analysis. Test sections and flash tank coupons were sent to AECC's Sacramento facilities for preparation prior to analysis. Test sections and coupons were cut, measured, and packaged for shipment. Figure V-3 shows the preparation, distribution, and flow of samples.

Position No.	Description	Test 19								Test 20							
		Single-Flash - Pumped & Unpumped (99 Hours)								Dual-Flash - 100 & 200 PSI Unpumped (103 Hours)							
		A ₁	A ₂	SiO ₂	Cond	Gas	CO ₂	H ₂ S*	pH	A ₁	A ₂	SiO ₂	Cond	Gas	CO ₂	H ₂ S	pH
V-5	Inlet Brine (V/L)	6	6	3			2		6	8	8	4			3		8
V-15A	Flash Tank A (V)				3	3			2								
V-19A	Flash Tank A (L)	8	8	4			3		8	6	6	3			2		6
V-19B	Flash Tank B (L)									6	6	3			2		6
V-19C	Flash Tank C (L)									8	8	3			2		8
V-25A	Flash Tank A (V)							3*					4	4		8	4
V-25B	Flash Tank B (V)												4	3		3	4
V-25C	Flash Tank C (V)												4	2		2	4
V-39	Reinjection line (L)	6	6	2					6								
V-208	Test Section (Inlet) (L)	6	6	3			1		6	2	2	1					2
V-209	Test Section (Outlet) (L)	5	5	3					5	2	2	1					2
V-309	Test Section (Outlet) (L)	4	4	2					4	6	6	2			2		6
V-409	Test Section (Outlet) (L)	4	4	2					4								
V-509	Test Section (Outlet) (L)	4	4	2					4								
Blanks		1		2			1		1	1	4				2		4
Totals		44	43	23	3	3	7	3*	46	39	42	17	12	9	13	13	54

* - Bubbling through Zn Acetate unsuccessful.

L - Liquid

V - Vapor

A₁ - Ra & Fa

A₂ - Ru & Fu

TABLE V-2 NUMBER OF LIQUID & GAS SAMPLES COLLECTED

<u>Test</u>	<u>Flash Tank Coupons</u>									<u>Test Section Samples</u> (Cut Radial Rings)			
	Tank A			Tank B			Tank C			Straight Pipe	Expansion/ Contraction	3/4" Orifice	1" Orifice
	80	81	83	80	81	83	80	81	83				
No. 15, Check Out	1	1											
Nos. 16, 17 & 18, Check Out	1	1	1	1	1	1	1	1	1				
No. 19, Single-Flash	1	1	1							8	8	8	8
No. 20, Dual-Flash	1	1	1	1	1	1	1	1	1	8	8	8	8
TOTALS	11			6			6			16	16	16	16

TABLE V-3: NUMBER OF SOLID SAMPLES COLLECTED FOR ANALYSIS

South Brawley Well Site - Mercer 2

Liquid/Gas
samples from
field test

Vetter Research
(Costa Mesa, CA)

- Liquid, gas, &
scale analysis
- ICP, GC, etc.

Solid samples from
field test (test
sections, coupons, &
selected bulk samples)

AECC
Lab
(Sacramento, CA)

(Radial Rings &
Coupons Disks)

(Radial Rings &
Selected Bulk
Samples)

Los Alamos
National
Laboratory
(New Mexico)

- Scale Analysis
- X-Ray
- SEM

Prepare Solid Samples for Analysis

- Cut test section & flash tank coupons
 - Radial rings
 - Cross section
 - Coupon disks
- Stabilize selected samples with N₂
filled containers
- Measure & record

Scale Characterization

- Measure scale profiles of pipe component
- Calculate deposition rates
- Scale description
- Photographs

Figure V-3. Sample Preparation & Analysis Flow Chart

V. (continued)

Solid samples were forwarded to Vetter Research and Los Alamos National Laboratory for analysis. Those samples which were shipped to Los Alamos were packaged under nitrogen (N_2) in order to stabilize chemical reactions for long storage periods.

Flash tank coupons were cut from flanged coupon supports in the field. Coupon scale deposition was measured prior to shipment to Vetter Research for analysis. Test sections were shipped via flatbed truck to AECC in Sacramento after they had been wrapped at the test site to minimize air intrusion. At AECC's facility in Sacramento, sections were cut radially and cross-sectionally. Two sets of 1-inch rings were cut from each test section: 2 feet upstream and 2 feet downstream from the entry and exit of the middle pipe component. Both Vetter Research and Los Alamos National Laboratory received upstream and downstream rings. Measurements of scale thickness were taken and recorded prior to shipment.

Each individual pipe component of a test section was then cross-sectioned, i.e., entry elbow, mid-component (orifice, expansion/contraction, straight pipe), and exiting tee or elbow. Scale profiles and deposition rates were computed and recorded for each of the pipe components. Scale chips taken from each component were analyzed under a microscope for general appearance, structure, and color information. Color and black-and-white photographs were taken of each component cross section and of selected scale chips.

Analytical procedures performed by Vetter Research and Los Alamos National Laboratory are as follows:

Vetter Research (Liquid, Gas, and Solid Analysis)(Ref. 8)

Gas Analysis Procedure - A 30-ml sample of gas was drawn through a sealed gas sampling bulb into a gas-tight syringe. Approximately 10 ml of gas was flushed through a Valco sample injector, and 1.0 ml of sample was then injected into a CTR-I8700 concentric column for chromatographic analysis. The field gas mixtures were calibrated against commercially prepared gas mixtures at ambient temperature, using helium as the carrier gas and a thermal conductivity detector. Methane was confirmed with a flame ionization detector.

V. (continued)

Inductively Coupled Plasma Emission Spectrometry (ICP) - Acidified brine and condensate samples were analyzed by ICP following the appropriate sample preparation. Brines were diluted by a factor of 100 and acidified to 2% HCl in order to provide concentration ranges of the elements compatible with the limitations of the instrument and acid strength identical to the standards. Condensates were acidified to 2% HCl with no dilution needed. The accuracy of the analyses was verified by frequent comparisons of the results with standardized brines of similar composition.

Solid Sample Preparation (ICP) - Scale deposits were removed from the pipe segments and coupons. Portions of each for ICP analysis were ground up into fine homogeneous powders and dried at 110°C. Approximately 0.1 gram of each was weighed, placed in a Teflon beaker, and digested with 10 mls of aqua regia. The supernatant was decanted into a 100 ml Nalgene volumetric flask. The residue was treated with HCl and HF to dissolve silica. This solution was also added to the flask. If any residue remained, the last step was repeated with mild heating. Following the addition of all digestate fractions, the solution was diluted to 100 ml and thoroughly mixed prior to analysis.

Solid Sample Preparation (Chloride) - Sample preparation for chloride analysis required selection of large chunks of the original "wet" scale. Each chunk was weighed and then digested with nitric acid only. The supernatant and subsequent washes were decanted into a 100 ml volumetric flask, diluted to volume, and mixed prior to analysis.

Sulfate - Barium chloride was added to an acidified sample to form barium sulfate crystals of uniform size. The turbidity caused by this precipitate was measured in a turbidimeter, and the sulfate ion concentration was determined by comparison of the reading with a standard curve.

Chloride - Chloride was determined by a colorimetric titration with mercuric nitrate, which forms soluble, slightly dissociated mercuric chloride. In the pH range 2.3 - 2.8, diphenylcarbazone indicates the end point of this titration by the formation of a purple complex with the excess mercuric ions.

V. (continued)

Carbonate/Bicarbonate - Carbonate and bicarbonate concentrations were determined by a titration with a standardized acid to pH end points of 8.3 and 4.6.

H₂S Determination - Once the gas containing H₂S had been sparged through a CdSO₄ solution, the amount of CdS which had precipitated was determined. First, a known quantity of iodine in solution was added. Then concentrated HCl was added to dissolve the cadmium sulfide. The sulfide released in solution is oxidized to S, and the remaining excess of the iodine solution determined by titration with a standard sodium thiosulfate solution.

Los Alamos National Laboratory (Scale Analysis)

X-Ray Diffraction Procedure - The relative contributions of identifiable compounds to the crystalline fraction of scales and other precipitates were determined with the aid of a Norelco vertical diffractometer using Cu characteristic radiation and with a graphite monochromator. Samples, which had been ground to minus 325 mesh under an inert atmosphere, were mounted in aluminum holders in air and run at ambient conditions at angles (2θ) from 4° to 70°. The patterns were read, indexed, and compared with data in the Pattern Diffraction Files of the Joint Committee on Powder Diffraction Systems or with patterns given in Crystal Data, Determinative Tables, prepared by the same committee.

VL CHECKOUT TESTS

As mentioned in Section IV.C (Test Plan), the two aborted tests in October and December of 1980 were used to check out equipment and verify operating and sampling procedures. These checkout tests were performed for the most part while operating in parallel with the site operator's test equipment. The first checkout test (No. 15) in October 1981 was a single-flash test which lasted approximately 28 hours. The second checkout test in December 1981 was made up of a series of multiple-flash tests (Nos. 16, 17, and 18) for a total of approximately 39 hours.

A. SITE AND EQUIPMENT

A plan view of the hydroscale test equipment at the GKI/MCR well site is shown in Figure VI-1. The hydroscale equipment and instrumentation control trailers were situated approximately 200 feet north of the wellhead. A 4-inch pipe provided the brine supply from a 10-inch wellhead discharge pipe to the hydroscale trailer. The brine leaving the hydroscale trailer was discharged through a 4-inch pipe connected approximately 200 feet away into a 10-inch low-pressure flashed brine line operated by the site operator. Steam discharging from the hydroscale trailer was overboarded through a 6-inch pipe into a Baker tank. The tank also served as a catch basin in case of brine overflow. To accommodate drainage requirements for the system after testing, a 4-inch pipe conducted fluid to a holding pond approximately 100 feet away.

B. SINGLE-FLASH CHECKOUT TEST

1. Process Description: The purpose of the subject checkout test was to verify the operational performance of the hydroscale test equipment under single-flash conditions. The following goals were set for the checkout test:
 - a. Determine the ability of the hydroscale system to control the incoming brine.
 - b. Establish material mass balances around the system to define concentrations and compositions of all streams entering and leaving.
 - c. Conduct a fail-safe test of the brine emergency bypass system to determine its operability.

Figure VI-1. Hydroscale Equipment & Well Site Piping Layout

VI (continued)

- d. Establish improvements to the test equipment for improved operational performance in future tests.

The single-flash test reduced the pressure of the incoming wellhead brine from 475 psig to approximately 50 psig in a one-step flash operation. Figure VI-2 depicts the simplified version of the process P&ID for a single-flash test. Only Flash Tank A was used; the other flash tanks, Tanks B and C, were blocked off from flow. Flow control of the incoming brine feed to Tank A was achieved by the throttling control valve, LCV-10A. Pressure in Tank A was maintained by the pressure control valve, PCV-12A. The brine liquid level in Tank A was set by the discharge flow control valve, FCV-38.

In startup operation, all control valves were in their fail-safe mode, that is, without air and electrical controls. In this operating mode, the pressure control valve, PCV-12A, and brine bypass valve, ROV-6, were open. The throttling control valve, LCV-10A, was 15 percent open (a position set to maintain flow through the system when in the brine emergency bypass mode).

Upon manually opening the brine supply block valves, V-70 and V-71, the brine passed directly through the flash tank and into the reinjection line leading to site operator's brine treatment reactor. Once flow was established through the system, the control valves were set for the desired control condition, and the emergency bypass valve, ROV-6, was closed. In the event of an electrical or pneumatic failure, all valves could be set to return to their original startup position, a fail-safe precaution. This emergency setup kept the brine supply flowing steadily throughout the operational period and allowed a stable well flow between site operator and AECC equipment.

Figure VI-2. Simplified P&ID for Single-Flash Checkout Test No. 15
(10/27/80 thru 10/28/80)

VL (continued)

2. System Operational Behavior: The system operational control was maintained for a 28-hour test period at a flowrate of approximately 17 GPM. During this period, the brine emergency bypass system, which prevents high-pressure (wellhead) two-phase flow from entering the site operator's injection equipment, was activated and found to be operationally acceptable. However, there was a problem in activating the pneumatic brine throttling valve, LCV-10A, from its fixed open position. The cause was the inability of the valve and its actuator to respond to the load created by the high-pressure differential across the valve. In later tests this valve was replaced by a 6-inch, 300-lb V-partial ball valve, Fisher 478-UR. All of the other control components (valves, level indicators, etc.) performed as expected.

Early in the test, the site operator shut off flow to the GKI/MCR system for a brief period (less than an hour). Flow continued to AECC, and during this period the wellhead pressure decreased. Just prior to this decline in pressure (after site operator shutdown), brine flow to the hydroscale test unit increased from 17 to 60 GPM. This increase can only be explained by a reduction in the ratio of the gas phase in the test unit brine supply line. Wellhead pressure and hydroscale brine injection flowrate profiles are shown in Figure VI-3. Other evidence of the presence of a gas phase in the brine supply comes from pressure and temperature drops between the wellhead connection and the hydroscale trailer. Drops of 30 psi in pressure and 23°F in temperature were observed when both the site operator and AECC were receiving well fluid. These drops were attributed to convection and radiation heat transfer losses, estimated to be 3×10^5 Btu/hr, from the 200 ft brine supply pipe. This had the effect of decompressing the gas phase, causing thermal and pressure decay. If the flow was entirely in a liquid state, such reductions in pressure and temperature would not have been predicted to be as great, even when considering frictional flow losses. Material balance calculations indicated a 94 vol % gas in the brine supply line under flow conditions when the site operator and AECC were drawing a total of approximately 500 to 700 GPM from the well.

Figure VI-3. Wellhead Pressure, Temperature, and Injection Flow Rates vs Time (Test No. 15, 10/27/80 thru 10/28/80)

VL (continued)

The 4-inch brine supply tee off the 10-inch wellhead discharge pipe was essentially separating the gas phase from the total well flow. To minimize this condition in later tests, the AECC brine supply connection was modified to take flow from the bottom of the 10-inch wellhead discharge pipe via a 10-inch tee and a 10-inch x 4-inch eccentric reducer.

3. Results: The test results compiled from the process operating data and sampling analyses are as follows:
 - a. The wellhead brine received at the hydroscale trailer was two-phase, 94.8 vol. % steam and noncondensable gases.
 - b. The flash tank and reinjection brine flows were laden with suspended solids made up of heavy metal sulfides/oxides or hydroxides and silica which formed at a rate of 0.2 lb/hr per GPM of incoming brine flow.
 - c. The flash tank scales varied from a 155-mil-thick, soft, powdery type of material which formed in the liquid region to that of a 5 to 10-mil-thick hard, brittle material which formed in the two-phase region.
 - d. Equipment changes required:
 - (1) Replacement for inlet throttling valve, LCV-10A;
 - (2) Steam discharge muffler;
 - (3) Replacement of the 10-inch x 4-inch tee at the brine supply connection.

C. MULTIPLE-FLASH CHECKOUT TEST

1. Process Description: The purpose of the subject checkout test was to verify the operational performance of the hydroscale test equipment under multiple-flash conditions. The following goals were set for the checkout test:
 - a. Determine the ability of the hydroscale system to control the incoming brine under multiple-flash operating conditions.
 - b. Establish material mass balances to define concentrations and compositions of all streams entering and leaving the system.
 - c. Conduct a high-pressure, fail-safe test of a brine emergency bypass to determine its operability.

VL (continued)

- d. Evaluate the performance of the replacement throttling control valve (LCV-10A), a 6-inch Fisher 478-UR.
- e. Evaluate the effectiveness of a 10-inch tee with a 10-inch x 4-inch eccentric reducer in minimizing gas flow in the AECC brine supply line.
- f. Evaluate the effectiveness of a 12-inch steam muffler in reducing noise.
- g. Identify any test equipment requirements or changes.

The multiple-flash operation involved a reduction of the pressure of the incoming brine supply flow down to a lower pressure in a series of flash stages. In three mini-tests (Nos. 16, 17 & 18), to be discussed, three flash stages were employed. Figure VI-4 depicts the simplified version of the process P&ID for this flash operation. As shown, the three flash tanks, Tanks A, B, and C, were series connected. Flow control of the incoming brine was achieved by the throttling control valve, LCV-10A. Pressure control in Tanks A, B, and C was maintained by pressure control valves PCV-12A, PCV-12B and PCV-12C, respectively. The brine liquid levels in Tanks A, B, and C were set by the discharge flow control valves LCV-10B, LCV-10C, and FCV-38, respectively.

The startup operation was the same as for the single-flash operation previously described. Tanks B and C were blocked from flow in order to set the system in a single-flash mode. After flow was established in Tank A, the emergency bypass valve ROV-6 was closed, and Tanks B and C were brought on stream. In the event of an electrical or pneumatic failure, valve ROV-6 opens and the flow automatically returns to a fail-safe single-flash status.

2. System Operational Behavior: The system was started up in a single-flash mode through Tank A. Later in the test, Tanks B and C were introduced to stage the incoming brine supply through three stages of flash. In Test No. 16, only Tank A was employed for a short test period of 3-1/2 hours for the purpose of verifying the changes made to system since the October test (No. 15). The replacement brine throttling control valve, LCV-10A, was found to be acceptable in operating against the flow forces of the incoming brine supply.

Figure VI-4. Simplified P&ID for Dual-Flash Checkout Tests 16, 17, and 18 (12/8/80 thru 12/12/80)

VI. (continued)

The 10-inch tee with the 10-inch x 4-inch eccentric reducer off the 10-inch wellhead line appeared to greatly reduce the gas flow in AECC brine supply line. Material mass balance calculations indicated two-phase flow with 70 vol. % liquid and 30 vol. % steam/noncondensable gases. However, the 12-inch muffler did not reduce noise level to an acceptable level. The problem was rectified by teeing a five-foot section of 12-inch perforated pipe to the muffler located just below the top wall of the steam discharge Baker tank as shown in Figure VI-5.

Figure VI-5. 12-Inch Steam Muffler Discharging into Baker Tank

VL (continued)

In Test No. 17, brine was flashed through three separate pressure stages of 200, 100, and 50 psig, respectively. After approximately 3 hours of operation, the Tank A steam valve, PCV-12A, began to show signs of sticking. Shutdown of the test after 7 hours was required to inspect and clean the steam valve. Figure VI-6 shows inlet and outlet views of steam valve PCV-12 laden with scale. The system responded to the emergency shutdown (opening of ROV-6) with a strong water hammer, which resulted from the initially hotter brine from Tank A contacting the cooler injection brine from the site operator's equipment. A controlled shutdown procedure was adopted to avoid any future cavitation problems.

Inspection of the Tank A steam valve indicated a hard scale buildup on the upstream side of the ball orifice. Downstream, a thick granular salt-like deposit was caked behind the ball orifice. All of the downstream salt-like materials were soluble in hot water; however, the hard scale on the upstream side had to be scraped.

The following test, Test No. 18, ran 28 hours continuously without serious equipment malfunctions. However, the Tank A steam valve stuck again after approximately 4 hours. It was decided to ignore the valve and to control the pressure by throttle control of the brine supply. Flow was brought up to the required flowrate of 200 to 250 GPM for piping component tests. The resultant impact on the site operator's testing was significant. Apparently, the AECC test equipment was taking an appreciable and uncharacteristically large cut of the liquid phase from the wellhead supply. As a result, the site operator was receiving a disproportionate volume of gas, thereby causing control and testing difficulties.

In order to avoid possible disruption to the site developers' 30-day test program, AECC agreed to suspend testing. Before final shutdown, a pressure traverse was performed on Tank B in order to provide brine vapor data without the presence of noncondensable gases. The site operator shut his system down during this period, thus allowing the AECC equipment total wellhead flow. Figure VI-7 shows wellhead pressure, temperature, and injection flowrates for the checkout test period.

Figure VI-6. Flash Tank A Steam Valve - PCV 12A

Figure VI-7. Wellhead Pressure, Temperature and Injection Flow Rates vs. Time
(Test Nos. 16, 17, & 18 12/8/80 thru 12/12/80).

VI. (continued)

3. Results: The test results compiled from the process operating data and sampling analyses show the following:
 - a. The wellhead brine flow received at the hydroscale trailer was two-phase, 26.2 vol. % steam/noncondensable gases and 73.8 vol. % liquid. This represented a one-third reduction in gas flow volume from the previous single-flash test. The 10-inch x 4-inch eccentric reducer as a replacement for the tee connection off the wellhead supply appeared to be effective in separating the liquid flow phase from the wellhead discharge line.
 - b. The flash tanks and reinjection brine flows were laden with suspended solids made up of heavy metal sulfides/oxides or hydroxides and silica which had formed in Tanks A, B, and C.

VII. RESULTS OF STEAM AND GAS ANALYSIS FOR CHECKOUT AND POWER CYCLE TESTS

Flash tank results are divided into two parts:

1. Results of experiments for flashed brine characterization, and
2. Steam and noncondensable gas analysis.

The flashed-brine characterization experiments were conducted during the checkout tests of October and December. These tests provided the pressure and temperature data required to determine the flashed brine saturation curve. The noncondensable data were collected for both checkout and power cycle tests. The data are comprised of gas chemistries, vapor and liquid flow measurements, and flash-tank pressures and temperatures.

A. BRINE VAPOR PRESSURE ANALYSES

The brine vapor pressure-temperature relationships were required in order to assess the concentration and quantity of noncondensable gases in the vapor phase. The brine vapor pressure is herein defined as the pressure of the flashed brine and does not include the pressure of the noncondensable gases. The fact that most of the noncondensable gases are released in the first-stage flash permitted assessment of brine vapor pressures from second- and third-stage flashes.

In a multiple-flash process, the first stage, Tank A, acted as a noncondensable gas separator, and Tanks B and C became the second- and third-stage steam separators. Operating under these conditions, the brines in Tanks B and C were at saturation conditions without being influenced by noncondensable gases. Consequently, the resulting vapor pressures and temperatures reflect only the steam pressure characteristics of the brine.

During Test No. 18 conducted in December, three flash tanks were staged in series to check out multiple-flash operations and to provide the vapor pressure/temperature brine profile. Each of the three flash-tank pressures was varied and the corresponding temperatures were recorded. Flash-tank pressure ranges are as follows:

- Tank A 210 to 150 psia (7 points),
- Tank B 115 to 90 psia (6 points), and
- Tank C 95 to 60 psia (6 points).

VII. (continued)

During the October single-flash checkout test (Test No. 15), flash Tank A pressures were varied between approximately 110 and 60 psia (7 points). All of these data are plotted in Figure VII-1. The pressure-temperature data for Tank C and B fall on a single curve which corresponds closely to that for a saturation curve of a 20.0 wt. percent NaCl solution (Ref. 1).

A least-square fit of the above curve to the Clausius-Clapeyron equation,

$$\log_{10}P = -\Delta H_v/2.303R(T+460) + C,$$

yielded the following equation:

$$\log_{10}P = -3721.5(\Delta H_v)/(T+460) + 6.6604.$$

Solving the above equation for the average brine latent heat of vaporization resulted in:

$$\Delta H_v = 17021.2 \text{ Btu/lb mole or } 39,516 \text{ Joules/gm mole}$$

B. DETERMINATION OF STEAM AND NONCONDENSABLE GAS FLOWS

All of the steam and noncondensable gases received in the wellhead brine flow along with those produced during single- and multiple-stage flashing were released to the atmosphere. Most of the noncondensable gases were discharged in the first-stage flash. This is due to the fact that most of these gases were in the vapor portion of the brine supply. The quantity of noncondensable gases soluble in brine after the first-stage flash was found to be low due to the high salinity of the brine, approximately 30 wt. % dissolved solids. The concentration of the gases in the discharge steam line varied considerably in the early checkout tests (Nos. 15-18) performed in October and December. This was because the gas fraction in the brine supply was influenced by operating in parallel with site operator, i.e., splitting the well flow. However, during the dedicated flow tests (Nos. 19 and 20), gas levels were considerably more stable.

The solubility of the noncondensable gases, particularly CO₂ appears to diminish when the brine salt content is near the saturation point (Ref. 4). Therefore, noncondensable gases in the liquid phase after initial flash were assumed to be nonexistent.

Figure VII-1. Brine Saturation Curves

VII. (continued)

The relationship between brine enthalpy and temperature was derived from a least-squares fit of the reference literature (Ref. 1) data for a 30 wt. % NaCl solution and is expressed as $H_b = 0.3675T^{1.0896}$ Btu/lb. This approach is similar to that which was used by G.L. Dittman in his report, "Calculation of Brine Properties" (Ref. 3).

A brief summary of the methods used to calculate the gas flows and concentrations is as follows:

1. Derive an isentropic process flow for complete system (Appendix B.1).
2. Derive brine latent heat of vaporization from saturation curve.
3. Derive equation for enthalpy from reference NaCl solution data (Appendix B.2).
4. Solve process flow equations to determine vapor flow quantities and concentrations (sample calculation, Appendix B.3).
5. Compare calculated steam flows with those measured (Appendix B.4).
6. Develop a table of results (see Table VII-1).

The 30 wt. % NaCl solution was chosen because wellhead brine chemistries yielded 18-20 wt. % NaCl and 7-10 wt. % other salts (KCl, CaCl_2 , etc.). (See Appendix B.2 for calculation of brine salt concentration.) The influence of these other salts on the brine enthalpy was assumed to equal that of NaCl. Review of the literature (Ref. 5 and 6) shows that NaCl, KCl, and CaCl_2 aqueous solutions have similar heat capacities; this suggests that the enthalpy differences ($H_{b3}(\text{brine out}) - H_{b1}(\text{brine in})$) for these solutions are nearly equal. The fact that the calculated steam flows agree with the measured flows tends to confirm the assumptions of the process analysis. However, if equipment is available to perform direct brine enthalpy measurements, brine samples should be analyzed in order to verify assumptions and calculations.

Table VII-1 shows the steam and noncondensable gas concentration for Tests 15, 18, 19, and 20.

VII. (continued)

TABLE VII-1

DISCHARGE STEAM/NONCONDENSABLE GAS CONCENTRATIONS

Test No.	Date	H ₂ O	CO ₂	N ₂	Concentration (wt. %)		H ₂ S	Mode of Operation
					CH ₄	Ar+O ₂ (1)		
15	10/28/80	56.8	42.2	0.3	0.4	0.3	—	AECC in parallel flow off wellhead. Brine supply received from center tap (tee) off wellhead supply.
18	12/11/80	89.6	9.6	0.6	0.1	0.2	—	AECC in parallel flow off wellhead. Brine supply received from bottom tap (modified tee) off wellhead supply.
19-1	1/08/81	73.3	22.9	2.8	0.1	0.8	—	AECC in direct flow off wellhead.
19-2	1/12/81	65.3	32.9	1.1	0.2	0.5	—	
20-1 (2)	2/03/81	65.2	32.4	1.6	0.3	0.5	.005	Same as above.
20-2 (2)	2/05/81	65.6	33.6	0.3	0.3	0.2	.002	

Notes:

- (1) Laboratory analysis did not distinguish between Ar and O₂. However, due to the reducing nature of the fluid, it is doubtful that O₂ is present.
- (2) Concentrations are from the sum of the discharges of Tanks A, B, and C.

VIII. RESULTS: BRINE AND SCALE ANALYSIS

The objectives of the brine and scale analyses were to characterize the incoming brine and follow the changes in the brine chemistry throughout the testing process. Scale depositions on both the flash tank coupons and the test sections were measured and analyzed for mineralogical and elemental content. This information is provided in test section and flash tank figures for each testing series. These are included in this chapter.

The hydroscale testing was made up of a single-flash test series in January (Test No. 19) and a multiple-flash (dual-flash) test series in February (Test No. 20). Tests were conducted at the Mercer 2 well in South Brawley, California, one of the deepest wells in the Imperial County (approximately 13,500 feet total depth). Wellhead temperatures and pressures experienced while test equipment was operating were in excess of 436°F and 450 psig, respectively. Table VIII-1 shows the results of wellhead brine chemistry analyses for Tests 19 and 20. Additional chemistry analyses were performed by Los Alamos on four samples taken from Tests 19 and 20. These comparative results are shown in Appendix E, Table E.5. Liquid brine samples drawn for the above wellhead brine analyses were taken from a 6:00 o'clock position on the 4-inch brine inlet pipe downstream of the 10-inch tee concentric reducer and approximately 25 feet from the wellhead. Inlet brine flow was two-phase, and approximately 5 to 8% of the total flow by weight (expressed in lb/hr), was calculated to be in a vapor phase.

A. TEST OBJECTIVES

The objective of the subject tests was to expose the various pipe sections to both single- and two-phase flashed brine effluents from both the single- and dual-flashed power cycles. Specifically, test goals were as follows:

1. Expose a set of four piping test sections to flashed brines from each flash cycle for a minimum of two days,
2. Expose a set of flash tank coupons at each of the flash pressure conditions,
3. Analyze changes brine chemistry as a function of flashing pressure and components in the test section, and
4. Evaluate and characterize scale depositions in both flash tanks and test sections.

