GW - 40

WORK PLANS

SOIL AND GROUND WATER INVESTIGATIONS AND REMEDIAL ACTION PLAN

GIANT INDUSTRIES, INC.
BLOOMFIELD REFINERY
BLOOMFIELD, NEW MEXICO

June 1987

Prepared for:

MONTGOMERY & ANDREWS, P.A.
325 Paseo de Peralta
Santa Fe, New Mexico 87504-2307

Prepared by:

Geoscience Consultants, Ltd.
500 Copper Avenue, N.W., Suite 200
Albuquerque, New Mexico 87102

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JUL 17 1987
OIL CONSERVATION DIVISION
SANTA FE

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REPLY TO SANTA FE OFFICE

July 17, 1987

HAND DELIVERED

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

Re: Giant Industries, Inc./Bloomfield Refinery

Dear Mr. LeMay:

On behalf of our client, Giant Industries, Inc., I am enclosing a report on investigations of soil and ground water contamination at Giant's Bloomfield Refinery, prepared for us by Geoscience Consultants, Ltd. The latter part of the report outlines a remedial action plan for the containment and removal of such contamination. As you will see, our consultants believe that the implementation of this plan will be effective in preventing contamination originating within the refinery from migrating off the refinery site. However, our consultants also recognize that such actions cannot address the far more extensive contamination emanating from the Lee Acres landfill. After you have had an opportunity to review the report, we will be happy to discuss it with you and with members of your staff.

Sincerely,

Edmund H. Kendrick

EHK:jem:17
Enclosure
File #8361-85-09
Copy: Mr. David Boyer (w/o enclosure)

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1.0 EXECUTIVE SUMMARY

At the request of Montgomery and Andrews, P.A., Geoscience Consultants, Ltd. (GCL) performed site investigations at the Giant Bloomfield Refinery (GBR) to assess the environmental quality of the site. These investigations revealed several discrete areas of soil and ground water contamination. After evaluation, GCL began remedial action to remove or contain the contamination. Subsequent to initial remedial action, GCL performed additional studies and has developed a comprehensive remedial action plan. This report presents the results of all soil and ground water investigations performed to date by GCL at the Giant Bloomfield Refinery and describes the completed and proposed remedial actions.

GCL removed for treatment all known contaminated soil that feasibly could be excavated. Approximately 4500 cubic yards of contaminated soil have been spread within two bermed areas to prevent run-on and run-off while natural biodegradation takes place. Chemical analyses indicate that this process is effectively breaking down the oil and aromatic hydrocarbons in this soil.

The ground water contamination zones on the refinery site consist of three localized plumes as well as a regional plume resulting from past waste disposal practices at the Lee Acres Landfill. The on-site sources are identified in this report as the Diesel Spill Area, the Southern Refinery Area, and the Truck Fueling Area, each of which has exhibited floating product in some observation wells. For each of these ground water contamination areas, GCL has taken steps to identify the extent of the plume, contain the product on-site and remove the product contamination.

What about Spills in NE Area -

The Lee Acres Landfill, which is located hydrologically upgradient from the refinery on land administered by the Bureau of Land Management (BLM), has generated a contaminant plume that GCL believes underlies much of the western portion of the refinery site in the course of moving in a southerly direction to the Lee Acres Subdivision. This plume geometry is supported by the analytical results of several ground water samples

which have been found to contain contaminants characteristic of contamination at the Lee Acres Landfill specifically several chlorinated solvents not generated by any known refinery source.

GCL supervised the drilling of 40 boreholes on refinery property in order to obtain information about the depth, lateral extent, and chemical quality of the contaminant plumes. Data from this drilling program were used to design the remedial action plan presented in this report. Eight recovery wells (3 in the Diesel Spill Area, 1 in the Truck Fueling Area, and 4 in the Southern Refinery Area) have been completed and fitted with product-recovery pumps.

There have been three studies assessing the role of Lee Acres Landfill as a potential contamination source: a terrain electromagnetic conductivity survey performed by the New Mexico Environmental Improvement Division (NMEID) (McQuillan and Longmire, 1986); an analysis of existing information for the BLM (AEPCO, Inc., 1986); and a soil gas survey for the BLM (Tracer Research Corporation, 1986). These studies identified the existence of a contaminant plume originating at the landfill and suggested that the landfill was the likely source of chlorinated hydrocarbons found in the well water of several domestic wells located in the Lee Acres Subdivision. GCL understands that the United States Geological Survey (U.S.G.S.) has installed ground water piezometers in the vicinity of the landfill and plans to conduct additional studies.

GCL is currently operating recovery pumps in the Diesel Spill Area, the Truck Fueling Area and the Southern Refinery Area to remove floating product and contaminated ground water. Data have shown that the current degree of pumping in the Diesel Spill Area is sufficient to contain and remove the floating product plume in that area. Data from the Southern Refinery Area indicate that continuous pumping from two previously existing wells and from the two additional recovery wells described in this remedial action plan will effectively contain the floating product plume in this area. One recovery well installed in the Truck Fueling Area is expected to capture the plume resulting from the recent diesel leak in that area.

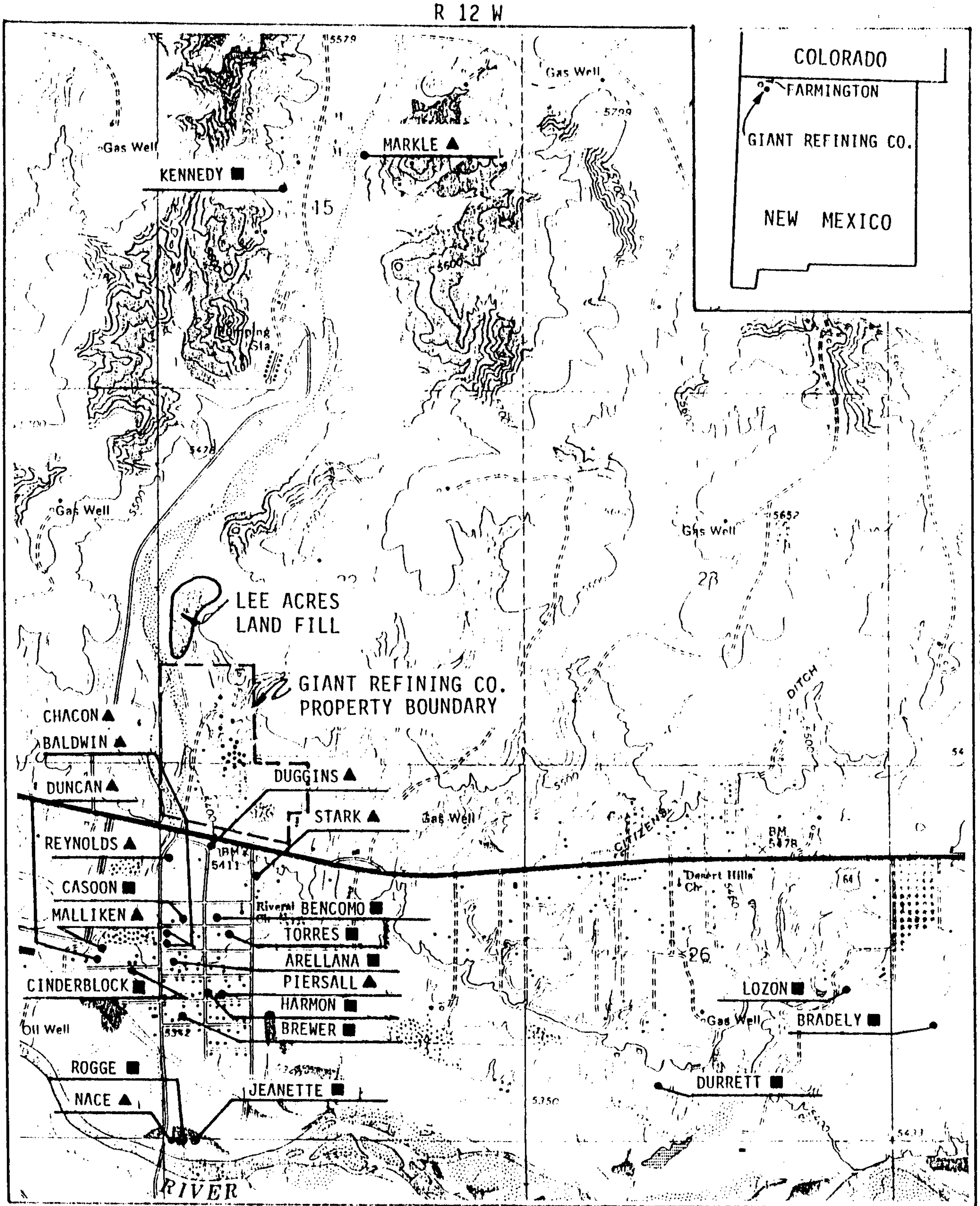
GCL believes that the remedial action plan presented in this report will be effective in preventing contamination -- both free-phase product and associated dissolved-phase product -- originating at the three on-site sources discussed above from migrating off the refinery site.

