GW - 40

GENERAL CORRESPONDENCE

YEAR(S): 1988

DISCHARGE PLAN APPLICATION
FOR
GIANT BLOOMFIELD REFINERY
BLOOMFIELD, NM

March 1, 1988

Prepared for:

MONTGOMERY & ANDREWS, P.A.
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For Submission to:

Environmental Bureau
NM Oil Conservation Division
Santa Fe, NM 87105

Prepared by:

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REPLY TO SANTA FE OFFICE

March 1, 1988

FEDERAL EXPRESS

Mr. William J. LeMay
Director
Oil Conservation Division
State Land Office
310 Old Santa Fe Trail
Santa Fe, New Mexico 87501

Re: Discharge Plan Application (GW-40)
Giant Industries, Inc./Bloomfield Refinery

Dear Mr. LeMay:

On behalf of our client, Giant Industries, Inc., I am enclosing the discharge plan application for Giant's Bloomfield Refinery, prepared for us by Geoscience Consultants, Ltd. The application consists of one volume of text, two volumes of appendices and one volume of plates. After you have had an opportunity to review the application, we would be pleased to discuss it with you and with members of your staff.

Very truly yours,

Edmund H Kendrick

Edmund H. Kendrick

EHK/gr:14
Enclosures
File #8361-85-09
✓ cc: Mr. David Boyer (w/3 sets of encls.)

DISCHARGE PLAN APPLICATION
FOR
GIANT BLOOMFIELD REFINERY
BLOOMFIELD, NM

SUBMITTED BY:

Randall T. Hicks
GCL Program Manager

DATE:

2/25/88

Randall T. Hicks for CLAUDE SCHLEYER
GCL Project Director

2/25/88

AFFIRMATION

I hereby certify that I am familiar with the information contained in and submitted with this application and that such information is true, accurate and complete to the best of my knowledge and belief.

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS
CERTIFICATE NUMBER
6777
AIPG
RANDALL T. HICKS
CERTIFIED PROFESSIONAL GEOLOGIST

Randall T. Hicks   2/25/88

Randall T. Hicks   (Date)

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1.0 EXECUTIVE SUMMARY

Giant Industries, Inc. (Giant), P.O. Box 256, Farmington, New Mexico, 87499, proposes to discharge approximately 81 acre feet per year of treated water to infiltration trenches and land application sites on the Giant Bloomfield Refinery property. The water is derived from wells which are part of a remedial action at the site. The water will meet WQCC limits after 25 to 30 days of tank storage and, if required, subsequent air stripping. Other discharges at the site are associated with domestic sewage from the offices and maintenance shops and are exempt from Water Quality Control Commission (WQCC) Discharge Plan Requirements (WQCC Regulation 3-105B).

The refinery is located in the NW ¼, Section 27, and SW ¼, Section 22, Township 29 N, Range 12 W, San Juan County, near Bloomfield, New Mexico. The ground water most likely affected by this discharge is at a depth of approximately 25 feet and has a Total Dissolved Solids content of about 5000 mg/l.

Giant proposes to adopt wastewater management and operation systems to provide environmental protection. These include:

1) Treatment of pumped water through tank storage and, if necessary, a packed-tower air stripper, prior to discharge.

2) Use of infiltration trenches for disposal of water which meets WQCC ground water limits.

3) Use of sprinklers, as necessary, for disposal of water which will meet WQCC ground water limits.

4) Land application of water which will meet WQCC ground water limits to enhance in-situ treatment of soil.

5) Thorough monitoring of the remedial action system and site operations to minimize the potential for spills and leaks associated with site activities.

6) Thorough ground-water monitoring to determine the impact of the remedial action discharges.

7) Reporting results of monitoring to NMOCD.

Giant is committed to carrying out sound disposal practices and to this end submits this application. Likewise, Giant is committed to cooperating fully with NMOCD in connection with obtaining NMOCD approval of a discharge plan.

2.0 GENERAL INFORMATION

2.1 NAME OF DISCHARGER/LEGALLY RESPONSIBLE PARTY

All correspondence regarding this discharge plan should be sent to the address below:

Robert L. McClenahan, Jr.
Environmental Coordinator
Giant Refining Company
Route 3, Box 7
Gallup, NM 87301
(505) 722-3833

Giant requests that copies of correspondence also be sent to:

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(602) 274-3584

Randall T. Hicks
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Geoscience Consultants, Ltd.
500 Copper Avenue, NW
Albuquerque, NM 87102
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2.2 LOCATION OF DISCHARGE

The Giant Bloomfield Refinery (GBR) is located along hydrologic flow lines extending between the Lee Acres Landfill to the north and the Lee Acres Subdivision to the south. The precise location of the refinery is NW ¼, Section 27, and SW ¼, Section 22, T.29 N., R.12 W. in San Juan County, New Mexico, approximately 5 miles west of the town of Bloomfield.

Figure 2-1 shows the location of the refinery and illustrates a one mile area around the Giant Bloomfield Refinery. All wells within one mile of the refinery are listed in Table 2-1. Figure 2-2 explains the township and range system of numbering wells in New Mexico. A large scale topographic map detailing the refinery site, on-site wells, etc. is shown in Plate 1.

2.3 LOCAL LAND USE

The Giant Bloomfield Refinery is bounded on the north and west by Federal and State lands. This includes Federal lands in Sections 21

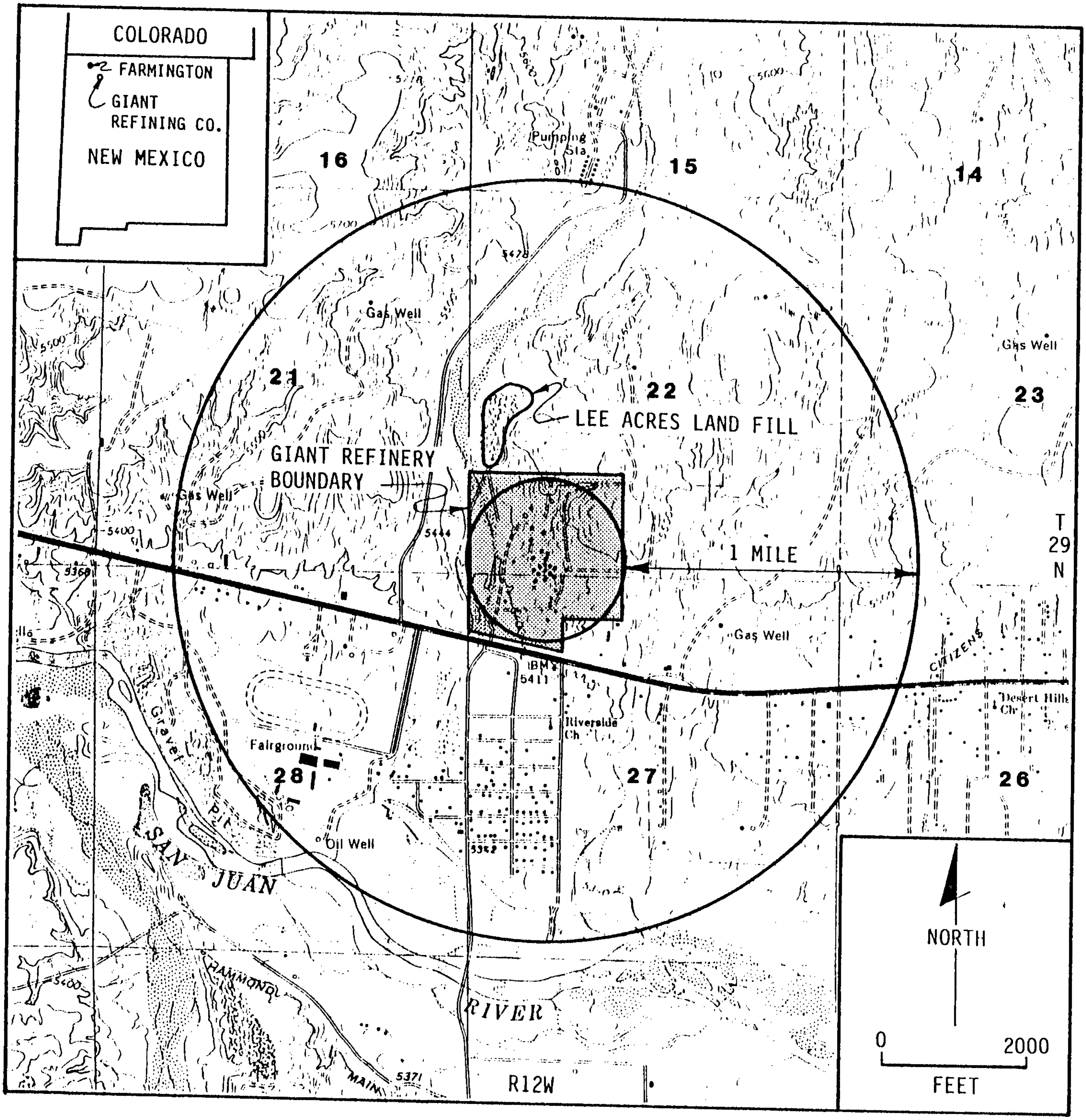


FIGURE 2-1

ONE MILE RADIUS, GIANT BLOOMFIELD REFINERY

SOURCE: USGS QUADRANGLE MAP-HORN CANYON,NM (7.5 MINUTE SERIES)

TABLE 2-1

ALL WELLS WITHIN A 1 MILE RADIUS OF THE
GIANT BLOOMFIELD REFINERY
(FEBRUARY 1988)

WELL LOCATION	DEPTH (ft)	DATA SOURCE
29.12.14.11	180	State Engineers Office
29.12.15.143	155	State Engineers Office
29.12.20.333	28	State Engineers Office
29.12.21.4222A	55	U.S. Geological Survey
29.12.21.4222B	46.5	U.S. Geological Survey
29.12.21.4244A	42.5	U.S. Geological Survey
29.12.21.4422	43.5	U.S. Geological Survey
29.12.21.4444	57	U.S. Geological Survey
29.12.22.1321	61.5	U.S. Geological Survey
29.12.22.1331	52.5	U.S. Geological Survey
29.12.26.21	47	State Engineers Office
29.12.26.211	100	State Engineers Office
29.12.26.24	38	State Engineers Office
29.12.26.34	47	State Engineers Office
29.12.26.42	70	State Engineers Office
29.12.26.42	50	State Engineers Office
29.12.26.422	45	State Engineers Office
29.12.26.422	45	State Engineers Office
29.12.27.13	63	State Engineers Office
29.12.27.131	50	State Engineers Office
29.12.27.133	55	State Engineers Office
29.12.27.133	51	State Engineers Office
29.12.27.134	35	State Engineers Office
29.12.27.31	35	State Engineers Office
29.12.27.31	87	State Engineers Office
29.12.27.31	25	State Engineers Office
29.12.27.311	25	State Engineers Office
29.12.27.311	32	State Engineers Office
29.12.27.313	32	State Engineers Office
29.12.27.414	24	State Engineers Office
29.12.29.114	20	State Engineers Office
29.12.29.114	21	State Engineers Office
29.12.29.114	19	State Engineers Office
29.12.29.124	20	State Engineers Office
29.12.29.132	16	State Engineers Office
29.12.29.133	18	State Engineers Office
29.12.33.2411	850	N.M. Bureau of Mines
29.12.33.2	51	State Engineers Office
29.12.34.11	15	State Engineers Office
29.12.34.113	15	State Engineers Office
29.12.34.421	43	N.M. Bureau of Mines
29.12.34.4341	100	N.M. Bureau of Mines
29.12.35.342	20	N.M. Bureau of Mines

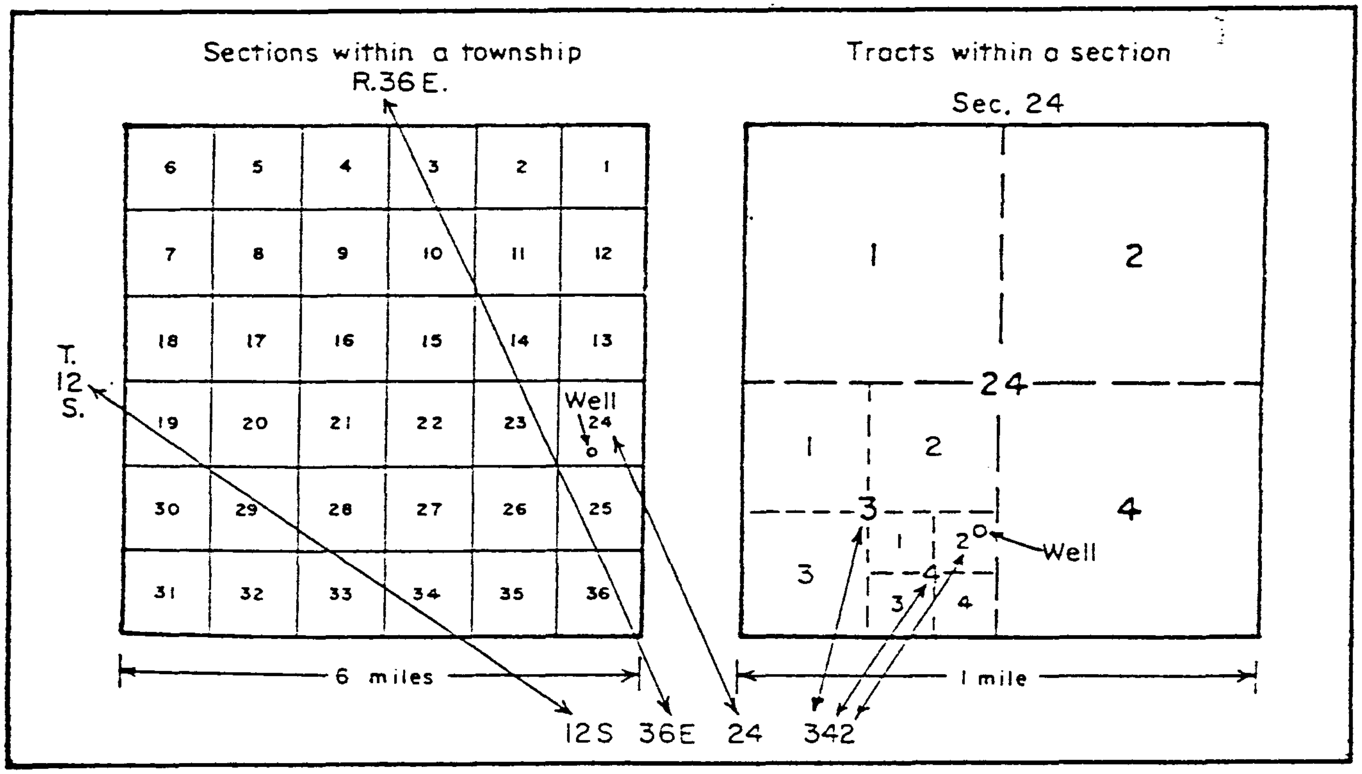


FIGURE 2-2

TOWNSHIP AND RANGE SYSTEM OF NUMBERING WELLS IN NEW MEXICO and 22, T.29 N., R.12 W., and State lands in Sections 28 and 21, T.29 N., R.12 W. The southern perimeter of the refinery borders U.S. Highway 64. Privately-owned lands lie south of the highway in Sections 27 and 28, T.29 N., R.12 W. The refinery borders privately-owned lands on the east in Sections 22 and 27, T.29 N., R.12 W. Land ownership status is based upon data from the San Juan County Manager's office.

2.4 HISTORY OF OPERATION

This refinery is currently mothballed with respect to the refining of petroleum. The site was operated as a crude oil refinery from 1973 to 1982. The volume of crude refined at the site ranged from 2,000 bbls/day in the mid 1970's to 13,500 bbls/day in the early 1980's. The principal refined products produced were gasolines, diesel, kerosene, liquified petroleum gas (LPG), and fuel oil.

The site is currently used for several other activities by Giant. The Ciniza Pipe Line, Inc. Company office is located on the site. The Crude Oil Branch of Giant's Transportation Division runs its dispatching and truck maintenance operations from this location. These operations employ approximately 20 full-time personnel in addition to truck drivers and temporary laborers who are at the facility part-time.

The site is located downgradient from the Lee Acres Landfill. A remedial action is presently on-going at the refinery. The purpose of the remedial action is to contain and clean-up any contamination presently on Giant's property which has been caused by site operations.

2.5 REGULATORY INDEX

Table 2-2 presents the regulatory index. This table provides a guide to locating information that satisfies each of the requirements of the WQCC Regulations applicable to this discharge plan.

TABLE 2-2

REGULATORY INDEX

WQCC REGULATION REQUIRED IN DISCHARGE PLAN		SECTION IN DISCHARGE PLAN
1-201		1.0, 2.0
3-106	C.1	3.3
3-106	C.2	Plate 1, 2.2, 6.0
3-106	C.3	3.4
3-106	C.4	5.4
3-106	C.5	6.0
3-106	C.6	5.3
3-107		6.0

3.0 PROPOSED DISCHARGES

Giant proposes to discharge treated ground water as part of a remedial action at the site. The source of these discharges will be ground water recovered from the following four areas: the Diesel Spill, Truck Fueling and Southern Refinery areas and the firefighting drill area seep (see Plate 1). Figure 3-1 shows the conceptual design of the ground-water remedial action plan for these areas.

The remedial action will consist of pumping recovery wells, temporary storage of produced water in above-ground storage tanks, treatment by air-stripping, if necessary, and discharge to infiltration trenches and land application sites. Discharge to land application sites may be utilized to assist in the remediation of soil.

Six large tanks will be employed to store produced water from the entire remedial action:

Tank 23	210,000 gallon capacity
Tank 24	840,000 gallon capacity
Tank 27	210,000 gallon capacity
Tank 32	210,000 gallon capacity
Tank 34	210,000 gallon capacity
Tank 37	420,000 gallon capacity

Prior to discharge from a tank, the stored water will be sampled and chemically analyzed for dissolved hydrocarbon constituents using EPA methods 601/602. The results of the testing will determine the appropriate level of treatment required. If tank storage does not render the produced water acceptable for discharge, a packed tower air-stripper and/or sprinklers will be employed for final treatment of dissolved volatile hydrocarbon constituents to WQCC ground water limits.

3.1 SOURCES OF DISCHARGED WATER

3.1.1 Diesel Spill Area Ground Water Remedial Action

Three pumping wells (GBR-14, GBR-27, GBR-28) are utilized for remedial action in the Diesel Spill Area. They are designed to remove the floating product and associated dissolved phase plume in that area and

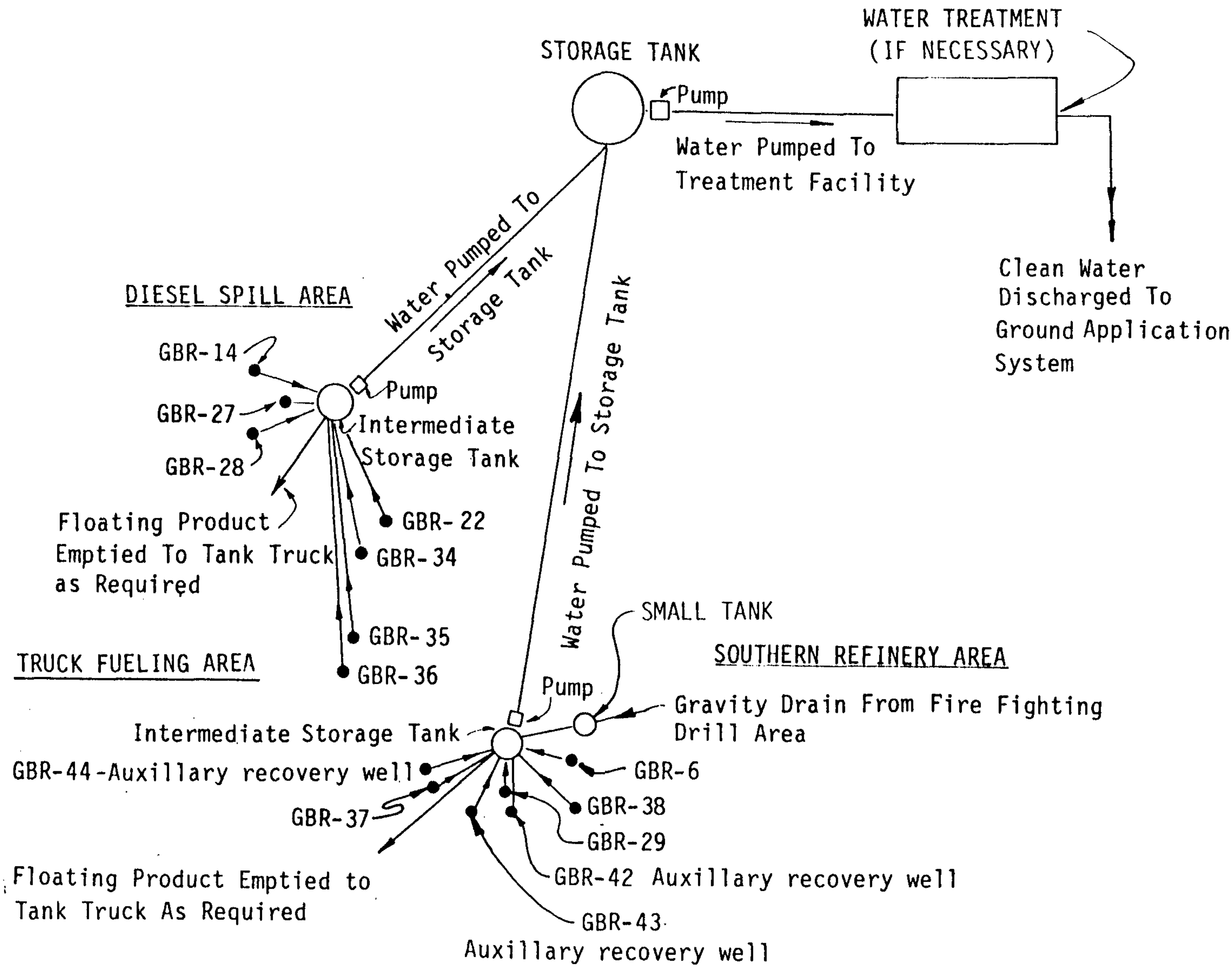


FIGURE 3-1

SCHEMATIC DIAGRAM OF GROUND WATER RECLAMATION SYSTEM

FOR THE GIANT BLOOMFIELD REFINERY

any areas upgradient of their capture zone. Each well is equipped with an air-driven recovery pump as shown in Figure 3-2, and pumps about 1 gpm.

To assure long term, reliable operation, Giant has installed a large capacity air compressor and direct piping from the 21,000 gallon intermediate storage tank to long-term storage tanks, eliminating the necessity of truck transfer. It is expected that at least a year of pumping will be required in this area.

3.1.2 Southern Refinery Area Ground Water Remedial Action

A four-well pumping network (GBR-6, GBR-29, GBR-37 and GBR-38) has been installed to capture petroleum hydrocarbons which may have originated from the refinery site. Three additional wells (GBR-42, GBR-43, GBR-44) have been installed as auxiliary wells in the event that wells in the recovery system become inoperable. An air-operated recovery pump similar to those installed in the Diesel Spill Area is installed in GBR-6. Submersible pumps (Figure 3-3) are installed in the six other wells. GBR-6 is pumped routinely to remove floating product. The three recovery wells with submersible pumps yield approximately 30 gpm (total).

The system will operate as described unless monitoring data demonstrate that the system is inadequate or inefficient. Pumping will continue until it is determined that refinery-related contamination is below WQCC ground water limits.

3.1.3 Truck Fueling Area Ground Water Remedial Action

Air-operated recovery pumps, similar to those used in the Diesel Spill Area, are installed in wells GBR-22, GBR-34 and GBR-35. Each pump discharges into the intermediate storage tank in the Diesel Spill Area at a rate of about 1 gpm. A submersible recovery pump similar to those installed in the Southern Refinery Area has been installed in GBR-36 and will produce about 3-7 gpm. It is anticipated that pumping will continue in this area for about one year.

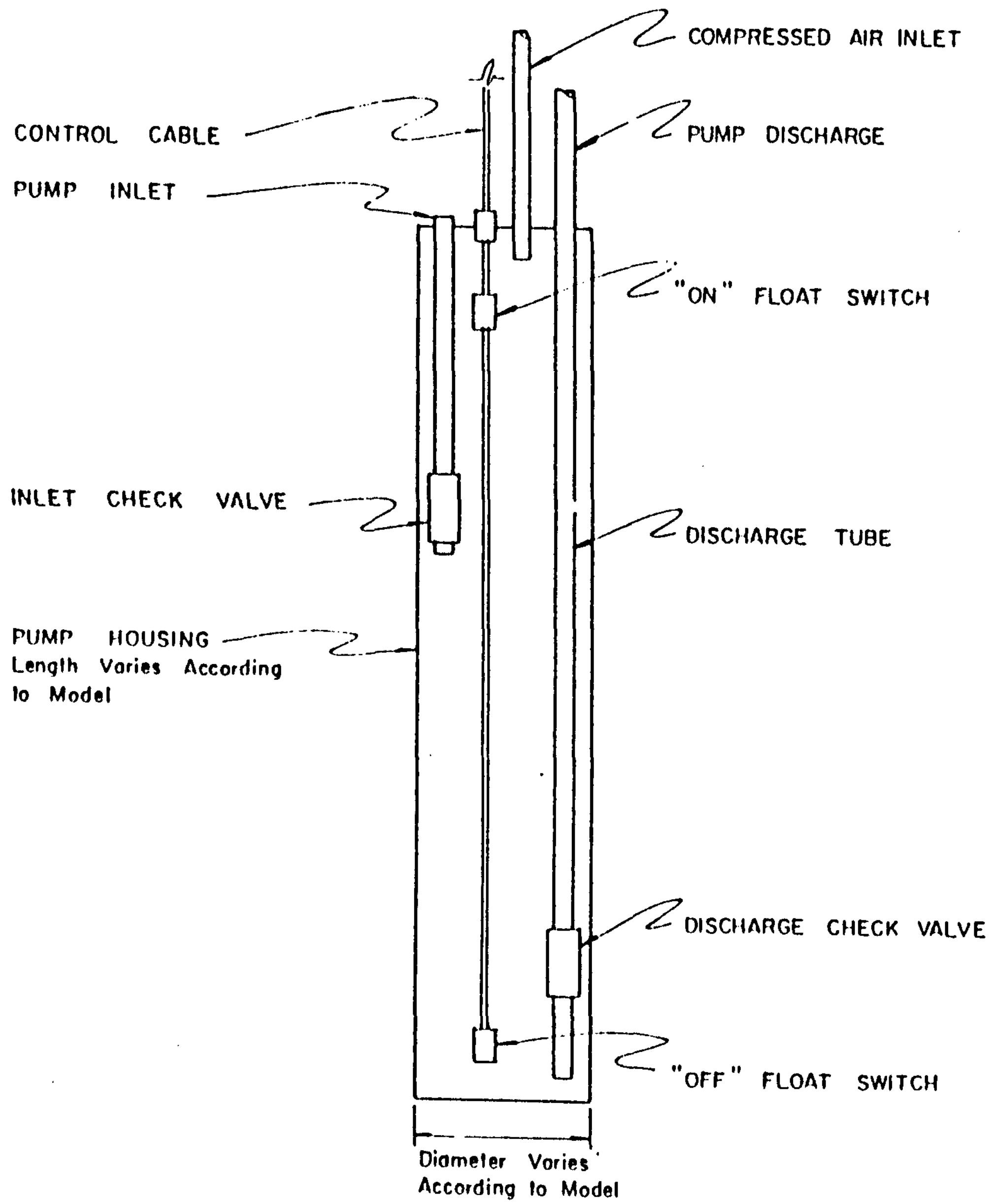


FIGURE 3-2

TYPICAL AIR DRIVEN HYDROCARBON RECOVERY PUMP

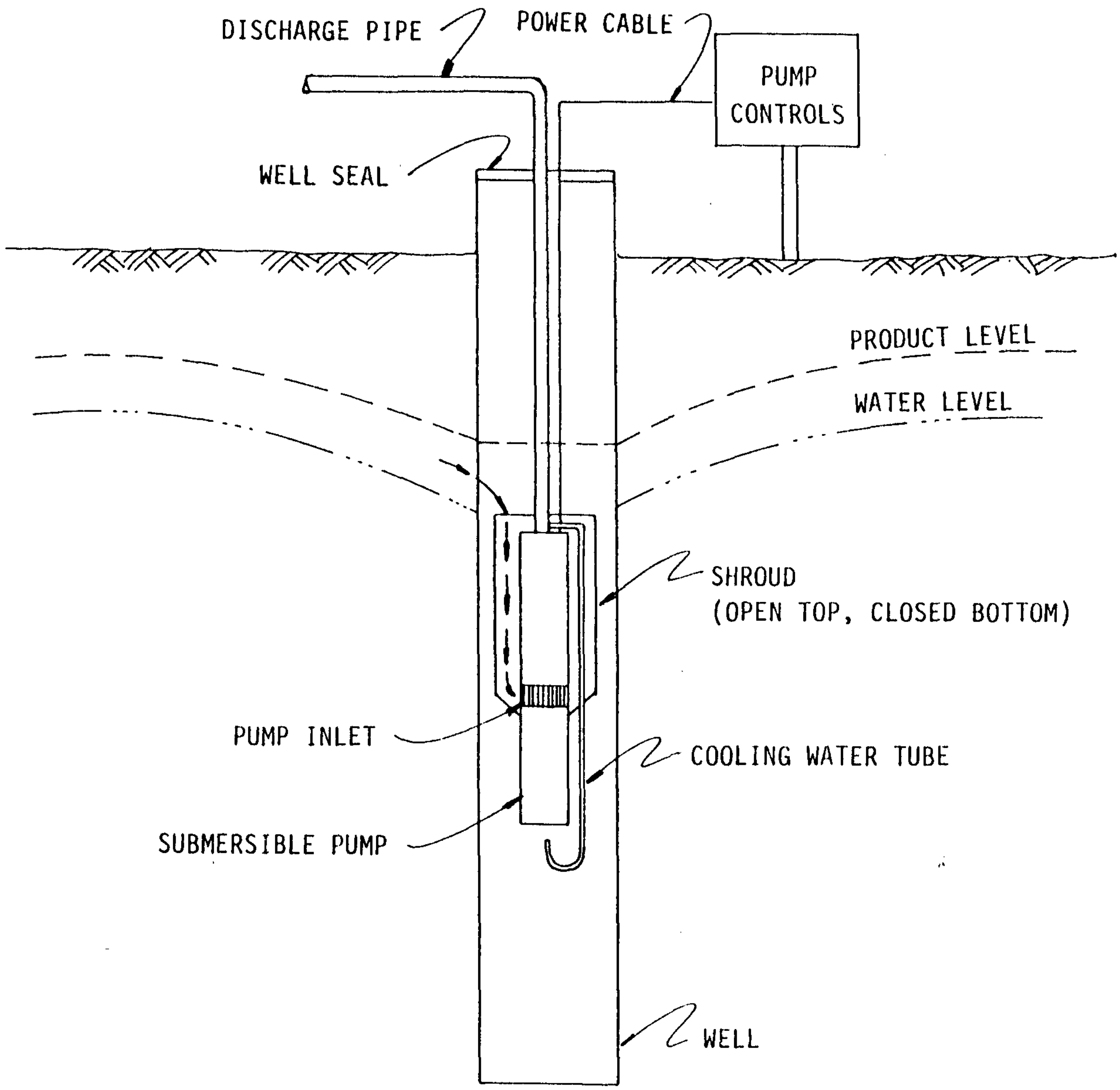


FIGURE 3-3

SUBMERSIBLE PUMP ADAPTED FOR FLOATING PRODUCT REMOVAL

3.1.4 Fire Fighting Drill Area Seep

Water from the fire fighting drill area seep in the Southern Refinery Area is currently being collected by a perforated PVC pipe laid in a gravel filled trench (Figure 3-4). The water is piped by gravity to a small intermediate storage tank that is periodically emptied by tank truck and transported for storage in above ground tanks.

3.1.5 Septic Tank Leach Fields

Discharge from three septic tanks at the refinery site is routed to three respective leach fields which were designed and built in compliance with NMEID specifications. Locations of the leach fields are shown on Plate 1. The domestic sewage discharged to the leach fields does not exceed 2000 gallons per day and is not commingled with the facility wastewater; therefore, the leach fields are not subject to WQCC Discharge Plan Requirements and are not discussed further.

3.2 TREATMENT OF WATER PRIOR TO DISCHARGE

3.2.1 Pumping and Storage

Most of the water pumped from the recovery systems contains dissolved hydrocarbon concentrations in the low ppm or ppb range. Samples taken from the Diesel Spill Area indicate that most dissolved petroleum hydrocarbons are removed by the action of pumping and discharging into the intermediate storage tank (Table 3-1). Samples of water from this tank are below WQCC limits and in most cases are below detectable limits.

Floating product and contaminated water from the recovery wells and water from the fire fighting drill area seep will be collected in intermediate storage tanks, one in the Southern Refinery Area near GBR-29 and the other near GBR-28 in the Diesel Spill Area. Floating product will be removed from these intermediate storage tanks, as it accumulates. The remaining water will be transferred to long-term storage tanks for testing and treatment as needed, or it will be directly routed to the air stripper after sampling indicates that dissolved hydrocarbon constituents

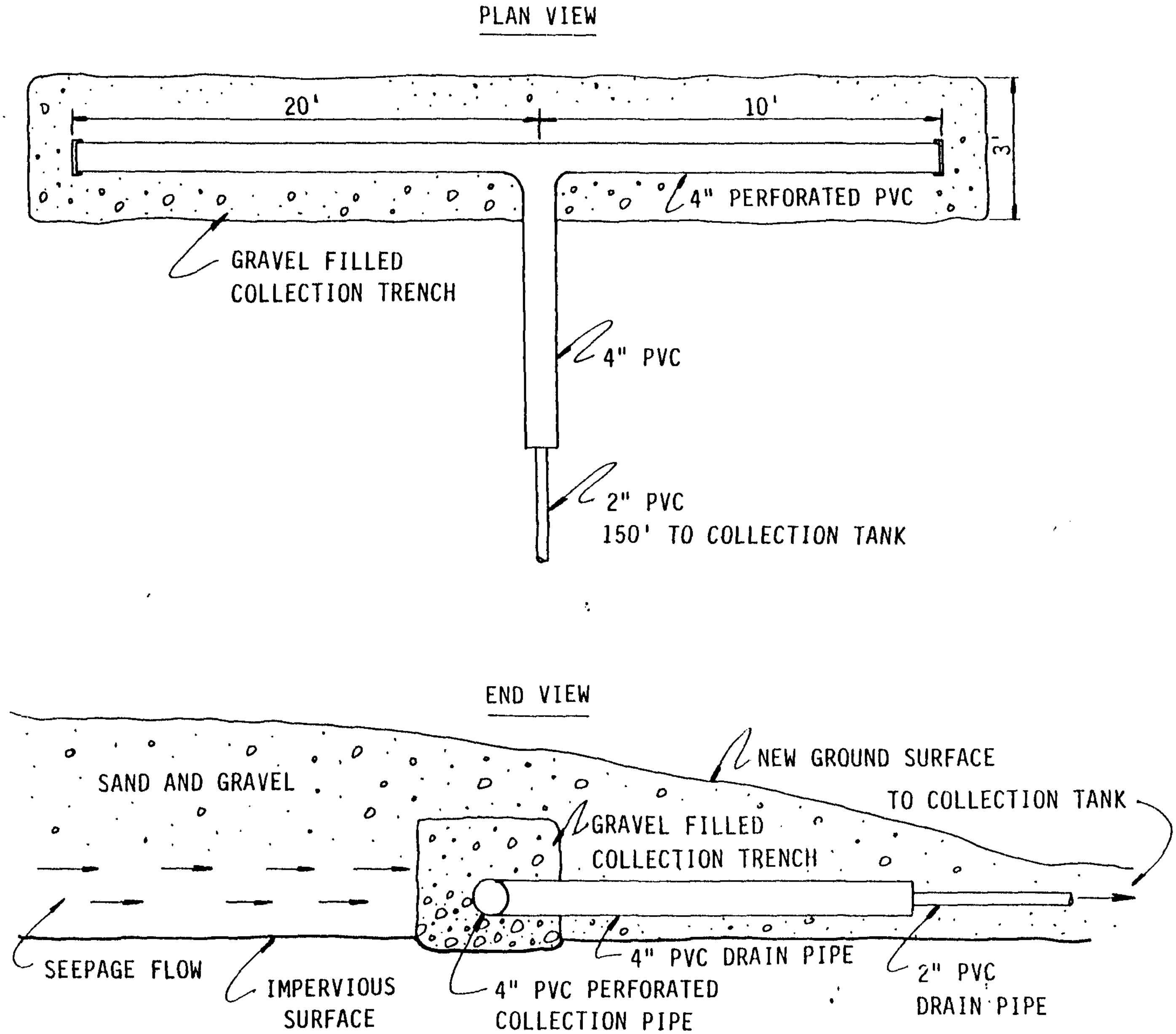


FIGURE 3-4

SEEPAGE COLLECTOR NEAR FIRE FIGHTING DRILL AREA

GIANT BLOOMFIELD REFINERY

TABLE 3-1
GIANT INDUSTRIES BLOOMFIELD REFINERY
SPRINKLER TEST RESULTS
BTEX AND CHLORINATED HYDROCARBONS
(CONCENTRATIONS IN PPB)

	SPRINKLER TEST SAMPLES			SOURCE WELL SAMPLES					
	8611071410 PUMP HOSE IN STORAGE TANK	8611071400 BASE OF SPRINKLER	8611071420 SPRINKLER DISCHARGE	8606052000 GBR-27 OCD	8606052000 GBR-27 GCL	8605291600 GBR-28 GCL	8607151900 GBR-28 GCL	861121113 GBR-14 OCD	NOMINAL DETECTION LIMIT
BENZENE	2	ND	7	410	50	2419	319	ND	1
CHLOROBENZENE	ND	ND	ND					ND	1
1,2-DICHLOROBENZENE	ND	ND	ND					ND	1
1,3-DICHLOROBENZENE	ND	ND	ND					ND	1
1,4-DICHLOROBENZENE	ND	ND	ND					ND	1
ETHYLBENZENE	ND	ND	ND					ND	1
TOLUENE	ND	ND	ND	120	74	819	143	ND	1
XYLENES	ND	ND	ND	506	457	4019	224	ND	1
ACROLEIN	ND	ND	ND					ND	25
ACRYLONITRILE	ND	ND	ND					ND	25
BROMOFORM	ND	ND	ND					ND	5
CCL4	ND	ND	ND					ND	5
CHLORODIBROMEMETHANE	ND	ND	ND					ND	5
2-CHLOROETHVINYL ETHER	ND	ND	ND					ND	5
CHCL3	ND	ND	ND					ND	5
DICHLOROBROMOMETHANE	ND	ND	ND					ND	5
1,1-DCA	ND	ND	ND					ND	5
1,2-DCA	7.1	6.3	ND	6				9	5
1,3-DICHLOROPROPYLENE	ND	ND	ND					ND	5
METHYL BROMIDE	ND	ND	ND					ND	5
METHYL CHLORIDE	ND	ND	ND					ND	5
METHYLENE CHLORIDE	ND	ND	ND					ND	5
1,1,2,1-TETRACHLOROETHANE	ND	ND	ND					ND	5
TETRACHOROETHENE	ND	ND	ND					ND	5
TRANS-1,2-DICHLORO	ND	ND	ND					ND	5
1,1,1-TCA	ND	ND	ND					ND	5
1,1,2-TCA	ND	ND	ND					ND	5
TRICHLOROETHENE	ND	ND	ND					ND	5
VINYL CHLORIDE	ND	ND	ND					ND	5

ND - not detected
GCL - Geoscience Consultants, Ltd.
OCD - Oil Conservation Division

are at or below the concentration levels for efficient operation of the air stripper.

Limited storage is available at the refinery. With a total pumping rate of about 30 gpm, the residence time of produced water stored at the refinery site is approximately 25-30 days.

Site evidence suggests that the agitation of pumping and exposure to air in the storage tanks will cause much of the dissolved hydrocarbon constituents to volatilize. Produced water which meets WQCC limits may be discharged without further treatment. If further treatment is necessary, air stripping will be utilized.

3.2.2 Air Stripping

Air stripping, if necessary, will be achieved by using two air stripping methods:

- air stripping through the use of an air stripper tower, and
- the use of sprinklers as air stripping devices, while applying water to the ground

Most of the recovered ground water which requires treatment will be sent through an air stripper tower. The air stripper will be designed for a maximum flow rate of 100 gpm and be capable of reducing the concentration of dissolved volatile hydrocarbon compounds in accordance to the following schedule:

Compound	Influent (ppm) Sample Source 8710070745	Design Efficiency	Estimated Concentrations after Air Stripping (ppm)
Benzene	10	99.90	0.01
Toluene	20	96.25	0.75
Ethyl Benzene	5	85.00	0.75
Xylene	12.5	95.04	0.62
PAH's	0.5	99.40	0.03

The stripper will be a forced draft type tower, with approximate dimensions of 23′-5" high and 3′ in diameter. The stripper shell will be constructed of polyethylene with high efficiency packing. The blower required for the stripper will be a centrifugal type with a 5 hp, 1800 RPM motor. A complete control and monitor system will be provided. A typical air-stripper design is shown in Figure 3-5.

Sprinklers as air stripping devices will be used as required by Giant and after approval by NMOCD. It has been reported that this procedure reduces dissolved volatile hydrocarbons by at least 90% (Hazardous Waste Consultant, 1983). A test was conducted on November 7, 1986, to determine the extent to which dissolved hydrocarbon constituents would volatilize through application of recovered water to soil using a standard impulse-type irrigation sprinkler. Water for the sprinkler test was taken from the intermediate storage tank in the Diesel Spill Area that had received water from GBR-14, GBR-27 and GBR-28. Water from these three wells continued to be pumped into the tank so that both stored water and freshly-pumped water were used, which would be representative of normal operation. A jet pump was used to pump the water to a Rainbird model 25 BPJ impulse sprinkler at a rate of 3.3 gpm at 50 psi. Twelve quart jars were placed on the ground to collect the water that accumulated over a 30-minute period of sprinkling. Water from all of the jars was combined to make up the sample. Other samples of water were taken from the tank and from the pipe just before it entered the sprinkler.

Table 3-1 presents the chemical analyses of these samples and of water previously taken directly from the three pumped wells. Although BTEX levels of well water samples from GBR-27 and GBR-28 ranged from 50 to 4019 ppb, most of these compounds were not detected in the sprinkler-test samples. As another example, levels of 1,2-dichloroethane were reported at 6.0 ppb in a GBR-27 well water sample, 7.1 and 6.3 ppb from the tank before sprinkling, and were not detected after sprinkling.

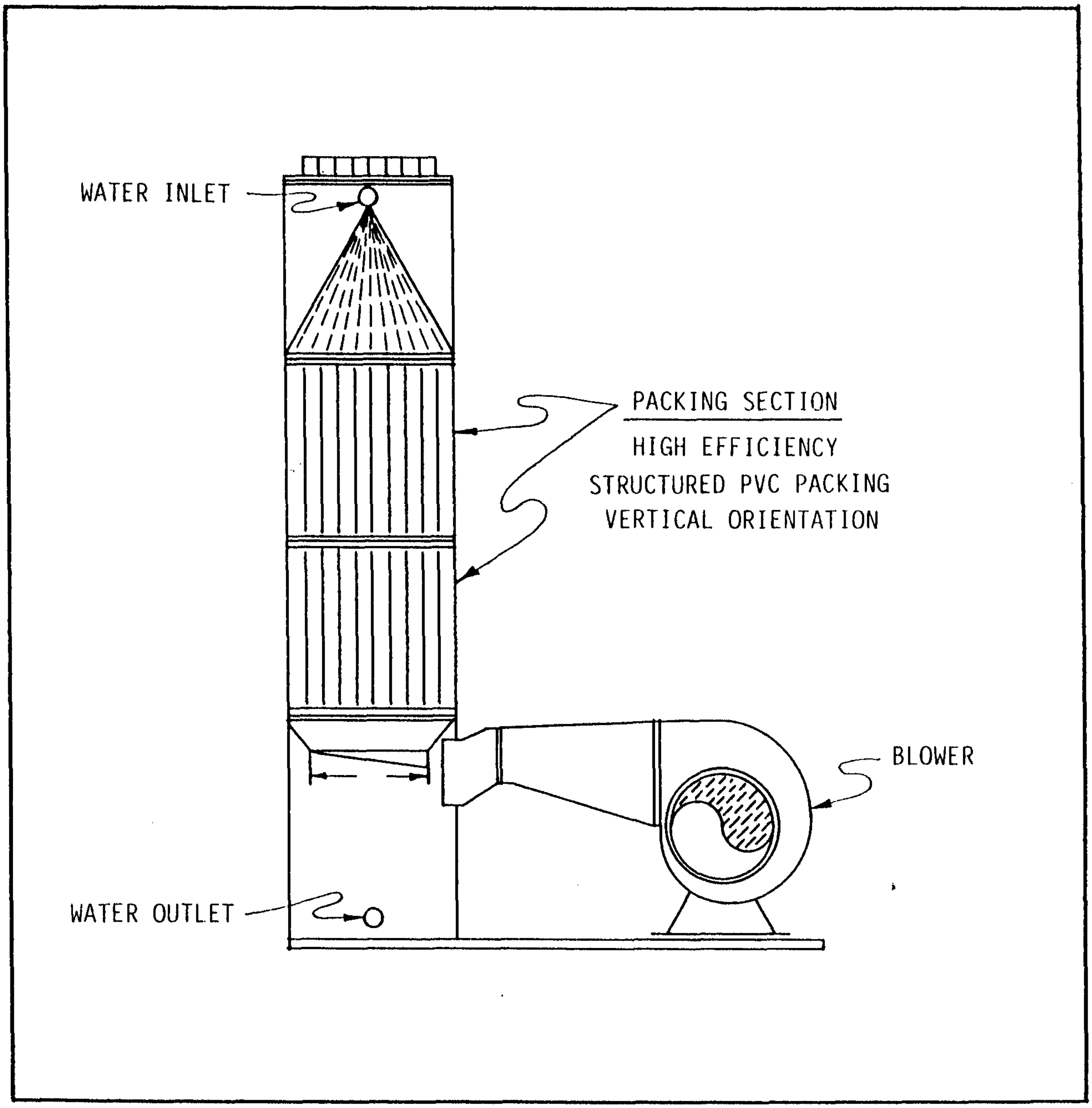


FIGURE 3-5

AIR STRIPPING TOWER SCHEMATIC

The data shows an anomaly where benzene was reportedly increased after sprinkling from 2 to 7 ppb. Since an actual increase in benzene is not probable, and because there is a significant overall reduction of benzene in the water when passing through the system, this appears to be caused by analytical variance or contamination in sample containers.

The sprinkler test did not show large reductions in dissolved hydrocarbon concentrations caused by sprinkling because most constituents had already been reduced below the limits of detection during storage in the intermediate storage tank. If this reduction continues to be observed, sprinkling will not be necessary, and direct discharge to land application sites may be used.

3.3 DISCHARGE LOCATIONS AND VOLUMES

3.3.1 Infiltration Trenches

Two locations are being considered for infiltration trenches:

- An infiltration trench upgradient of the Diesel Spill Area product plume, and
- an infiltration trench downgradient of the refinery site plumes, on the west bank of the arroyo.

The upgradient trench would provide a localized means of ground-water application, allowing for expediency in remediating the site. Aerated water from the air stripper can result in an increase of dissolved oxygen in ground water. The increased oxygen results in enhanced biodegradation of any downgradient petroleum hydrocarbons. Microorganisms can be added to this discharge to further enhance biodegradation. The downgradient trench would be utilized in concert with the recovery wells in the Southern Refinery Area to create a total hydraulic barrier at the site.

A schematic of a typical infiltration trench is shown in Figure 3-6. The infiltration trenches will be constructed according to New Mexico State requirements for septic tank effluent trenches (NMEID, 1983). They will be 2-feet deep (although the depth may vary to coincide with favorable

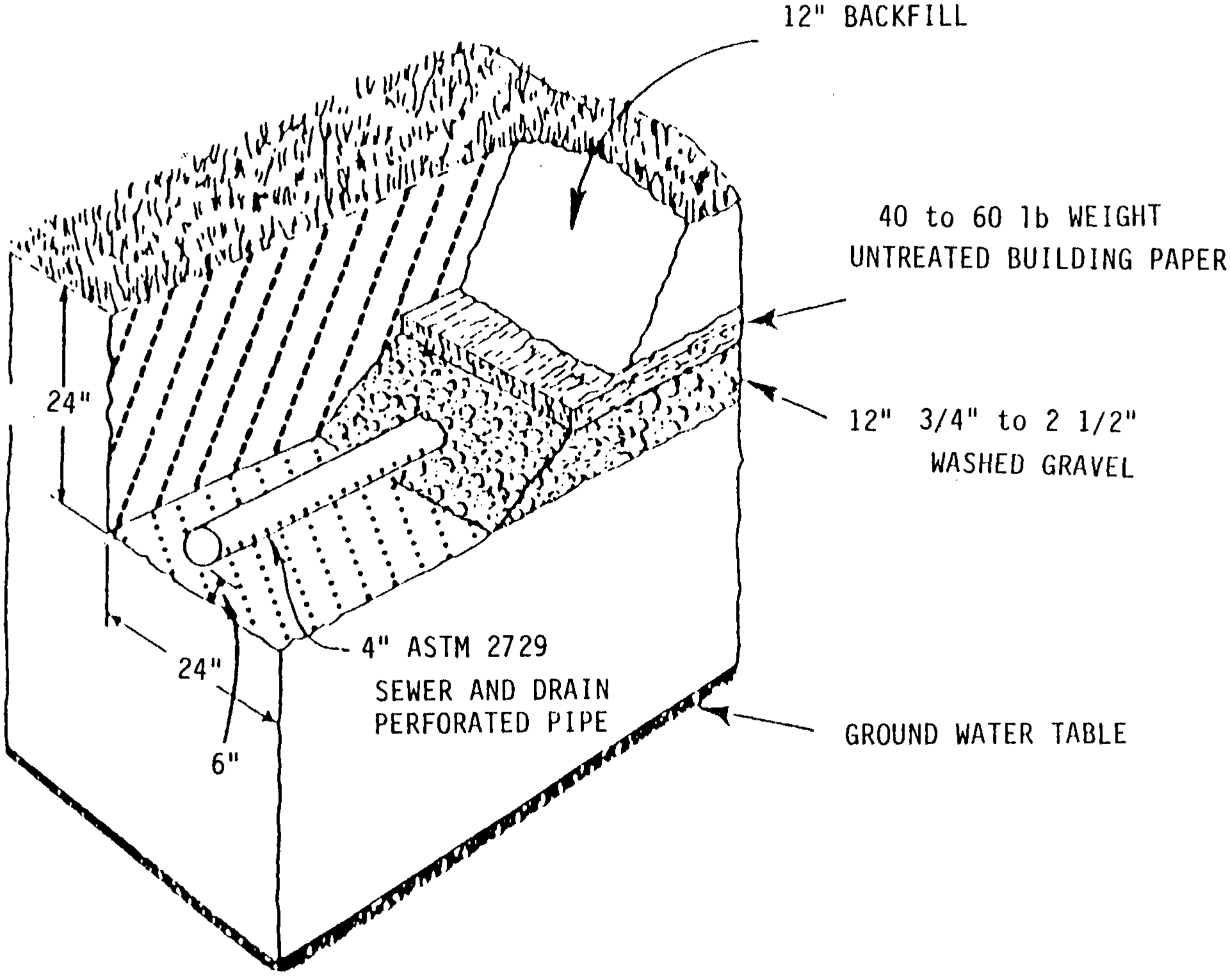


FIGURE 3-6

CUT AWAY VIEW OF TYPICAL DOWNGRADIENT INFILTRATION TRENCH percolation rates) by 2 to 4 feet wide and filled with gravel. Perforated PVC pipe will be laid in the bottom of the trenches through which water will be discharged. The length of the trenches will be determined by percolation tests which will establish the absorption capacity of the soil.

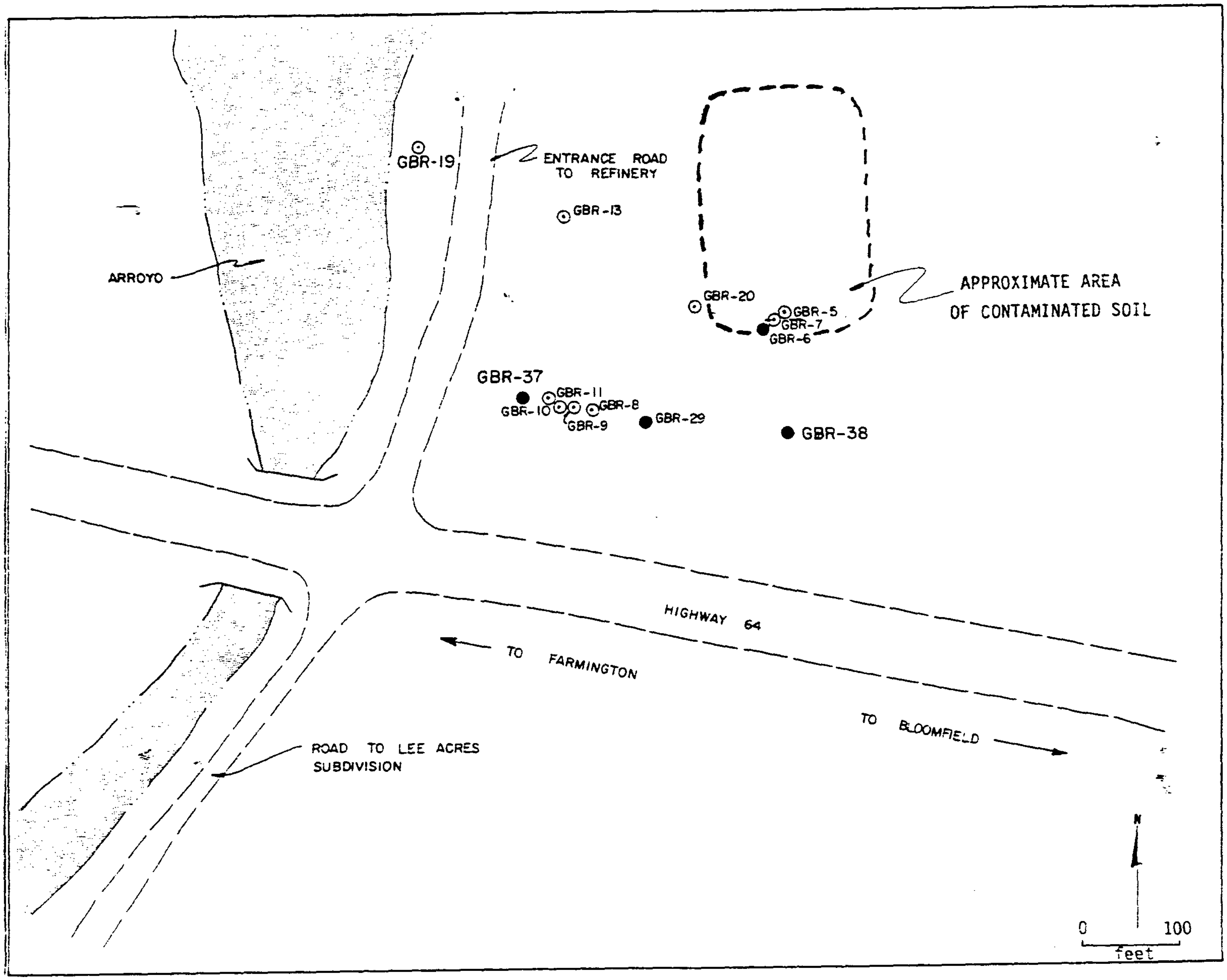
Plans and specifications for this discharge system will be submitted to NMOCD prior to construction. The plans will include results of the percolation test. It is anticipated that the bulk of the treated water will be discharged to the infiltration trenches.

3.3.2 Land Application Sites For Controlled Flooding

As part of the remedial action, Giant will discharge treated water to sites where contaminated soil is known to exist. At present, the only location where controlled flooding is planned is the Southern Refinery Area (Figure 3-7).

The area will be disked and leveled to facilitate infiltration of applied water. A 6-inch high berm will be constructed around the site to prevent any runoff. To ensure applied water will percolate into the zone of interest, the berms will be built upon native soils of the area, not the overlying gravel fill.

During frost-free periods, controlled flooding of treated ground water will be used in flushing the areas of contaminated soil in the Southern Refinery Area. Tests conducted on this soil demonstrate that the unsaturated zone (upper 25 feet) exhibits an average moisture content of 6.5% by weight and an open pore space of 25%. If enough water was supplied to saturate the upper 25 feet of soil, a significant volume of soil contamination would be flushed out of the soil as a wetted front of water and entrained product and would enter ground water and be subsequently captured by the recovery pumps. Assuming open pore space of 25%, saturation of the upper 25 feet of soil in the area of concern will require the application of 6.25 feet of reclaimed water over a relatively short period of time.



LEGEND

⊙ MONITOR WELLS

● RECOVERY WELLS

FIGURE 3-7

REMAINING IN-PLACE CONTAMINATED SOIL AND WELL LOCATIONS

SOUTHERN REFINERY AREA
GIANT - BLOOMFIELD

Giant proposes to approach this upper limit of water application through a series of test applications. After a period of 2 weeks during which total precipitation was less than 0.1 inch, eighteen inches of reclaimed ground water (about 25% of the maximum calculated open pore space) will be applied to the area of concern at a rate that does not result in excessive ponding on the area. The response of the soil and the aquifer will be monitored through the proposed monitoring schedule. The application rate will be adjusted after evaluation of the response. Water will be applied only during working hours when Giant personnel can monitor the application. It is anticipated that 5 days will be required to apply 18 inches of reclaimed water.

During water application, the recovery wells in the Southern Refinery Area will be pumped continuously, and the effects of the application of water will be monitored by evaluation of the thickness of floating product observed in GBR-5, GBR-7, GBR-13, GBR-20 and GBR-25. Tests will be conducted at successively higher or, if required, lower application rates until the floating product in the observation wells reaches a maximum thickness. Results of the test applications will determine the application rates of reclaimed water which will result in the desired flushing of product.

The tests described above will be performed in Spring 1988 unless weather conditions permit an earlier start date. Product recovery wells are in place and operational in the Southern Refinery Area and several months of ground-water level data are available to permit an adequate demonstration that the pumping network will capture any flushed product. Tables 3-2 and 3-3 present the available soil chemistry for this area.

3.3.3 Land Application Sites For Controlled Sprinkling

The purpose of controlled sprinkling is to dispose of water or to enhance in-situ treatment of soils. A location in the arroyo is presently proposed for periodic sprinkler application of treated water for water disposal. Other locations on the refinery site may be proposed in the future.

TABLE 3-2
GIANT INDUSTRIES BLOOMFIELD REFINERY
CHEMICAL ANALYSES, SOIL SAMPLES
SOUTHERN REFINERY AREA

ORGANIC PARAMETERS:

BTEX
CONCENTRATIONS LISTED IN PARTS PER BILLION

SAMPLE #	LOCATION	BENZENE	TOLUENE	ETHYL BENZENE	META	XYLENES ORTHO & PARA	XYLENES TOTAL
8512201240	GBR-5	ND	ND	ND	N/A	N/A	ND
		(0.01)	(0.01)	(0.01)	-	-	(0.01)
8512201410	GBR-5	ND	ND	3.90	N/A	N/A	ND
		(0.01)	(0.01)	(0.01)	-	-	(0.01)
8605011412	GBR-11	ND	ND	ND	N/A	N/A	ND
		(0.0001)	(0.0001)	(0.0001)	-	-	(0.001)
8605021516	GBR-13	ND	35000	32000	N/A	N/A	279000
		(0.0001)	(0.0001)	(0.0001)	-	-	(0.001)
8604021605	SSWCA	ND	167	468	NA	N/A	9950
	PIT #1	(1.0)	(0.1)	(0.1)	-	-	(1.0)
8604021550	SSWCA	ND	ND	ND	N/A	N/A	ND
	PIT #2	(0.1)	(0.1)	(0.1)	-	-	(1.0)
8604021618	SSWCA	ND	ND	ND	N/A	N/A	ND
	PIT #3	(0.1)	(0.1)	(0.1)	-	-	(1.0)
8604021635	SSWCA	ND	4842	3683	N/A	N/A	32569
	PIT #4	(1.0)	(0.1)	(0.1)	-	-	(1.0)

NA = not analyzed
ND = below detection limits
- = detection limits not provided

SSWCA = South Storm Water Containment Area

Detection limits in parentheses

M&A\TAB3-1.TAB

TABLE 3-3

GIANT INDUSTRIES BLOOMFIELD REFINERY
CHEMICAL ANALYSES, SOIL SAMPLES, SOUTHERN REFINERY AREA
ORGANIC PARAMETERS:
POLYNUCLEAR AROMATIC HYDROCARBONS,
CONCENTRATIONS LISTED IN PARTS PER BILLION

SAMPLE NO.	LOCATION	NAPTH	ANTHRA-CENE	PHENAN-THRACENE	BENZO (b) FLUORANTHENE	BENZO (k) FLUORANTHENE	BENZO (a) PYRENE	FLUOR-ANTHENE	1-METHYL NAPTHLENE	PYRENE	FLUORENE
8604021516	GBR-13	2530	1920	1000	ND	ND	NA	ND	ND	ND	ND
8604021605	PIT #1	ND	3040	2040	ND	ND	NA	ND	ND	ND	ND
8604021550	PIT #2	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND
8604021618	PIT #3	ND	339	330	ND	ND	NA	1254	ND	ND	ND
8604021635	PIT #4	2520	1540	2000	ND	ND	NA	4630	ND	5230	ND
8604021635	PIT #4 (split)	1500	ND	ND	ND	ND	ND	ND	NA	ND	150
Nominal Detection Limits		500	100	500	100	100	200	2000	-	2000	100

SAMPLE NO.	LOCATION	2-NITRO PHENOL	PHENOL	CRESOL	2,4-DIMETHYL PHENOL	2,4-DINITRO-PHENOL	4-NITRO-PHENOL	4,6-DINIT O-CRESOL	AMMONIA AS N	PHOSPHATE AS P	pH
8604021516	GBR-13	29000	31000	ND	ND	ND	ND	ND	NA	NA	NA
8604021605	PIT #1	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
8604021550	PIT #2	ND	3000	ND	ND	ND	ND	ND	NA	NA	NA
8605021618	PIT #3	ND	ND	ND	ND	ND	27000	ND	NA	NA	NA
8605021635	PIT #4	ND	50000	ND	ND	ND	ND	ND	NA	NA	NA
8605021635	PIT #4 (split)	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA
Nominal Detection Limits		1000	1000	1000	1000	1000	1000	1000	-	-	-

ND = not detected NA = not analyzed - = detection limit not provided

The sprinkler system will consist of typical lawn sprinklers and associated piping. All piping will be placed above-ground. Pumps will be used as required to deliver the treated water to the sprinklers at a suitable water pressure.

Sprinkling of treated water on contaminated or uncontaminated soil will be carefully controlled. A water balance analysis shows that the average application allowed on an area of approximately 3 acres, based on potential evapotranspiration rates, is more than 170,000 gallons per week. However, the application rate varies greatly according to the time of year. Regular application during the winter months is not proposed. Thus storage of water during the months of November through February is required. This water can be subsequently discharged when evapotranspiration permits in the spring or during selected times in winter.

Table 3-4 presents the evapotranspiration data of the area and a water application schedule for a land application site of approximately 3 acres. The water will be distributed evenly over any land application sites through an automatic sprinkler system. Berms will be constructed around such sites, as necessary, to contain applied water and to prevent run-on of storm water.

3.4 GROUND-WATER QUALITY AT DISCHARGE LOCATIONS

Giant plans to discharge treated ground water produced from the remedial action at various locations at the refinery site. In order to understand the impact of any discharges to the chemistry of the aquifer, a hydrochemical database was developed. The database includes samples taken by GCL and NMOCD. Tables 3-5 through 3-10 present all analytical results from existing monitor wells.

Increases in TDS and certain inorganic parameters must be accepted if dissolved petroleum hydrocarbons are to be removed from the aquifer. The flushing of contaminated soils could cause significant increases in the TDS of the aquifer.

TABLE 3-4

POTENTIAL EVAPOTRANSPIRATION (PET),
FARMINGTON, NEW MEXICO
AND
SCHEDULE FOR THE APPLICATION OF WATER TO
THE SOIL TREATMENT SITE

	NET LOSS PET-RAIN IN/DAY	APPLICATION RATE (IN/MIN)	APPLICATION TIMES MIN/DAY	MIN/WEEK	VOLUME APPLIED TO 3.1 ACRE SITE GAL/WK
MAR	.03	.01	3	21*	17,679
APR	.28	.01	28	196	165,000
MAY	.35	.01	35	245	206,249
JUN	.50	.01	50	350	294,642
JUL	.42	.01	42	294	247,500
AUG	.36	.01	36	252	212,143
SEP	.20	.01	20	140	117,857
OCT	.14	.01	14	98	82,499
				Total Gal/Yr	5,374,276

* During the month of March, a weekly application schedule will be used

References: Consumptive Use and Yields of Crops in New Mexico, New Mexico Water Resources Research Institute, WRRI Report No. 115, 1979

Temperature and Precipitation Summaries for Selected New Mexico Locations, Dr. Kenneth Kunkel, December 1984

TABLE 3-5

GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES

PHYSICAL PARAMETERS

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	pH	(uMHOS) CONDUCTIVITY	(CELSIUS) TEMP	TOTAL DISSOLVED SOLIDS (in parts) per million)
GBR-05	8606051745	OCD	7.00	3700	25.0	2865
GBR-07	8610171550	GCL	6.92	3600	19.0	NA
GBR-08	8610171615	GCL	6.86	7500	16.8	NA
GBR-09	8610171630	GCL	7.20	3550	17.0	NA
GBR-11	8606051705	OCD	7.00	7200	25.0	7593
GBR-13	8606051900	OCD	7.00	7800	18.5	10553
GBR-14	8610171215	GCL	6.80	2850	17.5	NA
GBR-15	8610171215	GCL	7.25	3450	15.6	NA
GBR-17	8605290830	GCL	NA	NA	NA	3024
GBR-17	8606051230	OCD	7.00	5500	18.5	4355
GBR-17	8610171050	GCL	6.97	2650	15.6	NA
GBR-18	8606051435	OCD	7.00	4100	17.0	4934
GBR-18	8610170815	GCL	7.55	4300	14.2	NA
GBR-19	8610171510	GCL	6.84	4250	17.2	NA
GBR-20	8606051730	OCD	7.00	3400	21.0	3473
GBR-20	8610171525	GCL	7.04	2800	18.2	NA
GBR-21D	8610170900	GCL	6.97	6000	14.1	NA
GBR-22	8610170950	GCL	6.45	6000	14.5	NA
GBR-24	8606052040	OCD	7.00	NA	NA	NA
GBR-24D	8610171130	GCL	7.28	3250	18.3	NA
GBR-25	8605091210	GCL	NA	NA	NA	5096
GBR-25	8610170925	GCL	6.81	5000	15.3	NA
GBR-26	8610171230	GCL	6.91	2300	18.2	NA
GBR-27	8606052000	OCD	7.00	7200	21.0	9023
	* SPLIT	GCL	7.00	7200	21.0	9023
GBR-29	8606051525	OCD	7.00	NA	NA	1293
GBR-30	8610171155	GCL	6.84	4300	17.1	NA
GBR-31	8610171350	GCL	6.60	5000	17.5	NA
GBR-32	8704301730	GCL	6.40	6300	15.8	NA
GBR-39	8610171330	GCL	7.28	2500	17.5	NA
SEEP (EAST)	8606051905	OCD	7.00	1600	21.5	NA
SEEP (WEST)	8510291450	OCD	NA	1550	21.0	NA
SEEP	8510241435	GCL	7.50	NA	NA	1258

GCL = Geoscience Consultants, Ltd.
OCD = Oil Conservation Division
NA = Not analyzed for this parameter
SEEP = Fire Fighting Drill Area Seep

M&A\TAB3-11.PRN

TABLE 3-6
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSES

INORGANIC PARAMETERS

CHEMICAL CONCENTRATIIONS
(mg/l)

WELLNO	SAMPLE NO.	SAMPLE SOURCE	HCO3	CALCIUM	CL-	CO3	K	MG	NA	SO4
GBR-05	8608051745	OCD	837.	320.	464.	0.	6.79	97.6	588.8	491.
GBR-11	8606051705	OCD	474.	1030.	2200.	0.	5.85	68.	782.	314.
GBR-13	8606051900	OCD	470.	1464.	3070.	0.	2.73	70.8	377.2	1332.
GBR-17	8606051230	OCD	376.	712.	1105.	0.	1.17	63.4	616.4	1202.
GBR-18	8606051435	OCD	122.	420.	262.	0.	6.13	29.3	4321.	3141.
GBR-20	8606051730	OCD	428.	420.	290.	0.	10.1	14.6	248.4	1776.
GBR-24	8606052040	OCD	NA	NA	NA	NA	NA	NA	NA	NA
GBR-27	8606052000	OCD	350.	1100.	2816.	0.	1.17	141.1	526.7	1530.
GBR-29	8606051525	OCD	106.	800.	1513.	0.	0.	63.	349.	1113.
GBR-32	8708051110	EID	270.	820.	1260.	NA	1.95	98.	669.	1770.
GBR-17	8708051212	EID	305.	464.	337.	NA	0.78	88.	380.	1340.
GBR-13	8708051305	EID	415.	1004.	1960.	NA	4.29	71.	1056.	1560.
SEEP	8510241735	GCL	NA	NA	98.	NA	NA	NA	NA	9.

GCL = Geoscience Consultants Ltd.
OCD = Oil Conservation Division
EID = New Mexico Environmental Improvement Division
NA = Not analyzed for this parameter
SEEP = Fire Fighting Drill Area Seep

TABLE 3-7

GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER ANALYSIS
CHEMICAL ANALYSIS
CHEMICAL CONCENTRATIONS IN MG/L

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Si	Sn	Sr	V	Zn
BEDSHAW	8708051415	EID	<0.1	<0.1	NA	0.3	<0.1	<0.1	370	<0.1	<0.05	<0.1	<0.1	2.8	NA	45	0.27	NA	<0.1	<0.1	NA	7.9	<0.1	5.9	<0.1	<0.1
BUSTOS	8708051510	EID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DUGGINS	8708051215	EID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-13	8708051305	EID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-17	8708051212	EID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-32	8708051110	EID	<0.1	7.7	NA	0.3	0.1	<0.1	840	<0.1	<0.05	<0.1	0.1	9.2	NA	64	1.1	NA	0.3	<0.1	NA	13	<0.1	14.0	<0.1	<0.1
HARMON	8708051200	EID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WATSON	8708051340	EID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-11	8606051705	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-11	8605291615	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.07	NA	NA	NA	NA	NA	NA
GBR-17	8605290830	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA
GBR-27	8606052000	OCD	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-27	8606052000	OCD	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-29	8605300945	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.14	NA	NA	NA	NA	NA	NA
GBR-29	8606051525	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
SEEP	8606051905	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
SEEP	8510241735	GCL	<0.05	NA	<0.05	NA	<1.0	NA	NA	<0.01	NA	<0.05	<0.01	32	<0.002	NA	1.2	NA	NA	<0.05	<0.01	NA	NA	NA	NA	NA
GBR-05	8611201640	OCD	<0.1	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-09	8611210820	OCD	<0.1	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-11	8611201515	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-11	8606051705	OCD	<0.1	<0.1	0.014	0.3	0.5	<0.1	970	<0.1	<0.1	<0.1	<0.1	6.9	<0.001	100	7.1	<0.1	0.2	<0.1	0	7.86	<0.1	19	<0.1	7.3
GBR-13	8611201735	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-17	8611211450	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-17	8606051230	OCD	<0.1	<0.1	0.01	0.3	<0.1	<0.1	730	<0.1	<0.1	<0.1	<0.1	<0.1	<0.001	60	<0.05	<0.1	<0.1	<0.1	0	5.9	<0.1	12	<0.1	<0.1
GBR-19	8611211510	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-24D	8611211105	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-24S	8611210945	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-27	8611211220	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-29	8606051525	OCD	<0.1	<0.1	0.08	0.4	<0.1	<0.1	814	<0.1	<0.1	<0.1	<0.1	<0.1	<0.001	83	5.8	<0.1	<0.1	<0.1	<0.1	9	<0.1	15	<0.1	<0.1
GBR-30	8611210930	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-31	8611211205	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SEEP	8510241430	OCD	NA	20	NA	5.4	0.8	ND	260	ND	ND	ND	ND	56	NA	36	7.2	ND	ND	ND	NA	2.1	ND	4.6	ND	0.1
SEEP	8606051905	OCD	<0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nominal Detection Limit			.05	.01	.05	.01	.005	.001	0.1	.01	0.1	.005	.002	.05	.0002	.01	.005	.01	.01	.001	.01	0.1	0.1	0.1	0.1	.004

GCL = Geoscience Consultants Ltd.
NA = Not analyzed for this parameter

EID = New Mexico Environmental Improvement Division
OCD = Oil Conservation Division

SEEP = Fire Fighting Drill Area Seep

TABLE 3-8
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

AROMATIC HYDROCARBONS
ORGANIC PARAMETERS

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	BENZENE	TOLUENE	ETHYL BENZENE	XYLENES PARA	XYLENES META	XYLENES ORTHO	XYLENES TOTAL
GBR-01	8606051115	GCL	ND	ND	NA	ND	ND	ND	ND
GBR-05	8601231410	GCL	830	638	229	-	-	-	2204
GBR-05	8606051745	OCD	530	200	1000	1000	2300	300	3600
GBR-05	8611201640	OCD	210	31	700	550	1400	81	2031
GBR-06	8611201545	OCD	70	ND	ND	1000	ND	240	1240
GBR-07	8610171550	GCL	8	10	11	-	-	-	33
GBR-07	8611201615	OCD	21	ND	ND	15	14	ND	29
GBR-08	8610171615	GCL	2670	1460	1890	-	-	-	6980
GBR-09	8610171630	GCL	41	66	54	-	-	-	138
GBR-09	8611210820	OCD	49	ND	ND	1	ND	1	2
GBR-10	8611210845	OCD	9500	1100	670	940	1600	590	3130
GBR-11	8604011412	GCL	<100	<100	<100	NA	NA	NA	<1000
GBR-11	8604010845	GCL	9.7	14.1	2.7	-	-	-	14.2
GBR-11	8605291615	GCL	9025	3088	NA	-	-	-	6981
GBR-11	8606051705	OCD	4600	3100	960	1000	2100	1100	4200
GBR-11	8611201515	OCD	6500	2800	680	690	1400	690	2780
GBR-13	8604151545	GCL	42	25	11	-	-	-	99
GBR-13	8605091550	GCL	129	32	3	-	-	-	105
GBR-13	8606051900	OCD	1300	12	130	250	410	71	731
GBR-13	8611201735	OCD	2900	1800	520	740	1500	630	2870
GBR-14	8610171215	GCL	ND	ND	ND	ND	ND	ND	ND
GBR-14	8611211135	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-15	8610171315	GCL	334	52	209	-	-	-	772
GBR-17	8605290830	GCL	ND	ND	NA	-	-	-	ND
GBR-17	8606051230	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-17	8607150730	GCL	ND	ND	NA	-	-	-	ND
GBR-17	8611211450	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-18	8605090925	GCL	ND	ND	ND	-	-	-	ND
GBR-18	8606051435	OCD	50	11	ND	ND	4	ND	4
GBR-18	8607081050	OCD	ND	1	ND	ND	ND	1	1
GBR-18	8607081100	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-18	8611211425	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-19	8610171515	GCL	112	105	111	-	-	-	306
GBR-19	8611211510	OCD	200	18	270	140	34	100	274
GBR-20	8605091040	GCL	ND	ND	ND	-	-	-	ND
GBR-20	8606051730	OCD	4	ND	<5	ND	ND	ND	ND
GBR-20	8611201711	OCD	41	ND	ND	28	22	ND	50
GBR-21	8605091700	GCL	ND	22	2	-	-	-	234
GBR-22	8605091350	GCL	ND	ND	ND	-	-	-	ND
GBR-23	8604181800	GCL	1513	823	NA	-	-	-	2092
GBR-24	8604181810	GCL	61160	58740	NA	-	-	-	120000
GBR-24	8605091625	GCL	1154	803	147	-	-	-	1020

TABLE 3-8 (CONT.)
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

AROMATIC HYDROCARBONS
ORGANIC PARAMETERS

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	BENZENE	TOLUENE	ETHYL BENZENE	XYLENES PARA	XYLENES META	XYLENES ORTHO	XYLENES TOTAL
GBR-24	8606052040	OCD	680	690	140	290	410	190	890
GBR-24S	8611210945	OCD	580	200	300	270	150	75	495
GBR-24D	8611211105	OCD	230	5	180	140	ND	7	147
GBR-25	8605091210	GCL	ND	ND	ND	-	-	-	ND
GBR-26	8605091515	GCL	ND	ND	ND	-	-	-	ND
GBR-26	8610171230	GCL	5280	119	54	-	-	-	1140
GBR-27	8605181400	GCL	ND	ND	ND	-	-	-	ND
GBR-27	8606052000A	OCD	410	120	ND	96	240	170	506
GBR-27	8606052000B	OCD	50	74	12	77	240	140	457
GBR-27	8510241435	GCL	5230	ND	3160	-	-	-	3250
GBR-27	8611211220	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-28	8605291600	GCL	2419	819	NA	-	-	-	4019
GBR-28	8607151900	GCL	319	143	NA	-	-	-	224
GBR-29	8606051525	OCD	2600	3000	600	700	1500	670	2870
GBR-29	8606051525	GCL	3818	3338	NA	-	-	-	5210
GBR-29	8605300945	GCL	388	643	NA	-	-	-	2000
GBR-29	8611201440	OCD	240	72	98	340	710	350	1400
GBR-30	8610171155	GCL	ND	ND	ND	ND	ND	ND	ND
GBR-30	8611210930	OCD	ND	ND	ND	52	28	9	89
GBR-31	8610171350	GCL	4	6	ND	-	-	-	14
GBR-31	8611211205	OCD	ND	ND	ND	ND	ND	ND	ND
GBR-32	8704301730	GCL	ND	ND	ND	NA	NA	NA	ND
GBR-39	8605091140	GCL	ND	ND	ND	-	-	-	ND
GBR-39	8610171330	GCL	144	148	179	-	-	-	356
SUPPLY WELL	8601231380	GCL	ND	ND	ND	NA	NA	NA	ND
SEEP	8606051905	OCD	28000	18000	1200	2200	5500	3000	10700
SEEP	8606051905	GCL	15500	11900	NA	-	-	-	ND
SEEP	8604011495	GCL	<1000	85000	42000	NA	NA	NA	36000
SEEP	8604011435	GCL	511000	103	48	-	-	-	1518
SEEP	8510241735	GCL	5230	ND	3160	-	-	-	3250
SEEP	8510241430	OCD	4100	ND	200	28	860	ND	888
SEEP	8510241450	OCD	2200	110	80	ND	80	ND	80
Nominal Detection Limit			1	1	1	-	-	-	1

GCL = Geoscience Consultants, Ltd.
OCD = Oil Conservation Division
NA = not analyzed for this parameter
ND = below detection limits
SEEP = Fire Fighting Drill Area Seep
\- = included in total xylene analysis

TABLE 3-9

GIANT BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSES

POLYNUCLEAR AROMATIC HYDROCARBONS
CONCENTRATIONS IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	NAPH	1-METHYL NAPH	2-METHYL NAPH	ACENAPTH -ALENE	ACENAPTHENE	FLUORENE	ANTHRACENE	PHENAN-THRACENE	FLUOR-ANTHENE	PYRENE	BENZO(a) ANTHRACENE	CHRYSENE	BENZO(b) FLUOR-ANTHENE	BENZO(k) FLUOR-ANTHENE	BENZO(a) PYRENE	DIBENZO(a,h) ANTHRACENE	INDENO (1,2,3-c,d) PYRENE	BENZO (g,h,i) PERYLENE
GBR-7	8610171550	GCL	ND	NA	NA	7	22	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-8	8610171615	GCL	50	NA	NA	244	473	78	69	4	ND	ND	3	ND	ND	ND	ND	ND	ND	ND
GBR-9	8610171630	GCL	49	NA	NA	19	48	7	16	ND	ND	10	7	ND	ND	ND	ND	ND	ND	ND
GBR-15	8610171315	GCL	ND	NA	NA	9	30	ND	7	ND	ND	8	ND	ND	ND	ND	ND	ND	ND	ND
GBR-19	8610171515	GCL	28	NA	NA	71	160	122	21	ND	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-26	8610171230	GCL	9	NA	NA	ND	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-27	8606052000	OCD	400	1100	2400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-31	8610171350	GCL	3	NA	NA	19	15	ND	14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-39	8610171330	GCL	ND	NA	NA	ND	6	ND	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nominal Detection Limits			1	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GCL = Geosciences Consultants Ltd.
OCD = Oil Conservation Division
ND = Below detection limits
NA = Not analyzed
- = No detection limit provided

TABLE 3-10
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS
CHLORINATED HYDROCARBONS

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	ACROLEIN	ACRYLON-ITRILE	BROMOFORM	CC14	DIBROMO-METHANE	DICHLORO-METHANE	DICHLORO-BROMOMETHANE	CHLORODI-BROMOMETHANE	CHLOROETHANE	2-CHLOROETHYL-VINYL ETHER	CHC13	1,1DCA	1,2-DCA	1,1-DCE
GBR-05	8608051745	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-05	8611201640	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-06	8611201545	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND
GBR-07	8611201615	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-09	8611210820	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	6	ND
GBR-10	8611210845	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND
GBR-11	8606051705	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND
GBR-11	8611201515	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND
GBR-13	8606051900	OCD	NA	NA	ND	ND	ND	25	ND	ND	ND	ND	ND	25	58	ND
GBR-13	8611201735	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	44	32	ND
GBR-14	8610171215	GCL	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-14	8611211135	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	ND
GBR-15	8610171315	GCL	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	78	ND
GBR-17	8606051230	OCD	NA	NA	ND	ND	ND	15	ND	ND	ND	ND	ND	20	ND	ND
GBR-17	8607150730	GCL	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND	ND	NA	ND
GBR-17	8611211450	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	6	ND	ND
GBR-18	8606051435	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-18	8611211425	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-19	8610171515	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	12	5.9	ND
GBR-19	8611211510	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	10	ND
GBR-20	8606051730	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND
GBR-20	8611201711	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-24	8606052040	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-24S	8611210945	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	60	ND
GBR-24D	8611211105	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	69	ND
GBR-26	8610171230	GCL	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	66	ND
GBR-27	8606052000A	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-27	8606052000B	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6	ND

TABLE 3-10 (CONT.)
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

CHLORINATED HYDROCARBONS

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	SAMPLE SOURCE	ACROLEIN	ACRYLON-ITRILE	BROMOFORM	CC14	DIBROMO-METHANE	DICHLORO-METHANE	DICHLORO-BROMOMETHANE	CHLORODI-BROMOMETHANE	CHLOROETHANE	2-CHLOROETHYL-VINYL ETHER	CHC13	1,1DCA	1,2-DCA	1,1-DCE
GBR-27	8510241435	GCL	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
GBR-27	8611211220	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	ND
GBR-28	8607151900	GCL	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND	ND	NA	ND
GBR-29	8606051525	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	36	ND
GBR-29	8611201440	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	34	ND	ND
GBR-30	8610171155	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND
GBR-30	8611210930	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-31	8610171350	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	11	ND	ND
GBR-31	8611211205	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	22	ND	ND
GBR-32	8704301730	GCL	NA	NA	ND	ND	NA	NA	NA	NA	ND	ND	ND	7.3	ND	ND
GBR-39	8610171330	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	31	ND
SEEP	8606051905	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	50	ND	49	ND
SEEP	8611211535	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND
Nominal Detection Limits			25	25	5	5	5	5	5	5	5	5	5	5	5	5

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed
ND = below detection limits

It must be recognized that increased TDS in the aquifer could be due to a number of factors which have little or nothing to do with refinery activities, such as increased recovery of saline fluids which are naturally occurring or were disposed of in the Lee Acres Landfill.