VIII (continued)

TABLE VIII-1

Wellhead Brine Chemistry
Tests 19 and 20

	Test 19 1/7/81 - 1/11/81 99 (hrs)	Test 20 2/2/81 - 2/6/81 (103.5 hrs)
Flowrate (lb/hr)*	1.30×10^5	1.422×10^5
Pressure (psig)*	450	446
Temperature (°F)*	436	432
Sample Point	V-5	V-5
No. of Samples	17	23
Constituent (mg/l)*		
Na	71,500	69,500
K	9,560	11,000
Li	266	403
Ca	23,300	23,300
Mg	441	434
Ba	2,460	2,440
Sr	1,905	1,850
B	272	284
Al	<3.	<3.
Fe	4,940	5,110
Mn	1,190	1,240
Pb	255	291
Zn	1,282	1,430
SiO ₂	627	600
SO ₄	1.	1.
CO ₂	456	553
HCO ₃	210	122
CO ₃	1.1	1.
Cl	171,000	174,000
TDS	286,000	314,000
pH	5.32	4.78

* Average Values.

The following trace elements were found to be less than established detection limits:

Ag <0.3; As <10; Au <0.9; Be <0.1; Cd <0.7; Ce <0.1; Co <0.9;
Cr <1; Cu <0.2; Ga <7; Ge <8; Hg <3; La <0.3; Mo <7.5; Ni <4;
PO₄ <10; Sb <4; Se <10; Sn <10; Ti <0.2; V <0.3; Zr <0.5 mg/l.

VIII. (continued)

B. SCALE ANALYSIS

The following optical microscopy and scanning electron microscopy (SEM) analysis was provided by the Los Alamos National Laboratory under the direction of Dr. Roy Feber.

The scale samples were mounted in resin by immersing them in Shell Epon 815 containing 10 parts per hundred of diethylene triamine. The resin was allowed to harden at room temperature under approximately 1000 psig nitrogen overpressure, and the mounted samples were given a post-cure at 60°C for two hours.

Standard metallographic procedures were used to polish the mounts: grinding on SiC papers, using kerosene as a lubricant, followed by diamond polishing on perforated Texmet, using ethylene glycol as a lubricant, and etching the samples by bombardment with 3 keV hydrogen ions to enhance optical contrast.

The samples were then examined by optical photomicrography for differences in optical reflectivity and by scanning electron microscopy for differences in secondary electron emission and elemental analysis using Energy Dispersive Spectroscopy (EDS). For examination by SEM, the samples were coated with approximately 100 Å of carbon prior to introduction under vacuum into a Model 104A Coates and Walter SEM.

Eight scale samples from four runs were taken from pipe test sections with 3/4-inch orifices and were examined by the above techniques.

Test No.	Sample No.	Average Pressure (psig)		Average Thickness
		Upstream	Downstream	
19-1 (1/8 - 1/10/81)	400SP-50-3	56.2	—	1.8 mm
	400SP-50-7	—	49.1	1.9
19-2 (1/10 - 1/11/81)	400SU-50-3	26.2	—	0.4
	400SU-50-7	—	20.0	0.5
20-1 (2/2 - 2/4/81)	400DU-100-3	88.8	—	1.2
	400DU-100-7	—	84.4	1.4
20-2 (2/4 - 2/6/81)	300DU-200-3	177.8	—	1.0
	300DU-200-9	—	168.8	0.4

VIII. (continued)

Sample pairs from the three 400 and the one 300 series test sections were from locations two feet upstream (-3) and two feet downstream (-7) from a 3/4-inch orifice located midway in a test section.

Whenever the orientation of the accompanying figures is important to interpretation, the edges of the scale adjacent to the pipe are shown at the bottom of the photograph.

General Comments: The scales are relatively porous, multiphase, and, except near the pipe, show limited layering or stratification. Broadly speaking, most of the scale consists mainly of two types of matrices.

- a. A matrix that is high in Si, medium in Fe, and low in Cl. Because X-ray does not show crystalline Si-containing compounds (except for two samples not discussed here which contained small amounts of quartz), this matrix is believed to be an Fe-containing amorphous silica, simply referred to as silica. From time to time, particles of variable composition containing other heavy metals (Pb, Mn, Cu, Ag) are associated with this matrix. With the techniques used, these particles could be frequently, (though not always) identified as sulfides. They have a very high, metallic optical reflectivity.
- b. A matrix of variable composition that is high in Fe and high in Cl. This matrix is believed to include the crystalline Fe-containing compounds detected by X-ray (Appendix Table D.2). The proportions of these Fe compounds can change on exposure to air. In particular, the $\beta\text{-Fe}_2(\text{OH})_3\text{Cl}$ in powdered scale samples has been observed by X-ray to oxidize with the simultaneous formation of $\beta\text{-FeO}(\text{OH})$. $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ has also been observed to increase in such samples, but at a slower rate. Although EDS makes it possible to detect variations in the Fe/Cl ratio in this matrix, it was not feasible in the time available to perform more detailed mappings of the individual compounds by SEM or other techniques. The compounds in this matrix are referred to somewhat imprecisely as "iron chlorides."

VIII. (continued)

- c. In addition, from time to time small regions of what appear to be lead chlorides are observed. PbCl_2 and $(\text{K},\text{Na})\text{Pb}_2\text{Cl}_5$ had been detected in some scale samples by X-ray. These regions also have high, though not metallic, optical reflectivity.
- d. Typically, the first 100 - 250 μ of scale which formed next to the pipe has fewer voids than the bulk scale and has a higher Fe/Cl ratio than the bulk crystalline Fe-containing matrix. From the location of this layer, it is believed to be associated with corrosion of the pipe.

The following photomicrographs will illustrate the general comments made above:

Figure VIII-1a is an optical photomicrograph at 40x of the lower 2/3 of the scale from Sample 400SP-50-3. The thin layer referred to above in Item d is visible at the bottom. Also visible in the lower half of the photomicrograph are regions of high optical reflectivity believed to be lead chlorides.

Figure VIII-1b is a SEM photomicrograph at 10,000x taken near the upper edge of the layer adjacent to the pipe which shows the typical dimensions of the compositional variations. The light area at the extreme upper left of the photo and the small ($<0.5\mu$), bright, and scattered particles are a lead chloride. The darkest areas are Fe-containing silica, and the areas intermediate in brightness are crystalline "iron chlorides."

Figure VIII-2a is an optical photomicrograph at 50x of a section of scale from Sample 400SP-50-7. The denser layer of Fe-containing material which forms next to the pipe is again visible at the bottom of the photomicrograph. The relatively large areas of lead chlorides which were visible in the companion Sample 400SP-50-3 were not visible in this sample, although small areas of this material were visible at high magnification. The very dark areas at the top of Figure VIII-2a are artifacts of sample preparation and are places where material has been plucked or dissolved out of the polished section.

Figure VIII-2b is an SEM photomicrograph at 10,000x of an area of Sample 400SP-50-7 near the center of the section. The dark areas on the leftmost two-thirds of the photo are Fe-containing silica. The lighter areas on the

CONDITIONS

298.8°F

56.2 psig (UPSTREAM)

49.1 psig (DOWNSTREAM)

33.0 gpm

49.2 hrs.

See Figures VIII-9, 10, 13 and Table VIII-2.

HIGH Fe/Cl RATIO LAYER
(NEAREST TO PIPE WALL)

LEAD CHLORIDES (HIGH REFLECTIVE AREAS)

CRYSTALLINE "IRON CHLORIDES
(INTERMEDIATE IN BRIGHTNESS)

Fe - CONTAINING SILICA
(DARKEST AREAS)

Figure VIII-1. Test Section 400-SP-50-3 (Upstream of 3/4-inch Orifice)

DENSER LAYER OF Fe - CONTAINING MATERIAL (NEAREST TO PIPE WALL)

CRYSTALLINE "IRON CHLORIDE" (LIGHT AREAS)

BRIGHTEST PARTICLE CONTAINS Ag, Cu, and S

Fe - CONTAINING SILICA (DARK AREAS)

Figure VIII-2. Test Section 400-SP-50-7 (Downstream of 3/4-inch Orifice)

VIII. (continued)

right contain crystalline "iron chlorides." The topography of the matrix is responsible for most of the variation in brightness. However, the brightest particle in the photo above and to the right of center turned out to contain Ag, Cu, and S.

Figure VIII-3a is a 200x optical photomicrograph of a section of scale from Sample 400SU-50-3. This particular mount does not show the layer next to the pipe, perhaps because the layer was destroyed when the sample was stripped from the pipe. No Pb or Ag was detected in this mount. Otherwise, the distribution of phases is by now familiar, as shown in the SEM photomicrograph at 1000x (Figure VIII-3b). The very brightly edged areas in Figure VIII-3b are due to instrumental effects.

An SEM photomicrograph at 1000x of Sample 400SU-50-7 is shown in Figure VIII-3c. The interpenetration of amorphous Fe-containing silica and crystalline "iron chlorides" is once again apparent. An additional feature of this picture is the growth of crystals of the iron chloride into voids.

Figure VIII-4a is an SEM photomicrograph of Sample 400DU-100-3 at 60x. Apparent toward the bottom of the figure, just above the layer adjacent to the pipe, is a dendritic growth of "lead chloride" in a high silica matrix. A view of this region with the SEM at 1000x is shown in Figure VIII-4b. The small, bright particles on the dendrites are lead sulfide-containing variable proportions of Ag. Figure VIII-4c is a 5000x SEM photomicrograph of another portion of this scale sample, again showing "iron chloride" growing into an epoxy-filled void. The dark area at the bottom of this figure is Fe-containing silica.

In the optical photomicrograph (80x) of a section of scale from Sample 400DU-100-7 (Figure VIII-5a), a "colony" of lead chloride in silica is visible at the top edge (brine-side) of the scale. SEM photomicrographs of this region (Figure VIII-5b, 1000x; Figure VIII-5c, 10,000x) show small, bright areas which contain Ag in lead sulfide. The remainder of the sample is typical.

CONDITIONS

265°F

26.2 psig (UPSTREAM)

20.0 psig (DOWNSTREAM)

36.7 gpm

25.3 hrs.

See Figures VIII-15, 16, 19 and Table VIII-3.

Figure VIII-3. Test Section 400-SU-50-3 (a & b) Upstream of 3/4-inch Orifice Plate and 400SU-50-7 (c) Downstream of 3/4-inch Orifice Plate

CONDITIONS:

317°F

88.8 psig (UPSTREAM)

84.4 psig (DOWNSTREAM)

37.0 gpm

47.5 hrs.

See Figures VIII-24, 25, 28 and Table VIII-5.

LEAD-CHLORIDE DENDRITE

PbS (BRIGHT SPOTS)

Fe-CONTAINING SILICA

Fe-CHLORIDE CRYSTALS

Figure VIII-4. Test Section 400-DU-100-3 (Upstream of 3/4-inch Orifice Plate)

Figure VIII-5. Test Section 400-DU-100-7 (Downstream of 3/4-inch Orifice Plate)

VIII. (continued)

Figure VIII-6a, an optical photomicrograph of Sample 300DU-200-3 at 100x, is one of the few pictures clearly showing (across the middle of the figure) the metallic reflectivity of particles of lead sulfide at low magnification. In Figure VIII-6b, a 1000x SEM photomicrograph taken in the area of one of these bright spots, the relatively large bright area near the center contains Pb and Ag, as do the small (approx. 3μ) nearby bright spots. The matrix at the lower half of the figure is silica, and that at the upper right is "iron chloride."

Figure VIII-7a is an optical photomicrograph of a thin section of scale from Sample 300DU-200-7 (200x). The bright areas near the top (brine-side) of the figure are lead sulfide in a high-silica matrix. This scale was one of the few showing evidence of layering away from the pipe. As shown in Figure VIII-7b, an SEM photomicrograph at the same magnification, beneath the galena-silica layer are found, in turn, a lighter-colored "iron chloride" layer, a layer or lens of the darker-colored silica, and, finally, an underlying two-phase layer of interpenetrating silica and "iron chloride" matrices.

Figure VIII-7c is an SEM photomicrograph at 2500x of a rather jumbled area containing lead sulfide (bright particles) associated with Ag in a dark-colored silica matrix which is in contact with "iron chloride" (upper right).

A major conclusion from these microscopic studies is that there are no significant differences in the types of scale deposited in the test loops that can be demonstrated with these microtechniques.

CONDITIONS:

339°F

177.8 psig (UPSTREAM)

168.8 psig (DOWNSTREAM)

31.7 gpm

49.7 hrs

See Figures VIII-30, 31, 34, 34a,
and Table VIII-6.

LEAD SULFIDE (BRIGHT SPOTS)

Figure VIII-6. Test Section 300-DU-200-3 (Upstream of 3/4-inch Orifice Plate)

LEAD SULFIDE (BRIGHT AREAS)
ON A HIGH-SILICA MATRIX

- I - GALENA-SILICA LAYER
- II - IRON-CHLORIDE LAYER
- III - SILICA LAYER (LENS)
- IV - INTERPENETRATING SILICA AND IRON-CHLORIDE MATRIX (TWO PHASE LAYER)

LEAD SULFIDE
(BRIGHT AREAS)

IRON-CHLORIDE
(INTERMEDIATE
AREA)

Figure VIII-7. Test Section 300-DU-200-7 (Downstream of 3/4-inch Orifice Plate)

VIII. (continued)

C. POWER CYCLE TEST RESULTS (Tests 19 and 20)

The test results are organized into a series of tables, test section figures, and flash tank figures for each test. The tests are grouped into two major sections, each with two subsections as follows:

- a. Test 19 Single-Flash Test Results (Test 19-1 pumped tests, and Test 19-2 unpumped test).
- b. Test 20 Dual-Flash Test Results (Test 20-1 unpumped 100-psig test, and Test 20-2 unpumped 200-psig test).

An index to the tables and figures will be found on the following pages.

VIII. (continued)

Index: Power Cycle Test Results

1.	Discussion of Single-Flash Test Operational Behavior	<u>Page</u>
2.	Test 19-1 Results: Single-Flash Pumped Brine	
	<u>Figure (Table) No.</u>	<u>Description</u>
	VIII-9	Flow diagram for Test 19-1 (pumped) 74
	VIII-10	Test section configuration for Test 19-1 (pumped) 75
	(VIII-2)	Test section brine chemistry analysis (pumped) 76
	VIII-11, 11a	Test section 200-SP 50 (straight pipe) 77, 78
	VIII-12, 12a	Test section 300-SP 50 (expansion/contraction) 79, 80
	VIII-13	Test section 400-SP 50 (3/4-inch orifice) 81
	VIII-14	Test section 500-SP 50 (1-inch orifice) 82
3.	19-2 Results: Single Flash Unpumped Brine	
	VIII-15	Flow diagram for Test 19-2 (unpumped) 84
	VIII-16	Test section configuration for Test 19-2 (unpumped) 85
	(VIII-3)	Test section brine chemistry analysis (unpumped) 86
	VIII-17	Test section 200-SU-50 (straight pipe) 87
	VIII-18	Test section 300-SU-50 (expansion/contraction) 88
	VIII-19	Test section 400-SU-50 (3/4-inch orifice) 89
	VIII-20	Test section 500-SU-50 (1-inch orifice) 90
4.	Tests 19-1 and 19-2 Results: Flash Tank	
	VIII-21	Flash Tank A brine flow and scale analysis 92
	(VIII-4)	Flash Tank A (50 psig) brine and vapor chemistry analysis 93
	VIII-22	Wellhead pressure, temperature, and flow vs time 94
5.	Discussion of Dual-Flash Test Operational Behavior	

VIII. (continued)

6. Test 20-1 Results: Dual-Flash (Unpumped) 100 psig		<u>Page</u>
<u>Figure (Table) No.</u>	<u>Description</u>	
VIII-24	Flow diagram for Test 20-1 (100 psig)	99
VIII-25	Test section configuration for Test 20-1 (100 psig)	100
(VIII-5)	Test section brine chemistry analysis for Test 20-1 (100 psig)	101
VIII-26	Test section 100-DU-100 (straight pipe)	102
VIII-27, 27a	Test section 300-DU-100 (expansion/contraction)	103,104
VIII-28	Test section 400-DU-100 (3/4-inch orifice)	105
VIII-29	Test section 500-DU-100 (1-inch orifice)	106
7. Test 20-2 Results: Dual-Flash (Unpumped) 200 psig		
VIII-30	Flow diagram for Test 20-2 (200 psig)	108
VIII-31	Test section configuration for Test 20-2 (200 psig)	109
(VIII-6)	Test section brine chemistry analysis for Test 20-1	110
VIII-32	Test section 100-DU-200 (straight pipe)	111
VIII-33, 33a	Test section 200-DU-200 (expansion/contraction)	112,113
VIII-34	Test section 300-DU-200 (3/4-inch orifice)	114
VIII-34a	Microphoto of scale build-up on inlet edges of 3/4-inch orifice (300-DU-200)	115
VIII-35	Test section 400-DU-200 (1-inch orifice)	116
VIII-35a	Microphoto of scale build-up on inlet edge of 1-inch orifice (400-DU-200)	117
8. Tests 20-1 and 20-2 Results: Flash Tank		
VIII-36	Flash Tank A (200 psig) brine flow and scale analysis	119
(VIII-7)	Flash Tank A (200 psig) brine and vapor chemistry analysis	120
VIII-37	Flash Tank B (100 psig) brine flow and scale analysis	121
(VIII-8)	Flash Tank B (100 psig) brine and vapor chemistry analysis	122
VIII-38	Wellhead pressure, temperature, and flow vs time	123

VIII. (continued)

1.0. Discussion of Single-Flash Test Operational Behavior

The single-flash tests required a direct transfer of the flashed brine effluent from Tank A through the piping sections to the injection pipe line. The brine transfer was made with and without the assistance of a pump. Figures VIII-9 and VIII-15 depict the simplified versions of a P&ID for pumped and unpumped flashed brine flows. The flow was directed to the test sections through block valve V-21A and controlled by flow control valve FCV-38. However, midway into the pumped test, control valves PCV-12A (steam), LCV-10A (brine inlet), and FCV-38 began to seize and finally became locked in position at the end of the 49.2 hour pumped test. The flow control for remainder of the test series (both pumped and unpumped) was accomplished by throttling with the brine supply block valve V-71. One hour into the unpumped test, the level in Tank A began to rise. In order to reduce and maintain the level, it was necessary to open the holding pond drain block valve V-75. However, twelve hours later, the holding pond valve V-75 was wide open, and some difficulty was experienced in maintaining the flow through the test sections. At approximately twenty-five hours into the unpumped test, testing was shut down due to a rainstorm which caused the voltage regulator of the diesel generator to fail. The unpumped test series ended after 25.3 hours of operation. Figure VIII-8 shows sludge buildup in block valve insert (V-21A) at the end of the test.

Figure VIII-8. Flash Tank A Block Valve Insert (V-21A)

VIII. (continued)

2.0 Test 19-1 Results:

Single-Flash Pumped Brine

Figure VIII-9. Flow Diagram for Test 19-1 (Pumped)

NOTES:

1. Dimensions and part numbers for all other test sections are the same except where indicated.
2. Dash lines on pipes indicate post test cutting positions and part interfaces.
3. All cut parts are marked with respective test section number and part number, e.g. 500SP-50-2.

*See Section VIII-B for SEM Analysis

Figure VIII-10. Test Section Configuration for Test 19-1 (Pumped)

	Inlet		Outlet (Test Sections)			
	Pump Inlet	Pump Outlet	200 St. Pipe	300 E/P	400 3/4" Orf.	500 1" Orf.
Flowrate (gpm)*	- 216.7 -		69.1	69.4	33.0	45.3
Pressure (psig)*	47.9	56.2	53.4	55.5	49.1**	52.2
Temperature (°F)*	296.5	298.8	-	-	-	-
Sample Point	V-19A	V-208	V-209	V-309	V-409	V-509
Element (mg/l)*						
Cl	188,000	193,000	198,000	198,000	198,000	197,000
Na	81,600	82,500	81,300	82,700	82,500	83,300
K	11,470	11,700	11,400	11,800	11,600	11,600
Li	323	336	334	359	331	309
Ca	26,800	27,500	26,900	27,000	26,400	26,700
Mg	494	503	493	500	492	501
Ba	2,790	2,852	2,845	2,820	2,770	2,760
Sr	2,157	2,207	2,177	2,150	2,140	2,130
B	298	306	302	299	298	305
Al	<3.	<3.	<3.	<3.	6.23	<3.
Fe	5,522	5,642	5,497	5,513	5,443	5,440
Mn	1,347	1,365	1,335	1,340	1,325	1,353
Pb	301	304	292	297	295	309
Zn	1,480	1,520	1,503	1,540	1,523	1,560
SiO ₂	662	621	620	560	564	568
SO ₄	<1.	<1.	<1.	<1.	<1.	<1.
CO ₃	<1.	<1.	<1.	<1.	<1.	<1.
HCO ₃	103	36	40	54	66	60
CO ₂	407	326	NA	NA	NA	NA
TDS*	321,000	315,000	338,000	340,000	339,000	339,000
pH*	4.78	5.02	4.91	4.81	5.22	5.55

* Avg. Values

** Calculated Value

TABLE VIII-2: TEST SECTION BRINE CHEMISTRY ANALYSIS - PUMPED
TEST 19-11/8/81 - 1/10/81 (49.2 HRS)

Straight Pipe Sections
Shown on Following Page
Figure VIII-11a

	UPSTREAM OF MIDLINE	DOWNSTREAM OF MIDLINE
SCALE DEPOSITION RATE*	.0011 IN./HR.	
GENERAL APPEARANCE, COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	HARD/TENACIOUS: BLACKISH GRAY BODY, BROWN-VEINED WITH GRAY FLECKS; RUST- COLORED (DRY); RIPPLED SURFACE (SOME GLAZING).	
COMPOSITION: MAJOR [MINOR]	$\beta\text{-Fe}_2(\text{OH})_3\text{Cl}$, $[\beta\text{-FeO}(\text{OH}) \text{ Akaganeite}, (\text{K}, \text{Na})\text{Pb}_2\text{Cl}_5]$ [Trace - $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}, \text{PbS}$]	
ELEMENT (% WT)		
Fe	44.0	43.3
SiO ₂	9.36	9.33
Cl	8.7	10.6
Pb	1.0	1.96
Ca	0.12	0.11
Mg	0.03	0.03
Al	<0.03	<0.03
Ag	0.01	0.04
DENSITY (gm/cc)	2.91	2.93

FIGURE VIII-11		
TEST SECTION		
200 - SP - 50		
SINGLE-FLASH - PUMPED		
STRAIGHT PIPE (2")		
69.1 GPM (7.1 FT/SEC)*		
49.2 HRS		
1255 (1/8) TO 1410 (1/10)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRES. (psig)*	56.2	53.4
TEMP. (°F)*	298.8	
PUMP	INLET	OUTLET
PRESS. (PSIG)*	47.9	56.2
TEMP. (°F)*	296.5	298.8

*AVG VALUE

Figure VIII-11a. Straight Pipe Sections (200-SP-50)

EXPANSION/CONTRACTION SECTIONS
SHOWN ON FOLLOWING PAGE,
FIGURE VIII-12a

	UPSTREAM	EXPANSION/CONTRACTION	DOWNSTREAM
SCALE DEPOSITION RATE*	.0013 IN./HR.	.0019 IN./HR.	.0014 IN./HR
GENERAL APPEARANCE/ COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	SIMILAR TO 200- SP-50	SOFTER THAN UPSTREAM; COARSER GRAIN; LIGHT RUST-COLORED SURFACE (SOME GLAZING); DARK BROWN BODY WITH A MUSTARD GREEN BASE	SIMILAR TO UPSTREAM
COMPOSITION: MAJOR [MINOR]	β -Fe ₂ (OH) ₃ Cl, [β -FeO(OH) Akaganeite], [Trace: FeCl ₂ ·4H ₂ O]		β -Fe ₂ (OH) ₃ Cl, [β -FeO(OH) Akaganeite, FeCl ₂ ·4H ₂ O], [Trace: α -FeO(OH) Goethite]
ELEMENT (% WT)		NA	
Fe	46.8		48.1
SiO ₂	8.29		11.5
Cl	7.9		<1.0
Pb	0.91		1.96
Ca	0.11		0.11
Mg	0.03		0.03
Al	0.08		0.05
Ag	0.04		0.07
DENSITY (gm/cc)	3.06	NA	3.10

FIGURE VIII-12		
TEST SECTION		
300 - SP - 50		
SINGLE-FLASH - PUMPED		
4" EXPANSION/2" CONTRACTION		
69.4 GPM (7.1 FT/SEC)		
49.2 HRS		
1255 (1/8) TO 1410 (1/10)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESS. (PSIG)*	56.2	55.4
TEMP. (°F)*	298.8	-
PUMP	INLET	OUTLET
PRESS. (PSIG)*	47.4	56.2
TEMP. (°F)*	296.5	298.8

*AVG. VALUE

Figure VIII-12a. Expansion/Contraction Sections (300-SP-50)

	UPSTREAM	3/4" ORIFICE	DOWNSTREAM
SCALE DEPOSITION RATE*	.0014 IN./HR.		.0011 IN./HR.
GENERAL APPEARANCE/ COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	SIMILAR TO 200- SP-50	UPSTREAM: SOFT, COARSE GRAINED- MUSTARD-COLORED - RIPPLED CORDOVAN COLORED SURFACE(SOME GLAZING)	HARD TENACIOUS: BLACK BODY WITH GRAY FLECKS, FINE RIPPLED SURFACE, MINIMAL GLAZING
COMPOSITION: MAJOR [MINOR]	[β -FeO(OH) Akaganeite, β -Fe ₂ (OH) ₃ Cl, (K,Na)Pb ₂ Cl ₅], [Trace: α -FeO(OH) Goethite, FeO(OH) Lepibrocrocite & FeCl ₂ ·4H ₂ O]		[β -Fe ₂ (OH) ₃ Cl, β -FeO(OH)], [Trace: FeCl ₂ ·4H ₂ O & (K,Na)Pb ₂ Cl ₅]
ELEMENT (% WT)		NA	
Fe	37.5		43.0
SiO ₂	21.3		16.1
Cl	4.3		6.3
Pb	7.57		4.21
Ca	0.37		0.27
Mg	0.05		0.04
Al	0.1		0.07
Ag	0.09		0.09
DENSITY (gm/cc)	2.79		2.99

FIGURE VIII-13		
TEST SECTION 400 - SP - 50		
SINGLE-FLASH - PUMPED		
3/4" ORIFICE		
33.0 GPM (3.4 FT/SEC)*		
49.2 HRS		
1255 (1/8) TO 1410 (1/10)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESS. (PSIG)*	56.2	49.1**
TEMP. (°F)*	298.8	-
PUMP	INLET	OUTLET
PRESS. (PSIG)*	47.9	56.2
TEMP. (°F)*	296.5	298.8

*AVG VALUE **CALCULATED VALUE

	UPSTREAM	1" ORIFICE	DOWNSTREAM
SCALE DEPOSITION RATE*	.00143 IN./HR.		.0013 IN./HR.
GENERAL APPEARANCE/ COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	SIMILAR TO 200- SP-50	HARD TENACIOUS:BLACK BODY WITH GRAY FLECKS AND RUST- COLORED VEINS;CORDOVAN-BROWN RIPPLED GLAZED SURFACE	HARD TENACIOUS:BLACK BODY WITH GRAY FLECKS - BROWN RIPPLED GLAZED SURFACE
COMPOSITION: MAJOR [MINOR]	[β -Fe ₂ (OH) ₃ Cl, β -FeO(OH), (K,Na)Pb ₂ Cl ₅], [Trace: FeCl ₂ 4H ₂ O, PbS & PbCl ₂]		[β -Fe ₂ (OH) ₃ Cl, β -FeO(OH)];[Trace: β -FeO(OH), FeCl ₂ 4H ₂ O, PbS, (K,Na)Pb ₂ Cl ₅]
ELEMENT (% WT)		NA	
Fe	44.0		49.4
SiO ₂	17.0		10.9
Cl	1.3		6.5
Pb	6.36		0.78
Ca	0.33		0.11
Mg	0.041		0.029
Al	0.08		0.11
Ag	0.07		0.05
DENSITY (gm/cc)	2.93	NA	2.99

FIGURE VIII-14			
TEST SECTION 500 - SP -50			
SINGLE FLASH - PUMPED			
1" ORIFICE			
45.3 GPM (4.6 FT/SEC)*			
49.2 HRS 1255 (1/8) TO 1410 (1/10)			
	INLET	OUTLET	
COMPONENT	ELBOW	TEE	
PRESS. (PSIG)*	56.2	52.2	
TEMP. (°F)*	298.8	-	
PUMP	INLET	OUTLET	
PRESS. (PSIG)*	47.9	56.2	
TEMP. (°F)*	296.5	298.8	

*AVG. VALUES

VIII. (continued)

3.0 Test 19-2 Results:

Single-Flash Unpumped Brine

Figure VIII-15. Flow Diagram for Test 19-2 (Unpumped)

NOTES:

1. Dimensions and part numbers for all other test sections are the same, except where indicated.
2. Dash lines on pipes indicate post test cutting positions and part interfaces.
3. All cut part are marked with respective test section number and part number, e.g. 500SP-50-2.

*See Section VIII-B for SEM Analysis.