2.0 HISTORICAL BACKGROUND OF INVESTIGATIONS

The Giant Bloomfield Refinery (GBR) is located along hydrologic flow lines extending between the Lee Acres Landfill in the north and the Lee Acres Subdivision in the south. Detectable levels of chlorinated solvents have been found in at least two domestic water wells in the Lee Acres Subdivision. BLM consultants and the NMEID have identified the Lee Acres Landfill as the most likely source of this domestic well contamination. Because the refinery lies between the landfill and the subdivision, the contamination from the landfill has affected a large portion of the refinery property.

The precise location of the refinery is NW 1/4, Section 27 and SW 1/4, 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 is a map of the area showing locations of the landfill, the refinery and known domestic water wells in the vicinity.

The Lee Acres Landfill was used from 1981 to 1986 as a modified sanitary landfill by San Juan County and was operated by the County Department of Public Works under a lease from the Bureau of Land Management-Farmington Resource Area (BLM). In addition to sanitary wastes, industrial liquid wastes were also dumped into liquid waste pits at the landfill. In April 1985, during a severe rain storm, one dike of the landfill liquid-waste pits failed and mixed industrial/domestic wastes entered an arroyo which extends in a southerly direction from the landfill, posing a possible threat to the San Juan River. During the same period, several releases of toxic H_2S gas from the liquid waste pits caused 15 people, including some on-site remedial workers, to experience difficulty in breathing, severe headaches, skin rashes, and other symptoms. Also during that time, the Governor called out the National Guard to secure the perimeter of the landfill. The NMEID ordered the landfill closed to liquid wastes, and a private contractor was hired by the NMEID to treat the pit contents with ferric chloride to control pH levels and prevent further releases of H_2S gas.



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

■ WELL LOCATIONS FROM STATE ENGINEERS DRILL LOGS
LITHOLOGIC DESCRIPTIONS AVAILABLE

▲ WELL LOCATIONS FROM NMEID
WATER CHEMISTRY DATA AVAILABLE

WELL LOCATIONS ARE APPROXIMATE

FIGURE 2-1

LOCATION MAP

Analyses of solid-phase waste and sludge samples collected from the Lee Acres Landfill by NMEID personnel and others indicated that the wastes contained elevated concentrations of highly volatile and mobile organic compounds. Some of these are toxic and/or carcinogenic, including toluene, benzene, trichloromethane, 1,1,1-trichloroethane, trichloroethylene, dichloromethane, ethylbenzene, and all three isomers of xylene. High concentrations of sulfide and strontium and trace amounts of naphthalene, phenanthrene, and 2-methyl naphthalene were also detected in the solid medium of the wastes. Compounds detected in the aqueous phase of the wastes were quite similar to those in the solid phase. The aqueous phase also contained 2,4-dimethylphenol, phenol, and 2- and 4-methylphenol. These findings indicated that the wastes in the liquid waste pits were slightly corrosive, highly volatile, slightly flammable, and potentially toxic. The chemical analyses of lagoon water samples from the landfill are shown in Appendix A.

Complaints related to the odor and taste of drinking water from wells in the Lee Acres Subdivision were registered by local residents. Residential well water samples collected downgradient from the landfill contained low but detectable concentrations of benzene, tetrachloroethane, trichloroethylene, 1,1-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethene, 1,1,1-trichloroethylene, and dichlorobromomethane. These results are included in Appendix A. The investigations that followed have indicated that contamination of at least two private wells in the Lee Acres subdivision could be linked to leachate from the landfill (McQuillan and Longmire, 1986).

Giant's potential role in the observed ground water contamination was questioned by regulatory authorities. GCL conducted surface and subsurface investigations on the refinery property that revealed specific locations of soil and ground water contamination. Soil contamination was found near several product storage tanks, the fire fighting drill area and the stormwater catchment area. Three ground water contamination plumes were discovered in locations identified as the Diesel Spill Area, the Southern Refinery Area, and the Truck Fueling Area. GCL then assessed the extent of this contamination and began remedial action. These on-site investigations have revealed that the Lee Acres Landfill contaminant plume is also present under the refinery property, complicating the delineation, containment and removal of any contaminants that may have originated from refinery sources.

3.0 SUMMARY OF INVESTIGATIONS

3.1 SOIL INVESTIGATIONS

Investigations have revealed several isolated locations of hydrocarbon contaminated soil (Section 5.0), and GCL has removed over 4500 cubic yards of this contaminated soil as part of a remedial action program (Section 7.0). The removed soil has been stored in bermed areas that are underlain by shale bedrock and do not contain shallow ground water.

3.2 GROUND WATER INVESTIGATIONS

GCL has drilled a total of 40 boreholes on the refinery site to characterize the general ground water regime and to investigate the nature and extent of the localized zones of ground water contamination. Of these 40 boreholes, 32 have been completed as wells. Table 3-1 lists all of the boreholes that have been drilled to date and their completion information; Table 3-2 lists their elevations and coordinates. Two entries are shown for GBR-21 and GBR-24 because each was completed with two casings in one borehole, screened at different depths to permit selective sampling of ground water from two separate zones. One zone is located below the floating product and the other intercepts the floating product.

GBR-1 through GBR-4 were boreholes advanced in the fire fighting drill area to define the nature and extent of the area. These borings did not encounter ground water and were not completed as wells. They were plugged with bentonite and abandoned. GBR-16, also in the fire fighting drill area, was completed as a 2-inch PVC piezometer, but was removed during the excavation of the area. GBR-12 was planned to be a monitor well but auger refusal above the water table precluded its completion. GBR-39 and GBR-40 were drilled in the Truck Fueling Area to determine the boundary of the plume, but were not completed as wells. GBR-14 (6-inch), GBR-27 (5-inch) and GBR-28 (6-inch) are PVC recovery wells in the Diesel Spill Area; GBR-6, GBR-29, GBR-37 and GBR-38 are 6-inch PVC recovery wells in the Southern Refinery Area. The remainder are 2-inch monitor wells or piezometers. Logs of all the borings are included in Appendix B, and the well locations are shown in Plate 1.

TABLE 3-1

DESCRIPTION OF WELLS AND BOREHOLES DRILLED AT THE GIANT BLOOMFIELD REFINERY

GBR WELL NO.	COMPLETION DATE	LOCATION	MATERIAL	DIAM.	DEPTH	SCREEN
1	12/20/85	BURN PIT	-	-	20'	NOT COMPLETED
2	12/20/85	BURN PIT	-	-	25'	NOT COMPLETED
3	12/20/85	BURN PIT	-	-	11'	NOT COMPLETED
4	12/20/85	BURN PIT	-	-	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	BURN PIT	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	04/23/87	FUELING AREA	---	---	43'	NOT COMPLETED
40	04/24/87	FUELING AREA	---	---	38'	NOT COMPLETED

GALV = Galvanized Steel
SS = Stainless Steel
PVC = Polyvinyl Chloride

TABLE 3-2

WELL ELEVATIONS AND COORDINATES

GBR WELL NO.	GROUND ELEVATION (IN FEET)	WELL COORDINATES (REFER TO PLATE 1) NORTH	EAST
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	5392.70	10248	11696
6	5392.38	10235	11680
7	5392.53	10241	11688
8	5387.57	10150	11487
9	5387.64	10155	11468
10	5387.73	10158	11459
11	5387.80	10160	11448
12	-	-	-
13	5390.30	10355	11465
14	5393.53	10978	11382
15	5394.82	10944	11411
16	-	-	-
17	5401.30	11240	11142
18	5419.80	12022	11528
19	5391.74	10439	11322
20	5391.60	10255	11601
21S	5397.60	10946	11493
21D	5397.60	10946	11493
22	5393.88	10751	11459
23	5400.60	11014	11563
24S	5393.50	11084	11447
24D	5393.50	11084	11447
25	5395.00	10854	11476
26	5394.10	10950	11422
27	5396.90	10937	11484
28	5395.30	10869	11419
29	5387.90	10135	11550
30	5394.63	11015	11382
31	5391.47	10794	11351
32	5412.76	12062	11143
33	5393.35	10689	11383
34	5393.43	10694	11445
35	5393.35	10644	11447
36	5392.36	10589	11378
37	5387.80	10168	11420
38	5391.62	10114	11688
39	-	-	-
40	-	-	-

\- Indicates that well was not completed

No map show[illegible]
[illegible]
[illegible]
Where [illegible]
[illegible]

Ground water investigations have revealed two localized contamination areas caused by recent transportation activities (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 aerially-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.