3.5 CONTINGENCY PLAN

The design of the remedial action, appropriate monitoring and the presence of a trained systems operator will minimize the chances of implementing a contingency plan. At the present time the following system failures are possible and must be addressed:

- malfunction of the air stripper
- malfunction of recovery pumps

If an air stripper is required, its failure would not result in serious problems. Sufficient storage does exit on site to permit storage of pumped water during air stripper repair. Periodic cessation of pumping is often recommended for product recovery remedial actions. Therefore, periodic shutdown of the recovery system may accompany servicing of the air stripper.

Several auxiliary recovery wells are presently "on standby" in the Southern Refinery Area. If one of the primary wells requires service, one of these auxiliary wells may be called into service. Because the southern refinery recovery system is predicted to be able to intercept any petroleum hydrocarbons which may be emanating from the refinery (See Appendix A), auxiliary wells in the Truck Fueling Area or the diesel spill area are not necessary.

It is not practical to attempt to foresee all possible scenarios which might need to be addressed. Giant proposes to develop and implement such contingency plans when appropriate.

4.0 SPILL/LEAK PREVENTION AND HOUSEKEEPING PRACTICES

4.1 OPERATING AND MAINTENANCE PROCEDURES

Although the Giant Bloomfield Refinery is not currently an active refinery, the site is being used for other activities by Giant. An office of Ciniza Pipe Line, Inc. is located on the site. The Crude Oil branch of Giant's Transportation Division operates a dispatching and truck maintenance facility from this location. Although these operations are relatively small, they are operated in a manner to prevent and mitigate any unplanned releases to the environment.

Processes and storage units associated with the remedial action or on-site operations are regularly observed by a number of personnel during normal operations, and any evidence or sign of spills/leaks is promptly reported to supervisory personnel so that repairs or cleanup can be effected. Berms around storage tanks at the refinery site are designed to contain any unplanned spills or releases. The proposed berm at the truck fueling facility will also minimize the impact of accidental releases.

Routine maintenance procedures conducted at the Giant refinery also help to assure that equipment remains functional and that the possibility of spills/leaks is minimized.

4.1.1 Pipe Testing

In addition to routine visual inspection of above ground piping systems, all piping utilized in the remedial action will be subjected to an air pressure test prior to use. The piping will be pressurized to 1 1/2 times the working pressure but not less than 50 psi, and the pressure maintained and monitored for a minimum of 60 minutes. Prior to installation, leaks may be detected by soaping all joints, while the system is under pressure (API 1615, November 1979).

Hydraulic pressure tests, will also be conducted on an annual basis to ensure continued integrity.

4.1.2 Tank Inspection

The storage tanks to be used in remediation and the existing process tanks (diesel storage tank and waste oil tank) will be subject to a monthly visual inspection by plant personnel.

4.1.3 Berm Integrity

All diversion and containment berms will undergo monthly visual inspection to ensure integrity.

4.2 TRUCK FUELING

At the Truck Fueling Area, an underground piping system is used to transport diesel fuel and its condition is not visible. To determine the integrity of the existing pipe, the piping will be subjected to a hydraulic test of 1½ times the working pressure but not less than 50 psig for a minimum of 60 minutes (Pace, February 1983).

In the event that a leak is detected, repairs will be made as necessary. Once the system is again operating, proper inventory control will be maintained to detect any product leakage. In addition, a monthly inspection of the Truck Fueling Area will be conducted to detect evidence of fuel surfacing from the system.

A concrete berm will be constructed around the fueling pad to contain loading spills.

A long term upgrade is proposed for the entire underground piping system. The pipe will be excavated and replaced with schedule 40 steel pipe that is galvanized, wrapped, or cathodically protected.

4.3 CHEMICAL AND ENVIRONMENTAL HAZARDS

Very small quantities of chemicals (such as Stoddard solvent and housekeeping supplies) are used at the Giant Refinery. Any spills or leaks would be very small in volume and easily contained in and removed from the immediate area.

4.4 CLEANUP PROCEDURES

Cleanup procedures would obviously vary with the nature and extent of any unplanned release. Potential methods are described below:

Spills or leaks of potentially contaminated water could occur from the long term storage tanks. Spills and leaks of product may occur from the diesel storage tank and the waste oil tank. Any release from these tanks would be contained in the berm around the tank.

If an oil spill occurs, general cleanup procedures would involve minor earthwork to prevent migration, and recovery of as much free liquid as possible. Recovered oil would then be transported to a pipeline injection system for inclusion as crude oil. Any material which may have soaked in the soil will be further investigated to determine if it can be left in place and allowed to naturally biodegrade or if removal or active remediation is necessary.

4.5 REPORTING

Should a release of materials occur, Giant will provide oral notification to NMOCD as soon as possible after discovery as required by WQCC Regulation 1-203.

4.6 GENERAL HOUSEKEEPING PROCEDURES

Chemicals are used in relatively small quantities at the refinery and are managed in a manner to prevent discharges to the environment. Any chemical spills which might occur would be immediately contained and disposed of according to proper practices.

Chemicals such as cleaning solvents are collected and recycled. Giant currently uses a non-halogenated solvent, Stoddard, for degreasing operations. The spent solvent which contains various aromatic and paraffinic hydrocarbons is combined with waste motor oil and is shipped off-site for recycling. No solvent is disposed of on site.

4.7 CLOSURE PLANS

The following closure plans explain the methods for closure of land discharge sprinkler systems and infiltration trenches, the network of monitoring/pumping wells, and the removal of any air strippers and their associated hardware. Abandonment of all trenches, wells, and hardware shall be started only after final confirmation by NMOCD that remediation is complete.

4.7.1 Sprinkler System/Infiltration Trench Closure

All plumbing/piping associated with the sprinkler system will be disconnected to prevent unauthorized use. All pipelines leading to the infiltration trenches will be disconnected and capped. The infiltration trenches shall be left in place.

4.7.2 Well Closures

All recovery and non-required monitor wells will be backfilled with bentonite grout.

4.7.3 Air Stripper Closure

Any air strippers and all associated hardware will be dismantled and removed from the site.

4.7.4 Berm Closure

Berms established for remedial actions - those around the contaminated soil site in the Southern Refinery Area and the excavated soil area- will be destroyed and the soil spread to resemble the original surface contours.

4.7.5 Fire Water Pond

The fire water storage pond is located at the northern end of the refinery property (Plate 1). The water is replenished on an as-needed basis from the San Juan River and is used by the County for McGee Park and San Juan Downs fire protection. Giant has discussed the need and obligation for the upkeep of this pond with San Juan County officials. As a result of these discussions the pond will be drained in the near future.

5.0 SITE CHARACTERISTICS

5.1 CLIMATE

The climate in the San Juan Basin is generally arid to semiarid, but precipitation varies considerably across the region (Table 5-1). Highest values of annual precipitation are associated with mountainous areas; 30 inches at Mount Taylor, 25 inches in the San Pedro Mountains, and 20 inches in the Chuska Mountains. In the central part of the basin, annual precipitation is generally 10 inches; values as low as 8 inches occur along the San Juan River west of Farmington and along the north-flowing reach of the Chaco River (Stone and others, 1983).

Most precipitation (approximately 60% of the total) occurs during summer months as local, often intense, thunderstorms. Higher elevations also receive considerable winter precipitation. The source of summer moisture generally is the Gulf of Mexico; the source of winter precipitation is the Pacific Ocean. Mountain barriers and the long distances lying between both of these sources and northwest New Mexico account for its aridity (Stone and others, 1983).

Maximum temperatures generally occur in July, and minimum temperatures in January. The highest maximum temperatures are associated with the lower elevations, such as the valleys of the Chaco and San Juan Rivers; lowest minimum temperatures are associated with the higher elevations (Stone and others, 1983).

Wind directions in the basin vary locally because of topography. Along the San Juan River, for example, easterly and westerly winds dominate, owing to the east-west orientation of the valley. Spring is the windiest season and spring wind velocities are strongest, averaging 10-12 mph, whereas summer winds average only 8 mph (Stone and others, 1983).

Class-A pan evaporation data for the region are sparse. An annual average of 67.37 inches has been reported for a station 3 miles northeast of Farmington for the period 1948-1962; the highest monthly value, 10.50 inches, was observed in June and the lowest value, 0.74 inches, was

TABLE 5-1 AVERAGE ANNUAL TEMPERATURE AND PRECIPITATION AT SELECTED STATIONS IN THE SAN JUAN BASIN

[1]Figures and letters indicate distance (mi) and direction from Post Office; [2]SJ = San Juan, MK = McKinley, SDV = Sandoval, RA = Rio Arriba, V = Valencia

Station	Elevation (ft)	Temperature: Mean max. (°F)	Temperature: Mean min. (°F)	Temperature: Yrs of record	Precipitation: Mean annual (inches)	Precipitation: Yrs of record	County and source[2]
Aztec Ruins National Monument	5,640	68	35	30	9.33	59	SJ
Bloomfield (35E)[1]	5,794	68	35	51	8.46	60	SJ
Chaco Canyon National Monument	6,125	68	34	25	8.67	28	SJ
Crownpoint	6,978	64	38	41	10.48	47	MK
Cuba	6,945	64	29	20	14	22	SDV
Dulce	6,950	63	25	43	17.08	52	RA
Farmington Airport	5,494	67	37	19	8.12	20	SJ
Fruitland	5,165	69	36	47	6.96	55	SJ
Ft. Wingate	7,000	64	36	34	13.62	69	MK
Gallup	6,465	67	31	8	9.44	12	MK
Grants–Milan Airport	6,520	66	32	8	8.83	13	V
Laguna	5,815	69	38	42	9.86	48	V
Lybrook	7,160	62	34	8	12.01	9	RA
Newcomb	5,565	70	35	11	5.35	13	SJ
Regina	7,450	62	29	42	16.15	46	SDV
Shiprock (1E)[1]	4,974	70	37	29	7.04	32	SJ
Tohatchi	6,800	66	39	34	10.47	43	MK

SOURCE: Stone, W.J. and others, 1983

observed in December. The average evaporation during the period May through October is 46 inches at El Vado Dam (28 mi southeast of Dulce) and 52 inches at Gallup; annual values of 63 inches and 72 inches have been estimated for these two stations, respectively (Stone and others, 1983). Potential evapotranspiration (PET) for the Farmington area is presented in Table 3-4 (Sammis and others, 1979).

5.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

The Giant Bloomfield Refinery is located in the west-central part of the San Juan Basin, a large asymmetric structural depression that contains up to 15,000 feet of Paleozoic and Mesozoic sediments (Figure 5-1). The greatest recorded stratigraphic thickness in the basin is 14,423 feet in an oil well located in Section 7, T.29 N, R.5 W near the structural center of the basin (Fassett and Hines, 1971).

The stratigraphy of the San Juan Basin is comprised of sedimentary rocks ranging in age from Cambrian to Holocene. During Late Cretaceous time, three basin-wide cycles of transgression and regression resulted in an intertonguing lithology of sandstone, siltstone, shale and coal found throughout the Cretaceous rocks in the basin. Sedimentary rocks of Jurassic and Cretaceous age crop out around the rim of the basin and over a broad area in the southern and western parts of the basin. Tertiary sedimentary rocks cover most of the central basin. Quaternary deposits are restricted mainly to the major river valleys. Quaternary deposition included the formation of outwash terraces along the San Juan River and its tributaries (Pleistocene), the growth and migration of sand dunes on higher plateaus (Pleistocene and Holocene), and the cutting and filling of alluvial channels throughout the area (Stone and others, 1983). Figures 5-1 and 5-2 illustrate the geologic structures and stratigraphy in the region.

The alluvial material in the San Juan River Valley forms the aquifer utilized for many water supply wells. In the side canyons, bedrock aquifers are typically employed for small domestic water supply wells.

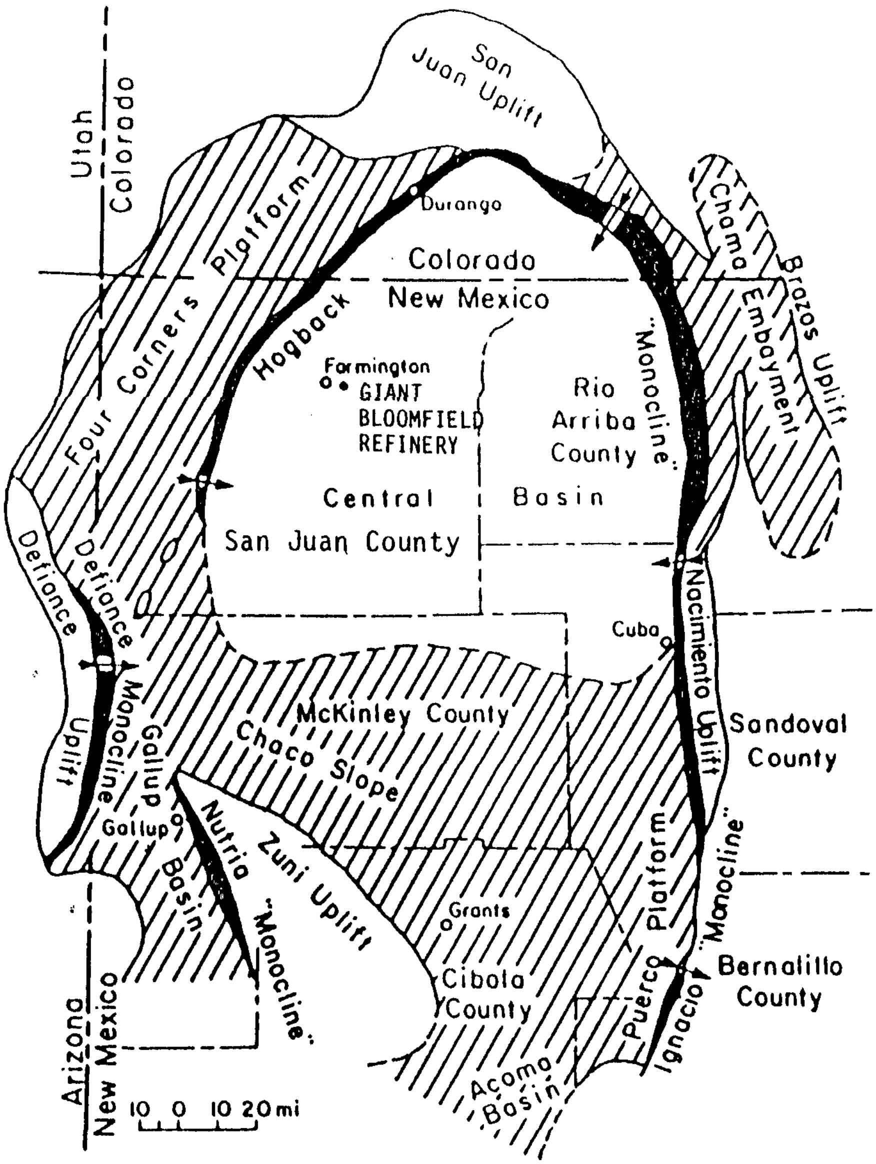


FIGURE 5-1

GEOLOGIC STRUCTURAL ELEMENTS IN THE SAN JUAN BASIN

(Source: Stone and Others, 1983)

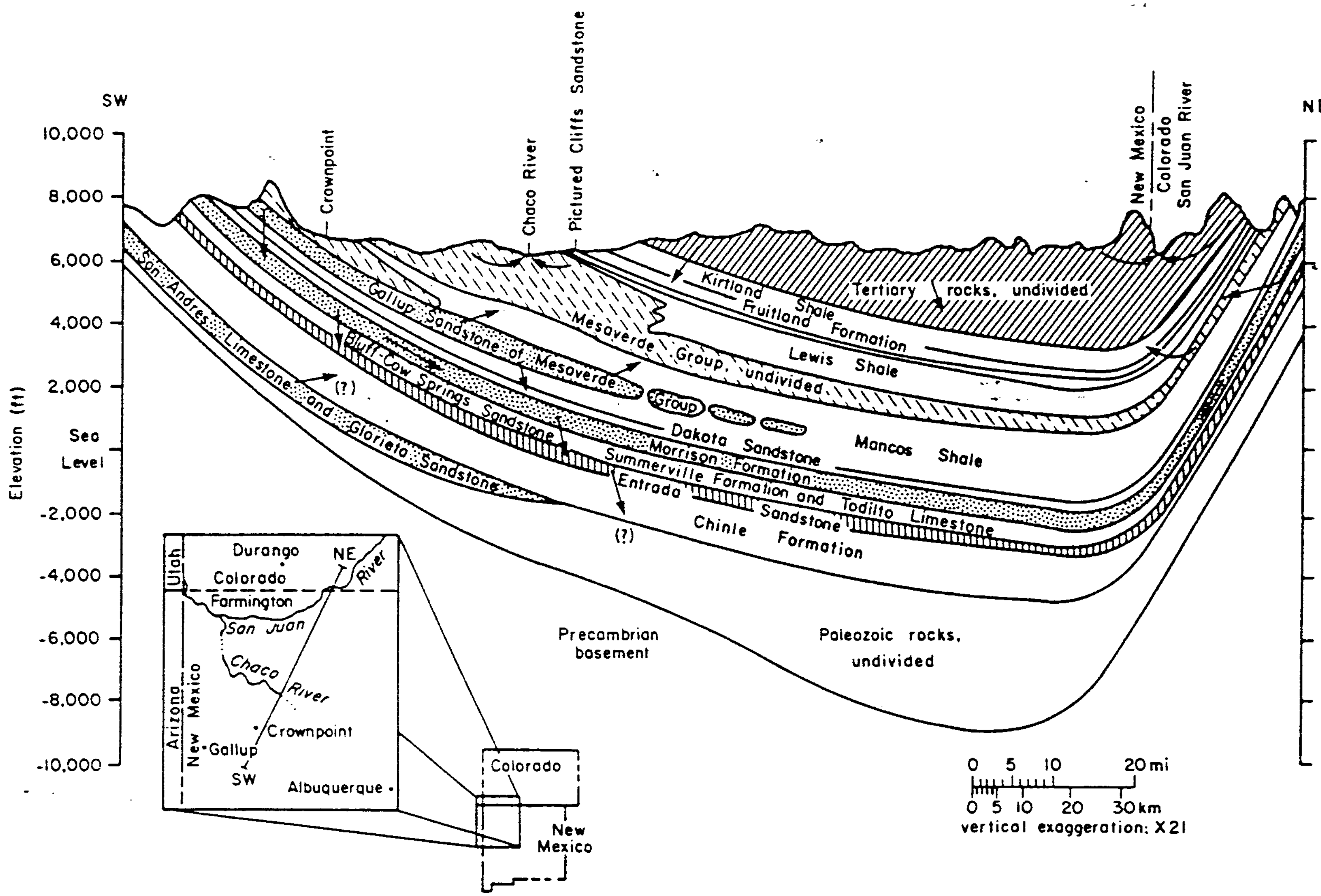


FIGURE 5-2

GENERALIZED HYDROGEOLOGIC CROSS-SECTION OF SAN JUAN BASIN, Showing Major Aquifers (stippled), Confining Beds (blank), And Directions of Ground Water Flow (arrows).
(Source: Stone and Others, 1983)

Three major ground-water systems are present in the Cretaceous and younger sedimentary deposits of this area of the San Juan Basin:

- Confined aquifers within Cretaceous and Tertiary sandstone units
- Water-table aquifers in Cretaceous and Tertiary sandstone units near outcrop areas
- Water-table aquifers in Quaternary alluvium in river valleys and along tributary channels

The Cretaceous sandstone aquifers of the San Juan Basin were deposited along strandplain beaches or at wave-dominated delta fronts in various coastal environments. The complexity of these intertonguing fluvial and marine deposits is a result of alternating transgressive/regressive pulses of the Cretaceous epicontinental sea. Occurrence of ground-water resources is associated with these sandstone aquifers, and is a function of their distribution and stratigraphic relationship with the less permeable units containing these sandstones. Recharge of the aquifers in Cretaceous sandstones is dependent upon outcrop distribution, elevation, climate in outcrop areas, lithologic characteristics of the unit and leakage from other units. Outcrops generally occur as narrow sinuous belts, few of which lie in areas of high precipitation. Most recharge is a result of the limited infiltration in outcrop areas, although leakage from adjacent units occurs locally. Hydraulic conductivity is generally low due to the fine-grained textures characteristic of these marine sediments.

Ground-water quality in Cretaceous sandstone aquifers is controlled by several factors. Total dissolved solids (TDS) concentrations increase as a function of increasing ground-water residence time and reduced transmissivity of aquifer materials. Fresher water is associated with high-transmissivity zones while saline water is associated with low-transmissivity zones. Ground water moving along the sandstone-shale interfaces that are common to these rocks tends to exhibit increased TDS concentrations (Stone and others, 1983). Water from these confined aquifers is suitable for stock and domestic use in some areas, although in most cases it is not considered a major source.

The Tertiary sandstone aquifers of the basin were deposited in fluvial or alluvial environments. Recharge to ground water is by infiltration through formation exposures along the flanks of the Nacimiento Uplift and on the broad plateaus that occur in the central part of the basin. The amount of recharge to Tertiary aquifers is higher than that of Cretaceous aquifers due to broader exposures in areas of high precipitation. Ground water in these aquifers flows from upland recharge areas to discharge areas along canyon floors. Springs and seeps result due to regional topographic and geomorphic controls. The hydraulic gradient is controlled primarily by topography, but is also affected by the structural attitude of the formations. Erosion has removed these units from much of the basin flanks.

Tertiary-sandstone aquifers have generally lower TDS concentrations than Cretaceous aquifers and commonly provide major sources of water for domestic and agricultural usage. The complex intertonguing of sandstone and shale units is the primary influence on TDS, as shown by values of specific conductance, which can be as high as 10,500 micromhos per centimeter (umhos/cm). One umhos/cm is roughly equivalent to 0.65 parts per million (ppm) of TDS.

Quaternary-sediment hosted aquifers occur primarily as valley fill in the major river valleys and consist of gravel, sand, silt and clay. Groundwater recharge results from drainage from irrigated lands, infiltration of surface runoff and leakage from bedrock aquifers. Flow directions are concurrent with topographic slope and river-flow directions, and hydraulic conductivity can be extremely high.

The quality of ground water in Quaternary river valley alluvium is highly variable and specific conductance may range from less than 1,500 to 6,000 umhos/cm (Stone and others, 1983). Water from this source is used for stock, irrigation and domestic purposes. In arroyos and tributaries of the major rivers, the ground-water quality is also highly variable; locally, specific conductance can be significantly higher than 6,000 umhos/cm.

5.3 SITE HYDROGEOLOGY

The refinery is located on weathered outcrops of the Nacimiento Formation which is comprised of shales, sandstones and siltstones of Cretaceous-Tertiary age. Immediately to the west is a large unnamed arroyo which is underlain by Quaternary alluvial sediments. Older Quaternary terrace deposits of cobbles and boulders are observed on the interfluvial ridges adjacent to the arroyo. These terrace deposits may have been utilized as fill on the refinery site. The San Juan River Valley is located south of the site and contains up to several hundred feet of alluvial fill.

The uppermost zone of ground water in the refinery area is an unconfined to partially confined water-table unit which is hosted by the weathered, locally porous sandstones and shales of the Nacimiento Formation and arroyo alluvium. These apparently discharge to the San Juan River alluvium to the south. Figure 5-3 is a generalized east-west cross section across the refinery site showing the relationship of the arroyo-fill to bedrock. Major hydrogeologic relationships are:

- An interconnected water-table aquifer, hosted by both valley and arroyo fill and the upper parts of the Nacimiento sandstone
- Ground water at a depth of 25 to 45 feet beneath the land surface
- An upper water-table surface generally conforming to topography; ground water slopes and flows from north or northeast to south (towards the San Juan River) through the refinery area
- Minor, local zones of perched ground water, lying 5 to 30 feet above the water table

Plate 1 shows an overall view of the site. Plates 2A and 2B present hydrogeologic cross sections of the refinery site, and the borings used to construct them. The specific locations of the cross sections on

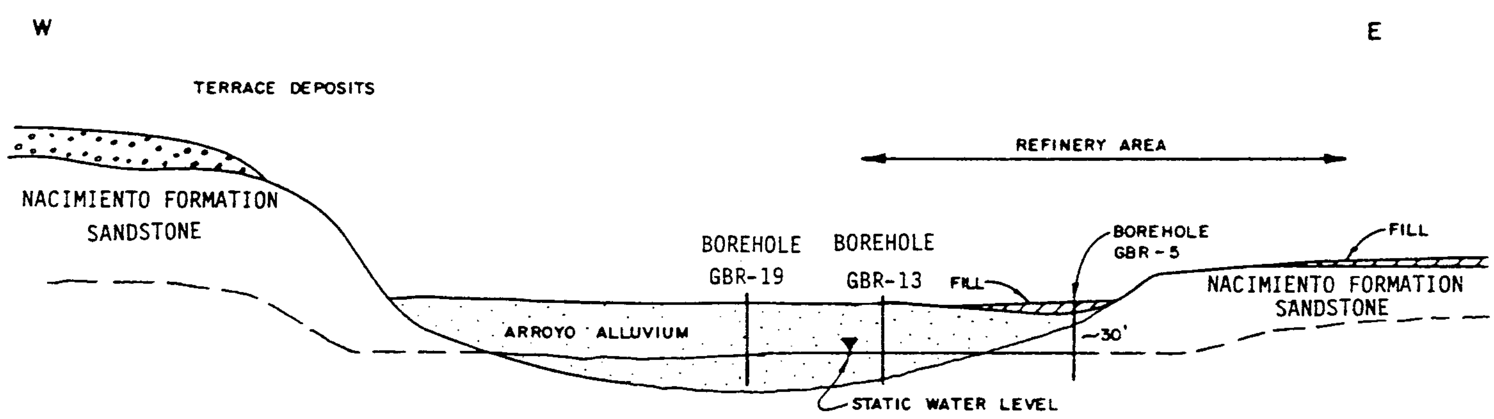


FIGURE 5-3

GENERALIZED EAST-WEST HYDROGEOLOGIC CROSS-SECTION ACROSS REFINERY SITE the refinery site are shown on Plate 3. Appendix B presents lithologic logs and completion diagrams for the monitor wells on site.

Water levels and floating product thicknesses of all wells on the refinery property were measured from April 1986 through present. A record of these measurements is shown in Appendix C. A water-table contour map was prepared (Figure 5-4) based on the static water levels of all the wells at the refinery measured in November 1986. This map is representative of static conditions of the aquifer since recovery pumping was not being done at the time.

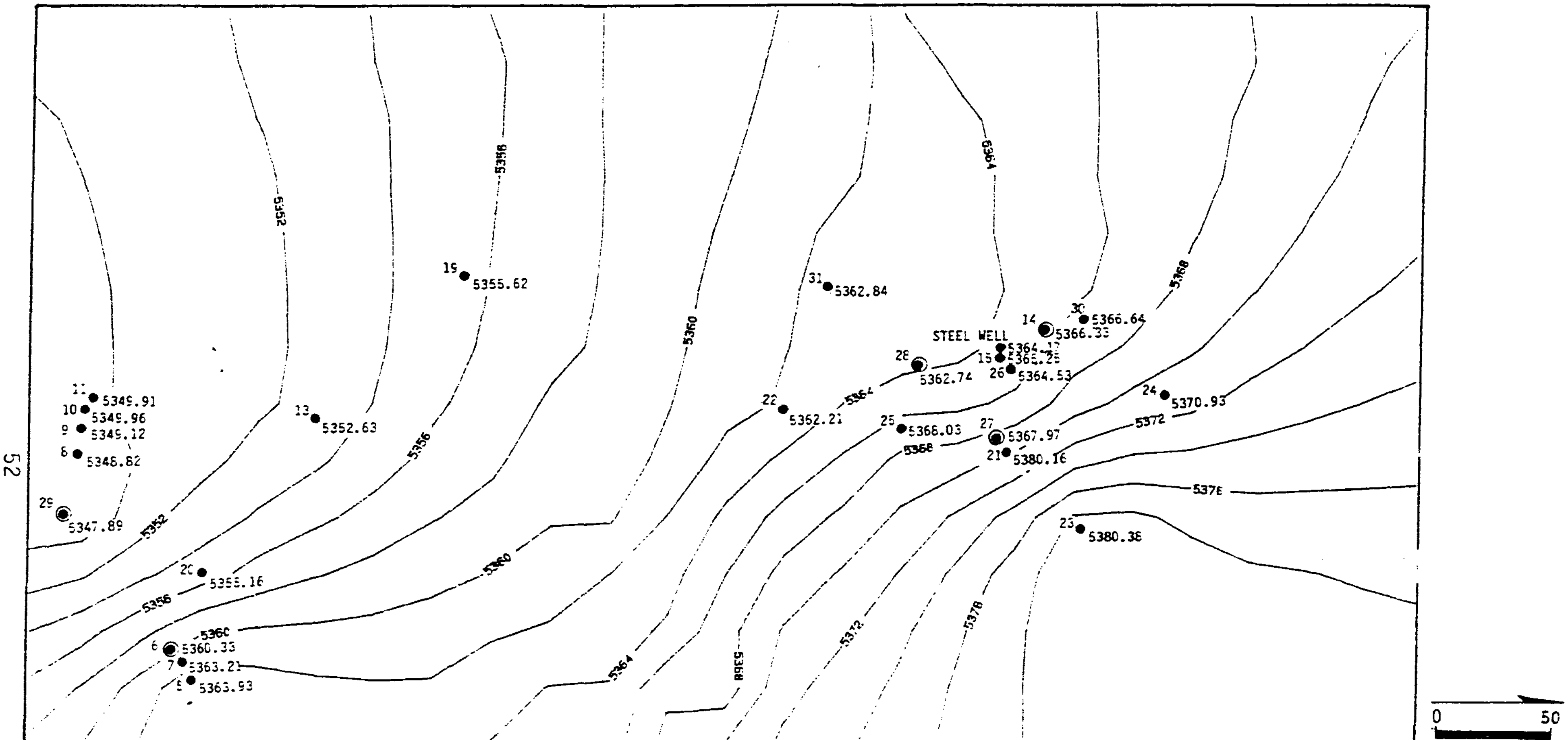
The effects of floating product on the water levels were considered in the maps by multiplying product thickness (Appendix C) by 0.8 and adding the result to the measured water elevation. Product density in the area is approximately 0.8 g/cm^3 (Table 5-2) and this calculation corrects for the difference in density between floating product and water. The result provides a value that is the actual potentiometric surface.

The water-table surface depicted in Figure 5-4 generally conforms to local topography. The ground-water gradient slopes and flows from:

- north to south in the arroyo toward the San Juan River
- northeast to southwest from east of the arroyo
- east to west at the arroyo boundary near the Diesel Spill Area

The water-table contour map presented in this report was generated by computer and represent the probable contour lines as interpreted from a significant number of data points.

Several pump tests were conducted in the Diesel Spill Area and the Southern Refinery Area. Analysis of the pump tests revealed small values of transmissivity and storativity observed near GBR-27 and GBR-14 and much higher values near GBR-29 in the Southern Refinery Area (Table 5-3).



Elevations in Feet above Sea Level, Measured in Monitor and Recovery Wells and Corrected for Floating Product, if Present.

FIGURE 5-4

GROUND WATER LEVEL CONTOUR MAP - GIANT BLOOMFIELD REFINERY, NOV. 1986

TABLE 5-2

GIANT BLOOMFIELD REFINERY
PRODUCT VISCOSITY DATA

WELL NO.	SAMPLE NO.	API GRAVITY	SPECIFIC GRAVITY[1]
GBR 5	8610071647	45.3	0.800
GBR 10	8610071630	46.1	0.797
GBR 11[2]	----------	46.1	0.797
GBR 13	8610071605	43.8	0.807
GBR 21[2]	----------	43.8	0.807
GBR 28	8610071540	34.2	0.854
GBR 29	8610071619	44.2	0.805

Samples Collected By GCL, Analyzed by Ciniza Refining Company

1 = at 20°C, calculated from API gravity
2 = determined by visual comparison with analyzed samples

TABLE 5-3

SUMMARY OF TRANSMISSIVITIES (T)
AND STORATIVITIES (S)
GIANT BLOOMFIELD REFINERY

DIESEL SPILL AREA	T(gpd/ft)	S
GBR 14	792	NA
GBR 15	128	0.0045
GBR 25	387	0.00016
GBR 27	126	NA
SOUTHERN REFINERY AREA		
GBR 8	2340	0.051
GBR 29	1040	NA

NA = Not Applicable
(S cannot be estimated at pumped wells due to borehole storage effects)

This implies that fine-grained sandstone, shale, and clay are more predominant in the northern part of the Diesel Spill Area and that coarse-grained sandstone dominates the geology in the southern part of the Diesel Spill Area and the Southern Refinery Area. Flow conditions appear to range from confined near GBR-27 where shale is present, to semi-confined near GBR-14 where clay is present, to unconfined near GBR-29, where clay and shale may be intermittently present but do not significantly affect flow. Descriptions of the pump tests and analysis of results are presented below.

5.3.1 Hydraulic Characteristics of the Diesel Spill Area

The first pump test was conducted using GBR-27 which is located in the center of the Diesel Spill Area plume. The well was pumped for 16 hours at a rate of 0.88 gpm on April 30 and May 1, 1986. A 24 hour test was planned but the well was pumped dry and the test was terminated early. The pumped well had a drawdown of 21 ft. at the end of the test, and an observation well 85 ft. away (GBR-25) had a drawdown of 8 inches.

Drawdown and recovery data for this pump test along with plots of drawdown and recovery versus time and a thorough analysis of the data are shown in Appendix D. These data were analyzed by both the Jacob and Theis methods and the following aquifer parameters were obtained using the data from both GBR-27 and GBR-25 correcting for borehole storage effects and for the effects of floating product which was present in GBR-27:

WELL AND TYPE OF ANALYSIS	TRANSMISSIVITY (gpd/ft)	STORATIVITY
GBR-27		
Theis	20.2	NA
GBR-25		
Theis	183.4	0.00028

Since floating product was not present in GBR-25, its calculated values for transmissivity and storativity are probably more reliable estimates of the consolidated aquifer parameters. For a saturated screened interval of 26 feet, the hydraulic conductivity was estimated to be 0.78 gpd/ft^2 near well GBR-25. This conductivity is well within the range of that normally encountered in sandstone (Freeze and Cherry, 1979). Storativities estimated on the basis of data from observation well GBR-25 are well within the range of storativities generally associated with confined or partially confined units.

A pump test was conducted using GBR-14 on November 6, 1986, in order to better define the characteristics of the alluvial aquifer in the Diesel Spill Area. GBR-14 was step tested at 1 and 5 gpm and subsequently test pumped at 2 gpm. Even at this low pumping rate, the well was pumped dry after 4 hours.

Data obtained during the pump test along with graphs of drawdown and recovery versus time and a detailed analysis of the data are shown in Appendix D. The graphs prepared from the drawdown data exhibit two distinct inflection points which occur at the end of casing and borehole dewatering.

Transmissivities obtained on the basis of early drawdown data at the pumped well (GBR-14) are fully discussed in Appendix D and are summarized below:

ESTIMATED TRANSMISSIVITY OF THE ALLUVIAL AQUIFER NEAR GBR-14

T (gpd/ft)

Pump Test	Theis Analysis
3 (Q = 5 gpm)	10.4
5 (Q = 2 gpm)	8.8

Using the average of the Theis values, the transmissivity of the alluvial aquifer was estimated at 9.6 gpd/ft. Assuming an average saturated thickness of 28 ft., this translates into a hydraulic conductivity of 0.34. gpd/ft^2, which is within the range of conductivity expected for clayey gravel.

Drawdown observed at well GBR-15 was not analyzed because a sufficient number of points are not available to warrant pump test analysis.

Estimated transmissivities for the Diesel Spill Area suggest that the Area is underlain by nonhomogeneous units comprised of sandstone and silty-to-clean sand and gravel.

A combined pump test utilizing GBR-14, GBR-27 and GBR-28 was conducted on November 19-21, 1986, for the purpose of identifying the combined effects of the three wells on the aquifer in the area of the floating product plume. The data from the test is presented in Appendix D along with plots of drawdown verses time for the three pumped wells and 6 observation wells.

No measurable drawdown response was observed in GBR-26 and only small drawdowns were observed in GBR-30 and GBR-39 even though they were each about 50 feet from the pumped wells. These wells were screened within clayey sand or sandy clay located at the base of the alluvium in which GBR-14 was screened. Since there appears to be hydraulic communication between the coarser grained alluvium and the underlying clayey sand and sandy clay layers, as indicated by the response in well GBR-15 which was also screened in these layers, it is likely that silt has migrated through the gravel pack and may be lodged in the screens of the unresponsive wells. Alternatively, there could be a higher incidence of clay or shale between GBR-14 and the unresponsive observation wells than between GBR-14 and GBR-15, but given the closeness of the responsive and unresponsive observation wells this does not appear likely. Due to the nonhomogeneity of the deposits, it was not possible to explicitly separate drawdown effects due to pumping at each well. Analysis of the 3-well pump test data was therefore not performed.

5.3.2 Hydraulic Characteristics of the Southern Refinery Area

A pump test was conducted using GBR-29 in the Southern Refinery Area November 4-7, 1986. The data from this test and thorough analysis are presented in Appendix D.

It was expected from observations during drilling of the well and from the experience of other wells on the site that GBR-29 would probably have a capacity of only about 1 gpm. Test pumping at 1 gpm, however, produced almost no drawdown and a rate of 2 gpm was subsequently used for the test. At 2 gpm, GBR-29 exhibited a drawdown of 9.0 inches after 31 hours and the nearest observation well, GBR-8, had a drawdown of 2.0 inches.

Transmissivity calculated on the basis of data from GBR-29 was estimated as 1042 gpd/ft., while transmissivity and storativity from the observation well (GBR-8) were determined to be 2339 gpd/ft. and 0.051, respectively, as tabulated below:

WELL	T(gpd/ft)	S
GBR-29	1042	NA
GBR-8	2339	0.051

Transmissivities calculated from the test can be viewed as overall transmissivities for the unconfined system occurring throughout the alluvium and sandstone in the absence of containing shale units. An average transmissivity of 1690 gpd/ft. can therefore be used to characterize the unconfined alluvial system underlying the Southern Refinery Area. The larger transmissivity relative to values observed in the Diesel Spill Area suggests that coarse-grained sandstone predominates in the Southern Refinery Area.

It is concluded that the alluvium and sandstone underlying the Southern Refinery Area are hydraulically connected in the vicinity of GBR-29 and GBR-8. This system is generally unconfined, but confined conditions may exist locally beneath shale units of limited areal extent.

5.3.3 Hydrogeologic Characteristics of the Truck Fueling Area

Seven exploratory boreholes were drilled in the Truck Fueling Area. Three of these were developed into 2-inch diameter recovery wells (GBR-22, GBR-34 and GBR-35). A 6-inch diameter recovery well was also installed (GBR-36). The lithologic logs of all the wells and boreholes are presented in Appendix B.

The hydrogeologic characteristics of the Truck Fueling Area are similar to those of the nearby Diesel Spill Area. Since an aquifer analysis was performed previously in the Diesel Spill Area, it was not considered necessary to perform such analysis in the Truck Fueling Area.

5.4 SURFACE WATER HYDROLOGY AND FLOODING POTENTIAL

An unnamed arroyo, which drains the site area, is a tributary to the San Juan River. Surface flow in the San Juan River is controlled by Navajo Dam, which forms a reservoir with a 1,700,000 acre-feet capacity (Stone, et al., 1983). The site area is located downstream from Navajo Dam and upstream from the San Juan/Animas River and the San Juan/La Plata River confluences. Because the Giant Bloomfield Refinery is located 100 feet higher (outside the floodplain of the 100 yr. flood) than the San Juan River, flooding potential from the San Juan is negligible (Appendix E).

The major local drainage is the unnamed arroyo. This ephemeral drainage flows north to south for approximately 22,000 feet at a 0.024 topographic gradient before reaching the refinery area. The volume of water produced by a 100 year flood event (Table 5-4) can be easily contained by this arroyo; therefore no operation or remediation facilities at the refinery are subject to flooding from a 100-year flood event. Cross section B/B′ (Plate 2A) illustrates the maximum extent of flooding on a 100-year cycle. The maximum flood extent in cross section B/B′ illustrates a worst case scenario in consideration of the choking effects caused by the culvert beneath U.S. Highway 64.

TABLE 5-4

HYDROLOGIC DATA SHEET FOR UNNAMED ARROYO
WEST OF GIANT BLOOMFIELD REFINERY

RECURRENCE INTERVAL:	10 YEARS	25 YEARS	50 YEARS	100 YEARS
Rainfall (24 hour)	1.7 in.	2.0 in.	2.3 in.	2.6 in.
Direct Runoff (Q)	0.40 in.	0.58 in.	0.75 in.	1.0 in.
Net Runoff (Qn)	0.28 in.	0.41 in.	0.53 in.	0.70 in.
Peak Discharge (cfs)	591.72 cfs	866.44 cfs	1120.04 cfs	1479.30 cfs
Volume of Runoff (acre-ft)	94.82 acre-ft	138.85 acre-ft	179.49 acre-ft	237.06 acre-ft

Note: Computations in Appendix E follow methods cited in Chapter 2, U.S.D.A. Soil Conservation Service Engineering Manual for Conservation Practices.

No distinct drainage patterns cut across refinery property. Sheet runoff is the only potential for run-on to remediation facilities. The natural gradient of the site will drain a 100 year runoff event of 2.6 inches in 24 hours (Table 5-4) with limited erosion and ponding.

6.0 MONITORING AND REPORTING

Two elements of the remedial design must be monitored:

- Quality and quantity of discharge
- Aquifer quality

All sampling will be conducted by personnel trained in sampling protocol. All samples will be analyzed pursuant to EPA methods outlined in appropriate guidance documents and in Standard Operating Procedures contained herein. Analytical Technologies (Tempe, AZ) and Radian Corporation (Austin, TX) will be used for most of the analytical services. Should circumstances arise which prohibit the use of the above laboratories, any laboratories selected to perform the analysis will follow EPA approved techniques and proper QA/QC methods. Samples may also be analyzed with a portable gas chromatograph. Complete QA/QC procedures for the selected laboratory will be submitted with the first set of analytical data. Reports to NMOCD will consist of the data outlined in the following sections. Reports will be submitted semi-annually in January and July. Reports will also include QA/QC procedures and the names and qualifications of the sampling staff. Field information will be recorded in a log book which is to remain on site.

6.1 TREATMENT SYSTEM MONITORING

Giant will oversee a program of continued surveillance to assure that the pumping systems operate properly. Each week, Giant personnel will monitor and record discharge meter readings (flow rate and total gallons) from recovery wells and discharge lines. General observations of the entire system and any repair actions taken will also be recorded.

On a weekly basis, water levels in all storage tanks will also be obtained and recorded in the log. Pipelines will be inspected for leaks.

Prior to discharging from a specific storage tank, a sample from the tank will be obtained and analyzed for dissolved hydrocarbon compounds (EPA Method 601/602). If the water to be discharged shows no dissolved hydrocarbon concentrations above WQCC limits, it will be discharged directly to the infiltration trenches or the land application areas. If dissolved hydrocarbon constituent levels exceed WQCC limits, the water will be air-stripped to achieve the required reductions. Air-stripper effluent will be sampled on a monthly basis for dissolved hydrocarbons (EPA Method 601/602).

The volume of water applied to the land surface or infiltration trenches will also be determined on a monthly basis.

On an annual basis, representative samples from each discharge stream (tank, airstripper, sprinkler) will be analyzed for WQCC parameters (3-103). Radio chemistry and PCB testing will not performed. An initial sample will be taken prior to discharge.

6.2 AQUIFER MONITORING

Giant has installed a system of observation (monitor) and recovery (pumping) wells. A description of wells and boreholes drilled at the refinery by GCL is listed in Table 6-1. Ground-water investigations have revealed two localized zones of petroleum hydrocarbons due to recent leaks (the Diesel Spill Area and the Truck Fueling Area), one localized area of ground-water degradation due to past refinery activities (the Southern Refinery Area), and one extensive plume associated with the Lee Acres Landfill. The Diesel Spill Area is north of the truck dispatching office, the Truck Fueling Area is northwest of the truck dispatching office, and the Southern Refinery Area is in the southwest corner of the refinery site (see Plate 1).

On a monthly basis, Giant will monitor and record water levels and product thicknesses in observation wells GBR-7, 8, 10, 13, 15, 17, 19, 21, 24, 25, and 33. Water levels will also be measured and recorded in all operating recovery wells.

Water quality samples from wells GBR-6, 8, 13, 15, 24D and 33 will be collected quarterly for analysis of BTEX (EPA Method 602) and TDS (EPA

TABLE 6-1

DESCRIPTION OF WELLS AND BOREHOLES DRILLED BY GCL AT THE GIANT BLOOMFIELD REFINERY (FEBRUARY 1988)

GBR WELL NO.	COMPLETION DATE	LOCATION	CASING MATERIAL	DIAM.	DEPTH	SCREEN
1	12/20/85	FFDA	-	-	20′	NOT COMPLETED
2	12/20/85	FFDA	-	-	25′	NOT COMPLETED
3	12/20/85	FFDA	-	-	11′	NOT COMPLETED
4	12/20/85	FFDA	-	-	25′	NOT COMPLETED
5	12/20/85	SOUTHERN	PVC	2"	55′	32′ - 52′
6	09/09/86	SOUTHERN	PVC	6"	65′	20′ - 60′
7	09/24/86	SOUTHERN	PVC,SS	2"	48′	31.6′ - 41.6′
8	10/01/86	SOUTHERN	PVC,SS	2"	58′	38′ - 53′
9	09/30/86	SOUTHERN	PVC,SS	2"	65′	50′ - 60′
10	09/29/86	SOUTHERN	PVC,SS	2"	45′	29′ - 39′
11	04/01/86	SOUTHERN	GALV.	2"	55′	40′ - 50′
12	04/03/86	SOUTHERN	-	-	42′	NOT COMPLETED
13	04/01/86	SOUTHERN	PVC	2"	48′	32′ - 42′
14	09/10/86	DIESEL SPILL	PVC	6"	65′	20′ - 60′
15	09/28/86	DIESEL SPILL	PVC,SS	2"	60′	45′ - 55′
16	05/28/86	FFDA	PVC	2"	25′	REMOVED
17	05/28/86	ARROYO	PVC,SS	2"	68′	31′ - 51′
18	05/28/86	NORTHERN	GALV.	2"	50′	35′ - 45′
19	10/01/86	SOUTHERN	PVC,SS	2"	51′	31′ - 46′
20	04/18/86	SOUTHERN	PVC	2"	48′	27′ - 37′
21S	04/16/86	DIESEL SPILL	PVC	2"	40′	17′ - 32′
21D	04/16/86	DIESEL SPILL	PVC	2"	41′	33′ - 38′
22	04/16/86	DIESEL SPILL	PVC	2"	48′	32′ - 42′
23	04/16/86	DIESEL SPILL	PVC	2"	48′	24′ - 34′
24S	04/17/86	DIESEL SPILL	PVC	2"	41′	23′ - 33′
24D	04/18/86	DIESEL SPILL	PVC	2"	46′	33′ - 43′
25	04/18/86	DIESEL SPILL	PVC	2"	48′	25′ - 35′
26	04/18/86	DIESEL SPILL	PVC	2"	42′	22′ - 62′
27	04/23/86	DIESEL SPILL	PVC	5"	67′	22′ - 62′
28	05/27/86	DIESEL SPILL	PVC	6"	69′	24′ - 64′
29	05/30/86	SOUTHERN	PVC	6"	72′	25′ - 65′
30	09/24/86	DIESEL SPILL	PVC,SS	2"	49′	25′ - 40′
31	09/15/86	DIESEL SPILL	PVC,SS	2"	45′	24.6′ - 39.6
32	04/22/87	ARROYO	PVC,SS	2"	45′	24′ - 39′
33	04/23/87	FUELING AREA	PVC	2"	48.5′	27′ - 43′
34	04/24/87	FUELING AREA	PVC,SS	2"	48′	27′ - 43′
35	04/24/87	FUELING AREA	PVC	2"	46′	25′ - 41′
36	04/30/87	FUELING AREA	PVC	6"	70′	25′ - 65′
37	04/28/87	SOUTHERN	PVC	6"	69′	26′ - 66′
38	04/29/87	SOUTHERN	PVC	6"	72	27′ - 67′
39	10/08/87	DIESEL SPILL	PVC	2"	40′	25′ - 35′
40	10/07/87	CENTRAL	PVC	2"	40′	26′ - 36′
41	10/07/87	CENTRAL	PVC,SS	2"	35′	26′ - 32′
42	12/15/87	SOUTHERN	PVC,SS	6"	63′	36.6′ - 52.3′

TABLE 6-1 (Cont.)

DESCRIPTION OF WELLS AND BOREHOLES DRILLED BY GCL AT THE
GIANT BLOOMFIELD REFINERY
(FEBRUARY 1988)

GBR WELL NO.	COMPLETION DATE	LOCATION	CASING MATERIAL	DIAM.	DEPTH	SCREEN
43	12/17/87	SOUTHERN	PVC,SS	6"	62′	34.5′ - 50.2′
44	12/17/87	SOUTHERN	PVC,SS	6"	59′	32.6′ - 48.3′
45	04/23/87	FUELING AREA	-	-	43′	NOT COMPLETED
46	04/24/87	FUELING AREA	-	-	38′	NOT COMPLETED
BH 1	10/07/87	CENTRAL	-	-	20′	NOT COMPLETED
BH 2	10/07/87	CENTRAL	-	-	28.5	NOT COMPLETED
BH 4	10/07/87	CENTRAL	-	-	10′	NOT COMPLETED
BH 6	10/07/87	CENTRAL	-	-	10′	NOT COMPLETED
BH 8	10/08/87	NORTHERN	-	-	18′	NOT COMPLETED
BH 9	10/10/87	NORTHERN	-	-	20′	NOT COMPLETED
BH 10	10/18/87	NORTHERN	-	-	15′	NOT COMPLETED
BH 11	10/08/87	NORTHERN	-	-	20′	NOT COMPLETED

GALV = Galvanized Steel
SS = Stainless Steel
PVC = Polyvinyl Chloride
FFDA = Fire Fighting Drill Area
\- = Does not apply

Method 160.1). Water levels and product thickness in all wells will be measured and recorded on a quarterly basis.

Where soil is to be treated in place, by the application of water to the land surface, such as the Southern Refinery Area, aquifer monitoring will be accomplished in the following manner. After treated ground water is applied, the wells in the vicinity of the treatment area will be monitored for water levels and product thickness on a weekly basis during active treatment. It is anticipated that the flushing of contaminated soils will result in an increase in the product thickness on ground water. As flushing continues to remove product from the soil, it is anticipated that the thicknesses observed after flushing will decrease.

6.3 SAMPLING AND ANALYSIS

This section provides a plan for sampling related to conducting remedial action at Giant's Bloomfield refinery.

Adherence to the procedures described herein will ensure the collection and analysis of ground-water samples which are:

- Free of contamination due to any possible effects incurred during withdrawal of water from the borehole,
- Representative of the physical and chemical characteristics of ground water in the uppermost aquifer, and
- Consistent with appropriate procedures for collection, preservation, handling and analysis.

This section is written as a practical guide for technical personnel engaged in water sampling. It describes in detail the philosophy, regulatory background, necessary equipment, operational requirements and handling procedures for collecting ground-water samples. Procedures outlined herein are modeled on those specified for use at sites subject to the strict requirements of the Resource Conservation and Recovery Act (RCRA), but have been adapted to meet the unique requirements of ground-water monitoring at the Bloomfield refinery. This procedure is also fully adequate for sampling air-stripper effluent or other sampling points.

6.3.1 Sampling Equipment And Supplies

Equipment needed for purging and sampling the monitor wells, the pumping wells, and the air-stripper effluent includes a stainless steel/teflon development pump, equipment necessary to operate the pump, a bailer, pH and electrical conductance meters, a field logbook, and other miscellaneous supplies. These are listed and described in the following sections.

6.3.2 Development Pump

Monitor wells will be purged with a stainless steel and teflon development pump which will be thoroughly cleaned before each use. Stainless steel bailers will be used for purging if necessary.

6.3.3 Bailer

Bailers with removable check valves will be utilized for sampling. The bailer will be constructed of stainless steel with a teflon ball check valve at the bottom and top, and will have a capacity of approximately 0.25 gallons. The bailer will be equipped with a clean rope or cable at least 50 feet in length. This bailer may also be used to sample light or heavy phase immiscibles ("floaters" or "sinkers") if present.

6.3.4 Field Analytical Equipment

Equipment necessary for field analyses includes a thermometer, specific conductance meter, pH meter, and spare batteries for the meters. Standard solutions must be included for field calibration of the pH and conductance meters.

6.3.5 Field Logbook

All field activities, observations and measurements will be recorded in a field logbook, which must be kept up to date. Items which should be recorded in the field logbook each time sampling is conducted include:

- Identification number of well
- Well depth
- Static water level depth and measurement technique
- Purge volume and pumping rate
- Time well purged
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Field analysis data and method(s)
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions

6.3.6 Other Equipment And Supplies

A list of other equipment and supplies needed for sampling is included in Section 3.1 of the Procedures for Purging and Sampling Wells, included as Appendix F of this document.

6.3.7 Equipment Cleaning and Prevention of Contamination

All equipment used for monitor well sampling shall be decontaminated prior to each use. Decontamination procedures are included as Appendix G of this document.

In some cases, it may be impractical for logistic reasons to decontaminate equipment in accordance with Appendix G. In these cases, the equipment shall be cleaned and rinsed as described in Appendix H.

Equipment blanks shall be taken by running distilled water over or through the cleaned equipment and collecting it in 40 ml septum vials, which shall then be carefully capped so that no air bubbles or headspace remain. The equipment blanks shall be labeled, assigned sample numbers, and handled identically with other samples collected during the sampling program. This will allow identification of any analytical irregularities that might occur due to incomplete decontamination of the equipment.

6.4 SAMPLING PROCEDURES

The complete sampling procedure for ground-water monitor wells includes measurement of water level and total well depth, testing for "floating" and/or "sinking" phases, purging and sample withdrawal from the well, field analyses for temperature, specific conductance, and pH, and sample preservation and storage. These procedures are described in detail in the accompanying texts of standard operating procedures. Their specific applications at Giant are discussed in this section.

6.4.1 Water Level Measurement

Before purging and sampling, uncap the well, allow it to equilibrate for 5 minutes, measure the depth to water (to the nearest 0.01 foot) using an electronic sounder or steel tape. Record this measurement in the field logbook. Depth measurements are made from the defined measuring point at the top of each well casing. For wells with known product, an interface probe will measure depth to product as well as depth to water. Detailed procedures for the measurements are described in Appendix I.

Since the elevations of the measuring points have been surveyed, the elevation of the water table can be determined by subtracting the depth to water from the known elevation at the measuring point.

6.4.2 Well Purging

Purge the well at a slow enough rate to prevent cascading of water down the sides of the well. The pump should initially be placed with its intake about 3 feet below the water level in the well, and slowly lowered to the bottom of the well, if necessary, to prevent pumping air. Pump until three casing volumes (Appendix F) have been purged from the well, or, if recovery is too slow to allow this, purge the well to dryness once and allow it to recover before sampling. Record the volume of water purged, rate of pumping, and any other pertinent data in the field logbook.

Detailed procedures for determining the volume to be purged and for the purging process are included in Appendix F.

6.4.3 Sample Collection

Samples will be collected using a stainless steel bailer which has been fully cleaned in the laboratory prior to arriving on site. Cleaning procedures are described in Appendix G.

Samples should be collected in the order they are listed in Appendix F, which also lists the sample volumes, types of containers, and preservatives to be used. Sample containers and preservatives will be supplied by the contract laboratory.

At all times during sampling, care will be taken to minimize agitation of the samples and limit sample contact with the atmosphere as much as possible, particularly while collecting samples for analysis of volatiles.

The well number, date and time of sampling, and sample number(s) will be recorded in the field logbook. Further discussion of standard sampling procedures will be found in Appendix F.

6.4.4 Field Analyses

Both the first and last samples collected at each well will be reserved for field determination of temperature, specific conductance, and pH.

Two additional samples for these parameters will be collected at convenient times during the sampling of the well. Detailed procedures for making these field analyses are described in Appendix J.

Record the results of the field analyses in the field logbook with a description of the sample's physical characteristics.

6.4.5 Sample Preservation And Storage

Samples will be preserved in accordance with the methods shown in Appendix F.

Promptly after labeling and sealing each sample container, place it on ice in a suitable closed container (ice chest) for preservation during transportation to the laboratory.

6.4.6 QA/QC Splits And Blanks

Quality Assurance/Quality Control (QA/QC) is a critical part of any ground-water sampling program. The QA/QC program at Giant will include trip blanks, equipment blanks as needed, and sample splits for analysis by independent laboratories. Other field QA/QC procedures are described in the following sections.

6.4.7 Trip Blanks

Before conducting each quarterly sampling program, fill one of each type of container listed in Appendix F (including the appropriate preservatives) with laboratory grade deionized water. Carry these blanks to the site, assign them a sample number in the same manner as the ground-water samples, and submit them to the contract laboratory with labels and chain-of-custody seals identical to those used for the ground-water samples. Record the sample number as "trip blank" in the field logbook, but do not indicate to the laboratory which samples are blanks. Request the same analyses as are performed on the ground-water samples.

6.4.8 Sample Splits

Annually, take duplicate samples (splits) for all constituents, from one of the downgradient monitor wells and a recovery well. Label, seal, and preserve these samples in the same manner as those sent to the contract laboratory. Store the sample splits on ice and transport them as soon as possible to an independent analytical laboratory for analyses.

6.4.9 Packing And Shipping Of Samples

Store all samples on ice in appropriate containers until delivery to the analytical laboratory. Most samples will be shipped to the laboratory by common carrier. Sample splits for independent analysis will be delivered directly or by common carrier, as appropriate, to the laboratory selected to perform the independent analyses.

Complete procedures for labeling, packing and shipping of water samples are included in Appendix K.

6.4.10 Chain-Of-Custody Procedures

Follow chain-of-custody procedures at all times during sample collection, transportation, and delivery to the analytical laboratory. Chain-of-custody procedures are described in detail in Appendix L.

6.5 ANALYTICAL METHODS AND QA/QC

All ground-water samples, except splits, will be analyzed by Analytical Technologies in Tempe, Arizona. QA/QC VOA splits from all wells will be analyzed by Radian in Austin, Texas. If any other laboratory is used, it will follow the proper EPA techniques and QA/QC methods.

6.5.1 Analytical Parameters And Methods

As described in previous sections, selected water samples will be analyzed for one or all of the following:

- Purgeable Hydrocarbons (EPA Method 601 or 602)
- WQCC Parameters
- Selected Field Parameters

All parameters will be determined in accordance with the methods outlined in 40 CFR Part 136, or comparable methods. Parameters and analytical techniques to be used are listed in Appendix F.

6.5.2 Laboratory QA/QC Procedures

Laboratory QA/QC procedures will include the use of:

- Standard samples
- Laboratory blanks
- Spiked samples
- Field blanks
- Sample splits sent to separate laboratories

The analytical laboratories will be required to maintain logbooks or similar records listing the sample preparation techniques, analytical methods, and experimental conditions applied to each sample, and the date, time, and person performing each processing step. The laboratories shall adhere to the standards and procedures set forth in Sections 1.2 through 1.5 of EPA Manual SW-846, Test Methods for Evaluating Solid Waste, which are included in this document as Appendix M.

Units of measure shall be reported with all analytical results. Units of concentration will be milligrams/liter (mg/l) or micrograms/liter (ug/l). Other units of measure must be justified and approved in advance by the person requesting the analyses.

Also, all sampling results will be reviewed by GCL for completeness and consistency, particularly for the following:

- All constituents requested were analyzed;
- All values are properly reported with appropriate units of measure shown;
- Detection limits are clearly indicated for parameters that were found to be "below detection limits" or "not detected;"
- Values reported for field blanks show no evidence of contamination or analytical error (i.e., different concentrations of any analyte than expected);
- Data values obtained for each analyte in QC samples (e.g., blanks, spiked samples) will be used as a measure of performance or as an indicator of potential sources of cross-contamination, but should not be used to alter or correct analytical data.

If the analytical results fail to meet any of these tests, retesting will be conducted as necessary.

6.6 SEMI-ANNUAL REPORTS

Semi annual reports will be prepared listing:

- Ground-water elevations;
- Product thickness on ground water;
- Quantities pumped;
- Quantities discharged;
- Locations of discharges;
- Relevant field information;
- Analytical results of discharge and ground-water samples; and
- Changes in the plan during the period.

7.0 SUMMARY OF MONITORING AND REPORTING

7.1 MONITORING

On a weekly basis Giant will:

- Perform a visual inspection of the recovery pumps, air stripper, storage tanks, pipelines, infiltration trenches and associated ancillary equipment.
- Monitor the total flow from each recovery well and discharge lines.
- Measure water levels in all storage tanks.
- Measure water levels and product thickness in wells immediately adjacent to areas being treated by the controlled application of treated water. Such monitoring will be implemented during active treatment of such sites.

On a monthly basis Giant will:

- Monitor the total flow applied to the land surface.
- Monitor the total flow discharged to infiltration trenches.
- Monitor water levels and product thickness in monitor wells GBR-7, 8, 10, 13, 15, 17, 19, 21, 22, 24, 25 and 33 and all operating recovery wells.
- Use EPA Method 601/602 to analyze discharges from the air-stripper

On a quarterly basis (March, June, September, December) Giant will:

- Measure water levels and product thickness in all wells.
- Use EPA Method 602 (Purgeable Hydrocarbons) and Method 160.1 (TDS) to analyze ground water samples from wells GBR-6, 8, 13, 15, 24D, and 33.

Prior to initial discharge and on an annual basis thereafter, Giant will:

- Use EPA methods to analyze representative discharge streams for WQCC Para-meters (3-103). Radiochemistry and PCB testing will not be performed.
- Perform hydraulic pressure tests of underground pipelines.

Prior to discharging from a specific storage tank Giant will:

- Use EPA Method 601/602 to analyze any stored water which is to be discharged without air stripping.

7.2 REPORTING

Giant will prepare semi-annual reports which tabulate:

- Ground-water elevations;
- Product thickness on ground water;
- Quantities pumped;
- Quantities discharged;
- Locations of discharges;
- Relevant field information;
- Analytical results of discharge and ground-water samples; and
- Changes in the plan during the period.

In accordance with WQCC Regulation 1-203, Giant will immediately notify the NMOCD of any unplanned release.

8.0 REFERENCES CITED

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M&A\RTHDISCH.RPT

DISCHARGE PLAN APPLICATION
FOR
GIANT BLOOMFIELD REFINERY
BLOOMFIELD, NM

PLATES 1 - A4

March 1, 1988

Prepared for:

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For Submission to:

Environmental Bureau
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Santa Fe, NM 87105

Prepared by:

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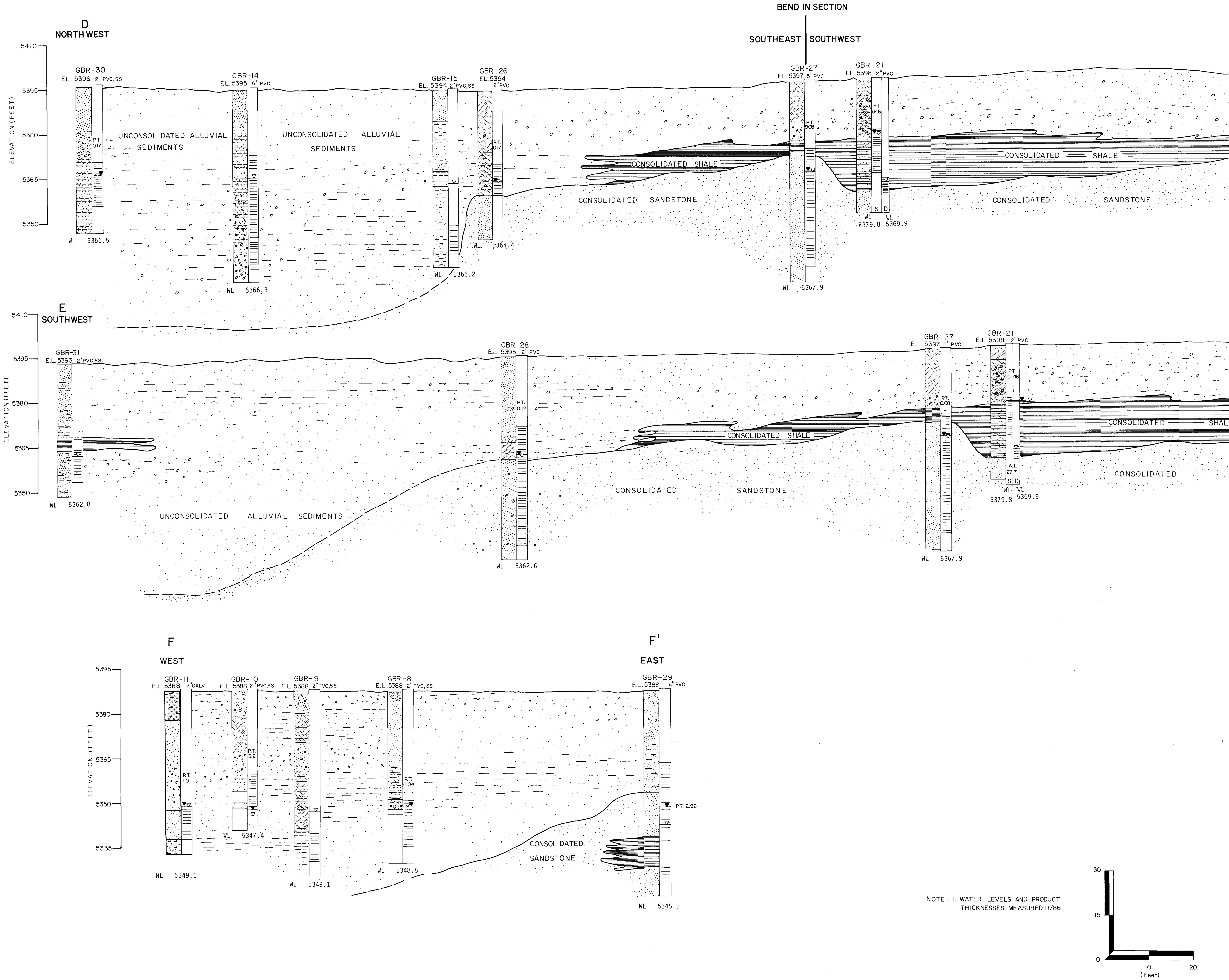
C
NORTH
C'
SOUTH
ELEVATION (FEET)
5410
5395
5380
5365
5350
GBR-23
EL. 5401
2" PVC
P.T. 0.02
WL 5380.4
GBR-25
EL. 5395
2" PVC
WL 5368.0
GBR-22
EL. 5394
2" PVC
WL 5359.8
GBR-13
EL. 5390
2" PVC
P.T. 0.4
WL 5352.3
GBR-11
EL. 5388
2" PVC
P.T. 1.04
WL 5349.1
CONSOLIDATED SANDSTONE
CONSOLIDATED SANDSTONE
UNCONSOLIDATED ALLUVIAL SEDIMENTS
B
SOUTH WEST
B'
NORTH EAST
5425
5410
5395
5380
5365
5350
5335
SANDSTONE OUTCROP
THIS PORTION OF SECTION APPROXIMATE BASED ON OUTCROP AND GEOMORPHIC EVIDENCE
MAXIMUM EXTENT OF 100 YEAR FLOOD
GBR-11
EL. 5388
2" PVC
PT 1.04
WL 5349.08
GBR-20
EL. 5392
2" PVC
WL 5355.2
GBR-5
EL. 5393
2" PVC
PT 0.7
WL 5363.4
GBR-16
EL. 5414
2" PVC
MEASURED 4/30
WELL NO LONGER EXITS
WL 5369.6
UNCONSOLIDATED ALLUVIAL SEDIMENTS
CONSOLIDATED SANDSTONE
A
NORTHWEST
A'
SOUTHEAST
5410
5395
5380
5365
5350
5335
THIS PORTION OF SECTION APPROXIMATE BASED ON OUTCROP AND GEOMORPHIC EVIDENCE
THIS PORTION OF SECTION APPROXIMATE BASED ON OUTCROP AND GEOMORPHIC EVIDENCE
GBR-17
EL. 5401
2" PVC and STAINLESS STEEL
WL 5369.6
GBR-24
EL 5394
2" PVC
WL 5370.9
P.T. 0.02
WL 5370.0
S
D
GBR-23
EL. 5401
2" PVC
P.T. 0.03
WL 5380.4
UNCONSOLIDATED ALLUVIAL SEDIMENTS
UNCONSOLIDATED ALLUVIAL SEDIMENTS
CONSOLIDATED SANDSTONE AND SHALES
CONSOLIDATED SANDSTONE AND SHALES
REFINERY PROPERTY BOUNDARY
STATE HIGHWAY 550
N
LOCATION MAP
SCALE: 1"=1000'
LEGEND
WATER LEVEL
W.L. WATER LEVEL IN FT. FROM TOP OF GROUND - MEASURED 11/86
PRODUCT LEVEL
P.T. PRODUCT THICKNESS IN FT. MEASURED 11/86
WELL CASING
SCREEN
S SHALLOW COMPLETION
D DEEP COMPLETION
CLAY
SAND
CLAYEY SAND
SAND AND GRAVEL
SILTY SAND
SANDSTONE
COBBLES AND BOULDERS
SHALE
SILTY SHALE
SANDY SHALE
NO RETURNS
SILT
30
15
0
50
100
GCL
HYDROGEOLOGIC CROSS SECTIONS
GIANT BLOOMFIELD REFINERY
CLIENT: GIANT BLOOMFIELD REFINERY
DATE: 7-30-86
DRAWN BY: KJK
CHECKED BY:
REVISED: 11/16/87
SCALE: VERT. 1"=15' HORZ. 1"=50'
PLATE 2A
AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS
CERTIFICATE NUMBER 6421
AIPG
ALBERTO A. GUTIERREZ
CERTIFIED PROFESSIONAL GEOLOGIST



GCL

HYDROGEOLOGIC CROSS SECTIONS (CONT'D.)
GIANT BLOOMFIELD REFINERY

CLIENT:	
DATE:	3-2-87
DRAWN BY:	KJK, EO
CHECKED BY:	
REVISED:	11/16/87
SCALE:	VERT. 1"=15' HORZ. 1"=10'

PLATE 2B

FEB 26 1988

MAR - 2 ...

OIL CONSERVATION ...

NOTES:

1. This map complies with the National Map Accuracy Standards.
2. Field surveys performed by San Juan Engineering, Farmington, New Mexico.
3. Vertical aerial photography exposed on July 22, 1978 with a Zeiss RMK A 15/23 precision aerial mapping camera, with a calibrated focal length of 152.58 mm.
4. Stereocompilation, final drafting, and photographic reproduction performed by Thomas R. Mann & Associates, Inc., Albuquerque, New Mexico.
5. 500 foot grid, based on a local coordinate system.

LEGEND

INDEX CONTOUR	5450
INTERMEDIATE CONTOUR	
DEPRESSION CONTOUR	
SPOT ELEVATION	5469.9
HORIZONTAL / VERTICAL CONTROL POINT	
BORING	
BACKHOE TRENCH	
BACKHOE PIT	
WELL LOCATION AND NUMBER	
RECOVERY WELL	

SCALE IN FEET

SCALE: 1"=100' (1:1200)

TOPOGRAPHIC / PHOTOBASE MAP OF THE GIANT REFINERY

SAN JUAN COUNTY, NEW MEXICO

SCALE: 1"= 100' (1:1200)

CONTOUR INTERVAL: 2'

VERTICAL DATUM: MEAN SEA LEVEL

1978

GCL

LOCATION MAP FOR HYDROGEOLOGIC CROSS SECTIONS

CLIENT: GIANT BLOOMFIELD REFINERY

DATE: 8-21-86

DRAWN BY: KJK

CHECKED BY:

REVISED: 11-16-87

SCALE: 1"=100'

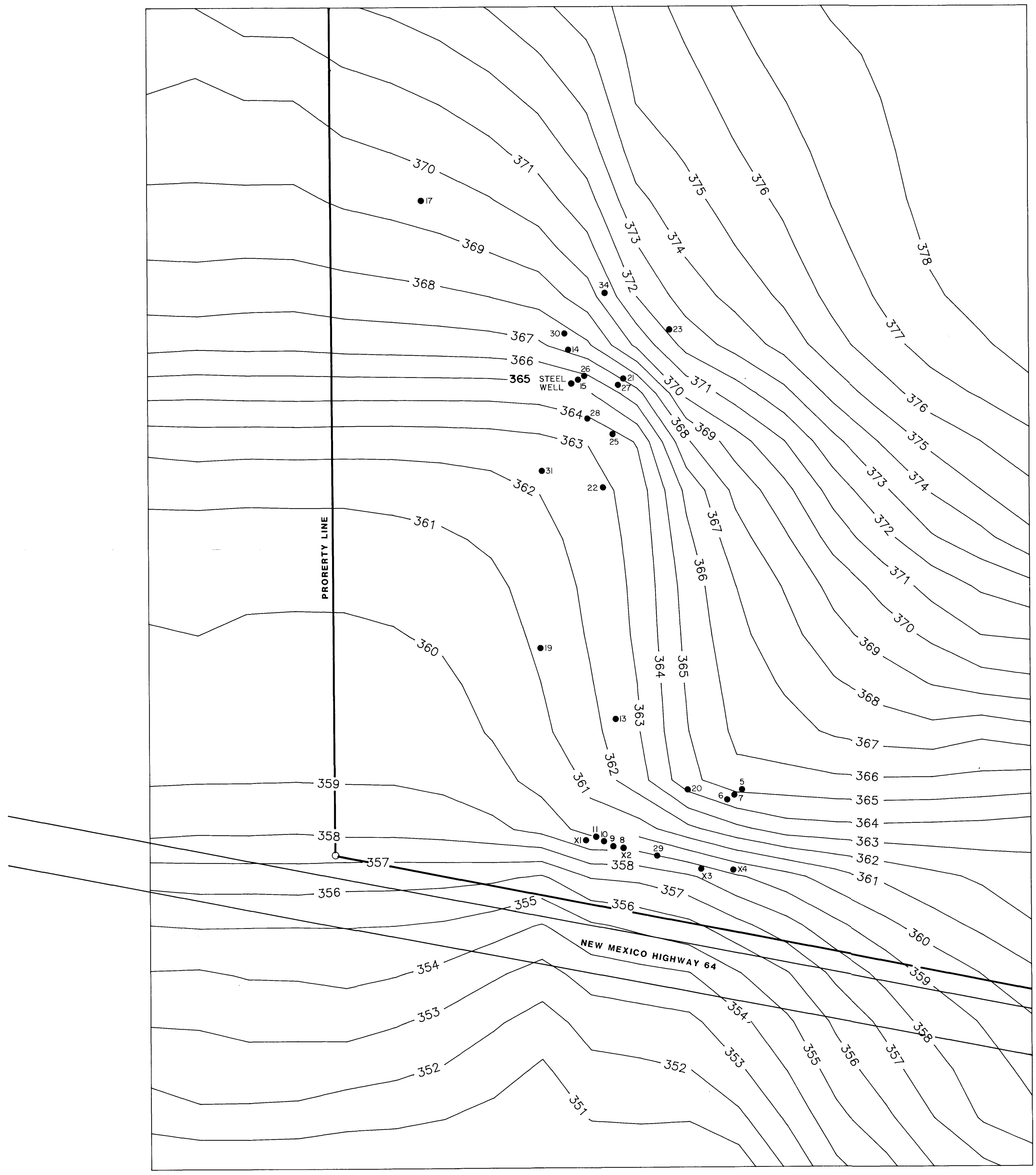
PLATE 3

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS CERTIFICATE NUMBER 6421 AIPG ALBERTO A. GUTIERREZ CERTIFIED PROFESSIONAL GEOLOGIST

FEB 26 1988

RECEIVED MAR - 2 1988 CONSERVATION DIVISION SANTA FE

CONSTANT - HEAD INNER BOUNDARY
FINE TO MEDIUM GRAINED SANDSTONE AND SHALE UNDERLYING THIN LAYER OF UNSATURATED SEDIMENTS
$K = 35\ gpd/ft^2$
ARROYO ALLUVIUM
$K = 1.8\ gpd/ft^2$
SANDSTONE (UNKNOWN GRAIN SIZE)
$K = 35\ gpd/ft^2$
LOW CONDUCTIVITY ZONE
$K = 1.3\ gpd/ft^2$
STEEL WELL
LOW CONDUCTIVITY ZONE
$K = 1.3\ gpd/ft^2$
X1 (GBR-37)
X2
X3
X4 (GBR-38)
SANDSTONE (UNKNOWN GRAIN SIZE)
$K = 35\ gpd/ft^2$
NEW MEXICO HIGHWAY 64
PROPERTY LINE
VALLEY SEDIMENTS
$K = 50\ gpd/ft^2$
CONSTANT-HEAD INNER BOUNDARY
LEGEND
WELL LOCATIONS
N
0
100
feet
GCL
HYDRAULIC CONDUCTIVITY ZONES
CLIENT:
DATE: 3/20/87
DRAWN BY: KJK
CHECKED BY:
REVISED: 11-16-87
SCALE: 1" = 100'
PLATE A1
FEB 26 1988



LEGEND

356 EQUIPOTENTIAL LINE (HEAD -5000 ft.)

5 WELL LOCATIONS

N

0 100 feet

GCL

SIMULATED EQUIPOTENTIAL SURFACE UNDER STEADY-STATE CONDITIONS

CLIENT:
DATE: 3-24-87
DRAWN BY:
CHECKED BY:
REVISED: 11/16/87
SCALE: 1"=100'

PLATE A2

FEB 26 1988

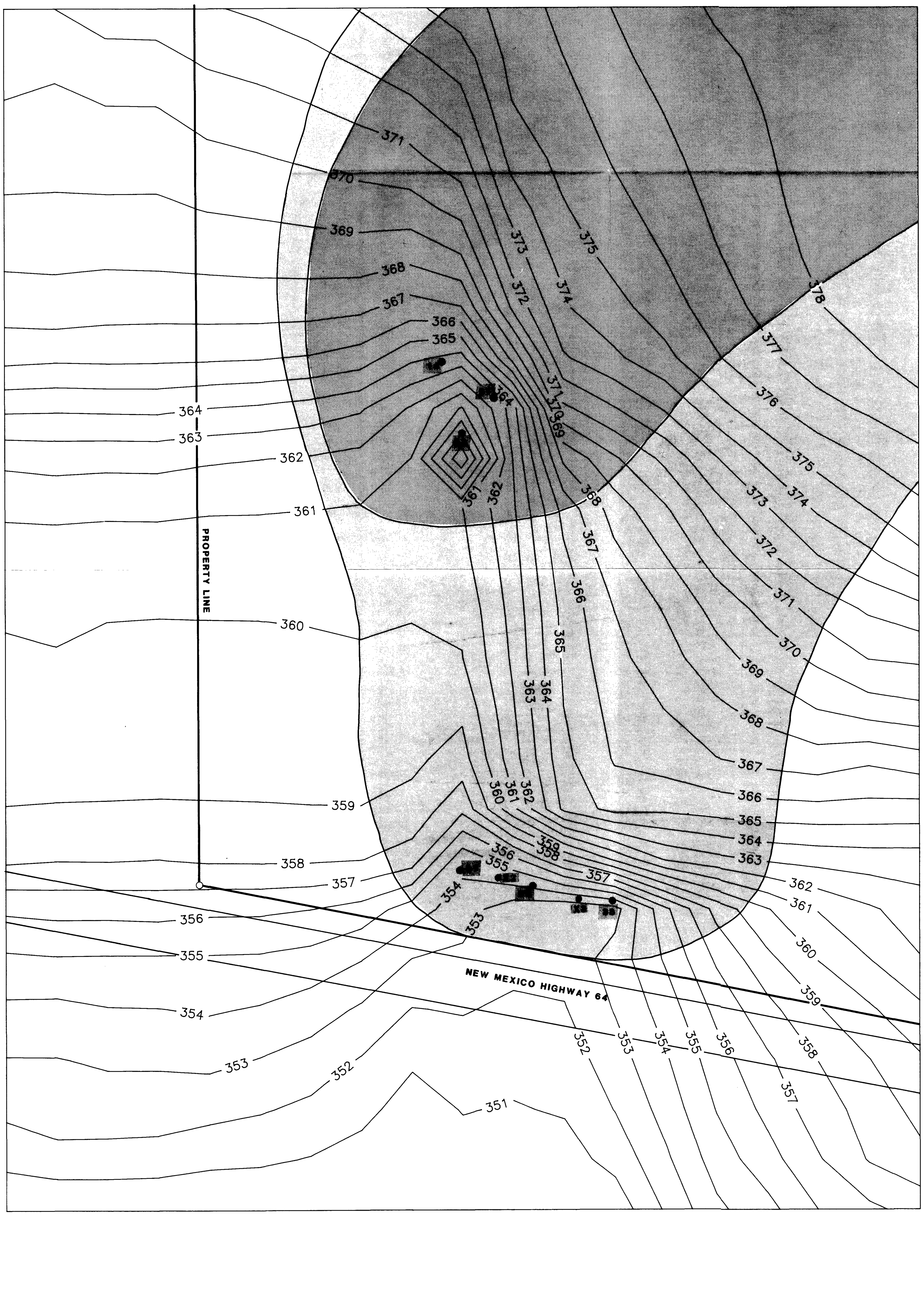
GCL

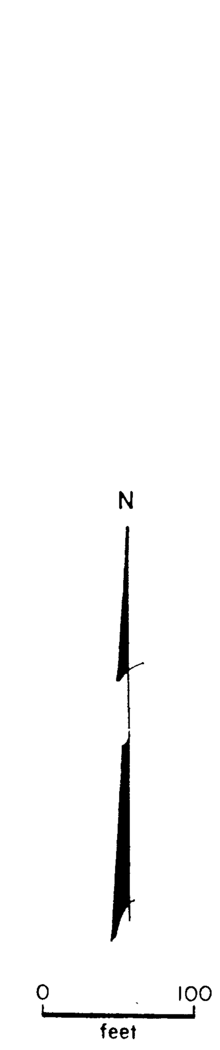
EQUIPOTENTIAL SURFACE DUE TO PROPOSED PUMPING STRATEGY

CLIENT:
DATE: 3-23-87
DRAWN BY: KJK
CHECKED BY:
REVISED: 11-16-87
SCALE: AS NOTED

PLATE A3

FEB 26 1988





LEGEND

ZONE OF CAPTURE ASSOCIATED WITH RECOVERY PUMPING IN DIESEL SPILL AREA

ZONE OF CAPTURE ASSOCIATED WITH RECOVERY PUMPING IN SOUTHERN REFINERY AREA

CONTOUR INTERVAL: 1 FT.