Figure VIII-16. Test Section Configuration for Test 19-2 (Unpumped)

	Inlet	Outlet (Test Sections)			
	200	200 St. Pipe	300 E/C	400 3/4" Orif.	500 1" Orif.
Flowrate*(gpm)	167.0	44.9	45.8	36.1	40.2
Pressure*(psig)	26.2	22.1	21.8	20.0	22.0
Temperature*(°F)	265.1	-	-	-	-
Sample Point	V-19A	V-209	V-309	V-409	V-509
Element (mg/l)*			2 PHASE FLOW (Unable to Sample Brine)		
Cl	196,000	199,000			
Na	79,300	79,700			
K	10,000	11,000			
Li	301	314			
Ca	26,200	26,900			
Mg	510	476			
Ba	2,975	2,780			
Sr	2,110	2,150			
B	307	313			
Al	<3.	<3.			
Fe	5,515	5,580			
Mn	1,330	1,360			
Pb	304	297			
Zn	1,455	1,560			
SiO ₂	588	488**			
SO ₄	<1.0	<1.0			
CO ₃	<1.0	<1.0			
HCO ₃	101	8.1			
CO ₂ ***	326	NA			
TDS*	337,000	345,000			
pH*	5.52	4.86			

*Avg Values
**RU Samples
***CO₂ Samples taken
1 hr prior to test
Start

TABLE VIII-3 TEST SECTION BRINE CHEMISTRY ANALYSIS - UNPUMPED
TEST 19-2 1/10/82 - 1/11/81 (25.3 HRS)

	UPSTREAM OF MIDLINE	DOWNSTREAM OF MIDLINE
SCALE DEPOSITION*	~ .0024 IN./HR.	~ .0026 IN./HR.
GENERAL APPEARANCE/COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	HARD/BRITTLE BODY: INITIAL 2/3 - BLACKISH, WITH BROWN-VEINED STRUCTURES OF EQUAL AREA, TOP 1/3 A LIGHT-YELLOWISH RUST (SCALE SOFT & FLUFFY) RIPPLED SURFACE (INTERMITTENT GLAZING).	
COMPOSITION: MAJOR [MINOR]	[β -FeO(OH) Akaganeite, γ -FeO(OH) Lepidocrocite], [Trace: α -FeO(OH) Goethite]	
ELEMENT (% WT)		
Fe	31.8	35.8
SiO ₂	23.3	26.9
Cl	4.5	1.8
Pb	2.69	0.36
Ca	0.77	0.59
Mg	0.04	0.04
Al	< 0.03	0.04
Ag	0.03	0.02
DENSITY (gm/cc)	2.42	2.60

FIGURE VIII-17		
TEST SECTION 200 - SU - 50		
SINGLE-FLASH - UNPUMPED		
STRAIGHT PIPE (2")		
44.9 GPM (4.6 FT/SEC.)*		
25.3 HRS 1840 (1/10) TO 200 (1/11)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESSURE (psig)*	26.2	22.1
TEMPERATURE (°F)*	265.1	—
PUMP	OUTLET	INLET
PRESSURE	—	—
TEMP.	—	—

*AVG VALUE

	UPSTREAM	EXPANSION/CONTRACTION	DOWNSTREAM
SCALE DEPOSITION*	~ .003 IN./HR.	.0039 IN./HR	.0027 IN./HR
GENERAL APPEARANCE/COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	SAME AS 200 - SU - 50	BLACK BASE WITH GRAYISH WHITE FLECKS - UPPER HALF LIGHT RUST-COLORED, RIPPLED SURFACE (SOFT/FLUFFY)	SIMILAR TO UPSTREAM
COMPOSITION: MAJOR [MINOR]	[β -FeO(OH) Akaganeite, Trace: α -FeO(OH) Goethite]		β -FeO(OH) Akaganeite
ELEMENT (% WT)			
Fe	28.8	NA	43.6
SiO ₂	27.6		20.1
Cl	< 1.0		< 1.0
Pb	0.45		0.28
Ca	0.77		0.54
Mg	0.04		0.03
Al	< 0.04		0.08
Ag	0.02		0.02
DENSITY ¹ (gm/cc)	2.59		2.80

FIGURE VIII-18		
TEST SECTION 300 - SU - 50		
SINGLE-FLASH - UNPUMPED		
4" EXPANSION/2" CONTRACTION		
45.8 GPM (4.7 FT/SEC.)*		
25.3 HRS		
'1840 (1/10) TO 2000 (1/11)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESSURE (psig)*	26.2	21.8
TEMPERATURE (°F)*	265.1	—
PUMP	INLET	OUTLET
PRESSURE	—	—
TEMP.	—	—

*AVG VALUE

	UPSTREAM	3/4" ORIFICE	DOWNSTREAM
SCALE DEPOSITION *	~ .0022 IN./HR		.0015 IN./HR.
GENERAL APPEARANCE/COLOR (DRY) (Pitting/Uniform Corrosion Present Throughout Section)	SIMILAR TO 200 - SU - 50		HARD TENACIOUS: BLACK BODY WITH GRAY FLECKS, FOLLOWED BY YELLOW STRIPE, BROWN CORDOVAN STRIPE, LIGHT BROWN STRIPE AND DARK CORDOVAN RIPPLED SURFACE (INTERMITTENT GLAZING)
COMPOSITION: MAJOR [MINOR]	[β -FeO(OH) Akaganeite; $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ Upstream only]; [Trace: β -Fe ₂ (OH) ₃ Cl, α -FeO(OH) Goethite, γ -FeO(OH) Lepidocrocite]		
ELEMENT (% WT)			
Fe	44.3		55.3
SiO ₂	23.6		7.76
Cl	2.8	NA	2.4
Pb	0.22		0.1
Ca	0.42		0.32
Mg	0.04		0.03
Al	0.08		0.08
Ag	0.01		0.01
DENSITY (gm/cc)	2.67	NA	3.19

FIGURE VIII-19		
TEST SECTION 400 - SU - 50		
SINGLE-FLASH - UNPUMPED		
3/4" ORIFICE		
36.1 GPM (3.7 FT/SEC.)*		
25.3 HRS 1840 (1/10) TO 2000 (1/11)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESSURE (psig) *	26.2	20.00
TEMPERATURE (°F)*	265.1	—
PUMP	INLET	OUTLET
PRESSURE	—	—
TEMP	—	—

*AVG VALUE

	UPSTREAM	1" ORIFICE	DOWNSTREAM
SCALE DEPOSITION *	~ 0.0017 IN./HR.	—	~ .0009 IN./HR.
GENERAL APPEARANCE/COLOR (Pitting/Uniform Corrosion Present Throughout Section)	SOFT SCALE: CRUMBLES. GREENISH MUSTARD-COLORED BODY; GLAZED DARK-BROWN (RUST); RIPPLED SURFACE	HARD BLACK-BODIED SCALE NEAREST OPENING (FACE); SOFTER MUSTARD- COLORED SCALE UPSTREAM OF ORIFICE	FIRMER SCALE, FINER-GRAINED DARK MUSTARD BODY - MICRO-RIPPLED DARK-CORDOVAN GLAZED SURFACE
COMPOSITION: MAJOR [MINOR]	[β -FeO(OH), and one unknown composition] [$\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$, (K,Na) Pb_2Cl_5]	[β -Fe ₂ (OH) ₃ Cl; β -FeO(OH), $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$], [Trace: γ -FeO(OH)]	
ELEMENT (% WT)		NA	
Fe	38.4		42.5
SiO ₂	28.9		9.63
Cl	2.9		2.8
Pb	1.71		0.07
Ca	0.45		0.14
Mg	0.04		0.02
Al	0.08		0.07
Ag	0.02		0.02
DENSITY (gm/cc)	2.59	NA	2.88

FIGURE VIII-20			
TEST SECTION 500 - SU - 50			
SINGLE-FLASH - UNPUMPED			
1" ORIFICE			
40.2 GPM (4.1 FT/SEC.) *			
25.3 HRS 1840 (1/10) TO 2000 (/11)			
	INLET	OUTLET	
COMPONENT	ELBOW	TEE	
PRESSURE (psig) *	26.2	22.0	
TEMPERATURE (°F) *	265.1	—	
PUMP	INLET	OUTLET	
PRESSURE	—	—	
TEMP	—	—	

*AVG VALUE

VIII. (continued)

4.0 Flash Tank Results:

(Tests 19-1 and 19-2)

SCALE ANALYSIS ~ COUPONS ~					
SAMPLE POINT	SC-80A	SC-83A	SC-81A	SC-82A	TANK BOTTOM RUBBLE
SCALE THICKNESS (IN)	.117	.120	.17	NOTE 2	NOTE 2
SCALE RATE (MIL/HR)	1.2	1.2	1.7		
GENERAL APPEARANCE/COLOR	NA	NA	NA	NOTE 2	NOTE 2
MAJOR COMPOSITION	NOTE 3	NOTE 4	NOTE 5		
ELEMENT (WT%)					
Fe	50.90	46.4	43.20	N/A	N/A
SiO ₂	0.85	6.85	11.70		
Cl	15.30	7.9	< 1.0		
Pb	5.00	26.0	1.27		
Ca	0.14	0.11	0.17		
Mg	0.02	0.02	0.03		
Al	< 0.03	0.12	0.04		
Ag	0.13	0.09	0.04		
DENSITY (gm/cc)	3.28	3.05	2.79	NOTE 2	NOTE 2

NOTES:

- Average Value
- 1. Approximate value (TI & TE Inoperative)
- 2. Black Sludge Type Material Unattached to Coupon SC-82A - Wet Bulk Density 2.06 gm/cc
- 3. MODERATE TO MAJOR: Fe₂(OH)₃Cl;
MINOR: PbS(Galenite), PbCl₂(Cotunnite), FeO(OH)α(Goethite), β(Akaganeite) and γ(Lepidocrocite)
- 4. MODERATE: FeO(OH)β(Akaganeite);
TRACE: Fe₂(OH)₃Cl
- 5. MODERATE: FeO(OH)β(Akaganeite);
MINOR: Fe₂(OH)₃Cl

FIGURE VIII-21

FLASH TANK A BRINE FLOW
& SCALE ANALYSIS
(TESTS 19-1 & 19-2)

SINGLE FLASH
50 PSIG (NOMINAL)

99 HOURS

1700 1/7 TO 2000 1/11

	Inlet Wellhead Brine	Outlet Steam/Noncond.	Brine
Flowrate (lbs/Hr)** (GPM)	1.30 x 10 ⁵ -	0.163 x 10 ⁵ -	1.137 x 10 ⁵ 200
Pressure (psig)*	450	44.7	44.7
Temperature (°F)*	436	289.6	289.6
Sample Point	V-5	V-15A	V-19A
Element (mg/l)*		<u>Condensate</u>	
Cl	171,000	3,225-16,900	190,000
Na	71,500	9,110	80,900
K	9,560	225	11,300
Li	266	32.7	318
Ca	23,300	< 0.01	26,600
Mg	441	56.7	497
Ba	2,460	361	2,798
Sr	1,905	290	2,145
B	272	40.8	300
Al	< 3.	< 0.03	< 3.
Fe	4,940	744	5,556
Mn	1,190	175	1,342
Pb	255	0.489	302
Zn	1,282	152	1,473
SiO ₂	627	40.2(RU)	635
SO ₄	< 1.	< 1.	< 1.
HCO ₃	210	368	102
CO ₃	< 1.	< 1.	< 1.
TDS	286,000	5,470-29,700	324,000
pH	5.32	6.36	5.09
H ₂ S	-	-	-
CO ₂	456 (mg/l)	Gas {	407 (mg/l)
N ₂	-		-
Ar + O ₂	-		-
Methane	-		-

*AVG. Values

**Extrapolated Values

TABLE VIII-4 FLASH TANK A BRINE/VAPOR CHEMISTRY ANALYSIS (TESTS 19-1 & 19-3)
1/8/81 - 1/11/81 (99 Hrs.)

Figure VIII-22. Wellhead Pressure, Temperature and Flow vs Time (Tests 19-1 and 19-2)

VIII. (continued)

5.0 Discussion of Dual-Flash Test Operational Behavior

Prior to initiating the dual-flash test series, a flash tank blowdown line was installed to alleviate flow problems experienced at the end of the single-flash tests. At the bottom of each flash tank, a valved line was brought out to a header which emptied into the holding pond drain line. This allowed for the intermittent emptying of flash-tank liquids and sludges to the holding pond and thereby avoided sludge buildup and carryover into brine lines.

Testing was resumed on 3 February 1981 when well flows were transferred from the site operator's equipment to the AECC testing equipment. The dual- or multiple-flash test series required the direct transfer of the flashed brines from either Tank A or B to the piping test section and then to flash Tank C. All brine flows exiting from the test sections were diverted to Tank C whose flashing pressure was set at 50 psig. Ideally, the flow from the 200 psig test sections would have been diverted into Tank B (100 psig); however, piping configurations necessitated exiting flows into Tank C (50 psig). In this situation (200 psig tests), Tank B (100 psig) was idled by allowing only a minimal bypass flow from Tank A (200 psig) in order to maintain a minimum liquid level. This condition was maintained for the final 50 hours of testing.

The initial set of test sections was operated with the flashed brine effluents from Tank B (100 psig). Figures VIII-16 and VIII-22 are simplified versions of the P&ID (Figure III-5) for the 100 and 200 psig test section flows. Flash tank brine levels were controlled by the downstream control valves LCV-10B, LCV-10C, and FCV-38. The automatic brine emergency bypass valve, ROV-6, was set for the manual control prior to testing to prevent the flow cavitation problem experienced when operated in previous checkout tests. In place of the automatic bypass, the tank level control valves LCV-10B, LCV-10C, and FCV-38 were positioned to open in the event of a power or pneumatic failure. This arrangement would ensure a sufficient well flow to avoid killing the well.

VIII. (continued)

Flash Tank B brine effluent was flowed through the piping sections for 49.8 hours. After 12 hours from the start of the test, the brine level in Tank C began to rise and was being overboarded into the steam line. The problem was traced to a flow restriction in the injection line between block valve V-76 and V-74. The restriction was bypassed by installing a blind flange on the holding pond side of the blowdown line entrance tee and opening the Tank blowdown valve and the pond bypass valve V-73. This allowed the major portion of Tank C's effluent brine to exit from the bottom of the tank and on around the restriction via the blowdown line. No further level control or brine overboarding problems were experienced. Cause of the problem was identified when injection lines were disassembled at the end of testing. Due to heavy scaling on the thermal well of the injection line RTD (TE85) and the surrounding pipe wall, the brine flow area was reduced by approximately 60 to 70%. Figure VIII-2 shows views of the inlet and outlet of the scaled RTD thermal well.

Early in the testing period, level control valves LCV-10B, LCV-10C, and FCV-38 and the steam pressure control valve PCV-12A began to seize. An attempt was made to manually cycle the valves to break loose scale deposits from the valve seats. However, at the end of the first series of tests (100 psig), all of the subject valves were no longer responding to pneumatic signals. Water injected via a sampling valve port (V-25) was somewhat successful in keeping the pressure control valve PCV-12A operable for a longer period of time. The pressure control of Tank A after valve PCV-12A had seized was accomplished by manually throttling flow with the brine supply block valve V-71. All flash tank levels were manually controlled by block valves V-9B, V-9C, and V-76, respectively. The last 50 hours of testing was accomplished by operating in this manner.

Figure VIII-23. Injection Line RTD (TE85) Thermal Well

VIII. (continued)

6.0 Test 20-1 Results:

Dual-Flash (Unpumped) 100 psig

Figure VIII-24. Flow Diagram for Test 20-1 (100 psig)

NOTES:

1. Dimensions and part numbers for all other test sections are the same except where indicated.
 2. Dash lines on pipes indicate post test cutting positions and part interfaces.
 3. All cut parts are marked with respective test section number and part number, e.g. 500SP-50-2.
- *See Section VIII- B for SEM Analysis

Figure VIII-25. Test Section Configuration for Test 20-1 (100 psig)

	Inlet	Outlet Test Sections			
	Test Section Header	100 St. Pipe	300 E/C	400 3/4" Orif.	500 1" Orif.
Flowrate (gpm)*	237.4	65.4	76.1	37.0	58.9
Pressure (psig)*	88.8	85.9	83.8	84.4	82.7
Temperature (°F)*	317.7	-	-	-	-
Sample Point	V-19B	V-109	V-309	V-409	V-509
Element (mg/l)*				2 PHASE (Unable to sample Brine)	
Cl	193,000	Plugged Sample Port	193,000		
Na	75,200		76,900		
K	12,100		12,000		
Li	339		334		
Ca	26,500		26,500		
Mg	478		476		
Ba	2,750		2,730		
Sr	2,038		2,026		
P	310		311		
Al	<3.		<3.		
Fe	5,678		5,595		
Mn	1,365		1,365		
Pb	327		322		
Zn	1,575		1,575		
SiO ₂	524		472		
SO ₄	<1.		<1.		
CO ₃	<1.		<1.		
HCO ₃	40.2		37.0		
CO ₂	283		331		
TDS*	340,000		352,000		
pH*	5.11		5.05		

*Avg Values

TABLE VIII-5 TEST SECTION BRINE CHEMISTRY ANALYSIS FOR TEST 20-1 (100 psig)
2/2/81 - 2/4/82 (49.6 Hrs.)

	UPSTREAM OF MIDLINE	DOWNSTREAM OF MIDLINE
SCALE DEPOSITION RATE*	~ .0015 IN/HR	
GENERAL APPEARANCE/ COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGHOUT SECTION)	HARD/TENACIOUS: BLACK BODY WITH BROWN VEINS OF EQUAL AREA, THIN BLACK BASE - ORANGE-BROWN RIPPLED SURFACE	
COMPOSITION: MAJOR [MINOR]	[β -Fe ₂ (OH) ₃ Cl, β -FeO(OH) Akaganeite, Trace: α -FeO(OH) Goethite, γ -FeO(OH) Lepibocrocite, FeCl ₂ ·4H ₂ O]	
ELEMENT (% WT)		
Fe	45.2	47.4
SiO ₂	11.4	12.0
Cl	6.5	8.3
Pb	0.12	0.11
Ca	0.16	0.15
Mg	0.06	0.06
Al	0.05	0.09
Ag	0.09	0.09
DENSITY (gm/cc)	3.07	2.99

FIGURE VIII-26			
TEST SECTION 100 - DU - 100			
DUAL-FLASH - UNPUMPED			
STRAIGHT PIPE (2")			
65.4 GPM (6.7 FT/SEC)*			
49.6 HRS 1615 (2/2) TO 1755 (2/4)			
	INLET	OUTLET	
COMPONENT	ELBOW	TEE	
PRESSURE (psig)*	88.8	85.9	
TEMPERATURE (°F)*	317.7	—	
PUMP	INLET	OUTLET	
PRESSURE	—	—	
TEMP.	—	—	

*AVERAGE VALUE

	UPSTREAM	EXPANSION/CONTRACTION	DOWNSTREAM
SCALE DEPOSITION RATE*	~ .0014 IN/HR	~ .0012 IN/HR	~ .0013 IN/HR
GENERAL APPEARANCE/COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGHOUT SECTION)	HARD TENACIOUS: BLACK BODY WITH BROWN VEINS OF EQUAL AREA; THIN BLACK BASE-ORANGE BROWN RIPPLED SURFACE	BROWN POROUS FINE CRYSTALLINE STRUCTURED BODY - ORANGE-BROWN RIPPLED SURFACE (SOME GLAZING)	SIMILAR TO UPSTREAM (SOME GLAZING)
COMPOSITION: MAJOR [MINOR]	β -Fe ₂ (OH) ₃ Cl; [β -FeO(OH) Akaganeite], [Trace: FeCl ₂ ·4H ₂ O; α -FeO(OH) Downstream only]		
ELEMENT (% WT)			
Fe	53.7	NA	49.6
SiO ₂	4.21		4.92
Cl	6.4		16.2
Pb	0.09		0.11
Ca	0.07		0.07
Mg	0.04		0.04
Al	0.04		0.16
Ag	0.10		0.04
DENSITY (gm/cc)	3.09	NA	3.21

FIGURE VIII-27		
TEST SECTION 300 - DU - 100		
DUAL-FLASH - UNPUMPED		
4" EXPANSION/2" CONTRACTION		
76.1 GPM (7.8 FT/SEC) *		
49.5 HRS		
1615 (2/2) TO 1750 (2/4)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESSURE (psig)*	88.8	83.8
TEMPERATURE (°F)*	317.7	—
PUMP	INLET	OUTLET
PRESSURE	—	—
TEMP.	—	—

*AVERAGE VALUE

Figure VIII-27a. Test Section 300-DU-100 (Expansion/Contraction)

	UPSTREAM OF MIDLINE	3/4" ORIFICE	DOWNSTREAM
SCALE DEPOSITION RATE*	~ .0013 IN/HR	—	~ .0013 IN/HR
GENERAL APPEARANCE/COLOR (PITTING/UNIFORM CORROSION PRESENT) THROUGHOUT SECTION	HARD TENACIOUS: BLACK BODY WITH BROWN VEINS OF EQUAL AREA; THIN BLACK BASE-ORANGE BROWN RIPPLED SURFACE	—	SIMILAR TO UPSTREAM (SOME GLAZING)
COMPOSITION: MAJOR [MINOR]	$[\beta\text{-FeO(OH)}, \beta\text{-Fe}_2(\text{OH})_3\text{Cl}]$; [Trace: $\alpha\text{-FeO(OH)}, \text{FeCl}_2 \cdot 4\text{H}_2\text{O}$]		$\beta\text{-Fe}_2(\text{OH})_3\text{Cl}, [\beta\text{-FeO(OH)}]$; [Trace: $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$]
ELEMENT (% WT)			
Fe	47.2		51.1
SiO ₂	12.5		7.1
Cl	7.6		13.8
Pb	4.42		1.17
Ca	0.16		0.11
Mg	0.07		0.06
Al	0.12		0.12
Ag	0.17		0.10
DENSITY (gm/cc)	3.05		3.08

FIGURE VII-28		
TEST SECTION 400 - DU - 100		
DUAL-FLASH - UNPUMPED		
3/4" ORIFICE		
37.0 GPM (3.8 FT/SEC)*		
47.5 HRS		
1805 (2/2) TO 1740 (2/4)		
	INLET	OUTLET
COMPONENT	ELBOW	ELBOW
PRESSURE (psig)*	88.8	84.4
TEMPERATURE (°F)*	317.7	—
PUMP	INLET	OUTLET
PRESSURE	—	—
TEMP.	—	—

*AVERAGE VALUE

	UPSTREAM	1" ORIFICE	DOWNSTREAM
SCALE DEPOSITION RATE*	~ .0011 IN/HR	—	~ .0013 IN/HR
GENERAL APPEARANCE/ COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGHOUT SECTION)	HARD/TENACIOUS: BLACK BODY WITH BROWN VEINS OF EQUAL AREA; THIN BLACK BASE - ORANGE-BROWN RIPPLED SURFACE	—	SIMILAR TO UPSTREAM (SOME GLAZING)
COMPOSITION: MAJOR [MINOR]	[β -Fe ₂ (OH) ₃ Cl, β -FeO(OH), FeCl ₂ ·4H ₂ O]		β -Fe ₂ (OH) ₃ Cl; [β -FeO(OH)], [Trace: γ -FeO(OH) Lepidocrocite, FeCl ₂ ·4H ₂ O]
ELEMENT (% WT)			
Fe	41.4		40.2
SiO ₂	3.38		13.0
Cl	2.1		2.4
Pb	0.03		8.91
Ca	0.03		0.18
Mg	0.03		0.10
Al	0.13		0.39
Ag	0.01		0.13
DENSITY (gm/cc)	3.07		3.04

FIGURE VIII-29			
TEST SECTION 500 - DU - 100			
DUAL FLASH - UNPUMPED			
1" ORIFICE (2")			
58.9 GPM (6.0 FT/SEC) *			
47.5 HRS 1805 (2/2) TO 1740 (2/4)			
	INLET	OUTLET	
COMPONENT	ELBOW	ELBOW	
PRESSURE (psig) *	88.8	82.7	
TEMPERATURE (°F) *	317.7	—	
PUMP	INLET	OUTLET	
PRESSURE	—	—	
TEMP.	—	—	

*AVERAGE VALUE

VIII. (continued)

7.0 Test 20-2 Results:
Dual-Flash (Unpumped) 200 psig

Figure VIII-30. Flow Diagram for Test 20-2 (200 psig)

NOTES:

1. Dimensions and part numbers for all other test sections are the same except where indicated.
2. Dash lines on pipes indicate post test cutting positions and part interfaces.
3. All cut parts are marked with respective test section number and part number, e.g. 500SP-50-2.

*See Section VIII - B for SEM Analysis

Figure VIII-31. Test Section Configuration for 20-2 (200 psig)

	Inlet		Outlet Test Sections			
	Tank A Outlet	Test Section Header	100 St. Pipe	200 E/C	300 3/4" Orif.	400 1" Orif.
Flowrate (gpm)*	221.7	221.7	65.1	55.1	31.7	69.8
Pressure (psig)*	193.7	177.8	168.4	169.6	168.8	161.7
Temperature (°F)*	366.1	-	-	-	-	-
Sample Point	V-19A	V-208	V-109	V-209	V-309	V-409
Element (mg/l)*						
Cl	181,000	183,000	(plugged sample port)	193,000	191,000	2 Phase FLOW (Unable to sample brine)
Na	70,600	72,000		77,000	75,900	
K	11,300	11,400		11,900	11,600	
Li	317	317		326	327	
Ca	24,300	23,900		25,400	25,400	
Mg	453	449		474	464	
Ba	2,545	2,565		2,705	2,690	
Sr	1,935	1,915		2,060	2,045	
P	293	287		304	302	
Al	<3.	<3.		<3.	<3.	
Fe	5,268	5,180		5,470	5,420	
Mn	1,275	1,255		1,335	1,320	
Pb	289	289		301	307	
Zn	1,475	1,465		1,555	1,530	
SiO ₂	531	583		541	568	
SO ₄	<1.	<1.		<1.	<1.	
CO ₃	<1.	<1.		<1.	<1.	
HCO ₃	82.2	154		136	75.4	
CO ₂	314	-		-	297	
TDS*	326,000	337,000		336,000	336,000	
pH*	4.78	4.72		4.8	4.79	

*Avg Values

TABLE VIII-6 TEST SECTION BRINE CHEMISTRY ANALYSIS FOR
TEST 20-2 (200 psig) 2/4/81 - 2/6/81 (48.5 HRS)

	UPSTREAM OF MIDLINE	DOWNSTREAM OF MIDLINE
SCALE DEPOSITION RATE*	~ .00044 IN/HR	
GENERAL APPEARANCE/COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGHOUT SECTION)	HARD/BRITTLE (DRY) LUMPY LAYERED BODY RANGING FROM A BROWN BASE FOLLOWED BY BLACK, BROWN, AND DARK-BROWN LAYERS - RIPPLED SURFACE - INTERMITTENT GLAZING	
COMPOSITION: MAJOR [MINOR]	PbS, [β-FeO(OH) Akaganeite, PbCl ₂ , (K,Na)Pb ₂ Cl ₅], [Trace: β-Fe ₂ (OH) ₃ Cl]	
ELEMENT (%) WT)		
Fe	27.0	31.3
SiO ₂	23.8	11.8
Cl	4.4	2.4
Pb	4.4	12.8
Ca	0.59	0.33
Mg	0.19	0.11
Al	0.63	0.45
Ag	0.56	0.07
DENSITY (gm/cc)	3.14	3.21

FIGURE VIII-32		
TEST SECTION 100 - DU - 200		
DUAL-FLASH - UNPUMPED		
STRAIGHT PIPE (2")		
65.1 GPM (6.7 FT/SEC) *		
49.5 HRS 1800 (2/4) TO 1925 (2/6)		
	INLET	OUTLET
COMPONENT	ELBOW	TEE
PRESSURE (psig)*	178.8	168.4
TEMPERATURE (°F)*	339.0	-
PUMP	INLET	OUTLET
PRESSURE	-	-
TEMP	-	-

*AVG VALUE

	UPSTREAM	EXPANSION/CONTRACTION	DOWNSTREAM
SCALE DEPOSITION RATE*	~ .0006 IN/HR	~ .0006 IN/HR	~ .0004 IN/HR
GENERAL APPEARANCE/COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGHOUT SECTION)	HARD/BRITTLE (DRY); BLACK BODY WITH AN ORANGE/BROWN STRIP- GLAZED CRYSTALLINE	SIMILAR TO UPSTREAM EXCEPT SURFACE LITTERED WITH CLEAR TRAPEZOIDAL FACED CRYSTALS.	SIMILAR TO UPSTREAM EXCEPT SURFACE MORE IRREGULAR AND LUMPY
COMPOSITION: MAJOR [MINOR]	PbS, [β-FeO(OH) Akaganeite, (K,Na)Pb ₂ Cl ₅] [Trace: PbCl ₂]		
ELEMENT (%WT)			
Fe	27.2	N/A	33.5
SiO ₂	15.4		16.1
Cl	2.2		3.8
Pb	6.69		3.04
Ca	0.43		0.23
Mg	0.10		0.14
Al	0.45		0.59
Ag	1.16		0.12
DENSITY (gm/cc)	5.45	N/A	3.68

FIGURE VIII-33			
TEST SECTION 200 - DU - 200			
DUAL-FLASH - UNPUMPED			
4" EXPANSION/2" CONTRACTION			
55.1 GPM (5.6 FT/SEC.) *			
49.3 HRS 1755 (2/4) to 1910 (2/6)			
	INLET	OUTLET	
COMPONENT	ELBOW	TEE	
PRESSURE (psig) *	177.8	169.9	
TEMPERATURE (°F) *	339.0	-	
PUMP	INLET	OUTLET	
PRESSURE	-	-	
TEMPERATURE	-	-	