A pipeline leak in 1985 released an estimated 10,000 to 15,000 gallons of diesel fuel in the Diesel Spill Area. GCL originally detected free-floating product in four wells in the area but found only trace amounts of such product in other wells within 100 feet of the spill. Test pumping in the Diesel Spill Area demonstrated a very low hydraulic conductivity of the water-bearing zone in that area, which indicates that potentially degraded ground water is not migrating rapidly from its source, and can be removed by properly placed recovery wells.

In the Southern Refinery Area, GCL found free-floating product in 3 wells and discovered a water seep near the abandoned fire fighting drill area. Test pumping in this area and ground water modeling indicate that pumping from properly placed recovery wells will prevent off-site migration of floating product in this area.

The Truck Fueling Area is the site of localized ground water degradation caused by an underground pipeline leak at the fueling station in November 1986, that released approximately 15,000 gallons of diesel fuel. GCL investigated this area, identified the extent of the localized plume, and determined that it can be controlled by a recovery well placed at the leading edge of the plume.

3.3 PRODUCT RECOVERY INVESTIGATIONS

In order to assess the feasibility of product recovery, GCL has operated a pilot-scale recovery system in the Diesel Spill Area using GBR-27 as a recovery well. A traditional two-pump system, consisting of a water level depression pump and a product recovery pump, was used in this pilot operation. In a two-pump system, the water level depression pump removes water from the well in order to create a cone of depression and induce the flow of floating product into the well; and the product recovery pump, which is located at the oil/water interface, skims floating product off the water as it accumulates in the well. However, GCL determined on the basis of test pumping, that the traditional two-pump system was not appropriate for this situation, because an excessive amount of water was removed in relation to the amount of floating product recovered. GCL then found that a single top-filling pump was sufficient both to remove floating product and maintain a cone of depression. This type of pump was installed and used for the remainder of the pilot operation.

GCL then installed a full-scale hydrocarbon recovery system in the Diesel Spill Area using GBR-14, GBR-27 and GBR-28. Pumping from the three wells has proven to be effective in controlling the plume. Giant will continue long-term pumping as further described in Section 8.1.2.

GCL installed similar pilot-scale pumps in GBR-6 and GBR-29 in the Southern Refinery Area to test the recovery of floating product prior to the installation of a full-scale recovery system for that portion of the refinery. These investigations indicated that additional recovery wells were required in this area in order to effectively contain the plume. Actions taken in this area, described in Section 8.2.2 include the installation of two additional recovery wells.

All hydrocarbons and water that have been recovered to date from the hydrocarbon recovery systems are being stored in above-ground storage tanks at the refinery until appropriate methods of disposal or treatment are approved by the New Mexico Oil Conservation Division (NMOCD). GCL has taken samples of this water and has investigated the feasibility of using impulse sprinklers for land application of the water. Further information on water treatment and disposal is presented in Section 8.5.

3.4 LEE ACRES LANDFILL INVESTIGATIONS

The NMEID has treated the liquid waste pits at the landfill with ferric chloride to reduce hydrogen sulfide generation, closed the landfill to liquid waste disposal, and has subsequently closed the landfill to disposal of any wastes.

The following three reconnaissance studies of the Lee Acres Landfill have been conducted to assess the effects of its contamination and to make recommendations for further action: a terrain electromagnetic conductivity survey by the NMEID (McQuillan and Longmire, 1986); an analysis of existing information for the BLM (AEPCO, Inc., 1986); and a soil gas survey for the BLM (Tracer Research Corporation, 1986).

From these investigations, the NMEID has determined that chlorinated solvents associated with the Lee Acres Landfill ground water contamination plume are widespread throughout the alluvial sediments of the nearby arroyo, and GCL has determined that these contaminants extend well under the refinery property. The plume is characterized by the presence of specific chlorinated solvents that were found in wastewater at the landfill site, in domestic wells located south of the refinery property, and in monitor wells located on the refinery property.

Additional investigations are being planned by the BLM to further evaluate the effects of the landfill contamination. The first of these began in January 1987, and includes the construction of a series of piezometers near the landfill to be used to establish the hydrologic conditions of the site. Seismic and electrical resistivity surveys were also conducted. To date these studies, which are being done by the U.S. Geological Survey (USGS) for the BLM, have only provided limited preliminary data.

4.0 HYDROGEOLOGY OF THE SITE

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 of the refinery and on Giant's property is a large unnamed arroyo which is underlain by 30 to 60 feet of 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 units merge hydrologically with the San Juan River alluvium to the south. Figure 4-1 is a generalized east-west cross section across the refinery site showing the relationship of the arroyo alluvium to bedrock. Major hydrogeologic features of the site 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, with ground water flow from north or northeast to south (towards the San Juan River) through the refinery area; and
- 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 the refinery site are shown on Plate 3.

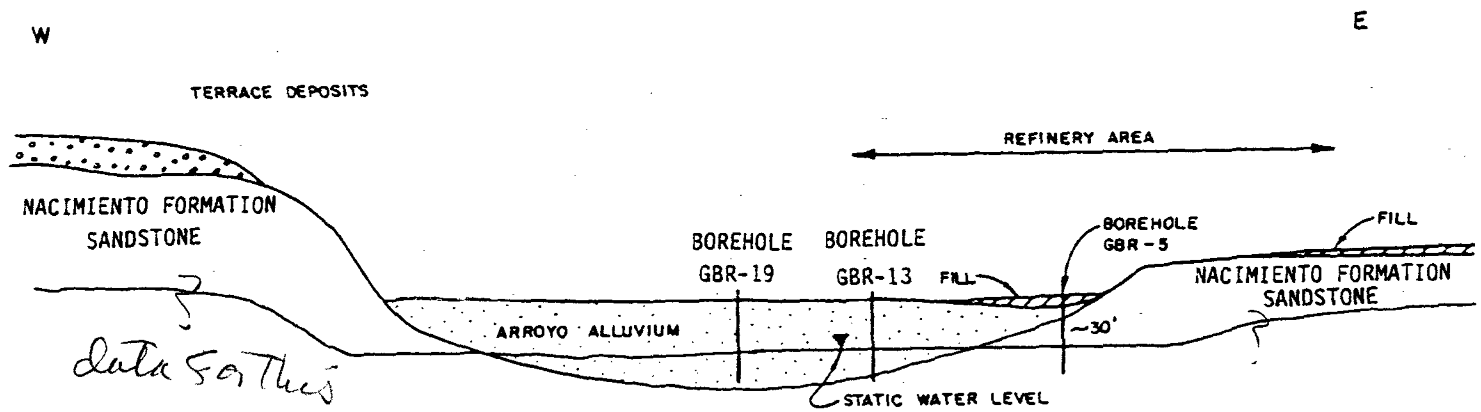


FIGURE 4-1

GENERALIZED EAST-WEST HYDROGEOLOGIC CROSS-SECTION ACROSS REFINERY SITE

GCL measured water levels and floating product thicknesses in all wells on the refinery property from April through November 1986. A record of these measurements is shown in Table 4-1. A water table contour map was prepared (Figure 4-2) 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 because pumping was not being done at that time. Where floating product was encountered, the product thickness (Table 4-1) has been multiplied by 0.8 and added to the measured water elevation. This calculation corrects for the difference in density between floating product and water by taking into account a product density of approximately 0.8 g/cc (Table 4-2). The result provides a value that would be the actual potentiometric surface.

The water table surface depicted in Figure 4-2 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 in the area east of the arroyo; and
- east to west at the arroyo boundary near the Diesel Spill Area.

The water table contour maps presented in this report were 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 in the Southern Refinery Area. Analysis of the pump tests in the Diesel Spill Area revealed small values of transmissivity and storativity near GBR-27 and moderate values near GBR-14. High values were found in the Southern Refinery Area near GBR-29. These findings 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 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

Year? 1986?