GCL

APPROXIMATE CAPTURE ZONES UNDER PROPOSED RECOVERY STRATEGY

CLIENT:	
DATE:	3/19/87
DRAWN BY:	
CHECKED BY:	
REVISED:	11-16-87
SCALE:	1" = 100'

PLATE A4

FEB 26 1988

DISCHARGE PLAN APPLICATION
FOR
GIANT BLOOMFIELD REFINERY
BLOOMFIELD, NM

APPENDICES A - C

March 1, 1988

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APPENDIX A

FINITE-DIFFERENCE GROUND WATER FLOW MODEL

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LIST OF PLATES

1.0 EXECUTIVE SUMMARY

The Prickett Lonnquist Aquifer Simulation Model (PLASM) (Prickett, T.A. and C.G. Lonnquist, 1971, Selected Digital Computer Techniques for Ground Water Resource Evaluation, Illinois State Water Survey, Urbana, Bulletin 55) was used to predict the hydraulic impacts of pumping from existing and proposed recovery wells at the Giant Bloomfield Refinery Site. The model was first calibrated for steady-state conditions using projected long-term drawdown responses observed during pump testing at the recovery wells. Long-term impacts of recovery pumping were then predicted by imposing anticipated recovery discharges on the steady-state model. Results of the modeling study indicate that pumping at rates of 1 gpm at the three existing recovery wells in the Diesel Spill Area will be sufficient to capture the plume of product and dissolved contamination that extends over this area. The results also suggest that the installation and operation of the recovery wells in the Southern Refinery Area will be adequate to intercept all potentially contaminated ground water known or believed to be present north of the recovery wells.

Approximately 20 trial-and-error calibration runs were used to define the final model. Four transmissivity zones were used to characterize the flow domain. Artificial constant-head boundary conditions were imposed along three edges of the model, while an artificial no-flow boundary was used to characterize flow along the remaining edge. A 41-column by 49-row rectangular grid was used to represent an area of 2200 feet by 2975 feet. The recovery model included eight pumping wells withdrawing at rates of from 1 to 15 gpm. At steady-state, approximately 91,000 gallons per day of water would be produced for treatment, storage, and eventual disposal.

2.0 JUSTIFICATION FOR THE MODELING STUDY

Use of a finite-difference model to predict the hydraulic response of the unconfined to partially-confined aquifer underlying the site provides a systematic framework for understanding the natural flow dynamics of the aquifer. While analytical methods for analyzing aquifer hydraulics can be useful for gaining insight into the general characteristics of an aquifer, they cannot be used to evaluate a heterogeneous, unconfined or partially-confined aquifer of finite extent under conditions of a sloping water table. At the Bloomfield site, two distinct but hydraulically-connected units of sandstone and alluvium comprise the shallow aquifer. The subsurface hydrogeology is further complicated by the existence of discontinuous shale and clay layers distributed throughout the aquifer. These conditions preclude the use of simple Theis analysis for predicting the impacts of recovery.

In addition to permitting evaluation of aquifer response in the presence of heterogeneities and a sloping water table, the use of a numerical model also allows for accurate description of flow dynamics in an unconfined or partially-confined aquifer. The nonlinear nature of the flow equation under unconfined and partially-unconfined conditions requires iterative solution of the ground water flow equation. During early, transient stages of calibration, changes in transmissivity and in the storage coefficient resulting from aquifer dewatering can easily be accounted for using a numerical model.

A final justification for application of numerical modeling is the fact that a well-calibrated model offers a means of systematically defining areas of the site that require more intensive data collection. These areas can easily be identified through sensitivity analysis, during which the response of the calibrated model to small changes in parameters can be determined. Large changes in response indicate that a more refined model may be developed if additional data is acquired in the area where the large response occurs.

3.0 CALIBRATION OF THE FINITE-DIFFERENCE GROUND-WATER FLOW MODEL

3.1 OVERVIEW OF THE CALIBRATION METHODOLOGY

Development of a realistic predictive model requires that the parameters of the model be systematically adjusted until the historical behavior of the aquifer is duplicated. Such calibration, or history-matching, generally involves simultaneous adjustment of aquifer parameters until the model reproduces observed aquifer behavior. Using the known steady-state behavior and transient response of the aquifer, calibration of the model for the aquifer underlying the Giant Bloomfield Refinery proceeded as follows:

Phase 1: An initial steady-state calibration for overall hydraulic conductivity zones was performed using the current hydraulic head distribution to reflect natural, steady-state flow conditions.

Phase 2: This phase of calibration involved variation of hydraulic conductivity within previously-defined conductivity zones until estimated long-term drawdown was reproduced at recovery-well nodes. Single-well pump test results performed at GBR-14, GBR-27 and GBR-29 were used to estimate long-term drawdown under steady-state conditions. The actual inputs into the calibrated model differed from the data from test pumping. During this phase, as well as during Phase 1, the storage coefficient was set to zero in order to force instantaneous convergence to steady-state head. The steady-state head distribution generated using the final conductivity estimates closely matched the observed November 1986 water-table.

Phase 3: The final calibration phase will involve variation of the storage coefficient until short-term aquifer responses are duplicated. The hydraulic conductivity will be held fixed at the values obtained during Phase 2 steady-state calibration. This final phase of modeling will be completed after results of the 2-month pumping test (October-November, 1987) are evaluated and input into the model.

Division of the calibration procedure into steady-state and transient phases minimized the number of degrees of freedom associated with each calibration phase. During Phase 1 and 2, only the hydraulic conductivity distribution had an effect on the simulated steady-state head distribution and the storage coefficient was not explicitly considered during these phases. Calibration during the final, transient phase will involve only adjustment of the storage coefficient, with hydraulic conductivity fixed at the final values obtained during Phase 2. Use of this phased calibration approach eliminates the problems generally associated with simultaneously varying two parameters to match the observed aquifer response.

3.2 MODIFICATIONS OF PLASM

Certain modifications were made in the BASIC code for the 2-dimensional finite-difference PLASM algorithm in order to facilitate calibration. The modified code allows recalculation of adjusted hydraulic conductivity and rewrites the recalculated transmissivity onto the input file for subsequent model execution. In addition, the modified code adjusts the xy coordinates used to generate a hydraulic head plot file in order to account for an irregular grid. Finally, the modified code prints steady-state hydraulic head values to an external file rather than directly to a printer so that the simulated steady-state head distribution can be used to initialize the model for subsequent transient model execution.

3.3 MODEL SPECIFICATIONS

3.3.1 The Finite-Difference Grid

A finite-difference grid was constructed over the entire refinery site so that the effects of recovery in both the Diesel Spill Area and the Southern Refinery Area could be predicted simultaneously. Interaction between the two recovery sites was of some interest, since pumping at GBR-29 and at proposed wells in the Southern Refinery Area could conceivably draw some of the product from the Diesel Spill Area downgradient into the Southern Refinery Area. Moreover, pumping in the Diesel Spill Area at the three existing recovery wells could potentially reduce the natural southwestward hydraulic gradient in the Southern Refinery Area, minimizing the rate of pumping required to prevent additional off-site migration of potentially contaminated ground water.

Some initial consideration was given to orienting the grid such that rows and columns would be parallel and perpendicular to the overall south-westward hydraulic gradient over the site, as shown in the observed water table. This would have made it possible to input longitudinal and lateral dispersivity values directly during subsequent solute-transport simulation, with longitudinal dispersivity specified along columns corresponding to the direction of flow and transverse dispersivity specified along rows perpendicular to the flow direction. Instead, orientation of the grid columns in a north-south direction was chosen because this orientation permitted no-flow conditions to be assigned to nodes located along the western boundary, where water-table contours appeared to be perpendicular to the edges of the grid. This orientation greatly facilitated the modeling study.

The finite-difference grid was constructed to be very fine at the pumping sites, where large hydraulic gradients were expected to occur. Close spacing of rows and columns permitted more accurate definition of drawdown at the recovery wells, since the model generated average drawdown over a given nodal element. Drawdown averaged over a small element thus approached the drawdown that would occur at a point. Distances between columns and rows were expanded at increasing distances from recovery sites where hydraulic gradients were expected to gradually decline and where average drawdown in a given nodal element approached drawdown at any point in the element. The change in column or row spacing did not exceed a factor of two between adjacent cells anywhere in the grid, minimizing spatial-truncation errors during model execution.

A total of 49 rows and 41 columns comprised the grid, resulting in 2009 nodal points. The entire grid extended 2200 feet in the east-west or x-direction and 2975 feet in the north-south or y-direction. The dimensions of the grid were defined to be sufficiently large to avoid propagation of recovery well drawdown to the edges of the grid during calibration. Tables 1 and 2 list values of DELX (I) and DELY (J) describing the spacing between columns and rows. These spacings are shown plotted on Plate A1. The northwesternmost corner of the grid was located at a northing of 2500 feet and an easting of 10,400 feet.

Despite anticipation of radial flow during steady-state and transient pumping, a regular grid rather than a radial-segment grid was used throughout the flow domain. The loss of accuracy associated with using a regular grid near pumping wells was more than offset by the convenience of using a grid with regularly-spaced nodes.

3.3.2 Boundary Conditions

Since natural physical boundaries were not observed at the site, artificial boundary conditions were established around the flow domain. A no-flow boundary was specified along the western edge of the flow domain because observed equipotential lines appeared to be perpendicular to the edges of the grid. It was not clear whether this orientation of equipotential lines was due to the contouring process or whether it was due to southward channeling of water through the arroyo, which happened to be parallel to the boundary. Southward deflection of flowlines as water enters the arroyo from the east implies that the hydraulic conductivity of the arroyo is significantly larger than the conductivity of the adjacent sandstone.

Unlike water-table contours along the western edge of the grid, contours along the northern, eastern and southern edges of the flow domain are oblique to the edges of the grid. This suggests that water laterally enters or exits the system through these areas. Since the rates of influx and outflux of water were not known, constant-head conditions were assigned to these parts of the flow domain. This permitted the model to calculate the rate of influx, equal to the rate of outflux under steady-state conditions, for any given distribution of hydraulic conductivity. As long as steady-state conditions were maintained at these boundary nodes, there is no difference between assigning constant-head

TABLE 1
FINITE-DIFFERENCE GRID COLUMN
SPACING ARRAY DELX(I) (FT)

I	DELX(I)	I	DELX(I)
1	250	21	12.5
2	200	22	12.5
3	150	23	12.5
4	100	24	12.5
5	75	25	12.5
6	50	26	12.5
7	25	27	12.5
8	25	28	12.5
9	25	29	25
10	25	30	25
11	12.5	31	25
12	12.5	32	50
13	12.5	33	50
14	12.5	34	50
15	12.5	35	50
16	12.5	36	75
17	12.5	37	100
18	12.5	38	150
19	12.5	39	200
20	12.5	40	250

TABLE 2
FINITE-DIFFERENCE GRID ROW
SPACING ARRAY DELY(J) (FT)

J	DELY(J)	J	DELY(J)
1	300	25	50
2	250	26	50
3	200	27	100
4	150	28	100
5	100	29	100
6	100	30	50
7	100	31	50
8	75	32	25
9	75	33	25
10	50	34	25
11	50	35	25
12	25	36	12.5
13	25	37	12.5
14	25	38	12.5
15	12.5	39	12.5
16	12.5	40	25
17	12.5	41	25
18	12.5	42	50
19	12.5	43	50
20	12.5	44	50
21	25	45	100
22	25	46	100
23	25	47	100
24	25	48	100

and constant-flux conditions. This is because the saturated thickness and gradient at a boundary remains constant under steady-state conditions. Use of constant-head boundaries along the northern, eastern, and southern edges of the grid was valid during calibration phases involving pumpage as long as the pumping stresses did not propagate to the boundaries. Specification of constant-head conditions along these boundaries was easier to implement than assignment of constant-flux conditions, because hydraulic head along a constant-flux boundary would have to be adjusted during calibration whenever hydraulic conductivity was changed.

With lower heads assigned along the southern constant-head boundary, and higher heads specified along the eastern and northern constant-head boundaries, the steady-state throughflow Q of water was uniquely defined for any distribution of hydraulic conductivity. The distribution of hydraulic conductivity was then modified until the observed distribution of hydraulic gradients was obtained. Essentially, the steady-state calibration procedure focused on modifying hydraulic conductivity $K(x,y)$ at each node until the observed gradient $\Delta h/\Delta l$ across the nodal element was reproduced according to Darcy's Law:

$$q = K(x,y)\ \Delta h/\Delta l$$

where q equals the constant, but unknown, influx and outflux rate. Constant-head values along the northern, eastern, and southern boundaries were specified on the basis of observed water levels. Since data related to the observed hydraulic head distribution did not extend to the grid edges, constant heads were instead assigned along the edges of a rectangle constructed along the edges of the water-table contoured area (see Plate A1). When constant-head conditions were assigned along the top, bottom and right edges of this rectangle, the resulting head values between the rectangle and the grid edges automatically conformed to principles of ground-water flow. It should be noted, however, that the grid edges act as no-flow boundaries by default during model execution. Therefore, simulated head between the constant-head inner boundaries and the grid edges became less reliable close to the grid edges.

November 1986 water levels corrected for floating product were used to define constant-head values along the inner rectangular boundary (see Plate A1). Tables 3, 4 and 5 list the constant heads assigned to row 5 along the northern edge of the rectangle, row 48 along its southern edge and column 39 along its eastern edge. 5000 feet were subtracted from all head levels in order to minimize accumulation of round-off error during model execution. Constant head levels were maintained by setting the storage coefficient along these rows and columns at an effectively infinite value of 1×10^{22} to represent infinite sources and sinks. Any storage coefficient of S equal to 1.0 or greater could actually have been used.

3.4 STEADY-STATE CALIBRATION

After the grid was defined and boundary conditions were established, the model was initially calibrated by attempting to match the simulated steady-state hydraulic head distribution to the observed November 1986 water table. Since the steady-state head distribution is completely insensitive to the storage coefficient, this initial stage of calibration focused on adjustment of hydraulic conductivity values until the observed head distribution was duplicated. A storage coefficient of zero was therefore used. Subsequent transient calibration for storativity will involve duplication of pump-test drawdown to the extent possible, given the non-ideal behavior of the aquifer under pumping stresses.

3.4.1 Convergence to Steady-State

Steady-state calibration for hydraulic conductivity involved solution of the general flow equation:

$$K_{xx} \nabla h_x + K_{yy} \nabla h_y = S \frac{dh}{dt}$$

where K_{xx} = the hydraulic conductivity in the x-direction (along rows) [L/T]

TABLE 3
CONSTANT HEADS ALONG THE
NORTHERN INNER BOUNDARY (FT)

ROW 5:	COLUMN 2	371.0	21	375.1
	COLUMN 3	371.5	22	375.35
	COLUMN 4	371.9	23	375.35
	COLUMN 5	372.3	24	375.45
	COLUMN 6	372.6	25	375.55
	COLUMN 7	373	26	375.75
	COLUMN 8	373.15	27	375.85
	COLUMN 9	373.4	28	376.0
	COLUMN 10	373.6	29	376.15
	COLUMN 11	373.8	30	376.35
	COLUMN 12	373.9	31	376.6
	COLUMN 13	374.1	32	376.8
	COLUMN 14	374.2	33	377.25
	COLUMN 15	374.3	34	377.65
	COLUMN 16	374.4	35	378.0
	COLUMN 17	374.5	36	378.1
	COLUMN 18	374.65	37	378.2
	COLUMN 19	374.8	38	378.3
	COLUMN 20	374.9	39	378.6

TABLE 4
CONSTANT HEADS ALONG THE
SOUTHERN INNER BOUNDARY (FT)

ROW 48:	COLUMN 2	350	22	350
	COLUMN 3	350	23	350
	COLUMN 4	350	24	350
	COLUMN 5	350	25	350
	COLUMN 6	350	26	350
	COLUMN 7	350	27	350
	COLUMN 8	350	28	350
	COLUMN 9	350	29	350
	COLUMN 10	350	30	350
	COLUMN 11	350	31	350
	COLUMN 12	350	32	350
	COLUMN 13	350	33	350.7
	COLUMN 14	350	34	352.0
	COLUMN 15	350	35	353.0
	COLUMN 16	350	36	354.0
	COLUMN 17	350	37	354.75
	COLUMN 18	350	38	356.3
	COLUMN 19	350	39	357.4
	COLUMN 20	350		
	COLUMN 21	350		

TABLE 5
CONSTANT HEADS ALONG THE
EASTERN INNER BOUNDARY (FT)

COLUMN 39:	ROW 3	378.25	27	375.0
	ROW 4	378.5	28	373.4
	ROW 5	378.65	29	371.5
	ROW 6	378.75	30	370.0
	ROW 7	379.0	31	367.2
	ROW 8	379.0	32	366.0
	ROW 9	379.0	33	364.9
	ROW 10	378.9	34	364.2
	ROW 11	378.7	35	363.5
	ROW 12	378.5	36	362.95
	ROW 13	378.35	37	362.85
	ROW 14	378.25	38	362.75
	ROW 15	378.1	39	362.65
	ROW 16	378.0	40	362.55
	ROW 17	377.9	41	363.35
	ROW 18	377.75	42	362.2
	ROW 19	377.5	43	361.9
	ROW 20	377.35	44	361.15
	ROW 21	377.25	45	360.3
	ROW 22	377.0	46	359.5
	ROW 23	376.5	47	359.05
	ROW 24	376.2	48	357.4
	ROW 25	376.0		
	ROW 26	375.5		

K_{yy} = the hydraulic conductivity in the y-direction (along columns) [L/T]

∇h_x = the hydraulic gradient in the x-direction (along rows)

∇h_y = the hydraulic gradient in the y-direction (along columns)

h = the hydraulic head at any point [L]

S = the specific yield or storage coefficient at any point

In order to obtain instantaneous convergence to steady-state, the value of S was effectively set to zero at 10^{-22}. Since this removed the time derivative term from the right-hand side of the flow equation, the resulting equation was essentially equivalent to the Laplace equation describing steady-state flow:

$$K_{xx} \nabla h_x + K_{yy} \nabla h_y = 0$$

Alternatively, steady-state conditions could have been attained by using a non-zero value of S and by allowing the model to converge to steady-state over a finite period of time. The length of real time required for dh/dt to approach zero would depend on how close the specified initial conditions were to steady-state conditions, on the transmissive characteristics of the aquifer, and on the magnitude of S. This procedure would have required far more computer time than the procedure used to generate instantaneous convergence.

For the case of instantaneous convergence, the time derivative term does not explicitly appear in the flow equation. Under these circumstances, initial conditions become irrelevant and arbitrary initial heads of 362.5 feet were assigned to all variable-head nodes in the flow domain. When a uniform bedrock elevation of 300 feet is specified for all nodes, an initial saturated thickness of 62.5 feet is defined by the model prior to convergence to steady-state.

3.4.2 Average Saturated Thickness

Although saturated thickness for the model was initially set to 62.5 feet to reflect the average depth to the lower edge of recovery-well screens, saturated thickness generated by the model varied from 50 to 78 feet after convergence to steady-state. Since this range of saturated thickness was well above the 25-foot average saturated screened interval of recovery wells, it produced overestimated values of transmissivity and underestimated recovery-well drawdowns, causing the impacts of recovery tended to be conservatively-underestimated.

3.4.3 Hydraulic Conductivity Zoning

Hydraulic conductivity zones were defined over the flow domain according to observed geologic conditions. Hydraulic conductivity, rather than transmissivity, was used as the calibration parameter because the actual saturated thickness of the unconfined to partially-confined aquifer was unknown. In areas located outside of the regions of pump test influence, hydraulic conductivity was estimated on the basis of lithologic descriptions obtained from well logs.

Due to boundary influences, a sloping water table, and other non-ideal conditions affecting pump test results, hydraulic conductivities obtained from the pump tests required some adjustment until the behavior of the aquifer was reproduced. The pump-test conductivities represented an initial input to the iterative, trial-and-error calibration.

There are no perennial rivers affecting the hydrology at the site. Therefore, no attempt was made to incorporate stream leakance into the model calibration. Leakage from the fire water pond was not considered in Phase 1 or 2 model runs because a radial-flow analysis did not conclusively prove that the observed water table near the pond is impacted by pond leakage. Leakage between sandstone and shale layers was assumed to be slow relative to the overall dynamics of the flow system, and was ignored.

3.4.4 Iterative Trial-and-Error Calibration

Initial attempts at steady-state calibration focused on relative variation of hydraulic conductivity within geologic zones until the overall configuration of the observed water table was reproduced. This Phase 1 calibration was directed at generating the overall characteristics of the potentiometric surface through definition of hydraulic conductivity zones. Phase 2 calibration involved adjustment of hydraulic conductivity within previously-defined zones until the anticipated long-term, steady-state response to pumping stresses was duplicated. An error closure of 196 ft was used during both phases, allowing an average error of 0.1 feet at each of the 1960 active nodes.

3.4.4.1 Phase 1 Calibration

It became clear early in the calibration procedure that the closely spaced contours in the vicinity of the recovery wells in the Diesel Spill Area and near recovery-well GBR-29 in the Southern Refinery Area could not be duplicated by the previously-described zoning. In an effort to reproduce these closely-spaced contours, two low-permeability zones were constructed beneath these areas.

Hydraulic head simulated in the northeastern part of the flow domain with the initial conductivities was well below the observed head. This suggested that a ground water source should be included in that area. If such a source did exist, it might also explain why closely-spaced contours in the Diesel Spill Area could not be duplicated. However, steady-state injection of up to 1 gpm at a node in the 14th row and 28th column of the grid had no observable effect on the hydraulic gradients in the areas of interest. This injection rate was considered to be the maximum rate at which water could be migrating into the system through preferred pathways such as along buried pipelines from the northeast. Given the unlikelihood that such a source could be contributing at a rate of even 1 gpm, the calibration was continued without specifying an external source anywhere in the northeast part of the grid.

3.4.4.2 Phase 2 Calibration

To define absolute, rather than relative, hydraulic conductivities in each conductivity zone, use was made of the three single-well aquifer tests performed in the Diesel Spill Area and Southern Refinery Areas. Based on the drawdown data collected at each pump well, a long-term steady-state drawdown was extrapolated from double-log plots of the data. Hydraulic conductivities were then adjusted until the model-simulated drawdown at the pumping node, discharging at the aquifer-test rate, matched the estimated long-term drawdown at the pump well. The extrapolated long-term drawdown was intentionally underestimated so that adjusted model conductivities would be somewhat overestimated. Coupled with overestimated saturated thickness, overestimated conductivities represented a worst-case scenario for the case of recovery operations, because high transmissivities would result in small drawdowns and induced hydraulic gradients towards recovery wells. Using these somewhat overestimated transmissivities, it was possible to predict maximum discharges required to capture all contaminated ground water. If the aquifer zone containing the recovery well could support this maximum required discharge, then recovery could be expected to be successful.

Drawdown obtained at the pump nodes had to be adjusted for the finite-area cell associated with the node before it could be compared to the drawdown at a point sink such as a pump well. The adjustment was made according to the relation (Prickett and Lonnquist, 1971):

$$\Delta s = 0.3665\ (Q/T)\ \log\ (a/4.81\ r_w)$$

where

Δs = additional drawdown at the pump well beyond that predicted by the model (ft)

Q = pump-test discharge (gpd)

T = aquifer transmissivity (gpd/ft)

a = square root of the cell area associated with the pumping node (ft)

r_w = well radius (ft)

The procedure used to perform Phase 2 steady-state calibration was as follows:

1) Using the estimated conductivity of the zone containing the well and pump-test discharge, generate predicted drawdown s with the flow model.

2) Add Δs to the drawdown predicted by the model, s, to obtain actual drawdown at a point $s' = s + \Delta s$

3) If the value of s′ is approximately equal to steady-state drawdown at the pump well, as extrapolated from aquifer test data, the model has been calibrated for conductivity of the zone containing the pump node. If s′ does not match the observed drawdown, adjust transmissivity accordingly and repeat steps 1-3.

Table 6 lists the pump-test discharges and extrapolated steady-state drawdown at GBR-14, GBR-27, and GBR-29.

TABLE 6 EXTRAPOLATED STEADY-STATE DRAWDOWN AT RECOVERY WELLS

Well	Conductivity Zone	Q(gpd)	Extrapolated Steady-State Drawdown (ft)
14	Arroyo alluvium	1440	15
27	Low-K Sandstone	1440	20
29	Sandstone (SE)	2880	1

The conductivity in these zones was varied until the generated drawdown, adjusted for the finite-area pumping node, was equal to the extrapolated steady-state drawdown. Assuming that drawdown at any pump well was not significantly affected by pumping from the other wells, all recovery wells could be pumped simultaneously during this stage of the calibration procedure.

Use of extrapolated drawdown at the GBR-14, 27, and 29 pump-test wells permitted estimation of hydraulic conductivities in the arroyo alluvial zone, the low-conductivity sandstone zone, and the southeastern sandstone zone. Due to lack of pump-test data in the high-conductivity sandstone located in the northern part of the grid, conductivity in this zone was assumed to be equal to conductivity identified in the southeastern sandstone zone. Conductivity for the valley sediments in the southern part of the grid was estimated by matching the model drawdown and the observed drawdown at GBR-8 due to pump-testing at GBR-29. Since radial flow was not occurring at GBR-8 during the pump test, no drawdown correction was necessary when matching drawdown at GBR-8.

Table 7 lists the final estimates of conductivity obtained on the basis of the two-phase steady-state calibration. The similarity of conductivities obtained in the arroyo alluvium zone and in the adjacent low-conductivity sandstone zone suggests that the low-conductivity sandstone zone may actually be underlain by silty saturated overbank sediments associated with the arroyo. Although southward deflection of flowlines occurring in the arroyo would appear to suggest that the overall arroyo conductivity is larger than the conductivity of the sandstone, a lower conductivity was evident from pump test results. These results indicated larger drawdown in GBR-14 than in GBR-27 under an equivalent pumping stress.

Comparison of the final simulated steady-state head distribution (Plate A2) with the observed water table shows that while the closely-spaced contours in specific portions of the flow domain were not exactly duplicated, the overall regional characteristics of the steady-state water table were adequately reproduced using the zone conductivities listed in Table 7. The far-spaced equipotential lines evident immediately southwest of the Diesel Spill Area appeared to result from the flow geometry around the low-conductivity area. The stagnation point at which streamlines converged on each other produced a loss of hydraulic potential and a reduced hydraulic gradient. The same phenomenon occurs in the observed water table, although to a lesser extent.

TABLE 7
FINAL MODEL ZONE
HYDRAULIC CONDUCTIVITIES

ZONE	FINAL CONDUCTIVITY	
	(GPD/FT^2)	(FT/DAY)
Arroyo Alluvium	1.8	0.24
Sandstone (N)	35.	4.7
(SE)	35.	4.7
Low-K Sandstone	1.3	0.17
Valley Sediments	50.	6.7

No attempt was made to contour the simulated water table outside of the constant-head boundaries. Contouring of data over the entire flow domain would have implied a greater reliability of head data outside of the constant-head boundaries than was actually realized.

Table 8 is a listing of the final input parameters and variables used to generate the steady-state hydraulic head distribution using the PLASM finite-difference flow model.

3.5 PREDICTION OF RECOVERY-WELL IMPACTS

Plate A3 depicts the potentiometric surface in the Southern Refinery Area due to the proposed recovery-well pumpages listed in Table 9. A total of 91,000 gallons per day of water would be pumped under the suggested strategy. Large recovery drawdown was difficult to maintain in the Southern Refinery Area due to the moderately-high conductivity associated with the sandstone and valley sediments in the contaminated area. Targeted recovery discharges were chosen on the basis of the discharge that could be expected to be maintained for the indicated zonal transmissivities.

The steady-state potentiometric surface shown in Plate A3 would evolve in response to proposed recovery operations over a long period of time. The proposed pumping strategy would result in interception of all upgradient contamination in both the Southern Refinery Area and the Diesel Spill Area. In the case of the Diesel Spill Area, even down-gradient portions of the estimated plume could easily be captured by the proposed level of pumping.

Based on prediction of recovery-well impacts, the estimated plume in the Diesel Spill Area can be intercepted by three existing recovery wells operating at a discharge rate of 1 gpm. Given that these wells have been tested previously at rates of 1 gpm and appear to be capable of maintaining this discharge rate over long periods of time, proposed recovery operations in the Diesel Spill Area are likely to be successful.

TABLE 8

PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD

```
U
Y
N
 0

C
 1  365  196  7.48052
 41  49  0  0  0
 1  1  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  2  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  3  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  4  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  5  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  6  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  7  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  8  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  9  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  10  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  11  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  12  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  13  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  14  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  15  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  16  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  17  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  18  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  19  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  20  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  21  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  22  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  23  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  24  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  25  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  26  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  27  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  28  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  29  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  30  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  31  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  32  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  33  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  34  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  35  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  36  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  37  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  38  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  39  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  40  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  41  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  42  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  43  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  44  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  45  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  46  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  47  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  48  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 1  49  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 2  1  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 2  2  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 2  3  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 2  4  2187.5  2187.5  1E-22  362.5  0  0  0  0  300  35  35
 2  5  2485  2485  1E-22  371  0  0  0  0  300  35  35
 2  6  2464  2464  1E-22  370.4  0  0  0  0  300  35  35
 2  7  2441.25  2441.25  1E-22  369.75  0  0  0  0  300  35  35
 2  8  2415  2415  1E-22  369  0  0  0  0  300  35  35
 2  9  2376.5  2376.5  1E-22  367.9  0  0  0  0  300  35  35
 2  10  2338  2338  1E-22  366.8  0  0  0  0  300  35  35
 2  11  2317.001  2317.001  1E-22  366.2  0  0  0  0  300  35  35
 2  12  2293.501  2293.501  1E-22  365.7  0  0  0  0  300  35  35
 2  13  2292.5  2292.5  1E-22  365.5  0  0  0  0  300  35  35
 2  14  2283.75  2283.75  1E-22  365.25  0  0  0  0  300  35  35
 2  15  2275  2275  1E-22  365  0  0  0  0  300  35  35
 2  16  2268  2268  1E-22  364.8  0  0  0  0  300  35  35
 2  17  2261  2261  1E-22  364.6  0  0  0  0  300  35  35
 2  18  2257.5  2257.5  1E-22  364.5  0  0  0  0  300  35  35
 2  19  2250.5  2250.5  1E-22  364.3  0  0  0  0  300  35  35
```

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

2	20	2245.25	2245.25	1E-22	364.15	0	0	0	0	300	35	35
2	21	2240	2240	1E-22	364	0	0	0	0	300	35	35
2	22	2226	2226	1E-22	363.6	0	0	0	0	300	35	35
2	23	2215.5	2215.5	1E-22	363.3	0	0	0	0	300	35	35
2	24	2205	2205	1E-22	363	0	0	0	0	300	35	35
2	25	2192.75	2192.75	1E-22	362.65	0	0	0	0	300	35	35
2	26	2170	2170	1E-22	362	0	0	0	0	300	35	35
2	27	2117.5	2117.5	1E-22	360.5	0	0	0	0	300	35	35
2	28	2065	2065	1E-22	359	0	0	0	0	300	35	35
2	29	1995	1995	1E-22	357	0	0	0	0	300	35	35
2	30	1911	1911	1E-22	354.6	0	0	0	0	300	35	35
2	31	1890	1890	1E-22	354	0	0	0	0	300	35	35
2	32	1855	1855	1E-22	353	0	0	0	0	300	35	35
2	33	1837.5	1837.5	1E-22	352.5	0	0	0	0	300	35	35
2	34	1828.75	1828.75	1E-22	352.25	0	0	0	0	300	35	35
2	35	1820	1820	1E-22	352	0	0	0	0	300	35	35
2	36	1814.75	1814.75	1E-22	351.85	0	0	0	0	300	35	35
2	37	1813	1813	1E-22	351.8	0	0	0	0	300	35	35
2	38	1811.25	1811.25	1E-22	351.75	0	0	0	0	300	35	35
2	39	1807.75	1807.75	1E-22	351.65	0	0	0	0	300	35	35
2	40	1806	1806	1E-22	351.6	0	0	0	0	300	35	35
2	41	1800.75	1800.75	1E-22	351.45	0	0	0	0	300	35	35
2	42	1795.5	1795.5	1E-22	351.3	0	0	0	0	300	35	35
2	43	1785	1785	1E-22	351	0	0	0	0	300	35	35
2	44	1779.75	1779.75	1E-22	350.85	0	0	0	0	300	35	35
2	45	1776.25	1776.25	1E-22	350.75	0	0	0	0	300	35	35
2	46	1767.5	1767.5	1E-22	350.5	0	0	0	0	300	35	35
2	47	1758.75	1758.75	1E-22	350.25	0	0	0	0	300	35	35
2	48	1750	1750	1E+22	350	0	0	0	0	300	35	35
2	49	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	5	128.7	128.7	1E+22	371.5	0	0	0	0	300	1.8	1.8
3	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	45	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	46	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
3	47	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
3	48	90	90	1E+22	350	0	0	0	0	300	1.8	1.8
3	49	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	5	129.42	129.42	1E+22	371.9	0	0	0	0	300	1.8	1.8
4	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

4	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
4	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	46	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	47	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
4	48	90	90	1E+22	350	0	0	0	0	300	1.8	1.8
4	49	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
5	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
5	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
5	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	5	130.14	130.14	1E+22	372.3	0	0	0	0	300	1.8	1.8
5	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	46	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	47	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
5	48	90	90	1E+22	350	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CON'D)

5	49	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
6	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
6	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
6	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	5	130.68	130.68	1E+22	372.6	0	0	0	0	300	1.8	1.8
6	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	46	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	47	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
6	48	90	90	1E+22	350	0	0	0	0	300	1.8	1.8
6	49	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
7	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
7	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
7	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	5	131.4	131.4	1E+22	373	0	0	0	0	300	1.8	1.8
7	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

7	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	46	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	47	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
7	48	90	90	1E+22	350	0	0	0	0	300	1.8	1.8
7	49	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
8	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
8	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
8	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	5	131.67	131.67	1E+22	373.15	0	0	0	0	300	1.8	1.8
8	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	46	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	47	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
8	48	90	90	1E+22	350	0	0	0	0	300	1.8	1.8
8	49	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
9	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
9	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
9	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	5	132.12	132.12	1E+22	373.4	0	0	0	0	300	1.8	1.8
9	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

9	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	46	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
9	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
9	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
9	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
10	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
10	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
10	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
10	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	5	132.48	132.48	1E+22	373.6	0	0	0	0	300	1.8	1.8
10	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
10	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
10	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
10	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
10	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
11	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
11	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
11	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
11	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	5	132.84	132.84	1E+22	373.8	0	0	0	0	300	1.8	1.8
11	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF STEADY-STATE HEAD (CONT'D)

11	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	41	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	42	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	43	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	44	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	45	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
11	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
11	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
11	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
11	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
12	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
12	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
12	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	5	133.02	133.02	1E+22	373.9	0	0	0	0	300	1.8	1.8
12	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
12	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
12	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
12	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
13	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
13	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
13	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	5	133.38	133.38	1E+22	374.1	0	0	0	0	300	1.8	1.8
13	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

13	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
13	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
13	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
13	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
14	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
14	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
14	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	5	133.56	133.56	1E+22	374.2	0	0	0	0	300	1.8	1.8
14	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
14	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
14	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

14	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
14	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
15	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
15	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
15	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	5	133.74	133.74	1E+22	374.3	0	0	0	0	300	1.8	1.8
15	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	12	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	13	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	14	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	15	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	16	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	17	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	18	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	19	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	20	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	21	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	22	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	23	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	31	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	32	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	33	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	34	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	35	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	36	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	37	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	38	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	39	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	40	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
15	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
15	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
15	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
16	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
16	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
16	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	5	133.92	133.92	1E+22	374.4	0	0	0	0	300	1.8	1.8
16	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
16	24	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	25	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	26	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	27	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	28	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	29	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	30	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
16	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
16	32	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	33	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	34	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	35	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	36	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

16	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
16	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
16	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	4	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	5	134.1	134.1	1E+22	374.5	0	0	0	0	300	1.8	1.8
17	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
17	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
17	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
17	32	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	33	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	34	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	35	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	36	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
17	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
17	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	5	134.37	134.37	1E+22	374.65	0	0	0	0	300	1.8	1.8
18	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
18	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
18	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
18	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
18	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
18	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
18	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
18	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

18	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
18	32	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	33	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	34	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	35	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	36	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
18	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
18	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	5	134.64	134.64	1E+22	374.8	0	0	0	0	300	1.8	1.8
19	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
19	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
19	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
19	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
19	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
19	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
19	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
19	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
19	32	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	33	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	34	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	35	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	36	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
19	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
19	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	5	134.82	134.82	1E+22	374.9	0	0	0	0	300	1.8	1.8
20	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
20	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
20	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
20	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
20	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
20	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
20	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

20	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
20	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
20	32	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	33	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	34	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	35	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	36	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
20	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
20	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	5	2628.5	2628.5	1E+22	375.1	0	0	0	0	300	35	35
21	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
21	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
21	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
21	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
21	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
21	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
21	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
21	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
21	32	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	33	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	34	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	35	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	36	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
21	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
21	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	5	2637.25	2637.25	1E+22	375.35	0	0	0	0	300	35	35
22	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
22	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

22	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
22	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
22	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
22	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
22	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
22	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
22	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
22	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
22	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	5	2637.25	2637.25	1E+22	375.35	0	0	0	0	300	35	35
23	6	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
23	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
23	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
23	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
23	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
23	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
23	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
23	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
23	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

23	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
23	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
23	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	5	2640.751	2640.751	1E+22	375.45	0	0	0	0	300	35	35
24	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
24	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
24	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
24	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
24	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
24	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
24	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
24	37	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	38	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	39	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	40	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	41	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	42	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	43	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	44	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
24	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
24	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
25	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	5	2644.25	2644.25	1E+22	375.55	0	0	0	0	300	35	35
25	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	7	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
25	8	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
25	9	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
25	10	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
25	11	112.5	112.5	1E-22	362.5	0	0	0	0	300	1.8	1.8
25	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
25	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3

TABLE 8

PLASM INPUT PARAMETERS FOR GENERATION OF STEADY-STATE HEAD (CONT'D)

25	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
25	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
25	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
25	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
25	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
25	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
26	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	5	2651.25	2651.25	1E+22	375.75	0	0	0	0	300	35	35
26	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
26	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
26	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
26	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
26	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
26	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
26	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
27	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	5	2654.75	2654.75	1E+22	375.85	0	0	0	0	300	35	35
27	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

27	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
27	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
27	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
27	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
27	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
27	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
27	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
28	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	5	2660	2660	1E+22	376	0	0	0	0	300	35	35
28	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	12	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	13	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	14	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	15	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	16	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	17	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	18	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	19	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	20	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	21	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	22	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	23	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
28	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
28	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
28	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
28	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
28	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
28	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
29	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	5	2665.25	2665.25	1E+22	376.15	0	0	0	0	300	35	35
29	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

29	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
29	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
29	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
29	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
29	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
29	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
29	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
29	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
29	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
29	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
29	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
30	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	5	2672.25	2672.25	1E+22	376.35	0	0	0	0	300	35	35
30	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
30	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
30	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
30	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
30	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
30	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
30	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
30	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
30	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
30	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
30	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
31	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	5	2681	2681	1E+22	376.6	0	0	0	0	300	35	35
31	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

31	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
31	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
31	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
31	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
31	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
31	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
31	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
31	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
31	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
31	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
31	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
32	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	5	2688	2688	1E+22	376.8	0	0	0	0	300	35	35
32	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
32	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
32	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
32	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
32	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
32	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
32	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

32	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
32	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
32	48	2500	2500	1E+22	350	0	0	0	0	300	50	50
32	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
33	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	5	2703.75	2703.75	1E+22	377.25	0	0	0	0	300	35	35
33	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	32	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
33	33	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
33	34	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
33	35	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
33	36	81.25	81.25	1E-22	362.5	0	0	0	0	300	1.3	1.3
33	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
33	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
33	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
33	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
33	48	2535.001	2535.001	1E+22	350.7	0	0	0	0	300	50	50
33	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
34	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	5	2717.75	2717.75	1E+22	377.65	0	0	0	0	300	35	35
34	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

34	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
34	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
34	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
34	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
34	48	2600	2600	1E+22	352	0	0	0	0	300	50	50
34	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
35	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	5	2730	2730	1E+22	378	0	0	0	0	300	35	35
35	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
35	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
35	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
35	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
35	48	2650	2650	1E+22	353	0	0	0	0	300	50	50
35	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
36	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	5	2733.5	2733.5	1E+22	378.1	0	0	0	0	300	35	35
36	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

36	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
36	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
36	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
36	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
36	48	2700	2700	1E+22	354	0	0	0	0	300	50	50
36	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
37	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	5	2737.001	2737.001	1E+22	378.2	0	0	0	0	300	35	35
37	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
37	45	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
37	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
37	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
37	48	2737.5	2737.5	1E+22	354.75	0	0	0	0	300	50	50
37	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
38	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	5	2740.5	2740.5	1E+22	378.3	0	0	0	0	300	35	35
38	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMERERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

38	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	45	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
38	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
38	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
38	48	2815	2815	1E+22	356.3	0	0	0	0	300	50	50
38	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
39	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
39	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
39	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
39	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
39	5	2751	2751	1E+22	378.6	0	0	0	0	300	35	35
39	6	2756.25	2756.25	1E+22	378.75	0	0	0	0	300	35	35
39	7	2765	2765	1E+22	379	0	0	0	0	300	35	35
39	8	2765	2765	1E+22	379	0	0	0	0	300	35	35
39	9	2765	2765	1E+22	379	0	0	0	0	300	35	35
39	10	2761.5	2761.5	1E+22	378.9	0	0	0	0	300	35	35
39	11	2754.501	2754.501	1E+22	378.7	0	0	0	0	300	35	35
39	12	2747.5	2747.5	1E+22	378.5	0	0	0	0	300	35	35
39	13	2742.25	2742.25	1E+22	378.35	0	0	0	0	300	35	35
39	14	2738.75	2738.75	1E+22	378.25	0	0	0	0	300	35	35
39	15	2733.5	2733.5	1E+22	378.1	0	0	0	0	300	35	35
39	16	2730	2730	1E+22	378	0	0	0	0	300	35	35
39	17	2726.5	2726.5	1E+22	377.9	0	0	0	0	300	35	35
39	18	2721.25	2721.25	1E+22	377.75	0	0	0	0	300	35	35
39	19	2712.5	2712.5	1E+22	377.5	0	0	0	0	300	35	35
39	20	2707.25	2707.25	1E+22	377.35	0	0	0	0	300	35	35
39	21	2703.75	2703.75	1E+22	377.25	0	0	0	0	300	35	35
39	22	2695	2695	1E+22	377	0	0	0	0	300	35	35
39	23	2677.5	2677.5	1E+22	376.5	0	0	0	0	300	35	35
39	24	2667.001	2667.001	1E+22	376.2	0	0	0	0	300	35	35
39	25	2660	2660	1E+22	376	0	0	0	0	300	35	35
39	26	2642.5	2642.5	1E+22	375.5	0	0	0	0	300	35	35
39	27	2625	2625	1E+22	375	0	0	0	0	300	35	35
39	28	2569	2569	1E+22	373.4	0	0	0	0	300	35	35
39	29	2502.5	2502.5	1E+22	371.5	0	0	0	0	300	35	35
39	30	2450	2450	1E+22	370	0	0	0	0	300	35	35
39	31	2352.001	2352.001	1E+22	367.2	0	0	0	0	300	35	35
39	32	2310	2310	1E+22	366	0	0	0	0	300	35	35
39	33	2271.5	2271.5	1E+22	364.9	0	0	0	0	300	35	35
39	34	2247.001	2247.001	1E+22	364.2	0	0	0	0	300	35	35
39	35	2222.5	2222.5	1E+22	363.5	0	0	0	0	300	35	35
39	36	2203.251	2203.251	1E+22	362.95	0	0	0	0	300	35	35
39	37	2199.75	2199.75	1E+22	362.85	0	0	0	0	300	35	35
39	38	2196.25	2196.25	1E+22	362.75	0	0	0	0	300	35	35
39	39	2192.75	2192.75	1E+22	362.65	0	0	0	0	300	35	35
39	40	2189.25	2189.25	1E+22	362.55	0	0	0	0	300	35	35
39	41	2182.25	2182.25	1E+22	362.35	0	0	0	0	300	35	35
39	42	2177.001	2177.001	1E+22	362.2	0	0	0	0	300	35	35
39	43	2166.5	2166.5	1E+22	361.9	0	0	0	0	300	35	35
39	44	2140.25	2140.25	1E+22	361.15	0	0	0	0	300	35	35
39	45	2110.5	2110.5	1E+22	360.3	0	0	0	0	300	35	35
39	46	2975	2975	1E+22	359.5	0	0	0	0	300	50	50
39	47	2952.5	2952.5	1E+22	359.05	0	0	0	0	300	50	50
39	48	2870	2870	1E+22	357.4	0	0	0	0	300	50	50
39	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
40	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	5	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

40	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	45	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
40	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
40	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
40	48	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
40	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
41	1	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	2	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	3	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	4	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	5	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	6	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	7	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	8	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	9	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	10	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	11	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	12	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	13	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	14	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	15	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	16	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	17	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	18	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	19	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	20	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	21	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	22	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	23	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	24	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	25	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	26	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	27	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	28	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	29	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	30	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	31	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	32	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	33	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	34	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	35	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	36	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	37	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	38	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	39	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	40	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	41	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	42	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	43	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	44	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35

TABLE 8
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD (CONT'D)

41	45	2187.5	2187.5	1E-22	362.5	0	0	0	0	300	35	35
41	46	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
41	47	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
41	48	3125	3125	1E-22	362.5	0	0	0	0	300	50	50
41	49	3125	3125	1E-22	362.5	0	0	0	0	300	50	50

DESCRIPTION OF PLASM INPUT OPTIONS AND VARIABLES IN TABLE 8

Line	Option
1	U = unconfined flow
2	Y = predictor option in effect
3	N = mass-balance option not in effect
4	0 = % mass-balance error
5	English units used
6	C = constant pumping rate

Line	Variable
7	NSTEPS, DELTA, ERROR, CON
8	NC, NR, NP, NSP, NRT
9-2017	I, J, Tx, Ty, S, H, Q, R, RH, RD, BUT, Kx, Ky

NSTEPS = number of time steps
DELTA = time increment (days)
ERROR = total global error closure (ft)
CON = conversion factor
NC = number od columns
NR = number of rows
NP = number of pumping nodes
NSP = number of time increments per pumping change
NRT = number of rates in pumping schedule
I = nodal column number
J = nodal row number
Tx = transmissivity in the x-direction (gpd/ft)
Ty = transmissivity in the y-direction (gpd/ft)
S = Storage coefficient
H = initial hydraulic head (ft)
Q = withdrawal rate per unit area (gpd/ft^2)
R = leakance coefficient (gpd/ft^3
RH = source bed head (ft)
RD = confining layer bottom elevation (ft)
BOT = elevation of aquifer bottom (ft)
Kx = hydraulic conductivity in x-direction (gpd/ft^2)
Ky = hydraulic conductivity in y-direction (gpd/ft^2)

TABLE 9
PROPOSED LONG-TERM
RECOVERY-WELL PUMPING

Well	Column Location	Row Location	Hydraulic Conductivity (GPD/FT^2)	Q(GPM)
14	14	14	1.8	1
27	21	16	1.3	1
28	17	22	1.3	1
X1	17	36	50	15
X2	22	37	50	15
29	27	38	35	10
X3	31	39	35	10
X4	33	41	35	10

Interception of contaminated ground water in the Southern Refinery Area is expected to be somewhat more difficult than in the Diesel Spill Area because of higher-conductivity river valley sediments characteristic of the Southern Refinery Area; cones of depression that develop within these sediments in response to recovery pumping tend to be less steep than those produced in the silty low-conductivity arroyo alluvium or the sandstone units. As a result, greater discharge and a larger number of wells are expected to be required in order to recover a specific volume of contaminated ground water in the Southern Refinery Area compared to the Diesel Spill Area.

3.6 ACTIONS TAKEN TO DATE AND RECOMMENDATIONS FOR FUTURE WORK

The recovery system in the Diesel Spill Area is currently in place. At the present time, wells GBR-37 and GBR-38 shown in Plate A3 have been installed in the Southern Refinery Area as 6-inch recovery wells. Optimal placement of these wells was more dependent on the edges of the inferred plume than by aquifer yield. The three-well pumping strategy using wells GBR-29, GBR-37 and GBR-38 was tested over the period extending from October to November of 1987 in order to determine long-term aquifer response and recovery-well yields in the Southern Refinery Area.

The approximate capture zones predicted by the model for a five-well remedial action pumping strategy in the Southern Refinery Area are shown in Plate A4. In view of the conservative assumptions made regarding conductivity and saturated thickness, and preliminary evaluation of water level data during pumping (Appendix C), it is anticipated that the four-well system as proposed in the discharge plan will be sufficient.

APPENDIX B

LITHOLOGIC LOGS AND COMPLETION DIAGRAMS OF WELLS INSTALLED BY GIANT INDUSTRIES

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews   Well Number GBR-1

___ ¼ NE ¼ NW ¼ NW ¼   S 27 T 29 R 12   State New Mexico

County San Juan   Contractor Western Technology

Spud Date 12/20/85   Completion Date 12/20/85

Logs Run Lithology from cuttings   Logged By J.C. Hunter

Elevation 5414' topo   Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled With Hollow-Stem Auger (CME-55)

Depth	Litho	recov	Samples/Footage	Lithology/Remarks
0				0.0-10.0 (10.0') FILL: very coarse cobbles and small boulders of quartzite w/sand and gravel; dark gray; dark hydrocarbon stain and odor below 2.5'; damp.
10			8512200850/10.0' 8512200900/15.0'	10.0-20.0' (20.0') SANDSTONE : yellow-gray brown; silty and poorly sorted; fine-med grained; damp' faint hydrocarbon odor 10.0-15.0' dryer with no odor 15.0'-20.0'.
TD=20.0' 20			8512200916/20.0'	Borehole located on N side of old burn pit; 90.0' 165° to south fire hydrant' borehole backfilled w/cuttings and bentonite plug
25				85122000850 : 1 VOA, cuttings 8512200900 : 1 VOA, 1 Whirlpack, split spoon 8512200916 : 1 VOA, 1 Whirlpack, split spoon
30				

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-2

¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow-Stem Auger (CME_55)

Depth	Litho	Recov	Samples/Footage	Lithology/Remarks
0				0.0'-15.0' (15.0') FILL; very coarse cobbles and small boulders of quartyite w/sand and gravel; faint hydrocarbon odor 5.0'-10.0'; strong hydrocarbon odor 10.0'-15.0'; free water level encountered @ 10.0'; Hydrocarbon stains 5.0'-15.0'.
5				
10				
			8512201046/12.5'	
15				15.0'-25.0' (10.0') SANDSTONE : grades from medium gray (15.0 17.5') to yellow gray (17.5'-25.0'); strong hydrocarbon odor and some stains 15.0'-17.5'; faint odor and no stain 17.5'-25.0'; sand is fine-med grained, poorly sorted, silty; wet to 25.0'.
20				
TD=25.0' 25				
				Borehole located in center of old burn pit; 73.0', 148° to south hydrant; borehole backfilled with cuttings and bentonite plug @ bottom and @ top of water.
30				
				8512201046 : 1 VOA, 1 whirlpack, cuttings

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-3

¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow- Stem Auger (CME-55)

Depth	Litho	recov	Samples/footage	Lithology/remarks
0				0.0'-5.0' (5.0') FILL: very coarse cobbles and small boulder of quartyite; some sand and gravel; gray-gray brown; dry; faint hydrocarbon odor.
5				5.0'-7.5' (2.5') SANDY FILL: sand & gravel with some cobbles and boulders; browish gray; damp; faint hydrocarbon odor.
10				7.5'-12.5' (5.0') SANDSTONE: yellow-brown; fine grained; poorly sorted and silty; damp; very faint hydrocarbon odor; no stain.
TD=12.5' (Refused auger)				
15				Borehole located 51.0', 136° to south hydrant; backfilled w/ cuttings and bentonite plug @ bottom. Probably at or near south edge of burn pit.
20				
25				
30				

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-4

¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow-Stem Auger (CME-55)

Depth	Litho	Recov	Samples/footage	Lithology/remarks
0				0.0'-5.0' (5.0') FILL: Very coarse cobbles and small boulde brown-gray; dry, faint hydrocarbon odor; no stain.
5				5.0'-25.0' (20.0') SAND and STONE : gray-brown; soft and loose 5.0'-13.0', becomes harder and cosolidated 13.0'-25.0'; damp from 5.0'-10.0'; saturated 10.0'-25.0'; hydrocarbon odor and some stain 5.0' - 25.0'; water level poorly defined, about 10.0'.
▼? 10				
15				
20				
25 TD=25.0' refused auger				Located 97.0', 138° to south hydrant; backfilled with cuttings and bentonite plug @ bottom.
30				

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-5

___ ¼ ___ ¼ ___ ¼ ___ ¼ S ___ T ___ R ___ State New Mexico

County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5390' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow-Stem Auger (CME-55)

Depth	Litho	Recov	Samples/footage	Lithology/remarks
0				0.0'-5.0' (5.0') FILL: Very coarse cobbles and small boulders of quartyite; minor sand and gravel; dark gray with strong oily hydrocarbon stain and odor, dry-moist.
10				
20			8512201240/20.0'	5.0'-55.0' (50') SANDSTONE: dark gray-yellow gray; fine grained; poorly sorted; silty; strong hydrocarbon stain and odor 5.0'-25.0'; faint stain and some odor 25.5'- 55.0' ; water level at approximately 33.0', odor persists in saturated sand to total depth.
30				
5/30/86 33'				
40				
50			8512201410/55.0'	
TD=55.0' refused auger				Borehole covered and left open for later ground water sampling. Located below SW corner of south pad.
60				8512201240 : 1VOA, 1 whirlpack, cuttings
				8512201410 : 1VOA, 1 whirlpack, cuttings
				TD 53'6" TOC, screened from 31'6" to 51'6"
				gravel to 26'8", 50 lb. Bentonite @ 26'8"
				Backfill to surface

GCL

WELL LOGGING FORM

Page ____ of ____

Client: Montgomery & Andrews — Well Number: GBR-6

1/4 1/4 1/4 1/4 S 27 T 29 R 12 — State: New Mexico

County: San Juan — Contractor: Beeman Bros. Drilling Co.

Spud Date: 9/9/86 — Completion Date: 9/9/86

Logs Run: Lith from cuttings — Logged By: Martin

Elevation: ____ — Spud In (Fm.): ____

Remarks: Drilled with Air Rotary

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0'							0'-very coarse-grained cobbles, sand and gravel; dark brown with hydrocarbon odor.
10'							10'-coarse-grained sand and gravel with some cobbles; dark brown with hydrocarbon odor.
20'							20'-fine-grained sand; well-sorted; medium brown with hydrocarbon odor.
30'							30'-fine-grained sand; well-sorted; dark brown-black; strong hydrocarbon odor.
							35'-sandstone; mixed gray-green/yellow-brown with hydrocarbon odor.
40'							40'-sandstone; coarse-grained well-sorted; yellow-brown: faint hydrocarbon odor.
							45'-sandstone; coarse-grained, poorly-sorted; yellow-brown with some clay.
50'							50'-fine-grained, poorly-sorted; gray yellow/brown; water present.
							55'-shale; gray.
60'							60'-shale; minor medium-grained gravel, poorly-sorted; dark gray.
							65'-shale; dark brown.
70'							TD of 65'4" from surface, screened from 60'4" to 20'4" gravel to 12', bentonite to 6'5", cement grout w/5% bentonite to surface. Completed as 6" PVC recovery well with identical casing of 1" PVC attached to outside.

GCL

WELL LOGGING FORM

Client Montgomery & Andrews Well Number GBR 7

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 9-24-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks Drilled with Hollow Stem Auger

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0						0-5'	COBBLES AND SAND, 1/8"-5" in diam w/minor sand; fn-co gr; mod ylsh brn 10YR5/4
5						5-7.5'	SAND AND GRAVEL, dusky hlsh brn 10YR2/2; med-co gr sand
						7.5-10'	SAND AND GRAVEL, as above; at 10' hit hydrocarbon-stained sand; brnsh blck 5YR2/5
10						10-12.5'	SAND, w/1-2% small gravel; 1/2"-1" in diam; olive gry 5Y4/1; fn-co gr; hydrocarbon odor and stain
						12.5-15'	SAND, w/some gravels; 2-3% gravel, 1/4"-1 1/2" diam; sand olive gry 5Y4/1 and fn-co gr
15						15-16'	SAND, lt olive gry 5Y5/2; v fn-fn gr; slight hydrocarbon odor
						16-17'	SILTY SAND, olive gry 5Y4/1; v fn gr; hydrocarbon odor
						17-17.5'	SAND, olive gry 5Y4/1; v fn gr hydrocarbon odor
20						17.5-18.0	SAND, lt olive gry 5Y5/2; v fn gr; slight hydrocarbon odor
						18-22.5'	SAND, v fn gr w/some silt; lt olive gry 5Y5/2; slight hydrocarbon odor
						22.5-25.0'	SAND, as above, slight hydrocarbon odor
25						25-27'	GRAVEL AND SAND, hydrocarbon-stained
						27-30'	SAND, hydrocarbon-stained; grades from olive blck 5Y2/1 to blck N1; 1/4"-1/2" diam cobbles; fn fr sand
30						33-35'	SANDSTONE, weathered lt olive brn 5Y5/6; fn-med gr w/some silt; no hydrocarbon odor, no moisture
35						35-36'	CLAY, olive gry 5Y3/2; hydrocarbon odor; moist; minor sand
						36-40'	SAND AND SOME SILT, fn gr dusky yel 5Y6/4
40						40-41'	SAND, w/some silt, fn gr dk yelsh orng 10YR6/6, some gravel and quartzite at 40'
						41-43.5'	SAND, w/some silt, fn gr minor gravels, quartzite
						43.5-46'	SAND, grades from med-co gr sand to fn silty sand, dk yelsh orng
45							

WELL LOGGING FORM

Client Montgomery & Andrews Well Number GBR 7

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 9-24-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							
							46-47.5' SILTY SANDSTONE, lt gry to lt olive gry N7 to 5Y6/1
50							TD to 48' from surface, screened from 41'7.5" to 31'7.5", 6' blank on bottom, gravel pack to 24'10", bentonite plug to 19'8", cement grout w/5% bentonite to surface. Completed well with 2" PVC.
55							
60							
65							
70							
75							
80							
85							
90							

GCL

WELL LOGGING FORM

Client: Montgomery & Andrews   Well Number: (P-4) GBR 8

___1/4 ___1/4 ___1/4 ___1/4 S 27 T 29 R 12 State: New Mexico

County: San Juan   Contractor: Western Technologies

Spud Date: Completion Date: 10-1-86

Logs Run: Lithology   Logged By: Martin

Elevation: Spud In (Fm.):

Remarks: Drilled with Hollow Stem Auger

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH		REMARKS
0							0-5'	SILTY SAND, w/some cobbles, fn-med gr dk yelsh brn color 10YR4/2
5							5-10'	SAND, med-co gr; dk yelsh brn color 10YR4/2
10							10-25'	COARSE-GRAINED SAND, dk yelsh brn color 10YR4/2
15								
20								
25							25-30'	CLAYEY SAND, fn-med gr; dk yelsh brn color 10YR4/2
30							30-35'	SANDY CLAY, v fn-med gr, dk yelsh brn color 10YR4/2
35							35-38'	SANDY CLAY, fn-med gr olive gry color 5Y4/1; strong hydrocarbon odor
							38-38.33'	SANDY CLAY, fn-med gr mixed color of mod yelsh brn 10YR5/4 and olive gry 5Y4/1; strong hydrocarbon odor
							38.33-39.17'	SILTY SAND, fn-med gr olive gry color 5Y4/1 strong hydrocarbon odor
40							39.17-39.5'	SAND, co gr olive gry color 5Y4/1, strong hydrocarbon odor
45								

GCL

WELL LOGGING FORM

Client Montgomery & Andrews Well Number (P-4) GBR 8

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 10-1-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							
							TD to 58' from surface. Screened from 53' to 38', 5' blank on bottom. Gravel pack to 30', bentonite plug to 25', cement grout to surface. Completed with 2" PVC.
50							
55							
60							
65							
70							
75							
80							
85							
90							

GCL

WELL LOGGING FORM

Client Montgomery & Andrews Well Number GBR 9

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date 9-29-86 Completion Date 9-30-86

Logs Run Lithology Logged By Martin/Kaszuba

Elevation Spud In (Fm.)

Remarks Drilled with Hollow Stem Auger

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0						0-2.5'	SAND, med-fn gr w/rare pebbles; mod yelsh brn 10YR5/4
						2.5-5'	SAND, med-fn gr w/rare pebbles; mod yelsh brn 10YR5/4
5						5-7.5'	SAND, med-fn gr w/rare pebbles; mod yelsh brn 10YR5/4
						7.5-10'	CLAYEY SAND, med-fn gr; mod yelsh brn 10YR5/4
10						10-12.5'	CLAYEY SAND, co gr w/1-2% gravels; mod yelsh brn 10YR5/4
						12.5-15'	CLAYEY SAND, med-fn gr; mod yelsh brn 10YR5/4
15						15-17.5'	same as above
						17.5-20'	SAND, med gr; mod yelsh brn 10YR5/4
20						20-22.5'	SAND, med gr, w/occasional pebbles; mod yelsh brn 10YR5/4
						22.5-25'	same as above
25						25-27.5'	SAND, med gr, w/occasional pebbles; mod yelsh brn 10YR5/4
						27.5-30'	SANDY CLAY, med gr sand; dk yelsh brn 10YR4/2, faint HC odor
30						30-32.5'	CLAYEY SAND, fn-med gr; dk yelsh brn 10YR4/2, faint HC odor
						32.5-40'	SANDY CLAY, fn-med gr; olive gry 5Y4/1, strong HC odor
35							
40						40-45'	CLAY AND SAND, fn gr sand, dk yelsh orng 10YR6/6; clay is lt olive gry 5Y5/2
45						45-47.5'	SANDY CLAY/CLAYEY SAND, dusky yel 5Y6/4

GCL

WELL LOGGING FORM

Client: Montgomery & Andrews — Well Number: GBR 9

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

County: San Juan — Contractor: Western Technologies

Spud Date: 9-29-86 — Completion Date: 9-30-86

Logs Run: Lithology — Logged By: Martin/Kaszuba

Elevation: — Spud In (Fm.):

Remarks:

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							
							47.5-52.5' SANDY CLAY, med gr sand; lt olive gry 5Y5/2
50							
							52.5-52.9' SILT, olive gry 5Y4/1
							52.9-57.5' SHALE, grnsh gry 5GY6/1
55							
							57.5-62.5' SILT, grnsh gry 5GY6/1
60							
							TD of 65' from TOC. Completed with 2" PVC/ss flush joint. Sand pack to 37', bentonite to 18 1/2' (1.5 bags) cement grout w/5% bentonite to surface. Screened from 50-60', ss up to 35', PVC from 35' to TOC.
65							
70							
75							
80							
85							
90							

GCL

WELL LOGGING FORM

Client: Montgomery & Andrews — Well Number: (P-2) GBR 10

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

County: San Juan — Contractor: Western Technologies

Spud Date: — Completion Date: 9-29-86

Logs Run: Lithology — Logged By: Martin

Elevation: — Spud In (Fm.):

Remarks: Drilled with Hollow Stem Auger

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0-10'							SAND, med gr poorly sorted w/some cobbles; mod yelsh brn color 10YR5/4
10-15'							SAND, co-med gr mod yelsh brn color 10YR5/4 poorly sorted
15-20'							SAND, co-med gr poorly sorted; dk yelsh brn color 10YR4/2
20-30'							SAND, w/5% gravel co-med gr, poorly sorted; dk yelsh brn color 10YR4/2, faint HC smell
30-33'							SANDY CLAY, fn-med gr dk yelsh brn color 10YR4/2, faint HC odor
33-33.33'							SILTY SAND, fn-med gr; olive gry color 5Y4/1 well sorted, strong HC color
33.33-33.75'							SAND, fn-med gr well sorted; lt olive gry 5Y5/2, strong HC odor
33.75-34.67'							SILTY SAND, fn-med gr olive gry color 5Y4/1; well sorted; strong HC odor
38-38.92'							CLAYEY SAND, fn-med gr olive gry color 5Y4/1; strong HC odor
38.92-39'							SAND, fn-med gr grysh blck color N2; strong HC odor
39-39.67'							CLAYEY SAND, fn-med gr olive gry color 5Y4/1, strong HC odor
39.67-39.83'							CLAYEY SAND, co-med gr dusky yel color 5Y6/4; faint HC odor

GCL

WELL LOGGING FORM

Client Montgomery & Andrews Well Number (P-2) GBR 10

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 9-29-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							TD to 45' from surface. Screened from 39' to 29' 5' blank on bottom. Gravel pack to 23' bentonite plug to 18.5'; cement grout to surface. Completed with 2" PVC.
50							
55							
60							
65							
70							
75							
80							
85							
90							

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WELL LOGGING FORM

Page 1 of 1

Client: Montgomery & Andrews   Well Number: GBR-11

¼ SW ¼ NW ¼ NW ¼ S 27 T 29N R 12W State: New Mexico

County: San Juan   Contractor: Western Technologies

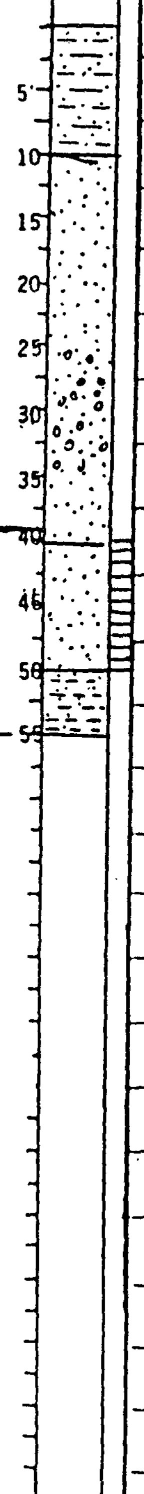
Spud Date: 4/1/86   Completion Date: 4/1/86

Logs Run: Lithology from cuttings   Logged By: J.C. Hunter

Elevation: 5388' (topo)   Spud In (Fm.): Nacimiento (Tertiary)

Remarks: Drilled w/HSA, completed as galv. steel piezometer (2.0") 80.7', 245 to N end of "GIANT" sign

Depth | Litho | recov



W.L. 39.75 4/2/86

TD@ 55

0'-10' (10') SILTY SAND : mod. yellow-brown (10yr 5/4); fine to med grained, poorly sorted, rounded to subrounded, no stain or odor.

10'-40' (30') SAND: med brown (5yr 4/4); med to coarse grained, med. sorted, subround to angular, no stain or odor.

25'-35': Quartzite and granite pebbles, subrounded, 1/8" -1".

40'-50' (10') SAND: Light olive gray (5y 6/1) to olive gray (5y 4/1) med grained, subangular, med sorted; distinct hydrocarbon stain and odor

50'-55' (5') CLAYEY SAND: Dark yellow brown (10yr 4/2); med grained sand with streaks of blackish red (5r 2/2) to med gray (NG) sticky wet clay; med hydrocarbon odor.

Completed as 2.0" galv steel piezometer
TD=57.2 from top of pipe, stickup=2.7
Screen from 40'-50', 5' blank on bottom
Screen packed w/washed sand, bentonite plug (½sack) @30-35'

50'7"
10' 1½' H2O

WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 12

___ ¼ ___ ¼ ___ ¼ ___ ¼ S___ T___ R___ State New Mexico

County San Juan Contractor Western Technologies

Spud Date 4/2/86 Completion Date 4/3/86

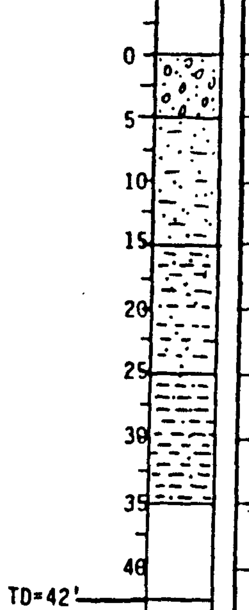
Logs Run Lithology from cuttings Logged By Nicholas

Elevation ________ Spud In (Fm.) ________

Remarks

Auger Refused @ 42"

Depth | Litho | recov



0-5' GRAVEL: ½" -12" cobbles predominately qaurtzite poorly sorted, subrounded to subangular.

5'-15' SILTY SAND: moderate yellowish brown, (10yr 5/4), fine to med grained, moderately well sorted.

15'-25',CLAYED SILTY SAND: light olive gray, (5y6/1), fine to med. grained, moderately well sorted.

25'-35' SILTY CLAY: dark yellowish brown, (10yr 4/2)

No cuttings would come up hole after 35'

Auger Refused at 42'

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WELL LOGGING FORM

Page ______ of ______

Client: Montgomery & Andrews — Well Number: GBR 13

___ ¼ ___ ¼ ___ ¼ ___ ¼ S ___ T ___ R ___ State: New Mexico

County: San Juan — Contractor: Western Technologies

Spud Date: ______ Completion Date: ______

Logs Run: Lith. from cuttings and cores — Logged By: J. Hunter

Elevation: 5392' topo — Spud In (Fm.): Nacimiento

Remarks: NW corner, South parking area

Depth	Description
0-20'	sand: moderate yellowish brn, med to fine grained
20-25'	clayey sand: mod brown, very fine sand with stringers of yellowish gray clay
25-30'	sand: mod brown to yellowish brown, fine-med gr., poorly sorted, locally clayey
30-35'	oil-stained (?) sand: mod gray to yel gray, fine gr., faint HC odor, stain increases w/depth
35-48'	sand/sandstone: mod yel brn to yel brn, very fine gr; poorly sorted, silty

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

Litho | recov

37'2"

TD=48'

Completed as 2.0" PVC piezometer, screen 32'-42'.

GCL

WELL LOGGING FORM

Page ______ of ______

Client: Montgomery & Andrews — Well Number: GBR-14

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

County: San Juan — Contractor: Beeman Bros. Drilling Co.

Spud Date: 9/10/86 — Completion Date: 9/10/86

Logs Run: Lith from cuttings — Logged By: Martin

Elevation: ______ — Spud In (Fm.): ______

Remarks: Drilled with Air Rotary

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0'							0'-coarse-grained, poorly-sorted sandy; medium brown.
10'							10'-coarse-grained, well-sorted clayey sand; mixed medium brown/dark gray-black; stained; strong hydrocarbon odor
20'							20'-coarse-grained, poorly-sorted clayey sand; light gray brown, no hydrocarbon odor.
30'							30'-coarse-grained, well-sorted clayey sand; medium to dark gray; faint hydrocarbon odor.
							35'-poorly-sorted clayey sand and gravel; medium brown.
40'							40'-poorly-sorted sandy gravel; dark brown.
							45'-poorly-sorted clayey sand and gravel; gray-brown.
50'							50'-poorly-sorted gravel; light gray.
							55'-well-sorted clayey gravel; medium gray.
60'							60'-well-sorted coarse-grained gravel; medium gray-brown.
							65'-poorly-sorted sand and gravel; dark gray.
70'							
							TD to 65' from surface, screened from 60' to 20', gravel pack 10'10", bentonite plug to 4'4", cement grout w/5% bentonite to surface completed as 6" PVC recovery well with identical 1" PVC casing attached to side.

GCL

WELL LOGGING FORM

Client Montgomery & Andrews Well Number (P-1) GBR 15

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 9-28-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks Drilled with Hollow Stem Auger

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0							0-5' SAND, med gr; mod brn color 5YR4/4
							5-7' SAND, med gr; mod brn color 5YR4/4, HC stain
5							7-10' SAND, med gr; blck N1; strong HC odor and stain
10							10-15' CLAYEY SAND, med gr, olive gry color 5Y4/1; HC odor
15							15-20' CLAYEY SAND, med gr w/2-5% gravels; olive gry color 5Y4/1, HC odor
20							20-25' SILTY SAND, med gr olive gry color 5Y4/1 faint HC odor
25							25-30' CLAY, fine to med gr, dark greenish-gray color 5GY4/1, HC odor
30							30-35' SANDY CLAY, fn-med gr olive gry 5Y3/2; HC odor
35 (Bedrock and water at 36.0')							35-40' CLAYEY, SILTY SAND, fn gr lt olive gry color 5Y5/2; HC odor
40							40-45' CLAYEY SAND, fn-med gr; grysh olive color 10Y4/2; faint HC odor
45							45-60' SANDY CLAY, fn-med gr; grnsh gry color 5GY6/1; HC odor

GCL

WELL LOGGING FORM

Client: Montgomery & Andrews | Well Number: GBR 15

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

County: San Juan | Contractor: Western Technologies

Spud Date: | Completion Date: 9-28-86

Logs Run: Lithology | Logged By: Martin

Elevation: | Spud In (Fm.):

Remarks:

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							
							TD to 60' from surface. Screened from 55' to 45', 5' blank on bottom. Gravel pack to 35', bentonite plug to 30', cement grout to surface. Completed with 2" PVC.
50							
55							
60							
65							
70							
75							
80							
85							
90							

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WELL LOGGING FORM

Page ______ of ______

Client: Montgomery & Andrews — Well Number: GBR 16

___ ¼ ___ ¼ ___ ¼ ___ ¼ S ___ T ___ R ___ State: New Mexico

County: San Juan — Contractor: Western Technologies

Spud Date: ______ Completion Date: ______

Logs Run: Lith. from cuttings and cores — Logged By: ______

Elevation: 5414 topo — Spud In (Fm.): Fill

Remarks: w end of burn pit

Depth	Litho	recov	
0			0-12' Fill: Gray to brn gry, very coarse boulders, cobbles and sand, local HC stain & odor
5			
10			
12.25' ▼			
15			12-25' Sandstone: mod yel brn, fine gr, very poor sorted, subrounded, mod HC odor
20			
25			
			Completed as 2.0" PVC piezometer, screen 10-20'.

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 17

___ ¼ ___ ¼ ___ ¼ ___ ¼ S 27 T 29 R 12 State New Mexico

County San Juan Contractor Beeman Bros. Drilling Co.

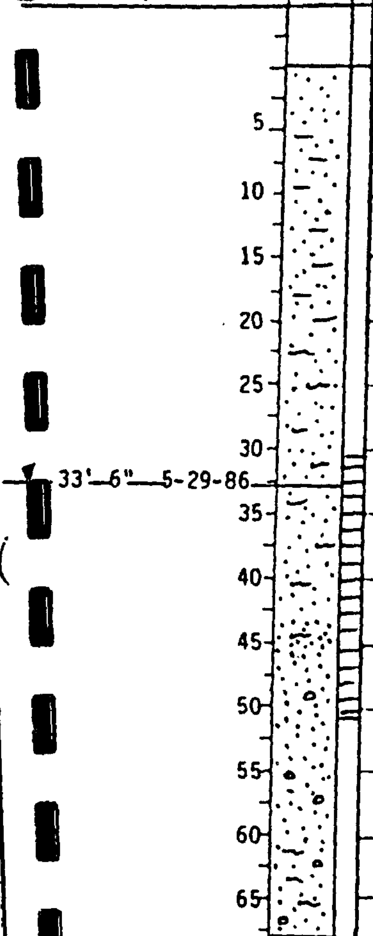
Spud Date 5/28/86 Completion Date 5/28/86

Logs Run Lith from cuttings Logged By NICHOLAS

Elevation ______ Spud In (Fm.) ______

Remarks Drilled With Air Rotary, completed as a 2" flush joint PVC and SS Well

Depth | Litho | recov



0-5' (5') sand, mod yellowish brn (10YR 5/4), very fine to coarse grained sand

5-10' (5') clayey sand, dk yellowish brn (10YR 4/2) fine to coarse grained sand with clay stringers

10-20' (10') clayey sand, mod yellowish brn (10YR 5/4) fine to med grained sand with clay stringers

20-45' (25') silty sand, mod yellowish brn, (10YR 5/4) fine to med grained sand grades coarser at 45'

45-60' (15') sand, mod yellowish brn (10yr 5/4) to lt olive grey (5Y 5/2), fine to coarse grained sand with some cobbles

60-68' (8') silty sand, greenish grey (5GY 6/1), fine to coarse grained sand w/some cobbles (1/2"-3"), 10-15%.

TD 68' to TOC, screened from 31'-51' ss screen, ss blanks on bottom, PVC risers. Gravel packed to 28', 100 lb bag Bentonite @ 28', Backfill to surface

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WELL LOGGING FORM

Page ____ of ____

Client Montgomery & Andrews Well Number GBR 18

___ ¼ ___ ¼ ___ ¼ ___ ¼ S ___ T ___ R ___ State New Mexico

County San Juan Contractor Western Technologies

Spud Date ____ Completion Date ____

Logs Run Lith from cuttings and cores Logged By ____

Elevation ____ Spud In (Fm.) ____

Remarks drilled w/ HSA

Depth | Litho | recov

0

5

10

12'4"

15

20

25

30

35

40

45

50

0-10' (10') fill: very coarse cobbles, some sand and gravel

10'-12.5' (2.5') sandy shale, yellowish brn

12.5-25' (12.5') sandstone: yellowish brn, med to fine grained poorly sorted

25'-30' shale: brn gry to rd brn, fissile, clayey, damp

30-38' siltstone: gry brn to brn gry; clayey, same thin, irregular sand stringers 1/4"-1/2"; moist

38-50' silty sandstone: yel brn to yel gry, very fine grained, poorly sorted, locally clayey

Completed as 2.0" galv. steel piezometer, screen 35'-45'.

GCL

WELL LOGGING FORM

Page 1 of 2

Client: Montgomery & Andrews — Well Number: (Obs W2) GBR 19

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

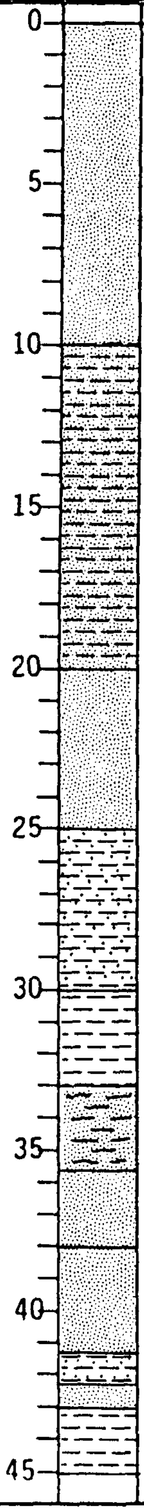
County: San Juan — Contractor: Western Technologies

Spud Date: — Completion Date: 10-1-86

Logs Run: Lithology — Logged By: Martin

Elevation: — Spud In (Fm.):

Remarks: Drilled with Hollow Stem Auger



RUN	FROM	TO	SAMPLE DEPTH	REMARKS	
				0-5'	SAND, fn-med gr, mod yelsh brn color 10YR5/4
				5-10'	SAND, med-co gr; mod yelsh brn color 10YR5/4
				10-20'	CLAYEY SAND, med-co gr; mod yelsh brn color 10YR5/4
				20-25'	SAND, med gr; mod yelsh brn color 10YR5/4
				25-30'	SANDY CLAY, v med-co gr; dk yelsh brn color 10YR4/2
				30-33'	CLAY, fn gr; dk yelsh brn color 10YR4/2
				33-35'	SILTY SAND, fn gr lt olive gry color 5Y5/2; HC odor
				35-35.83'	SILTY SAND, fn gr dk grnsh gry color 5GY4/1
				35.83-36.17'	SAND, med gr blck N1; wet w/HC strong HC odor
				36.17-36.5'	SAND, med gr lt olive gry color 5Y5/2; faint HC odor
				36.83-38'	SAND, co gr mod yelsh brn color 10YR5/4; no HC odor
				38-41.33'	SANDY CLAY, fn gr dk yelsh brn color 10YR4/2
				41.33-41.67'	SAND, fn-med gr; dk yelsh brn color 10YR4/2
				41.67-42.33'	CLAYEY SAND, v fn-med gr w/some cobbles and gravels; dk yelsh brn color 10YR4/2

GCL

WELL LOGGING FORM

Page 2 of 2

Client Montgomery & Andrews Well Number GBR 19

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 10-1-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							42.92-43' SAND, co gr yelsh gry color 5Y7/2
							43-48' CLAY, fn gr; olive gry color 5Y4/1; faint HC odor
50							
							TD to 51' from surface. Screened from 46' to 31', 5' blank on bottom. Gravel pack to 25', bentonite plug to 20' cement grout to surface. Completed with 2" PVC.
55							
60							
65							
70							
75							
80							
85							
90							

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 20

NW ¼ SE ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

County San Juan Contractor WesternTechnologies

Spud Date 4/18/86 Completion Date 4/18/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5394'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, no continous sampler used.

Depth	Litho	recov	
0–20			0-20' (20') SAND & GRAVEL : Moderate yellowish brown (10yr 5/4), med to coarse grained sand with 5%-30% gravel (½"-2"), No HC Odor.
20–30			20-30' (10') SILTY CLAY: Med light gray (N6) to med dark grey (N4), fine to med grained with some silt, hard drilling at 34', no HC ODOR.
30–48.5			30-48.5' (18.5') SANDSTONE: Med lt grey (N6) to med dk grey (N4), fine to med grained with some silt, hard drilling at 34', No HC odor.

WL 5-1 38.0'

TD=48'

Completed as 2" PVC Piezometer
Stickup 1' 10" TD 43'10" from top of casing
Screened interval 27'-37'
Sand to 25', Bentonite 2/3 Bag @ 25'
Backfill to 6', Bentonite 1/3 Bag @ 6'

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 21

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

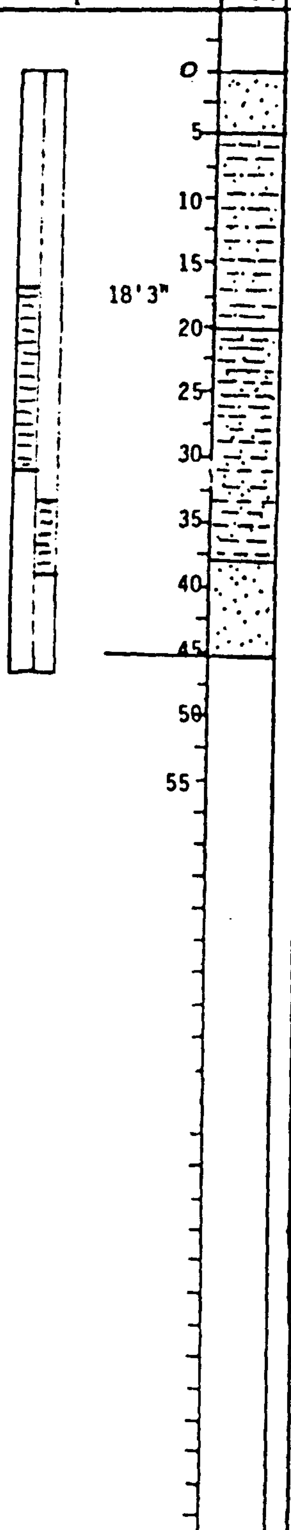
County San Juan Contractor Western Technologies

Spud Date 4/15/86 Completion Date 4/16/86

Logs Run Lithology from cuttings Logged By B Nicholas

Elevation 5398'(topo) Spud In (Fm.) Nacimiento

Remarks Drille with HSA, completed as 2' PVC Piezometer



0'-5' (5') SAND: Brown, fine to med grained

5'-20' (15') SILTY SAND : Brown, med to coarse grained with minor small cobbles.