*AVG VALUE

Figure VIII-33a. Test Section 200-DU-200 Expansion/Contraction

	UPSTREAM	3/4" ORIFICE	DOWNSTREAM
SCALE DEPOSITION RATE*	~ .0004 IN/HR	-	~ .0004 IN/HR
GENERAL APPEARANCE/ COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGH- OUT SECTION)	HARD/BRITTLE(DRY): BLACK FINE CRYSTALLINE GRAINED BODY WITH A THIN CRUMBLD BROWN SURFACE CRUST	DOWNSTREAM: BLACK BODY WITH BROWN STRIP - IRREGULAR SURFACE WITH CLEAR TRAPEZOIDAL FACED CRYSTALS SCATTERED ON SURFACE	SIMILAR TO ORIFICE PLATE SECTION (DOWNSTREAM) EXCEPT SURFACE MORE IRREGULAR WITH CRYSTAL REMNANTS (UNDEFINED SHAPE) SCATTERED ON SURFACE
COMPOSITION: MAJOR [MINOR]	PbS, [β-FeO(OH), (K, Na)Pb ₂ Cl ₅] [Trace: β-Fe ₂ (OH) ₃ Cl, PbCl ₂]		
ELEMENT (% WT)		N/A	
Fe	30.4		38.4
SiO ₂	20.9		12.1
Cl	3.6		9.7
Pb	6.8		5.57
Ca	0.81		0.21
Mg	0.18		0.10
Al	0.4		0.38
Ag	0.81		0.08
DENSITY (gm/cc)	3.12	N/A	3.1(SMALL SAMPLE)

FIGURE VIII-34		
TEST SECTION 300 - DU - 200		
DUAL-FLASH - UNPUMPED		
3/4" ORIFICE		
31.7 GPM (3.2 FT/SEC)*		
49.7 HRS 1750 (2/4) TO 1930 (2/6)		
	INLET	OUTLET
COMPONENT	ELBOW	ELBOW
PRESSURE (psig)*	177.8	168.8
TEMPERATURE (°F)*	339.0	-
PUMP	INLET	OUTLET
PRESSURE	-	-
TEMP	-	-

*AVG VALUE

Figure VIII-34a. Microphoto of Scale Build-Up on Inlet Edge of 3/4 in. Orifice (300-DU-200)

SCALE DEPOSITION RATE*	UPSTREAM	1" ORIFICE	DOWNSTREAM
	~.0004 IN./HR	---	~.0003 IN./HR
GENERAL APPEARANCE/COLOR (PITTING/UNIFORM CORROSION PRESENT THROUGH SECTION)	SIMILAR TO 300-DU-200, EXCEPT CLEAR/WHITISH TRAPEZOIDAL- SURFACED CRYSTALS SCATTERED ON SURFACE	SIMILAR TO UPSTREAM, EXCEPT A FINER GRAINED LITTER IS STRENN OVER SURFACE AND RHOMBIC FACED CRYSTALS (CLEAR) ARE SCATTERED ON SURFACE	BLACK BODY WITH BROWN STRIPES CRUMBLED IRREGULAR SURFACE WITH CRYSTAL REMNANTS IN RUBBLE
COMPOSITION: MAJOR [MINOR]	PbS, [one unknown composition, β -Fe ₂ (OH) ₃ Cl, β -FeO(OH) Akaganeite, FeCl ₂ ·4H ₂ O, PbCl ₂ , (K,Na)Pb ₂ Cl ₅ , α - Quartz]		
ELEMENT (% WT)	PbS, α - Quartz, [β -FeO(OH)]		
Fe	28.1		39.4
SiO ₂	18.7		12.6
Cl	2.3		3.3
Pb	6.36		8.57
Ca	0.39		0.27
Mg	0.12		0.14
Al	0.44		0.55
Ag	0.49		0.11
DENSITY (gm/cc)	3.33		3.42

FIGURE VIII-35			
TEST SECTION 400-DU-200			
DUAL-FLASH - UNPUMPED			
1" (ORIFICE)			
69.8 GPM (7.1 FT/SEC) *			
49.8 HRS 1745 (2/4) TO 1930 (2/6)			
	INLET	OUTLET	
COMPONENT	ELBOW	ELBOW	
PRESSURE (psig) *	177.8	161.7	
TEMPERATURE (°F) *	339.0	-	
PUMP	INLET	OUTLET	
PRESSURE	-	-	
TEMP.	-	-	

*AVG VALUE

Figure VIII-35a. Microphoto of Scale Build-Up on Inlet Edge of 1" Orifice (400-DU-200)

VIII. (continued)

**8.0 Flash Tank Results:
(Tests 20-1 and 20-2)**

SCALE ANALYSIS ~ COUPONS ~					
SAMPLE POINT	SC-80A	SC-83A	SC-81A	SC-82 ²	TANK BOTTOM RUBBLE
SCALE THICKNESS (IN.)	.082	0.523	0.040	NA	NA
SCALE RATE (MIL/HR)	0.8	0.5	0.4	NA	NA
GENERAL APPEARANCE/COLOR	NA	NA	NA		
MAJOR COMPOSITION	NOTE 3	NOTE 4	NOTE 5		
ELEMENT (% WT)					
Fe	31.60	8.37	24.0		
SiO ₂	4.41	8.34	22.7		
Cl	3.10	<1.0	<1.0		
Pb	13.00	12.6	6.04	NA	NA
Ca	0.12	0.02	0.26		
Mg	0.05	0.05	0.15		
Al	<0.03	0.4	0.49		
Ag	0.19	0.68	0.61		
DENSITY (gm/cc)	3.82	5.34	3.5	NA	NA

NOTES:

- * - Average Value
- 1. Wellhead
- 2. Scale coupon SC-82A replaced with a sludge blowdown line.
- 3. MODERATE TO MAJOR: PbS(Galena), PbCl₂(Cotunnite), FeO(OH)β(Akaganeite);
MINOR: FeO(OH)α(Goethite);
TRACE: FeO(OH)γ(Lepidocrocite)
- 4. MAJOR: PbS(Galena)
MINOR: Pb(OH)Cl
- 5. MODERATE TO MAJOR: PbS(Galena), Pb(OH)Cl;
MINOR: PbCl₂(Cotunnite);
TRACE: FeO(OH)β(Akaganeite)

FIGURE VIII-36

FLASH TANK A BRINE FLOW
& SCALE ANALYSIS
(TESTS 20-1 & 20-2)

DUAL FLASH
200 psig (NOMINAL)

103.5 Hours
1345 2/2 to 2115 2/6

	Inlet	Outlet	
	Well Head Brine	Steam/Non. Cond.	Brine
Flow Rate (lbs/Hr)	1.422×10^5	0.144×10^5	1.28×10^5
Flow Rate (gpm)	-	-	231.8
Pressure (psig)	446	186.5	186.5
Temperature (°F)	432	364.1	364.1
Sample Point	V-5	V-25A	V-19A
Element (mg/l)		<u>Condensate</u>	
Cl	174,000	3,500	182,000
Na	69,500		71,300
K	11,000		11,600
Li	403		321
Ca	23,300		24,700
Mg	434		457
Ba	2,440		2,574
Sr	1,850		1,953
B	284		296
Al	<3.		<3.
Fe	5,110		5,322
Mn	1,240		1,290
Pb	291		297
Zn	1,430		1,488
SiO ₂	600	-	581
SO ₄	<1.	<1.	<1.
HCO ₃	122	434	82
CO ₃	<1.	<1.	<1.
TDS*	314,000	6,290	328,000
pH*	4.78	5.64	4.7
H ₂ S		59.8	
CO ₂	533	Gas { 82.7 mole % 9.98 " 2.61 " 1.84 "	320
N ₂			
Ar + O ₂			
Methane			

*Avg Values

TABLE VIII-7 FLASH TANK A (200 psig) BRINE/VAPOR CHEMISTRY ANALYSIS -
TESTS 20-1 & 20-2 2/2/81 - 2/6/81 (103.5 Hrs.)

Avg. Residence Time 19.2 sec.

5. MODERATE: $\text{Fe}_2(\text{OH})_3\text{Cl}$, $\text{FeO}(\text{OH})\beta$ (Akaganeite)
 MINOR: $\text{FeO}(\text{OH})\alpha$ (Goethite), $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$, PbS (Galena) PbCl_2 (Cotunnite)
6. MODERATE: $\text{FeO}(\text{OH})\beta$ (Akaganeite)
 MINOR: $\text{Fe}_2(\text{OH})_3\text{Cl}$, $\text{FeO}(\text{OH})\alpha$ (Goethite)
 TRACE: PbS (Galena), PbCl_2 (Cotunnite)

NOTES:

*Average Value

1. Average flow data from test period 2/2 (1345) to 2/4 (1750), 49 Hrs. During following test period 200 psig test circuit effluents were bypassed to Tank C. Only a minimal non-measurable flow from Tank A was furnished during this period, 2/4 (1750) to 2/6 (2115), 54.5 Hrs.
2. Brine level for test period 2/2 (1345) to 2/4 (1750), 49 Hrs. Brine level for remaining period 2/4 (1750) to 2/6 (2115), 54.5 Hrs. was approximately 22".
3. Scale coupon SC-82B replaced with a sludge blowdown line.
4. MODERATE TO MAJOR: FeCO_3 (Siderite), Fe_3O_4 (Magnetite)
 MINOR: $\text{FeO}(\text{OH})\beta$ (Akaganeite)
 TRACE: PbS (Galena)

FIGURE VIII-37

FLASH TANK B BRINE FLOW & SCALE ANALYSIS (TESTS 20-1 & 20-2)

DUAL FLASH
100 PSIG (NOMINAL)

103.5 HOURS
1345 2/2 to 2115 2/6

	Inlet	Outlet	
	Brine (Outlet of Tank A)	Steam/Non.Cond.	Brine
Flow Rate (lbs/Hr)**	1.337×10^5	0.0254×10^5	1.3116×10^5
Flow Rate (gpm)	-	-	237.4
Pressure (psig)**	180.6	104.3	104.3
Temperature (°F)**	362.6	339.7	339.7
Sample Point	V-19A	V-25B	V-19B
Element (mg/l)*		<u>Condensate</u>	
Cl	182,000	13.4	193,000
Na	71,300		75,400
K	11,600		12,000
Li	321		338
Ca	24,700		26,200
Mg	457		476
Ba	2,574		2,710
Sr	1,953		2,035
B	296		309
Al	<3.		<3.
Fe	5,322		5,627
Mn	1,290		1,357
Pb	297		320
Zn	1,488		1,568
SiO ₂	581		538
SO ₄	<1.	<1.	<1.
HCO ₃	82	952	56.8
CO ₃	<1.	<1.	<1.
TDS*	328,000	37	342,000
pH*	4.7	6.33	5.16
H ₂ S		30.4	
CO ₂	320	Gas { 93.4 mole % 0.66 " <0.5 " 1.62 "	283
N ₂			
Ar + O ₂			
Methane			

*Avg Values

**Avg Value for Test Period 2/2 to 2/4

TABLE VIII-8 FLASH TANK B (100 psia) BRINE/VAPOR CHEMISTRY ANALYSIS -
TESTS 20-1 & 20-2 2/2/81 - 2/6/81 (103.5 Hrs.)

Figure VIII-38. Wellhead Pressure, Temperature and Flow vs Time (Tests 20-1 and 20-2)

IX. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are divided into five sections and are not listed in any order of priority:

- A. Brine Characteristics;**
- B. Steam and Noncondensable Gases;**
- C. Scale Characteristics;**
- D. Operating Recommendations, and**
- E. Test Equipment Summary**

A. BRINE CHARACTERISTICS

1. Wellhead brine (approximately 200 gpm)
 - Temperature ~ 436°F
 - Pressure ~ 450 psig
 - Total Dissolved Solids (TDS) ~ 280,000 - 320,000 mg/l
 - pH ~ 4.7 - 5.3(See Table VIII-1 for chemistry analysis)
2. Wellhead brine flows are two-phase.
3. Brine is corrosive to carbon steel. Testing of pipe sections shows physical evidence of pitting and corrosion at pipe wall beneath scale. X-ray analysis of scale samples shows a layered iron content which increases near the pipe walls.
4. Flashed brine saturation curves agree closely with that of a 20% NaCl solution (Ref. 5).

B. STEAM AND NONCONDENSABLE GASES

1. Inlet brine flows are two-phase. Calculations indicate that the vapor phase is approximately 5 to 8% of the total flow by weight.
2. Noncondensable gas content of incoming brine was approximately 4 to 5% of the total flow by weight.

IX. (continued)

3. Gas composition analysis of vapor derived from flashing process is as follows (1):

Constituent (% wt)	Single-Flash Tests		Multiple-Flash Tests	
	19-1	19-2	20-1	20-2
H ₂ O (steam)	73.3	65.3	65.2	65.6
CO ₂	22.9	32.9	32.4	33.6
N ₂	2.8	1.1	1.6	0.3
CH ₄	0.1	0.2	0.3	0.3
Ar+O ₂ (2)	0.8	0.5	0.5	0.2
H ₂ S	---	---	.005	.002

Notes:

- (1) Enthalpy values used for the calculation of gas flows were extrapolated from Geological Survey Bulletin 1421-B, Ref. 1.
- (2) Laboratory analysis did not distinguish between Ar and O₂. However, due to the reducing nature of the fluid, it is doubtful that O₂ is present.

C. SCALE CHARACTERISTICS

1. Scale Formation Types:

Test No.	Avg. Pressure (psig)	Type of Scale	Degree of Formation (1)
20-2	178	PbS (hard)	Light (0.4 - 0.6 mils/hr)
20-1	89	Fe ₂ (OH) ₃ Cl (hard) (2)	Heavy (1.1 - 1.5 mils/hr)
19-1	48	Fe ₂ (OH) ₃ Cl (2) (hard) & silica forms	Heavy (1.1 - 1.4 mils/hr)
19-2	26	SiO ₂ (crumbled-soft)	Extremely heavy (0.9 - 3.9 mils/hr)

Notes:

- (1) Deposition rate for flows ranging from 30 to 70 gpm per 2-inch pipe test section.
- (2) Fe₂(OH)₃Cl = iron hydroxychloride.

2. All scale depositions have a rippled or waved surface. Spacing or period varied for each test condition.
3. Both wellhead (inlet) and flashed brines contain large quantities of suspended solids. All of the pipe test sections exposed to the flashed brines show impingement as a major scale formation mechanism. The upstream faces of the test section orifices show this quite clearly.
4. The first flashing stage, regardless of pressure, develops an aerosol-type vapor laden with suspended solids.
5. The low-pressure flashing stage accumulates large amounts of a sludge-type scale material in the lower brine (liquid) section of the flash tanks.

IX. (continued)

D. OPERATING RECOMMENDATIONS

1. The wellhead vapor phase (primarily noncondensable gases) can be removed (stripped) from the brine prior to a steam flash. Experience with two types of take-off tees indicates the incoming gas (vapor phase) can be reduced by a factor of 6.
2. The minimum primary power flash pressure should be not less than 150 psig in order to avoid the heavy $\text{Fe}_2(\text{OH})_3\text{Cl}$ and SiO_2 scaling.
3. Primary (high pressure) steam lines will probably require a demister/separator at the downstream end near a turbine-generator installation.
4. To minimize particle carryover in the flashed steam, the vapor section height (volume) of the first-stage flash separator should be a minimum of twice that of a typical cyclone design. Use of internal baffles in lieu of increased volume is not recommended. However, some combination of separator volume increase (less than twice) with a carefully designed baffling system may provide a satisfactory solution.
5. The secondary (low-pressure) flashing stages (below 150 psig) will probably be a series of staged chemical-mineral recovery processes. Hopefully, mineral recovery will offset the increased equipment and operating costs.
6. All pneumatically operated control valves should be set to continuously cycle or oscillate in order to minimize seizure due to scale deposition. Primary control valves may require redundant systems or water/solvent injection methods to ensure operation.
7. Due to the large quantities of suspended solids at the lower pressures, piping directional changes or pressure drops should be minimized.
8. Installation of RTD-type thermal wells or any type of flow-obstructing device should be avoided in a space-limited brine stream.
9. All flash tanks should be equipped with tank bottom blowdown systems. This will allow for the periodic on-line removal of heavy-scale sludge-type materials from the tank bottoms.
10. All piping and valve layouts should be designed for ease of replacement and repair (cleaning).

IX. (continued)

E. TEST EQUIPMENT SUMMARY

1. Test equipment has successfully demonstrated its usefulness for short term testing at flowrates ranging from 100 to 300 gpm.
2. Equipment can be adapted to accommodate almost any type of brine ranging from calcium carbonates to those with high concentrations of heavy metal sulfides and/or silica.
3. Equipment is mobile and can be set up at any well site.
4. A wide range of testing and data gathering opportunities are possible due to the adaptability/flexibility of the equipment as designed.
5. The equipment can easily be integrated into mineral recovery or hybrid power conversion test programs.
6. Presently, the equipment is in good condition in storage at the Department of Energy's Geothermal Test Facility at East Mesa, California.

X. LITERATURE REFERENCES

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APPENDIX A

EQUIPMENT DESIGN

- A.1 Comparative Flash Tank Inlet/Outlet Relationships**
- A.2 Flash Tank Material Comparisons**
- A.3 Instrument Trailer Plan**
- A.4 Instrument Control Console**
- A.5 Instrumentation List**

A.1: COMPARATIVE FLASH TANK INLET/OUTLET RELATIONSHIPS

Type Location	Steam Outlet	Dimensions in Tank Diameters			
		Top to Steam Outlet	Top to Brine Inlet	Brine Inlet to Stream Outlet	Bottom to Brine Outlet
Nateco/Niland	Bottom	1	1	0	1
Surge/Niland	Top	0.1	0.5	0.4	—
Mitsubishi/RGI	Top	0	0.25	0.25	0
Brookhaven/Mesa	Top	0	1	1	0
RGI/Westmorland	Bottom	0.5	1	0.5	—
Webre/Wairakei	Bottom	1	2	1	0.5
Cyclone/Wairakei	Top	0	2	2	0.5
Mitsubishi/Ahuachapan	Bottom	0.5	1	0.5	0.5
Cerro Prieto	Bottom	—	1.5	—	0.5
Hydroscale	Top	0.3/0.8	0.8/1.3	0.5/1	0.5

A.2: FLASH TANK MATERIAL COMPARISONS

o 300 Psig Design Pressure o 3.5 Ft Dia by 12 Ft Height					
Material	Allowable Stress, Psi	Joint Eff.	Wall Thick, Inches	Weight,* Tons	Cost,* \$
Carbon	13700	0.65	0.72	6.5	19,000
Alloy	18700	0.65	0.53	4.8	25,000
Carbon	13700	1.00	0.47	4.3	15,000 plus X-ray
Alloy	18700	1.00	0.34	3.1	20,000 plus X-ray
*Per tank

ADDITIONAL REQUIREMENTS:

1. 12 V DC EMERGENCY LIGHTS
2. SHELVES ABOVE WORK BENCH; ONE 18" SHELF AND ONE 12" SHELF WITH AN ADDITIONAL 12" SHELF IF ADEQUATE ROOM TO BE USEFUL
3. ADDITIONAL 110 V AC OUTLET AT WORK BENCH IF NOT NORMALLY THERE

Figure A.3. Instrument Trailer (Casa Real Model 35C)

Figure A.4. Instrument Control Console

HYDROSCALE INSTRUMENTATION LIST

Page 1 of 4

Tag No.	Location	Sensor		Mfg.	Readout Device				Accuracy (plus or minus)	Remarks
		Type	Range		Gage	Chart	Meter	Tape		
TI-1	Brine Inlet	Bi-Metal	50°-450°F	Weksler	X				1% of range	
TE-2	Brine Inlet	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
PI-3	Brine Inlet	Bourdon	0-400 psig	Ametek	X				0.5% of span	0-400 span
PT-4	Brine Inlet	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
LT-10A	Tank-A	Buoyant Displacer	0-48 in.	Foxboro		X		X	0.5% of span	1.47-6.00 lb. span
LT-10B	Tank-B	Buoyant Displacer	0-48 in.	Foxboro		X		X	0.5% of span	1.47-6.00 lb. span
LT-10C	Tank-C	Buoyant Displacer	0-48 in.	Foxboro		X		X	0.5% of span	1.47-6.00 lb. span
PT-12A	Tank-A	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
PT-12B	Tank-B	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
PT-12C	Tank-C	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
PI-13A	Tank-A	Bourdon	0-400 psig	Ametek	X				0.5% of span	0-400 span
PI-13B	Tank-B	Bourdon	0-400 psig	Ametek	X				0.5% of span	0-400 span
PI-13C	Tank-C	Bourdon	0-100 psig	Ametek	X				0.5% of span	0-100 span
TI-16A	Tank-A	Bi-Metal	50°-450°F	Weksler					1% of range	
TI-16B	Tank-B	Bi-Metal	50°-450°F	Weksler					1% of range	
TI-16C	Tank-C	Bi-Metal	50°-450°F	Weksler					1% of range	
TE-17A	Tank-A	Pt. RTD	-328°-1220°F	YSI			X	X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-17B	Tank-B	Pt. RTD	-328°-1220°F	YSI			X	X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-17C	Tank-C	Pt. RTD	-328°-1220°F	YSI			X	X	0.2°F + 0.2% actual	$\alpha = 0.00392$
FE-24A	Tank-A	Annubar	0°-492° H ₂ O	Dieterich				X	1% actual	
FE-24B	Tank-B	Annubar	0°-492° H ₂ O	Dieterich				X	1% actual	
FE-24C	Tank-C	Annubar	0°-492° H ₂ O	Dieterich				X	1% actual	
PI-34	Brine Discharge	Bourdon	0-100 psig	Ametek	X				0.5% of span	0-100 span
PT-35	Brine Discharge	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
TI-36	Brine Discharge	Bi-Metal	50°-450°F	Weksler	X				1% of range	

A.5 Instrumentation List

A4

HYDROSCALE INSTRUMENTATION LIST

Page 2 of 4

Tag No.	Location	Sensor		Mfg.	Readout Device				Accuracy (plus or minus)	Remarks
		Type	Range		Gage	Chart	Meter	Tape		
TE-37	Brine Discharge	Pt. RTD	-329°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
FE-38	Brine Discharge	Vortex	0-320 gpm	Foxboro		X		X		
PT-40	Pump Inlet	Diaphragm	0-400 psig	Foxboro				X	0.5% of span	0-400 span
PI-41	Pump Inlet	Bourdon	0-300 psig	Ametek	X				0.5% of span	0-300 span
PT-42	Pump Discharge	Diaphragm	0-400 psig	Foxboro			X	X	0.5% of span	0-400 span
PI-43	Pump Discharge	Bourdon	0-300 psig	Ametek	X				0.5% of span	0-300 span
TI-44	Pump Discharge	Bi-Metal	50°-450°F	Weksler	X				1% of range	
TE-45	Pump Discharge	Pt. RTD	-328°-1220°F	YSI			X	X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-46	Pump By-Pass	Pt. RTD	-328°-1220°F	YSI			X	X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TI-47	Pump By-Pass	Bi-Metal	50°-450°F	Weksler	X				1% of range	
PI-48	Pump By-Pass	Bourdon	0-300 psig	Ametek	X				0.5% of span	0-300 span
PT-49	Pump By-Pass	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
TE-54	Test Outlet	Pt. RTD	-328°-1220°F	YSI			X	X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TI-55	Test Outlet	Bi-Metal	50°-450°F	Weksler	X				1% of range	
PT-56	Test Outlet	Diaphragm	0-400 psig	Foxboro		X		X	0.5% of span	0-400 span
PI-57	Test Outlet	Bourdon	0-200 psig	Ametek	X				0.5% of span	0-200 span
GEM-58	Brine Inlet	Vol. Displace.	0-40% vol.	Aerojet			X	X	0.1+1% actual	
GEM-59	Test Inlet	Vol. Displace.	0-40% vol.	Aerojet			X	X	0.1+1% actual	
AE-63	Test Inlet	See Remarks	0-14 pH	Leeds & Northrup			X	X	1% of range	Glass & Ref. Electrode, plus "J" Type Thermocouple
AE-64	Brine Inlet	See Remarks	0-14 pH	Leeds & Northrup			X	X	1% of range	
FE-102	Test Section 100	Volt. Induct.	0-150 gpm	Foxboro		X	X	X	1% of span	0-150 span
FE-202	Test Section 200	Volt. Induct.	0-150 gpm	Foxboro		X	X	X	1% of span	0-150 span
FE-302	Test Section 300	Volt. Induct.	0-150 gpm	Foxboro		X	X	X	1% of span	0-150 span
FE-402	Test Section 400	Volt. Induct.	0-150 gpm	Foxboro		X	X	X	1% of span	0-150 span
FE-502	Test Section 500	Volt. Induct.	0-150 gpm	Foxboro		X	X	X	1% of span	0-150 span

A.5 (continued)

A.5

HYDROSCALE INSTRUMENTATION LIST

Page 3 of 4

Tag No.	Location	Sensor		Mfg.	Readout Device			Tape	Accuracy (plus or minus)	Remarks
		Type	Range		Gage	Chart	Meter			
FE-602	Test Section 600	Volt. Induct.	0-150 gpm	Foxboro		X	X	X	1% of span	0-150 span
FE-702	Test Section 700	Volt. Induct.	0-400 gpm	Foxboro		X	X	X	1% of span	0-400 span
PT-104	Test Section 100	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-204	Test Section 200	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-304	Test Section 300	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-404	Test Section 400	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-504	Test Section 500	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-604	Test Section 600	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
TE-105	Test Section 100	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-205	Test Section 200	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-305	Test Section 300	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-405	Test Section 400	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-505	Test Section 500	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-605	Test Section 600	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
PT-106	Test Section 100	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-206	Test Section 200	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-306	Test Section 300	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-406	Test Section 400	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-506	Test Section 500	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
PT-606	Test Section 600	Strain Gage	0-300 psig	Sensotec				X	0.25% of range	
TE-107	Test Section 100	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-207	Test Section 200	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-307	Test Section 300	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-407	Test Section 400	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-507	Test Section 500	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$
TE-607	Test Section 600	Pt. RTD	-328°-1220°F	YSI				X	0.2°F + 0.2% actual	$\alpha = 0.00392$

A6

A.5 (continued)

HYDROSCALE INSTRUMENTATION LIST

Page 4 of 4

Tag No.	Location	Sensor		Mfg.	Readout Device			Accuracy (plus or minus)	Remarks
		Type	Range		Gage	Chart	Meter		
TE-110	Test Section 100	Thermocouple	32°-530°F	Omega				4°F	Chromel - Alumel
TE-111	Test Section 100	Thermocouple	32°-530°F	Omega				4°F	Chromel - Alumel
TE-112 thru	Test Section 100	Thermocouple	32°-530°F	Omega				4°F	Chromel - Alumel
TE-612	Test Section 600	Thermocouple	32°-530°F	Omega				4°F	Chromel - Alumel

A.5 (continued)

APPENDIX B

PROCESS ANALYSIS

- B.1 Derivations of Isentropic Process Analysis**
- B.2 Calculation of Brine Salt Concentrations**
- B.3 Sample Calculation of Steam and Noncondensable Gas Flows**
- B.4 Sample Orifice Plate Calculation**

B.1 PROCESS ANALYSIS

Derivation of Isentropic Process Analysis

Considering a steady state flow condition for the below shown flash tank,

From a mass balance,

$$w_1 = w_2 + w_3 \quad (1)$$

$$w_1 = w_{b1} + w_{ng1} + w_{s1} \quad (2)$$

$$w_2 = w_{s1} + w_{s2} + w_{ng2} \quad (3)$$

$$w_3 = w_{b3} + w_{ng3} \quad (4)$$

Combining (1), (2), (3) and (4),

$$w_{b1} + w_{ng1} + w_{ng2} + w_{b3} + w_{ng3} \quad (5)$$

From an energy balance,

$$q_1 = q_2 + q_3 \quad (6)$$

$$q_1 = H_{b1}w_{b1} + H_{ng1}w_{ng1} + H_{s1}w_{s1} \quad (7)$$

$$q_2 = H_{s2}w_{s1} + H_{s2}w_{s2} + H_{ng2}w_{ng2} \quad (8)$$

$$q_3 = H_{b3}w_{b3} + H_{ng3}w_{ng3} \quad (9)$$

Assuming,

$$w_{ng3} \ll w_{ng1} \approx w_{ng2} \quad (10)$$

$$(H_{ng1} - H_{ng2})w_{ng1} + (H_{s1} - H_{s2})w_{s1} \ll H_{b1}w_{b1} - H_{b3}w_{b3} \quad (11)$$

B.1 (continued)

Combining (6), (7), (8), (9) and (11),

$$H_{b1}w_{b1} = H_{s2}w_{s2} + H_{b3}w_{b3} \quad (12)$$

Proportioning gas concentrations with pressures,

$$w_{s1}/w_{ng1} = P_{s1}M_s/(P_1-P_{s1})M_{ng} \quad (13)$$

$$w_{s1} + w_{s2}/w_{ng2} = P_{s2}M_s/(P_2-P_{s2})M_{ng} \quad (14)$$

Dividing (13) by (14),

$$w_{s1}/w_{s1} + w_{s2} = P_{s1}(P_2-P_{s2})/P_{s2}(P_1-P_{s1}) \quad (15)$$

Combining (5), (10), (12), (14) and (15),

$$w_2 = \left[\frac{w_{b3} \Delta H_v / (H_{b3} - H_{b1} + \Delta H_v) - w_{b3}}{1 - P_{s1}(P_2 - P_{s2})/P_{s2}(P_1 - P_{s1})} \right] \times \left[1 + \frac{(P_2 - P_{s2})M_{ng}}{P_{s2}M_s} \right] \quad (16)$$

If no noncondensable gases are present, equation (16) may be reduced to

$$w_2 = \frac{w_{b3} \Delta H_v}{H_{b3} - H_{b1} + \Delta H_v} - w_{b3} \quad (16A)$$

With the exception of brine enthalpies H_{b3} and H_{b1} , all quantities in the above equation (16) were measured. The latent heat of vaporization, ΔH_v , was derived from vapor pressure/temperature data obtained in Test No. 18. The brine enthalpy data were extracted from literature on NaCl/water solutions, Reference 1.