TABLE 4-1

GIANT INDUSTRIES BLOOMFIELD REFINERY
CHRONOLOGY OF STATIC WATER LEVELS AND PETROLEUM PRODUCT THICKNESSES IN FEET
WELLS 5-16

DATE / WELL NO.-	GBR 5 W.L.	GBR 5 P.T.	GBR 6 W.L.	GBR 6 P.T.	GBR 7 W.L.	GBR 7 P.T.	GBR 8 W.L.	GBR 8 P.T.	GBR 9 W.L.	GBR 9 P.T.	GBR 10 W.L.	GBR 10 P.T.	GBR 11 W.L.	GBR 11 P.T.	GBR 13 W.L.	GBR 13 P.T.	GBR 14 W.L.	GBR 14 P.T.	GBR 15 W.L.	GBR 15 P.T.	GBR 16 W.L.	GBR 16 P.T.
4/3	-	-											5349.95	0	5354.75	0					-	-
4/15	5343.10	-											5349.91	0	5352.75	0					-	-
4/16	-	-											-	-	-	-					-	-
4/23	5341.20	0.00											5349.83	0	5352.68	0					5393.10	-
4/30	5342.54	0.00											5349.85	0	5352.79	0					5396.60	-
5/2	-	0.00											-	0	-	0					-	0
5/9	-	-											5349.83	-	5352.75	-						
5/28	-	0.00											-	0	-	0						
5/29	5358.21	1.38											-	0	5350.08	0						
5/30	-	0.08											-	0	-	0						
7/1	-	6.75											-	0	-	0						
7/15	-	)4.00											5349.75	0.40	5351.77	0.56						
7/31	5351.93	11.04											-	-	5350.71	0.83						
8/12	5351.63	11.49											5348.66	0.17	5350.39	1.42						
10/7	5362.31	1.00	5359.50	-	-	-	-	-	-	-	-	-	-	-	5351.50	0.75	5365.83	0	5364.62	0		
10/8	5362.81	0.83	5359.54	0	5363.00	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
10/8																						
(After Pumping GBR-7)	5362.89	0.75	5358.58	0	5353.30	0							-	-	-	-			-	-		
10/9	-	-	-	-	-	-	5348.42	0	5348.50	0	5345.50	2.33	5348.87	0.75	-	-	-	-	-	-		
10/9																						
(After Pumping GBR-31)	-	-	-	-	-	-	5348.33	0	-	-	5345.62	2.38	-	-	-	-	5365.75	0	5364.50	0		
10/16	-	-	5360.00	-	5362.80	0	5348.38	0	5348.54	0	-	-	-	-	-	-	-	-	5357.58	0		
10/17							5348.42	0	5347.92	0	-	-	-	-	-	-	5365.50	0	5363.46	0		
(after purging)																						
11/4	5363.10	0.71	5360.17	0.04	5362.50	0	5348.46	0.04	5348.71	0	5348.17	2.04	5348.32	1.50	5351.79	0.38	-	-	-	-		
(after purging)																						
11/5 (after purge)																						
(After Pumping GBR-29)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5366.46	0	5365.12	0		
11/19	5363.39	0.67	5360.33	0.08	5363.21	0	5348.79	0.04	5349.12	0	5347.42	3.17	5349.08	1.04	5352.33	0.38	5366.33	0	5365.25	0		
11/21																						
(After pump test)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5358.58	0	5360.37	0		

W.L. = WATER LEVEL IN FEET ABOVE SEA LEVEL
P.T. = PRODUCT THICKNESS IN FEET
\- = NO MEASUREMENT
0 = ZERO MEASUREMENT

TABLE 4-1 CONTINUED

GIANT INDUSTRIES BLOOMFIELD REFINERY
CHRONOLOGY OF STATIC WATER LEVELS AND PETROLEUM PRODUCT THICKNESSES IN FEET CONT.
WELLS 17-25

DATE / WELL NO. -	GBR 17 W.L.	GBR 17 P.T.	GBR 18 W.L.	GBR 18 P.T.	GBR 19 W.L.	GBR 19 P.T.	GBR 20 W.L	GBR 20 P.T	GBR 21(S) W.L.	GBR 21(S) P.T.	GBR 21(D) W.L	GBR 21(D) P.T.	GBR 22 W.L	GBR 22 P.T.	GBR 23 W.L.	GBR 23 P.T.	GBR 24(S) W.L.	GBR 24(S) P.T.	GBR 24(D) W.L.	GBR 24(D) P.T.	GBR 25 W.L.	GBR 25 P.T.
4/3	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/15	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/16	-	-	-	-			-	-	5379.62	-	5372.92	-	5361.33	-	-	-	-	-	-	-	-	-
4/23	-	-	5407.15	-			5364.35	-	5377.70	-	5366.55	-	5361.00	-	5377.15	-	5370.70	-	5370.10	-	5367.65	-
4/30	-	-	5407.50	-			5354.00	-	5366.67	-	5370.94	-	5361.21	-	5378.50		5368.79		5368.62		5367.08	
5/2	-	-	-	0			-	0	5377.50	1.92	5370.54	0	5361.11	0	5378.71	0.01	5368.79	0.08	5368.17	0	5366.17	0
5/9	-	-	5407.75	-			5354.08	-	5289.67	-	5368.42	-	5361.17	-	5379.12	-	5368.83	-	5368.33	-	5367.21	-
5/28	-	-	-	0			-	0	-	-	-	0	-	0	-	-	-	-	-	0	-	0
5/29	5367.75	0	-	0			5352.17	0	5375.29	-	5369.67	0	5357.58	0	5375.71	-	5369.54	-	5365.12	0	5365.29	0
5/30	-	0	-	0			-	0	-	1.06	-	0	-	0	-	0.01	-	0.08	-	0	-	0
7/1	-	0	-	0			-	0	-	-	-	0	-	0	-	-	-	-	-	0	-	0
7/15	5367.78	0	5407.23	0			5353.18	0	5368.83	1.04	5371.58	0	5361.07	0	5377.45	0.02	5368.07	0.01	5368.70	0	5367.55	0
7/31	5368.31	0	5411.46	0			5354.20	0	5378.12	0.80	5371.54	0	5360.96	0	5379.23	0.04	5369.57	0	5369.32	0	5367.74	0.04
8/12	5367.89	0	5410.78	0			5354.20	0	5379.04	0.42	5372.25	0	5361.11	0	5379.22	0.03	5369.72	0.03	5369.08	0	5367.81	0
10/7	-	-	-	-	-	-	-	-	5379.37	0.50	5370.71	0	5361.84	0	5379.69	0	5369.87	0.04	5369.16	0	5365.90	0
10/8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10/9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10/9 (After Pumping GBR-31	-	-	-	-	5355.00	0	-	-	-	-			5361.75	0	5379.69	0	5369.91	0.04	5369.08	0	5367.86	0
10/16	5369.06	0	5408.52	0	5355.00	0	5354.66	0	-	-	5363.58	0	5361.46	0	-	-	-	-	5366.62	0	5366.28	0
10/17 (after purging)	5369.06	0	5402.72	0	5355.00	0	5354.50	0	-	-	5360.79	0	5361.38	0	-	-	-	-	5368.20	0	5367.03	0
11/4	-	-	-	-	-	-	5354.87	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11/5 (After Pumping GBR-29)	5369.31	0	5408.56	0	5355.42	0	-	-	5379.71	0.50	5369.71	0	-	-	5379.98	0.02	5370.53	0.04	5369.58	0	5368.03	0
11/19	5369.64	0	5408.89	0	5355.62	0	5355.16	0	5379.79	0.46	5369.92	0	5359.84	2.96	5380.36	0.02	5370.91	0.02	5370.03	0	5368.03	0
11/21 (After pump test)	-	-	-	-	-	-	-	-	5379.75	0.33	5366.34	0	5360.04	2.79	5380.36	0	5369.45	0	5367.82	0	5366.95	0