20'-38' (18') SANDY SHALE: Brown, fine grained, grades to yellowish brown at 25'. HC ODOR.

38'-46' (8') SANDSTONE : Med. bluish gray (5B5/1), med to coarse grained with local small cobbles (½"-1½") HC ODOR and sheen in sampler.

Dual Completion as 2" PVC Piezometer
Stickup 3'3" TD 40'3" and 41'3" from top of casing
Screened intervals 17-32' and 33-38'
Caved in snad to 6', Bentonite (3/4 Bag) @ 6'
Bentonite (¼Bag)@ 2'

WELL LOGGING FORM

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Page 1 of 1

Client Montgomery & Andrews Well Number GBR 22

NE ¼ NW ¼ NW ¼ NW ¼ S____ T____ R____ State New Mexico

County San Juan Contractor Western Technologies

Spud Date 4/15/86 Completion Date 4/16/86

Logs Run Lithology from cuttings Logged By Hicks/Nicholas

Elevation 5394.5"(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, continous sampler and spit spoon used completed as 2' PVC Piezometer

Depth | Litho | recov

0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

4/16 32'8"

TD = 48'

0-2.5' (2.5') SAND & GRAVEL FILL: Brown, some HC odor from surface spills

2.5'-15.0' (12.5') SAND: Mod yellowish brown (10yr5/4) (2.5'-12.5') grades to Lt. brown at 12.5'(5yr5/6), med grained, well sorted contains gravels (12/5'-15.0') HC Odor

15.0-22.5' (7.5) CLAYEY SAND: Brown, grades to dark brown at 17.5', some clay balls increasing with depth, HC odor.

22.5'-32.5' (10') SAND : Brown, fine to med grained, well sorted, clean , some clay from (22.5'-27.5'), black stained sand at 30', HC Odor.

32.5'-38.0' (5.5') SANDSTONE: Green to yellow green, consolidated grades to yellow brown at 36.5'.

38'-43' (5') No Returns.

43'-48' SANDSTONE: gray, med to coarse grained, no HC odor

Completed as 2' PVC Piezometer
Stickup 3'5" TD 49.5' from top of casing
Screen from 32'-42', 4' blank on bottom
Sand to 32', Backfill to 26', 3/4 Bag Bentonite @ 26'
Backfill to 2', 1/4 Bag Bentonite @2'

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 23

SW ¼ NE ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

County San Juan Contractor Western Technologies

Spud Date 4/16/86 Completion Date 4/16/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5401'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled With Hsa, continous sampler used 22'-48.5'

Depth | Litho | recov

4/16 WL24'4"

TD = 48.5'

0-15' (15') SILTY SAND: mod yellowish brown (10yr5/4), very fine grained, with small amounts of cobbles (½"-1"), grades coarser at 10', HC Odor.

15'-22' (7') SAND & GRAVEL: Mod yellowish brown(10yr 5/4) to pale brown (5yr 5/2), med to coarse grained sand with cobbles (¼"-3"), HC Odor

22'-26' (4') SHALE: Grayish Brown (5yr 3/2) to yellowish grey (5y7/2), localized sand lenses, some weathering in shale, no HC Odor.

26'-48.5' (22.5) SANDSTONE: Weathered, light olive gray (5y5/2) from 26-27', med lt gray (N6) to med gray (N5), fine to med grained, slight HC odor(?) from 26'-27'.

Completed as 2" PVC Piezometer
Stickup 3' TD 41'10" from top of casing
Screen from 23'10" to 33'10" 5' Blank on Bottom
Sand to 23', 2/3 Bag Bentonite @ 23', Backfill to 5', 1/3 Bag Bentonite at 5'

Geoscience Consultants, Ltd

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews   Well Number GBR 24

NW ¼ NW ¼ NW ¼ NW ¼   S 27 T 29N R 12 W State New Mexico

County San Juan   Contractor Western Technologies

Spud Date 4/17/86   Completion Date 4/17/86

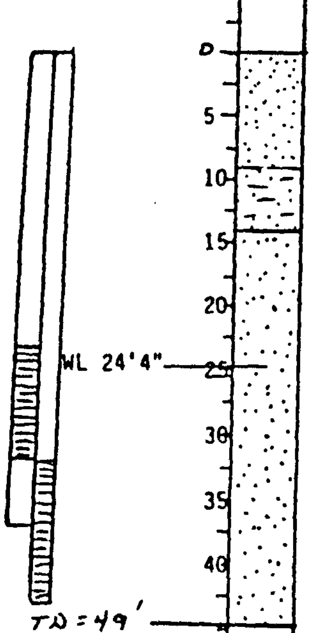
Logs Run Lithology from cuttings   Logged By Nicholas

Elevation 5395' (topo)   Spud In (Fm.) Nacimiento

Remarks

Drilled with HSA, continous sampler used from 9'-49'

Depth | Litho | recov



0'-9' (9') SAND : Moderate yellowish brown, (10yr5/4), med to coarse grained, No HC Odo

9'-14' (5') SILTY SANDSTONE: Moderate yellowish brown (10yr 5/4) to olive gray (5y4/1) weathered, very fine to fine grained, No HC Odor.

14'-49' (35') SANDSTONE: lt olive grey (5y 6/1), fine grained, contains minor gravels 28' (1"-1½"), HC Odor at 29'

Dual Completion as 2' PVC Piezometer
Stickup 3'3"   TD41'3" and 46'3" from top of casing
Screened intervals 23-33' and 33'-43'
Caved to 33', sand to 22', Bentonite 2/3 Bag
@22', Backfill to 6', Bentonite 1/3 Bag @ 6'.

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 25

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

County San Juan Contractor Western Technologies

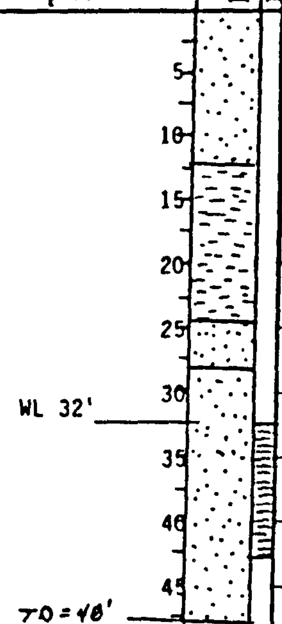
Spud Date 4/17/86 Completion Date 4/18/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5395'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, used continous sampler from 17'-48'

Depth | Litho | recov



0'-17' (17') SAND: Mod yellowish brown (10yr5/4), med to coarse grained with some smallcobbles from 5'-17', HC Odor

17'-24' (7') SHALE: Dark yellowish brown, (10yr4/2), with pale yellowish orange stringers (10yr8/6) from 23'-24', soft . slight HC Odor

24'-28' SANDSTONE': Moderate yellowish brown (10yr5/4) with streaks of dark yellowish orange (10yr 6/6), fine to med grained, weathered, NO HC odor.

28'-48' SANDSTONE: Ranges in color from lt gray (N7), to moderate yellowish brown (10yr5/4) from 28-33', greenish gray (5G6/1) to dark yellowish orange (10yr6/6) from 33'-43', med to coarse grained, grades coarser at 38', grades to lt gray (N7) at 43',contains small cobbles from 28-43', shale stringers from 43-48', no HC odor

Completed as 2" PVC Piezometer
Stickup 2' 0" TD 50' to top of casing
Screened interval 33-43', caved to 35', sand to 23'
Bentonite 2/3 Bag @ 23', Backfill to 6'
Bentonite 1/3 Bag at 6'

Geoscience Consultants, Ltd

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 26

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12 W State New Mexico

County San Juan Contractor PSI Western Technologies

Spud Date 4/18/86 Completion Date 4/18/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5396' (topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, continous sampler was not used.

Depth | Litho | Recov

0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

4/23 WL 31'4"

TD = 50'

0-7' (7') SAND : moderate yellowish brown (10yr5/4), med to fine grained, well sorted, no HC odor

7'-21' (14') SAND: HC stained, ranges from med dark gray (N4), grayish black (N2), to med gray (N5), fine to med grained, contains cobbles at 15', clay lenses from 12'-15' strong HC odor

21'-35' (14') CLAYEY SAND: HC stained, ranges in color from med gray (N5) to grayish black (N2), very fine to fine grained, moist, HC odor.

35'-50' (15') SANDSTONE: med dark gray (N4), fine to med grained with some clay, wet HC odor.

Completed as 2" PVC Piezometer
Stickup 1'6" TD 41'6" from top of casing
Screened interval 25-35', caved to 26',
Sand to 23', Bentonite @23 2/3 Bag, Backfill to
5', Bentonite 1/3 Bag at 5'

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 27

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R12W State New Mexico

County San Juan Contractor Beeman Brothers

Spud Date 4/23/86 Completion Date 4/23/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5397'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with Air Rotary, completed as 5" PVC Well

Depth | Litho | Recov

0-5' (5') SAND: Grayish orange (10yr7/4); fine to coarse grained, no HC odor

5-15' (10') SAND: Mod yellowish brown (10yr5/4); fine to med grained with some silt, contains some cobbles at 13', (2-3%)

15-20' (5') SAND & GRAVEL : Mod yellowish brown (10yr5/4) ; fine to med grained with some silt, contains 30% gravels

20-25' (5') SHALE: Dusky yellow (5y6/4)

WL 5/2 35'10"

25-67' (42') SANDSTONE: Lt gray (N7), very fine to med grained, grades to mod yellowish brown (10yr5/4) from 32'-34'

Completed as 5" PVC well
Stickup 1'4" TD 68'4" from top of casing
Screen from 22-62' , 5' Blank on Bottom
Sand to 18', Bentonite (1sack) 1 18'

TD=67'

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 28

___ ¼ ___ ¼ ___ ¼ ___ ¼ S 27 T 29 R 12 State New Mexico

County San Juan Contractor Beeman Bros. Drilling Co.

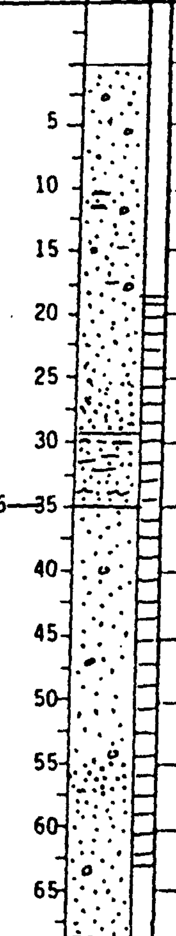
Spud Date 5/27/86 Completion Date 5/27/86

Logs Run Lith from cuttings Logged By NICHOLAS

Elevation ______ Spud In (Fm.) ______

Remarks Drilled With Air Rotary, completed as 6" PVC recovery well

Depth | Litho | recov



0-10' (10') sand, mod. yelish brn (10YR 5/4), med to coarse grained w/some cobbles.

10-20' (10') sand, mod. yelish brn (10YR 5/4), coarse to med grained with some cobbles and lt brn clay stringers

20-29' (9') sand, mod. yelish brn (10YR 5/4), fine to coarse grained, grades coarser at 27'

29-30' (1') silty clay, brown

30-32' (2') sandy clay, brown, med. to fine grained sand.

32-35' (3') Silty Sand, greyish black, HC ODOR, fine to med. grained sand w/brn clay stringers.

35-38' (3') sandstone, lt olive grey (5Y 5/2)

38-69' (31') sandstone, med. lt grey (N8), graded to dk greenish grey (5GY 4/1) at 58', grades to dk grey (N3) at 63', fine to coarse grained sandstone with some cobbles, grading coarser from 55-57'

TD 68' 6" stickup 2', screened from 23'6" to 63'6", Bentonite @ 16' (100 lb bag), gravel packed to 16', TD from TOC 70'6"

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 29

¼ ¼ ¼ ¼ S 27 T 29 R 12 State New Mexico

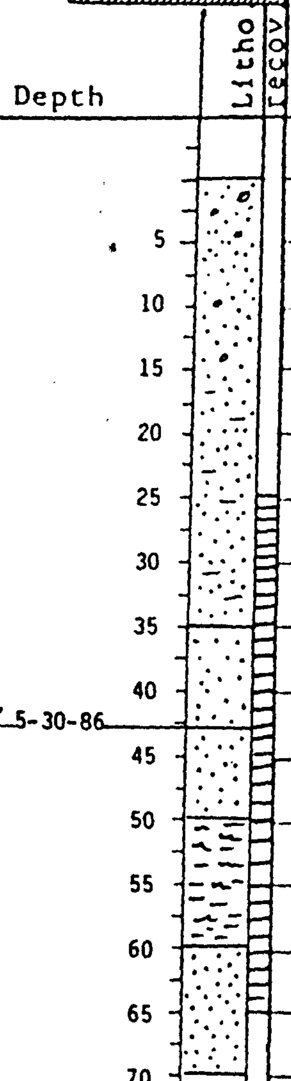
County San Juan Contractor Beeman Bros. Drilling Co.

Spud Date 5/29/86 Completion Date 5/30/86

Logs Run Lith from cuttings Logged By NICHOLAS

Elevation ______ Spud In (Fm.) ______

Remarks Drilled With Air Rotary, completed as a 6" PVC recovery well



0-5' (5') sand and gravel, pale yellowish brn (10YR 6/2), gravels (1/4"-1'), sand; fine to coarse grained

5-15' (10') sand, greyish orange (10YR 7/4), med. to coarse grained w/some cobbles

15-35' (20') clayey sand, dk yellowish brn (10YR 4/2), fine to coarse grained sand with increasing clay content from 30-35'

35-40' (5') sandstone, greenish grey (5GY 6/1), H.C. ODOR, fine to coarse grained with some silt.

40-50' (10') sandstone, mod. yellowish brn (10YR 5/4), fine to coarse grained sand, grades med. to coarse at 45'

50-60' (10') silty clay, lt olive grey (5Y 6/1) from 50-55', brownish grey (5YR 4/1) from 55-60, increasing clay content at 55'

60-70' (10') sandstone, greenish grey (5 GY 6/1) to med. lt grey (N6), fine to med. grained

TD 72' from TOC, screened interval from 25'-65', gravel packed to 15', 100 lb bag Bentonite @ 15', backfill to the surface

WELL LOGGING FORM

Client: Montgomery & Andrews | Well Number: (X-1) GBR 30

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

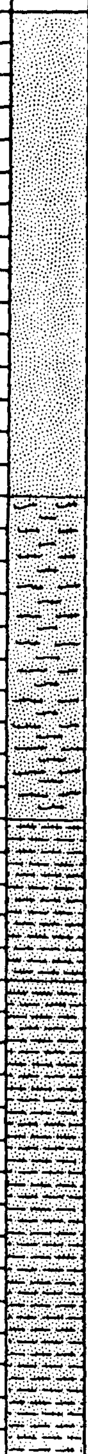
County: San Juan | Contractor: Western Technologies

Spud Date: | Completion Date: 9-24-86

Logs Run: Lithology | Logged By: Martin

Elevation: | Spud In (Fm.):

Remarks: Drilled with Hollow Stem Auger



DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0							0-5' SAND, med gr mod yelsh brn 10YR5/4
5							5-10' SAND, med-co gr mod yelsh brn 10YR5/4
10							10-15' SAND, w/1-2% gravels; med-co gr mod yelsh brn 10YR5/4
15							15-20' SILTY SAND, fn-med gr olive blck 5Y2/1; strong HC odor and stain
20							20-25' SILTY SAND, med gr, dk grnsh bry 5GY4/1; strong HC odor and stain
25							25-30' CLAYEY SAND, med-gr, olive blck 5Y2/1, strong HC odor and stain
30							30-33' SANDY CLAY, fn-med gr, olive gry 5Y4/1; faint HC odor; wet
							33-45' SANDY CLAY, fn-med gr, lt olive gry 5Y5/2; faint HC odor; wet
35							
40							
45							TD to 49'. Screened from 40' to 25', sand pack to 19'2"

GCL

WELL LOGGING FORM

Client Montgomery & Andrews Well Number (X-1) GBR 30

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State New Mexico

County San Juan Contractor Western Technologies

Spud Date Completion Date 9-24-86

Logs Run Lithology Logged By Martin

Elevation Spud In (Fm.)

Remarks

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
45							
							5' blank on bottom, bentonite plug to 13'11", cement grout w/5% bentonite to surface. Completed with 2" PVC.
50							
55							
60							
65							
70							
75							
80							
85							
90							

GCL

WELL LOGGING FORM

Client: Montgomery & Andrews | Well Number: (X-2) GBR 31

1/4 1/4 1/4 1/4 S 27 T 29 R 12 State: New Mexico

County: San Juan | Contractor: Western Technologies

Spud Date: | Completion Date: 9-25-86

Logs Run: Lithology | Logged By: Martin

Elevation: | Spud In (Fm.):

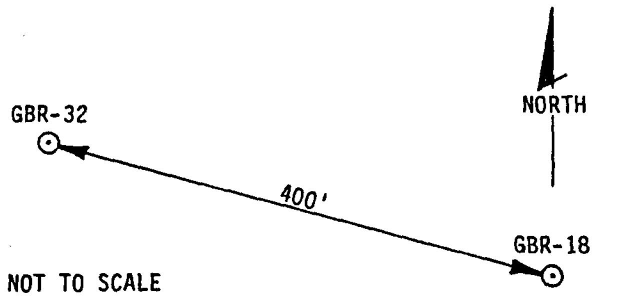
Remarks: Drilled with Hollow Stem Auger

DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0							0-5' SAND, med gr, mod yelsh brn 10YR5/4
5							5-10' CLAYEY SAND, med-co gr, dk yelsh brn 10YR4/2
10							10-20' SILTY SAND, med-co gr, dk yelsh brn 10YR4/2
15							
20							20-25' CLAYEY SAND, med-co gr, dk yelsh brn 10YR4/2 HC odor (?), v v faint
25							25-30' CLAY, fn gr, dk yelsh brn 10YR4/2
30							30-33' SANDY CLAY, fn-med gr, lt olive gry 5Y5/2
Water level @ 33'							33-37' GRAVEL LAYER
35							
Bedrock 37'							37-45' SANDY CLAY, fn-med gr lt olive gry 5Y5/2
40							TD to 45', screened from 39'7" to 24'7", 5' blank on bottom, sand pack to 19.33', bentonite plug to 13'4" cement grout w/5% bentonite to surface. Completed with 2" PVC.
45							

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



___1/4 ___1/4 ___1/4 SW 1/4 S22 T29N R12W

SITE ID: MONT & AND LOCATION ID: (NW) GBR-32

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5412 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: HOLLOW STEM AUGER W/SPLIT SPOONS,

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: 4/21/87 DATE COMPLETED: 4/22/87

FIELD REP.: J.P. KASZUBA, S.J. COLARULLO, R.T. HICKS

COMMENTS: 7" BOREHOLE, SPOONS WET AT 33'-36'.

BEDROCK @ 37.5'. TD=45'

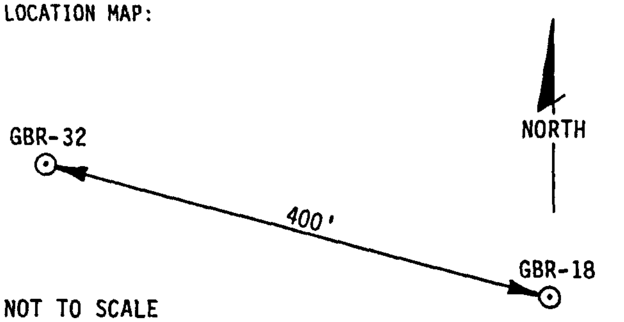
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0										
				1	4.5	6.0				4.5-4.7' SAND, fn- to cs-gr, poor sorting, tan color.
										4.7-5.2' SAND, fn- to med-gr, mod sorting, tan color.
5										5.2-6.0' SAND, med- to cs-gr, mod sorting, tan color.
10				2	9.5	11.0				9.5-11.0' SAND, as above.
15				3	14.5	16.0				14.5-16.0' SAND, as above.
20				4	19.5	21.0				19.5-21.0' SAND, as above.
25				5	24.5	26.0				24.5-25.2' SILT, lt brn, includes ~10% fn-gr sand and ~10% clay.
										25.2-26.0' SAND, med- to cs-gr, mod sorting, lt brn
30				6	29.5	31.0				29.5-31.0' SAND, as above, includes ~10% silt

BORHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 __1/4 SW 1/4 S22 T29N R12W

SITE ID: MONT & AND LOCATION ID: (NW) GBR-32
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): 5412 (TOPO)
STATE: NEW MEXICO COUNTY: SAN JUAN
DRILLING METHOD: HOLLOW STEM AUGER W/SPLIT SPOONS,
DRILLING CONTR.: WESTERN TECH.
DATE STARTED: 4/21/87 DATE COMPLETED: 4/22/87
FIELD REP.: J.P. KASZUBA, S.J. COLARULLO, R.T. HICKS
COMMENTS: 7" BOREHOLE, SPOONS WET AT 33'-36'.
BEDROCK @ 37.5'. TD=45'

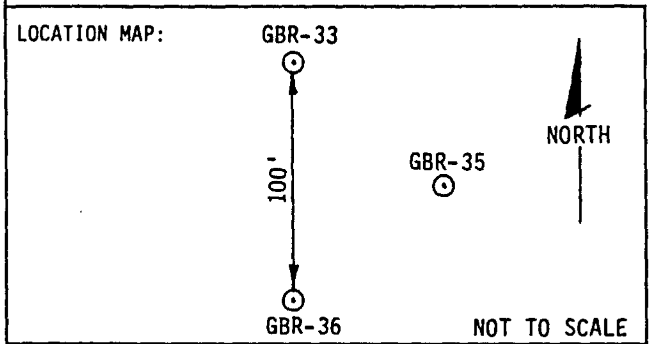
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
30										
				7	34.5	36.0				34.5-34.9' SLOUGH, no returns. 34.9-36.0' SAND, cs- to v cs- gr, poor sorting, brn color. Minor granules (3-15 mm), little clay. Saturated, no odor.
35										
				8	37.5	38.0				37.5-38.0 SANDSTONE, fn- to med- gr, minor cs, mod sorting, friable, poorly cemented (weathered upper portion), mottled tan/white color.
				9	39.5	40.0				39.5-39.7' SANDSTONE, as above. 39.7-40.0' SANDSTONE, as above, but rust-colored w/limonite stain.
40										
				10	44.5	45.0				44.5-45.0' SANDSTONE, as above, but blue-grey color and significant clay (10-20%). TD to 45' 2" SS blank 40'-45', SS 20 slot screen 25'-40', SS blank 20-25', 2" PVC to surface. Sandpack to 17.5', bentonite plug to 11.2', cement grout w/5% bentonite to surface.
45										
50										
55										
60										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (EX-1) GBR-33

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: HSA W/CONTINUOUS SAMPLER, 7" BOREHOLE

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: 4/22/87 DATE COMPLETED: 4/23/87

FIELD REP.: J.P. KASZUBA

COMMENTS: CUTTINGS FROM AUGER 0'-5'. BEGIN CONTINUOUS SAMPLING AT 8'.

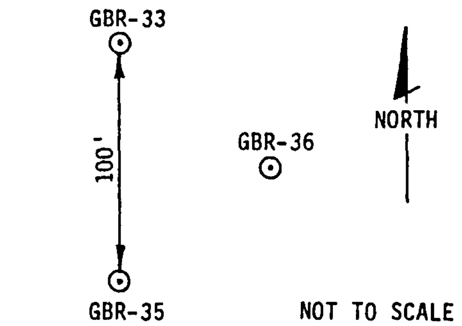
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
0										0-2'	GRAVEL, & sand fill
										~2-5'	SAND, med-gr, minor fn and cs, mod sorting, tan brn color. No odor.
5											
				1	8	13				8.0-11.0'	No Returns.
10										11.0-11.5'	SAND, as above, minor 1 cm dia, rounded pebbles.
										11.5-12.3'	SAND, fn- to med- gr, mod sorting, brn color. No odor.
										12.3-13.0'	SAND, fn- gr, 10-20% silt, very minor clay, mod sorting, brn color. No odor.
				2	13	18				13.0-15.5'	No Returns.
15										15.5-17.2'	SAND, med-gr, minor fn and cs, mod sorting, tan brn color. No odor.
										17.2-18.0'	SAND, fn- to med-gr, minor 1 cm dia pebbles, poor sorting, brn color. No odor.
				3	18	23				18.0-20.3'	No Returns.
20										20.3-20.8'	SAND, med-gr, minor fn- and cs, minor 1-5 cm dia pebbles, poor sorting, lt brn color. No odor.
										20.8-21.1'	SAND, fn- to med- gr, mod sorting, brn color. No odor.
										21.1-21.4'	SAND, as @ 20.3'-20.8'.
										21.4-22.0'	SANDY CLAY, brn, sand is fn- gr, well sorted. No odor.
										22.0-23.0'	SAND, as @ 20.3'-20.8'.
25				4	23	28				23.0-25.7'	No Returns.
										25.7-26.1'	SAND, as @ 20.3'-20.8', but pebbles common. No odor.
										26.1-26.2	CLAY, brn, no odor.
										26.2-26.8'	CLAYEY SAND, lt olive brn color, sand is fn- to med- gr, well-sorted.
										26.8-28.0'	CLAY, brn, no odor.
				5	28	33				28.0-30.3'	No Returns.
30											

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

LOCATION DESCRIPTION: ____________

SITE ID: MONT & AND LOCATION ID: (EX-1) GBR-33

SITE COORDINATES (ft.):

N ____________ E ____________

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

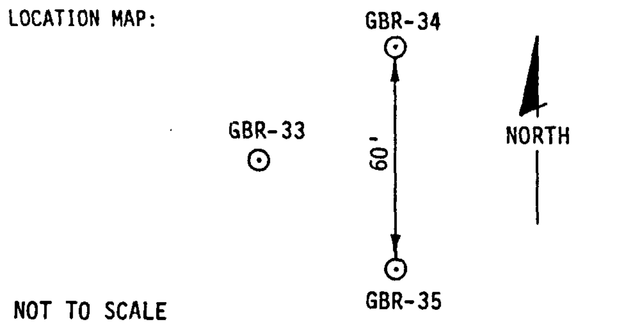
COMMENTS: SATURATED @ ~36'. BEDROCK @ 41.2' (~40' BY DRILLER'S RECKONING). TD=49.5'. NO DIESEL NOTED DURING DRILLING.

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
30										30.3-32.2'	CLAY, brn, no odor. Contains minor med- gr sand @ 31.9'-32.0'. No odor.
										32.2-32.7'	CLAYEY SAND, olive brn, sand is fn- to med-gr, mod sorting. No odor. Sample placed in clean water yields no floating product.
										32.7-33.0'	CLAY, olive color, contains minor fn- gr sand. Faint HC degradation odor.
				6	33	38				33.0-36.2'	No Returns.
35										36.2-36.8'	SAND, med- to cs- gr, well-sorted. Saturated. Black HC stain @ 36.2-36.3'. Dk grey HC stain @ 36.3'-36.5'. Grey HC stain @ 36.5'-36.8'. Strong HC odor. Sample placed in clean water yields floating HC.
40										36.8-37.2'	SAND, as above, but brown color (no HC stain). Saturated. Faint HC odor. Sample placed in clean water yields no floating HC.
										37.2-37.6'	SAND, brn, fn- to med- gr, well-sorted. Faint HC odor(?).
										37.6-38.0'	SAND, brn, med- to cs- gr, well-sorted. Faint HC odor(?). Sample placed in clean water yields no floating HC.
45				7	38	43				38.0-39.6'	No Returns.
										39.6-41.2'	SAND, as above. Faint HC odor. Sample placed in clean water yields floating HC.
										41.2-43.0'	SANDSTONE, bleached tan color, med- to cs-gr, mod well-sorted. Rare pebbles up to 1 cm in dia. Friable, poorly cemented. Limonite stain @ 42.0'-42.6'. No HC odor. Sample placed in clean water yields no floating HC.
50				8	43	48				43.0-43.2'	No Returns.
										43.2-48.0'	SANDSTONE, as above, but poorly sorted & brn color. Limonite stain @ 45.8-46.2'. No HC odor.
				9	48	49.5				48-49.5'	No Returns.
55											TD=49.5'. 2" PVC blank 43-48.5', PVC screen (20 slot) 27'-43', PVC blank to surface. Sandpack to 22.5', bentonite plug to 17.5', cement grout w/5% bentonite to surface.
60											

BORHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (EX-2) GBR-34

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: HSA W/SPLIT SPOONS, 7" BOREHOLE

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: 4/23/87 DATE COMPLETED: 4/24/87

FIELD REP.: J.P. KASZUBA

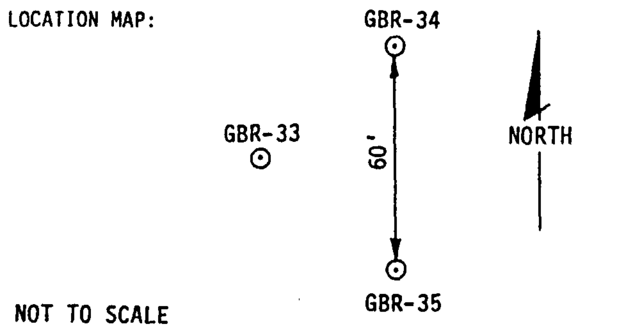
COMMENTS: CLAY @ 15.5-16.0'. SATURATED @ 30-31'. BEDROCK @ 37'. TD=48'.

LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
0											
				1	3.0	4.5				3.0-4.5'	SAND, tan, fn-to med- gr, mod sorting. Minor cs- gr sand & pebbles up to 0.5 cm. No HC odor.
5											
				2	8.0	9.5				8.0-8.5'	No Returns.
										8.5-9.1'	SAND, as above except pebbles more common & up to 3.0 cm dia.
10										9.1-9.5'	SAND, brn, fn- gr, well-sorted. Minor silt & clay. Rare cs- gr. No HC odor.
				3	13.0	14.5				13.0-13.3'	SAND, as above, but significant silt.
										13.3-13.8'	SAND, lt brn, med- to fn- gr, minor cs- gr. Poor sorting.
										13.8-14.1'	SAND, as @ 13.0'-13.3'.
15										14.1-14.5	SAND, lt brn, fn- gr, minor med- gr, minor silt, rare cs- gr, poorly sorted. No HC odor.
				4	18.0	19.5				18.0-18.3'	SAND, as above, but cs- gr more abundant.
										18.3-18.7'	CLAY, olive brn color, minor silt & fn- gr sand. No HC odor.
										18.7-19.5'	SAND, tan, fn- to med- gr, poorly sorted. No HC odor.
20											
				5	23.0	24.5				23.0-23.3'	CLAYEY SAND, brn, sand is med- to cs- gr, poorly sorted
										23.3-23.5'	SAND, as @ 18.7'-19.5'.
										23.5-24.5'	CLAY, olive brn color, minor silt & fn- gr sand. No HC odor.
25											
				6	28.0	29.5				28.0-28.3'	CLAY, as above. No HC odor.
										28.3-29.5'	SAND, dk brn, fn- to med- gr, well-sorted. No HC odor.
30											

BOREHOLE LOG (WELL)

GCL



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (EX-2) GBR-34

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: DIESEL ON SPLIT SPOONS IN SATURATED ZONE

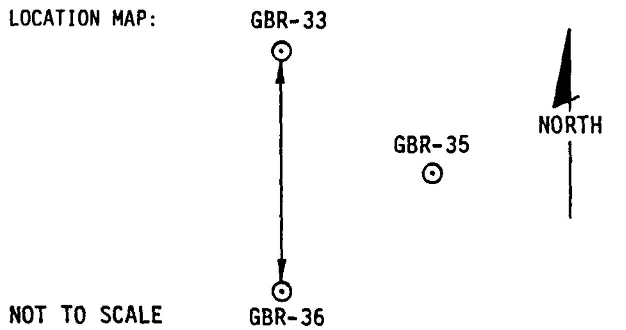
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
30										
				7	33.0	34.5				33.0-34.5' **SAND**, med- gr, minor fn- and cs- gr, well-sorted. Saturated. Black HC stain @ 34.2'-34.5'. Strong HC odor.
35										
				8	38.0	38.3				38.0-38.3' **SANDSTONE**, mottled tan color, fn- to med-gr, mod sorting. Poorly cemented, friable. Strong HC odor.
40										
				9	43.0	43.3				43.0-43.3' **SANDSTONE**, as above, but abundant cs- gr. No HC odor.
45										TD=48'. 2" PVC blank 43'-48', 20 slot screen 27'-43' (SS & PVC mix), PVC blank to surface. Sandpack to 22', bentonite plug to 17', cement grout w/5% bentonite to surface.
50										
55										
60										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (EX-4) GBR-35

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: HSA W/SPLIT SPOONS, 7" BOREHOLE.

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: 4/24/87 DATE COMPLETED: 4/24/87

FIELD REP.: J.P. KASZUBA

COMMENTS: SATURATED @ ~ 33.8'. BEDROCK @ 38'. TD=50. DIESEL ON SPLIT SPOONS FROM SATURATED ZONE.

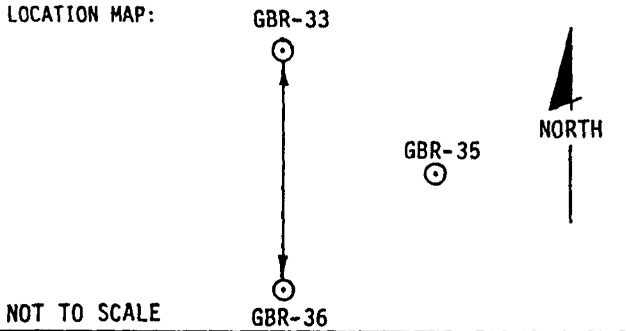
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
0											
				1	3.0	4.5				3.0-3.2'	Road Gravel.
										3.2-4.5'	SAND, tan, med- gr, minor fn- and cs- gr, poor sorting. No HC odor.
5											
				2	8.0	9.5				8.0-9.5'	SAND, lt brn, med- to cs- gr, mod sorting. Pebbles up to 2 cm dia common. No HC odor.
10											
				3	13.0	14.5				13.0-13.2'	No Returns.
										13.2-14.5'	SAND, lt brn, med- gr, minor cs- gr & pebbles up to 2 cm dia, well-sorted. No HC odor.
15											
				4	18.0	19.5				18.0-18.5'	SAND, as above.
										18.5-19.1'	SAND, lt brn, fn- to med- gr, well-sorted. Minor clay. No HC odor.
										19.1-19.6'	CLAYEY SAND, lt brn, sand is fn- to med-gr, mod sorted. No HC odor.
20											
				5	23.0	24.5				23.0-23.4'	SAND, brn, fn- gr, minor med- gr & clay, well-sorted. No HC odor.
										23.4-23.9'	SAND, tan, med- gr, minor fn-, cs- gr, & pebbles up to 2 cm dia, poorly sorted. No HC odor.
										23.9-24.5'	CLAY, olive brn, no HC odor. Sandy (fn- to med- gr) @ 24.1-24.2'.
25											
				6	28.0	29.5				28.0-28.5'	CLAY, as above.
										28.5-28.8'	SAND, brn, fn- gr, well-sorted. Pebbles (up to 3 cm dia) @ 28.7-28.8'. No HC odor.
										28.8-29.5'	CLAYEY SAND, brn, sand is fn- gr, well-sorted. Minor silt. Faint HC odor(?).
30											

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (EX-4) GBR-35

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: ______

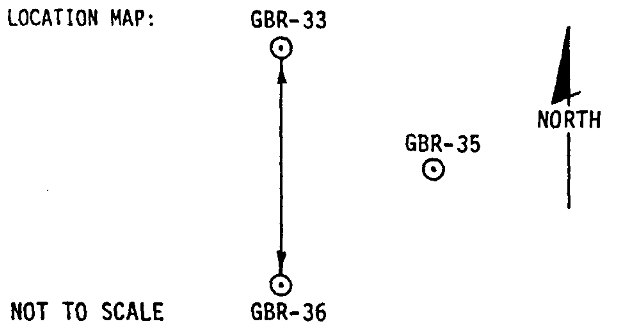
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
30											
				7	33.0	34.5				33.0-33.8'	No Returns
										33.8-34.5	SAND, olive brn, fn- to med- gr, well-sorted. Saturated. Black HC stain @ 33.9-34.5'. Strong HC odor.
35											
				8	38.0	38.3				38.0-38.3'	SANDSTONE, mottled tan/brn, med- gr, minor fn- and cs- gr, minor pebbles up to 1 cm dia, poorly sorted. Friable, poorly cemented. Saturated. No HC odor (?).
40											TD=50'. 2" PVC bottom blank 41'-46', PVC 20 slot screen 25'-41', PVC blank to surface. Sand pack to 19.7', bentonite plug to 12.7', cement grout w/5% bentonite to surface.
45											
50											
55											
60											

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



___1/4 ___1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (X5)GBR-36

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: AIR ROTARY, 10" BOREHOLE.

DRILLING CONTR.: BEEMAN BROTHERS

DATE STARTED: 4/29/87 DATE COMPLETED: 4/30/87

FIELD REP.: J.P. KASZUBA

COMMENTS: BEGIN USING WATER FOR LUBRICATION @ 25'. SATURATED @ ~33'. POOR RETURNS PAST 45'. TD=75'.

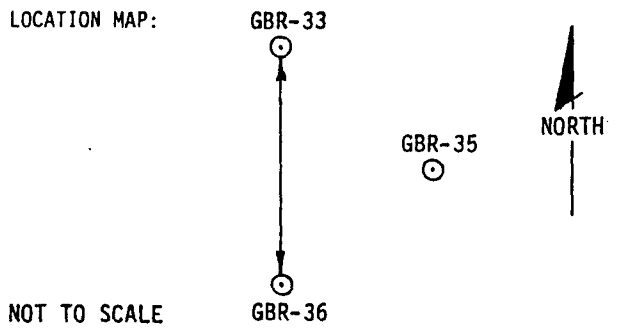
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0				1	0	5				0-5' SAND, lt brn, fn- to cs- gr, poorly sorted. Rounded pebbles < 1 cm dia (<1%). No HC odor.
5				2	5	10				5-10' SAND, as above.
10				3	10	15				10-15' SAND, brn, fn- to med-gr, minor cs- gr, mod sorting. No HC odor.
15				4	15	20				15-20' SAND, as above.
20				5	20	25				20-25' SAND, brn, fn- to cs- gr, poor sorting. Rounded pebbles, ≤ 1 cm dia (<5%). No HC odor.
25				6	25	30				25-30' SAND, lt brn, med- to cs- gr, minor fn- gr, mod sorting. Olive brn clay nod (<1%).
30										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (X5)GBR-36

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: SAME

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: SAME

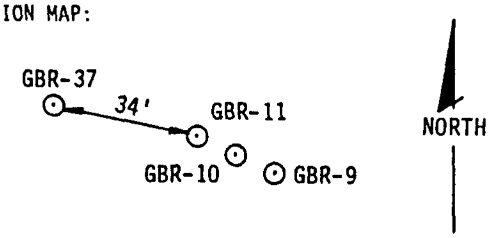
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
30				7	30	35				30-35' SAND, as above. Saturated (?). Faint HC odor (?). Olive brn clay nod (~15%).
35				8	35	40				35-40' CLAY, brn, black & grey HC stain, strong HC odor.
40				9	40	45				40-45' CLAY, as above.
45				10	45	50				45-50' CLAY, as above (50%), but slight grey HC stain in places, faint HC odor. Rounded pebbles (50%), ≤ 5 cm dia, various lith: qtzite, sandstone, granite.
50				11	50	55				50-55' CLAY, as above (30%), brn, no HC odor. Rounded pebbles (70%), as above.
55				12	55	60				55-60' PEBBLES, as above. TD=75'. 6" PVC blank 65'-70', 20 slot PVC screen 25-65', PVC blank to surface. 1" PVC screen 25-65', PVC blank 0-25'. Pea gravel (3/8") to 20', bentonite plug to 15, cement grout w/5% bentonite to surface.
60										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



NOT TO SCALE

__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

Page 1 of 3

SITE ID: MONT & AND LOCATION ID: (X1)GBR-37

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5388 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: AIR ROTARY, 10" BOREHOLE.

DRILLING CONTR.: BEEMAN BROTHERS

DATE STARTED: 4/28/87 DATE COMPLETED: 4/28/87

FIELD REP.: J.P. KASZUBA, S.J. COLARULLO

COMMENTS: BEGIN USING WATER FOR LUBRICATION @ 20'.

CONTAMINATION @ ~34.

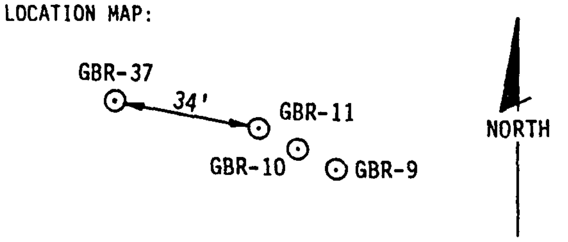
LOCATION DESCRIPTION: ______

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
0				1	0	5'				0-5'	SAND, brn, med- to cs- gr, minor fn- gr & angular pebbles (≤ 1 cm dia). Mod sorting. No HC odor.
5				2	5	10'				5-10'	SAND, as above.
10				3	10	15'				10-15'	SAND, lt brn, med-gr, minor cs- and fn- gr, mod sorting. Clay nodules (~1%). Subrounded, ≤ 5 cm dia pebbles (~1%). No HC odor.
15				4	15	20'				15-20'	SAND, lt brn, med- to cs- gr, minor fn-, mod sorting. Angular pebbles, <1 cm dia (~1%). No HC odor.
20				5	20	25'				20-25'	SAND, tan, cs- gr, minor med- and fn- gr, mod sorting. Rounded pebbles, ≤ 1 cm dia (5%), ≤ 4 cm (1%). No HC odor.
25				6	25	30'				25-30'	SAND, as above, except 10% rounded pebbles (1-4 cm dia). No HC odor.
30											

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



NOT TO SCALE

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (X1)GBR-37

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): 5388 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: SAME

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: SATURATION @ ~ 34'. BEDROCK @ 54'. TD=73'.

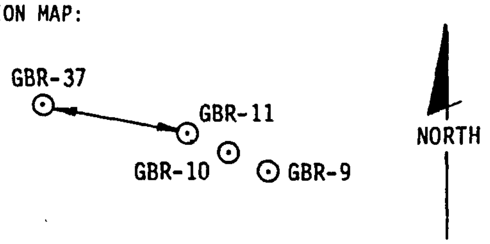
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
30				7	30	35				30-35'	SAND, as above, but fn- gr more abundant. Pebbles (30%) now sub-rounded to sub-angular. Brn clay nod (<5%), some (<1%) w/HC odor & stain. Saturated (?).
35				8	35	40				35-40'	SAND, as above, but grey HC stain & strong HC odor. Sub-rounded pebbles (~30%). ~0.5 cm dia, rare 3 cm dia. No clay.
40				9	40	45				40-45'	SAND, as above, but lt grey HC stain, faint HC odor.
45				10	45	50				45-50'	SAND, as above, but abundant fn- & med- gr, poorly sorted. Sub-rounded pebbles (20%), 0.5 cm dia. Lt brn color, no HC stain or odor.
50				11	50	55				50-54'	SANDY CLAY, golden brn, sand is fn- gr, minor med- gr, mod sorting. No HC odor.
										54-55'	SANDSTONE, grey brn, med- to cs- gr, mod sorting. Poorly cemented, friable. No HC odor.
55				12	55	60				55-60'	CLAYSTONE, blue grey, minor fn- gr sand. Poorly cemented, friable. No HC odor.
60											

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



NOT TO SCALE

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (X1)GBR-37

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): 5388 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: SAME

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: SAME

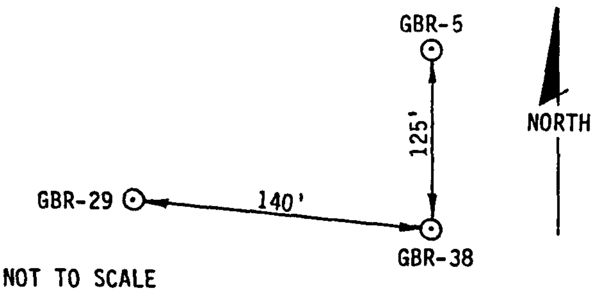
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
60				13	60	65				60-65' CLAYEY SANDSTONE, blue grey, fn- gr, well sorted. Significant clay (up to 50%). Some fragments display brick red and blue grey color.
65				14	65	70				65-70' CLAYEY SANDSTONE, as above, but sand is fn- to cs- gr, poorly sorted; less clay (25%). Fragments lack red color. TD=73'. 6" PVC blank 66'-69', 20 slot PVC screen 26'-66', PVC to surface. 1" PVC screen 28'-68', PVC blank 0'-28'. Pea gravel (3/8"), to 23', bentonite plug to 17', cement grout w/5% bentonite to surface.
70										
75										
80										
85										
90										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



NOT TO SCALE

__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (X4)GBR-38

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): 5393 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: AIR ROTARY, 10" BOREHOLE.

DRILLING CONTR.: BEEMAN BROTHERS

DATE STARTED: 4/28/87 DATE COMPLETED: 4/29/87

FIELD REP.: J.P. KASZUBA

COMMENTS: BEGIN USING WATER FOR LUBRICATION @ 15'. SATURATED @ ~37', BEDROCK @ 49'. TD=75'.

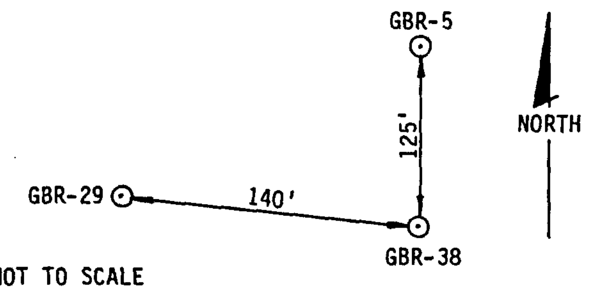
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION	
0				1	0	5				0-5'	SAND, brn, fn- gr, minor med- gr, well sorted. No HC odor.
5				2	5	10				5-10'	SAND, grey brn, fn- to med- gr, mod sorting. Brn clay nodules (<1%). Sub-rounded pebbles, 0.5 cm dia (<1%). No HC odor.
10				3	10	15				10-15'	SAND, as above, but brn. Lacks clay. No HC odor.
15				4	15	20				15-20'	CLAY, brn, minor fn- gr sand. No HC odor.
20				5	20	25				20-25'	CLAY, as above, but no sand. No HC odor.
25				6	25	30				25-30'	SAND, lt brn, fn- to cs- gr, poorly sorted. Saturated (?). No HC odor.
30											

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



NOT TO SCALE

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (X4)GBR-38

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): 5393 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: SAME

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: SAME

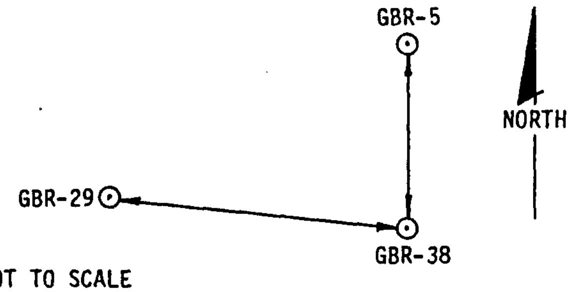
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
30				7	30	35				30-35' SAND, as above.
35				8	35	40				35-40' SAND, as above, but includes <1% sandstone. Sandstone is mottled tan/brn, med- to cs-gr, mod sorting. No HC odor.
40				9	40	45				40-45' SAND, as above, ≤10% of total. Angular, ≤5 cm dia qtzite chips (90%). No sandstone. No HC odor.
45				10	45	50				45-49' SAND, as above (90%). Large pebbles absent, small (≤0.5 cm) pebbles present (~10%). No HC odor.
										49-50' SANDSTONE, mottled lt brn, med- to cs- gr, poorly sorted. Poorly cemented, friable. Ho HC odor.
50				11	50	55				50-55' SANDSTONE, as above, but mottled blue-grey color (~5%). Blue-grey clay (<1%). Sand & pebbles as @ 45'-49' (~90%).
55				12	55	60				55-60' SANDSTONE, as above.
60										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



NOT TO SCALE

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (X4)GBR-38

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): 5393 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: SAME

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: SAME

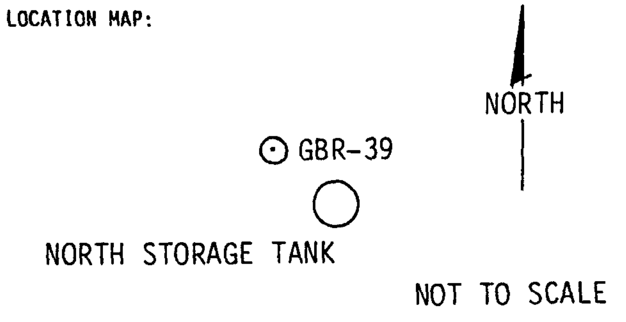
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
60				13	60	65				60-65' CLAY, blue-grey & brick red. Claystone (<1%) in same colors.
65				14	65	70				65-70' CLAYSTONE, as above (25%), contains minor fn-gr sand & silt. Sandy claystone (75%), blue-grey & brick red, sand is fn- gr.
70				15	70	75				70-75' SANDY CLAYSTONE, as above (70%). Clayey sandstone (25%), mottled white & blue-grey color, sand is med- to cs- gr, poorly sorted. Qtzite & sand (~5%) as @ 40-45'. TD=75'. 6" PVC blank 67'-72', PVC 20 slot screen 27'-67', PVC blank to surface. 1" PVC screen, 27'-67', PVC blank 0'-27'. Pea gravel (3/8") to 20', bentonite plug to 15, cement grout w/5% bentonite to surface.
75										
80										
85										
90										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (EX-3) GBR-39

SITE COORDINATES (ft.):

N ______ E ______

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: HSA W/SPLIT SPOONS, 7" BOREHOLE

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: 4/23/87 DATE COMPLETED: PLUGGED 4/24/87

FIELD REP.: J.P. KASZUBA

COMMENTS: BOREHOLE NOT COMPLETED AS A WELL. GRAVELS @ 32'. SATURATED @ ~ 33.5'. BEDROCK @ ~ 38'. TD=43'.

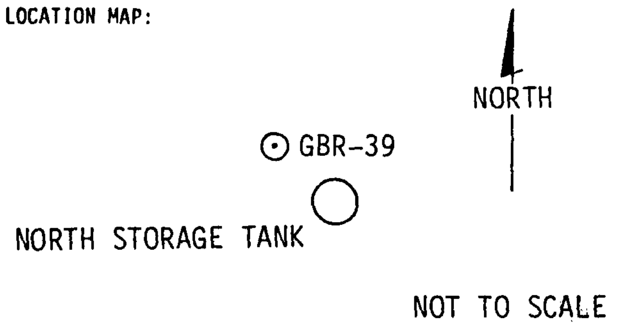
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0										
				1	3.0	4.5				3.0-4.5' SAND, tan, fn- to med- gr, minor cs- gr, mod sorting. No HC odor.
5										
				2	8.0	9.5				8.0-9.1' SAND, lt brn, fn- gr, minor med- gr, well-sorted. No HC odor. 9.1-9.4' SAND, brn, fn- gr, well-sorted. Abundant silt & clay. No HC odor. 9.4-9.5' SAND, as @ 8.0-9.1'.
10				3	13.0	14.5				13.0-13.4' No Returns. 13.4-13.8 SAND, lt brn, med- gr, poor sorting. Minor cs- gr. No HC odor. 13.8-14.1' SAND, brn, fn- to cs- gr, poorly sorted. Abundant silt & clay. No HC odor. 14.1-14.2' SAND, lt brn, med- to cs- gr, poorly sorted. No HC odor. 14.2-14.5' SAND, brn, fn- gr, well-sorted. Abundant silt & clay. No HC odor.
15										
				4	18.0	19.5				18.0-18.8' CLAY, brn, minor fn- gr sand. No HC odor. 18.8-19.5 SAND, lt brn, fn- gr, well-sorted. No HC odor.
20				5	23.0	24.5				23.0-23.2' CLAY, brn, minor cs- gr sand & <0.5 cm dia pebbles. No HC odor. 23.2-23.7' SAND, lt brn, med- to cs- gr, poor sorting. No HC odor. 23.7-24.5' CLAY, as @ 23.0-23.2'. Sandy @ 24.2-24.3'. No HC odor.
25										
				6	28.0	29.5				28.0-29.5' CLAY, as @ 23.0-23.2', but lacks pebbles. No HC odor.
30										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: MONT & AND LOCATION ID: (EX-3) GBR-39

SITE COORDINATES (ft.):

N ____ E ____

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: NO DIESEL NOTED DURING DRILLING.

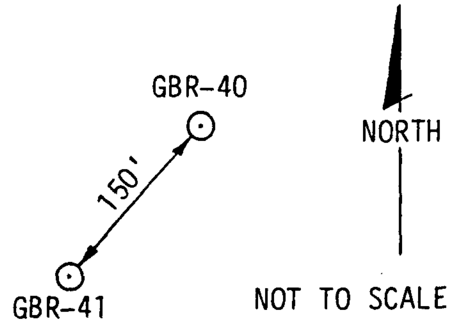
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
30										
				7	33.0	34.5				33.0-33.4' CLAY, as above. No HC odor. 33.4-33.5' GRAVEL, rounded, 2-5 cm dia. 33.5-34.5' SAND, lt brn, med- gr, well-sorted. Minor pebbles (up to 2 cm dia). Saturated. Strong HC odor. Black HC stain @ 33.5-34.0. Grey HC stain @ 34.0-34.2'. Lt grey stain @ 34.2-34.5'.
35										
				8	38.0	38.3				38.0-38.3' SANDSTONE, med- gr, minor fn-, cs- gr, pebbles (2-4 cm dia), mod sorting. Friable, poorly cemented. Limonite stain. Saturated. Faint HC odor (?).
40										
				9	43.0	43.3				43.0-43.3' SANDSTONE, as above, but lt brn color, cs-gr more abundant.
45										
50										
55										
60										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



__1/4 __1/4 NW 1/4 NW 1/4 S27 T29N R12W

SITE ID: MONT & AND LOCATION ID: (EX-5)GBR-40

SITE COORDINATES (ft.):

N ____ E ____

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: HSA W/SPLIT SPOONS. 7" BOREHOLE.

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: 4/24/87 DATE COMPLETED: PLUGGED4/24/87

FIELD REP.: J.P. KASZUBA

COMMENTS: BOREHOLE NOT COMPLETED AS A WELL. SATURATED @ 33.0-34.5'. TD=38'.

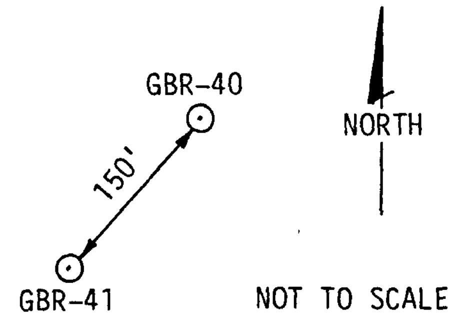
LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0										
				1	3.0	4.5				3.0-3.3' Road Gravel.
										3.3-4.5' SAND, tan, med- to cs- gr, mod sorting. No HC odor.
5										
				2	8.0	9.5				8.0-9.5' No Returns.
10										
				3	13.0	14.5				13.0-13.6' SAND, lt brn, med- to cs- gr, mod sorting. No HC odor.
										13.6-14.5' SAND, lt brn, fn- to med- gr, minor cs- gr, mod sorting. No HC odor.
15										
				4	18.0	19.5				18.0-18.9' SAND, brn, med- to cs- gr, mod sorting. Angular pebble fragments (up to 2 cm across) @ 18.7-18.9'. No HC odor.
										18.9-19.5' SAND, lt brn, fn- to med- gr, mod sorting. No HC odor.
20										
				5	23.0	24.5				23.0-23.5 SAND, lt brn, fn- to cs- gr, minor silt & pebbles (up to 2 cm across), poorly sorted, no HC odor.
										23.5-24.1' SAND, tan, fn- to med- gr, minor silt & cs- gr, mod sorting. No HC odor.
										24.1-24.5' SAND, tan, med- to cs- gr, minor fn- gr, well-sorted. No HC odor.
25										
				6	28.0	29.5				28.0-29.5' CLAY, olive brn. No HC odor.
30										

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: MONT & AND LOCATION ID: (EX-5) GBR-40

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): 5394 (TOPO)

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: SAME

DRILLING CONTR.: WESTERN TECH.

DATE STARTED: SAME DATE COMPLETED: SAME

FIELD REP.: SAME

COMMENTS: MINOR DIESEL ON SPLIT SPOONS FROM SATURATED ZONE. BEDROCK @ 39'.

LOCATION DESCRIPTION:

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
30										
				7	33.0	34.5				33.0-33.8' CLAYEY SAND, dark olive brn, sand is fn-gr, well-sorted. Saturated. Faint HC odor.
										33.8-34.5 CLAY, as @ 28.0-29.5, but saturated & faint HC odor(?).
35										
				8	38.0	39.5				38.0-38.9' CLAYEY SAND, brn, sand is fn- to med- gr, mod sorting. Saturated. Faint HC odor(?).
										38.9-39.5' SANDSTONE, mottled tan/brn, med- gr, minor cs- gr, mod sorting. Poorly cemented, friable. Saurated.
40										
45										
50										
55										
60										

APPENDIX C

WATER LEVELS AND FLOATING PRODUCT THICKNESSES

APPENDIX C

GIANT INDUSTRIES BLOOMFIELD REFINERY
STATIC WATER LEVELS AND FLOATING PRODUCT THICKNESSES IN FEET

WELL NUMBER
GBR-05

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/15/86	5343.10	0.00	5343.10
04/23/86	5341.20	0.00	5341.20
04/30/86	5342.54	0.00	5342.54
05/29/86	5358.21	1.38	5359.31
07/31/86	5351.93	11.04	5360.76
08/12/86	5351.63	11.49	5360.82
10/07/86	5362.31	1.00	5363.11
10/08/86	5362.89	0.75	5363.49
10/08/86	5362.81	0.83	5363.47
11/04/86	5363.10	0.71	5363.67
11/19/86	5363.39	0.67	5363.93
04/21/87	5363.60	0.17	5363.74
08/11/87	5363.18	1.08	5364.04
09/09/87	5362.95	1.14	5363.86
09/24/87	5362.88	1.13	5363.78
10/06/87	5362.74	1.19	5363.69
10/22/87	5362.74	1.19	5363.69
11/10/87	5362.59	1.13	5363.49
12/15/87	5362.55	1.13	5363.45
01/19/88	5362.73	0.93	5363.47

WELL NUMBER
GBR-06

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/07/86	5359.50	0.00	5359.50
10/08/86	5359.54	0.00	5359.54
10/08/86	5358.58	0.00	5358.58
11/04/86	5360.17	0.04	5360.20
11/19/86	5360.33	0.08	5360.39
04/21/87	5355.81	0.05	5355.85
08/11/87	5356.47	0.00	5356.47
09/09/87	5356.30	0.00	5356.30
09/24/87	5356.13	0.00	5356.13
10/06/87	5355.99	0.02	5356.01
10/22/87	5356.01	0.00	5356.01
11/04/87	5360.95	0.02	5360.97
11/10/87	5355.93	0.00	5355.93

WELL NUMBER
GBR-07

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/08/86	5363.00	0.00	5363.00
10/08/86	5363.30	0.00	5363.30
10/16/86	5362.80	0.00	5362.80
11/04/86	5362.50	0.00	5362.50
11/19/86	5363.21	0.00	5363.21
04/21/87	5362.53	0.25	5362.73
08/11/87	5362.15	0.00	5362.15
09/09/87	5362.03	0.00	5362.03
09/24/87	5362.03	0.00	5362.03
10/06/87	5361.90	0.00	5361.90
10/22/87	5361.84	0.00	5361.84
11/04/87	5361.78	0.02	5361.80
11/10/87	5361.82	0.00	5361.82
12/15/87	5361.65	0.00	5361.65
01/19/88	5361.74	0.00	5361.74

WELL NUMBER
GBR-08

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/08/86	5348.33	0.00	5348.33
10/08/86	5348.42	0.00	5348.42
10/09/86	5348.42	0.00	5348.42
10/09/86	5348.33	0.00	5348.33
10/16/86	5348.38	0.00	5348.38
10/17/86	5348.42	0.00	5348.42
11/04/86	5348.46	0.04	5348.49
11/19/86	5348.79	0.04	5348.82
04/21/87	5347.95	1.66	5349.28
05/06/87	5347.68	1.71	5349.05
08/11/87	5347.51	1.91	5349.04
09/09/87	5347.59	1.90	5349.11
09/24/87	5347.32	1.71	5348.69
10/06/87	5347.24	1.77	5348.66
10/22/87	5347.26	1.38	5348.36
11/10/87	5347.26	1.40	5348.38
12/15/87	5347.24	1.79	5348.67
01/19/88	5348.32	0.92	5349.06

WELL NUMBER
GBR-09

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/09/86	5348.50	0.00	5348.50
10/16/86	5348.54	0.00	5348.54
10/17/86	5347.92	0.00	5347.92
11/04/86	5348.71	0.00	5348.71
11/19/86	5349.12	0.00	5349.12
04/21/87	5348.62	1.E-2	5348.63
05/06/87	5348.56	0.00	5348.56
08/11/87	5348.54	0.00	5348.54
09/09/87	5348.44	0.00	5348.44
09/24/87	5348.02	0.00	5348.02
10/06/87	5348.06	0.02	5348.08
10/22/87	5348.55	0.00	5348.55
11/10/87	5348.04	0.00	5348.04
12/15/87	5348.09	0.00	5348.09
01/19/88	5348.45	0.00	5348.45

WELL NUMBER
GBR-10

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/09/86	5345.62	2.38	5347.52
10/09/86	5345.50	2.33	5347.36
11/04/86	5348.17	2.04	5349.80
11/19/86	5347.42	3.17	5349.96
04/21/87	5348.64	1.30	5349.68
05/06/87	5348.44	1.50	5349.64
08/11/87	5347.84	2.16	5349.57
09/09/87	5347.90	2.06	5349.55
09/24/87	5347.94	1.61	5349.23
10/06/87	5347.88	1.85	5349.36
10/22/87	5347.86	1.52	5349.08
11/04/87	5347.88	1.67	5349.22
11/10/87	5347.90	1.75	5349.30
12/15/87	5347.82	1.91	5349.35
01/19/88	5347.94	1.90	5349.46

WELL NUMBER
GBR-11

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/03/86	5349.95	0.00	5349.95
04/15/86	5349.91	0.00	5349.91
04/23/86	5349.83	0.00	5349.83
04/30/86	5349.85	0.00	5349.85
07/15/86	5349.75	0.40	5350.07
08/12/86	5346.66	0.17	5346.80
08/12/86	5346.66	0.17	5346.80
10/08/86	5348.87	0.75	5349.47
10/09/86	5348.87	0.75	5349.47
11/04/86	5348.32	1.50	5349.52
11/19/86	5349.08	1.04	5349.91
04/21/87	5349.29	1.04	5350.12
05/06/87	5349.17	1.16	5350.10
08/11/87	5348.75	1.54	5349.98
09/09/87	5348.50	1.73	5349.88
09/24/87	5346.82	3.14	5349.33
10/06/87	5347.58	2.44	5349.53
10/22/87	5346.50	3.30	5349.14
11/10/87	5347.40	2.60	5349.48
12/15/87	5347.58	2.47	5349.56
01/19/88	5347.84	1.41	5348.97

WELL NUMBER
GBR-13

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/03/86	5354.75	0.00	5354.75
04/23/86	5352.68	0.00	5352.68
04/30/86	5352.79	0.00	5352.79
05/29/86	5350.08	0.00	5350.08
07/15/86	5351.77	0.56	5352.22
07/31/86	5350.71	0.83	5351.37
08/12/86	5350.39	1.42	5351.53
10/07/86	5351.50	0.75	5352.10
11/04/86	5351.79	0.38	5352.09
11/19/86	5352.33	0.38	5352.63
04/21/87	5352.91	0.02	5352.93
05/06/87	5352.88	0.04	5352.91
08/11/87	5352.67	0.02	5352.69
09/09/87	5352.63	0.00	5352.63
09/24/87	5352.49	0.00	5352.49
10/06/87	5352.42	0.02	5352.44
10/22/87	5352.26	0.00	5352.26
11/10/87	5351.72	1.04	5352.55
12/15/87	5350.84	1.84	5352.31
01/19/88	5351.13	1.65	5352.45

WELL NUMBER
GBR-14

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/07/86	5365.83	0.00	5365.83
10/08/86	5365.75	0.00	5365.75
10/09/86	5365.75	0.00	5365.75
10/17/86	5365.50	0.00	5365.50
11/05/86	5366.46	0.00	5366.46
11/19/86	5366.33	0.00	5366.33
11/21/86	5358.58	0.00	5358.58
04/21/87	5363.82	0.02	5363.84
08/11/87	5363.61	0.04	5363.64
09/09/87	5363.53	0.03	5363.55
09/24/87	5361.53	0.00	5361.53
10/06/87	5361.09	0.13	5361.19
10/22/87	5360.41	0.00	5360.41
11/04/87	5361.76	0.02	5361.78
11/10/87	5355.57	0.00	5355.57
12/15/87	5363.24	0.02	5363.26
01/19/88	5363.13	1.E-2	5363.14

WELL NUMBER
GBR-15

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/07/86	5364.62	0.00	5364.62
10/08/86	5364.50	0.00	5364.50
10/09/86	5364.50	0.00	5364.50
10/16/86	5357.58	0.00	5357.58
10/17/86	5363.46	0.00	5363.46
11/05/86	5365.12	0.00	5365.12
11/19/86	5368.47	0.20	5368.63
11/21/86	5360.37	0.00	5360.37
04/21/87	5368.47	0.02	5368.49
08/11/87	5367.61	0.00	5367.61
09/09/87	5367.38	0.00	5367.38
09/24/87	5366.64	0.00	5366.64
10/06/87	5366.56	0.02	5366.58
10/22/87	5365.68	0.00	5365.68
11/04/87	5366.50	0.02	5366.52
11/10/87	5365.56	0.01	5365.57
12/15/87	5366.72	0.00	5366.72
01/19/88	5367.50	0.02	5367.52

WELL NUMBER
GBR-17

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/29/86	5367.75	0.00	5367.75
07/15/86	5367.78	0.00	5367.78
07/31/86	5368.31	0.00	5368.31
08/12/86	5367.89	0.00	5367.89
10/16/86	5369.06	0.00	5369.06
10/17/86	5369.06	0.00	5369.06
11/05/86	5369.31	0.00	5369.31
11/19/86	5369.64	0.00	5369.64
08/11/87	5369.69	0.00	5369.69
10/06/87	5369.48	0.00	5369.48
10/22/87	5369.32	0.00	5369.32
11/10/87	5369.36	0.00	5369.36
12/15/87	5369.19	0.00	5369.19

WELL NUMBER
GBR-18

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
07/15/86	5407.23	0.00	5407.23
07/31/86	5411.46	0.00	5411.46
08/12/86	5410.78	0.00	5410.78
10/16/86	5408.52	0.00	5408.52
10/17/86	5402.72	0.00	5402.72
11/05/86	5408.56	0.00	5408.56
11/19/86	5408.39	0.00	5408.39
08/11/87	5408.19	0.00	5408.19
10/06/87	5408.44	0.00	5408.44
10/22/87	5408.02	0.01	5408.03
11/10/87	5399.82	0.00	5399.82
12/15/87	5408.94	0.00	5408.94

WELL NUMBER
GBR-19

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/09/86	5355.00	0.00	5355.00
10/16/86	5355.00	0.00	5355.00
10/17/86	5355.00	0.00	5355.00
11/05/86	5355.42	0.00	5355.42
11/19/86	5355.62	0.00	5355.62
04/21/87	5355.19	0.15	5355.31
05/06/87	5355.18	0.16	5355.31
08/11/87	5354.82	0.27	5355.04
09/09/87	5354.81	0.25	5355.01
10/06/87	5354.64	0.22	5354.82
10/22/87	5354.56	0.20	5354.72
11/04/87	5354.56	0.25	5354.76
11/10/87	5354.56	0.25	5354.76
12/15/87	5354.47	0.29	5354.70
01/19/88	5354.54	0.39	5354.85

WELL NUMBER
GBR-20

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/29/86	5352.17	0.00	5352.17
07/15/86	5353.18	0.00	5353.18
07/31/86	5354.20	0.00	5354.20
08/12/86	5354.20	0.00	5354.20
10/16/86	5354.66	0.00	5354.66
10/17/86	5354.50	0.00	5354.50
11/04/86	5354.87	0.00	5354.87
11/19/86	5355.16	0.00	5355.16
04/21/87	5353.93	0.00	5353.93
08/11/87	5354.60	0.16	5354.73
09/09/87	5354.45	0.27	5354.67
09/24/87	5353.88	0.27	5354.10
10/06/87	5354.29	0.33	5354.55
10/22/87	5354.14	0.33	5354.40
11/10/87	5354.00	0.35	5354.28
12/15/87	5354.22	0.37	5354.52
01/19/88	5354.05	0.51	5354.46

WELL NUMBER
GBR-21

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/02/86	5370.54	0.00	5370.54
05/29/86	5369.67	0.00	5369.67
07/15/86	5371.58	0.00	5371.58
07/31/86	5371.54	0.00	5371.54
10/07/86	5370.71	0.00	5370.71
10/16/86	5363.58	0.00	5363.58
10/17/86	5360.79	0.00	5360.79
11/05/86	5369.71	0.00	5369.71
11/19/86	5369.92	0.00	5369.92
11/21/86	5369.34	0.00	5369.34
11/21/86	5366.34	0.00	5366.34
04/21/87	5369.91	0.00	5369.91
08/11/87	5369.52	0.00	5369.52
09/09/87	5369.41	0.00	5369.41
09/24/87	5369.31	0.00	5369.31
10/06/87	5369.08	0.00	5369.08
11/04/87	5368.92	0.02	5368.94
11/10/87	5369.06	0.00	5369.06
12/15/87	5368.60	0.00	5368.60
01/19/88	5369.23	0.00	5369.23

WELL NUMBER
GBR-21

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/02/86	5377.50	1.92	5379.04
07/15/86	5368.83	1.04	5369.66
07/31/86	5378.12	0.80	5378.76
08/12/86	5379.04	0.42	5379.38
10/07/86	5379.37	0.50	5379.77
11/05/86	5379.71	0.50	5380.11
11/19/86	5379.79	0.46	5380.16
11/21/86	5379.75	0.33	5380.01
04/21/87	5379.27	0.51	5379.68
08/11/87	5379.41	0.43	5379.75
09/09/87	5379.31	0.58	5379.77
09/24/87	5379.31	0.63	5379.81
10/06/87	5379.20	0.69	5379.75
11/04/87	5379.14	0.67	5379.68
11/04/87	5379.14	0.67	5379.68
11/10/87	5379.17	0.64	5379.68
12/15/87	5378.98	0.75	5379.58
01/19/88	5379.79	0.05	5379.83

WELL NUMBER
GBR-22

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/16/86	5361.33	0.00	5361.33
04/23/86	5361.00	0.00	5361.00
04/30/86	5361.21	0.00	5361.21
05/02/86	5361.11	0.00	5361.11
05/09/86	5361.17	0.00	5361.17
05/29/86	5357.58	0.00	5357.58
07/15/86	5361.07	0.00	5361.07
07/31/86	5360.96	0.00	5360.96
08/12/86	5361.11	0.00	5361.11
10/07/86	5361.84	0.00	5361.84
10/09/86	5361.75	0.00	5361.75
10/16/86	5361.46	0.00	5361.46
10/17/86	5361.38	0.00	5361.38
11/19/86	5359.84	2.96	5362.21
11/21/86	5360.04	2.79	5362.27
04/21/87	5360.82	0.23	5361.00
08/11/87	5362.05	0.25	5362.25
09/09/87	5360.58	0.04	5360.61
09/24/87	5361.35	0.00	5361.35
10/06/87	5359.74	0.65	5360.26
10/22/87	5359.77	0.62	5360.27
11/10/87	5359.60	0.83	5360.26
12/15/87	5359.39	0.96	5360.16
01/19/88	5360.50	1.12	5361.40

WELL NUMBER
GBR-23

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/02/86	5378.71	1.E-2	5378.72
07/15/86	5377.45	0.02	5377.47
07/31/86	5379.23	0.04	5379.26
08/12/86	5379.22	0.03	5379.24
10/07/86	5379.69	0.00	5379.69
10/09/86	5379.69	0.00	5379.69
11/05/86	5379.98	0.02	5380.00
11/19/86	5380.36	0.02	5380.38
11/21/86	5380.36	0.00	5380.36
04/21/87	5380.29	0.02	5380.31
08/11/87	5380.65	1.E-2	5380.66
09/09/87	5380.50	0.03	5380.52
09/24/87	5380.57	0.00	5380.57
10/06/87	5380.50	0.00	5380.50
10/22/87	5380.38	0.00	5380.38
11/10/87	5380.13	0.00	5380.13
12/15/87	5380.04	0.03	5380.06
01/19/88	5380.05	0.02	5380.07

WELL NUMBER
GBR-24

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/23/86	5370.10	0.00	5370.10
04/30/86	5368.62	0.00	5368.62
05/02/86	5368.17	0.00	5368.17
05/09/86	5368.33	0.00	5368.33
05/29/86	5365.12	0.00	5365.12
07/15/86	5368.70	0.00	5368.70
07/31/86	5369.32	0.00	5369.32
08/12/86	5369.08	0.00	5369.08
10/07/86	5369.16	0.00	5369.16
10/09/86	5369.08	0.00	5369.08
10/16/86	5366.62	0.00	5366.62
10/17/86	5368.20	0.00	5368.20
11/05/86	5369.58	0.00	5369.58
11/19/86	5370.03	0.00	5370.03
11/21/86	5367.32	0.00	5367.32
04/21/87	5370.47	0.02	5370.49
08/11/87	5370.79	0.00	5370.79
09/09/87	5370.68	0.00	5370.68
09/24/87	5369.98	0.00	5369.98
11/10/87	5369.50	0.00	5369.50
12/15/87	5369.79	0.00	5369.79
01/19/88	5369.81	0.00	5369.81

WELL NUMBER
GBR-24

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/02/86	5368.79	0.08	5368.85
07/15/86	5368.07	1.E-2	5368.08
07/31/86	5369.57	0.00	5369.57
08/12/86	5369.72	0.03	5369.74
10/07/86	5369.87	0.04	5369.90
10/09/86	5369.91	0.04	5369.94
11/05/86	5370.53	0.04	5370.56
11/19/86	5370.91	0.02	5370.93
11/21/86	5369.45	0.00	5369.45
04/21/87	5371.95	0.02	5371.97
08/11/87	5372.49	0.04	5372.52
09/09/87	5372.35	0.02	5372.37
09/24/87	5372.62	0.00	5372.62
10/06/87	5372.45	0.01	5372.46
11/04/87	5372.52	0.02	5372.54
11/10/87	5372.45	0.00	5372.45
12/15/87	5372.45	0.02	5372.47
01/19/88	5372.45	1.E-2	5372.46

WELL NUMBER
GBR-25

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/23/86	5367.65	0.00	5367.65
04/30/86	5367.08	0.00	5367.08
05/02/86	5366.17	0.00	5366.17
05/09/86	5367.21	0.00	5367.21
05/29/86	5365.29	0.00	5365.29
07/15/86	5367.55	0.00	5367.55
07/31/86	5367.74	0.04	5367.77
08/12/86	5367.81	0.00	5367.81
10/07/86	5365.90	0.00	5365.90
10/09/86	5367.86	0.00	5367.86
10/16/86	5366.28	0.00	5366.28
10/17/86	5368.20	0.00	5368.20
11/05/86	5368.03	0.00	5368.03
11/19/86	5368.03	0.00	5368.03
11/21/86	5366.95	0.00	5366.95
08/11/87	5369.12	0.04	5369.15
09/09/87	5369.96	0.00	5369.96
09/24/87	5369.24	0.00	5369.24
10/06/87	5369.83	0.00	5369.83
10/22/87	5369.03	0.00	5369.03
11/04/87	5368.99	0.02	5369.01
11/10/87	5368.58	0.00	5368.58
01/19/88	5368.59	0.02	5368.61

WELL NUMBER
GBR-26

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/23/86	5362.65	0.00	5362.65
04/30/86	5362.92	0.00	5362.92
05/02/86	5362.85	0.00	5362.85
05/09/86	5362.75	0.00	5362.75
05/29/86	5361.29	0.00	5361.29
07/15/86	5362.62	0.00	5362.62
07/31/86	5362.93	0.00	5362.93
08/12/86	5362.31	0.00	5362.31
10/07/86	5363.72	0.00	5363.72
10/09/86	5363.56	0.04	5363.59
10/16/86	5363.35	0.00	5363.35
10/17/86	5361.26	0.00	5361.26
11/05/86	5364.93	0.08	5364.99
11/19/86	5364.39	0.17	5364.53
11/21/86	5364.01	0.12	5364.11
04/21/87	5363.95	0.12	5364.05
08/11/87	5363.70	0.08	5363.76
09/09/87	5363.65	0.13	5363.75
09/24/87	5363.43	0.10	5363.51
10/06/87	5361.34	2.09	5363.01
10/22/87	5363.28	0.09	5363.35
11/10/87	5363.28	0.00	5363.28
12/15/87	5363.37	0.06	5363.42
01/19/88	5363.28	0.05	5363.32

WELL NUMBER
GBR-27

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/02/86	5360.16	7.17	5365.90
05/29/86	5357.67	8.67	5364.61
07/31/86	5364.75	2.91	5367.08
10/07/86	5367.25	0.42	5367.59
10/09/86	5367.08	0.38	5367.38
11/05/86	5368.08	0.29	5368.31
11/19/86	5367.91	0.08	5367.97
11/21/86	5357.16	0.00	5357.16
04/21/87	5379.27	1.E-2	5379.28
08/11/87	5379.71	0.12	5379.81
09/09/87	5379.80	0.00	5379.80
09/24/87	5379.77	0.00	5379.77
10/06/87	5378.60	0.00	5378.60
10/22/87	5375.88	0.01	5375.89
11/04/87	5379.51	0.02	5379.53
11/10/87	5379.61	0.00	5379.61
12/15/87	5379.63	0.00	5379.63
01/19/88	5369.57	0.00	5369.57

WELL NUMBER
GBR-28

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/29/86	5359.87	0.17	5360.01
07/15/86	5361.95	0.50	5362.35
07/31/86	5360.59	0.58	5361.05
08/12/86	5360.43	1.22	5361.41
10/07/86	5362.18	0.00	5362.18
10/09/86	5361.47	0.00	5361.47
11/05/86	5362.26	0.02	5362.28
11/19/86	5362.64	0.12	5362.74
11/21/86	5361.93	0.00	5361.93
04/21/87	5362.73	0.05	5362.77
08/11/87	5362.48	0.02	5362.50
09/09/87	5362.43	0.03	5362.45
09/24/87	5361.52	0.17	5361.66
10/06/87	5360.98	0.35	5361.26
10/22/87	5360.86	0.45	5361.22
11/04/87	5360.23	0.96	5361.00
11/10/87	5360.46	0.00	5360.46
12/15/87	5361.85	0.32	5362.11
01/19/88	5361.73	0.27	5361.95

WELL NUMBER
GBR-29

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/29/86	5345.00	0.00	5345.00
07/15/86	5342.85	4.50	5346.45
07/31/86	5341.02	7.34	5346.89
08/12/86	5341.61	6.50	5346.81
10/07/86	5342.27	6.25	5347.27
11/04/86	5343.02	5.58	5347.48
11/05/86	5345.94	2.04	5347.57
11/19/86	5345.52	2.96	5347.89
04/21/87	5348.66	0.02	5348.68
08/11/87	5348.43	1.E-2	5348.44
09/09/87	5348.96	0.00	5348.96
09/24/87	5348.47	0.00	5348.47
10/06/87	5347.74	0.00	5347.74
10/22/87	5347.72	0.00	5347.72
11/04/87	5347.09	0.03	5347.11
12/15/87	5348.22	0.10	5348.30
01/19/88	5348.43	0.41	5348.76

WELL NUMBER
GBR-30

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/07/86	5366.00	0.00	5366.00
10/09/86	5365.92	0.00	5365.92
10/16/86	5365.79	0.00	5365.79
10/17/86	5365.83	0.00	5365.83
11/05/86	5367.00	0.25	5367.20
11/19/86	5366.50	0.17	5366.64
11/21/86	5366.42	0.00	5366.42
04/21/87	5364.32	0.50	5364.72
08/11/87	5364.03	0.12	5364.13
09/09/87	5363.93	0.08	5363.99
09/24/87	5363.80	0.02	5363.82
10/06/87	5363.67	0.06	5363.72
10/22/87	5363.63	0.09	5363.70
11/10/87	5363.65	0.00	5363.65
12/15/87	5363.67	0.02	5363.69
01/19/88	5363.53	0.04	5363.56

WELL NUMBER
GBR-31

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
10/07/86	5362.30	0.00	5362.30
10/09/86	5362.21	0.00	5362.21
10/16/86	5362.00	0.00	5362.00
10/17/86	5362.00	0.00	5362.00
11/05/86	5362.42	0.00	5362.42
11/19/86	5362.84	0.00	5362.84
04/21/87	5360.92	0.00	5360.92
08/11/87	5360.62	0.04	5360.65
09/09/87	5360.63	0.00	5360.63
09/24/87	5360.52	0.00	5360.52
10/06/87	5360.35	0.00	5360.35
11/10/87	5360.27	0.00	5360.27

WELL NUMBER
GBR-32

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
08/11/87	5382.27	0.00	5382.27
10/06/87	5391.86	0.00	5391.86
10/22/87	5381.75	0.00	5381.75
11/10/87	5381.73	0.00	5381.73
12/15/87	5381.50	0.00	5381.50

WELL NUMBER
GBR-33

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/06/87	5358.48	1.00	5359.28
08/11/87	5359.31	0.15	5359.43
09/09/87	5359.23	1.04	5360.06
09/24/87	5359.19	1.06	5360.04
10/06/87	5358.83	1.21	5359.80
10/22/87	5359.06	0.88	5359.76
11/04/87	5358.98	1.00	5359.78
11/10/87	5359.06	0.92	5359.80
12/15/87	5359.31	0.66	5359.84
01/19/88	5359.31	0.71	5359.88

WELL NUMBER
GBR-34

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/06/87	5359.14	1.80	5360.58
08/11/87	5359.89	0.83	5360.55
09/09/87	5359.85	0.21	5360.02
09/24/87	5360.02	0.08	5360.08
10/06/87	5359.76	0.09	5359.83
10/22/87	5359.93	0.02	5359.95
11/10/87	5360.02	0.00	5360.02
12/15/87	5359.89	0.02	5359.91
01/19/88	5360.00	0.08	5360.06

WELL NUMBER
GBR-35

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/06/87	5356.00	4.40	5359.52
08/11/87	5355.59	4.46	5359.16
09/09/87	5354.11	5.81	5358.76
09/24/87	5352.71	7.00	5358.31
10/06/87	5354.50	4.98	5358.48
10/22/87	5352.50	6.98	5358.08
11/10/87	5354.92	4.50	5358.52
12/15/87	5355.46	4.00	5358.66
01/19/88	5357.21	2.17	5358.95

WELL NUMBER
GBR-36

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
05/06/87	5356.39	0.08	5356.45
08/11/87	5356.39	2.46	5358.36
09/09/87	5355.64	3.09	5358.11
09/24/87	5356.85	1.71	5358.22
10/06/87	5354.77	3.18	5357.31
10/22/87	5356.35	1.92	5357.89
11/10/87	5356.02	2.23	5357.80
12/15/87	5356.98	1.24	5357.97
01/19/88	5357.02	1.31	5358.07

WELL NUMBER
GBR-37

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
08/11/87	5348.94	0.08	5349.00
09/09/87	5348.88	0.02	5348.90
09/24/87	5348.57	0.00	5348.57
10/06/87	5348.53	0.00	5348.53
10/22/87	5347.20	0.04	5347.23
11/04/87	5348.76	0.02	5348.78
11/10/87	5347.74	0.00	5347.74
12/15/87	5348.61	0.02	5348.63
01/19/88	5348.68	0.02	5348.70

WELL NUMBER
GBR-38

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
08/11/87	5352.21	0.00	5352.21
09/09/87	5354.78	0.00	5354.78
09/24/87	5350.20	0.00	5350.20
10/06/87	5350.09	0.00	5350.09
10/22/87	5349.82	0.00	5349.82
11/04/87	5350.42	0.03	5350.44
11/04/87	5350.42	0.03	5350.44
11/10/87	5349.95	0.00	5349.95
12/15/87	5354.55	0.00	5354.55
01/19/88	5354.55	0.00	5354.55

WELL NUMBER
GBR-39

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
04/15/86	5363.17	0.00	5363.17
04/16/86	5363.08	0.00	5363.08
04/23/86	5362.80	0.00	5362.80
05/02/86	5363.12	0.00	5363.12
05/09/86	5362.92	0.00	5362.92
05/29/86	5363.04	0.00	5363.04
07/15/86	5362.96	0.00	5362.96
10/07/86	5363.71	0.00	5363.71
10/09/86	5363.56	0.00	5363.56
10/16/86	5362.79	0.00	5362.79
10/17/86	5363.04	0.00	5363.04
11/05/86	5364.21	0.00	5364.21
11/19/86	5364.17	0.00	5364.17
11/21/86	5363.79	0.00	5363.79
04/21/87	5364.76	0.06	5364.81
08/11/87	5364.49	0.00	5364.49
11/10/87	5363.53	0.00	5363.53
12/14/87	5374.02	0.00	5374.02
01/19/88	5363.85	9.998E-3	5363.86

WELL NUMBER
GBR-40

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
12/14/87	5370.35	0.00	5370.35

WELL NUMBER
GBR-41

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
11/11/87	5366.80	0.00	5366.80
12/14/87	5368.03	0.00	5368.03

WELL NUMBER
GBR-42

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
01/19/88	5349.05	0.00	5349.05

WELL NUMBER
GBR-43

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
01/19/88	5348.74	0.25	5348.94

WELL NUMBER
GBR-44

SAMPLE DATE	WATER ELEVATION	PRODUCT THICKNESS	CORRECTED WATER ELEVATION
01/19/88	5351.00	9.998E-3	5351.01

^Z

DISCHARGE PLAN APPLICATION
FOR
GIANT BLOOMFIELD REFINERY
BLOOMFIELD, NM

APPENDICES D - M

March 1, 1988

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APPENDIX D

AQUIFER ANALYSIS AT THE
GIANT BLOOMFIELD REFINERY

PUMP TESTS - DIESEL SPILL AREA
GBR-27
GBR-14
GBR-14, GBR-27, AND GBR-28
PUMP TEST - SOUTHERN REFINERY AREA - GBR-29

ANALYSIS OF AQUIFER TEST DATA OBSERVED IN DIESEL SPILL AREA

ANALYSIS OF AQUIFER TEST DATA OBSERVED AT GBR-27

During the spring of 1986 an aquifer test was performed in well GBR-27, which is screened within the sandstone aquifer underlying surface alluvial deposits. The well was pumped at a rate of 0.88 gpm for roughly 17 hours. Water level measurements obtained during the aquifer test were believed to be affected by the presence of floating product in the GBR-27 pump well, as well as in the GBR-25 and GBR-21 observation wells. Floating product was observed to increase from 9 feet to 16 feet in GBR-27 during pumping. Although product was not encountered at GBR-25, this could be attributed to the fact that the top of the screened interval was below the piezometric surface. Thus, any product floating above the water table could not be detected by in-hole probes. Floating product was especially considered to be a problem in well GBR-21, where water levels were observed to increase throughout the test, presumably in response to removal of product by pumping at GBR-27.