B.2 CALCULATION OF BRINE SALT CONCENTRATIONS

Determination of brine salt concentration based on Test 20 wellhead brine chemistry data:

$$C_{Cl} = 174,000 \text{ mg/liter}$$

$$C_{Na} = 69,500 \text{ mg/liter}$$

$$C_K = 11,000 \text{ mg/liter}$$

$$C_{Ca} = 23,300 \text{ mg/liter}$$

Assume compounds as,

NaCl, KCl, and CaCl₂

$$C_{ClNa} = 69,500 \times 35.5/23 = 107,272$$

$$C_{ClK} = 11,000 \times 35.5/39 = 10,013$$

$$C_{ClCa} = 23,300 \times 2 \times 35.5/40 = 41,357$$

$$C_S = C_{Na} + C_K + C_{Ca} + C_{ClNa} + C_{ClK} + C_{ClCa}$$

$$C_S = 69,500 + 11,000 + 23,300 + 107,000 + 10,000 + 41,400$$

$$C_S = 262,200$$

$$C_{SCl} = C_{ClNa} + C_{ClK} + C_{ClCa}$$

$$C_{SCl} = 107,000 + 10,000 + 41,400 = 158,400$$

Cl unaccounted,

$$C_{Clu} = C_{Cl} - C_{TCl} = 174,000 - 158,400$$

$$C_{Clu} = 15,600$$

Assume unaccounted Cl is combined with a molecular equivalent as a compound,

A Cl (MgCl₂, FeCl₂, etc.)

$$C_A = C_{Clu} = 15,600$$

$$C_T = C_A + C_{ClA} + C_S$$

$$C_T = 15,600 + 15,600 + 262,200$$

$$C_T = 293,400$$

approx. 30% wt total Cl salt solution

Conc. NaCl phase,

$$C_{NaCl} = C_{Na} + C_{ClNa}$$

$$C_{NaCl} = 69,500 + 107,000 = 176,500$$

approx. 18% wt NaCl salt solution.

B.3 SAMPLE CALCULATION OF STEAM AND NONCONDENSABLE GAS FLOWS

Flow Setup:

The mass and energy balances start with Tank C and proceed to Tanks B and A, respectively. The reason for this approach is that reinjection brine flow from Tank C was a measured value. The equations applicable to this situation are defined as follows:

$$w_2 = w_{b3} \left\{ \frac{\frac{\Delta H_v}{H_{b3} - H_{b1} + \Delta H_v} - 1}{1 - \frac{P_{s1} (P_2 - P_{s2})}{P_{s2} (P_1 - P_{s1})}} \right\} \left\{ 1 + \frac{(P_2 - P_{s2}) M_{ng}}{P_{s2} M_s} \right\}$$

where,

$$\text{LOG}_{10} P_s = -3721.5/(T+460) + 6.6604$$

$$H_b = 0.3675T^{1.0896} \text{ (Haas's data for 30\% wt mixture, Ref. 1)}$$

B.3 (continued)

Tank B and C inlet flows are primarily single-phase (liquid). No significant amounts of noncondensable gases were detected. Therefore, the equation for w_2 reduces to the following:

$$w_2 = w_{b3} \times (\Delta H_v / (H_{b3} - H_{b1} + \Delta H_v) - 1)$$

where:

$$P_2 \approx P_{s2}$$

The heat of vaporization is derived from the vapor pressure/temperature data measured from Tanks B and C with no noncondensable gases present:

$$\Delta H_v = 749.2 \text{ Btu/lb for 30\% wt mixture.}$$

For Test No. 20 (1215 - 1845 hours on 2/3/81)

Tank C,

$$P_1 = 110 \text{ psia}$$

$$T_1 = 341^\circ\text{F}$$

$$P_2 = 62 \text{ psia}$$

$$T_2 = T_3 = 300^\circ\text{F}$$

$$w_{b3} = 1.175 \times 10^5 \text{ lb/hr (measured)}$$

$$H_{b1} = 0.3675 \times 341 \times 1.0896 = 211.3 \text{ Btu/lb}$$

$$H_{b3} = 0.3675 \times 300 \times 1.0896 = 183.8 \text{ Btu/lb}$$

$$w_2 = 1.175 \times 10^5 \times (749.2 / (183.8 - 211.3 + 749.2) - 1)$$

$$w_2 = 0.046 \times 10^5 \text{ lb/hr}$$

Since noncondensable gases are not present,

$$w_{s2} = w_2 = 0.046 \times 10^5 \text{ lb/hr}$$

$$w_{b2} = w_{s2} + w_{b1} = 0.046 \times 10^5 + 1.175 \times 10^5$$

$$w_{b2} = 1.221 \times 10^5 \text{ lb/hr}$$

B.3 (continued)

Tank B,

$$P_1 = 210 \text{ psia}$$

$$T_1 = 369^\circ\text{F}$$

$$P_2 = 110 \text{ psia}$$

$$T_2 = T_3 = 341^\circ\text{F}$$

$$w_{b3} = 1.221 \times 10^5$$

$$H_{b1} = 0.3675 \times 369 \times 1.0896 = 230.3$$

$$H_{b3} = 0.3675 \times 341 \times 1.0896 = 211.3$$

$$w_2 = 1.221 \times 10^5 \times (749.2 / (211.3 - 230.3 + 749.2) - 1)$$

$$w_2 = 0.031 \times 10^5 \text{ lb/hr}$$

Since noncondensable gases are not present,

$$w_{s2} = w_2 = 0.031 \times 10^5 \text{ lb/hr}$$

$$w_{b2} = w_{s2} + w_{b1} = 0.031 \times 10^5 + 1.221 \times 10^5$$

$$w_{b2} = 1.252 \times 10^5 \text{ lb/hr}$$

Tank A,

$$P_1 = 462 \text{ psia}$$

$$T_1 = 411^\circ\text{F}$$

$$P_2 = 210 \text{ psia}$$

$$T_2 = T_3 = 369^\circ\text{F}$$

$$w_{b3} = 1.252 \times 10^5 \text{ lb/hr}$$

$$H_{b1} = 0.3675 \times 411 \times 1.0896 = 259.0$$

$$H_{b3} = 0.3675 \times 369 \times 1.0896 = 230.3$$

$$\text{Log}P_{s1} = -3721.5 / (411 + 460) + 6.6604$$

$$P_{s1} = 244 \text{ psia}$$

$$\text{Log}P_{s2} = -3721.5 / (369 + 460) + 6.6604$$

$$P_{s2} = 148 \text{ psia}$$

B.3 (continued)

$$w_2 = \left\{ \frac{1.252 \times 10^5 \times (749.2 / (230.3 - 259.0 + 749.2) - 1)}{1 - 244 \times (210 - 148) / (148 \times (462 - 244))} \right\} \times \left\{ 1 + (210 - 148) \times 42 / (148 \times 18) \right\}$$

$$w_2 = 0.183 \times 10^5 \text{ lb/hr}$$

Since noncondensable gases exist in Tank A,

$$w_2 = w_{s1} + w_{s2} + w_{ng2}$$

$$(w_{s1} + w_{s2}) / w_{ng2} = P_{s2} M_s / (P_2 - P_{s2}) M_{ng} = (148)(18) / (210 - 148)(42) = 1.0230$$

$$w_{s1} + w_{s2} = w_2 - w_{ng2}$$

$$(w_2 - w_{ng2}) / w_{ng2} = 1.0230$$

$$(0.183 \times 10^5 - w_{ng2}) / w_{ng2} = 1.0230$$

$$w_{ng2} = 0.091 \times 10^5 \text{ lb/hr}$$

$$w_{ng1} \approx w_{ng2} \text{ (Gases relatively insoluble in saturated salt brine)}$$

$$w_{s1} / w_{ng1} = P_{s1} M_s / (P_1 - P_{s1}) M_{ng} = (244)(18) / (462 - 244)(42) = 0.4797$$

$$w_{s1} = (0.4797)(0.091 \times 10^5) = 0.043 \times 10^5 \text{ lb/hr}$$

$$w_{s2} = w_2 - w_{s1} - w_{ng2}$$

$$w_{s2} = 0.183 \times 10^5 - 0.043 \times 10^5 - 0.091 \times 10^5$$

$$w_{s2} = 0.049 \times 10^5 \text{ lb/hr}$$

Adding all steam and noncondensable gases from Tanks A, B and C will equal total gases leaving system,

$$W_{Tgas} = W_{2A} + W_{2B} + W_{2C}$$

$$W_{Tgas} = 0.183 \times 10^5 + 0.031 \times 10^5 + 0.046 \times 10^5$$

$$W_{Tgas} = 0.260 \times 10^5 \text{ lb/hr}$$

B.3 (continued)

From VR analysis of gas sample 3881,

	N ₂	CO ₂	Ar+O ₂	CH ₄	H ₂ O & others
Vol. % (meas.)	6.74	85.0	1.78	2.05	4.43
Vol. % (dry)	7.05	88.94	1.86	2.14	0
Wt. % (dry)	4.69	93.08	1.42	0.81	0

$M_{ng} = 42.04$ lb/lb mole, determined from above analysis.

Determination of individual gas flows,

$$W_{ng} = 0.091 \text{ lb/hr}$$

$$W_{T_x} = C_x W_{ng}$$

$$W_{T_{N_2}} = (0.0469)(0.091 \times 10^5) = 426.8 \text{ lb/hr}$$

$$W_{T_{CO_2}} = (0.9308)(0.091 \times 10^5) = 8470.3 \text{ lb/hr}$$

$$W_{T_{Ar+O_2}} = (0.0142)(0.091 \times 10^5) = 129.2 \text{ lb/hr}$$

$$W_{T_{CH_4}} = (0.0081)(0.091 \times 10^5) = 73.7 \text{ lb/hr}$$

Determination of individual gas concentrations,

$$C_x = W_{T_x} / W_{T_{gas}} \times 100$$

$$C_{N_2} = 426.8 / (0.260 \times 10^5) \times 100 = 1.6\% \text{ wt (N}_2\text{)}$$

$$C_{CO_2} = 8470.3 / (0.260 \times 10^5) \times 100 = 32.4\% \text{ wt (CO}_2\text{)}$$

$$C_{Ar+O_2} = 129.2 / (0.260 \times 10^5) \times 100 = 0.5\% \text{ wt (Ar+O}_2\text{)}$$

$$C_{CH_4} = 73.7 / (0.260 \times 10^5) \times 100 = 0.3\% \text{ wt (CH}_4\text{)}$$

$$C_{H_2O} = 100 - C_{N_2} - C_{CO_2} - C_{Ar+O_2} - C_{CH_4}$$

$$C_{H_2O} = 65.2\% \text{ wt (H}_2\text{O)}$$

Determination of H₂S concentrations,

From analysis of gas samples 3851 and 3852 and averaging results:

$$(96.0 + 114) / 2 = 105 \text{ mg H}_2\text{S/liter of condensate from Tank A}$$

$$W_T = (w_{s1A} + w_{s2A})(3.785 \text{ liters/gal})(7.486 \text{ gal/ft}^3) / 62.4 \text{ lb/ft}^3$$

B.3 (continued)

$$W_T = (0.043 \times 10^5 + 0.049 \times 10^5)(0.4537) = 4.174 \times 10^3 \text{ liters/hr}$$

$$W_{T_{H_2S}} = (105 \text{ mg/liter})(4.174 \times 10^3 \text{ liters/hr}) / (1000 \text{ mg/gm})(454 \text{ gm/lb})$$

$$W_{T_{H_2S}} = 0.965 \text{ lb/hr}$$

$$C_{H_2S} = 0.965 / (0.260 \times 10^5) \times 100 = 0.005\% \text{ wt } (H_2S)$$

B.4 SAMPLE ORIFICE PLATE CALCULATIONS*

P_1	= Inlet pressure	= 22.3 psig
P_2	= Outlet pressure	~ atmospheric (14.7 psia)
T_1	= Inlet temperature	= 720°R
T_2	= Outlet temperature	~ 720°R
A_o	= Orifice area ($\pi/4(4.0)^2$)	= 12.5664 in. ²
β	= Orifice diameter ratio 4.00/6.00	= 0.67
C_D	= Orifice discharge coefficient (reference curve @ β , page 67)	= 0.92
γ	= c_p/c_v	= 1.33
g	= gravity	= 32.2 ft/sec ²
R	= gas constant	= 1544/M
M	= molecular weight	= 22.81
W	= steam/noncondensable gas flow	= lb/hr
W^*	= steam/noncondensable gas flow; process flow analysis (Appendix B.3)	= lb/hr

*Reference (7): Stearns, R.F., Johnson, R.R., Jackson, R.M., Larson, C.A., "Flow Measurement With Orifice Meters," D. Van Nostrand Company, Inc., New York, N.Y.

B.4 (continued)

$$P_2/P_1 = \frac{14.7}{36.7} \leq 0.5 \text{ (i.e., sonic flow condition)}$$

$$W = C_D C_W A_0 P_1$$

$$\text{where: } C_W = \sqrt{\frac{\gamma g}{R T_1} \cdot \left(\frac{2}{\gamma + 1} \right) \frac{\gamma + 1}{\gamma - 1}} \quad (\text{equation for sonic flow})$$

$$C_W = 0.017289/\text{sec}$$

$$\text{and } W = (0.92)(0.017289)(12.5664)(22.3 + 14.7)(3600)$$

$$W = 2.6623 \times 10^4 \text{ lb/hr}$$

$$W^* = 2.604 \times 10^4 \text{ lb/hr}$$

(calculated flow from process analysis using Reference (7) enthalpy data, see Appendix B.3, Page B7)

B.4 (continued)

Figure B.4 Steam Measuring Orifice Plate at End of Test 20

APPENDIX C

SYSTEM MASS BALANCES

- C.1 Test 19-1 (1/8/81)
- C.2 Test 19-2 (1/10/81)
- C.3 Test 20-1 (2/3/81)
- C.4 Test 20-2 (2/5/81)

Checkout Tests

- C.5 Test 15 (10/27/80)
- C.6 Test 16, 17, & 18 (12/11/80)

TEST 19 (1/8/81 Thru 1/11/81)

C.1 HYDROSCALE SYSTEM MASS BALANCE FOR TEST SECTION EXPOSURE TO 50 PSIG SINGLE FLASHED PUMPED BRINE

(Test No. 18, 1/8/81 thru 1/10/81) (1)

Position	SL-1 Wellhead Brine	SL-2 Flash Tank A Steam/Noncond. Gases (2)	SL-3 Flash Tank A Brine	SL-4 Reinjection Brine	SL-5 Atm. Discharge Steam/Noncond. Gases (2)	Test Section 200	Test Section 300	Test Section 400	Test Section 500	Test Section 200	Test Section 300	Test Section 400	Test Section 500
Flow Rate GPM	248.2/876.7 (6)	---	216.5	214.6 (5)	---	75.5	76.4	36.1	49.7	75.5	76.4	36.1	49.7
Lbs/Hr	$1.355 \times 10^5 / 0.972 \times 10^4$ (7)	2.209×10^4	1.231×10^5	1.231×10^5	2.209×10^4	4.283×10^4	4.334×10^4	2.048×10^4	2.819×10^4	4.283×10^4	4.334×10^4	2.048×10^4	2.819×10^4
Temperature °F	398	297	297	274	230	303	303	303	303	303	303	303	303
°C	203	147	147	134	110	150	150	150	150	150	150	150	150
Pressure PSIA	454	64	64	65	21	74	74	74	74	70	73	66(3)	69
ATM	30.9	4.4	4.4	4.4	1.4	5.0	5.0	5.0	5.0	4.8	4.9	4.5	4.7
TDS Mg/Liter	---	---	290,000	341,000	---	297,000	---	---	---	336,000	338,000	338,000	342,000
Lbs/Hr	---	---	2.823×10^4	3.320×10^4	---	1.023×10^4	---	---	---	1.158×10^4	1.182×10^4	0.557×10^4	0.776×10^4
TSS (8) Mg/Liter	---	---	---	---	---	---	---	---	---	---	---	---	---
Lbs/Hr	---	---	---	---	---	---	---	---	---	---	---	---	---
Noncond. Gases (4) Mg/Liter	---	---	---	---	---	---	---	---	---	---	---	---	---
Lbs/Hr	0.589×10^4	0.589×10^4	---	---	0.589×10^4	---	---	---	---	---	---	---	---

NOTES:

1. Data averaged between 1840 and 2230 hrs. on 1/8/81.
2. Steam and noncondensable gases flows were determined from thermodynamic relationships.
3. Downstream pressure determined from upstream pressure and flow across a 3/4" dia. orifice.
4. Noncondensable gas flows determined from brine vapor pressure data (saturation curve) obtained in Test No. 18.
5. Reinjection flow based on a VR measurement at 2000 hr.
6. Liquid/gas volumetric flow ratio, 77.9% vol. gas.
7. Liquid/gas weight flow ratio, 6.7% wt. gas.
8. No data available.

C.2 HYDROSCALE SYSTEM MASS BALANCE FOR TEST SECTION EXPOSURE TO 50 PSIG SINGLE FLASHED PUMPED AND UNPUMPED BRINE

(Test No. 19, 1/10/81 thru 1/11/81) (1)

Position	SL-1 Wellhead Brine	SL-2 Flash Tank A Steam/Noncond. Gases (2)	SL-3 Flash Tank A Brine	SL-4 Reinjection Brine	SL-5 Atm. Discharge Steam/Noncond. Gases (2)	PUMPED TEST SECTIONS										UNPUMPED TEST SECTIONS (8)					T
						Test Section 200	Test Section 300	Test Section 400	Test Section 500	Test Section 200	Test Section 300	Test Section 400	Test Section 500	Test Section 200	Test Section 300	Test Section 400	Test Section 500	Test Section 200	Test Section 300	Test Section 400	
Flow Rate GPM	187.9/786.5 (6)	---	162.8	160.9 (5)	---	51.2	48.8	25.4	33.6	51.2	48.8	25.4	33.6	55.6	74.6	41.0	63.0	55.6	74.6	41.0	3
Lbs/Hr	$1.024 \times 10^5 / 0.935 \times 10^4$ (7)	1.917×10^4	9.259×10^4	9.259×10^4	1.917×10^4	2.913×10^4	2.777×10^4	1.445×10^4	1.912×10^4	2.913×10^4	2.777×10^4	1.445×10^4	1.912×10^4	3.175×10^4	4.260×10^4	2.341×10^4	3.598×10^4	3.175×10^4	4.260×10^4	2.341×10^4	
Temperature °F	402	296	296	266	227	295	295	295	295	298	300	300	301	286	286	286	286	285	286	286	
°C	224	147	147	130	108	146	146	146	146	147	149	149	149	141	141	141	141	140	141	141	
Pressure PSIA	459	67	67	63	20	67	67	67	67	64	67	62(3)	64	46	45	46	45	46	45	44	
ATM	31.2	4.6	4.6	4.3	1.4	4.6	4.6	4.6	4.6	4.4	4.5	4.2	4.4	3.1	3.1	3.1	3.1	.31	3.1	3.0	
TDS Mg/Liter	283,000	29,700	335,000	340,000	29,700	---	---	---	---	340,000	---	---	---	---	---	---	---	---	---	---	
Lbs/Hr	2.240×10^4	178	2.454×10^4	2.491×10^4	178	---	---	---	---	0.797×10^4	---	---	---	---	---	---	---	---	---	---	
TSS Mg/Liter	129	---	285	494	---	---	---	---	---	194	---	---	---	---	---	---	---	---	---	---	
Lbs/Hr	10	---	21	36	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
Noncond. Gases (4) Mg/Liter	---	---	---	---	---	---	---	---	---	4.5	---	---	---	---	---	---	---	---	---	---	
Lbs/Hr	0.665×10^4	0.665×10^4	---	---	0.665×10^4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	

NOTES:

1. Data averaged between 1040 and 1350 hrs. on 1/10/81.
2. Steam and noncondensable gases flows were determined from thermodynamic relationships. Annubar flow sensors appeared to be plugged early in test.
3. Downstream pressure determined from upstream pressure and flow across a 3/4" dia. orifice. Pressure measurement indicated a value higher than upstream pressure.
4. Noncondensable gas flows determined from brine vapor pressure data (saturation curve) obtained in Test No. 18.
5. Reinjection flow based on a VR measurement at 1130 hr. Flow to pond started at 1840 hr.
6. Liquid/gas volumetric flow ratio, 80.3% vol. gas.
7. Liquid/gas weight flow ratio, 8.4% wt. gas.
8. Data averaged between 1900 and 2100 hrs. on 1/10/81. Flash tank mass balance was not calculated for this period due to flow diversion to pond, i.e., not measured.

TEST 20 (2/2/81 Thru 2/4/81)

C.3 HYDROSCALE SYSTEM MASS BALANCE FOR TEST SECTION EXPOSURE TO 100 PSIG MULTIPLE FLASHED UNPUMPED BRINE

(Test No. 20, 2/2/81 thru 2/4/81) (1)

Position	SL-1 Wellhead Brine	SL-2 Flash Tank A Steam/Noncond. Gases (2)	SL-3 Flash Tank A Brine	SL-4 Reinjection Brine	SL-5 Atm. Discharge Steam/Noncond. Gases (2)	SL-6 Flash Tank B Steam/Noncond. Gases (2)	SL-7 Flash Tank B Brine	SL-8 Flash Tank C Steam/Noncond. Gases (2)	SL-9 Flash Tank C Brine	Test Section 100	Test Section 300	Test Section 400	Test Section 500	Test Section 100	Test Section 300	Test Section 400	Test Section 500
Flow Rate GPM	238.8/1124.4 (6)	---	226.6	203.8 (5)	---	---	218.4	---	206.7	67.7	71.3	32.0	53.0	67.7	70.0/282.1 (8)	31.6/85.9 (8)	52.1/178.5 (8)
Lbs/Hr	$1.302 \times 10^5 / 1.338 \times 10^4$ (7)	1.834×10^4	1.252×10^5	1.175×10^5	2.604×10^4 (3)	0.314×10^4	1.220×10^5	0.456×10^4	1.175×10^5	3.781×10^4	3.995×10^4	1.795×10^4	2.965×10^4	3.781×10^4	$3.946 \times 10^4 / 490$ (8)	$1.780 \times 10^4 / 150$ (8)	$2.934 \times 10^4 / 310$ (8)
Temperature °F	411	369	369	262	---	341	341	300	300	342	334	331	339	342	323	319	323
°C	210	187	187	128	---	172	172	149	149	172	168	166	170	172	162	159	162
Pressure PSIA	462	210	210	62	15	110	110	62	62	101	100	104	102	103	101	102	100
ATM	31.4	14.3	14.3	4.2	1.0	7.4	7.4	4.2	4.2	6.9	6.8	7.1	6.9	7.0	6.9	6.9	6.8
TDS Mg/Liter	312,000	9,740	332,000	---	---	30	336,000	810	352,000	---	---	---	---	---	356,000	---	---
Lbs/Hr	3.135×10^4	67	3.237×10^4	---	---	0.070	3.214×10^4	2.8	3.271×10^4	---	---	---	---	---	1.130×10^4	---	---
TSS Mg/Liter	780	---	87	---	---	---	456	---	256	---	---	---	---	---	---	---	---
Lbs/Hr	78	---	8.5	---	---	---	44	---	24	---	---	---	---	---	---	---	---
Noncond. Gases (4) Mg/Liter	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lbs/Hr	0.906×10^4	0.906×10^4	---	---	0.906×10^4	---	---	---	---	---	---	---	---	---	---	---	---

NOTES:

1. Data averaged between 1215 and 1845 hrs. on 2/3/81.
2. Steam and noncondensable gases flows were determined from thermodynamic relationships.
3. Flow orifice measurement at the same location was 2.662×10^4 lbs/hr.
4. Noncondensable gas flows determined from brine vapor pressure data (saturation curve) obtained in Test No. 18.
5. Reinjection flow based on a VR measurement at 1800 hr.
6. Liquid/gas volumetric flow ratio, 82.4% vol. gas.
7. Liquid/gas weight flow ratio, 9.3% wt. gas.
8. Liquid/steam flow ratio.
9. Total suspended solids expressed as silica, heavy metal sulfides and oxides.

C.4 HYDROSCALE SYSTEM MASS BALANCE FOR TEST SECTION EXPOSURE TO 200 PSIG MULTIPLE FLASHED UNPUMPED BRINE

(Test No. 20, 2/4/81 thru 2/6/81) (1)

Position	SL-1 Wellhead Brine	SL-2 Flash Tank A Steam/Noncond. Gases (2)	SL-3 Flash Tank A Brine	SL-4 Reinjection Brine	SL-5 Atm. Discharge Steam/Noncond. Gases (2)	SL-6 Flash Tank B Steam/Noncond. Gases (2)	SL-7 Flash Tank B Brine	SL-8 Flash Tank C Steam/Noncond. Gases (2)	SL-9 Flash Tank C Brine	Test Section 100	Test Section 200	Test Section 300	Test Section 400	Test Section 100	Test Section 200	Test Section 300	Test Section 400
Flow Rate GPM	211.9/972.2 (6)	---	200.8	178.2 (5)	---	See Note 8	See Note 8	---	180.9	65.3	67.3	31.0	89.7	65.3	67.3	31.0	89.7
Lbs/Hr	$1.152 \times 10^5 / 1.176 \times 10^4$ (7)	1.591×10^4	1.110×10^5	1.032×10^5	2.379×10^4 (3)	---	---	0.788×10^4 (8)	1.032×10^5	3.601×10^4	3.718×10^4	1.716×10^4	4.956×10^4	3.601×10^4	3.718×10^4	1.716×10^4	4.965×10^4
Temperature °F	408	368	368	250	---	332	332	289	289	373	369	364	358	356 (9)	311 (9)	320 (9)	325 (9)
°C	209	187	187	121	---	167	167	143	143	189	187	184	181	180	155	160	163
Pressure PSIA	459	211	211	57	15	105	105	58	58	184	183	184	181	184	184	183	176
ATM	31.2	14.4	14.4	3.9	1.0	7.1	7.1	3.9	3.9	12.5	12.4	12.5	12.3	12.5	12.5	12.4	12.0
TDS Mg/Liter	318,000	32,600	319,000	---	---	40	---	270	370,000	---	---	334,000	---	---	---	---	---
Lbs/Hr	2.948×10^4	189	2.787×10^4	---	---	---	---	1.8	3.057×10^4	---	---	0.461×10^4	---	---	---	---	---
TSS Mg/Liter	745	---	512	---	---	---	---	---	137	---	---	329	---	---	---	---	---
Lbs/Hr	67	---	45	---	---	---	---	---	11	---	---	4.5	---	---	---	---	---
Noncond. Gases (4) Mg/Liter	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lbs/Hr	0.818×10^4	0.818×10^4	---	---	0.818×10^4	---	---	---	---	---	---	---	---	---	---	---	---

NOTES:

1. Data averaged between 0930 and 1800 hrs. on 2/5/81.
2. Steam and noncondensable gases flows were determined from thermodynamic relationships.
3. Flow orifice measurement at the same location was 2.318×10^4 lbs/hr.
4. Noncondensable gas flows determined from brine vapor pressure data (saturation curve) obtained in Test No. 18.
5. Reinjection flow based on a VR measurement at 1200, 1800, and 2000 hr.
6. Liquid/gas volumetric flow ratio, 82.1% vol. gas.
7. Liquid/gas weight flow ratio, 9.2% wt. gas.
8. Brine flow entering Tank B could not be determined. Tank B steam flow included in Tank C steam flow.
9. Lower temperature measurements was due to flashing across block valve used to manually control the flow during this period.

CHECKOUT TESTS 15 (10/27/80 and 18 (12/11/80)

C.5 HYDROSCALE SYSTEM MASS BALANCE FOR SINGLE FLASHED BRINE OPERATION

(Test No. 15, 10/27/80 thru 10/28/80) (1)

Position	SL-1 Wellhead Brine	SL-2 Flash Tank A Steam/Noncond. Gases (2)	SL-3 Flash Tank A Brine	SL-4 Reinjection Brine	SL-5 Atm. Discharge Steam/Noncond. Gases (2)
Media					
Flow Rate					
GPM	29.0/445.0 (5)	---	23.7	23.5	---
Lbs/Hr	$1.564 \times 10^4 / 0.500 \times 10^4$ (6)	0.706×10^4	1.358×10^4	1.358×10^4	0.706×10^4
Temperature					
°F	425	279	279	257	265 (4)
°C	218	137	137	125	129 (4)
Pressure					
PSIA	472	55.5	55.5	54.4	15.7 (4)
ATM	32.1	3.8	3.8	3.7	1.1 (4)
TDS					
Mg/Liter	---	---	320,000	330,000	---
Lbs/Hr	---	---	0.314×10^4	0.324×10^4	---
TSS (7)					
Mg/Liter	---	---	607	852	---
Lbs/Hr	---	---	5.9	8.4	---
Noncond. Gases					
Mg/Liter	---	---	---	---	---
Lbs/Hr	0.305×10^4	0.305×10^4	---	---	0.305×10^4

NOTES:

1. Data averaged between 1130 and 1340 hrs. on 10/28/81.
2. Steam and noncondensable gases flows were determined from thermodynamic relationships. Annubar flow sensors appeared to be plugged early in test.
3. All noncondensable gas flows determined from brine vapor pressure data obtained in Test No. 18.
4. Gage reading at 0630 hr., last recorded reading.
5. Liquid/gas volumetric flow ratio, 83.9% vol. gas.
6. Liquid/gas weight flow ratio, 24.2% wt. gas.
7. Total suspended solids express as silica, heavy metal sulfides and oxides.