W.L. = WATER LEVEL IN FEET ABOVE SEA LEVEL
P.T. = PRODUCT THICKNESS IN FEET
- = NO MEASUREMENT
0 = ZERO MEASUREMENT

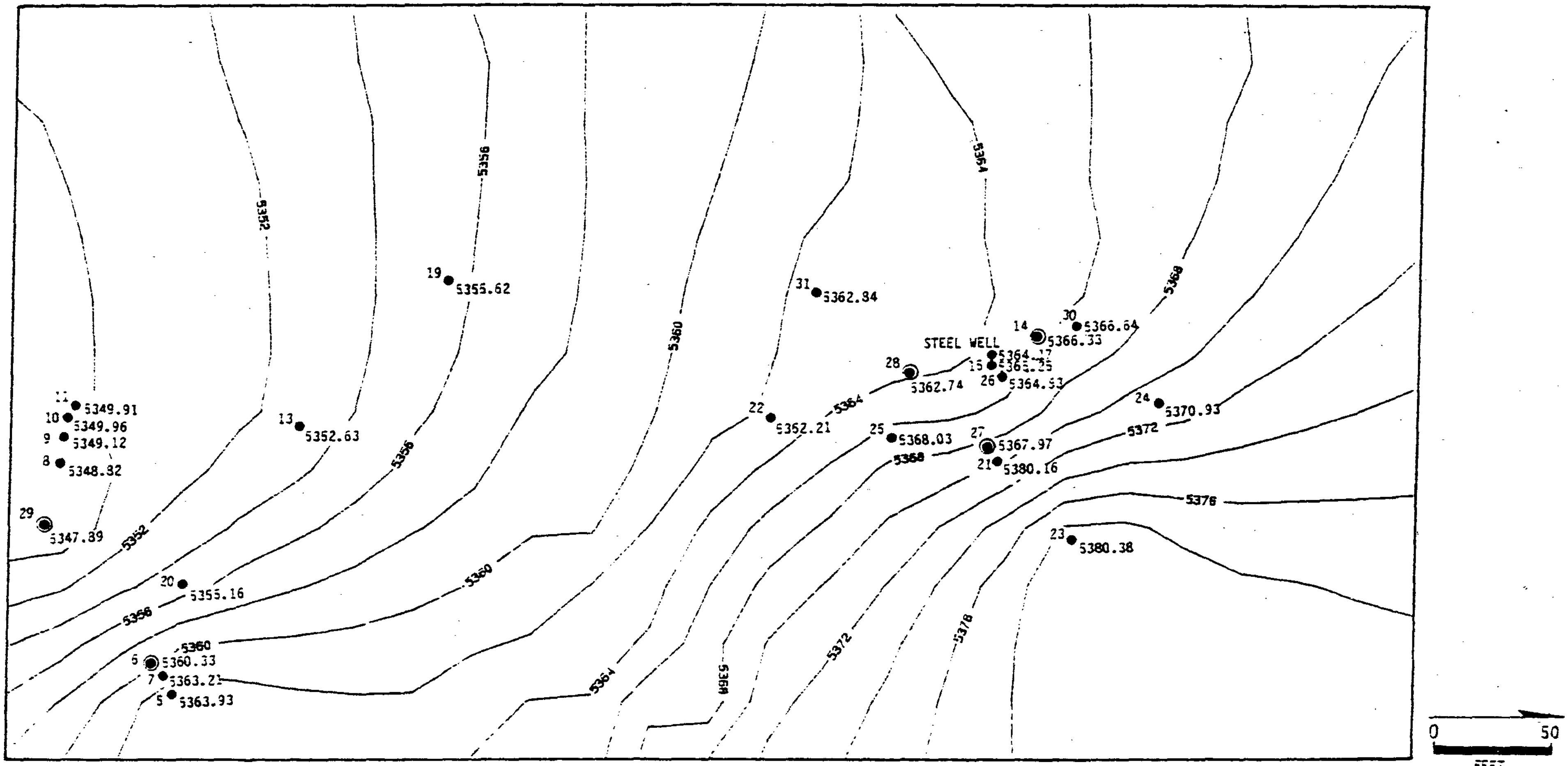
BLOOMWEL

TABLE 4-1 CONTINUED

GIANT INDUSTRIES BLOOMFIELD REFINERY
CHRONOLOGY OF STATIC WATER LEVELS AND PETROLEUM PRODUCT THICKNESSES IN FEET CONT.
WELLS 26-31

DATE / WELL NO.-	GBR 26 W.L.	GBR 26 P.T.	GBR 27 W.L.	GBR 27 P.T.	GBR 28 W.L	GBR 28 P.T	GBR 29 W.L.	GBR 29 P.T.	GBR 30 W.L.	GBR 30 P.T.	GBR 31 W.L.	GBR 31 P.T.	STEEL WELL W.L	STEEL WELL P.T.
4/3	-	-	-	-	-	-	-	-					-	-
4/15	-	-	-	-	-	-	-	-					5363.17	-
4/16	-	-	-	-	-	-	-	-					5363.08	-
4/23	5362.65	-	-	-	-	-	-	-					5362.80	-
4/30	5362.92		5357.04	-	-	-	-	-					-	-
5/2	5362.85	0	5360.16	7.17	-	-	-	-					5363.12	0
5/9	5362.75	-	-	-	-	-	-	-					5362.92	-
5/28	-	0	-	8.08	-	-	-	-					-	0
5/29	5361.29	0	5357.67	8.67	5359.87	0.17	5345.00	0					5363.04	0
5/30	-	0	-	8.98	-	0.13	-	0					-	0
7/1	-	0	-	9.00	-	-	-	1.60					-	0
7/15	5362.62	0	-	-	5361.95	0.50	5342.85	4.50					5362.96	0
7/31	5362.93	0	5364.75 (after being pumped)	2.91	5360.59	0.58	5341.02	7.34					-	-
8/12	5362.31	0	-	-	5360.43	1.22	5341.61	6.50					-	-
10/7	5363.72	0	5367.25	0.42	5362.18	0	5342.27	6.25	5366.00	0	5362.30	0	5363.71	0
10/8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10/9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10/9 (After Pumping GBR-31)	5363.56	0.04	5367.08	0.38	5361.47	0	-	-	5365.92	0	5362.21	0	5363.56	0
10/16	5363.35	0	-	-	5358.43	-	-	-	5365.79	0	5362.00	0	5362.79	0
10/17	5361.26	0	-	-	-	-	-	-	5365.83	0	5362.00	0	5363.04	0
(after purging) 11/4	-	-	-	-	-	-	5343.02	5.58	-	-	-	-	-	-
11/5 (After Pumping GBR-29)	5364.93	0.08	5368.08	0.29	5362.26	0.02	5345.94	2.04	5367.00	0.25	5362.42	0	5364.21	0
11/19	5364.39	0.17	5367.91	0.08	5362.64	0.12	5345.52	2.96	5366.50	0.17	5362.84	0	5364.17	0
11/21 (After pump test)	5364.01	0.12	5357.16	0	5361.93	0	-	-	5366.42	0	-	-	5363.79	0

W.L. = WATER LEVEL IN FEET ABOVE SEA LEVEL
P.T. = PRODUCT THICKNESS IN FEET
- = NO MEASUREMENT
0 = ZERO MEASUREMENT



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

◉ RECOVERY WELL

● MONITOR WELL

FIGURE 4-2

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

TABLE 4-2

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 GBR

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

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 an analysis of results are presented below and summarized in Table 4-3. A detailed description of these tests, of data collected and of calculations performed is presented in Appendix C.

4.1 HYDROGEOLOGIC CHARACTERISTICS OF THE DIESEL SPILL AREA

4.1.1 GBR-27 Pump Test

GCL conducted the first pump test 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 feet at the end of the test, and an observation well 85 feet 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 C. The aquifer parameters that were obtained using the data from both GBR-27 and GBR-25, correcting for the effects of floating product in GBR-27, are shown in Table 4-3.

GCL considers the calculated values for transmissivity and storativity for GBR-25 to be more representative of these aquifer characteristics in the Diesel Spill Area than those for GBR-27 because floating product was not present in GBR-25. 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.

4.1.2 GBR-14 Pump Test

GCL conducted a pump test 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, graphs of drawdown and recovery versus time, and a detailed analysis of the data are shown

TABLE 4-3

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	T(gpd/ft)	S
GBR 8	2340	0.051
GBR 29	1040	NA

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

in Appendix C. The analysis shows that the expanding cone of depression created by pumping GBR-14 encountered a less transmissive formation at the edge of the arroyo. The average transmissivity for GBR-14 was twice as large as the maximum transmissivity calculated for GBR-27 in the same area. Although transmissivity is only twice as large, the hydraulic conductivity of the alluvium could be an order of magnitude larger when differences in saturated thicknesses are considered. Thus, the sandstone acts as a low conductivity barrier when encountered by lateral stresses induced by pumpage of the adjacent alluvium.

Characteristics of the alluvium near GBR-15, which was used to monitor the effects of this pump test, are also shown in Table 4-3. The estimated transmissivity of 128 gpd/ft. equals a hydraulic conductivity of 1.7 gpd/sq. ft., which is within the lower part of the range normally associated with silty sand. Storativity near GBR-15 was estimated as 0.0045, a value indicative of partially-confined conditions that may be encountered in the presence of extensive clay lenses.