Water levels in the pump well became progressively depressed both in response to lowering of the piezometric surface and to accumulation of product in the borehole. Analysis of drawdown data obtained at the pump well therefore requires consideration of the effect of increasing product pressure head during the test. The decrease in product pressure head at observation wells, where floating product was continually being removed, should also be considered when analyzing drawdown data obtained at the observation wells. Although it is difficult to account for complex dynamics attributed to two-phase flow between wells, it is possible to consider the effects of product thickness on water level measurements within any well at any given time during the aquifer test.

If it is assumed that the total head of water at any well is the sum of both the measured elevation head and a pressure head ascribed to the occurrence of floating product, the total hydraulic head (h) of water can be expressed as:

$$h = z + \frac{p}{d_{product} \cdot g} \quad \frac{d_{product}}{d_{H_2O}}$$

where z = observed elevation head [L]

p = pressure of the product $[M/LT^2]$

$d_{product}$ = density of the product $[M/L^3]$

d_{H_2O} = density of water $[M/L^3]$

g = the gravitational constant $[L/T^2]$

The expression $p/(d_{product} \cdot g)$ is equivalent to the pressure head of the product in units of product height, and must be converted to length of water through multiplication by the ratio $d_{product}/d_{H_2O}$.

The resulting expression

$$h = z + \frac{p}{d_{H2O} \cdot g}$$

is the familiar Bernoulli equation for the hydraulic head of water, neglecting a velocity head term. The actual hydraulic head of the water, in the absence of product, can therefore be determined by simply multiplying the observed product thickness $(p/d_{product} \cdot g)$ by an estimate of $d_{product}/d_{H2O}$ and adding it to the observed elevation head z.

If product thickness is known before and after pumping, it can be estimated during intermediate times by plotting a line between initial and final thickness versus the logarithm of time (see Figure F-1). Use of this plot for estimating product thickness at GBR-27 for intermediate times of the aquifer test implies a rapid increase in thickness during early time, with a progressively slower rate of increase at later times. Such behavior would be expected on the basis of initially steep hydraulic gradients at the onset of pumping and a large corresponding initial influx of product. Figure F-1 was constructed by assuming that product thickness at GBR-27 did not begin to increase until 1 minute after pumping began. This initial time was chosen purely on the basis of expediency; use of smaller times of initial accumulation resulted in fluctuating corrected water levels and negative corrected drawdowns during early times.

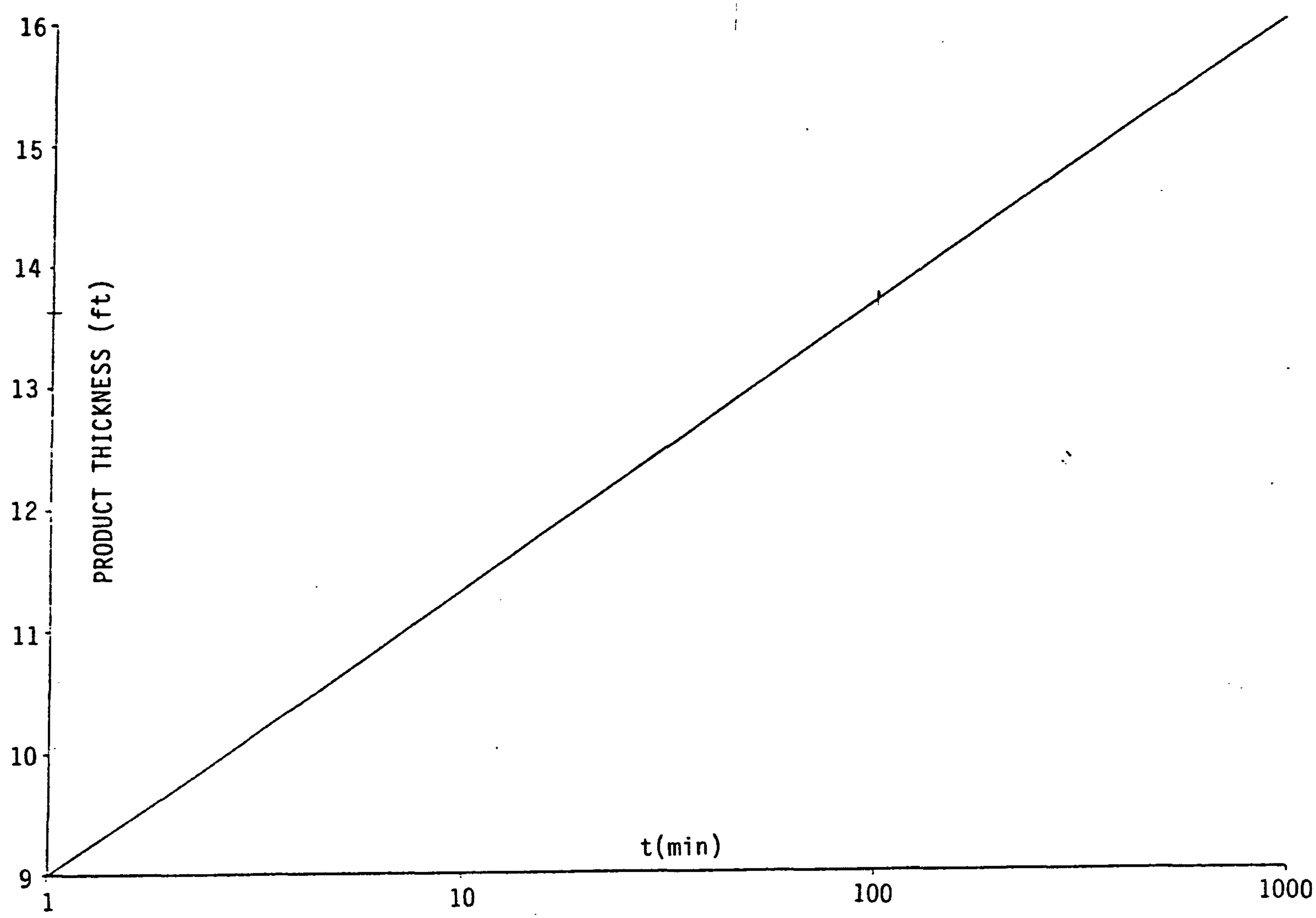


FIGURE F-1
PRODUCT THICKNESS IN GBR-27 DURING SPRING 1986 AQUIFER TEST

It should be noted that there is no need to reduce product thickness by a factor of four before applying the correction, since in-hole water level elevations were observed during the test. Because it is these elevations that are being corrected, the actual in-hole product thickness should be used. However, borehole product thickness is generally four times the anticipated thickness in the aquifer and should be used in performing other calculations such as the volume of product in the aquifer.

A major assumption implicit to the approach described above is that the dynamics of water flow in the aquifer remain unaltered by the occurrence of floating product. Specifically, it is assumed that the hydraulic gradients characteristic of the floating product, which may differ significantly from those of the underlying water, do not greatly affect the rate of water transmission to the pump well or the rate of water migration away from observation wells. In reality, within areas where the gradient of the product is large, the gradient of the piezometric surface will also tend to be large and would cause greater lateral flow of water than would otherwise occur in the absence of product (see Figure F-2). In the event that the product gradient is directed opposite to the naturally-occurring piezometric gradient, the actual piezometric gradient would be reduced or even reversed by the presence of product. Depending upon the location of the pump or observation wells, transmissivities calculated on the basis of pump test data could be significantly over- or underestimated.

ANALYSIS OF DRAWDOWN DATA OBSERVED AT GBR-27

Drawdown data observed during aquifer testing of well GBR-27 were analyzed to account for casing and borehole storage effects. Judging from the shape of the double-logarithmic drawdown vs. time plot shown in Figure F-3, withdrawal of water from casing and borehole storage appears to have controlled the rate of drawdown, uncorrected for product, in well GBR-27 during early stages of pumping. A linear response to pumping occurred until a time of approximately 3.7 minutes, after which data conformed to another linear relation until a time of 140 minutes.

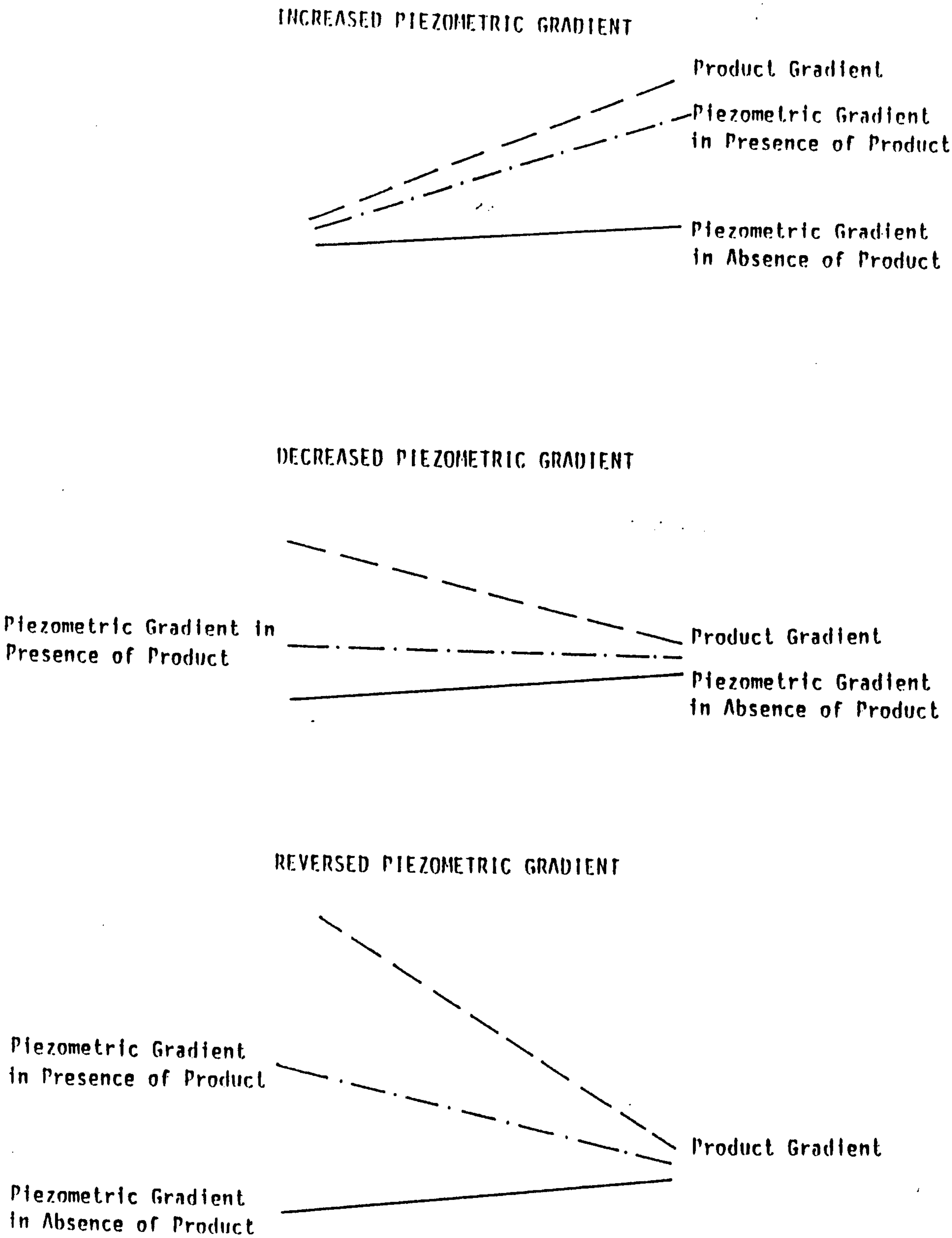


FIGURE F-2
SCHEMATIC REPRESENTATION OF THE EFFECTS OF
PRODUCT GRADIENT ON THE PIEZOMETER GRADIENT

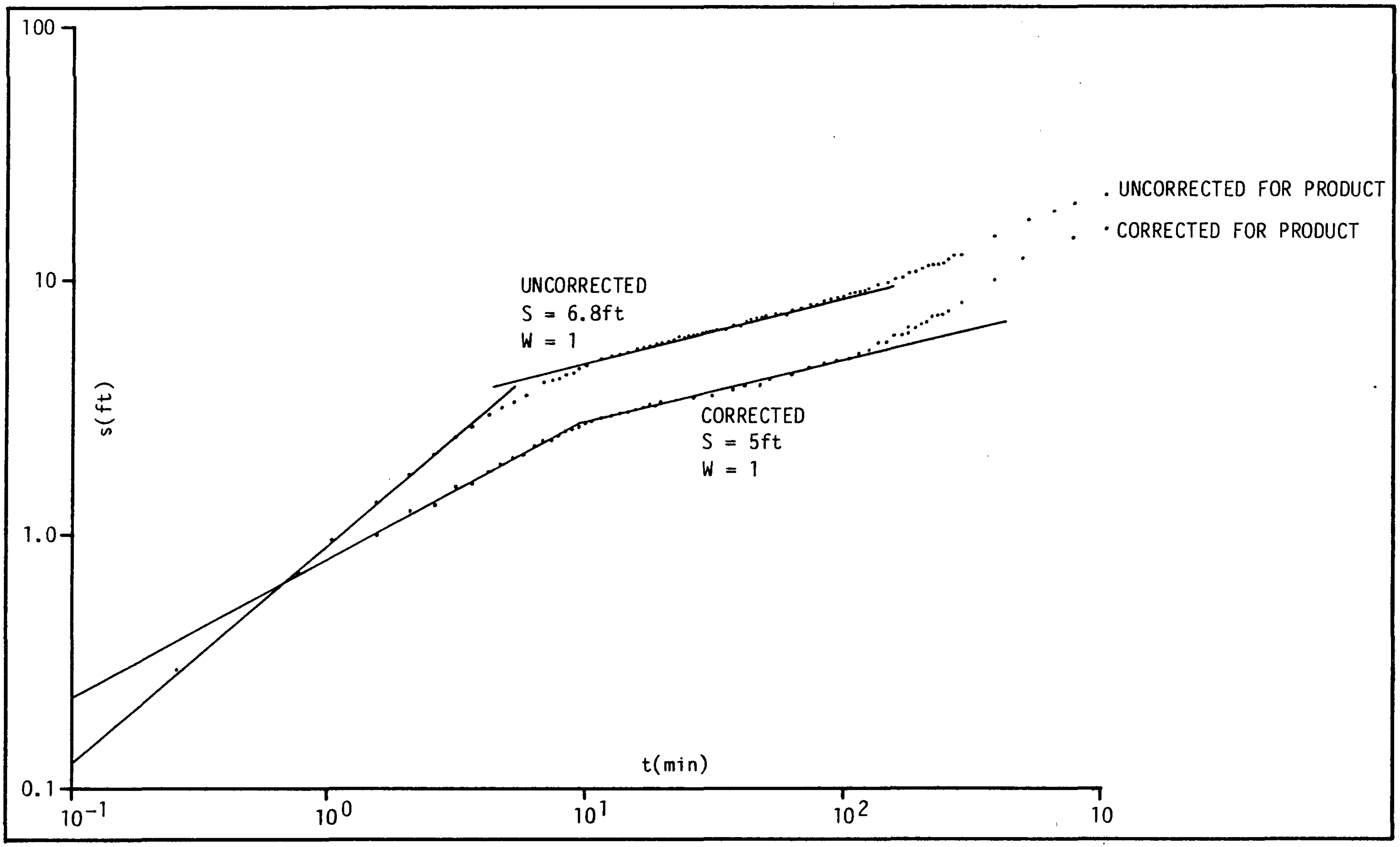


FIGURE F-3
THEIS PLOT OF DRAWDOWN VS. TIME AT GBR-27

Thereafter, the uncorrected data conformed to a Theis curve as the aquifer itself became stressed by the withdrawal of water.

The observed linear relations between drawdown and time were a result of the constant rate of discharge, which produced constant rates of casing and borehole dewatering. Casing dewatering occurred until a time of 3.7 minutes, when an uncorrected drawdown of 3.2 feet was attained. The following calculation substantiated that dewatering of the 5-inch well casing (r_w = 2.5 inches) at a rate of 0.88 gpm was responsible for the observed uncorrected drawdown of 3.2 feet after 3.7 minutes:

$$Q = 0.88 \frac{\text{gal}}{\text{min}} \; \frac{\text{ft}^3}{7.481 \text{ gal}} = 0.12 \text{ ft}^3/\text{min}$$

$$\begin{aligned} V &= \pi \, (r_w/12)^2 \, s_{t\,=\,3.7} \\ &= \pi \, (2.5/12)^2 \, (3.2) \text{ ft}^3 \\ &= 0.44 \text{ ft}^3 \end{aligned}$$

$$\begin{aligned} t &= V/Q = 0.44 \text{ ft}^3/(0.12 \text{ ft}^3/\text{min}) \\ &= 3.7 \text{ minutes} \end{aligned}$$

Between times of 3.7 and 140 minutes, uncorrected drawdown in the well appeared to conform to another linear relation controlled by dewatering of the borehole surrounding the well casing. Calculations suggest that an effective borehole diameter of 18.2 inches (r_b = 9.1 inches) would be responsible for an uncorrected borehole drawdown of 10 feet:

$$Q = 0.12 \text{ ft}^3/\text{min}$$

$$V = \pi \left[(r_b/12)^2 - (r_w/12)^2\right] s_t = 140 \text{ min}$$

$$= \pi \left[(9.1/12)^2 - (2.5/12)^2\right] (10) \quad \text{ft}^3$$

$$= 16.7 \text{ ft}^3$$

$$T = V/Q = 16.7 \text{ ft}^3/(0.12 \text{ ft}^3/\text{min})$$

$$= 140 \text{ minutes}$$

Since the actual borehole diameter is equal to 10 inches, the observed response may be related to fracturing or disturbance of the fine- to medium-grained sandstone at distances of up to roughly 8 inches from the edge of the borehole. Such fracturing may have produced little resistance to flow at radial distances of up to 18 inches.

Estimation of uncorrected aquifer transmissivity was performed on the basis of data observed after 140 minutes, when uncorrected drawdown vs. time data conformed to a Theis curve and both casing and borehole storage became depleted. A match point of s = 6.8 feet and W(u) = 1 was used to calculate an uncorrected transmissivity as follows:

$$T = \frac{114.6\ Q}{s} W(u)$$

$$= 114.6 \frac{(0.88 \text{ gpm})}{6.8 \text{ ft}} (1)$$

$$= 14.8 \text{ gpd/ft}$$

A similar analysis was performed using drawdown corrected for product thickness using a match point of s = 5 ft, W(u) = 1 for data observed after 115 minutes, when both casing and borehole storage became depleted:

$$T = \frac{114.6 \ (0.88 \text{ gpm})}{5 \text{ ft}} (1)$$

$$= 20.2 \text{ gpd/ft}$$

For a saturated screened interval extending from approximately 36 to 62 feet in depth, the saturated thickness under conditions of horizontal flow in stratified sandstone was equal to 26 feet. Since this screened interval intercepted only a fine- to medium-grained sandstone, the resulting hydraulic conductivity of 0.78 gpd/ft^2 was considered to be characteristic of this unit. This conductivity is well within the range of that encountered in sandstone (Freeze and Cherry, 1979).

Drawdown data observed at pump well GBR-27 was analyzed using the straight-line semi-log Jacob plot shown in Figure F-4. The change in slope of the water level vs. log time plot at a time of 100 minutes was related to early borehole storage effects, which produced a slower rate of drawdown in the well than would otherwise occur if the aquifer material were controlling response. Analysis of late-time data resulted in an estimated transmissivity of 1.6 ft^2/day. For an initial saturated screened interval of 26 feet, hydraulic conductivity was estimated to be 0.06 ft/day.

JACOB ANALYSIS OF RECOVERY DATA OBSERVED AT GBR-27

As indicated by the plot of water level vs. log t/t′ shown in Figure F-5, the rate of recovery is much smaller during early recovery times than during later recovery times (t/t′<5). Again, this was attributed to borehole storage effects, which were more dominant during early recovery times when the borehole and casing rapidly received replenishing ground water. When a straight line was fitted to the recovery data at large recovery time, transmissivity was estimated to be 1.5 ft^2/day.

Jacob analysis of GBR-27 late-recovery drawdown corrected for product pressure head using a density ratio of 0.82 typical of kerosene (CRC Handbook of Chemistry and Physics, p. F-3) yielded a transmissivity of 1.6 ft^2/day and a hydraulic conductivity of 0.06 ft/day. This conductivity estimate was approximately equal to the conductivity obtained with uncorrected pump-well drawdown, suggesting that the presence of product did not greatly affect aquifer response during late stages of recovery.

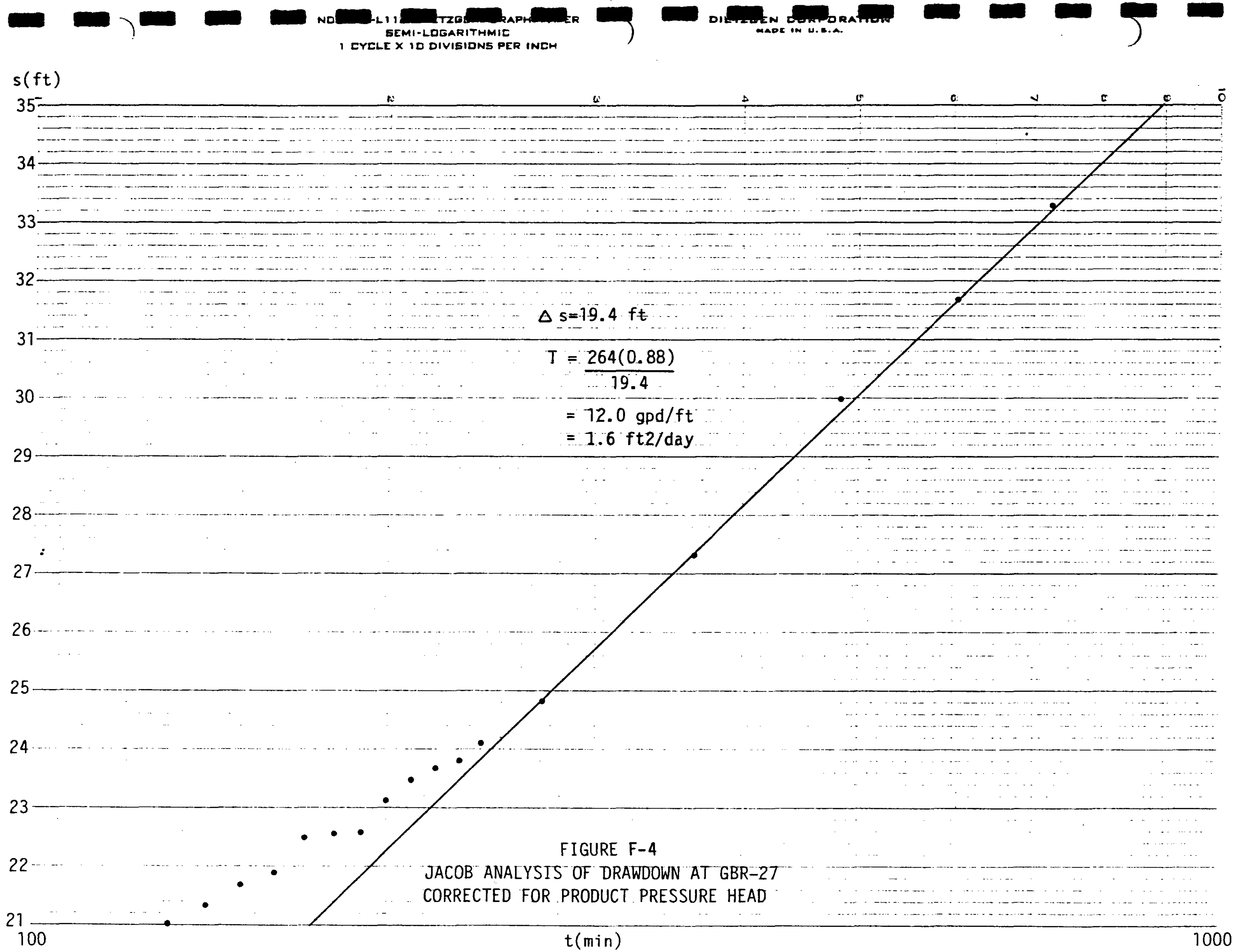


FIGURE F-4
JACOB ANALYSIS OF DRAWDOWN AT GBR-27
CORRECTED FOR PRODUCT PRESSURE HEAD

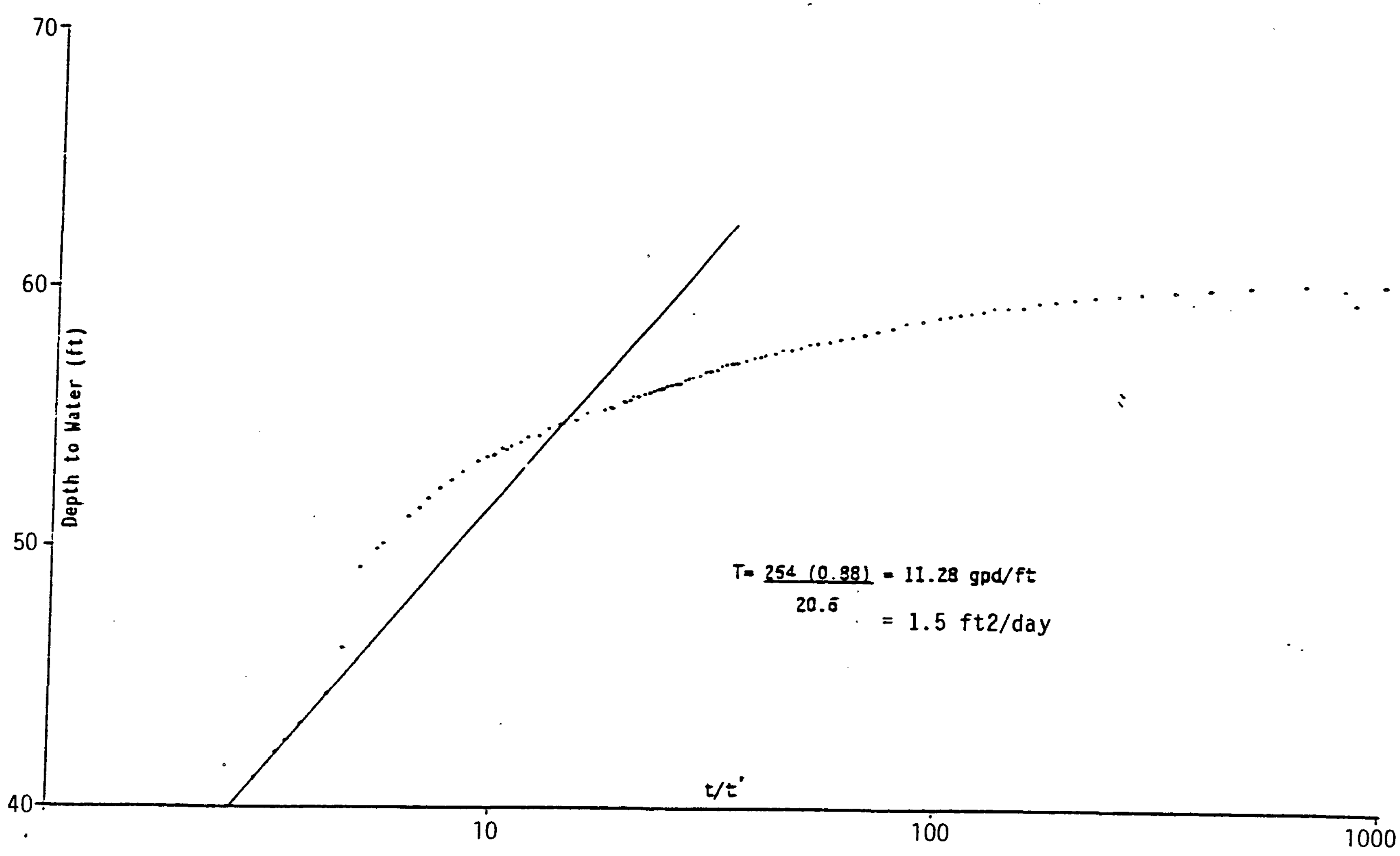


FIGURE F-5
GBR-27 RECOVERY DATA 5/1/86

ANALYSIS OF AQUIFER TEST DATA OBSERVED AT GBR-25

Strictly speaking, Jacob analysis of uncorrected drawdown data obtained from GBR-25 for early and moderate times was not possible. In order for analysis of the straight-line semi-logarithmic plot shown in Figure F-6 to be valid, the value of $u = r^2S/4Tt$ must be smaller than 0.01 for all values of t involved in the straight-line fit. The value of u for GBR-25 was less than 0.01 only for t > 694 minutes, assuming T and S values of 56 ft^2/day and 0.00017 estimated from the overall data. Ideally, analysis would be performed by using data for t > 694 minutes, obtaining new estimates of T, S, u and a new lower time limit. Iterative application of the method would eventually allow convergence to the actual values of T and S. Since there was little data for t > 694 minutes, recourse to the Theis method was believed to yield more reliable estimates of aquifer parameters.

Using the double logarithmic plot of drawdown vs. time for GBR-25 shown in Figure F-7, a match point of W(u)=1, u=1, s=0.55 feet, and t=26 minutes was obtained. These values yielded estimates of T = 24.5 ft^2/day and S = 0.00028, which were both of the same order of magnitude as parameters estimated from Jacob analysis (see Figure F-6). Correction for product pressure head at GBR-25 was not possible because no data related to changing product thickness at the well were available. Due to the low values of S calculated from all analyses at GBR-25, the aquifer was assumed to be confined in the vicinity of the pump test and drawdowns were not corrected for unconfined conditions. The occurrence of confined conditions in the vicinity of GBR-25 was related to the existence of a shale layer along the eastern edge of the Diesel Spill Area. Assuming an initial saturated screened interval of 26 feet at the pump well, a hydraulic conductivity of 0.94 ft/day was estimated for the sandstone unit screened by the GBR-27 pump well and well GBR-25.

EVALUATION OF AQUIFER TEST DATA OBSERVED AT GBR-21

In the absence of changing barometric conditions, the observed 1.8-foot rise in water levels at GBR-21 can only be ascribed to the removal of floating product by the GBR-27 pump well. As product moved out of the observation borehole, the product pressure head decreased and caused a

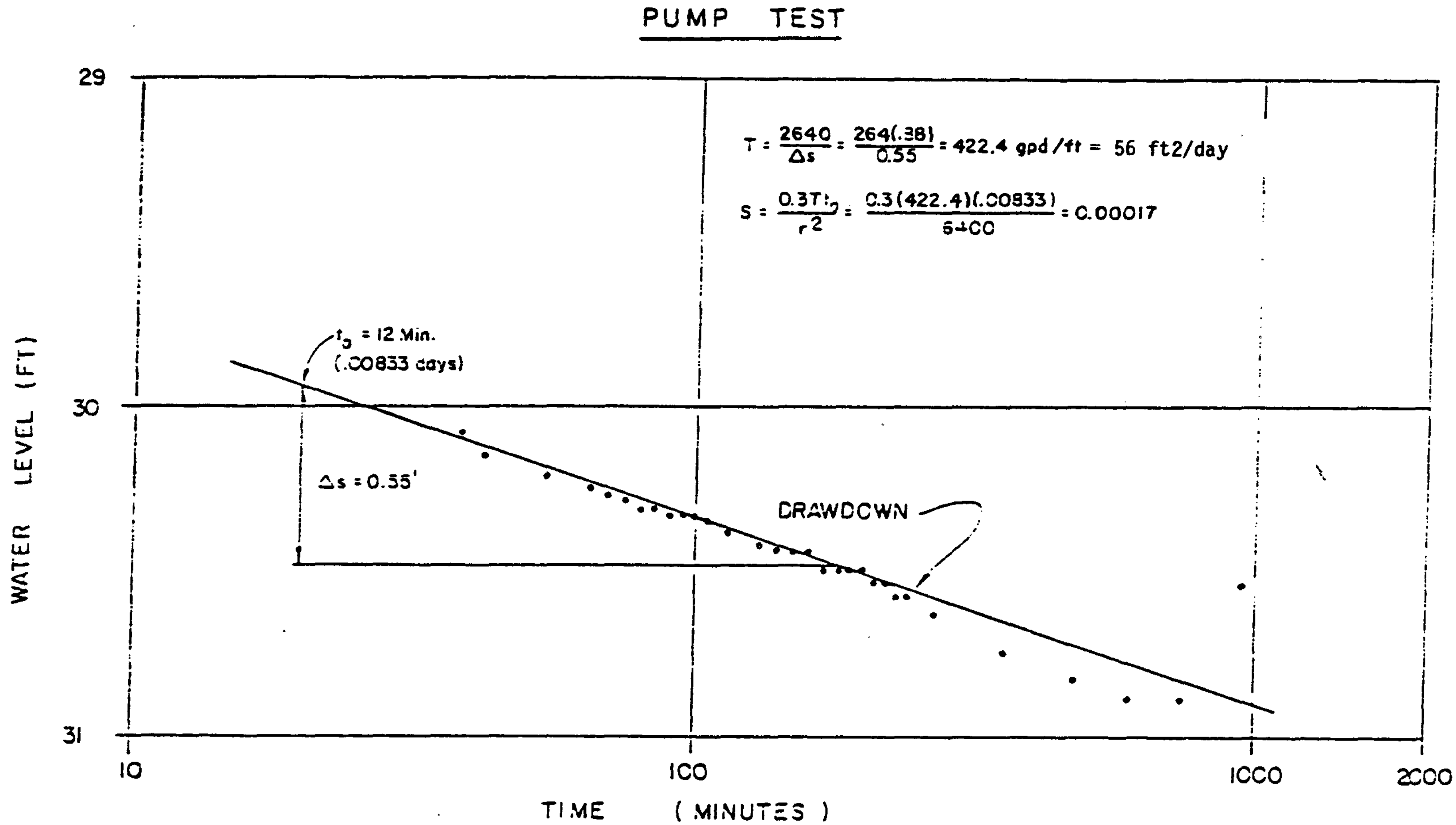


FIGURE F-6

GIANT - BLOOMFIELD
OBSERVATION WELL
WELL NO. GBR 25
4/30/86

4/30/8

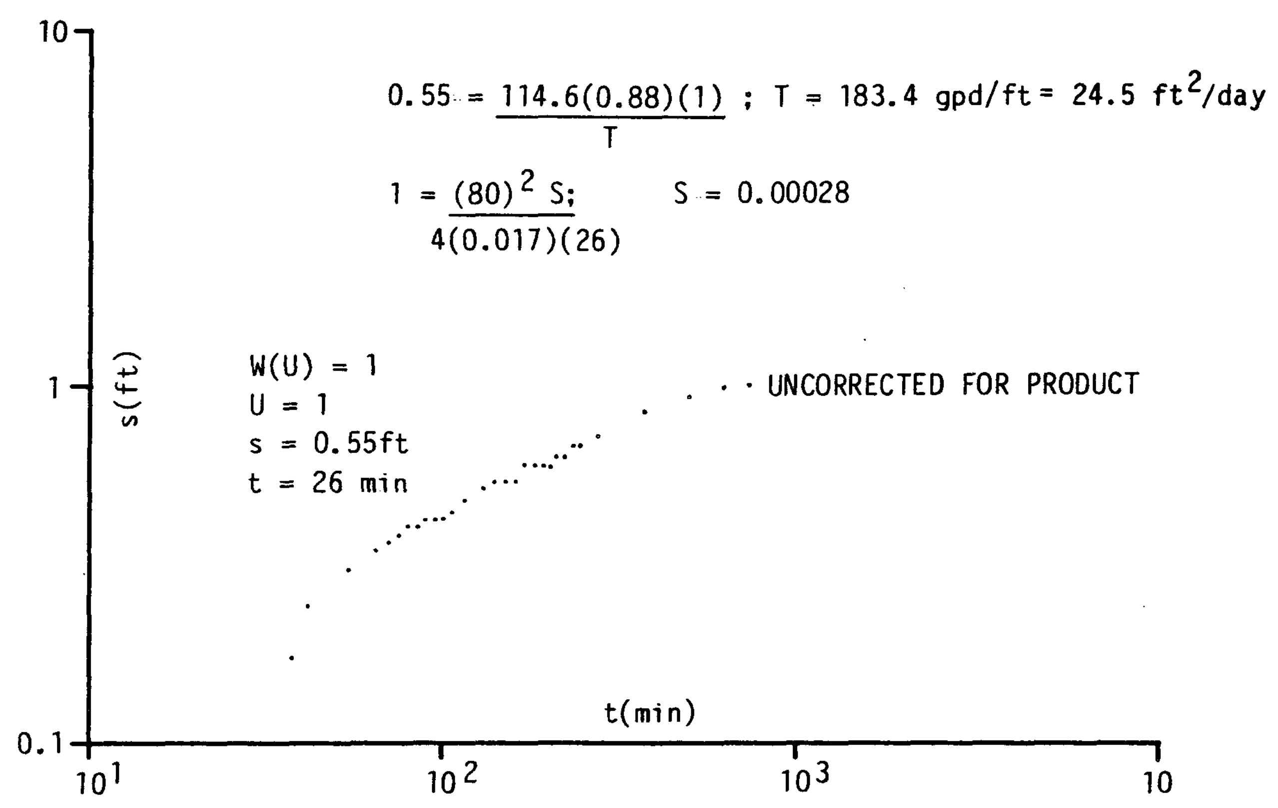


FIGURE F-7
THEIS PLOT OF DRAWDOWN DATA FROM GBR-25

simultaneous rise in the piezometric level. Removal of 2.2 feet of product would be required to generate a 1.8-ft rise in the water table, assuming a specific gravity of 0.82 for the product. Due to lack of data pertaining to the decrease in product thickness during pumping, it was not possible to correct drawdown data for product pressure head. No estimates of T or S could therefore be obtained using drawdown observed at GBR-21.

SUMMARY OF SANDSTONE AQUIFER PARAMETERS

Sandstone aquifer parameters obtained on the basis of drawdown and recovery data observed in wells GBR-27 and GBR-25 while pumping well GBR-27 at a rate of 0.88 gpm are summarized in Table F-1 below. Storativity at the pump well could not be determined due to the high storage associated with the pump borehole and its distorting effects on calculations for S_y.

Table F-1: Sandstone Aquifer Test Results

WELL	TYPE OF ANALYSIS	K (ft/day)	S_y
GBR-27	Jacob w/uncorrected drawdown	0.08	NA
	w/corrected drawdown	0.10	NA
	Jacob recovery	0.06	NA
GBR-25	Theis w/uncorrected drawdown	0.94	0.00028

NA = not applicable

ANALYSIS OF AQUIFER TEST DATA OBSERVED AT GBR-14

Three aquifer tests were performed at well GBR-14, which is screened in the saturated portion of the alluvium overlying the sandstone. Well GBR-14 was pumped at rates of 1, 5, and 2 gpm following complete recovery from previous pumping.

ANALYSIS OF DRAWDOWN DATA OBSERVED AT GBR-14

When drawdown observations obtained at pump well GBR-14 during three separate aquifer tests were plotted on double-log paper in Figures F-8, F-9 and F-10, as many as three distinct inflection points were identified for each pump test. These distinct changes in slope were even more clearly indicated on semi-log plots of the drawdown data because changes in drawdown were more evident when plotted on an arithmetic scale rather than a log scale (see Figures F-11, F-12 and F-13). Inflection points in the double-log plots and slope changes in the semi-log plots appeared to be the result of casing and borehole dewatering during early-to-moderate

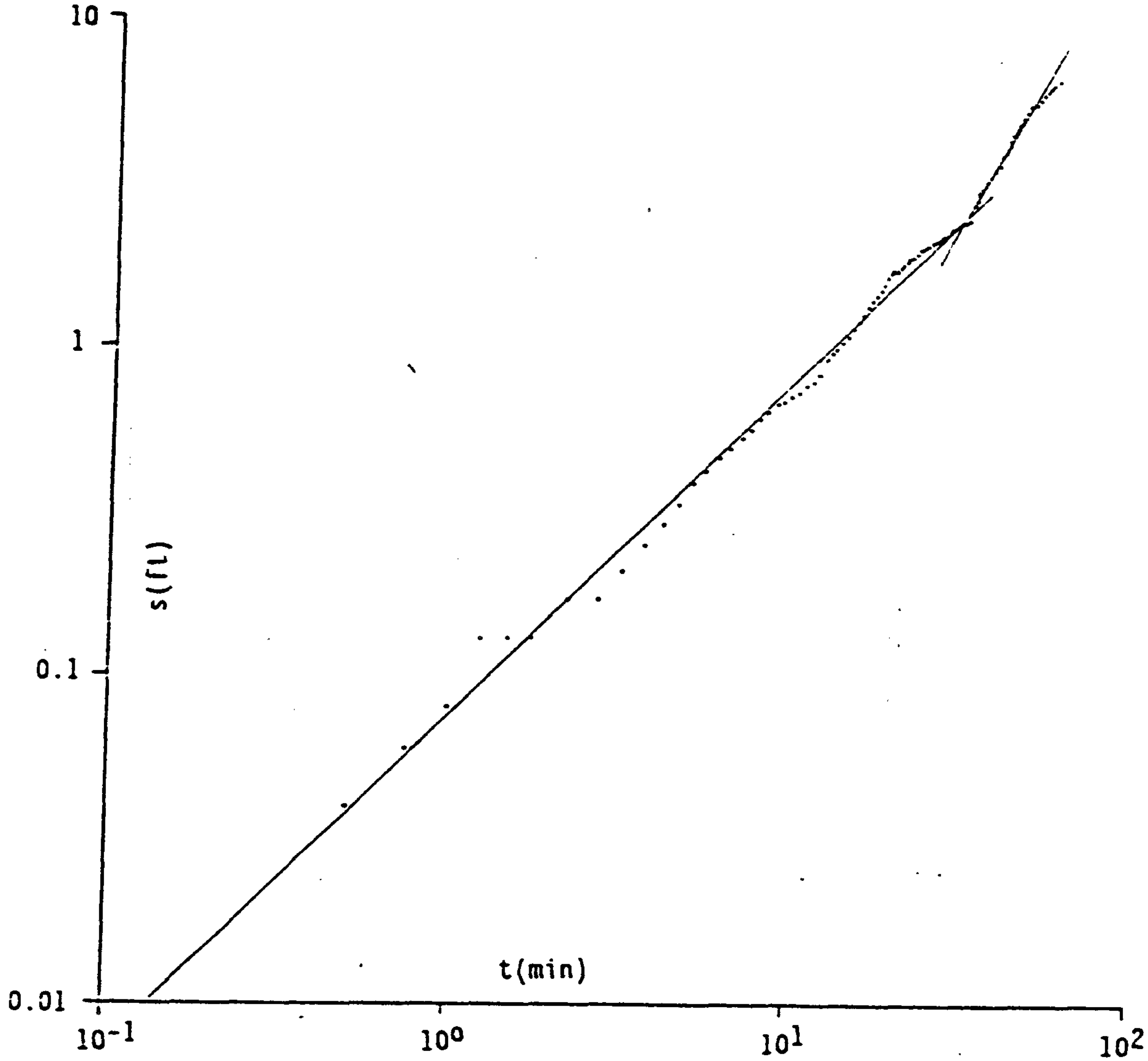


FIGURE F-8

DOUBLE LOG PLOT OF DRAWDOWN VS. TIME FOR PUMP TEST 1 AT GBR-14

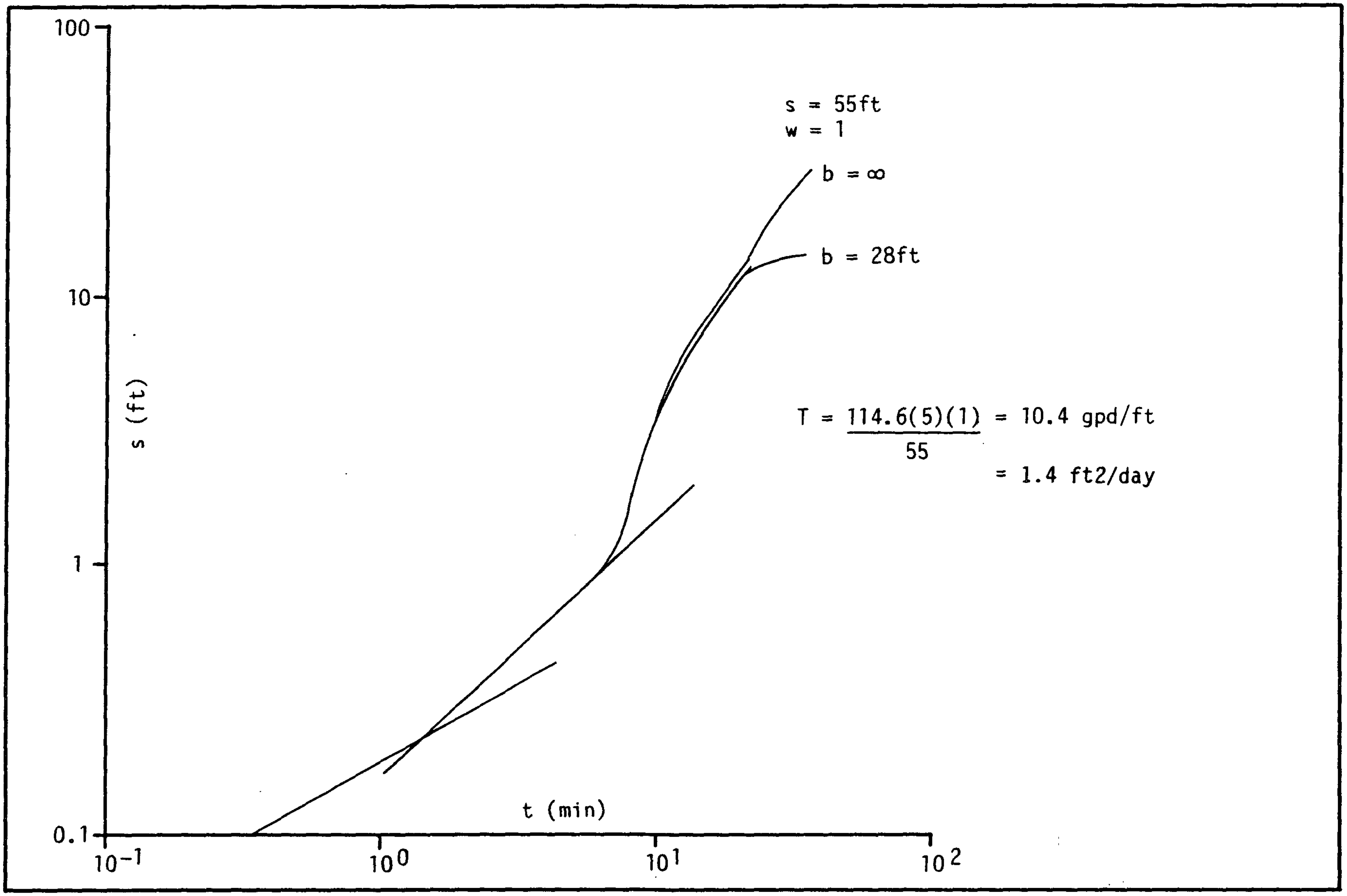


FIGURE F-9
DOUBLE LOG PLOT OF DRAWDOWN VS. TIME FOR PUMP TEST 3 AT GBR-14

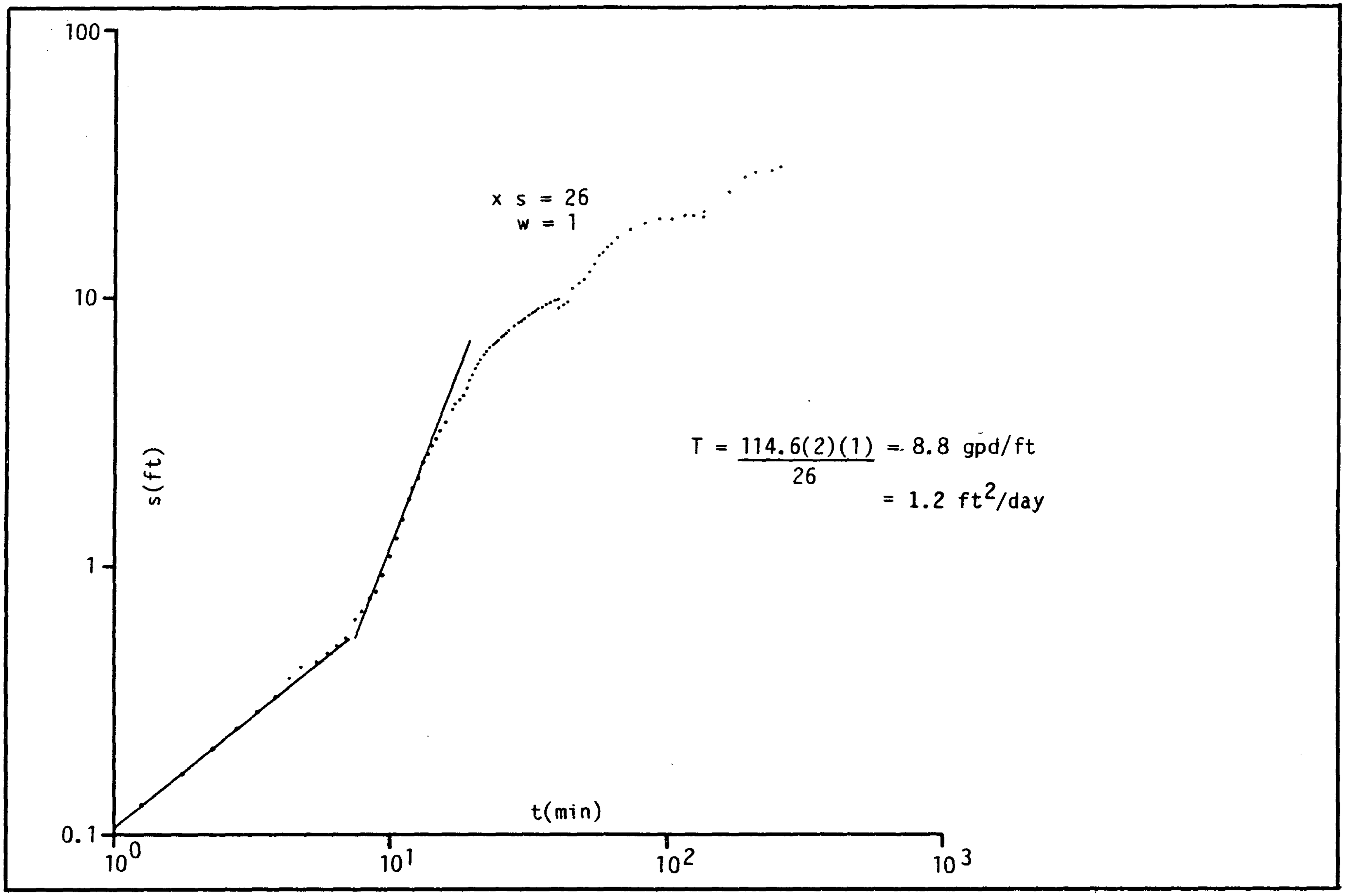


FIGURE F-10

DOUBLE LOG PLOT OF DRAWDOWN VS. TIME FOR PUMP TEST 5 AT GBR-14

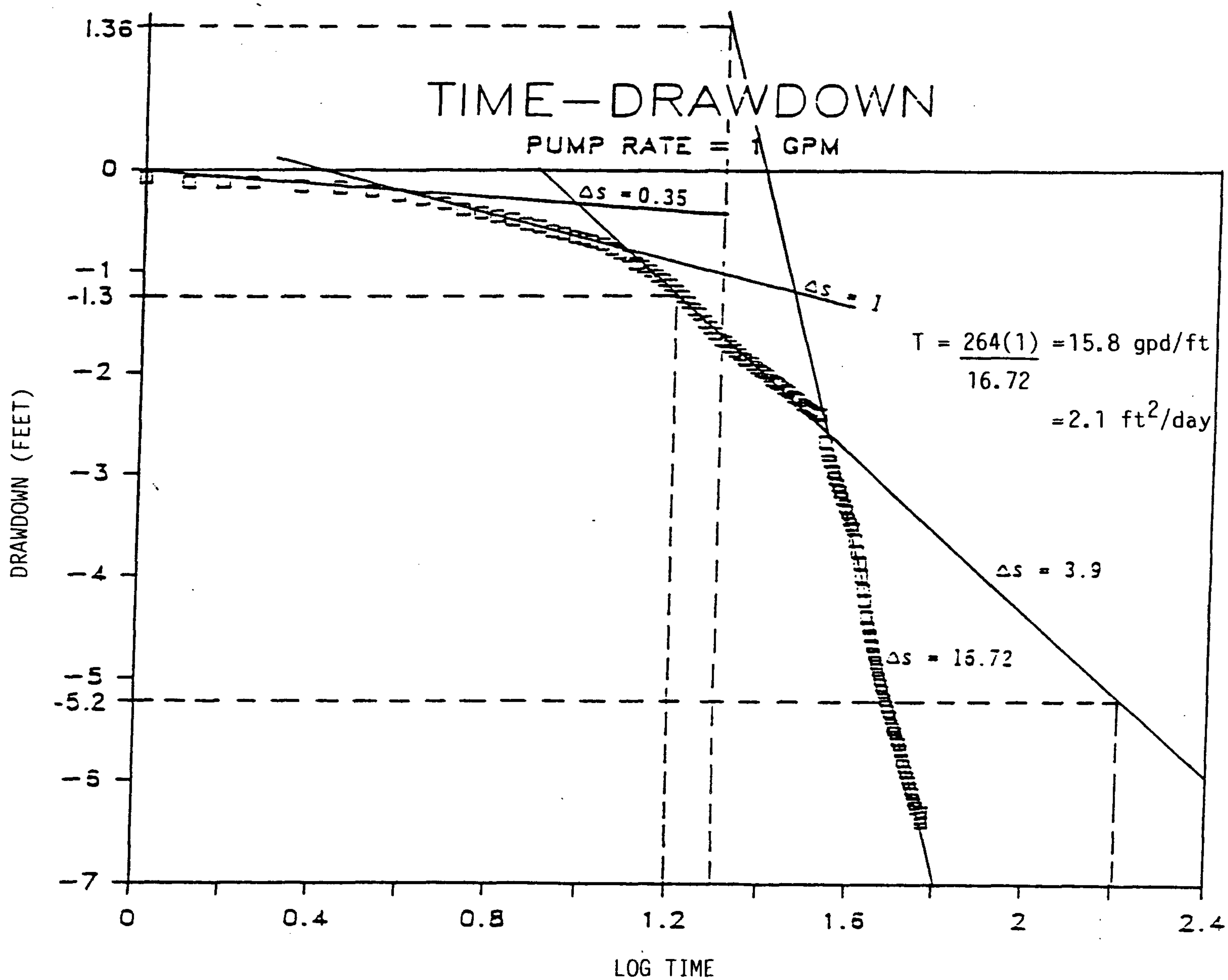


FIGURE F-11
SEMILOG PLOT OF DRAWDOWN VS. TIME
FOR PUMP TEST 1 AT GBR-14

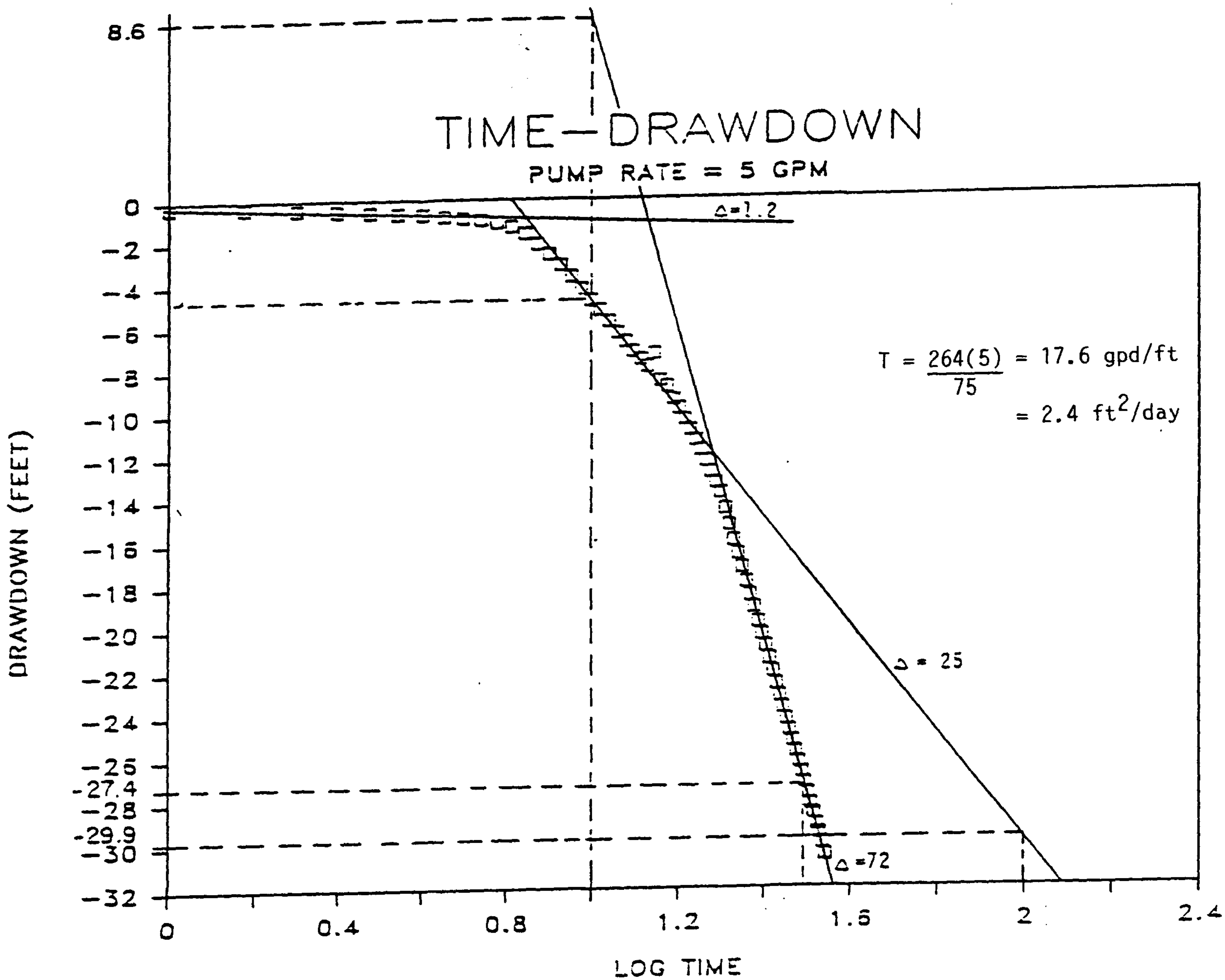


FIGURE F-12
SEMILOG PLOT OF DRAWDOWN VS. TIME
FOR PUMP TEST 3 AT GBR-14

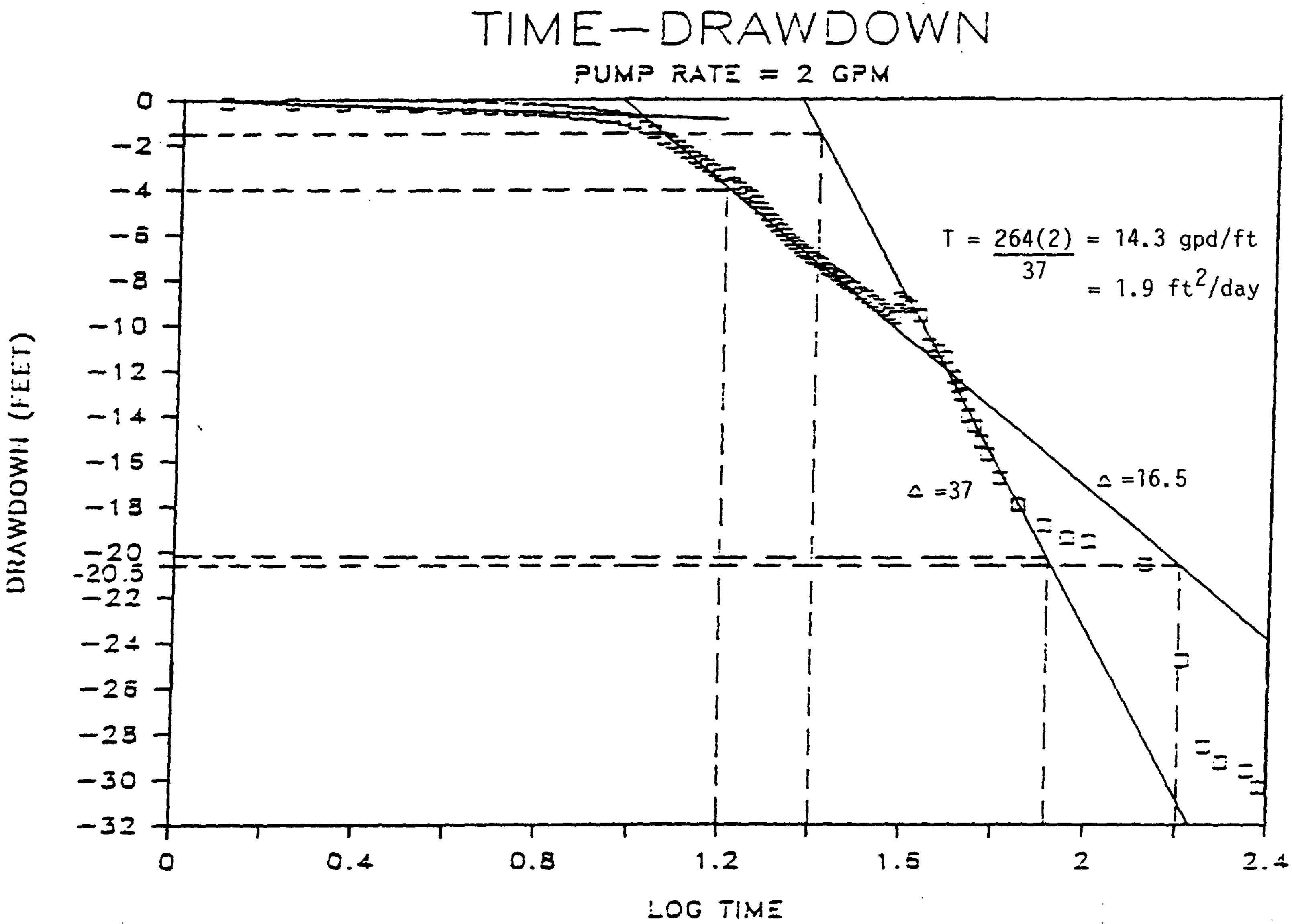


FIGURE F-13

SEMILOG PLOT OF DRAWDOWN VS. TIME
FOR PUMP TEST 5 AT GBR-14

stages of pumping, when storage of water in the well, rather than the hydraulic conductivity of the alluvium screened by GBR-14, controlled the rate of drawdown in the well.

Since floating product was not observed in GBR-14 during testing, correction for product pressure head was not needed. However, a correction was applied to all drawdown observations obtained in the unconfined alluvial aquifer to account for the effects of decreasing saturated thickness and consequent decreases in transmissivity during dewatering of the aquifer. Correction for unconfined conditions was performed according to the Jacob relation (Kruseman and DeRidder, 1970):

$$s' = s - \frac{s^2}{2b}$$

Where s' = drawdown which would occur in an equivalent confined aquifer under conditions of constant transmissivity

s = observed drawdown in the unconfined alluvial aquifer under conditions of decreasing transmissivity

b = the estimated average saturated screened interval length at the pump well

The correction did not substantially alter the plots when the initial saturated screened interval thickness of 28 feet was used, even during pump test 3 when large water level declines were observed in response to pumpage of 5 gpm (see Figure F-9).

Inflection points in the double-log plots occurred at progressively earlier times for increasing discharge rates because dewatering occurred faster under conditions of higher discharge. The final inflection was absent from the data observed during test 1, since discharge was too small at 1 gpm to completely dewater the casing and borehole. Dewatering was complete in the well and borehole after 7 minutes and 15 minutes of pumping at rates of 5 gpm (test 3) and 2 gpm (test 5), respectively (see Figures F-9 and F-10).

Although drawdown response during test 5 after dewatering indicated an increase in transmissivity at a depth at which clayey-sand lithology occurred, decreased transmissivity was evident at this depth during test 3. The overall transmissivity of the gravel, clayey sand and clayey gravel at well GBR-14 was estimated, without distinction between lithologic units, to be 1.2 and 1.4 ft^2/day. These transmissivity estimates translate to hydraulic conductivity values of 0.04 and 0.05 ft/day for a saturated screened interval of 28 feet, less than half of the conductivity of the underlying sandstone calculated according to drawdown corrected for product at GBR-27. The low conductivity estimate was presumably the result of the presence of large amounts of clay in the alluvial deposits.

Transmissivity was also estimated using Jacob analysis of the semi-logarithmic drawdown vs. time plots of data observed at GBR-14. The slopes of final segments were assumed to be characteristic of the alluvial aquifer after casing and borehole dewatering were completed. Transmissivities of 2.1, 2.4, and 1.9 ft^2/day were calculated for data observed during pump test 1, 3, and 5, respectively. Hydraulic conductivities of the alluvium were therefore estimated to be 0.08, 0.09, and 0.07 ft/day for an initial saturated screened interval of 28 feet. These estimates were closer in magnitude to those obtained using drawdown observed when stressing the underlying sandstone.

ANALYSIS OF RECOVERY DATA OBSERVED AT GBR-14

Analysis of late-time recovery data observed following the three pump tests and plotted in Figures F-14, F-15 and F-16 yielded transmissivities of 12.7, 2.3, and 4.6 ft^2/day. The resulting hydraulic conductivities of 0.45, 0.08, and 0.16 ft/day for the alluvial aquifer were much more variable than conductivities estimated from pump test data, despite the tendency for recharge during recovery to be more constant than the discharge rate during pumping phases of the tests. Due to the large variability of conductivities estimated from recovery data, they were not considered representative of the alluvial aquifer. Conductivities estimated from analysis of pump test data were instead considered to be characteristic of the alluvium, with a value of 0.05 ft/day corresponding

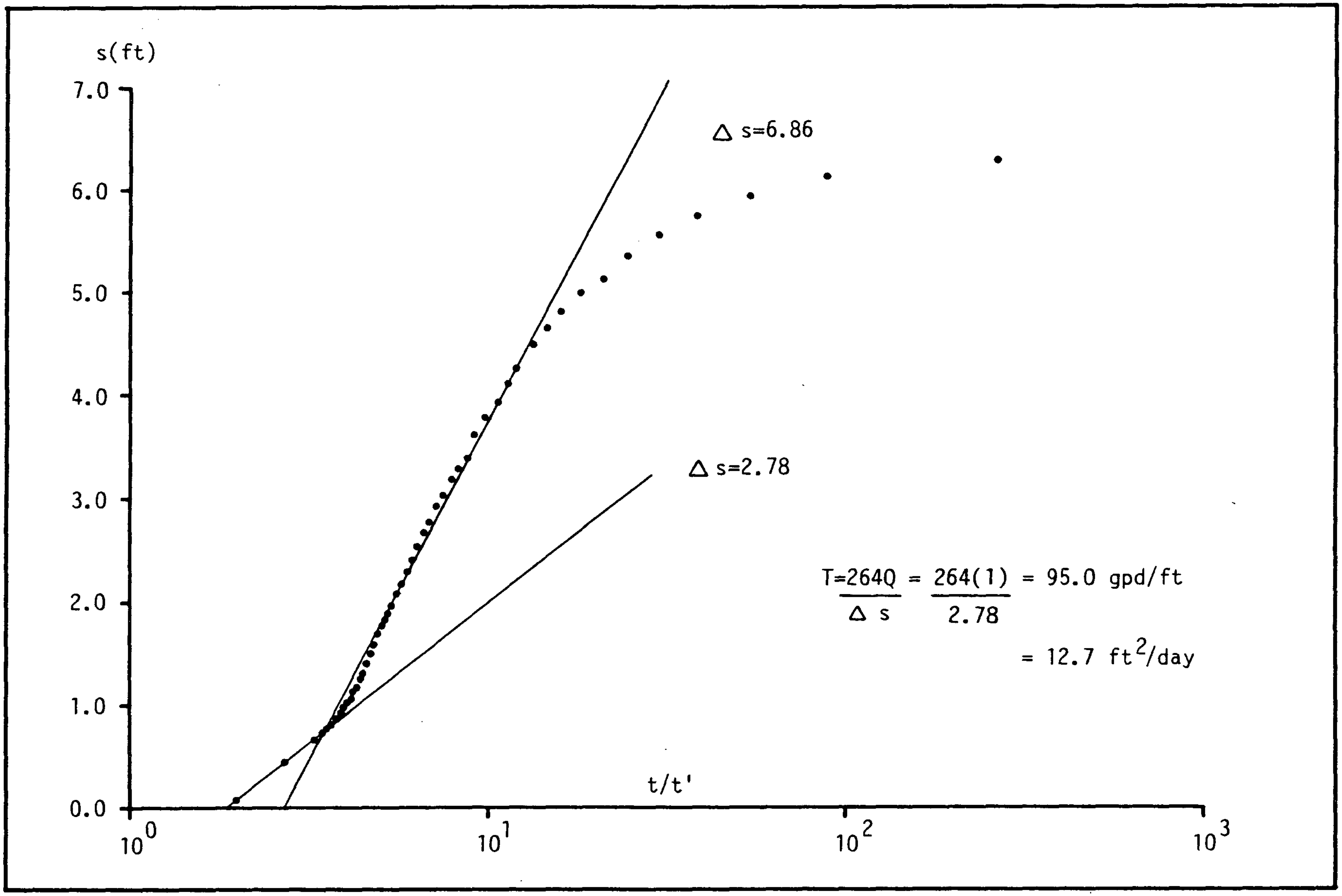


FIGURE F-14

SEMILOG PLOT OF RECOVERY DRAWDOWN VS. T/T'
DURING RECOVERY TEST 1 AT GBR-14

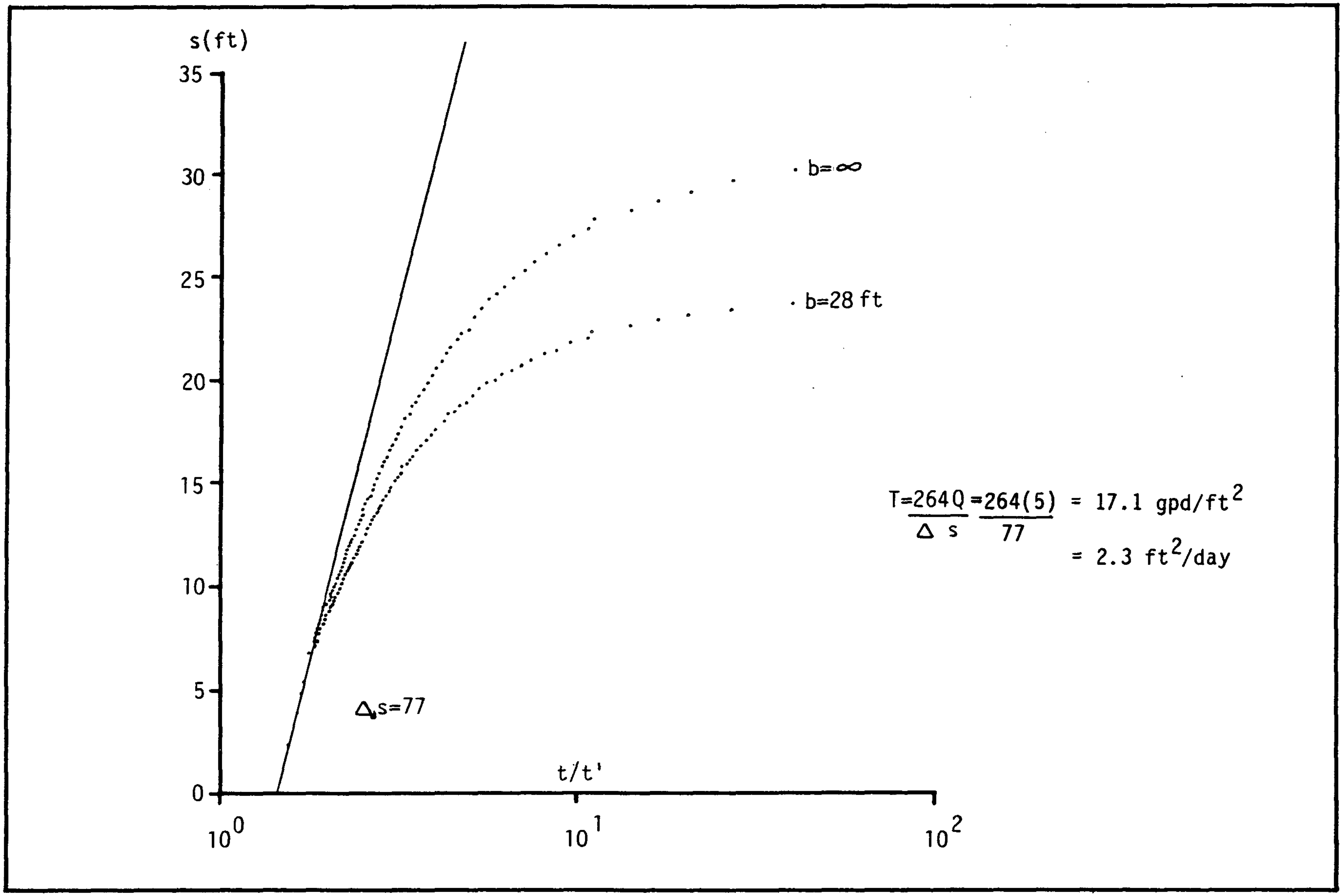


FIGURE F-15

SEMILOG PLOT OF RECOVERY DRAWDOWN VS. T/T'
DURING RECOVERY TEST 3 AT GBR-14

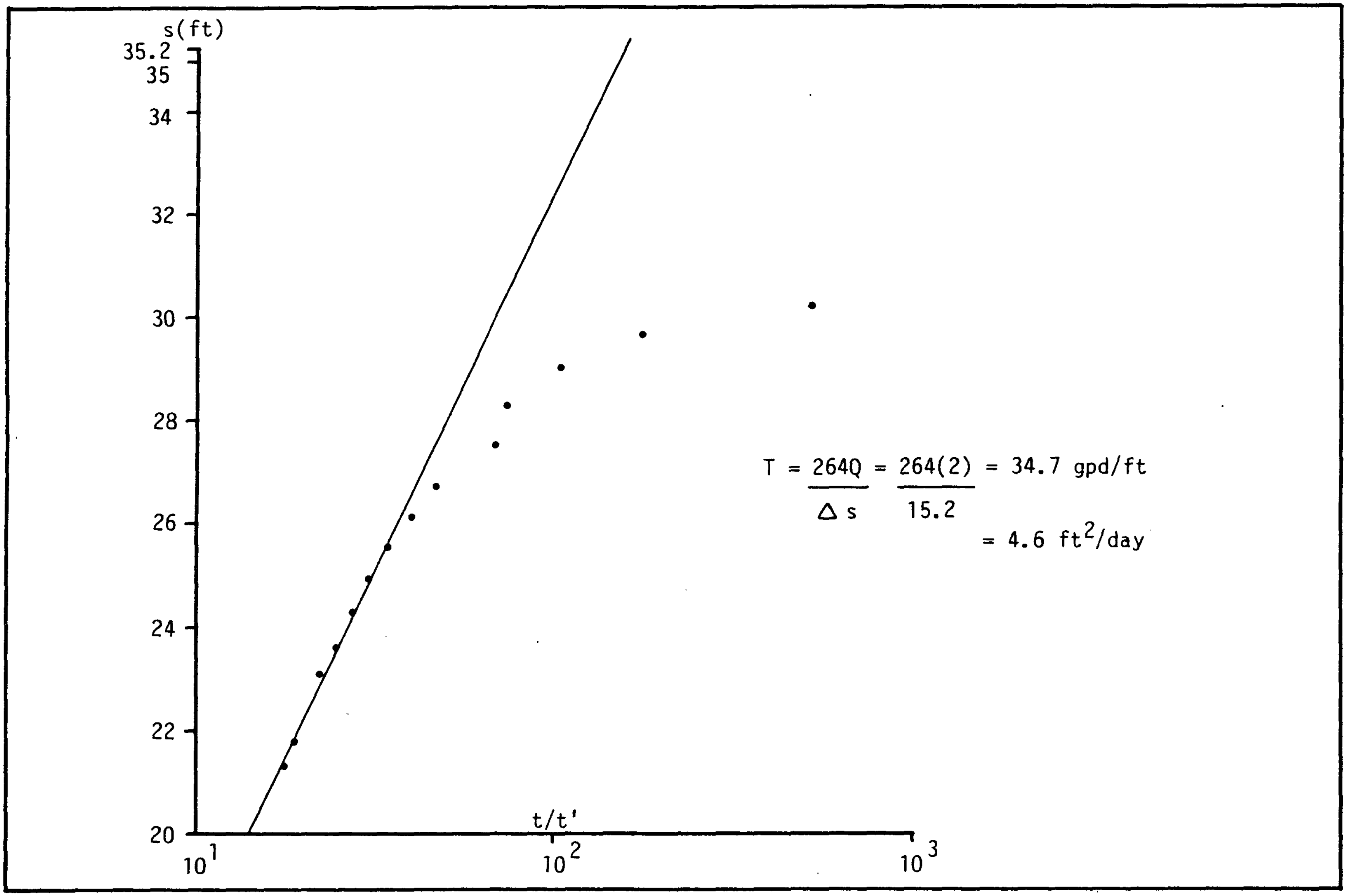


FIGURE F-16
SEMILOG PLOT OF RECOVERY DRAWDOWN VS. T/T'
DURING RECOVERY TEST 5 AT GBR-14

to deposits containing clay and a value of 0.08 ft/day associated with cleaner, coarse-grained deposits.

Table F-2 summarizes hydraulic conductivity values estimated from data collected while pumping the alluvial aquifer penetrated by GBR-14. Specific yield could not be determined from data observed at the pump well.