C.6 HYDROSCALE SYSTEM MASS BALANCE FOR DUAL FLASHED BRINE OPERATION

(Test No. 18, 12/11/80 thru 12/12/80) (1)

Position	SL-1 Wellhead Brine	SL-2 Flash Tank A Steam/Noncond. Gases (2)	SL-3 Flash Tank A Brine	SL-4 Reinjection/ Brine	SL-5 Atm. Discharge Steam/Noncond. Gases (2)	SL-6 Flash Tank B Steam/Noncond. Gases (2)	SL-7 Flash Tank B Brine	SL-8 Flash Tank C Steam/Noncond. Gases (2)	SL-9 Flash Tank C Brine
Media									
Flow Rate									
GPM	123.6/44.6 (4)	---	122.1	110.9	---	---	118.0	---	112.6
Lbs/Hr	$6.789 \times 10^4 / 0.062 \times 10^4$ (5)	0.116×10^4	6.734×10^4	6.373×10^4	0.487×10^4	0.161×10^4	6.573×10^4	0.210×10^4	6.363×10^4
Temperature									
°F	383	374	374	274	280	348	348	312	312
°C	195	190	190	134	138	176	176	156	156
Pressure									
PSIA	471.4	207.4	207.4	60.1	19.9	112.8	112.8	69.1	69.1
ATM	32.1	14.1	14.1	4.1	1.4	7.7	7.7	4.7	4.7
TDS									
Mg/Liter	---	---	293,000	---	---	---	321,000	---	328,000
Lbs/Hr	---	---	1.567×10^4	---	---	---	1.685×10^4	---	1.679×10^4
TSS (6)									
Mg/Liter	---	---	---	---	---	---	---	---	---
Lbs/Hr	---	---	---	---	---	---	---	---	---
Noncond. Gases (3)									
Mg/Liter	---	---	---	---	---	---	---	---	---
Lbs/Hr	0.049×10^4	0.049×10^4	---	---	0.049×10^4	---	---	---	---

NOTES:

1. Data averaged between 1430 and 1640 hrs. on 12/11/80.
2. Steam and noncondensable gases flows were determined from thermodynamic relationships. Annubar flow sensors appeared to be plugged early in test.
3. All noncondensable gas flows determined from brine vapor pressure data obtained from subject test.
4. Liquid/gas volumetric flow ratio, 26.2% vol. gas.
5. Liquid/gas weight flow ratio, 0.9% wt. gas.
6. Changing wellhead conditions prevented accurate determination of total suspended solids.

APPENDIX D

SCALE DATA SHEETS

- D.1 Scaling Rate Data Summary (Tests 15 - 20)**
- D.2 Los Alamos X-Ray Diffraction Data Sheets**

SCALING RATE DATA SUMMARY

(Test No. 15)

Sample Ident.	Sample Description	Sample Location	Environment Media	Scale Thickness (inches)	Scaling ⁽¹⁾ Rate (mils/hr)
SC-80A	4" Dia. Coupon	Tank A Steam Discharge	Steam & Non-condensable Gases	0.005 to 0.010	0.2 to 0.4
SC-81A	2" Dia. Coupon	Tank A Bottom Sidewall	Flashed Brine	0.155	5.5
SC-82A	8" Dia. Coupon	Tank A Bottom Wall	Flashed Brine	See Note 2	

NOTES:

1. Based on 28 hours of operating time.
2. Scale sludge-type material unattached to the coupon.

SCALING RATE DATA SUMMARY

(Tests No. 16, 17, & 18)

Sample Ident.	Sample Description	Sample Location	Environment Media	Scale Thickness (inches)	Scaling Rate (1) (mils/hr)
SC-80A	4" Dia. Coupon	Tank A Steam Discharge	Steam & Non-condensable Gases	0.0385	1.0
SC-81A	2" Dia. Coupon	Tank A Bottom Sidewall	Flashed Brine	0.0316	0.8
SC-82A	8" Dia. Coupon	Tank A Bottom Wall	Flashed Brine	See Note 2	
SC-83A	2" Dia. Coupon	Tank A Upper Sidewall	Flashed Steam & Brine	0.0518	1.4
SC-80B	4" Dia. Coupon	Tank B Steam Discharge	Steam & Non-condensable Gases	0.0072	0.2
SC-81B	2" Dia. Coupon	Tank B Bottom Sidewall	Flashed Brine	0.0783	2.1
SC-82B	8" Dia. Coupon	Tank B Bottom Wall	Flashed Brine	See Note 3	
SC-83B	2" Dia. Coupon	Tank B Upper Sidewall	Flashed Steam & Brine	0.0949	2.5
SC-80C	4" Dia. Coupon	Tank C Steam Discharge	Steam & Non-condensable Gases	0.0036	0.1
SC-81C	2" Dia. Coupon	Tank C Bottom Sidewall	Flashed Brine	0.0338	0.9
SC-82C	8" Dia. Coupon	Tank C Bottom Wall	Flashed Brine	See Note 4	
SC-83C	2" Dia. Coupon	Tank C Upper Sidewall	Flashed Steam & Brine	0.1294	3.4

NOTES:

1. Based on 38.1 hrs of operating time.
2. Scale sludge-type material unattached to coupon with wet bulk density of 2.14 gm/cc.
3. Scale sludge-type material unattached to coupon with wet bulk density of 1.75 gm/cc.
4. Scale sludge-type material unattached to coupon with wet bulk density of 1.96 gm/cc.

SCALING RATE DATA SUMMARY

(Test No. 19)

Sample Ident.	Sample Description	Sample Location	Environment Media	Scale Thickness (inches)	Scaling Rate (mils/hr)
SC-80A	4" Dia. Coupon	Tank A Steam Discharge	Steam & Non-condensable Gases	0.1169	1.2 (1)
SC-81A	2" Dia. Coupon	Tank A Bottom Sidewall	Flashed Brine	0.1698	1.7 (1)
SC-82A	8" Dia. Coupon	Tank A Bottom Wall	Flashed Brine	See Note 4	
SC-83A	2" Dia. Coupon	Tank A Upper Sidewall	Flashed Steam & Brine	0.1198	1.2 (1)
SV-20A	4" Plug Valve	Tank A Brine Discharge	Flashed Brine	0.2441	2.4 (1)
STC-200	0.1250" Dia. Thermocouple	Test Section 200-SP-50	Single Flash, Pumped Brine	0.0844	1.7 (2)
STC-300	0.1250" Dia. Thermocouple	Test Section 300-SP-50	Single Flash, Pumped Brine	0.0847	1.7 (2)
STC-400	0.1250" Dia. Thermocouple	Test Section 400-SP-50	Single Flash, Pumped Brine	0.1174	2.3 (2)
STC-500	0.1250" Dia. Thermocouple	Test Section 500-SP-50	Single Flash, Pumped Brine	0.1026	2.0 (2)
STC-200	0.1250" Dia. Thermocouple	Test Section 200-SU-50	Single Flash, Unpumped Brine	0.1062	4.4 (3)
STC-300	0.1250" Dia. Thermocouple	Test Section 300-SU-50	Single Flash, Unpumped Brine	0.0673	2.8 (3)
STC-400	0.1250" Dia. Thermocouple	Test Section 400-SU-50	Single Flash, Unpumped Brine	0.0168	0.7 (3)
STC-500	0.1250" Dia. Thermocouple	Test Section 500-SU-50	Single Flash, Unpumped Brine	0.0530	2.2 (3)
SV-12A (5)	4" Vee-Ball Valve	Tank A Steam Discharge	Steam & Non-condensable Gases	0.1151	1.2 (1)
SV-12A (6)	4" Vee-Ball Valve	Tank A Steam Discharge	Steam & Non-condensable Gases	0.5821	5.8 (1)

SCALING RATE DATA SUMMARY

(Test No. 19), continued

Sample Ident.	Sample Description	Sample Location	Environment Media	Scale Thickness (inches)	Scaling Rate (mils/hr)
SP-20A	4" Pipe	Between V-20A & V-21A	Flashed Brine	0.2881	See Note 7
SV-21A	4" Plug Valve	Tank A Brine Disch. to Pump	Flashed Brine	0.1835	2.5 (8)
SV-704A	4" Plug Valve	Test Rig Brine Return	Flashed Brine	0.1826	1.8 (1)

NOTES:

1. Based on 100 hours of operating time.
2. Based on 50.25 hours of operating time.
3. Based on 24.2 hours of operating time.
4. Scale sludge-type material unattached to coupon with wet bulk density of 2.063 gm/cc.
5. Upstream of ball orifice.
6. Downstream of ball orifice.
7. Approx. 2" x 3" unattached scale plate.
8. Based on 74.4 hours of operating time.

SCALING RATE DATA SUMMARY

(Test No. 20)

Sample Ident.	Sample Description	Sample Location	Environment Media	Scale Thickness (inches)	Scaling Rate (mils/hr)
SC-80A	4" Dia. Coupon	Tank A Steam Discharge	Steam & Non-condensable Gases	0.0817	0.8 (1)
SC-81A	2" Dia. Coupon	Tank A Bottom Sidewall	Flashed Brine	0.0404	0.4 (1)
SC-83A	2" Dia. Coupon	Tank A Upper Sidewall	Flashed Steam & Brine	0.0523	0.5 (1)
SC-80B	4" Dia. Coupon	Tank B Steam Discharge	Steam & Non-condensable Gases	0.1472	1.4 (1)
SC-81B	2" Dia. Coupon	Tank B Bottom Sidewall	Flashed Brine	0.1265	1.2 (1)
SC-83B	2" Dia. Coupon	Tank B Upper Sidewall	Flashed Steam & Brine	0.1790	1.7 (1)
SC-80C	4" Dia. Coupon	Tank C Steam Discharge	Steam & Non-condensable Gases	0.0374	0.4 (1)
SC-81C	2" Dia. Coupon	Tank C Bottom Sidewall	Flashed Brine	0.2764	2.7 (1)
SC-83C	2" Dia. Coupon	Tank C Upper Sidewall	Flashed Steam & Brine	See Note 5	
STC-100	0.1249" Dia. Thermocouple	Test Section 100-DU-100	Dual Flash, Unpumped Brine	0.0836	1.7 (2)
STC-300	0.1251" Dia. Thermocouple	Test Section 300-DU-100	Dual Flash, Unpumped Brine	0.0810	1.6 (2)
STC-400	0.1249" Dia. Thermocouple	Test Section 400-DU-100	Dual Flash, Unpumped Brine	0.0620	1.4 (3)
STC-500	0.1249" Dia. Thermocouple	Test Section 500-DU-100	Dual Flash, Unpumped Brine	0.0682	1.5 (3)
STC-100	0.1249" Dia. Thermocouple	Test Section 100-DU-200	Dual Flash, Unpumped Brine	0.0336	0.7 (4)
STC-300	0.1248" Dia. Thermocouple	Test Section 300-DU-200	Dual Flash, Unpumped Brine	0.0179	0.4 (4)

SCALING RATE DATA SUMMARY

(Test No. 20), Continued

Sample Ident.	Sample Description	Sample Location	Environment Media	Scale Thickness (inches)	Scaling Rate (mils/hr)
STC-400	0.1249" Dia. Thermocouple	Test Section 400-DU-200	Dual Flash, Unpumped Brine	0.0299	0.6 (4)
STC-500	0.1249" Dia. Thermocouple	Test Section 500-DU-200	Dual Flash, Unpumped Brine	0.0161	0.3 (4)

NOTES:

1. Based on 102.5 hours of operating time.
2. Based on 49.75 hours of operating time.
3. Based on 45.75 hours of operating time.
4. Based on 49.5 hours of operating time.
5. No noticeable scale formation observed.

D.2 LOS ALAMOS X-RAY DIFFRACTION DATA SHEETS

TEST SECTION SAMPLE NO.	β Fe ₂ (OH) ₃ Cl	β -FeO(OH) (Magnetite)	α -FeO(OH) (Goethite)	FeO(OH) (Lepidocrocite)	Fe Cl ₂ · 4H ₂ O	NaCl	PbS	Pb Cl ₂	(K, Na) Pb ₂ Cl ₅	Other
100 DU-100-3	M	W	T	O	T	VW	O	O	O	
100 DU-100-7	M	M	O	T	T	VW	O	O	O	
100 DU-200-3	O	VW	O	O	O	VW	S	VW	VW	
100 DU-200-7	T	VW	O	O	O	M	S	O	T	
200 SP-50-3	M-S	W	O	O	T	T	T	O	VW	
200 SP-50-7	M-S	W	O	O	T	T	O	O	T	
200 DU-200-3	T	VW	O	O	O	W	S	T	VW	
200 DU-200-9	T	W	O	O	O	VW	S	T	VW	
300 SP-50-3	M-S	W-M	O	O	T	VW	O	O	O	
300 SP-50-9	M-S	W-M	T	O	VW	VW	O	O	O	
300 SU-50-3	O	W-M	T	O	O	M-S	O	O	O	
300 SU-50-9	O	M-S	O	O	O	M-S	O	O	O	
* 300 DU-100-3	M-S	W	O	O	T	VW	O	O	O	
300 DU-100-9	S	VW	T	O	T	T	O	O	O	
300 DU-200-3	T	VW	O	O	O	M	S	T	VW	
300 DU-200-7	T	VW	O	O	O	W	S	T	T	
400 SP-50-3	W	M-W	T	T	T	W	O	O	VW	
400 SP-50-7	M	W	O	O	T	W	O	O	T	
400 SU-50-3	T	M	T	T	VW	W	O	O	O	
400 SU-50-7	T	M	T	T	O	W	O	O	O	
400 DU-100-3	W-M	M	T	O	R	M	O	O	O	
400 DU-100-7	S	W	O	O	T	W	O	O	O	
400 DU-200-3	VW	VW	O	O	VW	W	S	VW	VW	α - QTZ (VW) UNKNOWN (M)
* 400 DU-200-7	O	VW	O	O	O	S	S	O	O	α -QTZ (M-S)
500 SP-50-3	W-M	W	O	O	R	VW	T	T	VW	
500 SP-50-7	M	W	O	T	T	T	T	O	T	
500 SU-50-3	O	W-M	O	O	VW	M-S	O	O	W	UNKNOWN (M)
500 SU-50-7	W-M	W	O	T	VW	VW	O	O	O	
* 500 DU-100-3	M	W-M	O	O	VW	T	O	O	O	
500 DU-100-7	S	W	O	T	T	O	O	O	O	
200 SU-50-3	O	W-M	T	W	O	M	O	O	O	
200 SU-50-7	O	W-M	T	VW	O	M	O	O	O	

LEGEND: S = Major, M = Moderate, W = Minor, T = Trace, O = Undetected

* - Not Sealed

[illegible]

LEGEND: S = Major, M = Moderate, W = Minor, T = Trace, O = Undetected

APPENDIX E

CHEMISTRY DATA SHEETS

- E.1 Single-Flash Checkout Test (No. 15)**
- E.2 Multiple-Flash Checkout Test (No. 18)**
- E.3 Single-Flash Test (No. 19)**
- E.4 Dual-Flash Test (No. 20)**
- E.5 Los Alamos Comparative Chemistry Analysis of Inlet Brine Samples
3694 (FA), 3695 (RA), 3808 (FA), and 3810 (RA)**

GRI/MCULLOCH MERCER 2 WELL TEST NO. 15 BRINE SAMPLES

AEC	LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	P	CU	FE	HM	PB	ZR	STO2	SO4	HC03	CO3	PH	CL	TDS
V-7	3501	10/28/80	11:30:1 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	497.	<1.	5.80	22700	40300
V-7	3502	10/28/80	11:40:1 0 FA	9440	1290	50.0	3530	62.5	347.	266.	48.9	<0.01	653.	162.	13.0	124.	78.7	N/R	N/R	N/R	N/R	N/R	N/R
V-7	3503	10/28/80	11:50:1 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	487.	<1.	5.80	19500	35000
V-7	3504	10/28/80	12: 0:1 0 RA	4170	520.	16.5	1470	26.1	146.	115.	26.8	<0.01	233.	60.8	3.46	42.3	33.0	N/R	N/R	N/R	N/R	N/R	N/R

E.1 Single-Flash Checkout Test (No. 15)

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.

N/R indicates not requested to be analyzed. S indicates requested but not yet analyzed.

AS <0.31 AS <10.01 AU <0.91 BE <0.11 CB <0.71 CE <13.01 CD <0.91 CR <1.11 AL <2.61 BA <4.51

DE <7.51 HS <3.01 LA <0.31 MD <7.51 NI <3.51 SE <14.01 SN <11.01 TI <0.71 V <0.31 ZR <0.51 P04 <10.0

GKI/MCCULLOCH HENDER 2 WELL TEST NO. 13 DRIF SAMPLES

WELL LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	CU	FE	MN	PR	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS	
V-19A	3511	10/28/80 121101 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	65.0	<1.	5.50	194000	320000
V-19A	3512	10/28/80 121151 0 RA	78300	12600	310.	28900	533.	2810	2260	335.	<0.2	5760	1410	481.	1640	625.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19A	3513	10/28/80 131251 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	33.0	<1.	5.20	195000	320000
V-19A	3514	10/28/80 131401 0 FA	76800	12500	375.	28500	525.	2780	2220	328.	<0.2	5630	1390	444.	1620	517.	N/R	N/R	N/R	N/R	N/R	N/R	

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested, but not yet analyzed.
 AG <0.31 AS <10.01 AU <0.91 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 AL <2.61 GA <4.51
 BE <7.51 HD <3.01 LA <0.31 HD <7.51 HI <3.51 SE <14.01 SH <11.01 TI <0.21 V <0.31 ZR <0.51 PO4 <10.0

E.1 (Continued)

E2

GRI/MCCULLOCH HERCER 2 WELL TEST NO. 15 BRINE SAMPLES

AEC	LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	CU	FE	MN	PN	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
U-39	3521	10/28/80	12:55: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	48.0	<1.	5.40	197000	330000
U-39	3522	10/28/80	13: 0: 0 RA	89500	12500	370.	29100	529.	2830	2310	333.	1.78	5780	1410	435.	1440	582.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3523	10/28/80	13: 5: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	19.0	<1.	5.03	197000	220000
U-39	3524	10/28/80	13:15: 0 FA	77200	12500	370.	27900	521.	2750	2140	323.	1.53	5570	1390	441.	1410	515.	N/R	N/R	N/R	N/R	N/R	N/R

E.1 (Continued)

Values expressed in milligrams per liter. Milligrams per liter and parts per billion used interchangeably.
 N/R indicates not requested to be analyzed. \$ indicates requested, but not yet analyzed.
 AG <0.3\$ AS <10.0\$ AU <0.9\$ BE <0.1\$ CB <0.7\$ CE <13.0\$ CD <0.9\$ CR <1.1\$ MI <2.4\$ SA <6.5\$
 GE <7.5\$ MG <3.0\$ LA <0.3\$ MO <7.5\$ NI <3.5\$ SE <14.0\$ SN <11.0\$ TI <0.2\$ V <0.3\$ ZR <0.5\$ PQ <10.0

GRI/MCCULLOCH MERCER 2 WELL TEST NO. 15 NONCONDENSIBLE GAS SAMPLES

AECC LDC.	VR CODE	SAMPLE IDENTIFICATION				N2	CO2	Ar+O2	Methane
V-15A	3515	10/28/80	12:40: 0	None		0.400	92.4	0.600	2.70
V-15A	3516	10/28/80	12:47: 0	None		1.70	92.0	1.00	2.60

Results are expressed in mole percent.

E.1 (Continued)

E4

BK1/HO31/LOCH MERCER 2 WELL TEST NO. 18 BRINE SAMPLES

MECC	LOC.	VR CODE	SAMPLE ID	CO2	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PO	ZN	SI02	SO4	HC03	CO3	PH	CL	TDS	
U-19A	3541	12/11/80	14:28: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	5.00	178000	293000
U-19A	3542	12/11/80	14:32: 0 RA		74400	11800	354.	25400	484.	2480	2030	262.	<3.	5120	1240	318.	1430	475.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19A	3543	12/11/80	14:40: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	5.00	177000	290000
U-19A	3544	12/11/80	14:43: 0 FA		73300	11500	355.	24900	479.	2590	2030	264.	<3.	4790	1140	292.	1350	461.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19A	3545	12/11/80	14:43: 0 RU B11-10w		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	
U-19A	3546	12/11/80	14:45: 0 NaOH	7520	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	
U-19A	3547	12/11/80	14:53: 0 ZnAc		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3548	12/11/80	14:45: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3549	12/11/80	0:14:48 RA		73400	12400	371.	23700	484.	2520	2020	244.	<3.	4800	1170	321.	1360	453.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3550	12/11/80	14:55: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	
U-19C	3561	12/11/80	15:40: 0 ZnAc		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	3.80	190000	321000
U-19B	3562	12/12/80	9: 6: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3563	12/12/80	9:18: 0 RA		76800	12100	370.	26100	494.	2700	2080	259.	<3.	4710	1150	326.	1340	402.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3564	12/12/80	9:10: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	2.70	191000	318000
U-19B	3565	12/12/80	9:13: 0 FA		77000	12100	371.	26400	507.	2760	2120	262.	<3.	4770	1170	335.	1360	427.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3566	12/12/80	10:40: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	3.20	152000	254000
U-19B	3567	12/12/80	10:50: 0 RA		56900	8590	243.	18900	370.	1960	1700	182.	<3.	3390	850.	235.	989.	297.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3568	12/12/80	11:10: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	3.90	160000	280000
U-19B	3569	12/12/80	11:10: 0 FA		59400	9030	278.	19900	388.	2040	1580	192.	<3.	3540	893.	238.	1030	299.	N/R	N/R	N/R	N/R	N/R	N/R	
U-19B	3570	12/12/80	12:25: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	3.30	173000	294000

E.2 Multiple-Flash Checkout Test (No. 18)

Values are expressed in milligrams per liter. Milligrams per liter and parts per million are used interchangeably.
 N/R indicates the ion was not requested to be analyzed. Also analyzed but not listed are the following constituents:
 AG <0.31 AS <10.01 AU <0.91 BE <0.11 CB <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 GA <6.51
 GE <7.51 HB <3.01 LA <0.31 MB <7.51 NT <3.51 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZR <0.51 PO4 <10.0

DK1/MCCULLOCH MERCER 2 WELL TEST NO. 18 BRINE SAMPLES

AEC	LOC.	VR CODE	SAMPLE ID	CO2	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	HC03	CL03	PH	CL	TDS
V-19B	3551	12/11/80	15: 01: 0 FA		74800	12200	371.	25000	495.	2620	2040	269.	<3.	4880	1190	330.	1390	453.	N/R	N/R	N/R	N/R	N/R	N/R
V-19B	3552	12/11/80	15: 31: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	40.1	N/R	N/R	N/R	N/R	N/R	N/R
V-19B	3553	12/11/80	15: 71: 0 NaOH	12000	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
V-19B	3554	12/11/80	15:11: 0 ZnAc		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3555	12/11/80	15:10: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	3.00	194000	328000
V-19C	3556	12/11/80	15:12: 0 RA		80600	13000	389.	24700	497.	2570	2120	269.	<3.	4890	1200	334.	1400	418.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3557	12/11/80	15:19: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	2.40	193000	378000
V-19C	3558	12/11/80	15:30: 0 FA		79900	12700	379.	27500	524.	2840	2150	269.	<3.	4920	1200	335.	1400	446.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3559	12/11/80	15:13: 0 FU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	42.9	N/R	N/R	N/R	N/R	N/R
V-19C	3560	12/11/80	15:55: 0 NaOH	10000	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
V-19B	3571	12/12/80	12:30: 0 RA		77700	12800	373.	27100	505.	2710	2100	261.	<3.	4780	1170	357.	1370	408.	N/R	N/R	N/R	N/R	N/R	N/R
V-19B	3572	12/12/80	12:35: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	2.70	197000	321000
V-19B	3573	12/12/80	12:40: 0 FA		75200	12500	372.	25400	486.	2560	2040	254.	<3.	4590	1130	342.	1320	358.	N/R	N/R	N/R	N/R	N/R	N/R
V-19B	3574	12/12/80	13: 01: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	39.1	N/R	N/R	N/R	N/R	N/R
V-19C	3575	12/12/80	9:33: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	2.90	197000	331000
V-19C	3576	12/12/80	9:37: 0 RA		2530	340.	12.0	733.	23.7	86.6	74.7	8.25	<3.	57.4	32.6	7.57	7.78	13.3	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3577	12/12/80	9:43: 0 FA		2820	401.	14.0	837.	21.4	99.0	83.2	8.00	<3.	56.1	38.5	5.48	0.859	<2.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3578	12/12/80	9:53: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	512.	<1.	6.80	5490	8740
V-19C	3579	12/12/80	10:30: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	3.40	193000	332000
V-19C	3580	12/12/80	10:30: 0 RA		78200	13000	384.	27000	511.	2660	2160	265.	<3.	4830	1190	356.	1390	364.	N/R	N/R	N/R	N/R	N/R	N/R

Values are expressed in milligrams per liter. Milligrams per liter and parts per million are used interchangeably.
 N/R indicates the ion was not requested to be analyzed. Also analyzed but not listed are the following constituents:
 AG <0.31 AS <10.01 AU <0.71 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 BA <6.51
 GE <7.51 HG <3.01 LA <0.31 NO <7.51 NI <3.51 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZR <0.51 PD4 <10.0

GKI/MCDILLOCH HERCER 2 WELL TEST NO. 10 PRIME SAMPLES

REC'D	LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	P	AL	FE	MM	PB	ZN	SI02	SO4	HC03	CO3	PH	CL	TDS
V-19C	3581	12/12/80	10:45: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	3.00	190000	327000
V-19C	3582	12/12/80	10:50: 0 FA	74800	12200	364.	24900	493.	2570	2000	256.	<3.	4620	1140	332.	1330	351.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3583	12/12/80	12:42: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	2.00	182000	324000
V-19C	3584	12/12/80	12:43: 0 RA	75700	11600	350.	25400	478.	2690	2070	256.	<3.	4600	1130	334.	1320	377.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3585	12/12/80	12:55: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.30	150000	256000
V-19C	3586	12/12/80	13: 01: 0 FA	30000	4540	133.	9120	194.	977.	778.	96.0	<3.	1420	439.	104.	513.	135.	N/R	N/R	N/R	N/R	N/R	N/R

E.2 (Continued)

E7

Values are expressed in milligrams per liter. Milligrams per liter and parts per million are used interchangeably.
 N/R indicates the ion was not requested to be analyzed. Also analyzed, but not listed, are the following constituents:
 AG <0.3> AS <10.0> AU <0.9> BE <0.1> CB <0.7> CE <13.0> CO <0.9> CR <1.1> CU <0.2> GA <6.5>
 GE <7.5> HG <3.0> LA <0.3> NI <7.5> NI <3.5> SE <14.0> SH <11.0> SI <0.2> V <0.3> ZR <0.5> PO4 <10.0>

OKI/MCCULLOCH MERCER 2 WELL TEST NO. 18 NONCONDENSIBLE GAS SAMPLES

AECC LOC.	VR CODE	SAMPLE IDENTIFICATION	N2	CO2	Ar+O2	Methane
V-15A	3531	12/11/80 161501 0	7.7	81.9	2.0	1.9
V-15B	3532	12/11/80 161531 0	6.9	83.1	2.1	0.9

Results expressed in mole percent.