Then b=75'?

4.1.3 Combined GBR-14, GBR-27 and GBR-28 Pump Test

See p. 53

GCL conducted a combined pump test utilizing GBR-14, GBR-27 and GBR-28 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 are presented in Appendix C along with plots of drawdown versus time for the three pumped wells and the six observation wells in the area. The closest observation wells were GBR-26, GBR-30 and the Steel Well.

No measurable drawdown response was observed in GBR-26, and only small drawdowns were observed in GBR-30 and the Steel Well even though they were each about 50 feet from the pumped well. 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

(see fig 6.6, p. 53)

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.

4.2 HYDROGEOLOGIC CHARACTERISTICS OF THE SOUTHERN REFINERY AREA

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

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 inches after 31 hours and the nearest observation well, GBR-8, had a drawdown of 2 inches.

Transmissivity calculated on the basis of data from GBR-29 was estimated as 1040 gpd/ft., while transmissivity and storativity from the observation well (GBR-8) were determined to be 2340 gpd/ft. and 0.051, respectively. 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.

GCL concludes 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.

4.3 HYDROGEOLOGIC CHARACTERISTICS OF THE TRUCK FUELING AREA

GCL has drilled 5 exploratory boreholes in the Truck Fueling Area which are designated GBR-33, GBR-34, GBR-35, GBR-39 and GBR-40. Three of these were developed into 2-inch diameter observation wells (GBR-33, GBR-34 and GBR-35. GCL also installed a 6-inch diameter recovery well designated GBR-36. The lithologic logs of all the wells and boreholes are presented in Appendix B.

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

Do Not necessarily agree!

5.0 SOIL CONTAMINATION

5.1 INVENTORY OF CONTAMINATED SOIL SITES

GCL investigated the Bloomfield Refinery site to identify potential sources of contamination. As a result, the following areas were identified.

- Wastewater Retention Pond
- Evaporation Pond
- Fire Fighting Drill Area
- Storage Tank Water Drain Areas
- Storage Tank Bottom Containment Areas
- Underground Catch Tank in Truck Loading Area
- Stormwater Containment Areas
- Amoco Produced Water Pits
- Oil/Water Separator Area

The refinery operations relating to each of these areas is discussed below including, where possible, relevant dates of operation and waste disposal practices. The locations of each area can be found on the Site Location Map (Plate 1), except for the Storage Tank Bottom Containment Areas, which are not shown because they were located next to the tanks from which the waste material came.

5.1.1 Wastewater Retention Pond

Prior to construction of the oil/water separator and evaporation pond system, all oily refinery wastewaters were discharged to an unlined wastewater retention pond. Located approximately 25 feet south of the area where the oil/water separator eventually was constructed, the wastewater retention pond was in operation approximately from 1973 to 1978. The pond was about 30 x 30 feet in area with an estimated depth of 10-15 feet. The quantity of oily water discharged to this pond is unknown. However, during this period, the refinery was operated at a production capacity of approximately 2000 bbls/day, and the wastewater retention pond was of sufficient volume to contain all wastewater. When use of the wastewater retention pond was discontinued, the oily wastewater in the pond was recycled through the crude unit and the remaining sludges were left in place and covered.

5.1.2 Evaporation Pond

A synthetically-lined evaporation pond, designed for containment of oil/water separator effluent, was constructed in 1978. The pond was originally 50 feet square x 15 feet deep with a total capacity of 280,500 gallons. As refinery operations continued to expand during 1979-1980, the capacity of the pond was occasionally reached. When in 1980 the pond was expanded toward the south over an old storm-water catch basin, portions of the synthetic liner were removed. The pond was used to retain oil/water separator effluent until refinery operations ceased in June 1982.

5.1.3 Fire Fighting Drill Area

A pit was used as a fire fighting drill area to conduct fire fighting exercises in conjunction with neighboring fire departments until June 1979 when construction of the reformer unit began. The pit was approximately 20 feet long x 15 feet wide x 10 feet deep and exercises were scheduled on a weekly basis as weather permitted. Common practice was to partially fill the pit with water and float 1-2 barrels of crude oil on the surface. One or two gallons of gasoline were then added to help ignite the crude oil. As the oily material burned, fire fighters controlled or extinguished the fire. When the use of the pit for fire fighting exercises ceased, the pit, including any remaining residues of burned hydrocarbons, was covered with fill.

5.1.4 Storage Tank Water Drain Areas

Two unlined pits were used to dispose of water/paraffin wastes that were drained from crude Tanks 1 and 2. This practice may date from 1975 until the refinery closed in 1982. The pit next to Tank 1 was approximately 15 feet square x 7 feet deep. The pit next to Tank 2, which was covered over in 1984, was approximately 10 feet square x 7 feet deep.

5.1.5 Storage Tank Bottom Containment Areas

While the refinery was in operation, unknown quantities of unrecoverable tank bottoms were removed from six storage tanks (Tank Nos. 1, 4, 5, 13, 14 and 16) and buried within the respective containment berms. The refinery followed the common industry procedure of recycling all recoverable tank bottoms and burying small quantities of unrecoverable bottoms in the containment area next to the tank.

5.1.6 Underground Catch Tank in Truck Loading Area

Between 1973 and 1975, an underground catch tank was installed to contain occasional product spills from the truck loading dock. The materials that accumulated in the tank were transferred to an above ground storage tank and were eventually fed back into the process stream. GCL supervised the removal of this tank from the ground so that contaminated soil in the area could be excavated.

5.1.7 Stormwater Containment Areas

Several stormwater containment areas (natural, closed depressions) have been identified from aerial photographs of the Bloomfield Refinery. One area was located approximately 25 feet south of the evaporation pond and measured 50 feet x 30 feet. A 1978 aerial photo shows what appears to be a berm in this area. This area, which apparently remained swampy throughout much of the year, received storm-water runoff from the refinery. This particular area was filled in when the evaporation pond was expanded in 1980 and is now partially covered by the southwestern corner of the unused evaporation pond. Two other stormwater containment areas were located at the base of the slope to the west of the fire fighting drill area. These were filled in when the parking lot area was leveled (see Plate 1).

5.1.8 Amoco Produced Water Pits

Amoco was operating a natural gas well at the northern end of the refinery property when Giant first purchased the refinery site and has continued to do so. Prior to 1985 all produced waters were discharged to unlined pits. These pits were replaced sometime in 1985 with fiberglass tanks. GCL has not been able to determine the quantities of produced waters that were discharged to these pits.

5.1.9 Oil/Water Separator

The abandoned oil/water separator was found to contain sludge that had accumulated from past operations. This sludge was completely contained in the concrete vessel. GCL has determined that this sludge should be removed from the refinery site.

5.2 SAMPLING OF CONTAMINATED SOIL SITES

GCL has taken soil samples from all of the excavated areas described in Section 5.1. The results of analysis of these samples are presented at the end of this section in Tables 5-1 and 5-2.

Prior to excavation, additional samples were taken from three areas: the Wastewater Retention Pond, the Fire Fighting Drill Area and the Stormwater Containment Area. A discussion of the sampling is summarized below.

5.2.1 Wastewater Retention Pond

GCL was unable to dig exploratory trenches or construct wells in the wastewater retention pond area because of uncertainties regarding the location of underground pipelines. Consequently, GCL dug one exploratory backhoe pit in what is believed to be the center of the area. Because underground lines in that area are within six feet of the surface, the backhoe pit was excavated to approximately 5.5 feet.

Oil-stained soil was observed from the surface to the bottom of the backhoe pit, with darker staining in the 2 to 4 foot depth interval. One laboratory analysis of samples collected in this area indicated that low levels of polynuclear aromatic hydrocarbons (PAH's) with some aromatic volatile hydrocarbons were present. However, the analysis of a composite sample by a second laboratory, showed detectable levels of naphthalene only, with no other PAH's present above detectable levels.

5.2.2 Fire Fighting Drill Area

Previous investigation by GCL indicated that leachate from a septic tank to the east of the fire fighting drill area may have flowed through this area toward the southwest and exited as a "seep" on the side of the topographic bench on which the fire fighting drill area was constructed. Additionally, some water may have originated from possible leaks in an underground fire line that runs north-south along the eastern edge of the fire fighting drill area. Giant discontinued its use of the fire line and the laundry facilities that discharge to the septic tank pending results of GCL's investigation of the fire fighting drill area.