TABLE F-2: ALLUVIAL AQUIFER TEST RESULTS

	K(ft/day)		
Pump Test	Theis Analysis	Jacob Analysis	Jacob Recovery Analysis
1 (Q = 1 gpm)	--	0.08	0.45
3 (Q = 5 gpm)	0.05	0.09	0.08
5 (Q = 2 gpm)	0.04	0.07	0.16
Average	0.045	0.080	0.230

ANALYSIS OF AQUIFER TEST DATA OBSERVED AT GBR-15

Analysis of drawdown data observed at well GBR-15 was not performed because a sufficient number of points were not available to allow aquifer properties to be reliably estimated.

ANALYSIS OF DRAWDOWN DATA AT GBR-26, GBR-30, AND THE STEEL WELL (GBR-39)

No measurable drawdown response was observed in wells GBR-26, GBR-30, and the GBR-39 during pumping at GBR-14. These wells were screened within clayey sand or sandy clay located at the base of the alluvium in which GBR-14 was screened. Since there appears to be hydraulic communication between the alluvium and the underlying clayey sand and sandy clay layers, as indicated by the response in well GBR-15 to pumpage at GBR-14, it is possible that silt has migrated through the gravel pack and become lodged in the screen of the unresponsive wells.

Table F-3 through F-7 list the raw water-level measurements collected at pump and observation wells while pumping at GBR-27 in the Diesel Fuel Spill Area. Measurements collected at GBR-14 are listed in Tables F-8 through F-13.

TABLE F-3
AQUIFER TEST DATA

Owner Giant Address Bloomfield, NM County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Pump Test No. 1

Measuring equipment Soilinst WL Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t_o)
Pump off: Date 5/1 Time ______ (t_i)
Duration of aquifer test:
Pumping 16 hrs. Recovery ______

Water Level Data
Static water level 40' 4.5"
Measuring point Top of Casing
Elevation of measuring point ______

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes ____ No ____
Duration ______ End ______

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
4/30/86	1530	0				40'4.5"		40.38						
		:15				8"		40.67						
		:30				10.5"		40.88						
		:45				41'1"		41.08						
		1:00				4"		41.33						
		1:30				8.5"		41.71						
		2:00				42'1"		42.08						
		2:30				5"		42.42						
		3:00				9.5"		42.79						
		3:30				43'0"		43.00						
		4:00				3.5"		43.29						
		4:30				6"		43.50						
		5:00				8"		43.67						
		5:30				10.25"		43.85						
		6:00				44'1"		44.08						
		6:30				3"		44.25						
		7:00				4"		44.33						
		7:30				6"		44.50						
		8:00				7.5"		44.63						
		8:30				8.5"		44.71						
		9:00				10"		44.83						
		9:30				11.5"		44.96						
		10:00				45'1"		45.08						
		11:00				2.5"		45.21						
		12:00				4.5"		45.38						
		13:00				6"		45.50						
		14:00				7"		45.58						

TABLE F-3 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield, NM County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Pump Test No. 1

Measuring equipment SOILINST WL Indicator

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (t.) Pump off: Date ____ Time ____ (t.) Duration of aquifer test: Pumping 16 hrs. Recovery ____	Static water level 40' 4.5" Measuring point Top of Casing Elevation of measuring point ____	How Q measured Bucket Depth of pump/air line 62' Previous pumping? Yes ____ No ____ Duration ____ End ____	

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
4/30/86		15.0				45'9"		15.75'						
		16.0				10"		15.83'						
		17.0				11.5"		15.96'						
		18.0				46'0"		16.00'						
		19.0				1.5"		16.13'						
		20.0				2.5"		16.21'						
		21.0				3.5"		16.29'						
		22.0				4.5"		16.38'						
		23.0				4.5"		16.38'						
		24.0				5.25"		16.44'						
		25.0				6"		16.50'						
		26.0				7"		16.58'						
		27.0				7.5"		16.63'						
		28.0				8"		16.67'						
		29.0				8.5"		16.71'						
		30.0				9"		16.75'						
		31.0				10"		16.83'						
		32.0				10"		16.83'						
		33.0				-		-						
		34.0				-		-						
		36.0				47'1"		47.08'						
		38.0				-		-						
		40.0				47'4"		47.33'						
		42.0				5"		47.42'						
		44.0				5.5"		47.46'						
		46.0				6"		47.50						
		48.0				8"		47.67						
		50.0				9"		47.75						

TABLE F-3 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Pump Test No. 1

Measuring equipment Soilinst WL Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t₀)
Pump off: Date ____ Time ____ (t'₀)
Duration of aquifer test:
Pumping 16 hrs. Recovery ____

Water Level Data
Static water level 40' 4.5"
Measuring point Top of Casing
Elevation of measuring point ____

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes ____ No ____
Duration ____ End ____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
4/30/86		52.0				-		-						
		54.0				-		-						
		56.0				-		-						
		58.0				-		-						
	1630	60.0				48'.5"		48.04						
		65.0				2.75"		48.23						
		70.0				4.5"		48.38						
		75.0				6.25"		48.52						
		80.0				9"		48.75						
		85.0				10"		48.83						
		90.0				11.5"		48.96						
		95.0				49'2"		49.17						
		100.0				2.5"		49.21						
		105.0				4.5"		49.38						
		110.0				5.5"		49.46						
		115.0				7"		49.58						
	1730	120.0				9"		49.75						
		130.0				50.5"		50.04						
		140.0				3.5"		50.29						
		150.0				6.75"		50.56						
		160.0				9"		50.75						
		170.0				51'3"		51.25						
	1830	180.0				3.5"		51.29						
		190.0				7"		51.58						
		200.0				9.5"		51.79						
		210.0				52.5"		52.00						
		220.0				3"		52.25						

TABLE F-3 (cont'd).
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 4/30 / 5/1 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Pumps Test No. 1

Measuring equipment Soilinst WL Indicator

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 1530 Time 4:30 (t.) Pump off: Date ____ Time ____ (t') Duration of aquifer test: Pumping 16 hrs. Recovery ____	Static water level 40' 4.5" Measuring point Top of Casing Elevation of measuring point ____	How Q measured Bucket Depth of pump/air line 62' Previous pumping? Yes ____ No ____ Duration ____ End ____	

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
4/30/86		230.0				52'4"		52.33						
	1930	240.0				7"		52.58						
	2000	270				53'2.5"		53.21						
		360				55'5.5"		55.46						
5/1/86	0000	480				57'11"		57.92						
	0200	600				59'4.5"		59.38						
	0400	720				60'10"		60.83						
	0800	960				62'1.5"		62.13						

TABLE F-4
AQUIFER TEST DATA

Owner Giant Address Bloomfield, NM County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Thomas

Well No. GBR-21 Distance from pumping well 12.3' Type of test Pump Test No. 1

Measuring equipment Powers WL Indicator

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (L)	Static water level 25' 7"	How Q measured Bucket	
Pump off: Date 5/1 Time 800 (L)	Measuring point Top of Casing	Depth of pump/air line 62'	
Duration of aquifer test:		Previous pumping? Yes ___ No ___	
Pumping 16 hrs. Recovery ___	Elevation of measuring point ___	Duration ___ End ___	

Date	t	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
4/30/86	0					25'7"		25.58'						
	11.0					25'7								
	12.0					25'.75"		25.06'						
	13.0					24'9"		24.75'						
	14.0					8"		24.67'						
	15.0					7.75"		24.65'						
	18.0					8.33"		24.69'						
	20.0					7.5"		24.63'						
	22.0					7.75"		24.65'						
	23.0					7.75"		24.65'						
	26.0					8.75"		24.73'						
	30.0					9"		24.75'						
	32.0					9.25"		24.77'						
	40.0					9.25"		24.77'						
	42.0					9.5"		24.79'						
	44.0					9.25"		24.77'						
	48.0					5.5"		24.46'						
	50.0					5.75"		24.48'						
	58.0					6"		24.50'						
	65.0					6.5"		24.54'						
	70.0					6.5"		24.54'						
	75.0					5.5"		24.46'						
	80.0					1"		24.08'						
	85.0					1"		24.08'						
	90.0					24'.5"		24.04'						
	95.0					24'		24.00'						

TABLE F-4 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield, NM County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Thomas

Well No. GBR-21 Distance from pumping well 12.3' Type of test Pump Test No. 1

Measuring equipment Powers WL Indicator

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (c) Pump off: Date ___ Time ___ (c) Duration of aquifer test: Pumping 16 hrs Recovery ___	Static water level 25' 7" Measuring point Top of Casing Elevation of measuring point ___	How Q measured Bucket Depth of pump/air line 62' Previous pumping? Yes ___ No ___ Duration ___ End ___	

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
4/30/86		100.0				24'0"		24.00'						
		105.0				.25"		24.04'						
		110.0				23'11.25"		23.94'						
		115.0				24'2.75"		24.23'						Sampled Well
	1730	120.0				2.75"		24.23'						
		130.0				1.5"		24.13'						
		140.0				1"		24.08'						
		150.0				24'0"		24.00'						
		160.0				23'11.5"		23.96'						
		170.0				11"		23.92'						
	1830	180.0				10.75"		23.90'						
		190.0				10.25"		23.85'						
		200.0				10"		23.83'						
		210.0				9.5"		23.79'						
		220.0				8.75"		23.73'						
		230.0				8.75"		23.73'						
	1930	240.0				8.25"		23.69'						
	2000	270.0				8.25"		23.69'						
		360.0				6.75"		23.56'						
[illegible]/86	0000	480.0				6.25"		23.52'						
	0200	600.0				5"		23.42'						
	0400	770.0				9"		23.75'						
	0800	960.0				4.25"		23.35'						

TABLE F-5

AQUIFER TEST DATA

wner Giant Address Bloomfield County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Nicholas

ell No. GBR-25 Distance from pumping well 50 ft. Type of test Pump Test No. 1

easuring equipment Powers W.L. Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t.)
ump off: Date 5/1 Time 0800 (t.)
uration of aquifer test:
Pumping 16 hrs. Recovery

Water Level Data
Static water level 29' 11"
Measuring point Top of Casing
Elevation of measuring point

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes No
Duration End

Comments on factors affecting test data

ate	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
4/30/86		0				29'11"	29.91							
		38				30'1"	30.08							
		42				30'1.75"	30.15							
		54				30'2.5"	30.21							
		65				30'3"	30.25							
		70				30'3.25"	30.27							
		75				30'3.5"	30.29							
		80				30'3.75"	30.31							
		85				30'3.75"	30.31							
		90				30'4"	30.33							
		95				30'4"	30.33							
		100				30'4"	30.33							
		105				30'4.25"	30.35							
		115				30'4.5"	30.78							
		130				30'5"	30.42							
		140				30'5.25"	30.44							
		150				30'5.25"	30.44							
		160				30'5.25"	30.44							
		170				30'6"	30.50							
		180				30'6"	30.50							
		190				30'6"	30.50							
		200				30'6"	30.50							
		210				30'6.5"	30.54							
		220				30'6.5"	30.54							
		230				30'7"	30.58							
		240				30'7"	30.58							
		270				30'7.5"	30.63							
		360				30'9"	30.75							

TABLE F-5 (cont'd)

AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 4/30/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-25 Distance from pumping well 50 Type of test Pump Test No. 1

Measuring equipment Powers W.L. Indicator

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (t.) Pump off: Date 5/1 Time 0800 (t.) Duration of aquifer test: Pumping 16 hrs. Recovery	Static water level 29' 11" Measuring point Top of Casing Elevation of measuring point	How Q measured Bucket Depth of pump/air line 62' Previous pumping? Yes No Duration End	

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
		480				30'10"	30.83							
		600				30'10.5"	30.88							
		720				30'10.5"	30.88							
		960				30'6.5"	30.54							

TABLE F-6
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 5/1/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Recovery Test No. 1

Measuring equipment Soilinst WL Indicator

Time Data	Water Level Data	Discharge Data	
Pump on: Date 4/30 Time 1530 Pump off: Date 5/1 Time 0800 Duration of aquifer test: Pumping 16 hrs. Recovery 8 hrs	Static water level 40' 4.5" Measuring point Top of Casing Elevation of measuring point	How Q measured Bucket Depth of pump/air line 62' Previous pumping? Yes No Duration End	Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
5/1/86	0800		.15			-								
			.30			60'6.5"		60.54						
			.45			-		-						
			.60			4.75"		60.40						
			1.30			3.5"		60.29						
			2.0			2"		60.17						
			2.30			1"		60.08						
			3.0			59'11.75"		59.98						
			3.30			10.5"		59.88						
			4.0			10"		59.83						
			4.30			9"		59.75						
			5.0			8"		59.67						
			5.30			7"		59.58						
			6.0			6"		59.50						
			6.30			5"		59.42						
			7.0			4.25"		59.35						
			7.30			3.25"		59.27						
			8.0			2.25"		59.19						
			8.30			1.5"		59.13						
			9.0			.5"		59.04						
			9.30			59'0"		59.00						
			10.0			58'11.25"		58.94						
			11.0			9.5"		58.77						
			12.0			8"		58.67						
			13.0			7"		58.58						
			14.0			5.25"		58.44						
			15.0			4"		58.33						

TABLE F-6 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 5/1/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Recovery Test No. 1

Measuring equipment Soilinst WL Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t.)
Pump off: Date 5/1 Time 0800 (t.)
Duration of aquifer test:
Pumping 16 hrs. Recovery 8 hrs.

Water Level Data
Static water level 40' 4.5"
Measuring point Top of Casing
Elevation of measuring point

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes No
Duration End

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate
5/1/86			16.0		58'2.5"		58.21			
			17.0		1"		58.08			
			18.0		58'0"		58.00			
			19.0		57'11.5"		57.94			
			20.0		10"		57.83			
			21.0		9"		57.75			
			22.0		8.25"		57.69			
			23.0		7.5"		57.63			
			24.0		6.25"		57.52			
			25.0		5.5"		57.46			
			26.0		4.5"		57.38			
			27.0		3.75"		57.31			
			28.0		2.75"		57.23			
			29.0		2"		57.17			
	0830		30.0		1"		57.08			
			31.0		.5"		57.04			
			32.0		56'11.5"		56.96			
			33.0		10.5"		56.88			
			34.0		9.75"		56.81			
			35.0		9.25"		56.77			
			36.0		8.25"		56.69			
			37.0		7.5"		56.63			
			38.0		6.5"		56.54			
			39.0		6"		56.50			
			40.0		5"		56.42			
			41.0		4.25"		56.35			

TABLE F-6 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 5/1/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Recovery Test No. 1

Measuring equipment Soilinst WL Indicator

Time Data
Pump on: Date 4/30 Time 1530
Pump off: Date 5/1 Time 0800
Duration of aquifer test:
Pumping 16 hrs. Recovery 8 hrs

Water Level Data
Static water level 40' 4.5"
Measuring point Top of Casing
Elevation of measuring point

Discharge Data
How Q measured Bucket
Depth of pump/air line
Previous pumping? Yes ___ No ___
Duration ___ End ___

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
5/1/86			42.0			-		-						
			43.0			56'3"		56.25						
			44.0			2.25"		56.19						
			45.0			1.5"		56.13						
			46.0			.75"		56.06						
			47.0			56'0"		56.00						
			48.0			55'11.5"		55.96						
			49.0			10.75"		55.90						
			50.0			9.5"		55.79						
			51.0			9"		55.75						
			52.0			8.5"		55.71						
			53.0			8"		55.67						
			54.0			7.5"		55.63						
			55.0			-		-						
			56.0			-		-						
			57.0			-		-						
			58.0			5"		55.42						
			59.0			5"		55.42						
	0900		60.0			4.5"		55.38						
			65.0			2"		55.17						
			70.0			54'11.5"		54.96						
			75.0			9.5"		54.79						
			80.0			7"		54.58						
			85.0			4.5"		54.38						
			90.0			3.25"		54.27						
			95.0			1.25"		54.10						

TABLE F-6 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 5/1/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-27 Distance from pumping well - Type of test Recovery Test No. 1

Measuring equipment

Time Data
Pump on: Date 4/30 Time 1530 (t_o)
Pump off: Date 5/1 Time 0800 (t_o')
Duration of aquifer test:
Pumping 16 hrs. Recovery 8 hrs

Water Level Data
Static water level 40' 4.5"
Measuring point Top of Casing
Elevation of measuring point

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes ___ No ___
Duration ___ End ___

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
5/1/86			100			53'11"		53.92'						
			105			9.5"		53.79'						
			110			7"		53.58'						
			115			6.5"		53.54'						
	1000		120			3.5"		53.29'						
			130			52'11.5"		52.96'						
			140			7"		52.58'						
			150			3.5"		52.29'						
			160			51'10.5"		51.88'						
			170			6.5"		51.54'						
	1100		180			2.5"		51.21'						
			210			50'2.5"		50.21'						
	1200		240			49'3"		49.25'						
			270			46'4.5"		46.38'						
	1300		300			44'1"		44.08'						
	1400		360			43'		43.00'						
	1500		420			42'1"		42.08'						
	1600		480			41'1"		41.08'						

TABLE F-7
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 5/1/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-21 Distance from pumping well 12.3 Type of test Recovery Test No. 1

Measuring equipment Powers WL Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t_o)
Pump off: Date 5/1 Time 0800 (t_o')
Duration of aquifer test:
Pumping 16 hrs. Recovery 8 hrs

Water Level Data
Static water level 25' 7"
Measuring point Top of Casing
Elevation of measuring point

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes ___ No ___
Duration ___ End ___

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
5/1/86	0800		.15			23'4.25"		23.35'						
			.30			4.25"		23.35'						
			.45			4.25"		23.35'						
			.60			4.25"		23.35'						
			1.30			4.25"		23.35'						
			2.0			4.25"		23.35'						
			2.30			4.25"		23.35'						
			3.0			4.5"		23.38'						
			3.30			4.25"		23.35'						
			4.30			4.25"		23.35'						
			6.0			4.25"		23.35'						
			7.0			3.25"		23.27'						
			8.0			3.25"		23.27'						
			9.0			3.25"		23.27'						
			10.0			3.25"		23.27'						
			13.0			3.25"		23.27'						
			15.0			3.25"		23.27'						
			17.0			3.25"		23.27'						
			22.0			3.25"		23.27'						
			29.0			3.25"		23.27'						
			57.0			4.5"		23.38'						
			70.0			3.125"		23.26'						
			80.0			2.5"		23.21'						
			85.0			3"		23.25'						
	1000		120.0			2.75"		23.23'						
			150.0			2.75"		23.23'						

TABLE F-7 (cont'd)
AQUIFER TEST DATA

Owner Giant Address Bloomfield County San Juan State NM

Date 5/1/86 Company performing test Geoscience Measured by Nicholas

Well No. GBR-21 Distance from pumping well 12.3 Type of test Recovery Test No. 1

Measuring equipment Powers WL Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t.)
Pump off: Date 5/1 Time 0800 (t.)
Duration of aquifer test:
Pumping 16 hrs. Recovery 8 hrs.

Water Level Data
Static water level 25' 7"
Measuring point Top of Casing
Elevation of measuring point

Discharge Data
How Q measured Bucket
Depth of pump/air line 62'
Previous pumping? Yes No
Duration End

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
5/1/86			210			23'2.5"		23.21						
			270			2.25"		23.19						
	1300		300			2"		23.17						
	1400		360			1.75"		23.15						
	1500		420			1.5"		23.13						
	1600		480			1.5"		23.13						

TABLE F-8
DRAWDOWN MEASUREMENTS
GBR-14
Q = 1 gpm

PUMPTEST 1

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
0.00	32.00	1.00	32.08	0.00	0.00	ERR
0.25	32.00	1.00	32.08	0.00	0.25	-0.60
0.50	32.00	1.50	32.13	-0.04	0.50	-0.30
0.75	32.00	1.75	32.15	-0.06	0.75	-0.12
1.00	32.00	2.00	32.17	-0.08	1.00	0.00
1.25	32.00	2.50	32.21	-0.13	1.25	0.10
1.50	32.00	2.50	32.21	-0.13	1.50	0.18
1.75	32.00	2.50	32.21	-0.13	1.75	0.24
2.25	32.00	3.00	32.25	-0.17	2.25	0.35
2.75	32.00	3.10	32.26	-0.17	2.75	0.44
3.25	32.00	3.50	32.29	-0.21	3.25	0.51
3.75	32.00	4.00	32.33	-0.25	3.75	0.57
4.25	32.00	4.50	32.38	-0.29	4.25	0.63
4.75	32.00	5.00	32.42	-0.33	4.75	0.68
5.25	32.00	5.70	32.48	-0.39	5.25	0.72
5.75	32.00	6.10	32.51	-0.42	5.75	0.76
6.25	32.00	6.50	32.54	-0.46	6.25	0.80
6.75	32.00	6.90	32.58	-0.49	6.75	0.83
7.25	32.00	7.40	32.62	-0.53	7.25	0.86
7.75	32.00	7.70	32.64	-0.56	7.75	0.89
8.25	32.00	8.20	32.68	-0.60	8.25	0.92
8.75	32.00	8.50	32.71	-0.63	8.75	0.94
9.25	32.00	8.90	32.74	-0.66	9.25	0.97
9.75	32.00	9.10	32.76	-0.67	9.75	0.99
10.15	32.00	9.40	32.78	-0.70	10.15	1.01
10.75	32.00	9.80	32.82	-0.73	10.75	1.03
11.25	32.00	10.30	32.86	-0.77	11.25	1.05
11.75	32.00	10.70	32.89	-0.81	11.75	1.07
12.25	32.00	11.10	32.93	-0.84	12.25	1.09
12.75	33.00	0.00	33.00	-0.92	12.75	1.11
13.25	33.00	0.40	33.03	-0.95	13.25	1.12
13.75	33.00	0.90	33.08	-0.99	13.75	1.14
14.25	33.00	1.50	33.13	-1.04	14.25	1.15
14.75	33.00	2.00	33.17	-1.08	14.75	1.17
15.25	33.00	2.60	33.22	-1.13	15.25	1.18
15.75	33.00	3.30	33.28	-1.19	15.75	1.20
16.25	33.00	3.90	33.33	-1.24	16.25	1.21
16.75	33.00	4.60	33.38	-1.30	16.75	1.22
17.25	33.00	5.40	33.45	-1.37	17.25	1.24
17.75	33.00	6.00	33.50	-1.42	17.75	1.25
18.25	33.00	6.90	33.58	-1.49	18.25	1.26
18.75	33.00	7.60	33.63	-1.55	18.75	1.27
19.25	33.00	8.30	33.69	-1.61	19.25	1.28

TABLE F-8 (CONT.)
DRAWDOWN MEASUREMENTS

PUMPTEST 1

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
19.75	33.00	9.00	33.75	-1.67	19.75	1.30
20.25	33.00	9.30	33.78	-1.69	20.25	1.31
20.75	33.00	9.80	33.82	-1.73	20.75	1.32
21.25	33.00	10.30	33.86	-1.77	21.25	1.33
21.75	33.00	10.70	33.89	-1.81	21.75	1.34
22.25	33.00	11.20	33.93	-1.85	22.25	1.35
22.45	33.00	11.40	33.95	-1.87	22.45	1.35
23.25	33.00	11.80	33.98	-1.90	23.25	1.37
23.75	34.00	0.20	34.02	-1.93	23.75	1.38
24.25	34.00	0.60	34.05	-1.97	24.25	1.38
24.75	34.00	0.90	34.08	-1.99	24.75	1.39
25.25	34.00	1.20	34.10	-2.02	25.25	1.40
25.75	34.00	1.70	34.14	-2.06	25.75	1.41
26.25	34.00	2.00	34.17	-2.08	26.25	1.42
26.75	34.00	2.20	34.18	-2.10	26.75	1.43
27.25	34.00	2.60	34.22	-2.13	27.25	1.44
27.75	34.00	2.90	34.24	-2.16	27.75	1.44
28.25	34.00	3.20	34.27	-2.18	28.25	1.45
28.75	34.00	3.60	34.30	-2.22	28.75	1.46
29.25	34.00	3.80	34.32	-2.23	29.25	1.47
29.75	34.00	4.10	34.34	-2.26	29.75	1.47
30.25	34.00	4.50	34.38	-2.29	30.25	1.48
30.75	34.00	4.70	34.39	-2.31	30.75	1.49
31.25	34.00	5.00	34.42	-2.33	31.25	1.49
31.75	34.00	5.20	34.43	-2.35	31.75	1.50
32.25	34.00	5.50	34.46	-2.38	32.25	1.51
32.75	34.00	5.70	34.48	-2.39	32.75	1.52
33.25	34.00	5.80	34.48	-2.40	33.25	1.52
34.25	34.00	9.00	34.75	-2.67	34.25	1.53
34.75	34.00	10.50	34.88	-2.79	34.75	1.54
35.25	34.00	11.30	34.94	-2.86	35.25	1.55
35.75	35.00	0.50	35.04	-2.96	35.75	1.55
36.25	35.00	1.30	35.11	-3.02	36.25	1.56
36.75	35.00	2.10	35.18	-3.09	36.75	1.57
37.25	35.00	2.90	35.24	-3.16	37.25	1.57
37.75	35.00	3.70	35.31	-3.22	37.75	1.58
38.25	35.00	4.60	35.38	-3.30	38.25	1.58
38.75	35.00	5.30	35.44	-3.36	38.75	1.59
39.25	35.00	6.20	35.52	-3.43	39.25	1.59
39.75	35.00	6.80	35.57	-3.48	39.75	1.60
40.25	35.00	7.30	35.61	-3.52	40.25	1.60
40.75	35.00	8.70	35.73	-3.64	40.75	1.61
41.25	35.00	10.00	35.83	-3.75	41.25	1.62
41.75	35.00	11.40	35.95	-3.87	41.75	1.62
42.25	36.00	0.90	36.08	-3.99	42.25	1.63

TABLE F-8 (CONT.)
DRAWDOWN MEASUREMENTS

PUMPTEST 1

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
42.75	36.00	2.50	36.21	-4.13	42.75	1.63
43.25	36.00	3.80	36.32	-4.23	43.25	1.64
43.75	36.00	5.70	36.48	-4.39	43.75	1.64
44.25	36.00	6.90	36.58	-4.49	44.25	1.65
44.75	36.00	7.90	36.66	-4.57	44.75	1.65
45.25	36.00	9.00	36.75	-4.67	45.25	1.66
45.75	36.00	10.00	36.83	-4.75	45.75	1.66
46.25	36.00	11.00	36.92	-4.83	46.25	1.67
46.75	36.00	11.80	36.98	-4.90	46.75	1.67
47.25	37.00	0.80	37.07	-4.98	47.25	1.67
47.75	37.00	1.60	37.13	-5.05	47.75	1.68
48.25	37.00	2.40	37.20	-5.12	48.25	1.68
48.75	37.00	3.30	37.28	-5.19	48.75	1.69
49.25	37.00	4.10	37.34	-5.26	49.25	1.69
49.75	37.00	4.60	37.38	-5.30	49.75	1.70
50.25	37.00	5.30	37.44	-5.36	50.25	1.70
50.75	37.00	6.30	37.53	-5.44	50.75	1.71
51.25	37.00	6.80	37.57	-5.48	51.25	1.71
51.75	37.00	7.20	37.60	-5.52	51.75	1.71
52.25	37.00	8.00	37.67	-5.58	52.25	1.72
52.75	37.00	8.50	37.71	-5.63	52.75	1.72
53.25	37.00	9.30	37.78	-5.69	53.25	1.73
53.75	37.00	10.40	37.87	-5.78	53.75	1.73
54.25	37.00	11.10	37.93	-5.84	54.25	1.73
54.75	37.00	11.80	37.98	-5.90	54.75	1.74
55.25	38.00	0.50	38.04	-5.96	55.25	1.74
55.75	38.00	1.00	38.08	-6.00	55.75	1.75
56.25	38.00	1.70	38.14	-6.06	56.25	1.75
56.75	38.00	2.30	38.19	-6.11	56.75	1.75
57.25	38.00	3.00	38.25	-6.17	57.25	1.76
57.75	38.00	3.40	38.28	-6.20	57.75	1.76
58.25	38.00	4.00	38.33	-6.25	58.25	1.77
59.75	38.00	4.60	38.38	-6.30	59.75	1.78
59.25	38.00	5.10	38.43	-6.34	59.25	1.77
59.75	38.00	5.70	38.48	-6.39	59.75	1.78

TABLE F-9
RECOVERY MEASUREMENTS
GBR-14

RECOVERY 1

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
0.00	38.00	4.50	38.38	-6.29	0.00	ERR
0.25	38.00	4.50	38.38	-6.29	0.25	-0.60
0.75	38.00	2.60	38.22	-6.13	0.75	-0.12
1.25	38.00	0.20	38.02	-5.93	1.25	0.10
1.75	37.00	9.90	37.83	-5.74	1.75	0.24
2.25	37.00	7.70	37.64	-5.56	2.25	0.35
2.75	37.00	5.30	37.44	-5.36	2.75	0.44
3.25	37.00	2.40	37.20	-5.12	3.25	0.51
3.75	37.00	0.80	37.07	-4.98	3.75	0.57
4.25	36.00	10.80	36.90	-4.82	4.25	0.63
4.75	36.00	8.80	36.73	-4.65	4.75	0.68
5.25	36.00	6.80	36.57	-4.48	5.25	0.72
5.75	36.00	4.40	36.37	-4.28	5.75	0.76
6.25	36.00	2.30	36.19	-4.11	6.25	0.80
6.75	36.00	0.20	36.02	-3.93	6.75	0.83
7.25	35.00	10.30	35.86	-3.77	7.25	0.86
7.75	35.00	8.30	35.69	-3.61	7.75	0.89
8.25	35.00	5.70	35.48	-3.39	8.25	0.92
8.75	35.00	4.50	35.38	-3.29	8.75	0.94
9.25	35.00	3.00	35.25	-3.17	9.25	0.97
9.75	35.00	1.30	35.11	-3.02	9.75	0.99
10.25	34.00	11.90	34.99	-2.91	10.25	1.01
10.75	34.00	10.30	34.86	-2.77	10.75	1.03
11.25	34.00	9.10	34.76	-2.67	11.25	1.05
11.75	34.00	7.40	34.62	-2.53	11.75	1.07
12.25	34.00	5.80	34.48	-2.40	12.25	1.09
12.75	34.00	4.60	34.38	-2.30	12.75	1.11
13.25	34.00	3.20	34.27	-2.18	13.25	1.12
13.75	34.00	1.80	34.15	-2.07	13.75	1.14
14.25	34.00	0.50	34.04	-1.96	14.25	1.15
14.75	33.00	11.50	33.96	-1.88	14.75	1.17
15.25	33.00	10.40	33.87	-1.78	15.25	1.18
15.75	33.00	9.30	33.78	-1.69	15.75	1.20
16.25	33.00	8.00	33.67	-1.58	16.25	1.21
16.75	33.00	6.90	33.58	-1.49	16.75	1.22
17.25	33.00	5.80	33.48	-1.40	17.25	1.24
17.75	33.00	4.70	33.39	-1.31	17.75	1.25
18.25	33.00	4.00	33.33	-1.25	18.25	1.26
18.75	33.00	3.20	33.27	-1.18	18.75	1.27
19.25	33.00	2.50	33.21	-1.13	19.25	1.28
19.75	33.00	1.70	33.14	-1.06	19.75	1.30
20.25	33.00	1.20	33.10	-1.02	20.25	1.31
20.75	33.00	0.60	33.05	-0.97	20.75	1.32
21.25	33.00	0.00	33.00	-0.92	21.25	1.33

TABLE F-9 (CONT.)
RECOVERY MEASUREMENTS

RECOVERY 1

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
21.75	32.00	11.70	32.98	-0.89	21.75	1.34
22.25	32.00	11.30	32.94	-0.86	22.25	1.35
22.75	32.00	11.00	32.92	-0.83	22.75	1.36
23.25	32.00	10.60	32.88	-0.80	23.25	1.37
23.75	32.00	10.40	32.87	-0.78	23.75	1.38
24.25	32.00	10.10	32.84	-0.76	24.25	1.38
25.25	32.00	9.60	32.80	-0.72	25.25	1.40
26.25	32.00	9.20	32.77	-0.68	26.25	1.42
27.25	32.00	8.70	32.73	-0.64	27.25	1.44
28.25	32.00	8.40	32.70	-0.62	28.25	1.45
29.25	32.00	8.10	32.68	-0.59	29.25	1.47
30.25	32.00	7.80	32.65	-0.57	30.25	1.48
31.25	32.00	7.30	32.61	-0.52	31.25	1.49
33.25	32.00	6.90	32.58	-0.49	33.25	1.52
36.25	32.00	6.30	32.53	-0.44	36.25	1.56

TABLE F-10
DRAWDOWN MEASUREMENTS
GBR-14
Q = 5 gpm

PUMPTEST 3

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
0.00	31.00	9.00	31.75	-0.08	0.00	ERR
0.25	31.00	10.00	31.83	-0.16	0.25	-0.60
0.75	31.00	10.90	31.91	-0.21	0.50	-0.30
1.25	31.00	11.50	31.96	-0.27	1.00	0.00
1.75	32.00	0.20	32.02	-0.37	1.50	0.18
2.25	32.00	1.40	32.12	-0.46	2.00	0.30
2.75	32.00	2.50	32.21	-0.52	2.50	0.40
3.25	32.00	3.30	32.28	-0.59	3.00	0.48
3.75	32.00	4.10	32.34	-0.67	3.50	0.54
4.25	32.00	5.00	32.42	-0.73	4.00	0.60
4.75	32.00	5.70	32.48	-0.81	4.50	0.65
5.25	32.00	6.70	32.56	-0.88	5.00	0.70
5.75	32.00	7.50	32.63	-0.98	5.50	0.74
6.25	32.00	8.70	32.73	-1.10	6.00	0.78
6.75	32.00	10.20	32.85	-1.29	6.50	0.81
7.25	33.00	0.50	33.04	-1.63	7.00	0.85
7.75	33.00	4.50	33.38	-2.13	7.50	0.88
8.25	33.00	10.50	33.88	-2.58	8.00	0.90
8.75	34.00	4.00	34.33	-3.08	8.50	0.93
9.25	34.00	10.00	34.83	-3.63	9.00	0.95
9.75	35.00	4.50	35.38	-4.21	9.50	0.98
10.25	35.00	11.50	35.96	-4.75	10.00	1.00
10.75	36.00	6.00	36.50	-5.21	10.50	1.02
11.25	36.00	11.50	36.96	-5.75	11.00	1.04
11.75	37.00	6.00	37.50	-6.29	11.50	1.06
12.25	38.00	0.50	38.04	-6.71	12.00	1.08
12.75	38.00	5.50	38.46	-7.17	12.50	1.10
13.25	38.00	11.00	38.92	-7.52	13.00	1.11
13.75	39.00	3.30	39.28	-7.89	13.50	1.13
14.25	39.00	7.70	39.64	-7.28	14.00	1.15
14.75	39.00	0.40	39.03	-8.54	14.50	1.16
15.25	40.00	3.50	40.29	-8.82	15.00	1.18
15.75	40.00	6.80	40.57	-9.42	15.50	1.19
16.25	41.00	2.00	41.17	-9.84	16.00	1.20
16.75	41.00	7.10	41.59	-10.35	16.50	1.22
17.25	42.00	1.20	42.10	-10.83	17.00	1.23
17.75	42.00	7.00	42.58	-11.33	17.50	1.24
18.25	43.00	1.00	43.08	-11.79	18.00	1.26
18.75	43.00	6.50	43.54	-12.29	18.50	1.27
19.25	44.00	0.50	44.04	-12.83	19.00	1.28
19.75	44.00	7.00	44.58	-13.33	19.50	1.29
20.25	45.00	1.00	45.08	-13.79	20.00	1.30
20.75	45.00	6.50	45.54	-14.54	20.50	1.31

TABLE F-10 (CONT.)
DRAWDOWN MEASUREMENTS

PUMPTEST 3

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
21.25	46.00	3.50	46.29	-15.29	21.00	1.32
21.75	47.00	0.50	47.04	-16.00	21.50	1.33
22.25	47.00	9.00	47.75	-16.63	22.00	1.34
22.75	48.00	4.50	48.38	-17.25	22.50	1.35
23.25	49.00	0.00	49.00	-17.92	23.00	1.36
23.75	49.00	8.00	49.67	-18.54	23.50	1.37
24.25	50.00	3.50	50.29	-19.08	24.00	1.38
24.75	50.00	10.00	50.83	-19.75	24.50	1.39
25.25	51.00	6.00	51.50	-20.33	25.00	1.40
25.75	52.00	1.00	52.08	-20.88	25.50	1.41
26.25	52.00	7.50	52.63	-21.46	26.00	1.41
26.75	53.00	2.50	53.21	-22.04	26.50	1.42
27.25	53.00	9.50	53.79	-22.63	27.00	1.43
27.75	54.00	4.50	54.38	-23.17	27.50	1.44
28.25	54.00	11.00	54.92	-23.71	28.00	1.45
28.75	55.00	5.50	55.46	-24.25	28.50	1.45
29.25	56.00	0.00	56.00	-24.79	29.00	1.46
29.75	56.00	6.50	56.54	-25.25	29.50	1.47
30.25	57.00	0.00	57.00	-25.75	30.00	1.48
30.75	57.00	6.00	57.50	-26.25	30.50	1.48
31.25	58.00	0.00	58.00	-26.71	31.00	1.49
31.75	58.00	5.50	58.46	-27.21	31.50	1.50
32.25	58.00	11.50	58.96	-27.67	32.00	1.51
32.75	59.00	5.00	59.42	-28.17	32.50	1.51
33.25	59.00	11.00	59.92	-28.58	33.00	1.52
33.75	60.00	4.00	60.33	-29.13	33.50	1.53
34.25	60.00	10.50	60.88	-29.50	34.00	1.53
34.75	61.00	3.00	61.25	-29.96	34.50	1.54
35.25	61.00	8.50	61.71	-30.50	35.00	1.54
35.75	62.00	3.00	62.25	31.75	35.50	1.55

TABLE F-11
RECOVERY MEASUREMENTS
GBR-14

RECOVERY 3

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
0.00	61.00	10.00	61.83	-30.08	0.00	ERR
1.00	61.00	10.00	61.83	-30.08	1.00	0.00
1.50	61.00	4.00	61.33	-29.58	1.50	0.18
2.00	60.00	10.00	60.83	-29.08	2.00	0.30
2.50	60.00	5.00	60.42	-28.67	2.50	0.40
3.00	59.00	11.50	59.96	-28.21	3.00	0.48
3.50	59.00	6.00	59.50	-27.75	3.50	0.54
4.00	59.00	0.50	59.04	-27.29	4.00	0.60
4.50	58.00	7.50	58.63	-26.88	4.50	0.65
5.00	58.00	2.50	58.21	-26.46	5.00	0.70
5.50	57.00	10.00	57.83	-26.08	5.50	0.74
6.00	57.00	5.00	57.42	-25.67	6.00	0.78
6.50	56.00	11.50	56.96	-25.21	6.50	0.81
7.00	56.00	7.50	56.63	-24.88	7.00	0.85
7.50	56.00	2.50	56.21	-24.46	7.50	0.88
8.00	55.00	10.00	55.83	-24.08	8.00	0.90
8.50	55.00	7.50	55.63	-23.88	8.50	0.93
9.00	55.00	2.00	55.17	-23.42	9.00	0.95
9.50	54.00	9.00	54.75	-23.00	9.50	0.98
10.00	54.00	1.50	54.13	-22.38	10.00	1.00
10.50	54.00	0.00	54.00	-22.25	10.50	1.02
11.00	53.00	8.00	53.67	-21.92	11.00	1.04
11.50	53.00	3.50	53.29	-21.54	11.50	1.06
12.00	52.00	11.00	52.92	-21.17	12.00	1.08
12.50	52.00	7.00	52.58	-20.83	12.50	1.10
13.00	52.00	3.00	52.25	-20.50	13.00	1.11
13.50	51.00	10.50	51.88	-20.13	13.50	1.13
14.00	51.00	7.00	51.58	-19.83	14.00	1.15
14.50	51.00	3.00	51.25	-19.50	14.50	1.16
15.00	50.00	11.50	50.96	-19.21	15.00	1.18
15.50	50.00	7.50	50.63	-18.88	15.50	1.19
16.00	50.00	5.00	50.42	-18.67	16.00	1.20
16.50	50.00	1.00	50.08	-18.33	16.50	1.22
17.00	49.00	9.50	49.79	-18.04	17.00	1.23
17.50	49.00	5.50	49.46	-17.71	17.50	1.24
18.00	49.00	1.00	49.08	-17.33	18.00	1.26
18.50	48.00	10.50	48.88	-17.13	18.50	1.27
19.00	48.00	6.50	48.54	-16.79	19.00	1.28
19.50	48.00	3.50	48.29	-16.54	19.50	1.29
20.00	48.00	0.00	48.00	-16.25	20.00	1.30
20.50	47.00	8.50	47.71	-15.96	20.50	1.31
21.00	47.00	5.00	47.42	-15.67	21.00	1.32
21.50	47.00	2.00	47.17	-15.42	21.50	1.33
22.00	46.00	11.00	46.92	-15.17	22.00	1.34

TABLE F-11 (CONT.)
RECOVERY MEASUREMENTS

RECOVERY 3

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
22.50	46.00	8.00	46.67	-14.92	22.50	1.35
23.00	46.00	5.00	46.42	-14.67	23.00	1.36
23.50	46.00	2.00	46.17	-14.42	23.50	1.37
24.00	45.00	11.00	45.92	-14.17	24.00	1.38
24.50	45.00	8.00	45.67	-13.92	24.50	1.39
25.00	45.00	5.00	45.42	-13.67	25.00	1.40
25.50	45.00	2.00	45.17	-13.42	25.50	1.41
26.00	44.00	11.00	44.92	-13.17	26.00	1.41
26.50	44.00	8.00	44.67	-12.92	26.50	1.42
27.00	44.00	6.00	44.50	-12.75	27.00	1.43
27.50	44.00	2.50	44.21	-12.46	27.50	1.44
28.00	44.00	0.00	44.00	-12.25	28.00	1.45
28.50	43.00	9.50	43.79	-12.04	28.50	1.45
29.00	43.00	7.50	43.63	-11.88	29.00	1.46
29.50	43.00	5.00	43.42	-11.67	29.50	1.47
30.00	43.00	3.00	43.25	-11.50	30.00	1.48
30.50	43.00	1.00	43.08	-11.33	30.50	1.48
31.00	42.00	10.50	42.88	-11.13	31.00	1.49
31.50	42.00	8.50	42.71	-10.96	31.50	1.50
32.00	42.00	6.50	42.54	-10.79	32.00	1.51
32.50	42.00	4.00	42.33	-10.58	32.50	1.51
33.00	42.00	2.50	42.21	-10.46	33.00	1.52
33.50	42.00	1.00	42.08	-10.33	33.50	1.53
34.00	41.00	11.00	41.92	-10.17	34.00	1.53
34.50	41.00	9.50	41.79	-10.04	34.50	1.54
35.00	41.00	8.00	41.67	-9.92	35.00	1.54
35.50	41.00	6.50	41.54	-9.79	35.50	1.55
36.00	41.00	5.00	41.42	-9.67	36.00	1.56
36.50	41.00	3.00	41.25	-9.50	36.50	1.56
37.00	41.00	1.50	41.13	-9.38	37.00	1.57
37.50	41.00	0.00	41.00	-9.25	37.50	1.57
38.00	40.00	10.50	40.88	-9.13	38.00	1.58
38.50	40.00	9.00	40.75	-9.00	38.50	1.59
39.00	40.00	7.50	40.63	-8.88	39.00	1.59
39.50	40.00	6.00	40.50	-8.75	39.50	1.60
40.00	40.00	4.50	40.38	-8.63	40.00	1.60
40.50	40.00	3.00	40.25	-8.50	40.50	1.61
41.00	40.00	1.50	40.13	-8.38	41.00	1.61
41.50	40.00	0.00	40.00	-8.25	41.50	1.62
42.00	39.00	10.50	39.88	-8.13	42.00	1.62
42.50	39.00	9.50	39.79	-8.04	42.50	1.63
43.00	39.00	7.50	39.63	-7.88	43.00	1.63
43.50	39.00	6.50	39.54	-7.79	43.50	1.64
44.00	39.00	5.00	39.42	-7.67	44.00	1.64
44.50	39.00	3.00	39.25	-7.50	44.50	1.65

TABLE F-11 (CONT.)
RECOVERY MEASUREMENTS

RECOVERY 3

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
45.00	39.00	1.50	39.13	-7.38	45.00	1.65
45.50	39.00	0.00	39.00	-7.25	45.50	1.66
46.00	38.00	10.50	38.88	-7.13	46.00	1.66
47.00	38.00	7.00	38.58	-6.83	47.00	1.67
48.00	38.00	3.50	38.29	-6.54	48.00	1.68
50.00	37.00	8.00	37.67	-5.92	50.00	1.70
52.00	37.00	1.50	37.13	-5.38	52.00	1.72
54.00	36.00	6.50	36.54	-4.79	54.00	1.73
56.00	36.00	0.50	36.04	-4.29	56.00	1.75
58.00	35.00	6.50	35.54	-3.79	58.00	1.76
60.00	35.00	1.50	35.13	-3.38	60.00	1.78

TABLE F-12
DRAWDOWN MEASUREMENTS
GBR-14
Q = 2 gpm

PUMPTEST 5

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
0.00	32.00	1.50	32.13	0.00	0.00	ERR
0.25	32.00	1.50	32.13	0.00	0.25	-0.60
0.75	32.00	2.00	32.17	-0.04	0.75	-0.12
1.25	32.00	3.00	32.25	-0.13	1.25	0.10
1.75	32.00	3.50	32.29	-0.17	1.75	0.24
2.25	32.00	4.00	32.33	-0.21	2.25	0.35
2.75	32.00	4.50	32.38	-0.25	2.75	0.44
3.25	32.00	5.00	32.42	-0.29	3.25	0.51
3.75	32.00	5.50	32.46	-0.33	3.75	0.57
4.25	32.00	6.00	32.50	-0.38	4.25	0.63
4.75	32.00	6.50	32.54	-0.42	4.75	0.68
5.25	32.00	6.70	32.56	-0.43	5.25	0.72
5.75	32.00	7.10	32.59	-0.47	5.75	0.76
6.25	32.00	7.50	32.63	-0.50	6.25	0.80
6.75	32.00	8.00	32.67	-0.54	6.75	0.83
7.25	32.00	9.00	32.75	-0.63	7.25	0.86
7.75	32.00	9.50	32.79	-0.67	7.75	0.89
8.25	32.00	10.50	32.88	-0.75	8.25	0.92
8.75	32.00	11.00	32.92	-0.79	8.75	0.94
9.25	33.00	0.50	33.04	-0.92	9.25	0.97
9.75	33.00	2.50	33.21	-1.08	9.75	0.99
10.25	33.00	4.50	33.38	-1.25	10.25	1.01
10.75	33.00	7.00	33.58	-1.46	10.75	1.03
11.25	33.00	10.50	33.88	-1.75	11.25	1.05
11.75	34.00	0.50	34.04	-1.92	11.75	1.07
12.25	34.00	3.00	34.25	-2.13	12.25	1.09
12.75	34.00	6.00	34.50	-2.38	12.75	1.11
13.25	34.00	8.50	34.71	-2.58	13.25	1.12
13.75	34.00	11.00	34.92	-2.79	13.75	1.14
14.25	35.00	1.00	35.08	-2.96	14.25	1.15
14.75	35.00	3.50	35.29	-3.17	14.75	1.17
15.25	35.00	6.00	35.50	-3.38	15.25	1.18
15.75	35.00	5.50	35.46	-3.33	15.75	1.20
16.25	35.00	10.50	35.88	-3.75	16.25	1.21
16.75	36.00	1.00	36.08	-3.96	16.75	1.22
17.25	36.00	3.50	36.29	-4.17	17.25	1.24
17.75	36.00	5.50	36.46	-4.33	17.75	1.25
18.25	36.00	8.50	36.71	-4.58	18.25	1.26
18.75	37.00	0.00	37.00	-4.88	18.75	1.27
19.25	37.00	3.00	37.25	-5.13	19.25	1.28
19.75	37.00	6.50	37.54	-5.42	19.75	1.30
20.25	37.00	9.00	37.75	-5.63	20.25	1.31
20.75	37.00	11.50	37.96	-5.83	20.75	1.32

TABLE F-12 (CONT.)
DRAWDOWN MEASUREMENTS

PUMPTEST 5

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
21.25	38.00	2.00	38.17	-6.04	21.25	1.33
21.75	38.00	4.50	38.38	-6.25	21.75	1.34
22.25	38.00	6.50	38.54	-6.42	22.25	1.35
22.75	38.00	8.50	38.71	-6.58	22.75	1.36
23.25	38.00	10.50	38.88	-6.75	23.25	1.37
23.75	39.00	0.00	39.00	-6.88	23.75	1.38
24.25	39.00	2.00	39.17	-7.04	24.25	1.38
24.75	39.00	3.00	39.25	-7.13	24.75	1.39
25.25	39.00	4.50	39.38	-7.25	25.25	1.40
25.75	39.00	6.00	39.50	-7.38	25.75	1.41
26.25	39.00	8.00	39.67	-7.54	26.25	1.42
26.75	39.00	9.50	39.79	-7.67	26.75	1.43
27.25	39.00	11.00	39.92	-7.79	27.25	1.44
27.75	40.00	0.00	40.00	-7.88	27.75	1.44
28.25	40.00	1.50	40.13	-8.00	28.25	1.45
28.75	40.00	3.00	40.25	-8.13	28.75	1.46
29.25	40.00	4.00	40.33	-8.21	29.25	1.47
29.75	40.00	5.50	40.46	-8.33	29.75	1.47
30.25	40.00	6.50	40.54	-8.42	30.25	1.48
31.25	40.00	9.00	40.75	-8.63	31.25	1.49
32.25	40.00	11.00	40.92	-8.79	32.25	1.51
33.25	41.00	1.50	41.13	-9.00	33.25	1.52
34.25	41.00	3.50	41.29	-9.17	34.25	1.53
35.25	41.00	6.00	41.50	-9.38	35.25	1.55
36.25	41.00	8.00	41.67	-9.54	36.25	1.56
37.25	41.00	10.00	41.83	-9.71	37.25	1.57
38.25	41.00	0.00	41.00	-8.88	38.25	1.58
39.25	41.00	2.00	41.17	-9.04	39.25	1.59
40.25	41.00	4.00	41.33	-9.21	40.25	1.60
42.25	41.00	9.00	41.75	-9.63	42.25	1.63
44.25	43.00	0.50	43.04	-10.92	44.25	1.65
46.25	43.00	3.50	43.29	-11.17	46.25	1.67
48.25	43.00	7.00	43.58	-11.46	48.25	1.68
50.25	44.00	5.50	44.46	-12.33	50.25	1.70
51.25	44.00	10.00	44.83	-12.71	51.25	1.71
52.25	45.00	2.50	45.21	-13.08	52.25	1.72
54.25	46.00	2.00	46.17	-14.04	54.25	1.73
56.25	46.00	7.50	46.63	-14.50	56.25	1.75
58.25	47.00	3.50	47.29	-15.17	58.25	1.77
60.25	47.00	10.50	47.88	-15.75	60.25	1.78
64.25	48.00	11.00	48.92	-16.79	64.25	1.81
70.25	50.00	1.00	50.08	-17.96	70.25	1.85
80.25	51.00	0.00	51.00	-18.88	80.25	1.90
90.00	51.00	6.50	51.54	-19.42	90.00	1.95
100.00	51.00	8.50	51.71	-19.58	100.00	2.00

TABLE F-12 (CONT.)
DRAWDOWN MEASUREMENTS

PUMPTEST 5

TIME (minutes)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
133.00	52.00	8.50	52.71	-20.58	133.00	2.12
162.00	56.00	11.00	56.92	-24.79	162.00	2.21
182.00	60.00	8.00	60.67	-28.54	182.00	2.26
199.00	61.00	4.00	61.33	-29.21	199.00	2.30
227.00	61.00	8.50	61.71	-29.58	227.00	2.36
241.00	62.00	5.50	62.46	-30.33	241.00	2.38

TABLE F-13
RECOVERY MEASUREMENTS
GBR-14

RECOVERY 5

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
0.00	62.00	4.00	62.33	-30.21	0.00	ERR
0.50	62.00	4.00	62.33	-30.21	0.50	-0.30
1.50	61.00	9.00	61.75	-29.63	1.50	0.18
2.50	61.00	1.50	61.13	-29.00	2.50	0.40
3.50	60.00	4.50	60.38	-28.25	3.50	0.54
4.50	59.00	7.50	59.63	-27.50	4.50	0.65
5.50	58.00	10.00	58.83	-26.71	5.50	0.74
6.50	58.00	3.00	58.25	-26.13	6.50	0.81
7.50	57.00	8.00	57.67	-25.54	7.50	0.88
8.50	57.00	0.00	57.00	-24.88	8.50	0.93
9.50	56.00	5.00	56.42	-24.29	9.50	0.98
10.50	55.00	9.00	55.75	-23.63	10.50	1.02
11.50	55.00	2.00	55.17	-23.04	11.50	1.06
12.50	54.00	7.00	54.58	-22.46	12.50	1.10
13.50	54.00	0.00	54.00	-21.88	13.50	1.13
14.50	53.00	5.00	53.42	-21.29	14.50	1.16

PUMP TEST DATA

TABLE F-14

GBR 14 (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	31.00	8.00	31.67	0.00	0.00	ERR
1348.00	108.00	35.00	2.00	35.17	-3.50	108.00	2.03
945.00	1305.00	39.00	1.00	39.08	-7.42	1197.00	3.12
1430.00	1590.00	39.00	1.00	39.08	-7.42	285.00	3.20
1845.00	1845.00	39.00	5.00	39.42	-7.75	255.00	3.27
939.00	2739.00	39.00	5.00	39.42	-7.75	894.00	3.44
1609.00	3129.00	39.00	5.00	39.42	-7.75	390.00	3.50

PUMP TEST DATA

TABLE F-15

GBR 27(a) (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	29.00	7.00	29.58	0.00	0.00	ERR
1415.00	135.00	NONE	NONE	--	--	135.00	2.13
1820.00	380.00	NONE	NONE	--	--	245.00	2.58
926.00	1286.00	NONE	NONE	--	--	906.00	3.11
1444.00	1604.00	NONE	NONE	--	--	318.00	3.21
1849.00	1849.00	NONE	NONE	--	--	245.00	3.27
849.00	2689.00	NONE	NONE	--	--	840.00	3.43
1629.00	3149.00	NONE	NONE	--	--	460.00	3.50

PUMP TEST DATA

TABLE F-16

GBR 27 (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	29.00	8.00	29.67	0.00	0.00	ERR
1415.00	135.00	36.00	4.00	36.33	-6.67	135.00	2.13
1820.00	380.00	37.00	2.00	37.17	-7.50	245.00	2.58
926.00	1286.00	38.00	0.00	38.00	-8.33	906.00	3.11
1444.00	1604.00	38.00	11.00	38.92	-9.25	318.00	3.21
1849.00	1849.00	39.00	7.00	39.58	-9.92	245.00	3.27
849.00	2689.00	39.00	7.00	39.58	-9.92	840.00	3.43
1629.00	3149.00	40.00	5.00	40.42	-10.75	460.00	3.50

PUMP TEST DATA

TABLE F-17

GBR 28(a) (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	33.00	9.00	33.75	0.00	0.00	ERR
1443.00	153.00	TRACE	TRACE	--	--	153.00	2.18
1815.00	375.00	TRACE	TRACE	--	--	222.00	2.57
921.00	1281.00	TRACE	TRACE	--	--	906.00	3.11
1452.00	1612.00	TRACE	TRACE	--	--	331.00	3.21
1852.00	1052.00	NONE	NONE	--	--	240.00	3.27
908.00	2708.00	NONE	NONE	--	--	856.00	3.43
1635.00	3155.00	NONE	NONE	--	--	447.00	3.50

PUMP TEST DATA

TABLE F-18

GBR 28 (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	33.00	10.50	33.88	0.00	0.00	ERR
1443.00	153.00	34.00	5.50	34.46	-0.58	153.00	2.18
1815.00	375.00	34.00	6.00	34.50	-0.63	222.00	2.57
921.00	1281.00	34.00	6.00	34.50	-0.63	906.00	3.11
1452.00	1612.00	34.00	7.00	34.58	-0.71	331.00	3.21
1852.00	1852.00	34.00	7.00	34.58	-0.71	240.00	3.27
908.00	2708.00	34.00	7.00	34.58	-0.71	856.00	3.43
1635.00	3155.00	34.00	7.00	34.58	-0.71	447.00	3.50

PUMP TEST DATA

TABLE F-19

GBR 15 (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	30.00	9.00	30.75	0.00	0.00	ERR
1351.00	111.00	32.00	0.50	32.04	-1.29	111.00	2.05
1842.00	402.00	33.00	4.00	33.33	-2.58	291.00	2.60
941.00	1301.00	34.00	7.50	34.63	-3.88	899.00	3.11
1434.00	1594.00	35.00	3.50	35.29	-4.54	293.00	3.20
1834.00	1834.00	35.00	7.00	35.58	-4.83	240.00	3.26
924.00	2724.00	35.00	7.00	35.58	-4.83	890.00	3.44
1612.00	3132.00	35.00	7.50	35.63	-4.88	408.00	3.50

PUMP TEST DATA

TABLE F-20

GBR 21S(b) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	21.00	6.00	21.50	0.00	0.00	ERR
1423.00	143.00	21.00	6.00	21.50	0.00	143.00	2.16
1822.00	382.00	21.00	6.00	21.50	0.00	239.00	2.58
928.00	1288.00	21.00	6.50	21.54	-0.04	906.00	3.11
1447.00	1607.00	21.00	6.50	21.54	-0.04	319.00	3.21
916.00	2716.00	21.00	6.50	21.54	-0.04	1109.00	3.43
1639.00	3159.00	21.00	6.50	21.54	-0.04	443.00	3.50

PUMP TEST DATA

TABLE F-21

GBR 21D (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	31.00	4.50	31.38	0.00	0.00	ERR
1443.00	163.00	32.00	5.00	32.42	-1.04	163.00	2.21
1824.00	384.00	32.00	7.00	32.58	-1.21	221.00	2.58
931.00	1291.00	33.00	7.00	33.58	-2.21	907.00	3.11
1439.00	1599.00	33.00	11.00	33.92	-2.51	608.00	3.20
918.00	2718.00	34.00	9.00	34.75	-3.38	1119.00	3.43
1620.00	3140.00	34.00	11.50	34.96	-3.58	422.00	3.50

PUMP TEST DATA

TABLE F-22

GBR 23(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	23.00	11.75	29.67	0.00	0.00	ERR
1426.00	146.00	TRACE	TRACE	--	--	146.00	2.16
1847.00	407.00	TRACE	TRACE	--	--	261.00	2.61
936.00	1296.00	TRACE	TRACE	--	--	889.00	3.11
1449.00	1609.00	TRACE	TRACE	--	--	313.00	3.21
1858.00	1858.00	NONE	NONE	--	--	249.00	3.27
846.00	2686.00	NONE	NONE	--	--	828.00	3.43
1633.00	3153.00	NONE	NONE	--	--	467.00	3.50

PUMP TEST DATA

TABLE F-23

GBR 23 (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	24.00	0.00	24.00	0.00	0.00	ERR
1426.00	146.00	24.00	5.50	24.46	-0.46	146.00	2.16
1847.00	407.00	24.00	3.50	24.29	-0.29	261.00	2.61
936.00	1296.00	24.00	3.00	24.25	-0.25	889.00	3.11
1449.00	1609.00	24.00	3.00	24.25	-0.25	313.00	3.21
1858.00	1858.00	24.00	2.00	24.17	-0.17	249.00	3.27
846.00	2686.00	24.00	2.00	24.17	-0.17	828.00	3.43
1633.00	3153.00	24.00	0.00	24.00	0.00	467.00	3.50

PUMP TEST DATA

TABLE F-24

GBR 24S(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	26.00	6.25	26.52	0.00	0.00	ERR
1401.00	121.00	26.00	9.25	26.77	-0.25	121.00	2.08
1835.00	395.00	27.00	5.50	27.46	-0.94	274.00	2.60
949.00	1309.00	27.00	7.50	27.63	-1.10	914.00	3.12
1524.00	1644.00	27.00	8.50	27.71	-1.19	335.00	3.22
1824.00	1824.00	27.00	9.25	27.77	-1.25	100.00	3.26
946.00	2746.00	TRACE	TRACE	--	--	927.00	3.44
1644.00	3164.00	NONE	NONE	--	--	418.00	3.50

PUMP TEST DATA

TABLE F-25

GBR 24S (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	26.00	6.50	26.54	0.00	0.00	ERR
1401.00	121.00	26.00	9.50	26.79	-0.25	121.00	2.08
1835.00	395.00	27.00	6.00	27.50	-0.96	274.00	2.60
949.00	1309.00	27.00	8.00	27.67	-1.13	914.00	3.12
1524.00	1644.00	27.00	9.00	27.75	-1.21	335.00	3.22
1824.00	1824.00	27.00	9.50	27.79	-1.25	180.00	3.26
946.00	2746.00	28.00	0.00	28.00	-1.46	922.00	3.44
1644.00	3164.00	28.00	0.00	28.00	-1.46	418.00	3.50

PUMP TEST DATA

TABLE F-26

GBR 24D (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	27.00	5.00	27.42	0.00	0.00	ERR
1358.00	118.00	28.00	1.00	28.08	-0.67	118.00	2.07
1837.00	397.00	28.00	1.50	28.13	-0.71	279.00	2.60
947.00	1307.00	29.00	5.00	29.42	-2.00	910.00	3.12
1521.00	1641.00	29.00	6.50	29.54	-2.13	334.00	3.22
1822.00	1822.00	29.00	7.50	29.63	-2.21	181.00	3.26
948.00	2748.00	29.00	7.50	29.63	-2.21	926.00	3.44
1617.00	3137.00	29.00	7.50	29.63	-2.21	389.00	3.50

PUMP TEST DATA

TABLE F-27

GBR 25 (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	29.00	0.00	29.00	0.00	0.00	ERR
1445.00	165.00	29.00	4.50	29.38	-0.38	165.00	2.22
1849.00	409.00	29.00	8.00	29.67	-0.67	244.00	2.61
934.00	1294.00	30.00	0.00	30.00	-1.00	885.00	3.11
1441.00	1601.00	30.00	0.00	30.00	-1.00	307.00	3.20
1856.00	1856.00	30.00	1.00	30.08	-1.08	255.00	3.27
844.00	2884.00	30.00	1.00	30.08	-1.08	1028.00	3.46
1623.00	3143.00	30.00	1.00	30.08	-1.08	259.00	3.50

PUMP TEST DATA

TABLE F-28

GBR 26(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	31.00	1.50	31.13	0.00	0.00	ERR
1408.00	128.00	31.00	2.00	31.17	-0.04	128.00	2.11
1828.00	388.00	31.00	3.00	31.25	-0.13	260.00	2.59
959.00	1319.00	31.00	4.00	31.33	-0.21	931.00	3.12
1455.00	1615.00	31.00	4.00	31.33	-0.21	296.00	3.21
1832.00	1832.00	31.00	4.00	31.33	-0.21	217.00	3.26
921.00	2721.00	31.00	4.50	31.38	-0.25	889.00	3.43
1652.00	3172.00	31.00	4.50	31.38	-0.25	451.00	3.50

PUMP TEST DATA

TABLE F-29

GBR 26(b) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	31.00	1.50	31.13	0.00	0.00	ERR
1408.00	128.00	31.00	4.00	31.33	-0.21	128.00	2.11
1828.00	388.00	31.00	5.00	31.42	-0.29	260.00	2.59
959.00	1319.00	31.00	6.00	31.50	-0.38	931.00	3.12
1455.00	1615.00	31.00	6.00	31.50	-0.38	296.00	3.21
1832.00	1832.00	31.00	6.00	31.50	-0.38	217.00	3.26
921.00	2721.00	31.00	6.00	31.50	-0.38	889.00	3.43
1652.00	3172.00	31.00	6.00	31.50	-0.38	451.00	3.50

PUMP TEST DATA

TABLE F-30

GBR 30(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	31.00	4.00	31.33	0.00	0.00	ERR
1405.00	125.00	31.00	5.00	31.42	-0.08	125.00	2.10
1832.00	392.00	31.00	5.50	31.46	-0.13	267.00	2.59
957.00	1317.00	31.00	6.00	31.50	-0.17	925.00	3.12
1527.00	1647.00	31.00	6.00	31.50	-0.17	330.00	3.22
1829.00	1829.00	31.00	6.00	31.50	-0.17	182.00	3.26
930.00	2730.00	31.00	6.00	31.50	-0.17	901.00	3.44
1649.00	3169.00	NONE	NONE	--	--	439.00	3.50

PUMP TEST DATA

TABLE F-31

GBR 30 (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	31.00	6.00	31.50	0.00	0.00	ERR
1405.00	125.00	31.00	6.00	31.50	0.00	125.00	2.10
1832.00	392.00	31.00	6.00	31.50	0.00	267.00	2.59
957.00	1317.00	31.00	7.00	31.58	-0.08	925.00	3.12
1527.00	1647.00	31.00	7.00	31.58	-0.08	330.00	3.22
1829.00	1829.00	31.00	7.00	31.58	-0.08	182.00	3.26
930.00	2730.00	31.00	7.00	31.58	-0.08	901.00	3.44
1649.00	3169.00	31.00	7.00	31.58	-0.08	439.00	3.50

PUMP TEST DATA

TABLE F-32

STEEL WELL (OBS WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	DEPTH TO WATER INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	29.00	9.50	29.79	0.00	0.00	ERR
1354.00	114.00	29.00	10.00	29.83	-0.04	114.00	2.06
1844.00	404.00	30.00	0.00	30.00	-0.21	290.00	2.61
942.00	1302.00	30.00	1.00	30.08	-0.29	898.00	3.11
1436.00	1596.00	30.00	2.00	30.17	-0.38	294.00	3.20
1836.00	1836.00	30.00	2.00	30.17	-0.38	240.00	3.26
926.00	2726.00	30.00	2.00	30.17	-0.38	890.00	3.44
1615.00	3135.00	30.00	2.00	30.17	-0.38	409.00	3.50

ANALYSIS OF MULTIPLE-WELL AQUIFER TEST DATA OBTAINED IN DIESEL SPILL AREA

Recent pumping performed simultaneously at wells GBR-14, GBR-27, and GBR-28 resulted in three separate cones of depression in the diesel spill area. Analysis of the drawdown data plotted in Figures F-17 through F-29 and listed in Tables F-8 to F-26 at each of the pump and observation wells involved separation of the effects of each pump well on total drawdown. Assuming that drawdown at all wells was sufficiently small to maintain constant transmissivity during the pump test and that flow could therefore be described using the Theis equation, drawdown due to simultaneous operation of several pump wells was additive. Therefore, separation of drawdown effects could be performed using the principle of superposition.

Drawdown at all observation wells was predicted using a simple computer program based on the Theis equation and the principle of superposition. Output from this program was considered to be a first approximation of drawdown generated by simultaneous discharge at the three pump wells.

Drawdown at each observation well due to separate pumping at each discharging well was calculated by the program using the equations:

$$u = \frac{1.87\ r^2 S}{Tt}$$

$$s = \frac{114.6\ Q\ W(u)}{T}$$

where

T = transmissivity between any pair of pump and observation wells (gpd/ft)

S = storativity between any pair of pump and observation wells

Q = discharge at the pump well (gpm)

r = distance between the pump and observation well (ft)

t = time since pumping began (days)

s = drawdown at the observation well (ft)

W(u) = the well function

The well function was approximated using the series

$$W(u) = -0.5772 - \ln u + u - \frac{u^2}{2x2!} + \frac{u^3}{3x3!} - \frac{u^4}{4x4!} + \frac{u^5}{5x5!}$$

Use of a greater number of terms resulted in computer storage overflow during program execution for certain values of T and S.

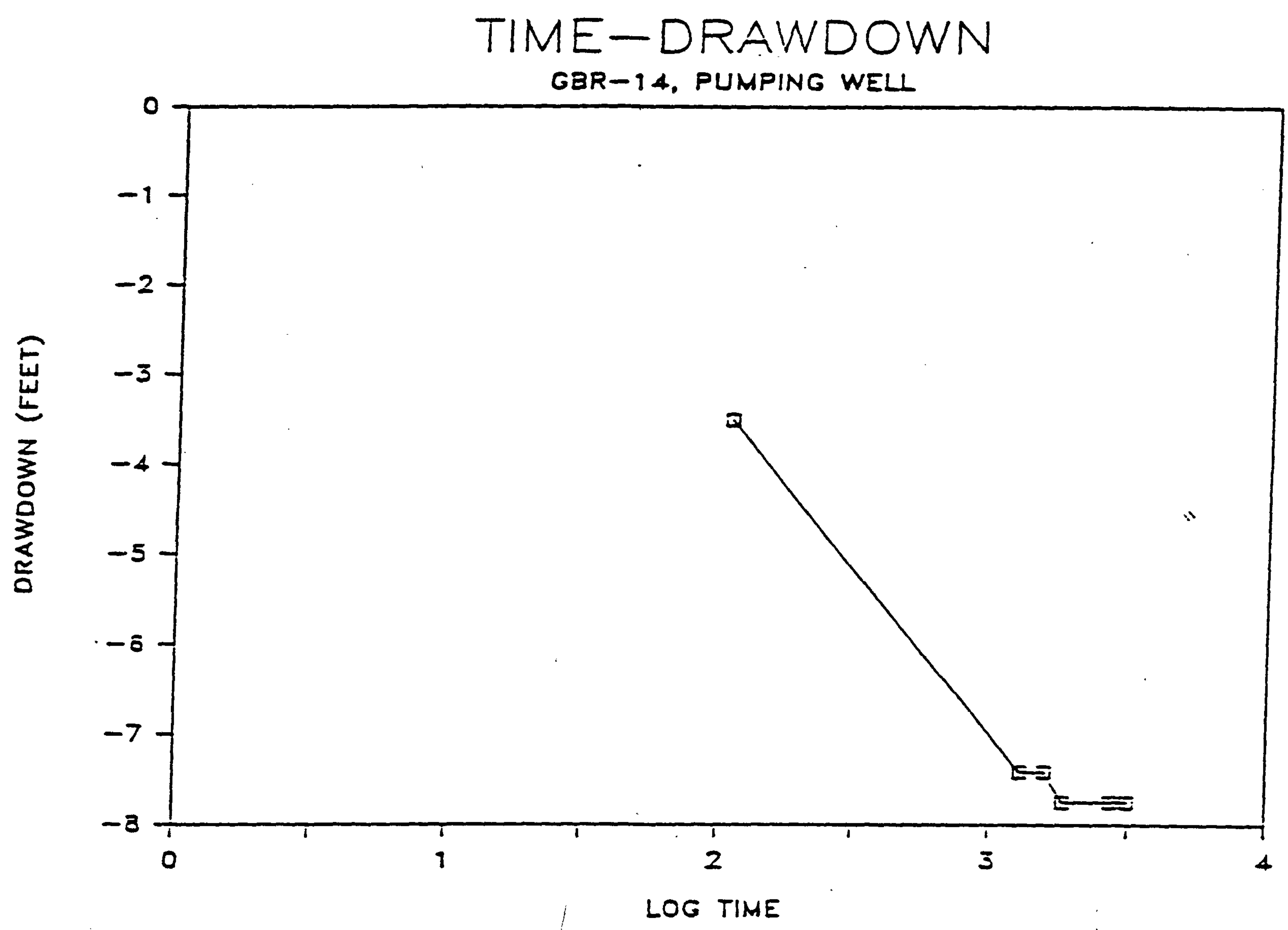
Average transmissivity and storativity values obtained as a result of pump tests performed at wells GBR-14 and GBR-27 were used to characterize the semi-confined part of the aquifer in the diesel spill area. Although GBR-14 was completed in the alluvium and most of the other wells were completed in the underlying consolidated sandstone, these two units were considered to be in hydraulic connection over much of the test area, as evidenced by the response of GBR-8 to pumping in GBR-29. Drawdown was predicted at all wells in response to each pumping well regardless of the unit of completion.

T and S for well GBR-28, for which no previous pump test had been performed, were initially adjusted until calculated drawdown responses at GBR-28 due to discharge at all three wells summed up to the observed response during times sufficiently early to approximate Theis behavior but sufficiently late to allow well interference to develop. Based on this approach, very large values of T and S were required to match drawdown at GBR-28.

Use of lower values of T and S for GBR-28 produced excessively large predicted drawdowns at the well when the effects of pumping at all wells were summed. There was geologic evidence that clayey sands south of GBR-14 and shale near GBR-27 could be inhibiting flow from GBR-28 to these wells, producing smaller drawdown at GBR-28 than predicted. When it was assumed that drawdown at GBR-28 was primarily influenced by pumping at GBR-28, a transmissivity of 2100 gpd/ft and a storativity of 0.02 were determined iteratively by adjusting T and S until predicted drawdown at this well due to its own pumping matched total observed drawdown. These large values of T and S relative to those obtained at the other pump wells may be related to the predominance of coarse-grained sandstone and cobbles encountered at this well, as evidenced by geologic logs.

Total observed drawdown at pump wells GBR-14 and GBR-27 is as much as three times the predicted drawdown when the drawdown influences of all pump wells are summed. These discrepancies are presumably the result of the interception of expanding cones of depression with low-permeability fine-grained sandstone, shale, or clay, which would tend to cause larger drawdowns than those predicted on the basis of the Theis equation.

Although the number of variables influencing drawdown in the aquifers underlying the site are too numerous to include in a simple Theis model, results imply that fine-grained sandstone, shale, and clay are more predominant in the northern part of the diesel spill area and that coarse-grained sandstone dominate the geology in the southern part of the spill area and in the southern refinery area. Flow conditions appear to range from confined near GBR-27 where shale is present, to semi-confined near GBR-14 where clay is present, to unconfined near GBR-28 and to the south, where discontinuous clay and shale layers do not significantly affect flow on a regional scale.