6K1/MCCULLOCH MERCER 2 WELL TEST NO. 18 STEAM CONDENSATE SAMPLES

AECC LOC.	WR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	HC03	CO3	PH	CL
V-15A	3533	12/11/80 16:35: 0 RU	2230	37.3	1.14	699	17.1	76.8	56.4	15.9	<0.03	58.0	18.4	<0.05	0.195	12.5	N/R	N/R	N/R	N/R	N/R
V-15C	3534	12/11/80 16:40: 0 RU	10.7	19.8	0.0300	2.25	0.621	0.174	0.249	3.99	<0.03	0.200	0.0567	0.0533	0.102	0.602	N/R	N/R	N/R	N/R	N/R
V-15B	3535	12/11/80 16:27: 0 RU	20.9	43.9	0.0500	<0.01	<0.04	<0.03	<0.07	5.40	<0.03	<0.003	<0.001	<0.05	<0.007	<0.07	N/R	N/R	N/R	N/R	N/R
V-24B	3536	12/12/80 13:15: 0 RU	302	43.6	1.30	80.4	1.87	9.60	7.94	6.66	<0.03	<0.003	1.87	<0.05	0.189	3.33	N/R	N/R	N/R	N/R	N/R
V-24B	3537	12/12/80 13:20: 0 RU	82.2	13.1	<0.01	23.6	0.711	3.24	2.60	5.45	<0.03	<0.003	0.390	0.104	0.0372	2.34	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. #Indicates requested but not yet analyzed.
 AG <0.0031 AS <0.011 AU <0.0091 BE <0.0011 CB <0.0071 CE <0.131 CD <0.0091 CR <0.0111 CU <0.0021 BA <0.0451
 GE <0.0751 HG <0.031 LA <0.0031 MD <0.0751 NI <0.0351 SE <0.141 SN <0.111 TI <0.0021 V <0.0031 ZR <0.0051 PO4 <1

E.2 (Continued)

GRI/MCCULLOCH MERCER 2 WELL TEST NO. 18 SOLID SAMPLES

MECC	LOC.	VR CODE	SAMPLE ID	HA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SIO2	CU	CR	AG	CL	DENS
SC-80C	3591	12/12/80	141 01 0	17600	7380	89.1	100.	248.	1020	218.	2170	<30	634000	5530	8210	4570	10500	455.	140.	<3.	N/R	N/R
SC-81C	3592	12/12/80	141 01 0	12200	2210	90.2	100.	240.	433.	459.	1150	<20	446000	7650	240000	551.	122000	1050	74.4	<2.	N/R	N/R
SC-83C	3593	12/12/80	141 01 0	6950	909.	33.1	100.	355.	368.	155.	985.	<20	291000	4020	292000	742.	230000	878.	75.7	<2.	N/R	N/R
SC-80B	3594	12/12/80	141 01 0	3700	261.	34.8	100.	<30	329.	154.	2310	<20	757000	4330	2910	4280	89000	180.	85.4	<3.	N/R	N/R
SC-81B	3595	12/12/80	141 01 0	15000	2860	92.4	5610	578.	723.	544.	1590	<20	470000	8860	5070	863.	95800	<2.	67.8	<3.	N/R	N/R
SC-83B	3596	12/12/80	141 01 0	12700	806.	75.6	1990	561.	344.	100.	1080	<20	353000	4130	185000	497.	199000	127.	61.6	<2.	N/R	N/R
SV-12A	3601	12/12/80	141 01 0	262000	787.	1120	113.	1000	8390	10200	100.	<20	25700	4760	396000	3560	59400	<2.	<9.	<2.	N/R	N/R
SC-80A	3602	12/12/80	141 01 0	18900	1600	58.8	2330	347.	287.	100.	608.	<20	165000	2840	560000	2050	99100	223.	44.1	<3.	N/R	N/R
SC-81A	3603	12/12/80	141 01 0	59200	<200	293.	26400	1520	1430	1650	793.	<20	159000	3700	200000	1990	206000	213.	36.7	<3.	N/R	N/R
SC-83A	3604	12/12/80	141 01 0	6560	3300	94.3	6000	739.	421.	799.	503.	<20	126000	4250	127000	986.	197000	532.	81.4	<3.	N/R	N/R
SC-80H	4501	12/12/80	01 01 0	N/R	N/R	N/R	2300	480.	N/R	N/R	N/R	<300	177000	N/R	225000	N/R	39800	N/R	N/R	940.	<10000	4.20
SC-80B	4502	12/12/80	01 01 0	N/R	N/R	N/R	3330	4210	N/R	N/R	N/R	16900	480000	N/R	12900	N/R	108000	N/R	N/R	110.	<1000	3.22
SC-80C	4503	12/12/80	01 01 0	N/R	N/R	N/R	3640	520.	N/R	N/R	N/R	1100	548000	N/R	3300	N/R	9400	N/R	N/R	80.0	<10000	3.33
SC-81A	4504	12/12/80	01 01 0	N/R	N/R	N/R	5640	1080	N/R	N/R	N/R	1700	354000	N/R	110000	N/R	94100	N/R	N/R	2100	8	8
SC-81B	4505	12/12/80	01 01 0	N/R	N/R	N/R	2940	660.	N/R	N/R	N/R	1200	498000	N/R	5600	N/R	36100	N/R	N/R	490.	92000	8.56
SC-81C	4506	12/12/80	01 01 0	N/R	N/R	N/R	3190	390.	N/R	N/R	N/R	<300	398000	N/R	90300	N/R	33900	N/R	N/R	1620	8	8
SC-83A	4507	12/12/80	01 01 0	N/R	N/R	N/R	8320	1530	N/R	N/R	N/R	2300	258000	N/R	142000	N/R	171000	N/R	N/R	1340	8	8
SC-83B	4508	12/12/80	01 01 0	N/R	N/R	N/R	2540	640.	N/R	N/R	N/R	500.	364000	N/R	111000	N/R	116000	N/R	N/R	1200	<10000	2.82

Values expressed in mg/kg. Milligrams per kilograms and parts per million used interchangeably.

N/R indicates not requested to be analyzed.

The following elements were found to be below the listed detection limit:

As 3.01, Au 100, Ba 8.0, Be 1.0, Cd 7, Co 100, Ga 70, Ge 80, Hg 30

8 indicates sample size too small to allow for 3 significant figures or insufficient sample for analysis.

E.2
(Continued)

E10

GRI/NOCHLOCH MERCER 2 WELL TEST NO. 18 SOLID SAMPLES

NECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	AL	CU	FE	PB	NH	ZN	B	S102
SS-82A	3611	12/12/80 14: 0: 0 Dissolved solid	33500	5700	166.	11000	640.	1160	587.	791.	1430	555000	62000	2160	1050	1890	161800
SP-82A	3612	12/12/80 14: 0: 0 Dissolved solid	187000	4480	179.	11900	1290	1220	748.	1790	8590	134000	52000	1320	821.	849.	250000
SS-82B	3613	12/12/80 14: 0: 0 Dissolved solid	96100	1830	237.	13100	2150	679.	543.	350.	1130	257000	38000	1890	1330	1140	85300
SP-82B	3614	12/12/80 14: 0: 0 Dissolved solid	159000	5330	144.	9970	273.	1040	370.	130	89.2	70500	862.	946.	851.	733.	457000
SP-82C	3615	12/12/80 14: 0: 0 Dissolved solid	35000	6630	179.	50200	4440	1640	4740	57.9	12.	346000	4900	4550	975.	1700	276000
SS-82C	3617	12/12/80 14: 0: 0 Dissolved solid	31600	9950	120.	26700	2330	1310	1510	1400	198.	56600	1360	853.	743.	316.	453000

E.2 (Continued)

Results are expressed in mg/kg or parts per million of a washed and dried sample. The following elements were found to be below the listed detection limit: As 3.0; Ar 100; Be 1.6; Cd 7; Co 1; Cr 9; Er 10; Ga 70; Ge 80; Hg 30; La 3; Mo 80; N 40; Pb 100; Se 40; Sr 100; Sn 100; Ti 2; V 3; and Zr 5.

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 18 SOLID SAMPLES

AECC LOC.	VR CODE	SAMPLE ID	PH	CL	CO3	HCO3	SO4	TBS
SC-82C	3616	12/12/80	141 01 0	4.70	207000	<1.	41.0	<1. 323000

Values expressed in mg/kg. Milligrams per kilograms and parts per million used interchangeably.
N/R indicates not requested to be analyzed.

E.2 (Continued)

E12

GR1/MCDULLOCH MERCER 2 WELL TEST NO. 19 BRINE SAMPLES

AECC LOC.	VR CODE	SAMPLE ID	CO2	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PR	ZN	SIO2	SO4	NO3	CO3	PH	CL	TDS
U-5	3691	1/ 9/81 15:31: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	187.	<1.	5.67	170000	283000
U-5	3692	1/ 9/81 15:33: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	67.3	N/R	N/R	N/R	N/R	N/R
U-5	3693	1/ 9/81 15:43: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	228.	<1.	5.53	170000	287000
U-5	3694	1/ 9/81 15:48: 0 FA		72100	9520	260.	23100	425.	2420	1979	262.	<3.	4890	1180	241.	1260	487.	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3695	1/ 9/81 15:53: 0 RA		72400	9690	265.	23500	436.	2480	1980	261.	<3.	4940	1190	267.	1280	488.	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3696	1/ 9/81 15:57: 0 NaOH	515	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3721	1/10/81 10:39: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3722	1/10/81 10:41: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	234.	<1.	5.52	172000	283000
U-5	3723	1/10/81 10:50: 0 RA		71200	9600	270.	23600	442.	2490	1880	279.	<3.	4990	1200	274.	1290	516.	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3724	1/10/81 10:55: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.68	170000	284000
U-5	3725	1/10/81 11: 4: 0 FA		71200	9630	266.	23200	439.	2470	1860	279.	<3.	4960	1200	257.	1290	503.	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3726	1/10/81 11:10: 0 NaOH	396	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3761	1/11/81 11:10: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.67	170000	290000
U-5	3762	1/11/81 11:15: 0 RA		71200	9430	267.	23300	449.	2460	1860	277.	<3.	4920	1190	243.	1280	500.	N/R	N/R	N/R	N/R	N/R	N/R
U-5	3763	1/11/81 11:20: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	71.3	N/R	N/R	N/R	N/R	N/R
U-5	3764	1/11/81 11:58: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	193.	<1.	5.82	171000	290000
U-5	3765	1/11/81 11:58: 0 RA		70700	9350	265.	23100	455.	2440	1880	276.	<3.	4920	1190	249.	1290	511.	N/R	N/R	N/R	N/R	N/R	N/R

E.3 Single-Flash Test (No. 19)

Values expressed in milligrams per liter. Milligrams per liter and parts per billion used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested, but not yet analyzed.
 AG <0.31 AS <10.01 AO <0.91 BE <0.11 CB <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 DA <6.51
 DE <7.51 DG <3.01 LA <0.31 MD <7.51 NI <3.51 SE <14.01 SH <11.01 TI <0.21 V <0.31 ZR <0.51 PM4 <10.0

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 19 BRINE SAMPLES

AECC LOC.	VP CODE	SAMPLE ID	CO2	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PR	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
V-19A	3621	1/ 8/81 18:40: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	69.1	<1.	4.90	166000	290000
V-19A	3622	1/ 8/81 18:42: 0 RA		87600	12400	361.	27400	507.	2880	2120	299.	<3.	5740	1390	308.	1570	520.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3623	1/ 8/81 18:55: 0 FA		87600	12200	361.	27400	504.	2870	2160	298.	<3.	5740	1390	302.	1570	489.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3624	1/ 8/81 18:58: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.50	183000	296000
V-19A	3625	1/ 8/81 19: 21: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	62.8	N/R	N/R	N/R	N/R	N/R
V-19A	3626	1/ 8/81 19:13: 0 NaOH	472	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3701	1/ 9/81 16:15: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.48	193000	331900
V-19A	3702	1/ 9/81 16:17: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	67.8	N/R	N/R	N/R	N/R	N/R
V-19A	3703	1/ 9/81 16:24: 0 RA		79800	10800	302.	27000	494.	2810	2300	294.	<3.	5560	1350	292.	1450	466.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3704	1/ 9/81 16:35: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.54	193000	329000
V-19A	3705	1/ 9/81 16:38: 0 FA		72200	11100	303.	24000	450.	2510	2030	264.	<3.	5000	1210	264.	1310	420.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3706	1/ 9/81 16:45: 0 NaOH	422	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3731	1/10/81 12:35: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	112.	<1.	5.38	196000	335000
V-19A	3732	1/10/81 12:40: 0 RA		81400	11200	308.	27500	508.	2840	2170	319.	<3.	5710	1380	301.	1500	538.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3733	1/10/81 12:30: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	67.9	N/R	N/R	N/R	N/R	N/R
V-19A	3734	1/10/81 12:45: 0 NaOH	326	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3736	1/10/81 12:45: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	120.	<1.	5.70	198000	342000
V-19A	3737	1/10/81 12:47: 0 FA		80800	11100	304.	27200	495.	2830	2160	312.	<3.	5650	1360	294.	1480	517.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3772	1/11/81 9:15: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	61.0	<1.	5.60	196000	335000
V-19A	3773	1/11/81 9:20: 0 RA		80100	10900	302.	26700	515.	3280	2170	312.	<3.	5620	1350	341.	1480	481.	N/R	N/R	N/R	N/R	N/R	N/R
V-19A	3774	1/11/81 9:45: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	55.8	N/R	N/R	N/R	N/R	N/R
V-19A	3775	1/11/81 9:25: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	140.	<1.	5.44	195000	338000
V-19A	3776	1/11/81 9:35: 0 FA		77400	10800	309.	25600	504.	2670	2050	302.	<3.	5410	1310	268.	1430	413.	N/R	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.

N/R indicates not requested to be analyzed. R indicates requested, but not yet analyzed.

AG <0.31 AS <0.01 AU <0.01 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CF <1.11 CU <0.21 HA <6.51

DE <7.51 HG <3.01 LA <0.31 MD <7.51 NI <3.51 SE <14.01 SM <11.01 TI <0.21 V <0.31 ZN <0.51 PM <10.0

OKI/MOCHILLOH MERCER 2 WELL TEST NO. 19 BRINE SAMPLES

WELL	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PS	ZN	ST02	SO4	MEQ3	CO3	PH	CL	TDS
U-39	3681	1/ 8/81 22:58: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	71.0	<1.	5.70	196000	341000
U-39	3682	1/ 8/81 23: 11 0 RA	81600	11400	303.	27000	496.	2790	2150	303.	<3.	5490	1340	308.	1350	471.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3683	1/ 8/81 23: 51 0 RU Bil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	66.1	N/R	N/R	N/R	N/R	N/R
U-39	3684	1/ 8/81 23: 61 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	39.0	<1.	5.40	198000	322000
U-39	3685	1/ 8/81 23: 81 0 FA	81600	11300	308.	27100	504.	2830	2160	309.	<3.	5590	1360	306.	1390	491.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3686	1/ 9/81 18:15: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	71.0	<1.	5.71	198000	336000
U-39	3687	1/ 9/81 18:18: 0 RA	81600	11300	306.	27000	506.	2800	2160	310.	<3.	5560	1360	299.	1390	467.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3688	1/ 9/81 18:20: 0 RU Bil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	42.4	N/R	N/R	N/R	N/R	N/R
U-39	3689	1/ 9/81 18:35: 0 FA	80400	11100	299.	26400	492.	2710	2150	304.	<3.	5470	1340	294.	1360	461.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3690	1/ 9/81 18:36: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	35.0	<1.	5.38	197000	335000
U-39	3751	1/10/81 13:15: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	10.0	<1.	4.72	199000	340000
U-39	3752	1/10/81 13:20: 0 RA	81900	11200	312.	27700	507.	2850	2210	321.	<3.	5710	1390	301.	1520	494.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3753	1/10/81 13:30: 0 FA	80700	10900	301.	27300	502.	2820	2160	315.	<3.	5600	1360	297.	1490	442.	N/R	N/R	N/R	N/R	N/R	N/R
U-39	3754	1/10/81 13:25: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	14.0	<1.	5.10	193000	343000

Values expressed in milligrams per liter. Milligrams per liter and parts per billion used interchangeably.
 N/R indicates not requested to be analyzed. B indicates requested, but not yet analyzed.
 AS <0.31 AS <10.01 MS <0.91 BE <0.11 CB <0.71 CE <13.01 CB <0.91 CR <1.11 CH <0.21 GA <6.51
 DE <7.51 MG <3.01 LA <0.31 MB <7.51 MI <3.51 SE <14.01 SH <11.01 TI <0.21 V <0.31 VR <0.51 PD4 <10.0

E.3 (Continued)

GKI/MCCULLOCH MERCER 2 WELL TFST NO. 19 DRINE SAMPLES

RECC LOC.	VR CODE	SAMPLE ID	CO2	NA	K	LI	CA	MS	BA	SR	B	AL	FE	MM	PD	ZR	SI02	SO4	HC03	CR3	PH	CL	TDS
V-208	3631	1/ 8/81 19:56: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	10.0	<1.	5.00	189000	297000
V-208	3632	1/ 8/81 19:59: 0 RA		83700	12200	363.	27900	499.	2890	2210	304.	<3.	5570	1350	343.	1540	499.	N/R	N/R	N/R	N/R	N/R	N/R
V-208	3633	1/ 8/81 20: 5: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.60	188000	296000
V-208	3634	1/ 8/81 20: 7: 0 FA		82600	12200	340.	27300	497.	2850	2190	302.	<3.	5530	1340	307.	1530	475.	N/R	N/R	N/R	N/R	N/R	N/R
V-208	3635	1/ 8/81 20:10: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	63.5	N/R	N/R	N/R	N/R	N/R
V-208	3711	1/ 9/81 17:20: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	57.0	<1.	5.23	196000	334000
V-208	3712	1/ 9/81 17:25: 0 RA		80600	11200	308.	27000	502.	2800	2250	296.	<3.	5660	1370	300.	1480	517.	N/R	N/R	N/R	N/R	N/R	N/R
V-208	3713	1/ 9/81 17:28: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	41.0	<1.	5.25	197000	334000
V-208	3714	1/ 9/81 17:30: 0 FA		82800	11400	311.	27700	513.	2880	2180	322.	<3.	5810	1400	305.	1530	502.	N/R	N/R	N/R	N/R	N/R	N/R
V-208	3715	1/ 9/81 17:33: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	60.6	N/R	N/R	N/R	N/R	N/R
V-209	3741	1/10/81 12: 3: 0 RU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	10.0	<1.	5.23	198000	340000
V-209	3742	1/10/81 11:58: 0 RU Dil-10x		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	66.4	N/R	N/R	N/R	N/R	N/R
V-209	3743	1/10/81 12: 5: 0 RA		80300	10900	303.	26900	496.	2850	2140	313.	<3.	5620	1360	291.	1490	485.	N/R	N/R	N/R	N/R	N/R	N/R
V-209	3744	1/10/81 12:10: 0 FU		N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	10.0	<1.	5.12	199000	342000
V-209	3745	1/10/81 12:13: 0 FA		79700	11100	306.	26900	501.	3020	2190	311.	<3.	5580	1350	291.	1470	451.	N/R	N/R	N/R	N/R	N/R	N/R
V-208	3746	1/10/81 12:12: 0 NaOH	326	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
N/R indicates not requested to be analyzed. S indicates requested but not yet analyzed.
MS <0.31 MS <10.01 MU <0.91 DE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 BA <6.51
BE <7.51 BS <3.01 LA <0.31 MO <7.51 MI <3.51 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZR <0.51 PD4 <10.0

OKI/METALLBOCH MERCER 2 WELL TEST NO. 19 DRINE SAMPLES

NECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PO	ZN	SI02	SO4	NO3	CO3	PH	CL	TDS
U-209	3641	1/ 8/81 20:39: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	45.0	<1.	4.80	195000	336000
U-209	3642	1/ 8/81 20:42: 0 RA	78200	11100	330.	25400	465.	2630	2070	283.	<3.	5190	1260	290.	1440	450.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3643	1/ 8/81 20:44: 0 RU B11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	66.0	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3644	1/ 8/81 20:50: 0 FA	83700	11900	354.	27500	500.	2850	2270	303.	<3.	2540	1350	303.	1350	454.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3645	1/ 8/81 20:53: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.50	200000	336000
U-209	3646	1/ 9/81 18:47: 0 RA	82200	11400	345.	26900	490.	2790	2210	299.	<3.	5460	1330	284.	1520	509.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3647	1/ 9/81 18:50: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	65.0	<1.	5.10	199000	329000
U-209	3648	1/ 9/81 18:54: 0 RU B11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	537.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3649	1/ 9/81 19: 0: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	8.10	<1.	4.70	198000	341000
U-209	3650	1/ 9/81 19: 21: 0 FA	83400	11000	340.	27900	505.	2930	2180	302.	<3.	5390	1340	297.	1560	482.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3781	1/11/81 10:45: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	8.10	<1.	4.84	199000	345000
U-209	3782	1/11/81 10:50: 0 RA	79700	11000	314.	26900	476.	2780	2150	313.	<3.	5580	1340	281.	1490	448.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3783	1/11/81 12:30: 0 RU B11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	10.7	N/R	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested but not yet analyzed.
 AG <0.3> AS <10.0> AU <0.2> BE <0.1> CB <0.7> CE <13.0> CO <0.9> CR <1.1> CU <0.2> HA <4.5>
 DE <7.5> HS <3.0> LA <0.3> MD <7.5> NI <3.5> SE <14.0> SN <11.0> TI <0.2> V <0.3> ZK <0.5> P04 <10.0>

E.3 (Continued)

GRI/MCCULLOCH MERCER 2 WELL TEST NO. 19 DRINE SAMPLES

RECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PN	ZN	SI02	SO4	HC03	CO3	PH	CL	TDS
V-309	3651	1/ 8/81 21: 8: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	55.0	<1.	4.97	198000	339000
V-309	3652	1/ 8/81 21:10: 0 RA	82900	11800	361.	27100	502.	2840	2150	300.	<3.	5540	1350	302.	1550	497.	N/R	N/R	N/R	N/R	N/R	N/R
V-309	3653	1/ 8/81 21:14: 0 RU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	524.	N/R	N/R	N/R	N/R	N/R
V-309	3654	1/ 8/81 21:21: 0 FA	83200	11800	361.	26600	495.	2780	2110	300.	<3.	5510	1340	300.	1540	430.	N/R	N/R	N/R	N/R	N/R	N/R
V-309	3655	1/ 8/81 21:24: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.67	198000	339000
V-309	3656	1/ 9/81 19:13: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	53.0	<1.	5.02	197000	343000
V-309	3657	1/ 9/81 19:15: 0 RA	82800	11500	351.	27800	498.	2890	2170	299.	<3.	5500	1340	291.	1540	490.	N/R	N/R	N/R	N/R	N/R	N/R
V-309	3658	1/ 9/81 19:17: 0 RU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	596.	N/R	N/R	N/R	N/R	N/R
V-309	3659	1/ 9/81 19:24: 0 FA	81700	11900	363.	26400	502.	2770	2170	296.	<3.	5500	1330	294.	1530	400.	N/R	N/R	N/R	N/R	N/R	N/R
V-309	3660	1/ 9/81 19:28: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.57	197000	338000

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested but not yet analyzed.
 AG <0.31 AS <10.01 AU <0.91 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 GA <6.51
 GE <7.51 HG <0.301 LA <0.31 MD <7.51 NI <0.351 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZR <0.51 PO4 <10.0

OK/MCCN LOCH HERCER 2 WELL TEST NR. 19 BRINE SAMPLES

AECC	LDC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PR	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
V-409	3661	1/ 8/81	21138: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	102.	<1.	5.79	198000	338000
V-409	3662	1/ 8/81	21140: 0 RA	83300	11900	358.	27000	477.	2840	2160	299.	3.	5520	1340	303.	1530	422.	N/R	N/R	N/R	N/R	N/R	N/R
V-409	3663	1/ 8/81	21142: 0 RU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	58.7	N/R	N/R	N/R	N/R	N/R
V-409	3664	1/ 8/81	21143: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.53	198000	338000
V-409	3665	1/ 8/81	21145: 0 FA	82900	11500	351.	26700	492.	2810	2160	300.	8.87	5460	1330	297.	1530	436.	N/R	N/R	N/R	N/R	N/R	N/R
V-409	3666	1/ 9/81	19133: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	30.0	<1.	5.57	197000	335000
V-409	3667	1/ 9/81	19135: 0 RA	81500	11500	308.	26400	488.	2750	2150	295.	4.80	5300	1310	285.	1510	460.	N/R	N/R	N/R	N/R	N/R	N/R
V-409	3668	1/ 9/81	19137: 0 RU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	54.1	N/R	N/R	N/R	N/R	N/R
V-409	3669	1/ 9/81	19147: 0 FA	82100	11400	304.	25400	490.	2700	2090	297.	6.23	5410	1320	294.	1520	344.	N/R	N/R	N/R	N/R	N/R	N/R
V-409	3670	1/ 9/81	19145: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	10.0	<1.	5.04	198000	341000

Values expressed in milligrams per liter. Milligrams per liter and parts per billion used interchangeably.

N/R indicates not requested to be analyzed. R indicates requested, but not yet analyzed.

AS <0.3> BS <10.0> BS <0.9> BE <0.1> CO <0.7> CE <13.0> CO <0.9> CR <1.1> CU <0.2> BA <6.3>

BE <7.5> MG <3.0> LA <0.3> MD <7.5> NI <3.5> SE <14.0> SH <11.0> TI <0.2> V <0.3> ZR <0.5> PO4 <10.0>

GKI/MCCULLOCH HENDER 2 WELL TEST NO. 19 BRINE SAMPLES

AEC	LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PN	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
V-509	3671	1/ 8/81	21:57: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	69.0	<1.	5.57	198000	342000
V-509	3672	1/ 8/81	21:59: 0 RA	83300	11500	408.	25700	495.	2710	2150	301.	<3.	5490	1340	301.	1540	413.	N/R	N/R	N/R	N/R	N/R	N/R
V-509	3673	1/ 8/81	22: 0: 0 RU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	58.2	N/R	N/R	N/R	N/R	N/R
V-509	3674	1/ 8/81	22: 5: 0 FA	83300	11500	307.	25600	500.	2670	2120	303.	<3.	5500	1340	333.	1550	380.	N/R	N/R	N/R	N/R	N/R	N/R
V-509	3675	1/ 8/81	22:12: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	46.8	<1.	5.60	195000	338000
V-509	3676	1/ 9/81	19:50: 0 RU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	55.4	N/R	N/R	N/R	N/R	N/R
V-509	3677	1/ 9/81	19:53: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	63.0	<1.	5.77	198000	335000
V-509	3678	1/ 9/81	19:55: 0 RA	82500	11500	309.	26800	497.	2800	2090	304.	<3.	5530	1350	297.	1540	454.	N/R	N/R	N/R	N/R	N/R	N/R
V-509	3679	1/ 9/81	19:58: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	59.0	<1.	5.25	195000	339000
V-509	3680	1/ 9/81	19:59: 0 FA	84100	11700	311.	27600	509.	2860	2160	311.	<3.	5640	1380	305.	1590	507.	N/R	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. < indicates requested but not yet analyzed.
 AS <0.31 AS <10.01 AU <0.91 BE <0.11 CB <0.71 CE <13.01 CD <0.91 CR <1.11 CU <0.21 BA <6.51
 SE <7.51 MB <3.01 LA <0.31 MO <7.51 NI <3.51 SE <14.01 SN <11.01 TT <0.21 V <0.31 ZR <0.51 PO4 <10.0

BKI/MCCULLOCH MERCER 2 WEI TEST NO. 19 NONCONDENSIBLE GAS SAMPLES

AETE LOC.	VR CODE	SAMPLE IDENTIFICATION				N2	CO2	Ar+O2	Helium
V-15A	3629	1/ 9/81	161451	0	None	14.4	74.1	3.49	6.350
V-15A	3708	1/10/81	131 01	0	None	4.48	84.2	1.82	1.50
V-15A	3739	1/11/81	111301	0	None	7.06	80.3	2.65	2.31

Results are expressed in mole percent.

E.3 (Continued)

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 19 STEAM CONDENSATE SAMPLES

AECC	LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	MO03	CO3	PH	CL	TDS
V-15A	3628	1/ 9/81	16:58: 0 RU	9110	225.	32.7	<0.01	56.7	341.	290.	40.8	<0.03	744.	175.	0.489	152.	40.2	N/R	N/R	N/R	N/R	N/R	N/R
V-15A	3738	1/10/81	13:15: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	321.	<1.	6.30	14900	29700.
V-15A	3771	1/11/81	10:50: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	415.	<1.	6.42	3225.	5470.

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested, but not yet analyzed.
 AG <0.31 AS <10.01 AU <0.91 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 GA <6.51
 GE <7.51 HG <3.01 LA <0.31 MC <7.51 NI <3.51 SE <14.01 SM <11.01 TI <0.21 V <0.31 ZR <0.51 PO4 <10.0

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 19 SOLID SAMPLES

AECID LOC.	VR CODE	SAMPLE ID	FE	STO2	CA	MG	AL	PB	AG	CL	DENS
200SP-50-4	3880	1/12/81	440000	93600	1180	299.	<300	9980	95.0	87000	2.91
200SP-50-8	3887	1/12/81	433000	93300	1080	272.	<300	19600	390.	106000	2.93
300SP-50-4	3895	1/12/81	468000	82900	1090	279.	808.	9100	381.	79000	3.06
300SP-50-10	3896	1/12/81	481000	115000	1130	281.	449.	19600	669.	<10000	3.10
400SP-50-4	3947	1/12/81	375000	213000	3740	461.	1020	75700	935.	43000	2.79
400SP-50-8	3948	1/12/81	430000	161000	2660	384.	740.	42100	871.	63000	2.99
500SP-50-4	3964	1/12/81	440000	170000	3290	405.	811.	63600	763.	13000	2.93
500SP-50-8	3965	1/12/81	494000	109000	1140	291.	1140	7780	476.	65000	2.99
200SU-50-4	3888	1/12/81	318000	233000	7730	425.	<300	26900	291.	45000	2.42
200SU-50-8	3889	1/12/81	358000	269000	5900	368.	446.	3580	190.	18000	2.60
300SU-50-4	3890	1/12/81	288000	276000	7720	430.	<300	4460	190.	<10000	2.39
300SU-50-10	3894	1/12/81	436000	201000	5420	331.	822.	2780	190.	<10000	2.80
400SU-50-4	3949	1/12/81	443000	236000	4150	352.	816.	2180	96.0	28000	2.67
400SU-50-8	3950	1/12/81	553000	77600	3190	246.	780.	1000	92.0	24000	3.19
500SU-50-4	3959	1/12/81	384000	289000	4500	367.	833.	17100	196.	29000	2.59
500SU-50-8	3966	1/12/81	425000	96300	1410	233.	741.	689.	174.	28000	2.88
SC-80A	4510	1/12/81	509000	8500	230.	160.	<300	50000	1260	153000	3.28
SC-81A	4511	1/12/81	432000	117000	1720	310.	400.	12700	370.	<10000	2.79
SC-83C	4512	1/12/81	464000	68500	1100	240.	1200	260000	900.	79000	3.05

Values expressed in mg/kg. Milligrams per kilogram and parts per million used interchangeably.
Weight percent may be derived by dividing values by 10000.
indicates sample size too small to allow 3 significant figures or insufficient sample for analysis.