A zone of ground water exists in sandstone and shale strata, approximately 5 feet below the base of the fill covering the fire fighting drill area. The ground water encountered under the fire fighting drill area had a hydrocarbon odor and a thin (<1/8") film of product. This water has an upper-surface elevation of approximately 5405 feet, in contrast to a water-level elevation of 5363 feet in well GBR-5, located 175 feet to the southwest. This difference of 42 feet in elevation over a lateral distance of 175 feet implies that the ground water under the fire fighting drill area is "perched" on an impermeable layer. Such a steep ground water gradient (1 foot in 4) could not be stable without substantial, continuous recharge, and no such recharge source was observed. The location of the "seep" relatively high on the sloped area west of the fire fighting drill area is consistent with the hypothesis of a perched ground water zone.

GCL drilled 4 boreholes (GBR-1 through GBR-4) in the fire fighting drill area for the purpose of collecting soil samples. In addition, GCL installed a 2.0" piezometer (GBR-16) in this ground water zone, located at the western edge of the fire fighting drill area. GBR-16 was removed during excavation of the fire fighting drill area.

Seven soil samples were taken from the fire fighting drill area. Excavation showed that the volume of contaminated soil in the immediate area of the fire fighting drill area was greater than previously anticipated, and large volumes appear to exist in the seep area and the area between the fire fighting drill area and the seep. The stained area observed in the aerial photograph represents a thin (1-4 inch) layer of oil-stained soil.

Thicker accumulations of stained soil (1-4 feet) were found in the central 250-300 square feet of the fire fighting drill area. Preliminary analyses of this soil material show that oil and grease and low levels of PAH's and aromatic volatile hydrocarbons were the primary contaminants.

5.2.3 Stormwater Containment Area

This area is located south and east of the office, immediately west of the fire fighting drain area seep. GCL excavated and collected 18 soil samples from 4 backhoe pits in this area, labeled "Pit #1" through "Pit #4" in the tables of soil analyses. This excavation indicated that visible soil contamination exists in an area of approximately 15,000 square feet, to a depth of at least 10 feet.

In December 1985, GCL selected a location in the parking lot below and southwest of the fire fighting drill area to advance a deeper borehole. The purpose of this borehole (GBR-5) was to allow the sampling of ground water in a location downgradient from the fire fighting drill area and the refinery. GCL encountered an unexpected zone of apparent hydrocarbon soil contamination up to 50 feet thick. Based upon auger cuttings, this zone extended from just below the surface of the ground to the water table at a depth of 33 feet, and another 15 to 20 feet below the water table. Continuous coring of similar areas indicates that "clean" sediments may exist between surface soil contamination and documented soil discoloration at the ground water/unsaturated zone interface. Analyses of soil samples show that benzene in concentrations up to 3.9 ppm existed at 55 feet below the surface of the ground, which is 25 feet beneath the water table.

GCL drilled another borehole near GBR-5 for the specific purpose of obtaining soil samples for moisture determination. The moisture profile of the soil is presented in Appendix E along with an analysis of the saturated and unsaturated hydraulic conductivity of the soil. The borehole used to collect these samples was developed into a monitor well (GBR-7).

The results of chemical analysis for all of the soil samples are presented in Tables 5-1 and 5-2.

TABLE 5-1
GIANT INDUSTRIES BLOOMFIELD REFINERY
CHEMICAL ANALYSES, SOIL SAMPLES

ORGANIC PARAMETERS:

BTEX
CONCENTRATIONS LISTED IN PARTS PER BILLION

SAMPLE #	LOCATION	BENZENE	TOLUENE	ETHYL BENZENE	META	XYLENES ORTHO & PARA	XYLENES TOTAL
8512191020	EVAPORATION POND	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191021	EVAPORATION POND	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191022	EVAPORATION POND	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191430	EVAPORATION POND	ND (0.01)	ND (0.01)	3.04 (0.01)	NA -	NA -	ND (0.01)
8512191440	EVAPORATION POND	ND (0.01)	ND (0.01)	3.80 (0.01)	NA -	NA -	ND (0.01)
8512191450	EVAPORATION POND	ND (0.01)	ND (0.01)	4.10 (0.01)	NA -	NA -	ND (0.01)
8512191157	STORAGE TANK BOTTOM CONTAINMENT AREAS	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191158	STORAGE TANK BOTTOM CONTAINMENT AREAS	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191159	STORAGE TANK BOTTOM CONTAINMENT AREAS	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191200	STORAGE TANK BOTTOM CONTAINMENT AREAS	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191201	STORAGE TANK BOTTOM CONTAINMENT AREAS	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191202	STORAGE TANK BOTTOM CONTAINMENT AREAS	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191459	AMOCO PRODUCED WATER PIT	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512191500	AMOCO PRODUCED WATER PIT	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512200850	GBR-1	ND (0.01)	ND (0.01)	9.37 (0.01)	NA -	NA -	ND (0.01)
8512200900	GBR-1	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512200916	GBR-1	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512201046	GBR-2	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512201240	GBR-5	ND (0.01)	ND (0.01)	ND (0.01)	NA -	NA -	ND (0.01)
8512201410	GBR-5	ND (0.01)	ND (0.01)	3.90 (0.01)	NA -	NA -	ND (0.01)
8605011412	GBR-11	ND (0.0001)	ND (0.0001)	ND (0.0001)	NA -	NA -	ND (0.001)
8605021516	GBR-13	(0.001 (0.0001)	35000 (0.0001)	32000 (0.0001)	NA -	NA -	279000 (0.001)

NA = not analyzed
ND = not detected

Detection limits in parentheses

Depths?

TABLE 5-1 (Cont.)
GIANT INDUSTRIES BLOOMFIELD REFINERY
CHEMICAL ANALYSES, SOIL SAMPLES

ORGANIC PARAMETERS:

BTEX
CONCENTRATIONS LISTED IN PARTS PER BILLION

SAMPLE #	LOCATION	BENZENE	TOLUENE	ETHYL BENZENE	META	XYLENES ORTHO & PARA	XYLENES TOTAL
8605021605	PIT #1 (a)	(0.001	167000	468000	NA	NA	9950000
		(0.0001)	(0.0001)	(0.0001)	-	-	(0.001)
8605021550	PIT #2 (a)	ND	ND	ND	ND	ND	NA
		(0.0001)	(0.0001)	(0.0001)	-	-	(0.001)
8605021618	PIT #3 (a)	ND	ND	ND	NA	NA	ND
		(0.0001)	(0.0001)	(0.0001)	-	-	(0.001)
8605021635	PIT #4 (a)	9000	270	100	84000	37000	NA
		(900)	(4)	(2)	(12000)	(24000)	-
8605021635	PIT #4 (a)	(1000	4842000	3683000	NA	NA	32569000
(split)		(100)	(100)	(100)	-	-	(1000)
8512181220	STORAGE TANK	ND	ND	ND	NA	NA	ND
	WATER DRAIN	(0.01)	(0.01)	(0.01)	-	-	(0.01)
8605020230	STORAGE TANK,	2.4	1.4	ND	ND	2.0	NA
	WATER DRAIN, FLOOR	(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605020225	STORAGE TANK, WATER	ND	ND	ND	ND	ND	NA
	DRAIN, SOUTH WALL	(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605020305	UNDER STAIRWAY (b)	17000	10000	ND	92000	66000	NA
		(2000)	(2000)	(1500)	(2000)	(4000)	-
8605020310	WEST WALL (b)	ND	ND	ND	ND	ND	NA
		(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605020320	SOUTH WALL (b)	ND	ND	ND	ND	ND	NA
		(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605020245	SOUTH WALL CENTER (c)	210	120	6.8	1400	1000	NA
		(10)	(10)	(5.0)	(10)	(20)	-
8605020250	NORTHWEST CORNER (c)	50000	10000	10000	230000	210000	NA
		(10000)	(10000)	(200)	(10000)	(20000)	-
8605020300	NORTH WALL CENTER (c)	ND	ND	ND	2300	5000	NA
		(400)	(400)	(200)	(400)	(800)	-
8605091410	NEAR SEEP	ND	ND	ND	ND	ND	NA
		(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605091420	MIDDLE OF	ND	ND	ND	ND	ND	NA
	EXCAVATION (d)	(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605091430	MIDDLE OF EAST	1.4	ND	ND	9.5	6.5	NA
	WALL (d)	(1.0)	(1.0)	(0.5)	(1.0)	(2.0)	-
8605091450	BLACK SLUDGE BELOW	2000	140	170	17000	9300	NA
	FIRE LINE (d)	(400)	(10)	(5)	(400)	(800)	-
8604031115	WASTEWATER RETENTION	ND	ND	ND	NA	NA	ND
	POND	(100)	(100)	(100)	-	-	(1000)
8604031115	WASTEWATER RETENTION	ND	ND	ND	670	880	NA
(split)	POND	(8)	(50)	(20)	(20)	(40)	-
8606051905	FIRE FIGHTING DRILL	15500	11900	NA	NA	NA	1100
	AREA	(100)	(100)	-	-	-	(100)
8604011445	FIRE FIGHTING DRILL	(1000	85000	42000	NA	NA	36000
	AREA	(100)	(100)	(100)	-	-	(1000)