TIME—DRAWDOWN
GBR—14, PUMPING WELL
DRAWDOWN (FEET)
0
−1
−2
−3
−4
−5
−6
−7
−8
0
1
2
3
4
LOG TIME

FIGURE F-17

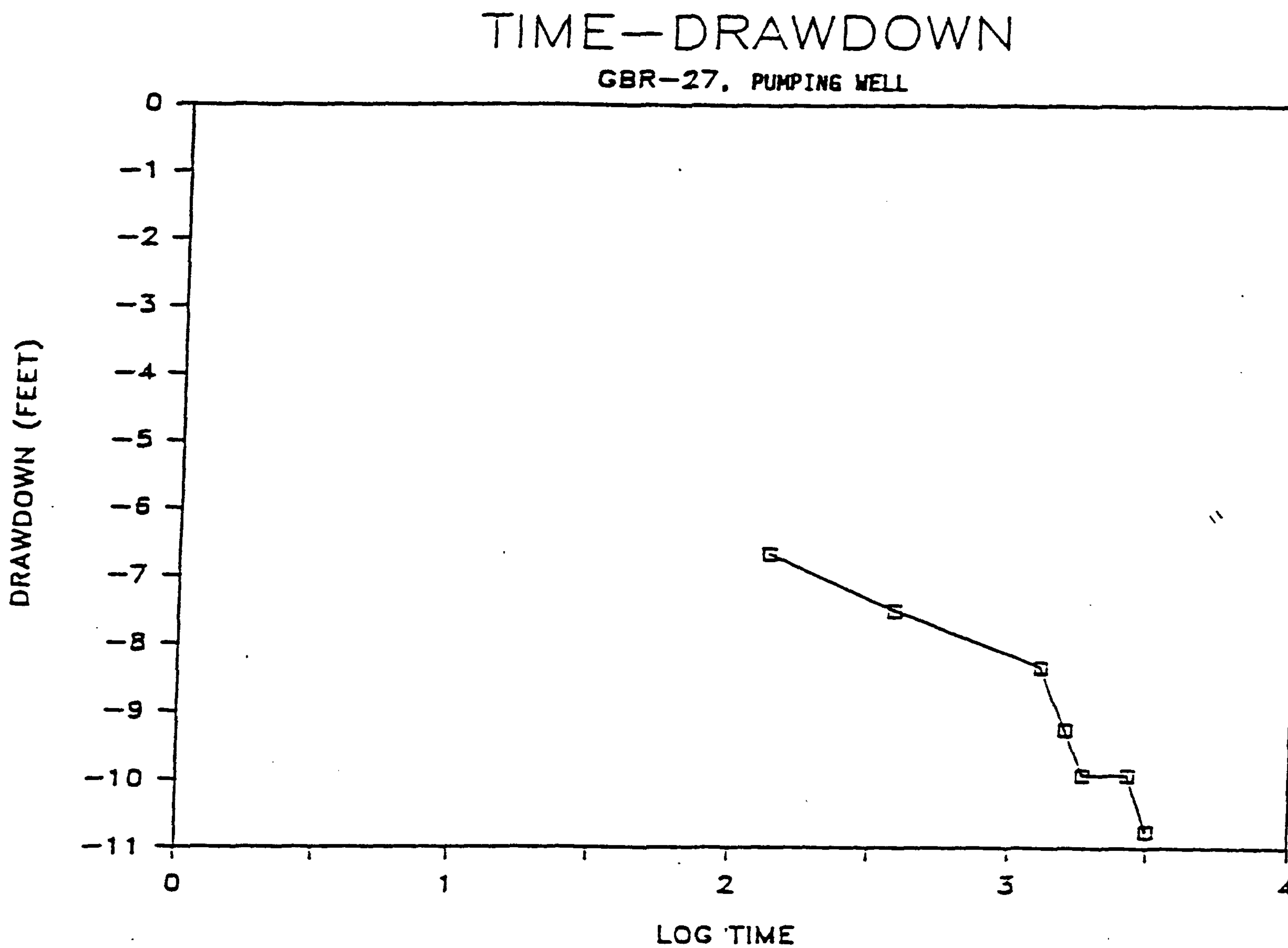

TIME—DRAWDOWN
GBR—27. PUMPING WELL
DRAWDOWN (FEET)
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
−10
−11
0
1
2
3
4
LOG TIME

FIGURE F-18

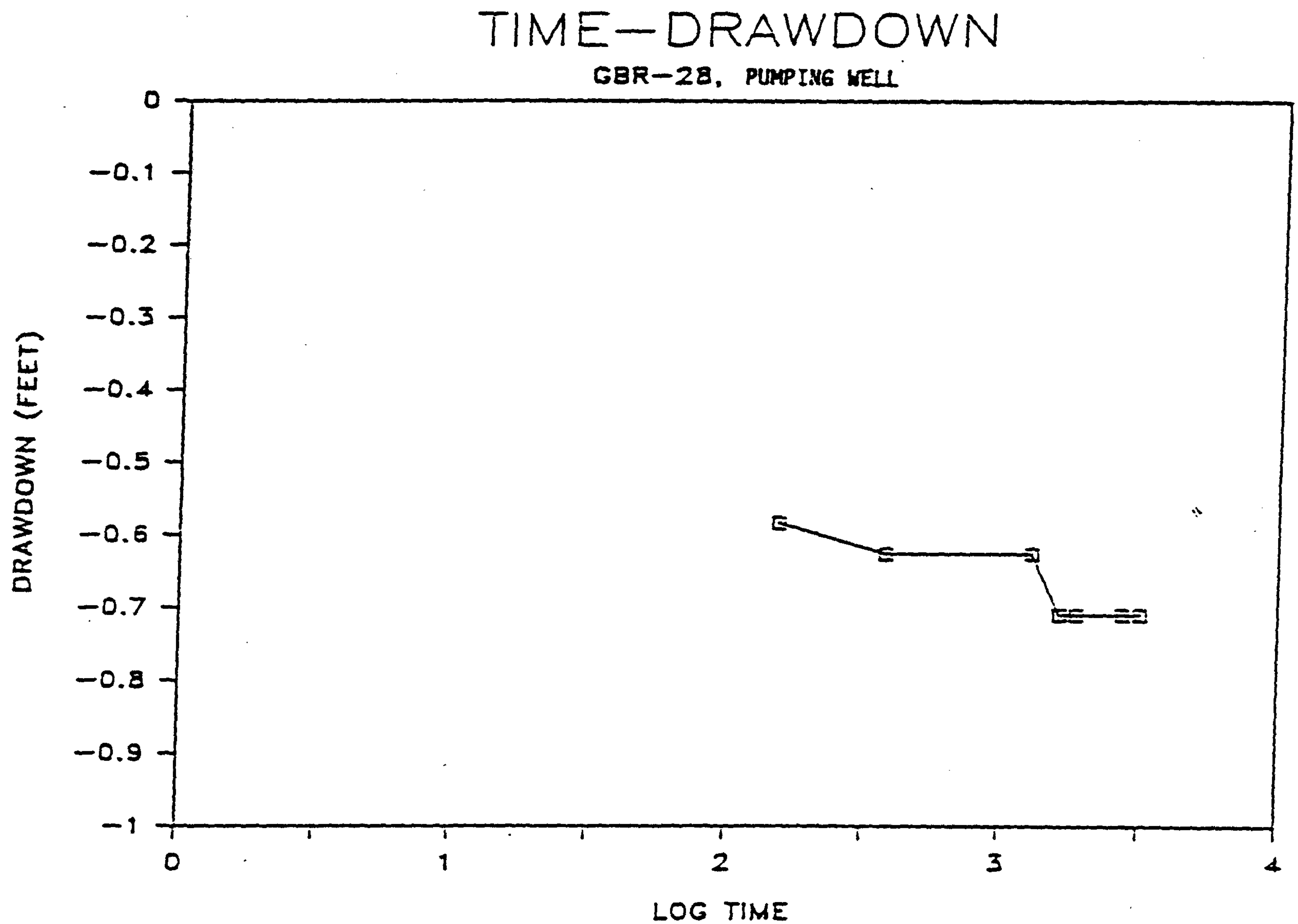
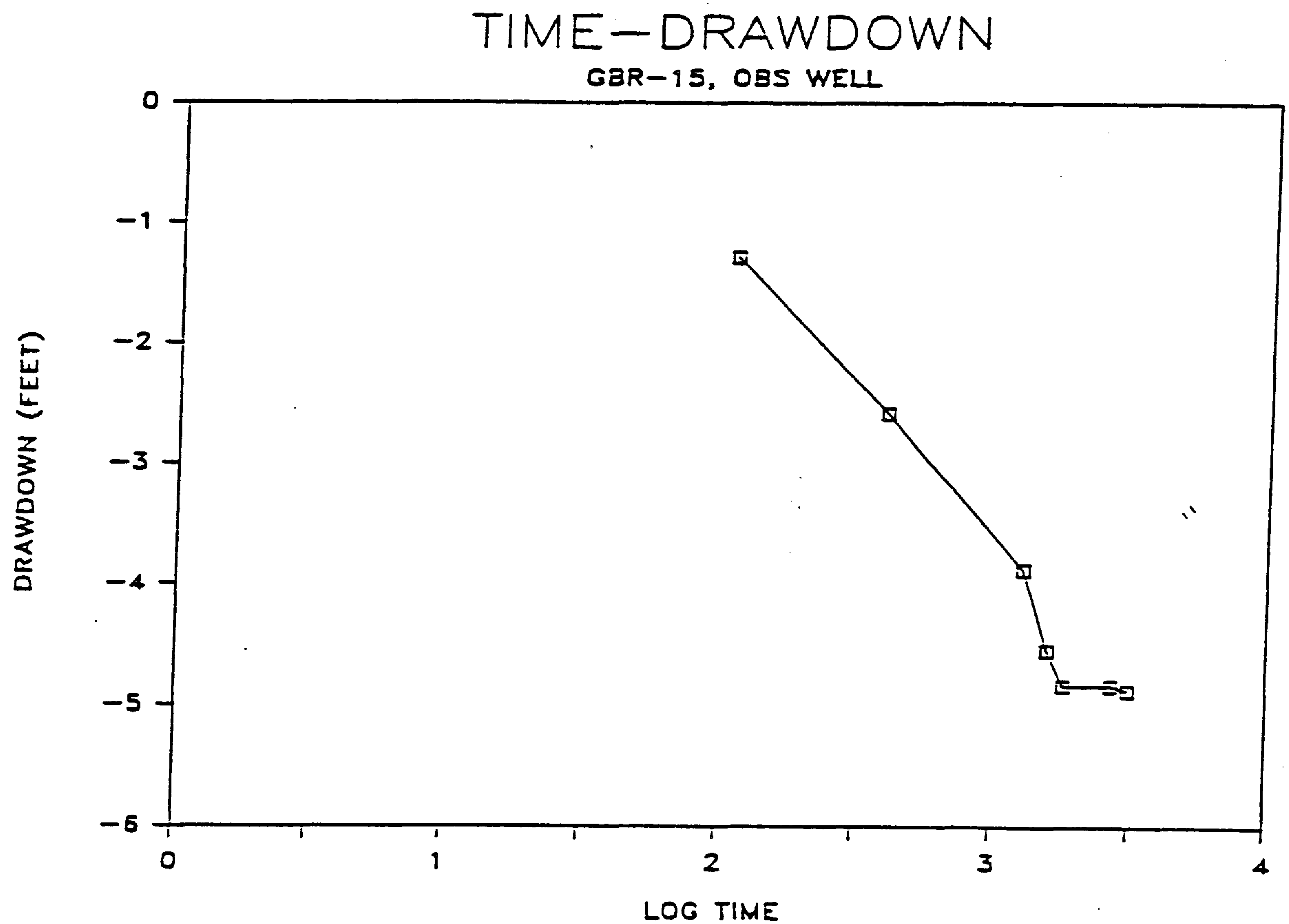

TIME—DRAWDOWN
GBR—28, PUMPING WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1
0
1
2
3
4
LOG TIME

FIGURE F-19



TIME—DRAWDOWN
GBR—15, OBS WELL
DRAWDOWN (FEET)
0
-1
-2
-3
-4
-5
-6
0
1
2
3
4
LOG TIME

FIGURE F-20

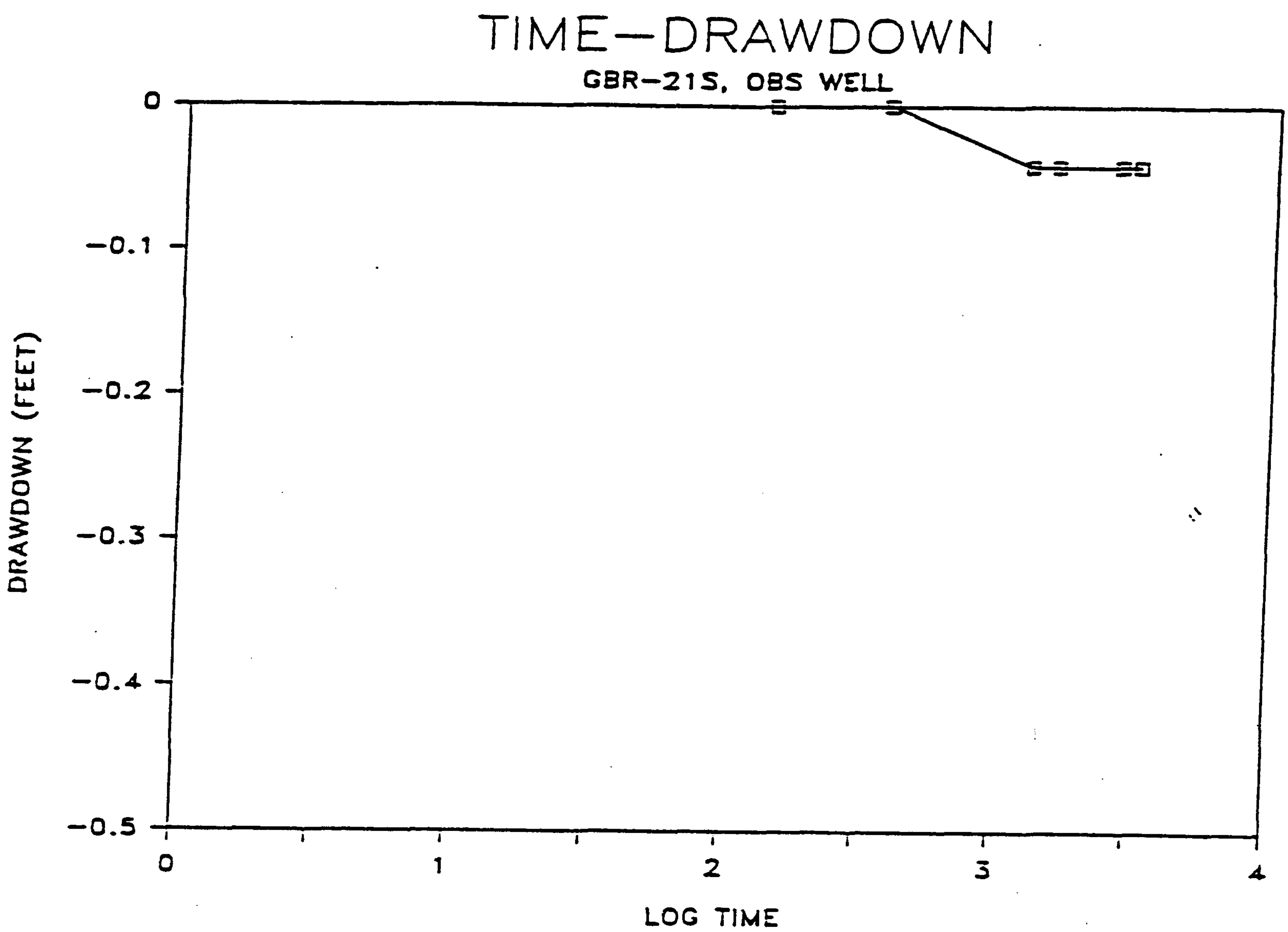

TIME—DRAWDOWN
GBR—21S, OBS WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
0
1
2
3
4
LOG TIME

FIGURE F-21

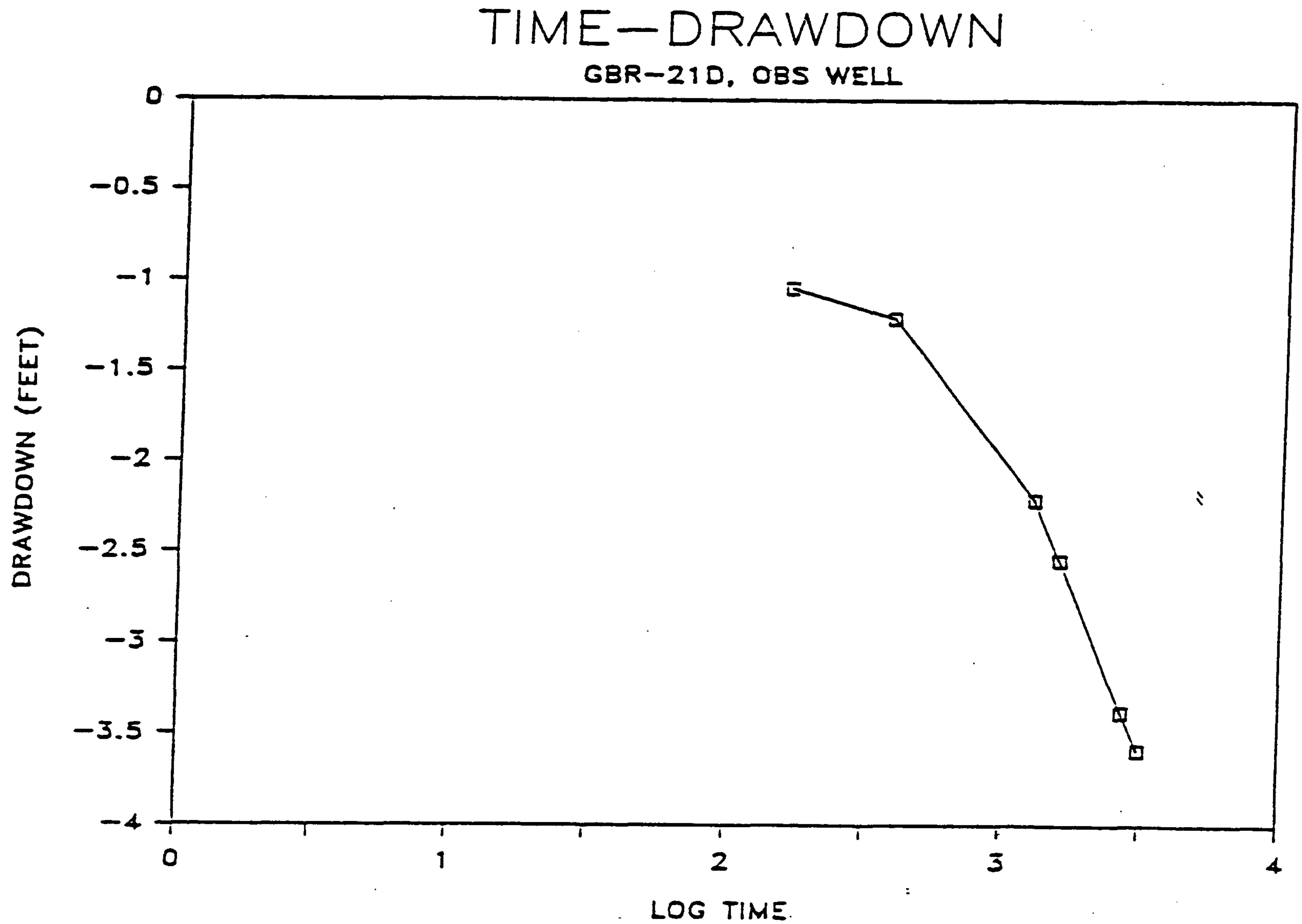

TIME—DRAWDOWN
GBR—21D, OBS WELL
DRAWDOWN (FEET)
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4
LOG TIME
0
1
2
3
4

FIGURE F-22

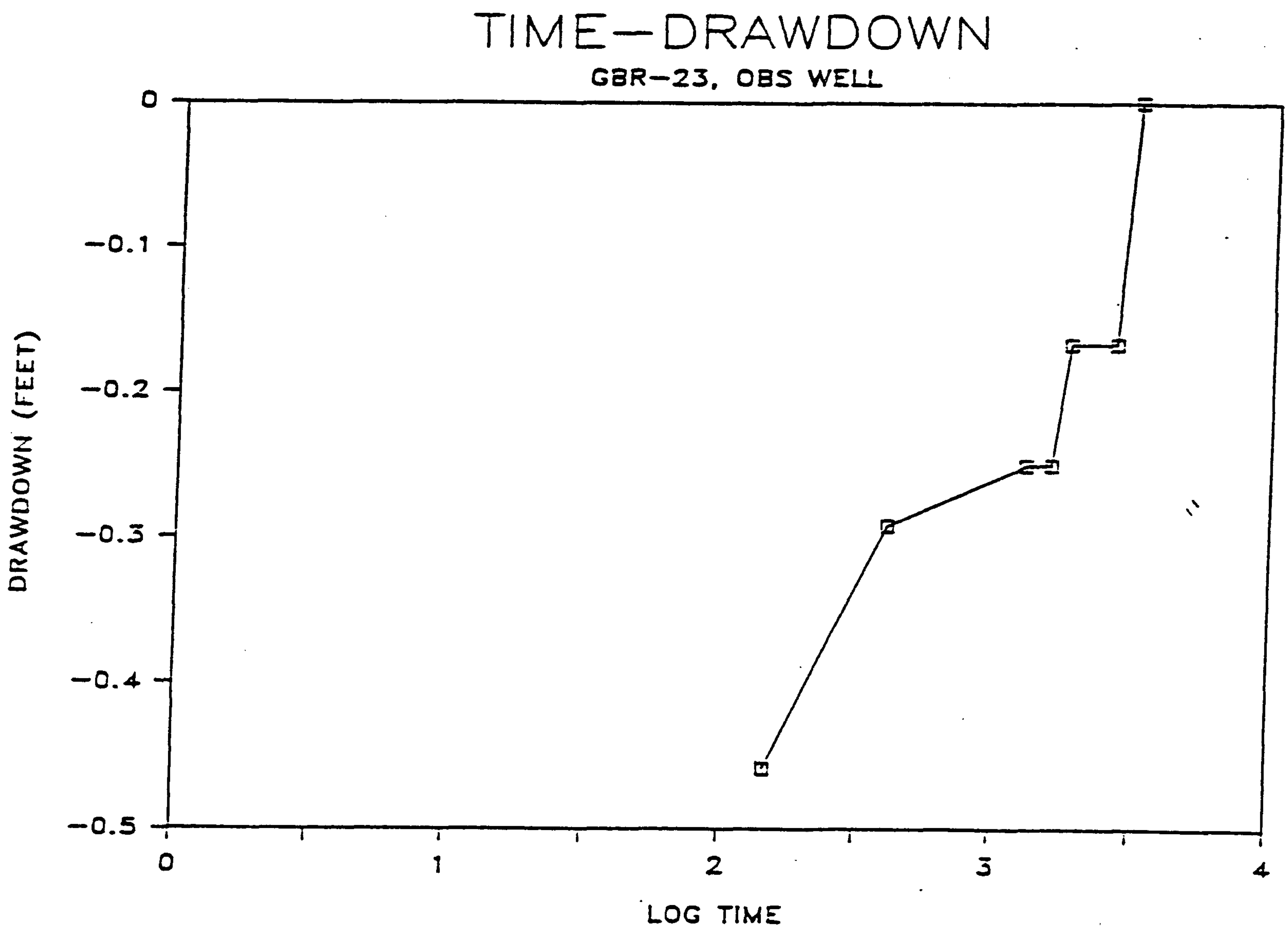

TIME—DRAWDOWN
GBR—23, OBS WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
0
1
2
3
4
LOG TIME

FIGURE F-23

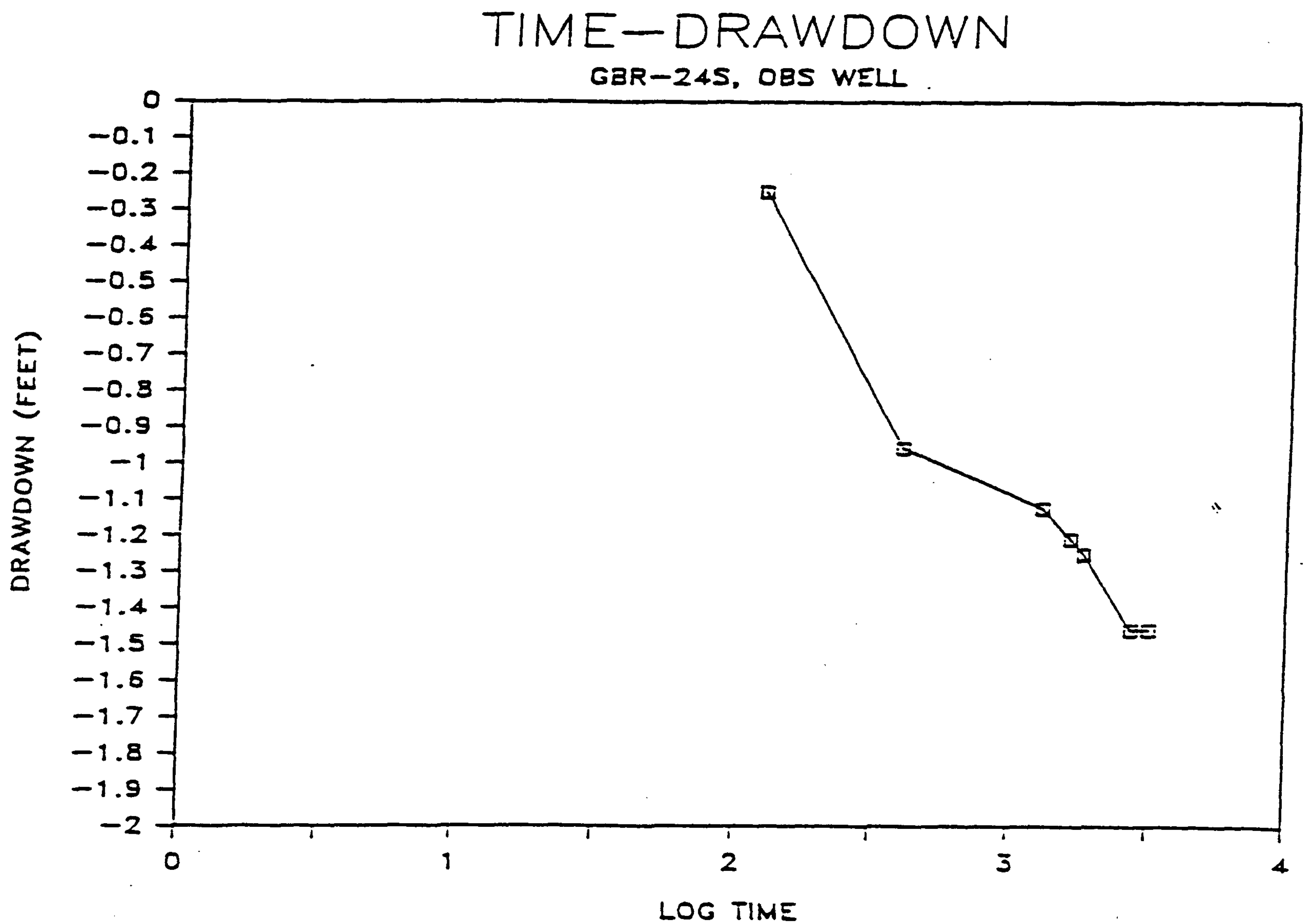
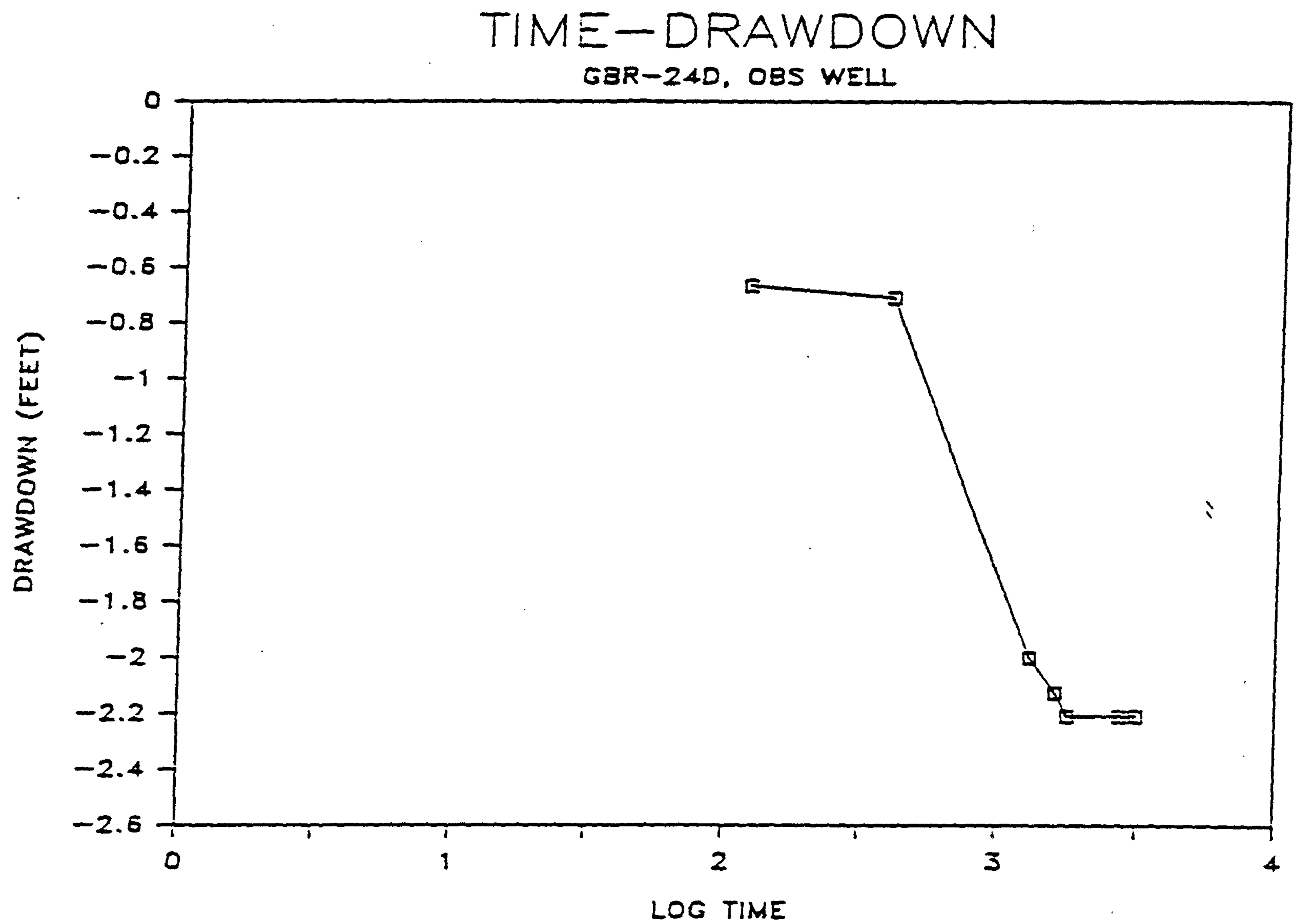

TIME—DRAWDOWN
GBR—24S, OBS WELL
DRAWDOWN (FEET)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
-1.8
-1.9
-2
0
1
2
3
4
LOG TIME

FIGURE F-24



TIME—DRAWDOWN
GBR—24D, OBS WELL
DRAWDOWN (FEET)
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−1.6
−1.8
−2
−2.2
−2.4
−2.6
0
1
2
3
4
LOG TIME

FIGURE F-25

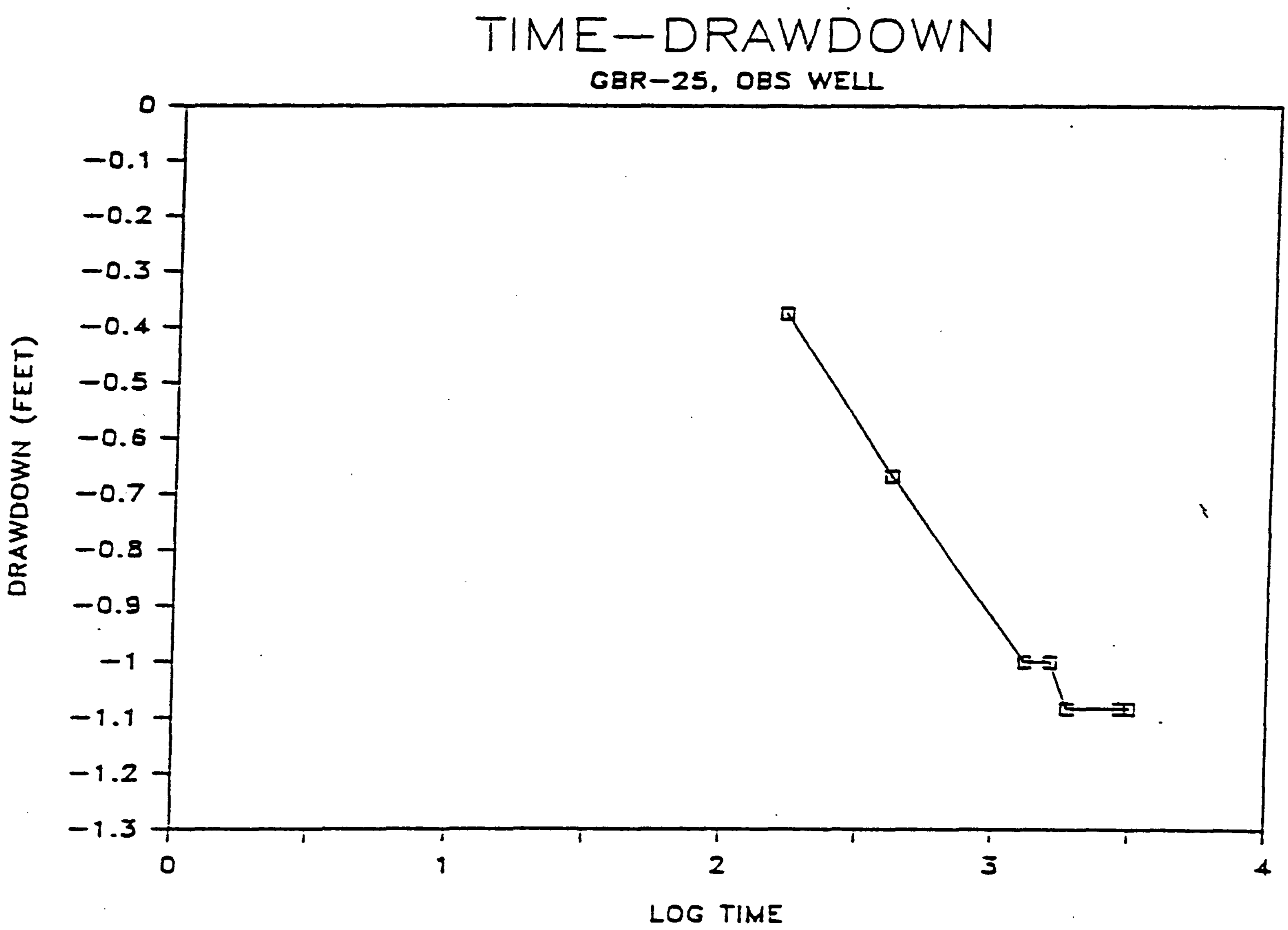

TIME—DRAWDOWN
GBR—25, OBS WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1
−1.1
−1.2
−1.3
0
1
2
3
4
LOG TIME

FIGURE F-26

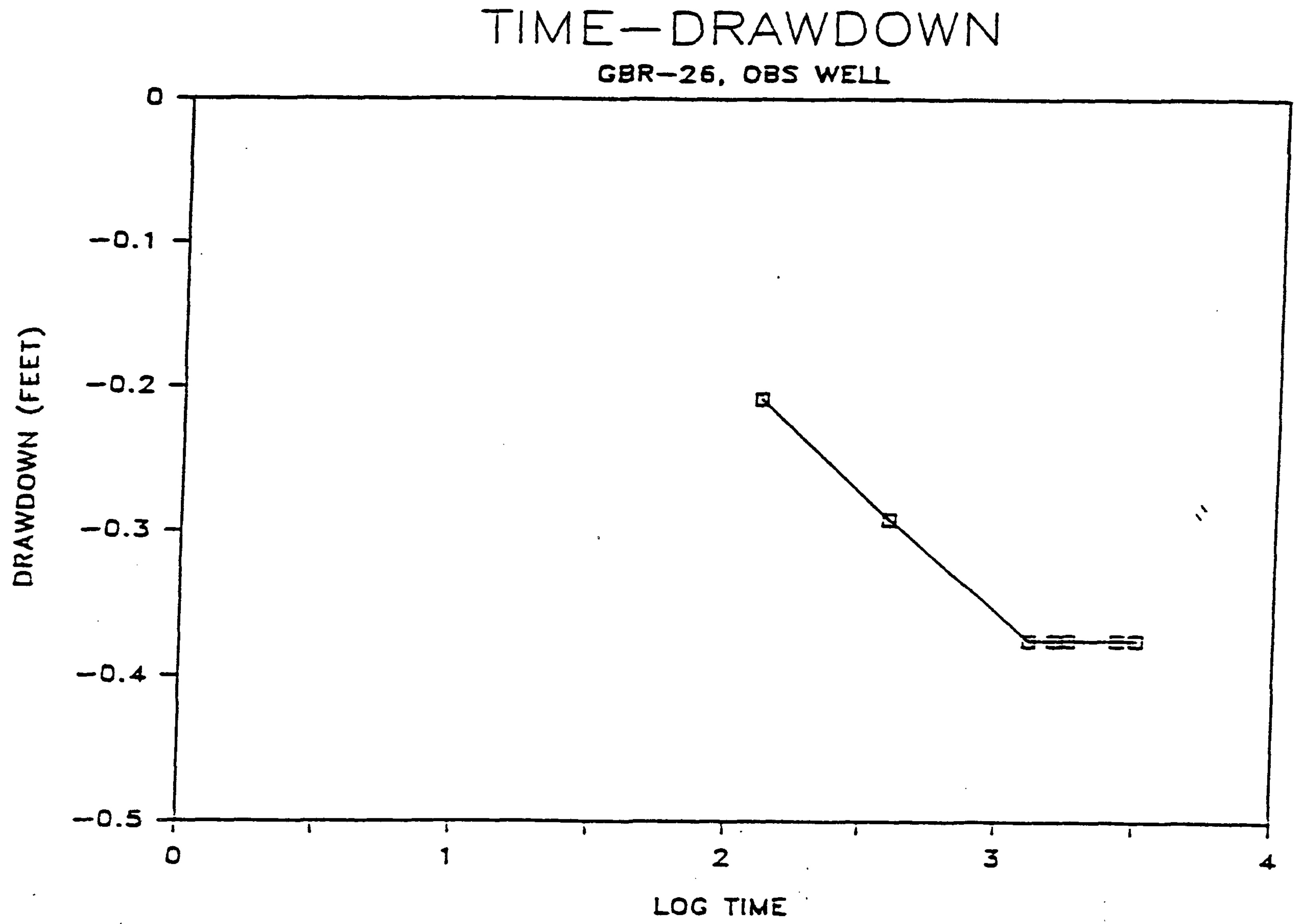

TIME—DRAWDOWN
GBR—26, OBS WELL
0
−0.1
−0.2
−0.3
−0.4
−0.5
DRAWDOWN (FEET)
0
1
2
3
4
LOG TIME

FIGURE F-27

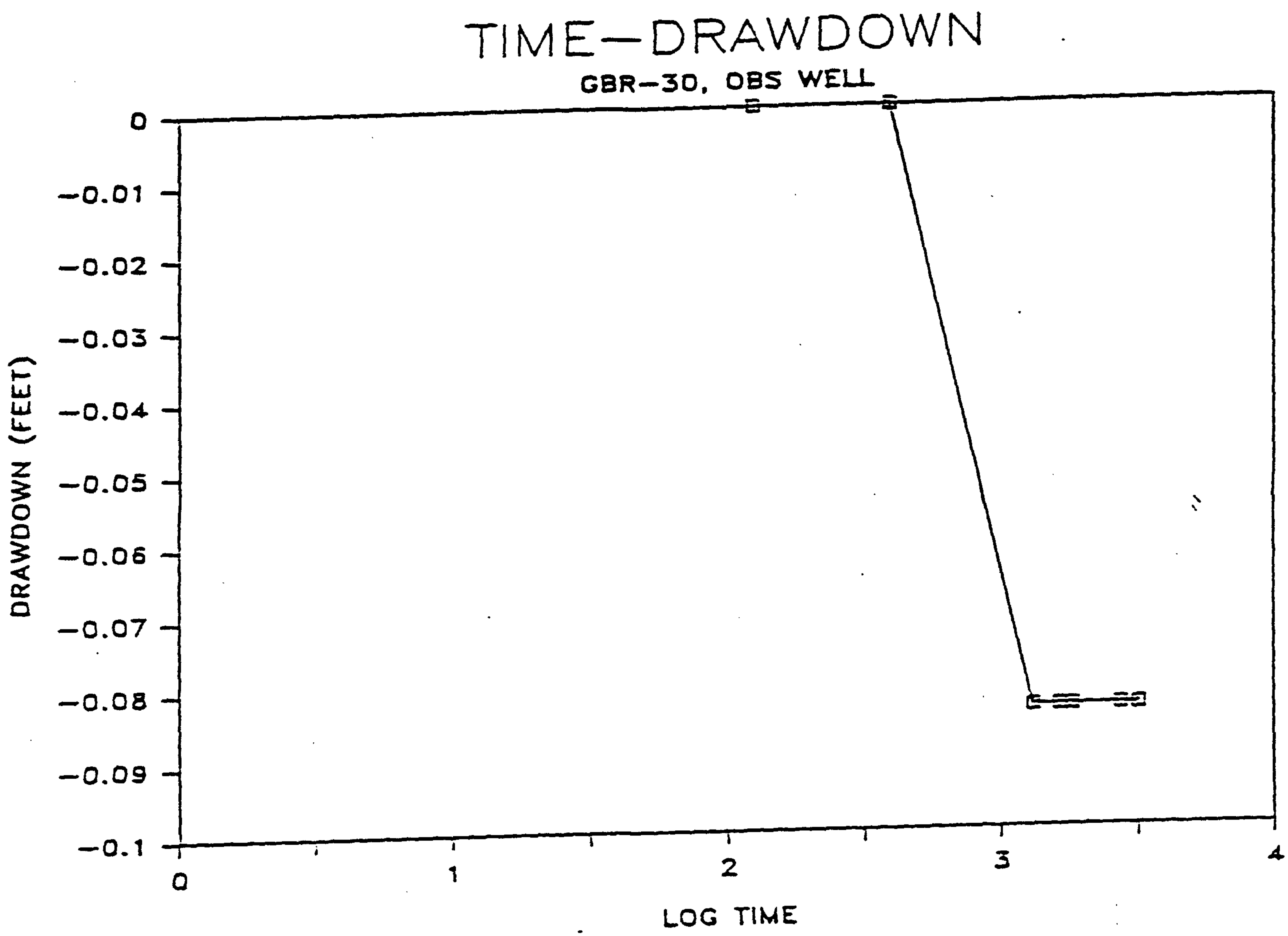

TIME—DRAWDOWN
GBR—30, OBS WELL
0
−0.01
−0.02
−0.03
−0.04
−0.05
−0.06
−0.07
−0.08
−0.09
−0.1
DRAWDOWN (FEET)
0
1
2
3
4
LOG TIME

FIGURE F-28

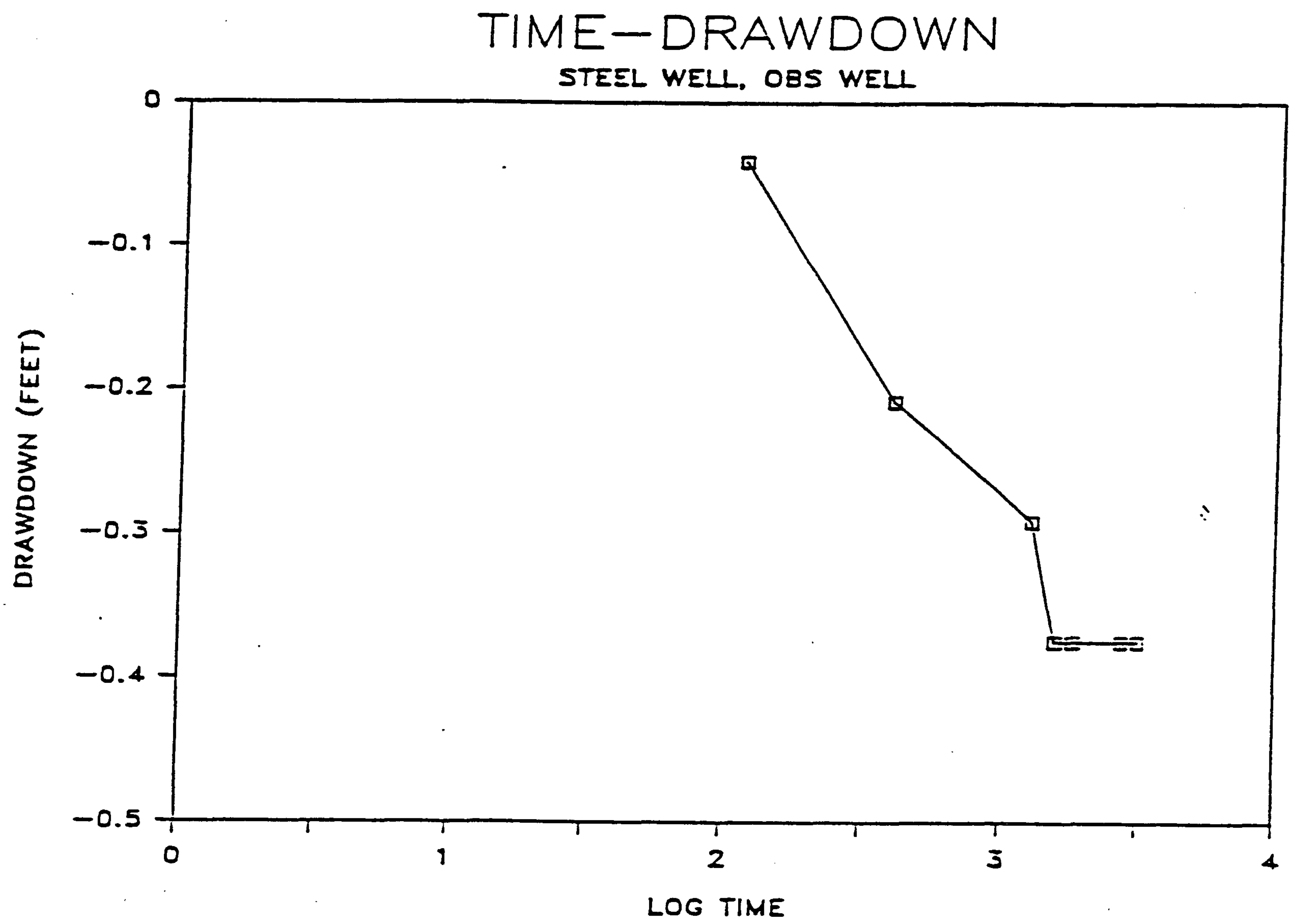
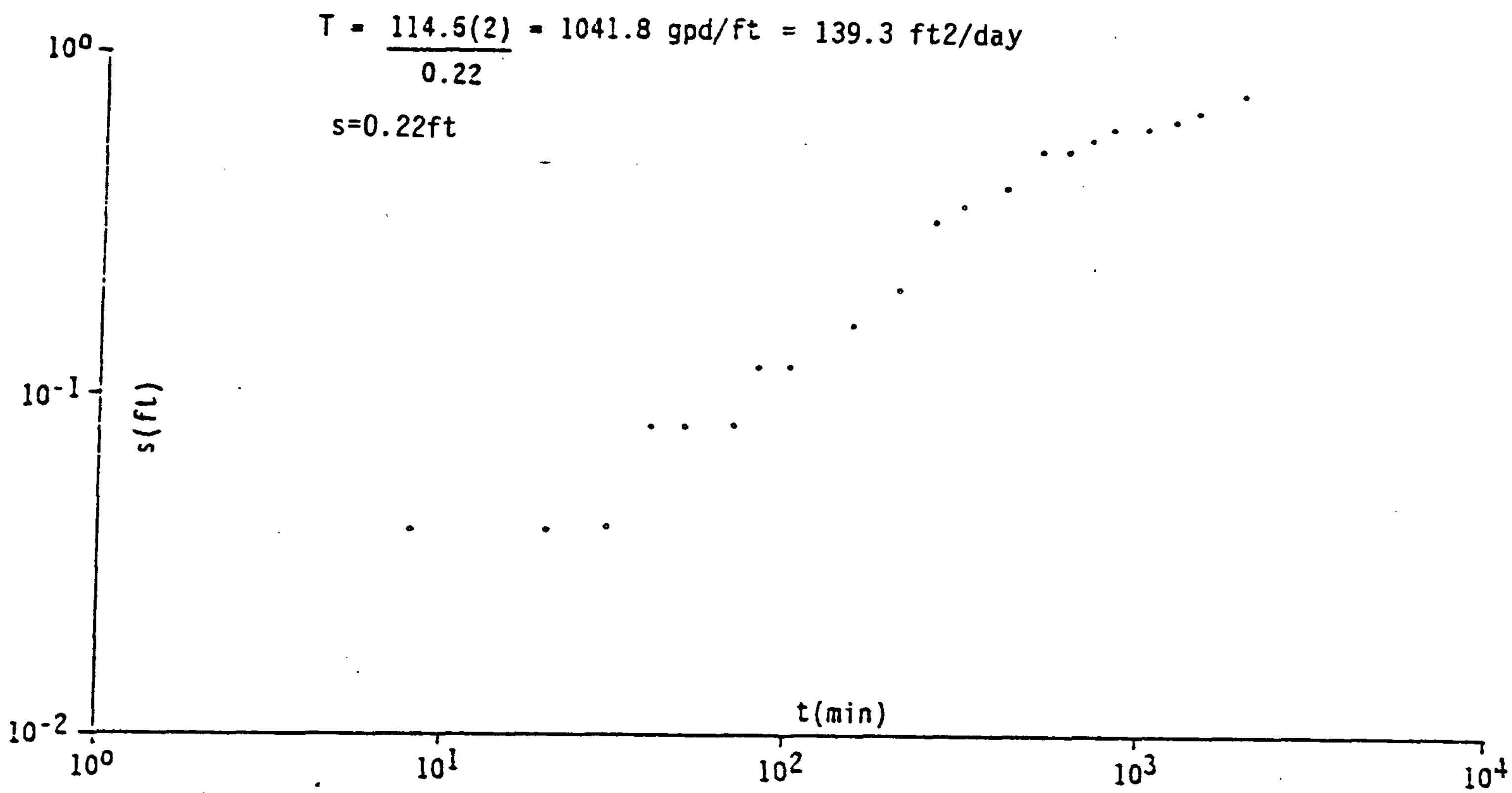

TIME—DRAWDOWN
STEEL WELL, OBS WELL
DRAWDOWN (FEET)
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
1
2
3
4
LOG TIME

FIGURE F-29

HYDROGEOLOGIC ANALYSIS OF SANDSTONE IN SOUTHERN REFINERY AREA

The pump test performed in the southern refinery area involved withdrawal of water from GBR-29, which had a screened interval extending throughout the alluvium and the underlying consolidated sandstone. However, since the piezometric surface occurred well below the alluvium, only the sandstone was stressed at the pump well. Observation well GBR-8, which was completed entirely within the alluvium to the northwest of GBR-29, exhibited a measurable response to pumping, indicating that the alluvium and sandstone are hydraulically-connected at the pump test site. Some response was evident at GBR-9, which was completed in sandy clay, silt, and shale at the base of the alluvium, but analysis of the data obtained at this well was hindered by the small resolution of drawdown measurements, which were obtained with an automatic measuring device and were accurate only to the nearest 0.5 inch. Changes in drawdown observed at GBR-9 were not sufficiently large to permit identification of aquifer behavior within the limits of measurement error. Upward leakage of ground water from the locally-confined system underlying the shale near GBR-9 did not appear to measurably influence drawdown at either GBR-29 or 8, as indicated by the absence of a flattened portion of Theis plots of the data recorded at GBR-29 or 8 within the bounds of measurement error. The shale was probably limited in areal extent to the vicinity of GBR-9 and did not contribute significantly to the overlying unconfined system.

Since there was no evidence of deviation from ideal Theis behavior for drawdown observed at GBR-29 or GBR-8, as shown in Figures F-30 and F-31, straightforward Theis fits were used to analyze the data. Transmissivity calculated on the basis of data from GBR-29 was estimated as 139 ft^2/day while T and S from data observed at GBR-8 were determined to equal 313 ft^2/day and 0.051. The moderately-high value of the storage coefficient suggested that shale was absent in the vicinity of the pump test site. Transmissivities calculated from the test can be viewed as overall transmissivities for the unconfined system occurring throughout the alluvium and sandstone in the absence of continuing shale units. An average transmissivity of 226 ft^2/day can therefore be used to characterize the unconfined system underlying the southern refinery area. The estimated value of storativity was well within the range normally encountered in unconfined aquifers.



F-30
DOUBLE LOG PLOT OF DRAWDOWN AT GBR-29

$$T = \frac{114.6(2)}{0.098} = 2338.8 \text{ gpd/ft} = 312.6 \text{ ft}^2\text{/day}$$

$$S = \frac{2338.8(0.128)}{1.87(56.3)^2} = 0.051$$

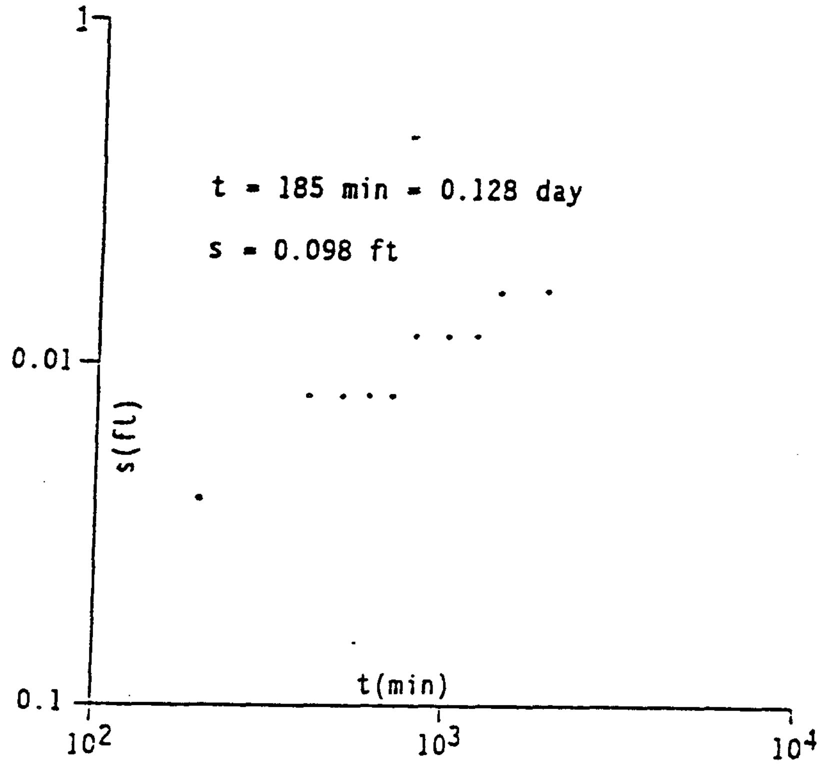


FIGURE F-31

DOUBLE LOG PLOT OF DRAWDOWN AT GBR-8 DUE TO PUMPING AT GBR-29

DISCHARGE AT GBR-29 REQUIRED TO INTERCEPT PRODUCT IN SOUTHERN REFINERY AREA

The rate of discharge that would be required at well GBR-29 in order to completely offset the natural southwestward-trending hydraulic gradient toward the subdivision can be estimated using general Theis analysis. The natural hydraulic gradient in the unconfined system was estimated using a map of water levels obtained during November and corrected for product thicknesses observed at that time. A flow line extending through GBR-29 perpendicular to the observed equipotential lines is shown in Figure F-32. On the basis of the 5351-ft and 5350-ft potential lines, which were the last lines generated by the plot routine along the southern edge of the map, the hydraulic gradient oriented perpendicular to the lines was defined as:

$$\left(\frac{dh}{dx}\right)_{max} = \frac{(5350-5351)\ \text{ft}}{12.5\ \text{ft}} = -0.08$$

and was equal to the maximum hydraulic gradient near well GBR-29.

Since interest was focused on the southern component of the gradient, which was the principle control on contaminant transport into the subdivision, this gradient was projected in the southern direction as follows:

$$\left(\frac{dh}{dx}\right)_{south} = \left(\frac{dh}{dx}\right)_{max} \cos A$$

$$= -0.08 \cos (60)$$
$$= -0.04$$

At a point located 300 feet south of GBR-29, the difference in head was determined as

$$h = \left(\frac{dh}{dx}\right)_{south} (300\ \text{ft}) = (-0.04)(300\ \text{ft}) = 12\ \text{ft}$$

Thus, pumping at GBR-29 can offset the natural southern component of the gradient only by generating at least 12 feet of drawdown at the well.

Using a transmissivity of 226 ft^2day and a storage coefficient of 0.05 from a previous pump-test analysis performed in the sandstone unit at GBR-29, a first approximation of the rate of discharge required to maintain a horizontal water table after 1 year of pumping can be estimated:

$$u = \frac{1.87\ (0.25)^2\ (0.05)}{1690.3\ (365)} = 9.5 \times 10^{-9}$$

$$W(u) = 17.8948$$

$$Q = \frac{12(1690.3)}{114.6\ (17.8948)} = 9.9 \text{ gpm}$$

However, this discharge creates drawdown at a point 300 feet south of the well, requiring even greater discharge to offset the resulting slight southward hydraulic gradient.

Using the discharge of 9.9 gpm, additional drawdown induced at a point 300 feet from the pump well was determined:

$$u = \frac{1.87\ (300)^2\ (0.05)}{1690.3\ (365)} = 1.4 \times 10^{-2}$$

$$W(u) = 3.7054$$

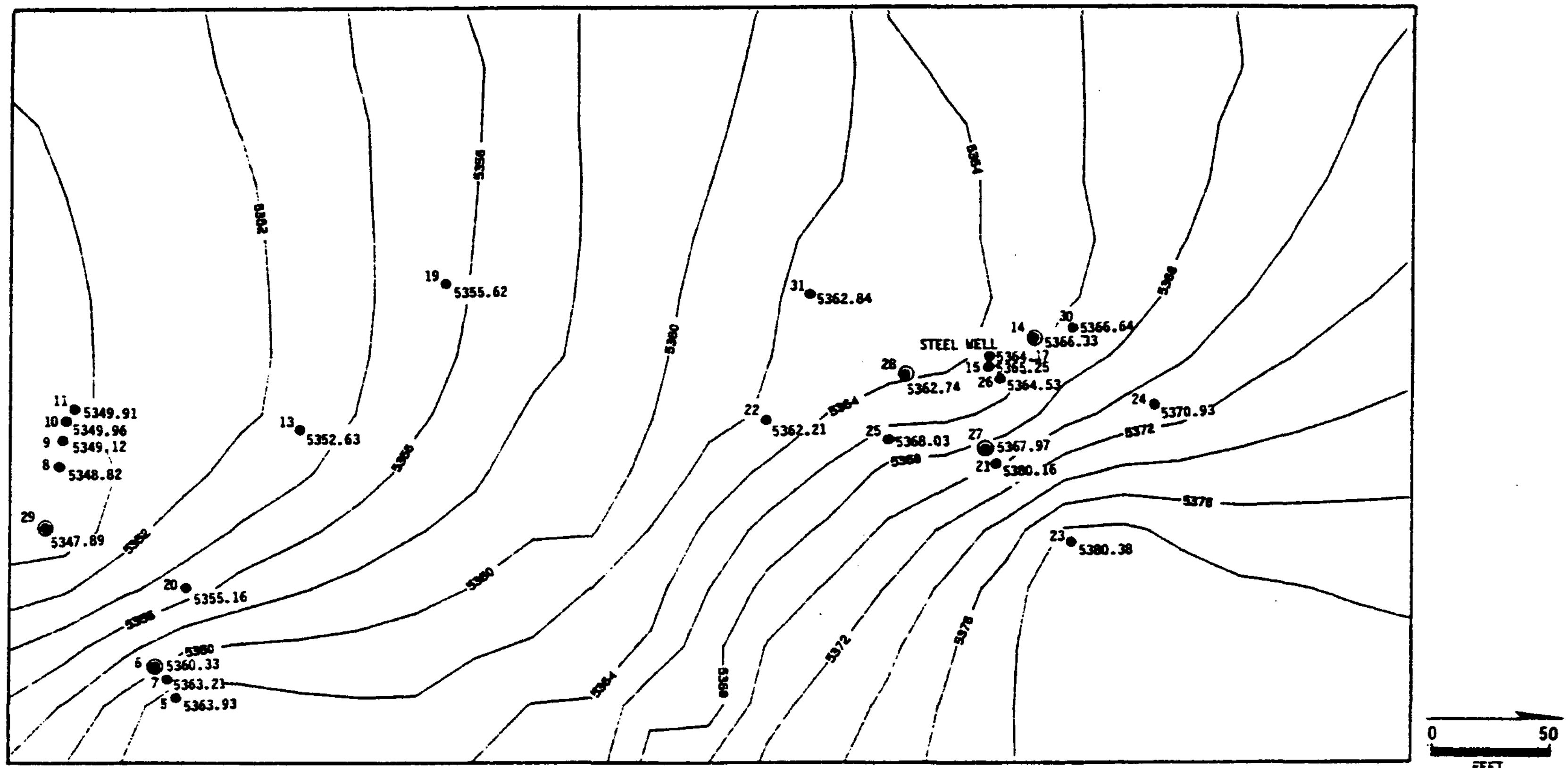
$$s = \frac{114.6\ (9.9)\ (3.705)}{1690.3} = 2.5 \text{ ft}$$

Pumpage at GBR-29 which would overcome the new estimate of 12 + 2.5 = 14.5 feet of head differential was estimated:

$$Q = \frac{14.5\ (1690.3)}{114.6\ (17.8948)} = 11.95 \text{ gpm}$$

Using this iterative method, the minimum rate of discharge required at GBR-29 was calculated until the change in discharge between iterations was negligible:

iteration	Q_{min} (gpm)
1	9.9
2	11.95
3	12.37
4	12.45
5	12.47



Elevations in Feet above Sea Level, Measured in Monitor and Recovery Wells and Corrected for Floating Product, if Present.

RECOVERY WELL

MONITOR WELL

FIGURE F-32

GROUND WATER LEVEL CONTOUR MAP - GIANT BLOOMFIELD REFINERY, NOV. 1986

The minimum rate of pumping required at GBR-29, assuming that T, S, and dh/dx observed near GBR-29 are representative of the unconfined system 300 feet south of the pump well, was 12.5 gpm.

REFERENCES

Kruseman, G.P. and N.A. DeRidder, 1970, Analysis and Evaluation of Pumping Test Data: International Institute for Land Reclamation and Improvement, the Netherlands.

Freeze, R.A. and J.A. Cherry, 1979, Ground Water: Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Todd, D.K., 1959, Ground Water Hydrology: John Wiley and Sons, New York.

APPENDIX E

CALCULATION OF 10, 25, 50, AND 100 YEAR FLOODS

CALCULATION OF 10, 25, 50 AND 100 YEAR FLOODS
(FROM U.S.D.A.S.C.S. ENGINEERING FIELD MANUAL FOR CONSERVATION PRACTICES)

Drainage Area	A = 6.35 mi^2 = 4064 acres
Runoff Curve No.	Cn = 82 (40% cover, B-group)
Time of Concentration	Tc = 1.1 hr
Channel Loss Factor	ClF = 0.7
Normal Annual Precipitation	Pa = 8.5 in.
Average Annual Temp.	Ta = 51°F
Climatic Index	CI = 100 Pa/Ta^2 = 0.3
Unit Discharge	(cfs/acre-in.) = 0.52
Direct Runoff (Q):	10 yr = 0.40 in.
	25 yr = 0.58 in.
	50 yr = 0.75 in.
	100 yr = 1.0 in.
Net Runoff (Qn): (Q)(Clf) = Qn	10 yr = 0.28 in.
	25 yr = 0.41 in.
	50 yr = 0.53 in.
	100 yr = 0.70 in.
Peak Discharge: (A)(Qn)(cfs/acre-in)	10 yr = 591.72 cfs
	25 yr = 866.44 cfs
	50 yr = 1120.04 cfs
	100 yr = 1479.30 cfs
Volume of Runoff: (Qn)(A)/12	10 yr = 94.82 acre-ft
	25 yr = 138.85 acre-ft
	50 yr = 179.49 acre-ft
	100 yr = 237.06 acre-ft

APPENDIX F

PROCEDURES FOR PURGING AND SAMPLING WELLS

Procedures for Purging and Sampling Wells

1.0 PURPOSE
To describe the Standard Operating Procedures SOP for purging and sampling wells.

2.0 SCOPE
This document describes procedures to be used in purging and sampling wells for determination of water quality and potential contamination. The procedures described in this document are consistent with the requirements of all Federal regulations, and are specifically designed to comply with ground water monitoring requirements under RCRA.

3.0 PROCEDURES
3.1 PREPARATIONS FOR SAMPLING
Before proceeding to the field area, be sure that all necessary equipment and supplies are on hand. To the extent possible, all equipment and supplies should be decontaminated in the laboratory before proceeding to the field area. Equipment decontamination procedures are described in a separate SOP.

Equipment and supplies needed for collecting representative ground water samples include:

- o An electronic water-level sounder,
- o Distilled water and wash bottles,
- o Brushes and laboratory soap,
- o Heavy plastic bags,
- o Paper towels or clean rags,
- o Zip-lock plastic bags,
- o Rubber gloves,
- o Several 500 ml beakers,
- o A submersible pump (at some sites there is a dedicated pump for each well) with appropriate attachments to enable purging and sampling the well,
- o A hose to direct pump discharge several feet away from the well, and containers for discharge if it is contaminated,
- o Plastic sheet film,

- A graduated bucket,
- A bottom-filling teflon or stainless steel bailer,
- All necessary sample containers with the appropriate volume of preservatives added to the containers by the laboratory,
- pH meter,
- Thermometers,
- Specific conductance meter,
- Field log book and sample forms,
- Ice and ice chest for samples,
- Strapping tape and shipping labels,
- Waterproof marking pen,
- Chain-of-Custody labels,
- Watch or stopwatch for use in determining pumping rates.

A nearby location of a steam cleaner is desirable in order to avoid long delays for cleaning of equipment, if necessary, between sampling of individual wells.

3.2 DETERMINE WATER LEVEL AND TEST FOR "FLOATERS" AND "SINKERS"

Using an electronic sounder ("water level probe") or other suitable device, measure the depth to water (DTW) in the well. If approximate total depth (TD) of the well is not known, it will also be necessary to measure total depth with the sounder. If approximate total depth is known, defer the measurement until after sampling has been completed. Use of the electronic sounder is described in a separate SOP. If the presence of floating or sinking immiscible phases is known or suspected, they must be evaluated and sampled <u>before</u> purging or other sampling.

After determining the water level and total depth, coat the electronic sounder's tape with an indicator paste which changes color when exposed to organic chemicals. Apply the paste in a thin layer over a 1-foot interval at the bottom of the tape, and over a 1- to 2-foot interval including the tape measurement corresponding to the water level elevation above the bottom of the well. Lower the sounder into the well so that it reaches the bottom of the well, and the upper paste zone spans the water level.

Withdraw the tape, and observe whether the indicator paste has changed color (refer to the manufacturer's instructions for the color change to be anticipated). If floating or sinking phases are present, they must be sampled before purging the well. Instructions for sampling "floaters" and "sinkers" are included in the following section.

3.3 COLLECTION OF "FLOATERS" AND "SINKERS"

3.3.1 Collection of Light Immiscibles (Floaters)

The approach to collection of floaters is dependent on the depth to the surface of the floating layer and the thickness of that layer. The thickness of the layer can be determined by using an interface probe, which indicates the depths to both top and bottom of the layer.

If the thickness of the floater is two feet or greater, a bottom valve bailer is the equipment of choice. Slowly lower the bailer until contact is made with the floater surface and lower the bailer to a depth less than that of the floater/water interface depth as determined by preliminary measures with the interface probe.

When thickness of the floating layer is less than 2 feet but the depth to the surface of the floating layer is less than about 15 feet, a peristaltic pump can be used to collect a sample.

When the thickness of the floating layer is less than two feet and the depth to the surface of the floating layer is beyond the effective "reach" of a peristaltic pump (greater than 25 feet), a bailer must be modified to allow filling only from the top. Disassemble the bailer's bottom check valve and insert a piece of two-inch diameter Teflon sheet between the ball and ball seat to seal off the bottom valve. Remove the ball from the top check valve, thus allowing the sample to enter from the top. To overcome buoyancy when the bailer is lowered into the floater, place a length of one-inch stainless steel pipe on the retrieval line above the bailer (this pipe may have to be notched to allow sample entry if the pipe remains within the top of the bailer). Lower the device, carefully measuring the depth to the surface of the floating layer, until the top of the bailer is level with the top of the floating layer. Lower the bailer an additional one-half thickness of the floating layer and collect sample. This technique is the most effective method of collection if the floater consists of only a few inches of materials.

3.3.2 Collection of Heavy Immiscibles (Sinkers)

The best method for collection of sinkers is use of a double check valve bailer. The key to collection is controlled, slow lowering and raising of the bailer to and from the bottom of the well. Collection methods when using a bailer are equivalent to those described above.

3.4 DETERMINE THE VOLUME OF WATER TO BE PURGED FROM THE WELL

This normally is at least 3 casing volumes, determined as follows:

- o Measure the true inside diameter of the casing, using a steel tape or ruler; convert to feet.

- o Find the true inside radius (r) of the casing by dividing the diameter by 2.

- o Determine 1 casing volume in cubic feet (V_{cf}) by calculating:

$$V_{cf} = 3.14 \times (r)^2 \times (TD - DTW).$$

- o Determine 1 casing volume in gallons by multiplying V_{cf} x 7.48 gals/ft^3.

- o Multiply by 3 to determine total volume of water to be pumped from the well.

The exception to this standard (other than program requirements) is in the case of low yield wells. When purging low yield wells, pump the well once to dryness. Samples should be collected as soon as the well recovers. When full recovery exceeds three hours, samples should be collected as soon as sufficient water volume is available.

3.5 PURGE THE WELL

Currently, standards allow for four options for purging wells. They are:

- o Teflon or stainless steel bailers

- o Existing dedicated equipment - Use of these devices must be approved by On-Site Representatives.

- o Peristaltic pumps - Use of these devices, suitable for shallow wells only, must be approved by the On-Site Representative.

- o Positive displacement bladder pump, capable of being completely disassembled and cleaned before use in each well.

At no time during purging should the evacuation rate be high enough to cause the ground water to cascade back into the well thus causing excessive aeration and potential stripping of volatile constituents.

The actual volume of purged water can be measured by several acceptable methods.

- o When bailers are used to purge, the actual volume of each bailer's contents can be measured using a calibrated bucket.

- o If a pump is used for purging, the pump rate can be determined by using a bucket and stopwatch, and the duration of pumping timed until the necessary volume is purged. A totalizing flow meter may be used, if available.

Monitor the pH, temperature, and specific conductance of the water purged to ensure that these parameters have stabilized by the time 3 casing volumes have been withdrawn. If stabilization has not been achieved at that time, continue purging until it is achieved.

3.6 DISPOSAL OF PURGED WATER

Dispose of pumped water in a manner which poses no threat of contamination to any surface or ground water in the vicinity. If the water is determined to be hazardous, it must be contained and disposed of according to appropriate regulations.

3.7 INITIAL SAMPLING FOR FIELD PARAMETERS

Begin sampling by withdrawing water from the well in accordance with the procedures of Section 3.8. Place the first water withdrawn in a 500 ml or larger flask or beaker which has been properly cleaned, then rinsed 3 times with the well water being recovered. Use this sample for field measurement of temperature, specific conductance, and pH. Procedures for these field measurements are described in a separate SOP document.

3.8 SAMPLE COLLECTION

3.8.1 General Considerations

The technique used to withdraw a ground water sample from a well should be selected based on a consideration of the parameters which will be analyzed. To ensure the ground water samples' representativeness, it is important to avoid physically altering or chemically contaminating the samples during collection, withdrawal, and containerization.

The preferred sampling device for all parameters is a double check valve stainless steel or Teflon bailer.

To the extent possible, no sampling device constructed of or containing neoprene, PVC, Tygon, silicone, polyethylene, or Viton will be used to collect ground-water samples.

In some cases, it may be necessary to use equipment already in the well to collect samples. This is particularly true of high volume, deep wells (>150 feet) where purging pumps are ineffective, and bailing is impractical. If existing equipment must be used, determine the make and model of the pump and check with the manufacturer concerning component construction materials.

General sampling procedures include the following:

- Clean sampling equipment should not be placed directly on the ground. Use a drop cloth or feed line from clean reels. If reels are used, avoid placing contaminated lines back on reels.
- Lower sampling equipment slowly into the well to avoid degassing of the water and damage to the equipment.
- If bailer cable is to be decontaminated and reused, it must be Teflon-coated or made of stainless steel. Braided polypropylene is also acceptable.
- Check the operation of bailer check valve assemblies to confirm free operation.

- o Purging pump flow rates should be adjusted to eliminate intermittent or pulsed flow. The settings should be determined during the purging operations. Flow rate should be less than 100 ml/minute when sampling for volatile organic compounds (VOC's).

- o Samples should be collected and containerized in the order of the parameters volatilization sensitivity. Table 3-1 lists the preferred collection order for some common ground-water parameters.

3.8.2 COLLECTION OF VOLATILE ORGANICS SAMPLES (VOAs)

VOAs should be collected from the first bailer removed from the well after purging, immediately following collection of the sample for field analyses. The most effective means of controlled collection of the sample is by employing two people. One person should retrieve the bailer from the well and place the bottom over a VOA container (40 ml septum vial) held by the second person. The second person should insert the Teflon bottom emptying device into the bailer, bring the vial to tip of the bottom emptying device, and tilt the vial to approximately 60° from the vertical.

Delivery of the sample from the bailer down the edge of the vial is accomplished when the person holding the bailer slowly opens the top check valve with a Teflon, glass, or stainless steel insert. As the vial is filled, the second person should return it to the vertical position.

Fill the septum vial until it is just overflowing. Cap the vial and invert. If a bubble exists, discard and repeat. Do not reopen the vial and add additional sample.

If a sampling pump is used, reduce the flow to less than 100 ml per minute prior to sample collection.

3.9 CONTAINERS

Collect and preserve all samples in approved containers and by the standard methods described in the Sampling and Analysis Plan for the project. The specific containers and preservatives used for each analyte may vary among laboratories. The standard methods of the laboratory selected for analysis will be followed in each project Sampling and Analysis Plan. Handle all samples in accordance with the procedures described in the SOP documents "Procedures for Packing and Shipping of Samples" and "Chain-of-Custody Procedures."

3.10 FINAL FIELD ANALYSES

Immediately after collection of all samples required in the Sampling and Analysis Plan, collect a final sample for field analyses, as described in Section 3.7 above. The purpose of these repeat analyses is to check for possible changes in water quality during the time of sampling. Samples used for field analyses should be discarded when the analyses are complete.

TABLE 3-1

PREFERRED ORDER OF SAMPLE COLLECTION

1. Volatile organics (VOA)
2. Purgeable organic carbon (POC)
3. Purgeable organic halogens (POX)
4. Extractable organics
5. Total metals
6. Dissolved metals
7. Total organic carbon (TOC)
8. Total organic halogens (TOX)
9. Phenols
10. Cyanide
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

3.11 MEASURE TOTAL DEPTH OF WELL

After collection and preservation of all samples and completion of final field analyses, measure depth to bottom of the well, using the electronic sounder. Use of the sounder is described in a separate SOP.

4.0 REFERENCES

U.S. Code of Federal Regulations, 1983, 40 CFR 264.97.

U.S. Environmental Protection Agency, 1986a, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, p. 97-114.

U.S. Environmental Protection Agency, 1986b, Test Methods for Evaluating Solid Waste: EPA Report SW-846; Volume I: Physical/Chemical Methods.

ROCKY MOUNTAIN ANALYTICAL LABORATORY

Organic Analytical Methodology

Parameter	Units	Nominal Detection Limit[a]	Methodology	Reference[1]	Preservation Bottle No.	Maximum Holding Time[b]
Purgeables	ug/l	1	Purge & Trap GC/MS	624	11	14 days
Base/Neutrals	ug/l	10	Extraction/GC/MS	625	12	7 days/40 days
Acids	ug/l	10	Extraction/GC/MS	625	12	7 days/40 days
Organochlorine Pesticides/PCB's	ug/l	0.01	Extraction/GC/ECD	608	13	7 days/40 days
		10	Extraction/GC/MS	625	12	7 days/40 days
Phenoxy Herbicides	ug/l	0.01	Extraction/GC/ECD	(2)	14	7 days/40 days
Total Organic Halogen (TOX)	ug/l	5	Adsorbtion/Coulometric	450.1(3)	15	-
Trihalomethanes (THM)	ug/l	1	Extraction/GC/ECD	(4)	11	14 days
		1	Purge & Trap GC/MS	(4)	11	14 days
Dioxin	ug/l	0.005	Extraction/GC/MS/ECD	613	16	7 days/40 days
Purgeable Halocarbons	ug/l	0.01	Purge & Trap/GC/Hall	601	11	14 days
Purgeable Aromatics	ug/l	1	Purge & Trap/GC/PID	602	17	14 days
Acrolein & Acrylonitrile	ug/l	100	Purge & Trap/GC/FID	603	18	14 days
Phenols by GC	ug/l	10	Extraction/GC/FID	604	16	7 days/40 days
Benzidines	ug/l	0.1	Extraction/HPLC	605	19	7 days/40 days
Phthalate Esters	ug/l	10	Extraction/GC/FID	606	12	7 days/40 days
Nitrosamines	ug/l	1	Extraction/GC/NPD	607	20	7 days/40 days
Nitroaromatics/isophorone	ug/l	1	Extraction/GC/FID & GC/ECD	609	12	7 days/40 days
Polynuclear Aromatics	ug/l	0.5	Extraction/HPLC	610	20	7 days/40 days
Haloethers	ug/l	1	Extraction/GC/Hall	611	17	7 days/40 days
Chlorinated Hydrocarbons	ug/l	0.02	Extraction/GC/ECD	612	12	7 days/40 days
Organophosphorus Pesticides	ug/l	0.1	Extraction/GC/NPD	622(5)	12	7 days/40 days
Triazine Pesticides	ug/l	0.1	Extraction/GC/NPD	(6)	12	7 days/40 days

References

(1) Federal Register, Vol. 44, No. 233, Monday, December 3, 1979.
(2) "Method for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," Federal Register, Vol. 38, No. 75, Part II.
(3) "Total Organic Halide," US EPA-EMSL, Cincinnati, November, 1980.
(4) Federal Register, Vol. 44, No. 231, Thursday, November 29, 1979, Appendix, Part I.
(5) "Method 622- Organophosphorus Pesticides," Proposed EPA Method, 304 (h) Committee.
(6) Federal Register, Vol. 38, No. 75, 1973.

Notes

[a] Nominal values are the best achievable with the listed analytical method for a typical component. Interferrences in specific samples may result in a higher detection limit.

[b] Applicable to NPDES Wastes as updated by Robert C. Booth, Director, EMSL-Cincinnati, September 22, 1981. Where two times are given, the first refers to the time to extraction, the second to the time of instrumental analysis.

ROCKY MOUNTAIN ANALYTICAL LABORATORY

Organic Analytical Methodology (continued)

Preservation Bottle No.	Parameter Group	Bottle	Preservation
11	Purgeables	40 ml glass with teflon lined silicone septum cap	4°C (thiosulfate if Cl_2 present)
17	Purgeables	40 ml glass with teflon lined silicone septum cap	4°C, HCl to pH less than 2 (thiosulfate if Cl_2 present)
18	Purgeables	40 ml glass with teflon lined silicone septum cap	4°C, adjust pH to 4 - 5 (thiosulfate if Cl_2 present)
16	Extractables	1 liter glass with teflon lined cap	4°C (thiosulfate if Cl_2 present)
19	Extractables	1 liter glass with teflon lined cap	4°C, adjust pH to 2 - 7 (thiosulfate if Cl_2 present)
12, 13, 14	Extractables	1 liter glass with teflon lined cap	4°C
20	Extractables	1 liter glass with teflon lined cap	4°C, store in dark (thiosulfate is Cl_2 present)
15	TOX	250 ml glass with teflon lined cap, single 1 liter glass with teflon lined cap, quad.	4°C, store in dark (thiosulfate if Cl_2 present)

ROCKY MOUNTAIN ANALYTICAL LABORATORY

Inorganic Analytical Methodology

Parameter	Units	Nominal Detection Limit[a]	Methodology	Reference	Preservation Bottle No.	Maximum Holding Time[b]
MAJOR IONS						
Sodium	mg/l	0.5	ICP Emission Spectroscopy	3	4	6 months
Potassium	mg/l	0.3	ICP Emission Spectroscopy	3	4	6 months
Calcium	mg/l	0.1	ICP Emission Spectroscopy	3	4	6 months
Magnesium	mg/l	0.1	ICP Emission Spectroscopy	3	4	6 months
Chloride	mg/l	3	Manual Titrimetric, Hg $(NO_3)_2$	1-325.3/2-407B	1	28 days
			Automated Colorimetric Ferricyanide	1-325.2	1	28 days
Fluoride	mg/l	0.1	Electrode	1-340.2/2-413B	1	28 days
Sulfate	mg/l	5	Manual Turbidimetric	1-375.4/2-426C	1	28 days
			Automated Colorimetric MTB	1-375.2	1	28 days
Total Alkalinity as $CaCO_3$ at pH 4.5	mg/l	5	Titrimetric	1-310.1/2-403	1	14 days
Carbonate Alkalinity as $CaCO_3$ at pH 8.3	mg/l	5	Titrimetric	1-310.1/2-403	1	14 days
Bicarbonate Alkalinity as $CaCO_3$ at pH 4.5	mg/l	5	Titrimetric	1-310.1/2-403	1	14 days
Hydroxide Alkalinity as $CaCO_3$	mg/l	5	Calculation	2-403	-	-
Nitrate+Nitrite as N	mg/l	0.1	Manual Cd Reduction - Colorimetric	1-353.3/2-418C	2	28 days
		0.1	Automated Cd Reduction - Colorimetric	1-353.2	2	28 days
Total Cations	meq/l	0.1	Calculation	2-104C	-	-
Total Anions	meq/l	0.1	Calculation	2-104C	-	-
Difference	%	0.1	Calculation	2-104C	-	-
RADIOCHEMISTRY						
Gross Alpha	pCi/l	0.1	Proportional Counter	2-703	5	6 months
Gross Beta	pCi/l	0.1	Proportional Counter	2-703	5	6 months
Radium 226	pCi/l	0.1	Separation - Counter	2-705	5	6 months
Radium 228	pCi/l	0.1	Separation - Counter	2-707	5	6 months
Uranium	mg/l	0.005	Fluorimetric	4-D2907-75	5	6 months

ROCKY MOUNTAIN ANALYTICAL LABORATORY

Inorganic Analytical Methodology (Continued)

Parameter	Units	Nominal Detection Limit[a]	Methodology	Reference	Preservation Bottle No.	Maximum HoldingTime[b]
TRACE METALS[c]						
Aluminum	mg/l	0.05	ICP Emission Spectroscopy	3	4	6 months
Antimony	mg/l	0.002	Furnace Atomic Absorption	1-204.2	4	6 months
Arsenic	mg/l	0.002	Furnace Atomic Absorption	1-206.2	4	6 months
Barium	mg/l	0.005	ICP Emission Spectroscopy	3	4	6 months
Beryllium	mg/l	0.001	ICP Emission Spectroscopy	3	4	6 months
Boron	mg/l	0.004	ICP Emission Spectroscopy	3	4	6 months
Cadmium	mg/l	0.002	ICP Emission Spectroscopy	3	4	6 months
Chromium	mg/l	0.005	ICP Emission Spectroscopy	3	4	6 months
Cobalt	mg/l	0.003	ICP Emission Spectroscopy	3	4	6 months
Copper	mg/l	0.002	ICP Emission Spectroscopy	3	4	6 months
Iron	mg/l	0.05	ICP Emission Spectroscopy	3	4	6 months
Lead	mg/l	0.025	ICP Emission Spectroscopy	3	4	6 months
		0.001	Furnace Atomic Absorption	1-239.2	4	6 months
Manganese	mg/l	0.005	ICP Emission Spectroscopy	3	4	6 months
Mercury	mg/l	0.0002	Cold Vapor Atomic Absorption	1-245.1	4	6 months
Molybdenum	mg/l	0.005	ICP Emission Spectroscopy	3	4	6 months
Nickel	mg/l	0.01	ICP Emission Spectroscopy	3	4	6 months
Selenium	mg/l	0.002	Furnace Atomic Absorption	1-270.2	4	6 months
Silver	mg/l	0.003	ICP Emission Spectroscopy	3	4	6 months
Strontium	mg/l	0.005	ICP Emission Spectroscopy	3	4	6 months
Thallium	mg/l	0.002	Furnace Atomic Absorption	1-279.2	4	6 months
Tin	mg/l	0.03	ICP Emission Spectroscopy	3	4	6 months
Titanium	mg/l	0.002	ICP Emission Spectroscopy	3	4	6 months
Vanadium	mg/l	0.002	ICP Emission Spectroscopy	3	4	6 months
Zinc	mg/l	0.004	ICP Emission Spectroscopy	3	4	6 months
INORGANIC PARAMETERS						
pH	units	0.01	Meter	1-150.1; 2-423	1	ASAP
Specific Conductance at 25°C	umhos/cm	1	Bridge	1-120.1; 2-205	1	28 days
Total Dissolved Solids	mg/l	10	Gravimetric, 180°C	1-160.1; 2-209B	1	7 days
Total Suspended Solids	mg/l	2	Gravimetric, 105°C	1-160.2	1	7 days
Total Solids	mg/l	10	Gravimetric, 105°C	1-160.3	1	7 days
Total Volatile Solids	mg/l	10	Gravimetric, 550°C	1-160.4	1	7 days
Ortho-Phosphate as P	mg/l	0.01	Single Reagent Colorimetric	1-365.2; 2-424F	1	48 hours

ROCKY MOUNTAIN ANALYTICAL LABORATORY

Inorganic Analytical Methodology (Continued)

Parameter	Units	Nominal Detection Limit[a]	Methodology	Reference	Preservation Bottle No.	Maximum Holding Time[b]
INORGANIC PARAMETERS (Continued)						
Total Phosphorus as P	mg/l	0.06	Digestion; ICP Emission Spectroscopy	1-4.1.4; 3	4	28 days
		0.01	Digestion - Colorimetric	1-365.2; 1-424C,F	2	28 days
Silica as SiO_2	mg/l	0.1	ICP Emission Spectroscopy	3	4	28 days
	mg/l	1	Colorimetric	1-370.1; 2-425C	1	28 days
Biological Oxygen Demand	mg/l	2	Dilution Bottle - D.O. Probe	1-405.1; 2-507	1	48 hours
Chemical Oxygen Demand	mg/l	5	Micro Colorimetric	1-410.4; 2-508A	2	28 days
Total Organic Carbon	mg/l	0.1	Oxidation-Infrared Absorption	1-415.1; 2-505	2	28 days
Ammonia as N	mg/l	0.1	Electrode	1-350.3; 2-417E	2	28 days
		0.1	Automated Colorimetric	1-350.1	2	28 days
Total Kjeldahl Nitrogen as N	mg/l	0.1	Digestion - Electrode	1-351.4; 2-420B	2	28 days
		0.1	Digestion - Colorimetric	1-351.2	2	28 days
Total Organic Nitrogen as N	mg/l	0.1	Calculation (TKN - NH_3)	-	-	-
Oil and Grease	mg/l	1	Freon Extraction-Gravimetric	1-413.1; 2-503A	3	28 days
Free Cyanide	mg/l	0.01	Chlorination-Distillation-Colorimetric	1-335.1; 2-412F,D	6	14 days
Total Cyanide	mg/l	0.01	Distillation - Colorimetric	1-335.2; 2-412B,D	6	14 days
Phenolics	mg/l	0.01	Distillation - Colorimetric	1-420.1; 2-510A,B	2	28 days
Fecal Coliform	Colonies/100 ml	1	Membrane Filter	2-909C	8	ASAP
Total Coliform	Colonies/100 ml	1	Membrane Filter	2-909A	8	ASAP
Bromide	mg/l	0.1	Colorimetric	2-405	1	28 days
Residual Chlorine	mg/l	0.05	Amperometric	1-330.2; 2-408C	1	ASAP
Hexavalent Chromium	mg/l	0.01	Colorimetric	1-218.4; 2-312B	1	24 hours
Color	units	5	Pt-Co Colorimetric	1-110.2; 2-204A	1	48 hours
Hardness as $CaCO_3$	mg/l	5	Calculation	2-314A	4	6 months
Nitrite as N	mg/l	0.01	Colorimetric	1-354.1; 2-419	1	48 hours
Sulfide	mg/l	0.05	Titrimetric - Electrode	1-376.1; 2-427B,D	7	7 days
Sulfite	mg/l	2	Titrimetric	1-377.1; 2-428	1	ASAP
MBAS (Surfactants)	mg/l	0.1	Colorimetric	1-425.1; 2-512A	1	48 hours
Turbidity	NTU	0.1	Turbidimeter	1-180.1; 2-214A	1	48 hours

ROCKY MOUNTAIN ANALYTICAL LABORATORY

Inorganic Analytical Methodology (Continued)

References

(1) "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, EMSL, Cincinnati, 1979.

(2) "Standard Methods for the Examination of Water and Wastewater", 15th Edition, APHA, 1980.

(3) Federal Register, 40 CFR 136, December 3, 1979; USEPA EMSL-Cincinnati, OH 45268.

(4) "Annual Book of ASTM Standards", Part 31, Water, 1980.

Notes

[a] Nominal values are the best achievable with the listed analytical method. Interferences in specific samples may result in a higher detection limit.

[b] Applicable to NPDES wastes as updated by Robert C. Booth, Director, EMSL-Cincinnati, September 22, 1981.

[c] Digestion procedure 1-4.1.4 used for elements determined by ICP Emission Spectroscopy when determining total metals. Digestion procedures for graphite furnace elements included with reference listed.

11/10/82

GUIDELINES FOR SAMPLE BOTTLES AND PRESERVATIVES[a]

Bottle No.	Parameters	Container	Preservative	Notes
1	Cl^-, F^-, $SO_4^=$, Tot. Alk., $CO_3^=$ Alk., HCO_3^- Alk., OH^- Alk., pH, spec. cond., TDS, TSS, TS, TVS, o-PO_4 SiO_2, BOD, Br^-, res. Cl_2, Cr^{+6}, color, NO_2^-, $SO_3^=$, MBAS, Turbidity.	1 liter poly	4° C	Provide unfiltered sample for solids and turbidity.
2	Tot. P, COD, TOC, NH_3, TKN, TON, Phenolics $NO_3 + NO_2$.	500 ml poly	2 ml 50% H_2SO_4, 4°C	
3	O & G	1 liter glass	4 ml 50% H_2SO_4, 4°C	Do not filter, collect directly in bottle.
4	Na, K, Ca, Mg, Al, Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, Tl, Sn, Ti, V, Zn, ICP, Hardness.	500 ml poly	5 ml 50% HNO_3	Provide separate samples for total and dissolved sample (filter before adding to bottle.)
5	Alpha, Beta, Ra^{226}, Ra^{228}, U	1 liter poly (no Ra^{228}) ½ gallon poly (with Ra^{228})	10 ml 50% HNO_3 20 ml 50% HNO_3	
6	Free CN, Tot. CN	500 ml poly	2 ml 50% NaOH, 4°C	
7	Sulfide	250 ml poly	1 ml 1 N Zn acetate, 1 ml 50% NaOH, 4°C	
8	Fecal coli., total coli.	8 oz. sterile	4° C	Collect directly in sterile bottle
11	VOA, purgeable organics, THM	2 - 40 ml glass vial	4° C	Completely fill bottle, leave no air bubbles.
12	B/NA	1 liter glass	4° C	
13	Pest./PCB	1 liter glass	4° C	
14	Herbicides	1 liter glass	4° C	
15	TOX	1 liter glass	4° C	

[a] Federal Register, 40 CFR 136, December 3, 1979, as updated by EPA, EMSL-Cincinnati, September 22, 1981.