E.3 (Continued)

GKI/MCDULLOCH MERCER 2 WELL TEST NO. 20 BRINE SAMPLES

Raw Unacidified Blanks

VR CODE	SAMPLE ID		CL	SO4	CO3	MCO3	PH	TDS
3972	2/ 3/81	01 01 0	<1.	<1.	<1.	<1.	5.80	<10
3973	2/ 5/81	01 01 0	<1.	<1.	<1.	<1.	5.00	<10
3974	2/ 6/81	01 01 0	<1.	<1.	<1.	<1.	5.77	<10

Raw Acidified Blank #

VR CODE	SAMPLE ID		HA	MG	SR	MM	FB	SI02
3975	2/ 6/81	01 01 0	1.02	0.0510	0.169	0.05390	0.0508	0.111

Sodium Hydroxide Blanks

VR CODE	SAMPLE POINT	SAMPLE ID		CO2
3976	V-19 C	2/ 3/81	01 01 0	537.
3977	V-19 C	2/ 4/81	01 01 0	475.

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 # Ice analysis: All ions other than those listed were less than the detection limit.
 CO2 values expressed in milligrams per liter of the condensed sample.

E.4 Dual-Flash Test (No. 20)

GKI/MCDULLOCH MERCER 2 WELL TEST NO. 20 URINE SAMPLES

AECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	MO03	CO3	PH	CL	TDS
V-5	3801	2/ 3/81 13:19: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	115.	<1.	4.72	170000	312000
V-5	3802	2/ 3/81 13:36: 0 RA	70600	10800	308.	23900	443.	2490	1900	289.	<3.	5250	1270	312.	1450	469.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3803	2/ 3/81 13:48: 0 FU D11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	52.6	N/R	N/R	N/R	N/R	N/R
V-5	3804	2/ 3/81 13:54: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	74.7	<1.	4.69	173000	327000
V-5	3805	2/ 3/81 14: 2: 0 FA	67900	10800	310.	22600	429.	2380	1830	282.	<3.	5040	1220	292.	1410	464.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3807	2/ 4/81 10:40: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	78.6	<1.	4.68	173000	306000
V-5	3808	2/ 4/81 10:41: 0 FA	70100	11700	305.	23800	442.	2460	1890	290.	<3.	5240	1260	292.	1450	491.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3809	2/ 4/81 10:48: 0 FU D11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	64.1	N/R	N/R	N/R	N/R	N/R
V-5	3810	2/ 4/81 10:58: 0 RA	70200	12000	308.	23100	437.	2410	1850	288.	<3.	5170	1250	298.	1440	487.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3902	2/ 4/81 11:18: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	125.	<1.	4.81	176000	314000
V-5	3903	2/ 5/81 9:140: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	157.	<1.	4.89	174000	303000
V-5	3904	2/ 5/81 9:151: 0 FA	70000	10800	296.	23700	428.	2460	1820	285.	<3.	5120	1240	276.	1430	489.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3905	2/ 5/81 9:153: 0 RA	68100	10500	296.	22700	418.	2370	1790	275.	<3.	4930	1200	285.	1390	480.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3906	2/ 5/81 9:153: 0 FU D11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	63.8	N/R	N/R	N/R	N/R	N/R
V-5	3907	2/ 5/81 10:113: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	106.	<1.	4.82	175000	328000
V-5	3909	2/ 6/81 9:158: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	135.	<1.	4.84	175000	309000
V-5	3910	2/ 6/81 10: 6: 0 FA	68700	10500	301.	23400	434.	2440	1840	280.	<3.	5050	1270	282.	1410	503.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3961	2/ 6/81 10:114: 0 FU D11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	59.4	N/R	N/R	N/R	N/R	N/R
V-5	3962	2/ 6/81 10:21: 0 RA	70400	10900	305.	23400	441.	2490	1890	281.	<3.	5080	1230	290.	1430	510.	N/R	N/R	N/R	N/R	N/R	N/R
V-5	3963	2/ 6/81 10:33: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	188.	<1.	4.75	176000	315000

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.

N/R indicates not requested to be analyzed. N indicates requested, but not yet analyzed.

AG <0.31 AS <10.01 AU <0.91 BE <0.11 CB <0.71 CE <13.01 CD <0.91 CR <1.11 CU <0.21 BA <6.51

DE <7.51 MG <3.01 LA <0.31 MO <7.51 NI <3.51 SE <14.01 SM <11.01 TI <0.21 V <0.31 ZR <0.51 PO4 <10.0

GRI/MCCULLOCH HERCER 2 WELL TEST NO. 20 PRIME SAMPLES

AEEC																						
LOC.	VR CODE	SAMPLE ID	HA	K	LT	CA	MS	BA	SR	S	AL	FE	HM	PB	ZH	SI02	SO4	MO3	CO3	PH	CL	TDS
U-19A	3811	2/ 3/81 15: 9: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3812	2/ 3/81 15:15: 0 RA	73400	12300	331.	25000	464.	2590	2010	303.	<3.	5440	1320	314.	1520	483.	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3813	2/ 3/81 15:21: 0 FA	71900	12100	328.	25700	461.	2670	1970	299.	<3.	5420	1320	313.	1510	474.	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3814	2/ 3/81 15:30: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3816	2/ 3/81 15:47: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	48.2	N/R	N/R	N/R	N/R	N/R
U-19A	3817	2/ 4/81 12:19: 0 FA	72300	11900	330.	25700	467.	2660	1970	304.	<3.	5500	1330	308.	1530	508.	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3818	2/ 4/81 12:22: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3819	2/ 4/81 12:39: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	59.2	N/R	N/R	N/R	N/R	N/R
U-19A	3820	2/ 4/81 12:48: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3911	2/ 4/81 13: 4: 0 RA	70600	11100	308.	24300	446.	2520	1930	288.	<3.	5200	1260	291.	1460	489.	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3913	2/ 5/81 14:10: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3914	2/ 5/81 15:20: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3915	2/ 5/81 15:20: 0 RA	69900	10900	310.	23700	439.	2450	1890	284.	<3.	5130	1240	278.	1430	504.	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3916	2/ 5/81 15:38: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3917	2/ 5/81 17:29: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3918	2/ 5/81 17:42: 0 FA	71300	11400	320.	24200	456.	2550	1950	291.	<3.	5240	1270	286.	1480	522.	N/R	N/R	N/R	N/R	N/R	N/R
U-19A	3919	2/ 5/81 17:49: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	64.9	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested but not yet analyzed.
 AS <0.31 AS <10.01 MU <0.91 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 BA <6.51
 DE <7.51 HS <3.01 LA <0.31 MO <7.51 NI <3.51 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZK <0.51 P04 <10.0

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 20 BRINE SAMPLES

MECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PR	ZN	SI02	SO4	NO3	CO3	PH	CL	TDS	
V-19B	3821	2/ 3/81 16:47: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	29.8	<1.	5.15	192000	336000
V-19B	3822	2/ 3/81 16:52: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	69.3	<1.	5.23	194000	339000
V-19B	3823	2/ 3/81 16:58: 0 FA	75700	12300	345.	77000	485.	2800	2080	317.	<3.	5720	1390	336.	1600	459.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19B	3824	2/ 3/81 17: 41: 0 RA	70500	11700	330.	25300	468.	2650	2000	297.	<3.	5360	1310	325.	1520	455.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19B	3826	2/ 3/81 17:11: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	50.4	N/R	N/R	N/R	N/R	N/R	
V-19B	3827	2/ 4/81 12:20: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	46.8	<1.	5.30	190000	348000
V-19B	3828	2/ 4/81 12:25: 0 RA	77200	12100	340.	26800	489.	2780	2090	310.	<3.	5680	1380	322.	1590	502.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19B	3829	2/ 4/81 13:21: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	14.6	<1.	4.73	193000	336000
V-19B	3830	2/ 4/81 13:28: 0 FA	77300	12300	340.	26800	479.	2770	2070	312.	<3.	5670	1380	323.	1590	495.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19B	3921	2/ 4/81 13:37: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	54.3	N/R	N/R	N/R	N/R	N/R	
V-19B	3923	2/ 6/81 13: 81: 0 RA	75800	11800	340.	25500	475.	2650	2010	307.	<3.	5530	1340	307.	1560	501.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19B	3924	2/ 6/81 15:16: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	108.	<1.	5.35	194000	350000
V-19B	3925	2/ 6/81 15:30: 0 FA	75500	11900	331.	25500	471.	2610	2050	309.	<3.	5520	1340	303.	1550	497.	N/R	N/R	N/R	N/R	N/R	N/R	
V-19B	3926	2/ 6/81 15:37: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	72.2	<1.	5.20	192000	341000
V-19B	3927	2/ 6/81 15:42: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	56.7	N/R	N/R	N/R	N/R	N/R	

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. S indicates requested, but not yet analyzed.
 AS <0.31 AS <10.01 AU <0.91 BE <0.11 CD <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 GA <6.51
 GE <7.51 HB <3.01 LA <0.31 MB <7.51 NI <3.51 SE <14.01 SH <11.01 TI <0.21 V <0.31 ZR <0.51 PO4 <10.0

6K1/MCD/LOCH MERCER 2 WELL TEST NO. 20 BRINE SAMPLES

WELL LOC.	VF CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	STOZ	SD4	NCB3	CO3	PH	CL	TDS
V-19C	3831	2/ 3/81 15120: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	11.7	<1.	4.97	193000	352000
V-19C	3832	2/ 3/81 15122: 0 RA	79500	12400	354.	27700	492.	2870	2070	321.	<3.	5790	1420	335.	1630	476.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3833	2/ 3/81 15152: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	3.12	196000	341000
V-19C	3834	2/ 3/81 15157: 0 FA	79100	12400	347.	26900	491.	2770	2070	319.	<3.	5740	1400	336.	1620	426.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3835	2/ 3/81 17135: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	28.3	N/R	N/R	N/R	N/R	N/R
V-19C	3837	2/ 4/81 12145: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	6.30	<1.	4.86	200000	354000
V-19C	3838	2/ 4/81 12155: 0 RA	80400	12700	357.	28000	501.	2890	2140	327.	<3.	5910	1440	335.	1640	444.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3839	2/ 4/81 13140: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	4.80	<1.	4.95	199000	352000
V-19C	3840	2/ 4/81 13145: 0 FA	79600	12900	357.	27400	498.	2800	2120	322.	<3.	5820	1420	333.	1640	430.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3932	2/ 5/81 151 0: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	81.5	<1.	5.45	199000	370000
V-19C	3933	2/ 5/81 15120: 0 RA	80400	12600	345.	27000	498.	2860	2180	318.	<3.	5730	1400	331.	1630	389.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3934	2/ 5/81 16136: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	69.3	<1.	5.33	201000	350000
V-19C	3935	2/ 5/81 16148: 0 FA	79500	12700	343.	27000	494.	2860	2190	317.	<3.	5700	1390	330.	1620	381.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3936	2/ 5/81 171 0: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	43.9	N/R	N/R	N/R	N/R	N/R
V-19C	3937	2/ 6/81 12153: 0 FA	79500	12300	341.	26700	490.	2830	2160	315.	<3.	5690	1390	317.	1610	450.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3938	2/ 6/81 13115: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	42.0	<1.	5.12	200000	401000
V-19C	3939	2/ 6/81 13118: 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	49.1	N/R	N/R	N/R	N/R	N/R
V-19C	3940	2/ 6/81 13127: 0 RA	79800	12300	350.	26700	490.	2810	2150	316.	<3.	5690	1380	321.	1610	449.	N/R	N/R	N/R	N/R	N/R	N/R
V-19C	3971	2/ 6/81 13136: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	77.0	<1.	5.26	196000	348000

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. #Indicates requested but not yet analyzed.
 AG <0.31 AS <10.01 AU <0.91 BE <0.11 CB <0.71 CE <13.01 CD <0.91 CR <1.11 CU <0.21 RA <6.51
 GE <7.51 MG <3.01 LA <0.31 MD <7.51 NI <3.51 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZR <0.51 PM <10.0

GKI/MCCILLOCH MERCER 2 WELL TEST NO. 20 BRINE SAMPLES

AECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
U-208	3981	2/ 6/81 11:31: 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	137.	<1.	4.74	186000	342000
U-208	3982	2/ 6/81 11:42: 0 FA	71000	11400	318.	23500	449.	2550	1900	285.	<3.	5170	1250	289.	1440	491.	N/R	N/R	N/R	N/R	N/R	N/R
U-208	3983	2/ 6/81 11:47: 0 FU B11-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	58.3	N/R	N/R	N/R	N/R	N/R	N/R
U-208	3984	2/ 6/81 12: 0: 0 RA	72200	11300	315.	24200	449.	2580	1930	289.	<3.	5190	1260	288.	1470	503.	N/R	N/R	N/R	N/R	N/R	N/R
U-208	3985	2/ 6/81 12: 4: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	175.	<1.	4.70	179000	331000

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
N/R indicates not requested to be analyzed. # indicates requested, but not yet analyzed.
AG <0.3# AS <10.0# AU <0.9# BE <0.1# CB <0.7# CE <13.0# CO <0.9# CR <1.1# CU <0.2# GA <6.5#
GE <7.3# HG <1.0# LA <0.3# MO <7.5# NI <3.5# SE <14.0# SN <11.0# TI <0.2# V <0.3# ZR <0.5# PO4 <10.0

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 20 BRINE SAMPLES

WELL LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	P	AL	FE	MN	PN	ZN	SI02	SO4	HC03	CO3	PH	CL	TDS
U-209	3991	2/ 6/81 171231 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	92.7	<1.	4.70	192000	333000
U-209	3992	2/ 6/81 171371 0 RA	76000	11700	321.	25300	471.	2710	2050	303.	<1.	5450	1330	290.	1550	444.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3993	2/ 6/81 171541 0 FA	77200	12000	330.	25200	476.	2700	2070	304.	<1.	5490	1340	303.	1560	442.	N/R	N/R	N/R	N/R	N/R	N/R
U-209	3994	2/ 6/81 181 01 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	169.	<1.	4.90	193000	330000
U-209	3995	2/ 6/81 181 51 0 FU D11-10%	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	54.1	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.
 N/R indicates not requested to be analyzed. B indicates requested but not yet analyzed.
 AG <0.31 AS <10.01 AU <0.71 BE <0.11 CB <0.71 CE <13.01 CD <0.91 CR <1.11 CU <0.21 GA <4.51
 GE <7.51 HG <3.01 LA <0.31 MD <7.51 NI <3.51 SE <14.01 SM <11.01 TI <0.21 V <0.31 ZN <0.51 PM <10.0

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 20 BRINE SAMPLES

ANAL	LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
U-309	3841	2/ 3/81	181351 0 RA	76900	12000	330.	26600	475.	2740	2050	308.	<3.	5390	1360	323.	1570	409.	N/R	N/R	N/R	N/R	N/R	N/R
U-309	3842	2/ 3/81	181361 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	39.0	<1.	5.38	188000	356000
U-309	3843	2/ 3/81	181401 0 FA	76700	11900	337.	26300	475.	7720	2020	310.	<3.	5390	1370	323.	1580	448.	N/R	N/R	N/R	N/R	N/R	N/R
U-309	3844	2/ 3/81	181421 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	4.14	195000	364000
U-309	3845	2/ 4/81	151351 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	3.40	<1.	4.73	193000	348000
U-309	3846	2/ 4/81	161 51 0 RA	77000	12000	338.	26500	479.	2710	2010	313.	<3.	5430	1370	322.	1580	448.	N/R	N/R	N/R	N/R	N/R	N/R
U-309	3847	2/ 4/81	161401 0 FA	76800	12000	331.	26600	473.	2750	2020	310.	<3.	5370	1360	317.	1570	418.	N/R	N/R	N/R	N/R	N/R	N/R
U-309	3848	2/ 4/81	161501 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	<1.	<1.	3.35	192000	339000
U-309	3849	2/ 4/81	171221 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	47.2	N/R	N/R	N/R	N/R	N/R	N/R
U-309	3951	2/ 5/81	131 61 0 FU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	64.4	<1.	4.69	191000	337000
U-309	3952	2/ 5/81	131101 0 FA	75400	11500	328.	24900	463.	2650	2010	300.	<3.	5380	1310	304.	1520	475.	N/R	N/R	N/R	N/R	N/R	N/R
U-309	3953	2/ 5/81	131111 0 FU Dil-10x	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	65.4	<1.	4.89	190000	334000
U-309	3954	2/ 5/81	131281 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	65.4	<1.	4.89	190000	334000
U-309	3955	2/ 5/81	131351 0 RA	76400	11700	326.	25800	465.	2730	2080	304.	<3.	5460	1330	309.	1540	471.	N/R	N/R	N/R	N/R	N/R	N/R

Values expressed in milligrams per liter. Milligrams per liter and parts per million used interchangeably.

N/R indicates not requested to be analyzed. *Indicates requested but not yet analyzed.

AG <0.31 AS <10.01 AU <0.91 BE <0.11 CB <0.71 CE <13.01 CO <0.91 CR <1.11 CU <0.21 EA <6.51

DE <7.51 HG <3.01 LA <0.31 MO <7.51 NI <3.51 SE <14.01 SN <11.01 TI <0.21 V <0.31 ZR <0.51 P04 <10.0

WILLIAMSON MERCER 2 WELL TEST NO. 20 DISSOLVED GAS SAMPLES

WELL LOC.	VR CODE	SAMPLE ID		CO2
U-5	3806	2/ 3/81	14:15: 0	319.
U-5	3901	2/ 4/81	11:13: 0	317.
U-5	3908	2/ 5/81	12:40: 0	824.
U-19A	3815	2/ 3/81	15:40: 0	326.
U-19A	3912	2/ 4/81	16:29: 0	314.
U-19B	3825	2/ 3/81	17: 9: 0	243.
U-19B	3922	2/ 4/81	16:47: 0	323.
U-19C	3836	2/ 3/81	18: 0: 0	308.
U-19C	3931	2/ 4/81	17:36: 0	402.
U-309	3850	2/ 4/81	17:30: 0	331.
U-309	3754	2/ 5/81	13:50: 0	232.

Values expressed in milligrams per liter of the condensed sample.

E.4 (Continued)

GKI/MCCULLOCH MERCER 2 WELL TEST NO. 20 STEAM NONCONDENSIBLE GAS SAMPLES

AECC									
LBC.	VR CODE	SAMPLE ID				N2	CO2	Ar+O2	Methane
U-25A	3881	2/ 3/81	15: 0: 0	None		6.74	85.0	1.78	2.05
U-25A	3882	2/ 4/81	12:40: 0	None		21.9	63.6	7.06	1.43
U-25A	3883	2/ 5/81	15:55: 0	None		1.29	89.4	0.740	1.93
U-25A	3884	2/ 6/81	16:55: 0	None		<0.5	92.9	0.870	1.95
U-25B	3891	2/ 3/81	17: 0: 0	None		0.520	93.5	<0.5	1.72
U-25B	3892	2/ 4/81	13: 0: 0	None		0.950	93.3	<0.5	1.06
U-25B	3893	2/ 6/81	16:25: 0	None		<0.5	93.4	<0.5	2.09
U-25C	3941	2/ 5/81	17:12: 0	None		1.08	91.8	<0.5	2.27
U-25C	3942	2/ 6/81	14: 0: 0	None		<0.5	92.6	<0.5	2.21

Results are expressed in mole percent.

E.4 (Continued)

E33

OKI/MCCULLOCH MERCER 2 WELL TEST NO. 20 STEAM CONDENSATE SAMPLES

WELL				ANALYSIS																			
LOC.	WELL	DATE	TIME	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PN	ZN	SIO2	SO4	HCO3	CO3	PH	CL	TDS
V-25A	3853	2/ 3/81	15:45: 0	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	CL	476.	CL	5.98	5470	9740
V-25A	3853	2/ 4/81	11:35: 0	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	CL	210.	CL	5.88	2840	5000
V-25A	3853	2/ 5/81	16:15: 0	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	CL	229.	CL	5.22	19200	32600
V-25A	3853	2/ 6/81	17:22: 0	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	R/R	CL	820.	CL	5.88	2200	4120

Values expressed in milligrams per liter, Milligrams per liter
and parts per million used interchangeably.
N/R indicates that the analysis was not requested.

E.4 (Continued)

GRI/MCCULLOCH MERCER 2 WELL TEST NO. 29 STEAM CONDENSATE SAMPLES

AECC LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PB	ZN	SI02	SO4	HCO3	CO3	PH	CL	TDS
V-25B	3862	2/ 3/81 16: 01 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	1020	<1.	6.49	18.6	39.0
V-25B	3864	2/ 4/81 11:45: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	976.	<1.	6.34	7.25	160.
V-25B	3865	2/ 5/81 16:49: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	1030	<1.	6.25	14.5	40.0
V-25B	3866	2/ 6/81 15: 01 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	781.	<1.	6.24	13.4	40.0

Values expressed in milligrams per liter. Milligrams per liter
and parts per million used interchangeably.
N/R indicates that the analysis was not requested.

GRI/NECHLOCH HERDER 2 WELL TEST NO. 20 STEAM CONDENSATE SAMPLES

NECC																							
LOC.	VR CODE	SAMPLE ID	NA	K	LI	CA	MG	BA	SR	B	AL	FE	MN	PD	ZN	STB2	SO4	HC03	CO3	PH	CL	TDS	
V-25C	3872	2/ 3/81 15:50: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	756.	<1.	7.71	289.	819.
V-25C	3873	2/ 4/81 11:40: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	742.	<1.	9.34	8.28	370.
V-25C	3874	2/ 5/81 17: 41 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	786.	<1.	4.05	24.9	270.
V-25C	3876	2/ 6/81 14:15: 0 RU	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	<1.	761.	<1.	6.05	8.28	180.

Values expressed in milligrams per liter. Milligrams per liter
and parts per million used interchangeably.
N/R indicates that the analysis was not requested.

E.4 (Continued)

6K1/MCCALLDON MERCER 2 WELL TEST NO. 70 SOLID SAMPLES

AEC LOC.	VR CODE	SAMPLE ID	FE	SI02	CA	MG	AL	PB	AG	CL	DENS
100BU-100-4	3868	2/ 6/81	452000	114000	1570	594.	480.	1170	860.	65000	3.47
100BU-100-8	3869	2/ 6/81	474000	120000	1500	544.	890.	1070	890.	83000	2.99
300BU-100-4	3898	2/ 6/81	537000	42100	645.	389.	411.	946.	943.	64000	3.09
300BU-100-10	3900	2/ 6/81	496000	49200	725.	404.	1580	1130	394.	162000	3.71
400BU-100-4	3943	2/ 6/81	472000	125000	1620	720.	1180	44200	1470	76000	3.05
400BU-100-8	3944	2/ 6/81	511000	71000	1070	574.	1150	11700	956.	138000	3.08
500BU-100-4	3957	2/ 6/81	414000	33800	324.	318.	1290	273.	80.0	21000	3.47
500BU-100-8	3958	2/ 6/81	402000	130000	1840	957.	3860	89100	1290	24000	3.04
100BU-200-4	3870	2/ 6/81	270000	238000	5890	1890	6330	44000	5650	44000	3.14
100BU-200-8	3877	2/ 6/81	313000	118000	3280	1090	4480	128000	680.	24000	3.21
200BU-200-4	3878	2/ 6/81	272000	154000	4300	1050	4530	66900	11600	22000	5.45
200BU-200-10	3879	2/ 6/81	335000	161000	2330	1350	5940	30400	1170	38000	3.68
300BU-200-4	3897	2/ 6/81	304000	209000	8090	1780	4030	68000	8100	36000	3.12
300BU-200-8	3899	2/ 6/81	384000	121000	7120	949.	3780	55700	784.	97000	3.10
400BU-200-4	3945	2/ 6/81	281000	187000	3930	1220	4360	63600	4930	23000	3.33
400BU-200-8	3946	2/ 6/81	394000	126000	2750	1420	5510	85700	1060	33000	3.42
SC-80A	4513	2/ 6/81	316000	44100	1200	460.	3300	130000	1940	31000	3.82
SC-80B	4514	2/ 6/81	484000	24800	3810	480.	800.	25800	1180	<10000	3.72
SC-81A	4515	2/ 6/81	240000	227000	2640	1530	4900	60400	6100	<10000	3.50
SC-81B	4516	2/ 6/81	500000	44900	880.	330.	1100	4700	1180	18000	3.02
SC-83A	4517	2/ 6/81	83700	83400	210.	540.	4000	126000	6820	<10000	5.34
SC-83B	4518	2/ 6/81	455000	85500	660.	450.	2830	73400	4930	114000	3.04

Values expressed in mg/kg. Milligrams per kilograms and parts per million used interchangeably.

Weight percent may be derived by dividing values by 10000.

0 indicates sample size too small to allow 3 significant figures or insufficient sample for analysis.

E.4 (Continued)

E.5 LOS ALAMOS COMPARATIVE CHEMISTRY ANALYSIS OF INLET BRINE SAMPLES 3694 (FA), 3695 (RA), 3808 (FA), and 3810 (RA)

Los Alamos results are shown on the attached sheet, and Vetter Research's reported results are shown in parentheses. Analyses were performed with a Direct Current Argon Plasma Emission Spectrometry using equipment manufactured by Spectrometrics, Inc. (Model Spectrascan 3B).

Samples were diluted 1 to 100 before analysis. Limits of detection were lower for Mo, Al, Ni, and Cr. Generally, results appear to correspond quite well with those of Vetter Research. Exceptions are Cd and Co, where signals indicated much larger concentrations. Also, silicon and alkali metals Na and K seem to have less sample-to-sample variation.

Results for silicon have to be multiplied by 2.139 to convert them to the same SiO_2 base as reported by Vetter Research. Low results for SiO_2 can probably be explained by precipitation or plating out of silica in the sample bottles. However, low results for Na and K are not so easy to explain. Further analyses by another method is suggested. Standards for 1 to 10 dilutions are currently being prepared in the hope that some of the limits of detection can be reduced further.

E.5 (continued)

Test No. Sample No. Sample Type	19		20	
	3694	3695	3808	3810
	FA	RA	FA	RA
<u>Constituent</u>				
Mg	431 ± 2 (425)	424 ± 4 (436)	435 ± 4 (442)	423 ± 6 (437)
Si	177 ± 2 (487 SiO ₂)	175 ± 2 (488 SiO ₂)	178 ± 1 (491 SiO ₂)	176 ± 2 (487 SiO ₂)
B	264 ± 3 (262)	264 ± 2 (261)	261 ± 3 (290)	260 ± 1 (288)
Cu	<0.3 (<0.2)	<0.3	<0.3	<0.3
Cd	7.5 ± .5	7.6 ± .5	7.4 ± .5 (<0.7)	7.3 ± .5
Ca	23,900 ± 210 (23,100)	24,300 ± 150 (23,500)	23,500 ± 110 (23,800)	23,900 ± 360 (23,100)
Ti	<0.8	<0.8	<0.8 (<0.2)	<0.8
Fe	4,690 ± 35 (4,890)	4,610 ± 45 (4,940)	4,690 ± 42 (5,240)	4,630 ± 29 (5,170)
Mo	<0.9	<0.9	<0.9 (<7.5)	<0.9
Mn	1,220 ± 7 (1,180)	1,230 ± 7 (1,190)	1,210 ± 2 (1,260)	1,210 ± 2 (1,250)
Pb	287 ± 1 (241)	305 ± 8 (267)	306 ± 3 (292)	310 ± 5 (298)
V	<0.9	<0.9	<0.9 (<0.3)	<0.9
Co	2.9 ± .5	2.9 ± .5	2.9 ± .5 (<0.9)	2.8 ± .5
Al	<0.9	<0.9	<0.9 (<3.0)	<0.9
Ba	2,510 ± 20 (2,420)	2,550 ± 10 (2,480)	2,490 ± 20 (2,460)	2,500 ± 45 (2,410)
Sr	1,820 ± 25 (1,970)	1,840 ± 30 (1,980)	1,280 ± 10 (1,890)	1,830 ± 35 (1,850)
K	8,980 ± 45 (9,520)	8,900 ± 73 (9,690)	8,910 ± 75 (11,700)	8,900 ± 60 (12,000)

E.5 (continued)

Test No. Sample No. Sample Type	19		20	
	3694	3695	3808	3810
	FA	RA	FA	RA
<u>Constituent</u>				
Ni	<1	<1	<1 (<3.5)	<1
Li	335 ± 4 (260)	327 ± 3 (265)	338 ± 4 (305)	332 ± 3 (308)
Na	62,700 ± 975	61,800 ± 935	63,400 ± 370 (70,100)	62,400 ± 420 (70,200)
W	<3	<3	<3	<3
Zn	1,390 ± 15 (1,260)	1,350 ± 30 (1,280)	1,440 ± 15 (1,450)	1,470 ± 7 (1,440)
Ag	<0.6	<0.6	<0.6 (<0.3)	<0.6
As	<14	<14	<14 (<10.0)	<14
Se	—	—	—	—
U	<6	<6	<6	<6
Cr	<0.1	<0.1	<0.1 (<1.1)	<0.1