APPENDIX G

PROCEDURES FOR DECONTAMINATION OF GROUND WATER SAMPLING EQUIPMENT

Procedures for Decontamination of Ground Water Sampling Equipment

1.0 PURPOSE

To describe the Standard Operating Procedures used for decontamination of ground water sampling equipment prior to field use.

2.0 SCOPE

To prevent contamination of ground water samples or monitor wells, all sampling equipment must be thoroughly cleaned prior to each use. This document describes the recommended procedures for cleaning of equipment and tools before a sampling program.

Sampling equipment dedicated to a particular well will be cleaned prior to installation and after any maintenance requiring removal from the well. Other equipment will be cleaned prior to each use.

Equipment used in each of several wells will be cleaned prior to use at each individual well.

These procedures are designed to fully comply with the requirements of RCRA ground water monitoring.

3.0 PROCEDURES

3.1 EQUIPMENT PREPARATION

Any equipment, either new or previously used, should be assumed to be contaminated and should undergo the level of decontamination appropriate to its intended use and construction. The following sections detail the various decontamination procedures to be used.

3.2 GENERAL LEVELS OF DECONTAMINATION

Level 1 Decontamination

Applicability - (1) All glassware and (2) stainless steel equipment whose construction will tolerate high temperatures of the muffle furnace and that will be used in collection and containerization of organic samples.

1. Thoroughly wash with nonphosphate detergent in hot water.
2. Rinse several times with tap water.
3. Rinse several times with deionized water.
4. Rinse once with acetone or methanol.
5. Rinse once with pesticide grade hexane.
6. Place in muffle furnace at 450°C for 15 to 30 minutes.

7. Allow to cool, protect from dust and other contaminants by sealing or covering with aluminum foil.

Level 2 Decontamination

Applicability (for organic samples) - All Teflon equipment and stainless equipment with components which would be damaged by high temperatures of the muffle furnace should be treated as follows. This procedure is also applicable where a muffle furnace is not available.

1. Thoroughly wash with nonphosphate detergent in hot water.

2. Rinse several times with tap water.

3. Rinse several times with deionized water.

4. Rinse once with acetone.

5. Rinse once with pesticide grade hexane.

6. Air dry in a dust free environment.

7. Cap or cover after drying; Teflon bailers and other applicable equipment should be sealed in plastic bags.

NOTE: Chromic acid can be used to remove persistent organic deposits.

Level 3 Decontamination

Applicability - Sample containers used for metals samples.

NOTE: Chromic acid should never be used to decontaminate equipment used for collecting samples analyzed for metals.

1. Wash thoroughly with nonphosphate detergent in hot water.

2. Rinse once with 1:1 nitric acid.

3. Rinse several times with tap water.

4. Rinse once with 1:1 hydrochloric acid.

5. Rinse several times with tap water.

6. Rinse several times with deionized water.

7. Invert and air dry in dust free environment.

Level 4 Decontamination

Applicability - Safety equipment such as respirators, boots, gloves, equipment susceptible to degradation by solvent rinsing.

1. Brush off loose dirt with soft bristle brush or cloth.

2. Rinse thoroughly with tap water.

3. Wash in nonphosphate detergent in warm water.

4. Rinse thoroughly with tap water.

5. Rinse thoroughly with deionized water.

6. Air dry in dust free environment; keep articles out of the sun.

7. Store in plastic bags.

Level 5 Decontamination

Applicability - Ancillary equipment such as ropes, extension cords, generators, hand carts.

1. Brush off loose dirt with stiff bristle brush.

2. Rinse off with high pressure water.

3. Air dry.

Once equipment has been allowed to dry, package the equipment to protect it from dust. Plastic bags are appropriate for larger items such as bailers and purging pumps; aluminum foil is preferred for glassware openings. After packaging the equipment, mark the packaging material with the date and level of decontamination and the initials of the individual certifying performance of the decontamination.

3.3 PROCEDURES FOR FIELD DECONTAMINATION OF SAMPLING EQUIPMENT

3.3.1 General Considerations

Field decontamination of equipment used for well purging, sample collection, and sample compositing is not to be considered a procedure of preference; rather it should be viewed as a last resort where logistical considerations and practical concerns outweigh the preferred use of dedicated equipment.

When field decontamination cannot be avoided, the following general rules should be adhered to:

1. Unless it is absolutely necessary, no equipment should be field decontaminated more than once between laboratory decontamination.

2. Equipment used to collect hazardous waste samples prior to decontamination should not subsequently be used for collection of environmental samples. In general, any equipment to be decontaminated should then be reused to collect samples of "lower quality" than the first sample collected.

3. All decontamination and subsequent use of decontaminated equipment should be documented in a field logbook.

4. Never reuse equipment if visual signs, such as discoloration, indicate that decontamination was insufficient.

3.3.2 Decontamination of Pumps

1. Submerge pumps in nonphosphate soap solution (e.g., Alconox).

2. Operate pump for a minimum of 10 minutes; recycle the soap solution to a wash basin through the entire length of hose when the hose must be reused.

3. Clean all exterior surfaces of both tubing and pump with bristle brush and clean cloth.

4. Submerge pump in tap water.

5. Operate pump for a minimum of 10 minutes; recycle the water to rinse basin through the entire length of hose.

6. Submerge pump in deionized water.

7. Pump volume of rinse basin for disposal (i.e., do not recycle deionized water).

8. Repeat Steps No. 6 and 7 two additional times.

9. Place pump and hose on rack to air dry.

10. Place pump and hose in plastic bag, or cover with plastic sheeting to prevent contamination during transport.

3.3.3 Decontamination of Bailers

1. Disassemble both top and bottom check valve assemblies.

2. Clean all component parts in nonphosphate soap solution using a bristle brush and a bottle brush to clean inside surfaces.

3. Rinse all surfaces five times with tap water.

4. Rinse all surfaces twice with methanol.

5. Rinse all surfaces five times with deionized water.

6. Place all components on rack and allow to air dry.

7. Wearing clean cotton gloves (powderless), reassemble bailer.

8. Place bailer in plastic bag, seal the bag, and label the bag indicating date of decontamination.

3.3.4 Decontamination of Compositing Containers

1. Scrub both inside and outside surfaces of container, lid, and Teflon liner with nonphosphate soap solution using a bristle brush.

2. Rinse five times with tap water.

3. Rinse once with methanol.

4. Rinse five times with deionized water.

5. Place on drying rack and allow to air dry.

6. Replace Teflon liner and lid.

7. Place label on lid and indicate date of decontamination.

When used equipment is to be return to GCL for thorough decontamination, Level 5 decontamination should be performed in the field. The equipment should then be sealed in a plastic bag and segregated from unused equipment.

4.0 REFERENCES

U.S Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, p. 106-107.

Analytical Methods

Parameter	Units	Nominal Detection Limit[a]	Methodology	Reference[1]	Preservation Bottle No.	Maximum Holding Time
Purgeables	ug/l	1	Purge & Trap GC/MS	624	11	14 days
Base/Neutrals	ug/l	10	Extraction/GC/MS	625	12	7 days/40 da
Acids	ug/l	10	Extraction/GC/MS	625	12	7 days/40 da
Organochlorine Pesticides/PCB's	ug/l	0.01	Extraction/GC/ECD	608	13	7 days/40 da
		10	Extraction/GC/MS	625	12	7 days/40 da
Phenoxy Herbicides	ug/l	0.01	Extraction/GC/ECD	(2)	14	7 days/40 da
Total Organic Halogen (TOX)	ug/l	5	Adsorbtion/Coulometric	450.1(3)	15	-
Trihalomethanes (THM)	ug/l	1	Extraction/GC/ECD	(4)	11	14 days
		1	Purge & Trap GC/MS	(4)	11	14 days
Dioxin	ug/l	0.005	Extraction/GC/MS/ECD	613	16	7 days/40 da
Purgeable Halocarbons	ug/l	0.01	Purge & Trap/GC/Hall	601	11	14 days
Purgeable Aromatics	ug/l	1	Purge & Trap/GC/FID	602	17	14 days
Acrolein & Acrylonitrile	ug/l	100	Purge & Trap/GC/FID	603	18	14 days
Phenols by GC	ug/l	10	Extraction/GC/FID	604	16	7 days/40 da
Benzidines	ug/l	0.1	Extraction/HPLC	605	19	7 days/40 da
Phthalate Esters	ug/l	10	Extraction/GC/FID	606	12	7 days/40 da
Nitrosamines	ug/l	1	Extraction/GC/NPD	607	20	7 days/40 da
Nitroaromatics/isophorone	ug/l	1	Extraction/GC/FID & GC/ECD	609	12	7 days/40 da
Polynuclear Aromatics	ug/l	0.5	Extraction/HPLC	610	20	7 days/40 da
Haloethers	ug/l	1	Extraction/GC/Hall	611	17	7 days/40 da
Chlorinated Hydrocarbons	ug/l	0.02	Extraction/GC/ECD	612	12	7 days/40 da
Organophosphorus Pesticides	ug/l	0.1	Extraction/GC/NPD	622(5)	12	7 days/40 da
Triazine Pesticides	ug/l	0.1	Extraction/GC/NPD	(6)	12	7 days/40 da

References

(1) Federal Register, Vol. 44, No. 233, Monday, December 3, 1979.
(2) "Method for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," Federal Register, Vol. 38, No. 75, Part II.
(3) "Total Organic Halide," US EPA-EMSL, Cincinnati, November, 1980.
(4) Federal Register, Vol. 44, No. 231, Thursday, November 29, 1979, Appendix, Part I.
(5) "Method 622- Organophosphorus Pesticides," Proposed EPA Method, 304 (h) Committee.
(6) Federal Register, Vol. 38, No. 75, 1973.

Notes

[a] Nominal values are the best achievable with the listed analytical method for a typical component. Interferrences in specific samples may res in a higher detection limit.

[b] Applicable to NPDES Wastes as updated by Robert C. Booth, Director, EMSL-Cincinnati, September 22, 1981. Where two times are given, th first refers to the time to extraction, the second to the time of instrumental analysis.

APPENDIX H

PROCEDURES FOR STEAM CLEANING OF GROUND WATER SAMPLING EQUIPMENT

Procedures for Steam Cleaning of Ground Water Sampling Equipment

1.0 PURPOSE

To describe the Standard Operating Procedures used in steam cleaning of ground water sampling equipment.

2.0 SCOPE

To prevent contamination of ground water samples or monitor wells, all sampling equipment must be thoroughly cleaned prior to each use. Steam cleaning is commonly the most efficient method of accomplishing this in the field.

This document describes procedures to be used in steam cleaning ground water sampling equipment. Sampling equipment dedicated to a particular well will be cleaned prior to installation and after any maintenance requiring removal from the well. Other equipment will be cleaned prior to each use. Equipment used in each of several wells will be cleaned prior to use at each individual well.

The procedures described in this SOP are intended to be used only when the more rigorous decontamination methods described in the SOP "Procedures for Decontamination of Ground Water Sampling Equipment" are impracticable for technical or logistical reasons.

3.0 PROCEDURES

Always wear gloves and safety glasses when operating the steam cleaner.

3.1 Disassemble any equipment, such as pumps, which cannot be thoroughly cleaned in an assembled condition.

3.2 Remove any obvious dirt or other foreign substances from all tools and equipment to be cleaned, using tap water, a brush, and soap if necessary. Arrange the tools and equipment on a clean, hard surface. Have heavy plastic bags in readiness to receive the cleaned tools and equipment.

3.3 Read the steam cleaner's operating instructions, and be certain that they are completely understood. Inspect the steam cleaner to ensure that it is properly fueled and in good working order, and that there are no solvents, detergents, or other foreign substances in the machine. Clean the steam cleaner, if necessary.

3.4 Start the steam cleaner and collect 2 samples of the water flowing from the steam nozzle in 40 ml septum vials (VOAs). Label and store these samples in accordance with the RCRA Sample Collection and Chain-of-Custody SOP's for use in checking for potential contamination of the steam cleaning equipment.

3.5 Thoroughly steam clean all equipment and tools, and rinse with distilled water.

3.6 Using an appropriate item of equipment (e.g., a bailer or a glass sample container) take an "equipment blank" sample by running distilled, deionized water over or through the equipment and collecting it in 2 40-ml septum vials. Close the vials securely, ensuring that no air or headspace remains in the vials. Assign sample numbers and store, transport, and analyze the equipment blanks in the same manner as other samples collected in the program. An equipment blank should be taken at each steam cleaning event.

3.7 Wearing clean disposable rubber gloves, reassemble any equipment that was disassembled for cleaning. Transfer all of the cleaned tools and equipment to clean plastic bags and secure the bags.

3.8 After cleaning, handle equipment no more than is essential for conducting the sampling procedure. Always wear clean, disposable rubber or cotton gloves when handling the clean equipment.

4.0 REFERENCES

U.S. Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, p. 106-107.

APPENDIX I

PROCEDURES FOR WATER LEVEL MEASUREMENT IN WELLS, USING ELECTRONIC SOUNDER

Procedures for Water Level Measurement in Wells, Using Electronic Sounder

1.0 PURPOSE

To describe the Standard Operating Procedures for measurement of water level in wells, using an electronic sounder ("probe").

2.0 SCOPE

Water level measurements are required prior to pumping and sampling of monitor wells, and are commonly made under many other circumstances where data on water table or potentiometric surface elevation are needed.

This document describes procedures for water level measurement using an electronic sounder, commonly referred to as a "water level probe." The sounder is designed so that, when it reaches ground water, a circuit is closed, resulting in a "beep" or in a strong reading on an ammeter. The depth to water from a surface reference point of known elevation is measured using a graduated tape attached to the sounder.

3.0 PROCEDURES

3.1 Prior to each measurement, clean the sounder with distilled water and dry it with a clean paper towel. Place clean plastic sheeting around the well head to assure that the sounder does not become contaminated by contact with the ground during the measurement procedures.

3.2 Remove the cap (if so equipped) from the well head and set it aside. If casing cap is unvented, allow about 10 minutes for water level in the well to equilibrate to atmospheric pressure.

3.3 Each well should have a measuring point which is accurately surveyed so that its exact elevation is known. (Commonly, this point is the top of the casing.) At RCRA sites, this point will be described in the Sampling and Analysis Plan. Be sure that the measuring point is known.

In some cases (e.g., regional ground water studies) the well being measured may not be surveyed accurately with respect to a known datum. In these cases, the depth measurement should be made from the top of the casing. Additionally, measure the "stick-up," i.e., the length of casing above the ground level, using a ruler or steel tape. Record this information to permit determination of water level based on the known ground surface elevation (from a topographic map or similar source).

3.4 Ensure that the sounder is turned on. Insert the sounder slowly into the well until a "beep" is heard (or a strong ammeter reading is observed). Using the graduated tape attached to the sounder, measure the depth to water from the measuring point, to the nearest 0.01 inch, and record it in the field log book.

3.5 Total depth of well should also be determined (after sampling). Turn the sounder off and insert it slowly into the well until the probe reaches the bottom of the well, which will be observed by the sudden reduction of tension on the tape. Jostle the tape slightly (up and down) to be certain that the probe has reached the bottom of the well, rather than being hung up on a casing joint, pump or similar irregularity. Measure total depth from the measuring point to the nearest 0.01 inch and record it in the field log book. Prior to measuring total depth be certain that pumps, wires, tubing or other obstructions will not tangle the probe and prevent probe removal. Note that the "zero point" on most probes is at the electrical contacts, which may not be at the bottom of the probe, so total depth measurements may have to be adjusted to reflect the additional probe length below the contacts.

3.6 Remove the sounder from the well and be certain that it is turned off and cleaned before storage or reuse.

3.7 Replace and lock (if so equipped) the well cap.

4.0 REFERENCES

U.S. Code of Federal Regulations, 1983, 40 CFR 264.97 (f).

U.S. Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, p. 99-100.

APPENDIX J

PROCEDURES FOR FIELD MEASUREMENT OF TEMPERATURE, SPECIFIC CONDUCTANCE, AND pH

Procedures for Field Measurement of Temperature, Specific Conductance, and pH

1.0 PURPOSE
To describe the Standard Operating Procedures for field measurement of temperature, specific conductance, and pH of water samples.

2.0 SCOPE
Water quality parameters which are physically or chemically unstable must be measured in the field immediately after collection of samples. Unstable parameters include temperature, specific conductance, and pH.

This document describes approved methods of measuring temperature, specific conductance, and pH in the field.

3.0 PROCEDURES FOR FIELD MEASUREMENTS
3.1 TEMPERATURE
3.1.1 Equipment
A mercury-filled thermometer or thermistor with accuracy to 0.1°C, should be used.

3.1.2 General Considerations
1. When possible, temperature measurements should be taken at the source; otherwise, an intermediate container may be used. When an intermediate container is used, readings should be taken as soon as possible.

2. Check the thermometer for separations in the mercury prior to each reading. These can be remedied by gently shaking the thermometer.

3. When taking a reading, hold the thermometer away from any surface, such as the sides or bottom of a container or stream.

3.1.3 Procedure
1. Take temperature reading by immersing the thermometer in the solution to be measured to the manufacturer's indicated immersion level.

2. Read the temperature to the nearest 0.1°C.

3. Record measurement on the pH data sheet (Figure 3-1).

FIGURE 3-1
pH DATA SHEET

Site ____

Date ____

Time of Sample Collection __________________

Time of Reading ____________________________

Well No. ___________________________________

In-Situ* Temperature (°C) __________________

Sample Temperature (°C) ____________________

Initial Sample pH Reading __________________

pH Calibration on _______________ Standard

4=_________ 7=_________ 10=_______

Sample pH

pH Recheck 4=______ 7=______ 10=______

*If sample is retained for pH measurement independent of field conditions, in-situ temperature measurement must still be taken.

3.1.4 Calibration

Thermometer should be checked monthly or before each sampling period against a National Bureau of Standards (NBS) certified thermometer.

3.2 SPECIFIC CONDUCTANCE

The procedures described below apply to the SI Model 33 S-C-T Meter. GCL employs several different types of conductance meters. The manufacturer's instructions should be consulted to determine the specific calibration procedures required for the meter being used.

3.2.1 Equipment

1. Conductivity Meter

2. Conductivity Cell

3. Standard 0.01N KCl Solution

4. NBS Standardized Thermometer, accuracy to 0.1°C.

3.2.2 Preparation of 0.01N KCl Solution

1. Use anhydrous KCl crystals; desiccated for 24 hours or baked at 100°C for two hours.

2. Weight out 0.744 grams of KCl and place in a 1,000-milliliter volumetric flask.

3. Using high grade distilled water at 25 ± 2°C, bring to full volume and mix well to dissolve all KCl crystals.

4. Store in glass bottle(s), and label as to date prepared.

5. Measure the conductivity of the distilled water used to prepare the solution. If any conductivity is present, this value must be corrected as 25°C and added to the value of the solution. The base conductivity value of the prepared solution using 0.744 grams of KCl is 1408.8 umhos/cm. Label the prepared solution as to the final conductivity value at 25°C.

3.2.3 General Considerations

A Salinity-Conductivity-Temperature Meter is the field instrument normally used for specific conductance determinations. Instructions which follow describe the use of this instrument. Other types of conductivity meters are available and commonly used. If another type of meter is used, these instructions should be modified as needed in accordance with the manufacturer's recommendations for the type of meter in use.

In general, the meter should be used in the following manner when taking all readings:

1. Adjust meter zero (if necessary) by turning the bakelite screw on the meter face so that the needle coincides with the zero on the conductivity scale.

2. Turn the <u>mode</u> control to <u>redline</u> and adjust the <u>redline</u> control knob so that the meter needle lines up with the redline painted on the meter face. If this cannot be accomplished, the batteries must be replaced. (This step may be performed without the probe plugged into the meter.)

3. Rinse the probe with deionized water before and after each reading.

4. When taking a reading, immerse the probe in the solution and move the probe up and down a few times to ensure proper circulation through the cell electrodes. Hold the probe steady and away from the sides and bottom of the container and read the measurement.

5. Read the meter needle to the nearest 1/4 of the scale graduations. Always estimate to the next higher 1/4 graduation, rather than "dropping" any value. All results are expressed in umhos/cm.

6. Conductance measurements should always be taken in an intermediate container, rather than a sample container.

7. The thermocouple in the probe does not measure temperature to the required accuracy, so an NBS standardized thermometer with an accuracy of 0.1°C is necessary for all temperature measurements.

3.2.4 Determination of Cell Constant

The cell constant is used to evaluate the proper functioning of the instrument probe. The cell constant will be calculated on a daily basis prior to any field measurements.

1. Measure the temperature of the 0.01N KCl standard solution to the nearest 0.1°C.

2. Turn the meter on to the X10 scale and measure the conductance of the standard 0.01N KCl solution. (Multiply the observed value by 10 to obtain the final result.)

3. Press the cell test button. The meter needle should not deflect more than 2 percent of the observed value. If deflection is >2 percent, the probe is fouled and requires cleaning before use.

4. Calculate the cell constant using the following formula:

$$C = \frac{K_m}{K_s} \times 100$$

where

C = Cell constant

K_m = Measured conductance of 0.01N KCl solution at measured temperature

K_s = Actual conductance of 0.01N KCl solution at measured temperature

The cell constant must be between 0.95 and 1.05. If not, the cell should be cleaned and the constant rechecked before use.

The following formula can also be used to calculate K_s values:

$$K_s = 1408.8 + 26.9019\ (T-25)$$

5. Record all data and calculation on the specific conductance calibration log (Figure 3-2).

3.2.5 Field Measurements

1. Measure the temperature of the sample to the nearest 0.1°C, using an NBS standardized thermometer.

2. Measure the specific conductance of the sample. Remember to multiply the meter scale factor (X1, X10, X100) when calculating results.

3. Obtain the temperature correction factor for the sample temperature measure in Step 1.

4. Multiply the specific conductance measured in Step 2 by the temperature correction factor to obtain the corrected specific conductance value.

5. Record all data and calculations on the specific conductance data sheet (Figure 3-3).

3.3 pH FIELD MEASUREMENT PROCEDURE

3.3.1 Required Equipment

1. pH meter and manufacturer manual of operation

2. NBS standardized thermometer, accuracy to 0.1°C

3. Standard buffer solutions: 4.0, 7.0, 10.0

4. Saturated KCl with AgCl solution (optional)

FIGURE 3-2
SPECIFIC CONDUCTANCE CALIBRATION LOG

SITE ______________________________

DATE ______________________________

TIME ______________________________

PERFORMED BY ______________________

YSI Model 33 S-C-T Meter

Serial No. ____________

Date of 0.01N KCl Standard Preparation ________________

________________ Changed KCl solution in Calibration Jar

Measurements

Temperature of Standard (°C) ________________

Uncorrected Reading (umhos/cm) ______________

Correction Factor ___________________________

Corrected Reading (umhos/cm) ________________

Calibration Verification

Cell Test Deflection (umhos/cm) _____________

Cell Constant _______________________________

NOTES:

a. Cell Constant = $\frac{\text{Corrected Reading umhos/cm}}{\text{1408.8 umhos/cm}}$

b. Cell constant must be between 0.95 and 1.05. If not, probe is fouled and requires cleaning.

c. Cell test deflection must be 2 percent of uncorrected reading.

Procedure performed as per Minimum Standards and Guidelines of Operation, Process and Wastewater Sampling Standards, Section 1.1.2.

__________ Initial   __________ QA/QC

FIGURE 3-3
SPECIFIC CONDUCTANCE DATA SHEET

Site ______________________________

Date ______________________________

Time of Sample Collection ______________

Time of Reading ______________________

Well No. ___________________________

Performed by ________________________

Temperature (°C) _____________________

Uncorrected reading (umhos/cm) __________

Correction Factor ____________________

Corrected reading (umhos/cm) ___________

______ Initial ______ QA/QC

3.3.2 General Considerations

Several types of pH meters are available for use. For differences in operation between meters, consult the appropriate manufacturer's manual of operation. In general, all meters should be used in the following manner:

1. Store electrode in saturated KCl solution or in 4.0 buffer when not in use.

2. Rinse the electrode with deionized water before and after each use.

3. When taking a reading, immerse the electrode in the solution fluid, stir gently for a few seconds. Hold the electrode steady and away from the sides and bottom of the container and read the measurement. Always record measurements to the nearest 0.1 unit.

4. pH readings should always be taken in an intermediate container, rather than a sample container.

5. Store the meter with the electrode disconnected, taking care not to soil or damage connections.

3.3.3 Operation Check Procedure

Each day prior to use, the pH meter will be check and calibrated to ensure proper operation.

1. Check expiration dates on buffers. Discard and replace if expired.

2. Check batteries in pH meter. Replace if necessary.

3. Check condition of electrode solution. If solution or gel is separated, gently shake electrode to consolidate solution, in KCl-filled probes, add solution if necessary.

4. Measure the temperature of the buffer(s) to the nearest 1.0°C with an NBS standardized thermometer. (Note: It is assumed that all buffer temperatures are equal if stored together.)

5. Set the temperature compensation dial to the buffer temperature measure in Step 4. (Note: For automatic temperature compensating meters, disregard this step.)

6. Using Table 3-1, find the corresponding buffer values for the measured temperature in Step 5. For this comparison estimate measured temperatures to the nearest 5°C.

7. Measure the pH of the 7.0 buffer solution.

TABLE 3-1
pH BUFFER TEMPERATURE CORRECTIONS

Temperature °C	Buffer Values		
	4.0	7.0	10.0
0	4.01	7.13	10.34
5	3.99	7.10	10.26
10	4.00	7.07	10.19
15	3.99	7.05	10.12
20	4.00	7.02	10.06
25	4.00	7.00	10.00
30	4.01	6.99	9.94

8. Adjust the calibration control knob until the meter reading corresponds to the appropriate value in Table 3-2.

9. Repeat Steps 6 and 7 using the 4.0 or 10.0 buffer solution. When the pH is measured with the 4.0 or 10.0 buffer solution, continue with the next step (No. 10). The choice of buffer solution depends on the range of pH anticipated in the material to be tested. If acidic material is expected, calibrate using 4.0 buffer; if basic material is expected, calibrate using 10.0 buffer. A 3-point calibration using all 3 buffers should be done if the approximate pH of the analyte is not known in advance.

10. Record all measurements on the <u>pH calibration log</u> (see Figure 3-4).

11. If measurements obtained are within 0.2 or the appropriate table values, the meter is functioning properly.

3.3.4 Sample pH Measurement Procedure

1. Measure the temperature of the sample to the nearest 1.0°C. When taking a pH measurement of a sample, set the temperature compensation dial to the measured temperature.

2. Take the "initial" sample reading. The purpose of this reading is to determine approximate pH of sample for calibration purposes.

3. Calibrate the pH meter to a standard within 2 pH units of "initial" sample reading following the procedures in Section 3.3.3, Operation Check Procedure Steps 3-9.

4. Measure the pH of the two other buffers.

5. Measure the pH of the sample.

6. Recheck the meter by measuring the pH of the two buffers (4.0 and 7.0).

7. Record all measurements on the <u>pH data sheet</u> (see Figure 3-1).

FIGURE 3-4

pH CALIBRATION LOG

Site

Date Time

Performed by

Instrument:

_______ Digi-Sense Model 5985-20

_______ Digi-Sense Model 5986-10

_______ Presto-Tek PA-11A

_______ Cole Parmer pH Wand Model No. 5985-75

_______ Nester pH pen*

Serial Number

_______ Changed buffers in pH kit

Temperature of Buffers (°C) _________

pH of buffers at measured temperature:

7=______ 4=______ 10=______

(See Table A3-2)

_______ Calibrated at 7.0 buffer value from Table C1-1.

Readings of other buffers: 4=______ 10=______

pH readings must be ± 0.2 units from table values for proper operation of meter.

*Nester pH pens are not temperature compensating instruments. Sample and buffer temperatures must be equal when using these units.

Procedure performed as per Minimum Standards and Guidelines of Operation, Process and Wastewater Sampling Standards, Section 1.1.3.

_______ Initial _______ QA/QC

4.0 REFERENCES

U.S. Environmental Protection Agency, 1986a, RCRA Grand-Water Monitoring Technical Enforcement Guidance Document, p. 107-108.

U.S. Environmental Protection Agency, 1986b, Test Methods for Evaluating Solid Waste: EPA Report SW-k846; Volume I: Physical/Chemical Methods, Methods 9040 and 9050.

APPENDIX K

PROCEDURES FOR LABELING, PACKING AND SHIPPING OF WATER SAMPLES

Procedures for Labeling, Packing and Shipping of Water Samples

1.0 PURPOSE

To describe the Standard Operating Procedures for the packing and shipping of water samples.

2.0 SCOPE

Proper handling of water samples between the time of field collection and that of laboratory analysis is critical in preserving the validity of analytical data. This document describes procedures to be used in labeling, packing, shipping, and storage of water samples.

These procedures are consistent with the requirements of all state and Federal regulations, including those for ground water monitoring programs under RCRA.

3.0 PROCEDURES

3.1 All samples will be collected and placed in tightly sealed glass or polyethylene containers, as appropriate, and preserved in accordance with the requirements of EPA document SW-846 and the standard practices of the laboratory which is to do the analyses. The specific containers and preservation techniques required will be included in the Sampling and Analysis Plan for each project.

3.2 Immediately upon collection, label each sample container with an adhesive label clearly indicating, in waterproof ink:

- o Project and site identification
- o Sample number
- o Sample preservation (e.g., H_2SO_4, $Na_2S_2O_3$)
- o Date and time of sampling
- o Name of sample collector

Standard practice is to assign a sample number of 10 digits, indicating the date and time of sampling, as follows:

- o Year (2 digits)
- o Month (2 digits)
- o Day (2 digits)
- o Time (24-hour clock; 4 digits)

Thus, for example, a sample collected at 2:45 p.m. (14:45 on the 24-hour clock) on May 15, 1987, would be assigned the sample number: 8705151445. Other systems of identifying samples may be used for certain projects, if desired.

Sample splits, spikes, and blanks required for QA/QC analysis will be labeled and given sample numbers according to the same scheme. All sample numbers and the source of the associated samples will be recorded in the Field Logbook.

Seal each sample container with a chain-of-custody seal, which is an adhesive seal clearly indicating, in waterproof ink:

- Sample number
- Project and site identification
- Date
- Signature and printed name of individual responsible for sampling.

These seals are not to be removed from the containers except by laboratory personnel. Complete Chain-of-Custody procedures are described in a separate SOP.

3.3 Since the great majority of analytes require preservation at low temperatures (4°C), it will be the normal policy to preserve <u>all</u> samples in ice chests at 4°C, unless specifically stated otherwise in the Sampling and Analysis Plan.

Immediately after affixing labels and chain-of-custody seals to the sample containers, place them on ice in an ice chest. During subsequent handling and shipping, ensure that enough ice remains in the chest to keep the samples at a temperature no greater than 4°C.

3.4 Ideally, samples will be directly delivered to the analytical laboratory by the person responsible for the sampling. If this is not possible, arrange for transportation by common carrier. Record each transfer of sample custody on the chain-of-custody form.

3.5 If shipping by common carrier is necessary, pack the samples securely, using clean paper, styrofoam beads, or similar clean material, so that there is no likelihood of breakage during transit. Seal each shipping container (ice chest or similar unit) with a chain-of-custody seal, and clearly label the package "FRAGILE-GLASSWARE" or with other appropriate indications of package contents. Include chain-of-custody documentation within the sealed container, as described in the chain-of-custody SOP.

Maintain full chain-of-custody records (as described in a separate SOP) showing all transfers of sample custody between the sampling point and the analytical laboratory.

4.0 REFERENCES

U.S. Code of Federal Regulations, 1983, 40 CFR 264.97.

U.S. Environmental Protection Agency, 1986a, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, p. 11-117.

U.S. Environmental Protection Agency, 1986b, Test Methods for Evaluating Solid Waste: EPA Report SW-846; Volume I: Physical/Chemical Methods.

APPENDIX L

CHAIN-OF-CUSTODY PROCEDURES

Chain-of-Custody Procedures

1.0 PURPOSE

To describe Standard Operating Procedures used to ensure complete chain-of-custody recording for all samples.

2.0 SCOPE

Formal chain-of-custody procedures are required for documentation of sample possession from time of collection to time of analysis on most projects.

The procedures described in this document are designed to meet all legal accountability requirements, including specifically those for sample documentation under RCRA.

3.0 PROCEDURES

3.1 The chain-of-custody program allows for the tracing of possession and handling of individual samples from the time of field collection through laboratory analysis. Elements of the chain-of-custody program include:

- Sample labels, which prevent misidentification of samples;
- Sample seals to preserve the integrity of the sample from the time it is collected until it is opened in the laboratory;
- Field logbook to record information about each sample collection during the monitoring program;
- Chain-of-custody record to establish the documentation necessary to trace sample possession from the time of collection to analysis;
- Sample analysis request sheets, which serve as official communication to the laboratory of the particular analysis(es) required for each sample and provide further evidence that the chain of custody is complete; and
- Laboratory logbook and analysis notebooks, which are maintained at the laboratory and record all pertinent information about the sample.

3.2 Immediately after sample collection, label each sample container with an adhesive label containing the information needed to positively identify the sample and the treatment appropriate for it. Labels are usually supplied by the laboratory which will perform the analyses, and in some cases may already be affixed to the sample containers. Mark the labels with a waterproof ink.

Include on the label:

- o Project and site identification
- o Sample number
- o Sample preservation (e.g., H_2SO_4, $Na_2S_2O_3$)
- o Date and time of sampling
- o Any other information needed for sample analysis.

Standard practice is to assign a sample number of 10 digits, indicating the date and time of sampling, as follows:

- o Year (2 digits)
- o Month (2 digits)
- o Day (2 digits)
- o Time (24-hour clock; 4 digits)

Thus, for example, a sample collected at 2:45 p.m. (14:45 on the 24-hour clock) on May 15, 1987, would be assigned the sample number: 8705151445. Other systems of identifying samples may be used for certain projects, if desired by the client.

Sample splits, spikes, and blanks required for QA/QC analysis will be labeled and given sample numbers according to the same scheme. Record all sample numbers and the source of the associated samples in the Field Logbook.

3.3 Seal each sample container with a chain-of-custody seal. The chain-of-custody seal is an adhesive seal with spaces for recording the following information:

- o Sample number
- o Project and site identification
- o Date
- o Signature and printed name of individual responsible for sampling.

Record this information on the seal, using a waterproof ink, and affix the seal over the lid of the sampling container so that the container cannot be opened until the seal is broken. The seal is not to be broken except by laboratory personnel at the time the sample container is opened for analysis. A typical chain-of-custody seal is shown in Figure 3-1.

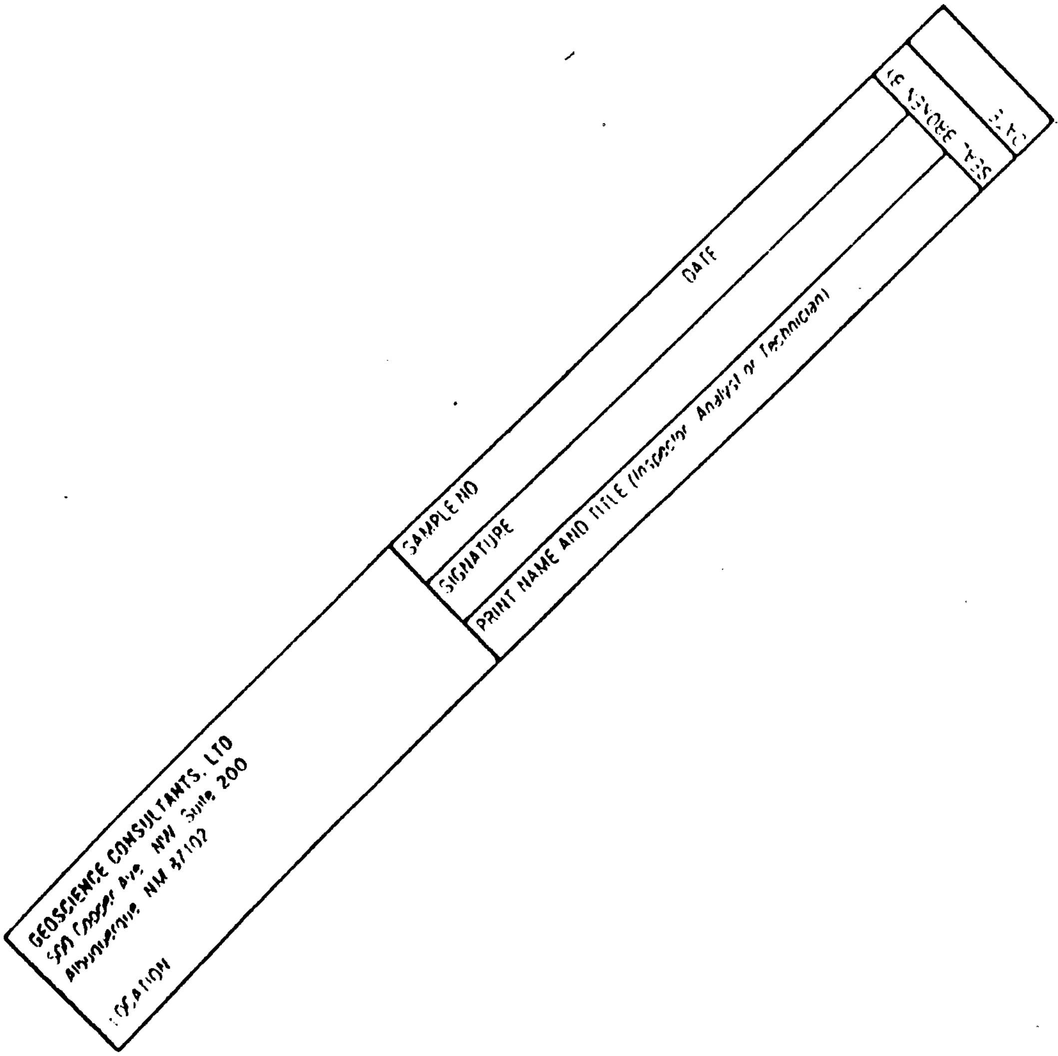


Figure 3-1 Chain of Custody Label

3.4 Record the sample number, date and time of sampling, and any other pertinent information in the Field Logbook.

3.5 Before delivering samples to the analytical laboratory or relinquishing possession to another person for delivery, fill out a chain-of-custody record. The chain-of-custody record must accompany the sample to the laboratory, and must record each change in sample custody from the person collecting the sample to the receiving party at the analytical laboratory. It must be signed by every person who has custody of the sample at any time.

The chain-of-custody record should contain:

- o Sample number(s)
- o Signature of collector
- o Date and time of collection
- o Sample type (e.g., ground water, immiscible layer)
- o Identification of sample site (well, spring, soil boring, etc.)
- o Number of containers
- o Signature of person(s) involved in the chain of possession
- o Inclusive dates of possession
- o Date of sample receipt by the laboratory

A typical chain-of-custody record form is shown in Figure 3-2.

3.6 Before delivering samples to the analytical laboratory, fill out a Sample Analysis Request Form. Typically, a unique form is developed for each project, taking into account the types of samples and analyses generally needed for the project. The Sample Analysis Request Form provides the analytical laboratory with information and instructions as to the types of samples received, preservation techniques used, and types of analyses to be performed.

The Sample Analysis Request Form should contain the following information:

- o Company and person requesting analyses
- o Sample number
- o Date of sampling
- o Project and job number or billing code

Geoscience Consultants, Ltd.
Albuquerque • Silver Spring

Chain of Custody

DATE ______ PAGE ______ OF ______

PROJ. MGR. ______
COMPANY ______
ADDRESS ______

SAMPLERS (SIGNATURE) (PHONE NO.)

ANALYSIS REQUEST

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418			PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE				NUMBER OF CONTAINERS

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT:	TOTAL NO. OF CONTAINERS	
PO NO.	CHAIN OF CUSTODY SEALS	
SHIPPING ID. NO.	REC'D GOOD CONDITION/COLD	
VIA:	CONFORMS TO RECORD	
	LAB NO.	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
(Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
(Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
(Printed Name) (Date)	(Printed Name) (Date)	(Printed Name)
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC.

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Figure 3-7

- Type of sample
- Number and type of sample containers
- Preservation methods
- Number and type of analyses requested

3.7 At time of sample delivery to the analytical laboratory, obtain signed copy of the Chain-of-Custody Record for client files. Also retain a copy of the Sample Analysis Request Form as a record of sample delivery and in case of any subsequent questions regarding the types of analyses requested.

3.8 If it is necessary to ship the samples to the analytical laboratory via commercial or common carrier (including truck, bus, plane, train, or other parcel delivery service), the following procedures will be followed.

Retain one copy of the chain-of-custody form, and seal the other copy or copies in a watertight pouch. Place the pouch inside the container containing the samples, and seal the entire container with a completed chain-of-custody seal and strapping tape so that it cannot be opened without breaking the seal. Record the name of the shipping company and the date, time, and place of delivery to the shipping company on the retained copy of the chain-of-custody form, signed by the person relinquishing the package to the shipping company. Instruct the receiving laboratory to verify the integrity of the package on arrival, and to certify the date, time, and place of delivery and the company making the delivery to the laboratory or to the location where the package is picked up by laboratory personnel. A copy of the chain-of-custody form containing the certification of delivery to the laboratory will be returned to GCL and retained, along with the copy certifying GCL relinquishment of the package to the shipping company.

4.0 REFERENCES

U.S. Code of Federal Regulations, 1983, 40 CFR 264.97.

U.S. Environmental Protection Agency, 1986a, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, p. 114-117.

APPENDIX M

LABORATORY QUALITY CONTROL PROCEDURES
(FROM EPA MANUAL SW-846)

CHAPTER ONE

QUALITY CONTROL

1.1 INTRODUCTION

Appropriate use of data generated under the great range of analytical conditions encountered in RCRA analyses requires reliance on the quality control practices incorporated into the methods and procedures. The Environmental Protection Agency generally requires using approved methods for sampling and analysis operations fulfilling regulatory requirements, but the mere approval of these methods does not guarantee adequate results. Inaccuracies can result from many causes, including unanticipated matrix effects, equipment malfunctions, and operator error. Therefore, the quality control component of each method is indispensable.

The data acquired from quality control procedures are used to estimate and evaluate the information content of analytical data and to determine the necessity or the effect of corrective action procedures. The means used to estimate information content include precision, accuracy, detection limit, and other quantifiable and qualitative indicators.

1.1.1 Purpose of this Chapter

This chapter defines the quality control procedures and components that are mandatory in the performance of analyses, and indicates the quality control information which must be generated with the analytical data. Certain activities in an integrated program to generate quality data can be classified as management (QA) and other as functional (QC). The presentation given here is an overview of such a program.

The following sections discuss some minimum standards for QA/QC programs. The chapter is not a guide to constructing quality assurance project plans, quality control programs, or a quality assurance organization. Generators who are choosing contractors to perform sampling or analytical work, however, should make their choice only after evaluating the contractor's QA/QC program against the procedures presented in these sections. Likewise, laboratories that sample and/or analyze solid wastes should similarily evaluate their QA/QC programs.

Most of the laboratories who will use this manual also carry out testing other than that called for in SW-846. Indeed, many user laboratories have multiple mandates, including analyses of drinking water, wastewater, air and industrial hygiene samples, and process samples. These laboratories will, in most cases, already operate under an organizational structure that includes QA/QC. Regardless of the extent and history of their programs, the users of this manual should consider the development, status, and effectiveness of their QA/QC program in carrying out the testing described here.

1.1.2 Program Design

The initial step for any sampling or analytical work should be strictly to define the program goals. Once the goals have been defined, a program must be designed to meet them. QA and QC measures will be used to monitor the program and to ensure that all data generated are suitable for their intended use. The responsibility of ensuring that the QA/QC measures are properly employed must be assigned to a knowledgeable person who is not directly involved in the sampling or analysis.

One approach that has been found to provide a useful structure for a QA/QC program is the preparation of both general program plans and project-specific QA/QC plans.

The program plan for a laboratory sets up basic laboratory policies, including QA/QC, and may include standard operating procedures for specific tests. The program plan serves as an operational charter for the laboratory, defining its purposes, its organization and its operating principles. Thus, it is an orderly assemblage of management policies, objectives, principles, and general procedures describing how an agency or laboratory intends to produce data of known and accepted quality. The elements of a program plan and its preparation are described in QAMS-004/80.

Project-specific QA/QC plans differ from program plans in that specific details of a particular sampling/analysis program are addressed. For example, a program plan might state that all analyzers will be calibrated according to a specific protocol given in written standard operating procedures for the laboratory (SOP), while a project plan would state that a particular protocol will be used to calibrate the analyzer for a specific set of analyses that have been defined in the plan. The project plan draws on the program plan or its basic structure and applies this management approach to specific determinations. A given agency or laboratory would have only one quality assurance program plan, but would have a quality assurance project plan for each of its projects. The elements of a project plan and its preparation are described in QAMS/005/80 and are listed in Figure 1-1.

Some organizations may find it inconvenient or even unnecessary to prepare a new project plan for each new set of analyses, especially analytical laboratories which receive numerous batches of samples from various customers within and outside their organizations. For these organizations, it is especially important that adequate QA management structures exist and that any procedures used exist as standard operating procedures (SOP), written documents which detail an operation, analysis or action whose mechanisms are thoroughly prescribed and which is commonly accepted as the method for performing certain routine or repetitive tasks. Having copies of SW-846 and all its referenced documents in one's laboratory is not a substitute for having in-house versions of the methods written to conform to specific instrumentation, data needs, and data quality requirements.

FIGURE 1-1

ESSENTIAL ELEMENTS OF A QA PROJECT PLAN

1. Title Page
2. Table of Contents
3. Project Description
4. Project Organization and Responsibility
5. QA Objectives
6. Sampling Procedures
7. Sample Custody
8. Calibration Procedures and Frequency
9. Analytical Procedures
10. Data Reduction, Validation, and Reporting
11. Internal Quality Control Checks
12. Performance and System Audits
13. Preventive Maintenance
14. Specific Routine Procedures Used to Assess Data Precision, Accuracy, and Completeness
15. Corrective Action
16. Quality Assurance Reports to Management

1.1.3 Organization and Responsibility

As part of any measurement program, activities for the data generators, data reviewers/approvers, and data users/requestors must be clearly defined. While the specific titles of these individuals will vary among agencies and laboratories, the most basic structure will include at least one representative of each of these three types. The data generator is typically the individual who carries out the analyses at the direction of the data user/requestor or a designate within or outside the laboratory. The data reviewer/approver is responsible for ensuring that the data produced by the data generator meet agreed-upon specifications.

Responsibility for data review is sometimes assigned to a "Quality Assurance Officer" or "QA Manager." This individual has broad authority to approve or disapprove project plans, specific analyses and final reports. The QA Officer is independent from the data generation activities. In general, the QA Officer is responsible for reviewing and advising on all aspects of QA/QC, including:

Assisting the data requestor in specifying the QA/QC procedure to be used during the program;

Making on-site evaluations and submitting audit samples to assist in reviewing QA/QC procedures; and,

f problems are detected, making recommendations to the data requestor and upper corporate/institutional management to ensure that appropriate corrective actions are taken.

In programs where large and complex amounts of data are generated from both field and laboratory activities, it is helpful to designate sampling monitors, analysis monitors, and quality control/data monitors to assist in carrying out the program or project.

The sampling monitor is responsible for field activities. These include:

Determining (with the analysis monitor) appropriate sampling equipment and sample containers to minimize contamination;

Ensuring that samples are collected, preserved, and transported as specified in the workplan; and

Checking that all sample documentation (labels, field notebooks, chain-of-custody records, packing lists) is correct and transmitting that information, along with the samples, to the analytical laboratory.

The analysis monitor is responsible for laboratory activities. These include:

Training and qualifying personnel in specified laboratory QC and analytical procedures, prior to receiving samples;

Receiving samples from the field and verifying that incoming samples correspond to the packing list or chain-of-custody sheet; and

Verifying that laboratory QC and analytical procedures are being followed as specified in the workplan, reviewing sample and QC data during the course of analyses, and, if questionable data exist, determining which repeat samples or analyses are needed.

The quality control and data monitor is responsible for QC activities and data management. These include:

Maintaining records of all incoming samples, tracking those samples through subsequent processing and analysis, and, ultimately, appropriately disposing of those samples at the conclusion of the program;

Preparing quality control samples for analysis prior to and during the program;

Preparing QC and sample data for review by the analysis coordinator and the program manager; and

Preparing QC and sample data for transmission and entry into a computer data base, if appropriate.

1.1.4 Performance and Systems Audits

The QA Officer may carry out performance and/or systems audits to ensure that data of known and defensible quality are produced during a program,.

Systems audits are qualitative evaluations of all components of field and laboratory quality control measurement systems. They determine if the measurement systems are being used appropriately. The audits may be carried out before all systems are operational, during the program, or after the completion of the program. Such audits typically involve a comparison of the activities given in the QA/QC plan with those actually scheduled or performed. A special type of systems audit is the data management audit. This audit addresses only data collection and management activities.

The performance audit is a quantitative evaluation of the measurement systems of a program. It requires testing the measurement systems with samples of known composition or behavior to evaluate precision and accuracy. The performance audit is carried out by or under the auspices of the QA Officer without the knowledge of the analysts. Since this is seldom achievable, many variations are used that increase the awareness of the analyst as to the nature of the audit material.

1.1.5 Corrective Action

Corrective action procedures should be addressed in the program plan, project, or SOP. These should include the following elements:

The EPA predetermined limits for data acceptability beyond which corrective action is required;

Procedures for corrective action; and,

For each measurement system, identification of the individual responsible for initiating the corrective action and the individual responsible for approving the corrective action, if necessary.

The need for corrective action may be identified by system or performance audits or by standard QC procedures. The essential steps in the corrective action system are:

Identification and definition of the problem;

Assignment of responsibility for investigating the problem;

Investigation and determination of the cause of the problem;

Determination of a corrective action to eliminate the problem;

Assigning and accepting responsibility for implementing the corrective action;

Implementing the corrective action and evaluating its effectiveness; and

Verifying that the corrective action has eliminated the problem.

The QA Officer should ensure that these steps are taken and that the problem which led to the corrective action has been resolved.

1.1.6 QA/QC Reporting to Management

QA Project Program or Plans should provide a mechanism for periodic reporting to management (or to the data user) on the performance of the measurement system and the data quality. Minimally, these reports should include:

Periodic assessment of measurement quality indicators, i.e., data accuracy, precision and completeness;

Results of performance audits;

Results of system audits; and

Significant QA problems and recommended solutions.

The individual responsible within the organization structure for preparing the periodic reports should be identified in the organizational or management plan. The final report for each project should also include a separate QA section which summarizes data quality information contained in the periodic reports.

Other guidance on quality assurance management and organizations is available from the Agency and professional organizations such as ASTM, AOAC, APHA and FDA.

1.1.7 Quality Control Program for the Analysis of RCRA Samples

An analytical quality control program develops information which can be used to:

- Evaluate the accuracy and precision of analytical data in order to establish the quality of the data;

- Provide an indication of the need for corrective actions, when comparison with existing regulatory or program criteria or data trends shows that activities must be changed or monitored to a different degree; and

- To determine the effect of corrective actions.

1.1.8 Definitions

ACCURACY: Accuracy means the nearness of a result or the mean ($\bar{x}$) of a set of results to the true value. Accuracy is assessed by means of reference samples and percent recoveries.

ANALYTICAL BATCH: The basic unit for analytical quality control is the analytical batch. The analytical batch is defined as samples which are analyzed together with the same method sequence and the same lots of reagents and with the manipulations common to each sample within the same time period or in continuous sequential time periods. Samples in each batch should be of similar composition.

BLANK: A blank is an artificial sample designed to monitor the introduction of artifacts into the process. For aqueous samples, reagent water is used as a blank matrix; however, a universal blank matrix does not exist for solid samples, and therefore, no matrix is used. The blank is taken through the appropriate steps of the process.
A reagent blank is an aliquot of analyte-free water or solvent analyzed with the analytical batch. Field blanks are aliquots of analyte-free water or solvents brought to the field in sealed containers and transported back to the

laboratory with the sample containers. Trip blanks and equipment blanks are two specific types of field blanks. Trip blanks are not opened in the field. They are a check on sample contamination originating from sample transport, shipping and from site conditions. Equipment blanks are opened in the field and the contents are poured appropriately over or through the sample collection device, collected in a sample container, and returned to the laboratory as a sample. Equipment blanks are a check on sampling device cleanliness.

CALIBRATION CHECK: Verification of the ratio of instrument response to analyte amount, a calibration check, is done by analyzing for analyte standards in an appropriate solvent. Calibration check solutions are made from a stock solution which is different from the stock used to prepare standards.

CHECK SAMPLE: A blank which has been spiked with the analyte(s) from an independent source in order to monitor the execution of the analytical method is called a check sample. The level of the spike shall be at the regulatory action level when applicable. Otherwise, the spike shall be at 5 times the estimate of the quantification limit. The matrix used shall be phase matched with the samples and well characterized: for an example, reagent grade water is appropriate for an aqueous sample.

ENVIRONMENTAL SAMPLE: An environmental sample or field sample is a representative sample of any material (aqueous, nonaqueous, or multimedia) collected from any source for which determination of composition or contamination is requested or required. For the purposes of this manual, environmental samples shall be classified as follows:

Surface Water and Ground Water;

Drinking Water -- delivered (treated or untreated) water designated as potable water;

Water/Wastewater -- raw source waters for public drinking water supplies, ground waters, municipal influents/effluents, and industrial influents/effluents;

Sludge -- municipal sludges and industrial sludges;

Waste -- aqueous and nonaqueous liquid wastes, chemical solids, contaminated soils, and industrial liquid and solid wastes.

MATRIX/SPIKE-DUPLICATE ANALYSIS: In matrix/spike duplicate analysis, predetermined quantities of stock solutions of certain analytes are added to a added to a sample matrix prior to sample extraction/digestion and analysis. Samples are split into duplicates, spiked and analyzed. Percent recoveries are calculated for each of the analytes detected. The relative percent difference between the samples is calculated and used to assess analytical precision. The concentration of the spike should be at the regulatory standard level or the estimated or actual method quantification limit. When the concentration of the analyte in the sample is greater than 0.1%, no spike of the analyte is necessary.

MQL: The method quantification limit (MQL) is the minimum concentration of a substance that can be measured and reported.

PRECISION: Precision means the measurement of agreement of a set of replicate results among themselves without assumption of any prior information as to the true result. Precision is assessed by means of duplicate/replicate sample analysis.

PQL: The practical quantitation limit (PQL) is the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

RCRA: The Resource Conservation and Recovery Act.

REAGENT GRADE: Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonomous terms for reagents which conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.

REPLICATE SAMPLE: A replicate sample is a sample prepared by dividing a sample into two or more separate aliquots. Duplicate samples are considered to be two replicates.

STANDARD CURVE: A standard curve is a curve which plots concentrations of known analyte standard versus the instrument response to the analyte.

SURROGATE: Surrogates are organic compounds which are similar to analytes of interest in chemical composition, extraction, and chromatography, but which are not normally found in environmental samples. These compounds are spiked into all blanks, standards, samples and spiked samples prior to analysis. Percent recoveries are calculated for each surrogate.

WATER: Reagent, analyte-free, or laboratory pure water means distilled or deionized water or Type II reagent water which is free of contaminants that may interfere with the analytical test in question.

1.2 QUALITY CONTROL

The procedures indicated below are to be performed for all analyses. Specific instructions relevant to particular analyses are given in the pertinent analytical procedures.

1.2.1 Field Quality Control

The sampling component of the Quality Assurance Project Plan (QAPP) shall include:

Reference to or incorporation of accepted sampling techniques in the sampling plan;

Procedures for documenting and justifying any field actions contrary to the QAPP;

Documentation of all pre-field activities such as equipment check-out, calibrations, and container storage and preparation;

Documentation of field measurement quality control data (quality control procedures for such measurements shall be equivalent to corresponding laboratory QC procedures);

Documentation of field activities;

Documentation of post-field activities including sample shipment and receipt, field team de-briefing and equipment check-in;

Generation of quality control samples including duplicate samples, field blanks, equipment blanks, and trip blanks; and

The use of these samples in the context of data evaluation, with details of the methods employed (including statistical methods) and of the criteria upon which the information generated will be judged.

1.2.2 Analytical Quality Control

A quality control operation or component is only useful if it can be measured or documented. The following components of analytical quality control are related to the analytical batch. The procedures described are intended to be applied to chemical analytical procedures; although the principles are applicable to radio-chemical or biological analysis, the procedures may not be directly applicable to such techniques.

All quality control data and records required by this section shall be retained by the laboratory and shall be made available to the data requestor as appropriate. The frequencies of these procedures shall be as stated below or at least once with each analytical batch.

1.2.2.1 Spikes, Blanks and Duplicates

General Requirements

These procedures shall be performed at least once with each analytical batch with a minimum of once per twenty samples.

1.2.2.1.1 Duplicate Spike

A split/spiked field sample shall be analyzed with every analytical batch or once in twenty samples, whichever is the greater frequency. Analytes stipulated by the analytical method, by applicable regulations, or by other specific requirements must be spiked into the sample. Selection of the sample to be spiked and/or split depends on the information required and the variety of conditions within a typical matrix. In some situations, requirements of the site being sampled may dictate that the sampling team select a sample to be spiked and split based on a pre-visit evaluation or the on-site inspection. This does not preclude the laboratory's spiking a sample of its own selection as well. In other situations the laboratory may select the appropriate sample. The laboratory's selection should be guided by the objective of spiking, which is to determine the extent of matrix bias or interference on analyte recovery and sample-to-sample precision. For soil/sediment samples, spiking is performed at approximately 3 ppm and, therefore, compounds in excess of this concentration in the sample may cause interferences for the determination of the spiked analytes.

1.2.2.1.2 Blanks

Each batch shall be accompanied by a reagent blank. The reagent blank shall be carried through the entire analytical procedure.

1.2.2.1.3 Field Samples/Surrogate Compounds

Every blank, standard, and environmental sample (including matrix spike/matrix duplicate samples) shall be spiked with surrogate compounds prior to purging or extraction. Surrogates shall be spiked into samples according to the appropriate analytical methods. Surrogate spike recoveries shall fall within the control limits set by the laboratory (in accordance with procedures specified in the method or within $\pm 20\%$) for samples falling within the quantification limits without dilution. Dilution of samples to bring the analyte concentration into the linear range of calibration may dilute the surrogates below the quantification limit; evaluation of analytical quality then will rely on the quality control embodied in the check, spiked and duplicate spiked samples.

1.2.2.1.4 Check Sample

Each analytical batch shall contain a check sample. The analytes employed shall be a representative subset of the analytes to be determined. The concentrations of these analytes shall approach the estimated quantification limit in the matrix of the check sample. In particular, check samples for metallic analytes shall be matched to field samples in phase and in general matrix composition.

1.2.2.2 Clean-Ups

Quality control procedures described here are intended for adsorbent chromatography and back extractions applied to organic extracts. All batches of adsorbents (Florisil, alumina, silica gel, etc.) prepared for use shall be checked for analyte recovery by running the elution pattern with standards as a column check. The elution pattern shall be optimized for maximum recovery of analytes and maximum rejection of contaminants.

1.2.2.2.1 Column Check Sample

The elution pattern shall be reconfirmed with a column check of standard compounds after activating or deactivating a batch of adsorbent. These compounds shall be representative of each elution fraction. Recovery as specified in the methods is considered an acceptable column check. A result lower than specified indicates that the procedure is not acceptable or has been misapplied.

1.2.2.2.2 Column Check Sample Blank

The check blank shall be run after activating or deactivating a batch of adsorbent.

1.2.2.3 Determinations

1.2.2.3.1 Instrument Adjustment: Tuning, Alignment, etc.

Requirements and procedures are instrument- and method-specific. Analytical instrumentation shall be tuned and aligned in accordance with requirements which are specific to the instrumentation procedures employed. Individual determinative procedures shall be consulted. Criteria for initial conditions and for continuing confirmation conditions for methods within this manual are found in the appropriate procedures.

1.2.2.3.2 Calibration

Analytical instrumentation shall be calibrated in accordance with requirements which are specific to the instrumentation and procedures employed. Introductory Methods 7000 and 8000 and appropriate analytical procedures shall be consulted for criteria for initial and continuing calibration.

1.2.2.3.3 Additional QC Requirements for Inorganic Analysis

Standard curves used in the determination of inorganic analytes shall be prepared as follows:

Standard curves derived from data consisting of one reagent blank and four concentrations shall be prepared for each analyte. The response for each prepared standard shall be based upon the average of three replicate readings of each standard. The standard curve shall be used with each subsequent analysis provided that the standard curve is verified by using at least one reagent blank and one standard at a level normally encountered or expected in such samples. The response for each standard shall be based upon the average of three replicate readings of the standard. If the results of the verification are not within ±10% of the original curve, a new standard shall be prepared and analyzed. If the results of the second verification are not within ±10% of the original standard curve, a reference standard should be employed to determine if the discrepancy is with the standard or with the instrument. New standards should also be prepared on a quarterly basis at a minimum. All data used in drawing or describing the curve shall be so indicated on the curve or its description. A record shall be made of the verification.

Standard deviations and relative standard deviations shall be calculated for the percent recovery of analytes from the spiked sample duplicates and from the check samples. These values shall be established for the twenty most recent determinations in each category.

1.2.2.3.4 Additional Quality Control Requirements for Organic Analysis

The following requirements shall be applied to the analysis of samples by gas chromatography, liquid chromatography and gas chromatography/mass spectrometry.

The calibration of each instrument shall be verified at frequencies specified in the methods. A new standard curve must be prepared as specified in the methods.

The tune of each GC/MS system used for the determination of organic analytes shall be checked with 4-bromofluorobenzene (BFB) for determinations of volatiles and with decafluorotriphenylphosphine (DFTPP) for determinations of semi-volatiles. The required ion abundance criteria shall be met before determination of any analytes. If the system does not meet the required specification for one or more of the required ions, the instrument must be retuned and rechecked before proceeding with sample analysis. The tune performance check criteria must be achieved daily or for each 12 hour operating period, whichever is more frequent.

Background subtraction should be straightforward and designed only to eliminate column bleed or instrument background ions. Background subtraction actions resulting in spectral distortions for the sole purpose of meeting special requirements are contrary to the objectives of Quality Assurance and are unacceptable.

For determinations by HPLC or GC, the instrument calibration shall be verified as specified in the methods.

1.2.2.3.5 Identification

Identification of all analytes must be accomplished with an authentic standard of the analyte. When authentic standards are not available, identification is tentative.

For gas chromatographic determinations of specific analytes, the relative retention time of the unknown must be compared with that of an authentic standard. For compound confirmation, a sample and standard shall be re-analyzed on a column of different selectivity to obtain a second characteristic relative retention time. Peaks must elute within daily retention time windows to be declared a tentative or confirmed identification.

For gas chromatographic/mass spectrometric determinations of specific analytes, the spectrum of the analyte should conform to a literature representation of the spectrum or to a spectrum of the authentic standard obtained after satisfactory tuning of the mass spectrometer and within the same twelve-hour working shift as the analytical spectrum. The appropriate analytical methods should be consulted for specific criteria for matching the mass spectra, relative response factors, and relative retention times to those of authentic standards.

1.2.2.3.6 Quantification

The procedures for quantification of analytes are discussed in the appropriate general procedures (7000, 8000) and the specific analytical methods.

In some situations in the course of determining metal analytes, matrix-matched calibration standards may be required. These standards shall be composed of the pure reagent, approximation of the matrix, and reagent addition of major interferents in the samples. This will be stipulated in the procedures.

Estimation of the concentration of an organic compound not contained within the calibration standard may be accomplished by comparing mass spectral response of the compound with that of an internal standard. The procedure is specified in the methods.

1.3 DETECTION LIMIT AND QUANTIFICATION LIMIT

The detection limit and quantification limit of analytes shall be evaluated by determining the noise level of response for each sample in the batch. If analyte is present, the noise level adjacent in retention time to the analyte peak may be used. For wave-length dispersive instrumentation, multiple determinations of digestates with no detectable analyte may be used to establish the noise level. The method of standard additions should then be used to determine the calibration curve using one digestate or extracted sample in which the analyte was not detected. The slope of the calibration curve, m, should be calculated using the following relations:

m = slope of calibration line

S_B = standard deviation of the average noise level

MDL = KS_B/m

For K = 3; MDL = method detection limit.

For K = 5; MQL = method quantitation limit.

1.4 DATA REPORTING

The requirement of reporting analytical results on a wet-weight or a dry-weight basis is dictated by factors such as: sample matrix; program or regulatory requirement; and objectives of the analysis.

Analytical results shall be reported with the percent moisture or percent solid content of the sample.

1.5 QUALITY CONTROL DOCUMENTATION

The following sections list the QC documentation which comprises the complete analytical package. This package should be obtained from the data generator upon request. These forms, or adaptations of these forms, shall be used by the data generator/reportor for inorganics (I), or for organics (O) or both (I/O) types of determinations.

1.5.1 <u>Analytical Results</u> (I/O: Form I)

Analyte concentration.

Sample weight.

Percent water (for non-aqueous samples when specified).

Final volume of extract or diluted sample.

Holding times (I: Form X).

1.5.2 Calibration (I: Form II; O: Form V, VI, VII, IX)

Calibration curve or coefficients of the linear equation which describes the calibration curve.

Correlation coefficient of the linear calibration.

Concentration/response data (or relative response data) of the calibration check standards, along with dates on which they were analytically determined.

1.5.3 Column Check (O: Form X)

Results of column chromatography check, with the chromatogram.

1.5.4 Extraction/Digestion (I/O: Form I)

Date of the extraction for each sample.

1.5.5 Surrogates (O: Form II)

Amount of surrogate spiked, and percent recovery of each surrogate.

1.5.6 Matrix/Duplicate Spikes (I: Form V, VI; O: Form III)

Amount spiked, percent recovery, and relative percent difference for each compound in the spiked samples for the analytical batch.

1.5.7 Check Sample (I: Form VII; O: Form VIII)

Amount spiked, and percent recovery of each compound spiked.

1.5.8 Blank (I: Form III; O: Form IV)

Identity and amount of each constituent.

1.5.9 Chromatograms (for organic analysis)

All chromatograms for reported results, properly labeled with:

- Sample identification
- Method identification
- Identification of retention time of analyte on the chromatograms.

1.5.10 Quantitative Chromatogram Report (O: Forms VIII, IX, X)

Retention time of analyte.

Amount injected.

Area of appropriate calculation of detection response.

Amount of analyte found.

Date and time of injection.

1.5.11 Mass Spectrum

Spectra of standards generated from authentic standards (one for each report for each compound detected).

Spectra of analytes from actual analyses.

Spectrometer identifier.

1.5.12 Metal Interference Check Sample Results (I: Form IV)

1.5.13 Detection Limit (I: Form VII; O: Form I)

Analyte detection limits with methods of estimation.

1.5.14 Results of Standard Additions (I: Form VIII)

1.5.15 Results of Serial Dilutions (I: Form IX)

1.5.16 Instrument Detection Limits (I: Form XI)

1.5.17 ICP Interelement Correction Factors and ICP Linear Ranges (when applicable) (I: Form XII, Form XIII).

1.6 REFERENCES

1. Guidelines and Specifications for Preparing Quality Assurance Program Plans, September 20, 1980, Office of Monitoring Systems and Quality Assurance, ORD, U.S. EPA, QAMS-004/80, Washington, DC 20460.

2. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, December 29, 1980, Office of Monitoring Systems and Quality Assurance, ORD, U.S. EPA, QAMS-005/80, Washington, DC 20460.

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SPILL/LEAKAGE PREVENTION AND EMERGENCY RESPONSE PLAN GIANT BLOOMFIELD REFINERY

December 9, 1988

First Revision March 8, 1990

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SPILL/LEAKAGE PREVENTION AND EMERGENCY RESPONSE PLAN GIANT BLOOMFIELD REFINERY

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GCL

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GCL

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1.0 EXECUTIVE SUMMARY

In accordance with the request of the New Mexico Oil Conservation Division (NMOCD), Geoscience Consultants, Ltd. (GCL) has prepared a Spill Prevention Control and Countermeasure (SPCC) Plan for the Bloomfield Refinery owned by Giant Industries, Inc. (Giant). In preparing this SPCC Plan, GCL has consulted EPA Regulations on Oil Pollution Prevention, 40 C.F.R. §112, as guidance. Giant no longer operates the refinery or uses the site for the storage of crude oil or refined products. Consequently, the SPCC Plan addresses the presently operating ground-water remediation system.

This plan provides details for spill and leak prevention and emergency response in the event of a spill or leak from the ground-water remediation system, and addresses the following:

- personnel training and spill prevention procedures
- equipment: materials of construction and integrity testing
- berm capacity and integrity testing
- potential for equipment failure
- response and cleanup procedures
- record keeping

This plan is submitted as a supplement to the discharge plan application (GW-40) submitted by Montgomery and Andrews on behalf of Giant for the ground-water remediation system at the refinery.

2.0 PURPOSE OF PLAN

The purpose of the SPCC Plan is to describe the methods established and equipment available at the Giant Bloomfield Refinery to prevent any unplanned discharges from the ground-water remediation system. GCL has consulted EPA regulations on Oil Pollution Prevention, 40 C.F.R. §112, as guidance for the organization and content of the Plan.

3.0 GENERAL SITE DESCRIPTION

The Giant Bloomfield Refinery is located along hydrologic flow lines extending between the Lee Acres Landfill in the north and the Lee Acres Subdivision in the south. The precise location of the refinery is NW 1/4, Section 27, and SW 1/4, Section 22, T.29N., R.12W. in San Juan County, New Mexico, approximately 5 miles west of the town of Bloomfield on U.S. Highway 64.

The refinery is not active with respect to refining of petroleum. The site is located downgradient from the Lee Acres Landfill and upgradient from domestic supply wells.

A remedial action program is currently in progress at the refinery site. The program consists of pumping ground water from recovery wells, temporary storage of recovered water in above-ground storage tanks, treatment of recovered water by air stripping, and discharge of treated water to infiltration trenches. Any free-phase hydrocarbons recovered by the system will be stored temporarily and then transported off-site for refining.

4.0 STORAGE TANKS

Nine existing tanks will be employed to store ground water recovered from the remediation system. Two small tanks, 25 and 50 barrels respectively, are employed for recovered hydrocarbon temporary storage. Enclosed with this submission is a revised Plate 1 of the Discharge Plan, which shows the location of all storage tanks. The following is a list of all tanks and their capacities:

Tank #	Capacity
Tank #21	10,000 barrels
Tank #22	10,000 barrels
Tank #27	5,000 barrels
Tank #32	5,000 barrels
Tank #34	5,000 barrels
Tank #35	5,000 barrels
Tank #37	10,000 barrels
Northern Intermediate Storage Tank	300 barrels
Southern Intermediate Storage Tank	300 barrels
Northern Hydrocarbon Storage Tank	50 barrels
Southern Hydrocarbon Storage Tank	25 barrels

4.1 MATERIALS OF CONSTRUCTION

All tanks used for water storage are constructed of steel; the southern hydrocarbon storage tank is constructed of fiberglass reinforced plastic; the northern hydrocarbon storage tank is constructed of steel. All tanks are chemically compatible with any recovered hydrocarbons.

4.2 FAIL-SAFE DEVICES

The intermediate storage tanks are equipped with liquid-level sensors and high-level alarms to warn of potential tank overfilling. The water levels of the long-term storage tanks are monitored visually on a weekly basis.

4.3 SECONDARY CONTAINMENT

The recovered water storage tanks are surrounded by earthen berms which have been adequately sized to contain spills or leaks. Calculations demonstrating the capacity of the berms are presented in Appendix A of this submission.

4.4 INTEGRITY TESTING

The eleven aboveground tanks will be subject to weekly visual inspection by operating personnel to observe any signs of deterioration, leaks which might cause a spill, or accumulation of recovered water or hydrocarbons inside the bermed areas. Tank supports and foundations will be included in these inspections. General observations of the entire system and repair actions taken will be recorded in a log. Liquid levels in all storage tanks will also be obtained and recorded in the log.

5.0 PIPING

5.1 PIPING IN SERVICE OR IN STANDBY SERVICE

Any ground-water remediation piping which is not in service or is in standby service will be capped and tagged with an appropriate designation of its origin.

5.2 ACTIVE PIPING

5.2.1 Materials of Construction

Piping used in the remediation operation are constructed of steel, PVC, and other hydrocarbon resistant plastics, all of which are chemically compatible with the hydrocarbon constituents found in the recovered water.

5.2.2 Integrity Testing

All aboveground valves and piping will be subjected to weekly visual inspection. The general condition of the piping, including valves, joints and piping supports, will be assessed. In addition to routine visual inspection of aboveground piping systems, all piping used in the remedial action will be subjected to a hydrostatic pressure test prior to use.

Hydrostatic pressure tests will also be conducted on an annual basis to ensure continued integrity.

6.0 TREATMENT SYSTEM

6.1 AIR STRIPPER

The air stripper assembly used to treat the recovered ground water is constructed of fiberglass reinforced plastic and is chemically compatible with the hydrocarbon constituents found in the ground water.

6.2 PUMPING SYSTEM

The inlet pump to the air stripper is constructed of cast iron and is compatible with the constituents present in the produced ground water.

6.3 INTEGRITY TESTING

The air stripper and its ancillary pump and equipment, as well as all ground water recovery pumps, are inspected on a weekly basis for any signs of deterioration or leakage.

6.4 FAIL-SAFE DEVICES

The water recovery, treatment, and discharge process is controlled by a microprocessor based control and shutdown panel. Several safety shutdown devices initiate a total system shutdown requiring manual reset before operation can be reestablished. They are:

High liquid level in Tank 102
Low liquid level in tank 102
Low air flow sensor at the air stripper
Upper high liquid level switch in the air stripper
(above the packing)
Lower high liquid level switch in the air stripper
(below the air inlet)

An abnormal event indicated by any one of these safety devices, as well as power failure, or a manual system shutdown results in the inlet water valve to tank 102 closing, power cutoff to all recovery wells, pumps and blowers, and an alarm signal consisting of a readily visible red beacon. The system will not restart until the alarm is cleared and the system is manually reset.

In addition to alarm and shutdown functions the panel controls the normal operation of the water treatment system including starting and stopping of pumps and blowers based on system water levels. To provide additional safety the panel utilizes a low ambient temperature switch to determine when temperatures are too low for air stripper operation. During periods of cold temperature water is diverted to long term storage.

The southern intermediate storage tank (tank 106) is fitted with level devices which sound an audible alarm in the case of an abnormal event.

7.0 CONTAINMENT STRUCTURES

Berms have been constructed to contain any leaks or spills.

7.1 BERM CAPACITY

Berms surrounding the water storage tanks were properly sized upon tank installation to contain any spill or leak from the tanks. Berms have been installed around both intermediate storage tanks.

7.2 INTEGRITY TESTING

All diversion and containment berms will undergo monthly visual inspection to ensure integrity.

7.3 RAINWATER DRAINAGE

Rainwater drainage not contained in the berms will flow to the arroyo which borders the refinery on the west side.

8.0 SECURITY

The facility site is entirely fenced with chainlink or barbed-wire fencing. Access to the facility through personnel and vehicular gates is limited to facility personnel, escorted visitors, or contractors.

9.0 PERSONNEL TRAINING AND SPILL PREVENTION PROCEDURES

Mr. Timothy A. Kinney is in charge of training personnel and keeping them current on spill prevention and detection procedures. Personnel are trained to regularly observe the remedial operations at the facility and report any evidence or sign of spills or leaks to supervisory personnel and to initiate repairs and cleanup.

Routine maintenance procedures conducted at the Giant Bloomfield Refinery also help to assure that equipment remains functional and that the possibility of spills or leaks is minimized.

10.0 POTENTIAL FOR EQUIPMENT FAILURE

10.1 PREDICTION OF FLOW DIRECTION

In the event of equipment failure resulting in the spillage of recovered ground water, the water will flow to the adjacent arroyo situated along the western border of the refinery. This arroyo drains towards the San Juan River.

10.2 RATE OF FLOW

The maximum rate of flow of recovered ground water would occur if the air stripper were to fail (as in the case of overflow) and such failure resulted in a spill or leak. Such an event could release up to 80 gpm of recovered ground water, depending upon the inlet pumping rate, if the outlet was totally plugged.

10.3 POTENTIAL TOTAL QUANTITY OF RECOVERED GROUND WATER DISCHARGED

The maximum total quantity of recovered ground water discharged in the event of a single tank failure would be roughly 420,000 gallons, based upon the capacity of the largest storage tank.

Assuming complete failure of all storage tanks, the maximum total quantity of recovered ground water discharged in a spill event would be 2,128,350 gallons.

11.0 REPORTING

In the event of an unplanned release of recovered ground water or hydrocarbons discovered by an employee (or reported to an employee by an outside person), such employee shall immediately notify the SPCC coordinator designated in this SPCC plan and, if he is not available, shall notify the person next in charge of the full details of the spill, including:

- Location of the spill.
- Estimated:
  1) Quantity spilled and area covered.
  2) Rate of spill.
  3) Time before spill would flow into drain or other conduit and be carried off the refinery site.
  4) Other factual information to assist in determining corrective action to be taken.

The SPCC coordinator, after being notified of details of the spill, shall determine the appropriate response based upon the magnitude and seriousness of the spill. If the SPCC coordinator determines that it is necessary, he shall immediately dispatch a spill clean-up crew. If outside assistance is required, such as the furnishing of heavy equipment, a local contractor shall be contacted by the coordinator. The SPCC coordinator is then responsible for orally notifying the Chief, Environmental Bureau, NMOCD within twenty-four hours of the following information: name and address of the facility; date, time, location and duration of the discharge; the source and cause of the discharge; chemical composition of the discharge; estimated volume of the discharge; and any action taken to mitigate immediate damage from the discharge. Within one week after learning of the discharge, the SPCC coordinator will send written notification to the same official verifying the prior oral notification and providing any appropriate additions or corrections. Within fifteen days after learning of the discharge, the SPCC coordinator will send a written report to the same official describing any corrective actions taken, or to be taken, relating to the discharge.

The following is a list of phone numbers of personnel and alternates to be contacted by employees in the event of a spill:

DESIGNATION	OFFICE PHONE NUMBER	HOME PHONE NUMBER
SPCC Coordinator Timothy Kinney	(505)-632-3306	(505)-334-3150
Refinery Manager Timothy Kinney	(505)-632-3306	(505)-334-3150
Site Contractor Randall Hicks	(505)-842-0001	(505)-256-7809
Alternate Martin Nee	(505)-842-0001	(505)-281-9162

12.0 SPILL CONTROL AND CLEANUP PROCEDURES

Actions to be taken by the spill cleanup crew to stop, contain and clean-up a spill of recovered ground water or hydrocarbons from the ground-water remediation system are detailed below:

- Repair Leak

  1) Shut off pumps if storage tanks or air stripper is leaking.

  2) Shut off upstream valves if piping is leaking.

- Contain the Spill

  1) If there is a bermed area to contain the spill, as in the case of the storage tanks, inspect the berm to be certain no water or hydrocarbons are seeping through the berm. If there is seepage, repair the berm immediately. Reclaim any free liquid within the berm and examine the interior of the berm for potential effects.

  2) If a small spill occurs outside the bermed areas, absorb the spill, if possible, by mopping or using collection agents.

  3) If the spill is running, confine the spill to a low area or depression.

  4) If the spill is running over a flat area, create a depression to confine the spill.

  5) If the spill has run off the site into a ditch or road, contain the recovered ground water or hydrocarbons by digging a depression just beyond the furthest point the spill has reached to confine it.

- Clean up the Spill

  1) If spill covers only a small area with a heavy concentration of hydrocarbons, assess the extent of contamination and remove the affected dirt and/or rock.

  2) If spill covers a large area, mark out the area that is contaminated and assess the extent of contamination. Subsequent action taken to remediate the area will be based upon the extent of contamination.

  3) In any spill, general cleanup procedures would involve minor earthwork to prevent migration and recovery of as much free liquid as possible. Any discolored soil removed in connection with clean-up will be taken to the bermed soil treatment area.

13.0 INSPECTION SUMMARY AND RECORD KEEPING

A summary of the inspection schedule to ensure integrity of the remediation system follows:

- All storage tanks, piping, and treatment system equipment shall undergo a weekly visual inspection for any signs of deterioration, leaks which might cause a spill, or accumulation of potentially contaminated water in the bermed area.

- Hydrostatic pressure tests of all piping will be conducted before initial use and on an annual basis thereafter to ensure continued integrity.

- The berms will be inspected on a monthly basis.

A log book will be kept of all inspections and the results.

APPENDIX A

GIANT BLOOMFIELD REFINERY
BERM VOLUME CALCULATIONS

GCL

GIANT BLOOMFIELD REFINERY
BERM VOLUME CALCULATIONS

TANK #	TANK CAPACITY	BERM CAPACITY		
21	10,000 barrels	Calculated area of berm	≈	21,077 sq. ft.
		Calculated effective volume of berm at 5.0' depth	≈	105,387 cu. ft. 788,831 gals. 18,781 barrels
22	10,000 barrels	Calculated area of berm	≈	21,077 sq. ft.
		Calculated effective volume of berm at 5.0' depth	≈	105,387 cu. ft. 788,831 gals. 18,781 barrels
27	5,000 barrels	(89.0' x 218.0') x 4.0'	≈	77,608.0 cu. ft. 580,507.8 gals. 13,821.6 barrels
32	5,000 barrels	(89.0' x 218.0') x 4.0'	≈	77,608.0 cu. ft. 580,507.8 gals. 13,821.6 barrels
34	5,000 barrels	(76.0' x 218.0') x 5.0'	≈	82,840.0 cu. ft. 619,643.2 gals. 14,753.4 barrels
35	5,000 barrels	(89.0' x 218.0') x 4.0'	≈	77,608.0 cu. ft. 580,507.8 gals. 13,821.6 barrels
37	10,000 barrels	(92.4' x 135.4') x 5.0'	≈	62,554.8 cu. ft. 467,909.9 gals. 11,140.7 barrels
Southern Intermediate	300 barrels	4,815 ft^2 x 2.42'	≈	11,652 cu. ft. 87,159 gals. 2,075 barrels
Northern Intermediate	300 barrels	1,743 ft^2 x 3'	≈	5,229 cu. ft. 39,112 gals. 931 barrels

LEGEND

MONITOR WELL •

PROPERTY BOUNDARY ———

NOTES:

1. Field Surveys Performed by Brewer Associates, Inc. of Farmington, New Mexico.
2. Vertical Aerial Photography Acquired on February 6, 1988 by New Mexico Aerial Surveys, Inc. Utilizing a Zeiss RMK A 15/23 Precision Aerial Mapping Camera.
3. Final Drafting and Photographic Reproductions Performed By Thomas R. Mann & Associates, Inc. of Albuquerque, New Mexico.
4. 500 Foot Grid Based on a Local Coordinate System.

'90 MAR 12 AM 9 08

N

SCALE IN FEET

100 50 0 100 200 300

SCALE: 1" = 100' (1:1200)

ORTHOPHOTO BASE MAP
OF THE
GIANT BLOOMFIELD REFINERY
SAN JUAN COUNTY, NEW MEXICO.

1988

PLATE 1

REV 1 3/90