NA = not analyzed
ND = not detected

Detection limits in parentheses

(a) Stormwater Containment Area
(b) Storage Tank Bottom Containment Areas
(c) Underground Truck Loading Area Catch Tank Excavation
(d) Wastewater Retention Pond

TABLE 5-2
GIANT INDUSTRIES BLOOMFIELD REFINERY
CHEMICAL ANALYSES, SOIL SAMPLES

ORGANIC PARAMETERS:

POLYNUCLEAR AROMATIC HYDROCARBONS, pH
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
3605021516	SBR-13	2530	1920	1000	ND	ND	NA	ND	ND	ND
3605021605	PIT #1 (a)	ND	3040	2040	ND	ND	NA	ND	ND	ND
3605021550	PIT #2 (a)	ND	ND	ND	ND	ND	NA	ND	ND	ND
3605021618	PIT #3 (a)	ND	339	330	ND	ND	NA	1254	ND	ND
3605021635	PIT #4 (a)	2520	1540	2000	ND	ND	NA	4630	ND	5230
3605021635	PIT #4 (a) (split)	1500	ND	ND	ND	ND	ND	ND	NA	ND
3604011445	FIRE FIGHTING DRILL AREA	<5	44	43	ND	ND	ND	34	ND	ND
(b)	FIRE FIGHTING DRILL AREA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3604031115	WASTEWATER RETENTION POND	ND	3700	ND	ND	ND	NA	6100	ND	2000
3604031115 (split)	WASTEWATER RETENTION POND	300	ND	ND	ND	ND	ND	ND	NA	ND

SAMPLE NO.	LOCATION	FLUORENE	2-NITRO PHENOL	PHENOL	CRESOL	2,4-DIMETHYL PHENOL	2,4-DINITRO-PHENOL	4-NITRO-PHENOL	4,6-DINITRO-O-CRESOL	AMMONIA AS N	ORTHO-PHOSPHATE AS P	pH
3605021516	SBR-13	ND	29000	31000	ND	ND	ND	ND	ND	NA	NA	NA
3605021605	PIT #1 (a)	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
3605021550	PIT #2 (a)	ND	ND	3000	ND	ND					NA	NA
3605021618	PIT #3 (a)	ND	ND	ND	ND	ND	ND	27000	ND	ND	NA	NA
3605021635	PIT #4 (a)	ND	ND	50000	ND	ND					NA	NA
3605021635	PIT #4 (a) (split)	150	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA
3604011445	FIRE FIGHTING DRILL AREA	<20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
(b)	FIRE FIGHTING DRILL AREA	NA	ND	ND	ND	ND	ND	ND	12250	500	23200000	6.8
3604031115	WASTEWATER RETENTION POND	ND	3000	16000	ND	ND	ND	ND	ND	NA	NA	NA
3604031115 (split)	WASTEWATER RETENTION POND	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA

ND = not detected
NA = not analyzed

(a) Storm Water Containment Area
(b) 3604011440, 3604011441, 3604011442
3604011443, 3604011444

6.0 GROUND WATER CONTAMINATION

6.1 INVENTORY OF CONTAMINATED GROUND WATER SITES

GCL determined existing ground water quality through a comprehensive sampling program utilizing all of the wells within refinery boundaries. Floating and/or dissolved hydrocarbons were found in several wells in the following areas:

- o Diesel Spill Area
- o Truck Fueling Area
- o Southern Refinery Area

Table 4-1 (in Section 4.0) is a chronological record from April through November 1986 of static water levels and floating product thicknesses, if any, in each of the wells on the site. Tables 6-1 through 6-6 summarize the results of physical and chemical analyses of water samples collected by GCL and the New Mexico Oil Conservation Division (NMOCD). When reviewing these tables, it should be noted that the date and time of day when a sample was taken is included in the sample number. For instance, the sample number listed in Table 6-1 for GBR-5 is 8606051745. Thus, this sample was taken on June 5, 1986 at 5:45 p.m. The results of these analyses indicate that the physical parameters (Table 6-1), and the inorganic ground water chemistry (Table 6-2 and Table 6-3) are typical of waters found in Cretaceous rocks of the San Juan Basin (Stone and others, 1983).

The organic analyses presented in Tables 6-4 through 6-6 indicate the extent of dissolved-phase ground water contamination by distinct chemical groups. One such group of contaminants, shown in Table 6-4, consists of aromatic organic compounds including benzene, toluene, ethylbenzene and xylene (BTEX). The presence of these contaminants is coincident with the floating product plumes in both the Diesel Spill Area (GBR-15, GBR-21, GBR-23, GBR-24, GBR-26, GBR-27, GBR-28, GBR-30 and the Steel Well), and the Southern Refinery Area (GBR-5, GBR-6, GBR-7, GBR-8, GBR-9, GBR-10, GBR-11, GBR-13 GBR-20 and GBR-29).

TABLE 6-1
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
ORGANIC CHEMICAL ANALYSIS

PHYSICAL PARAMETERS

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	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
STEELWELL	8610171330	GCL	7.28	2500	17.5	NA
EAST SEEP	8606051905	OCD	7.00	1600	21.5	NA
WEST SEEP	8510291450	OCD	NA	1550	21.0	
SEEP	8510241435	GCL	7.50	NA	NA	1258

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed for this parameter

TABLE 6-2

GIANT INDUSTRIES BLOOMFIELD REFINER
GROUND WATER SAMPLES
CHEMICAL ANALYSES

INORGANIC PARAMETERS

CHEMICAL CONCENTRATIONS IN MG/L

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	HCO3	Ca	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	33.4	616.4	1202
GBR-18	8606051435	OCD	122	420	262	0	6.13	29.3	432	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
SEEP	8606051525	OCD	100	100	134	0	0	14.6	4.6	70
SEEP	8510241435	GCL	NA	NA	98	NA	NA	NA	NA	9

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed for this parameter

TABLE 6-3

GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES

CHEMICAL ANALYSIS

CHEMICAL CONCENTRATIONS IN MG/L

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
GBR-05	8611201640	OCD	<0.1	<0.1	<0.005	0.6	0.2	<0.1	570	<0.1	<0.1
GBR-09	8611210620	OCD	<0.1	<0.1	<0.005	0.3	<0.1	<0.1	520	<0.1	<0.1
GBR-11	8605291615	GCL	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
GBR-11	8606051705	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-11	8611201515	OCD	<0.1	<0.1	0.013	0.3	0.4	<0.1	530	<0.1	<0.1
GBR-13	8611201735	OCD	<0.1	<0.1	<0.005	0.5	0.3	<0.1	1610	<0.1	<0.1
GBR-17	8605290830	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-17	8606051230	OCD	<0.1	<0.1	0.007	0.3	<0.1	<0.1	730	<0.1	<0.1
GBR-17	8611211450	OCD	<0.1	<0.1	<0.005	0.2	<0.1	<0.1	660	<0.1	<0.1
GBR-19	8611211510	OCD	<0.1	<0.1	<0.005	0.2	0.4	<0.1	390	<0.1	<0.1
GBR-24S	8611210945	OCD	<0.1	<0.1	<0.005	0.2	<0.1	<0.1	630	<0.1	<0.1
GBR-24D	8611211105	OCD	<0.1	<0.1	<0.005	0.3	0.1	<0.1	330	<0.1	<0.1
GBR-27	8606052000	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-27	8606052000	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-27	8611211220	OCD	<0.1	<0.1	<0.005	0.5	<0.1	<0.1	650	<0.1	<0.1
GBR-29	8605300945	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-29	8606051525	OCD	<0.1	<0.1	0.008	0.4	<0.1	<0.1	814	<0.1	<0.1
GBR-29	8606051525	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
GBR-30	8611210930	OCD	<0.1	<0.1	<0.005	0.3	<0.1	<0.1	190	<0.1	<0.1
GBR-31	8611211205	OCD	<0.1	<0.1	<0.005	0.5	<0.1	<0.1	1280	<0.1	0.3
SEEP	8510241430	OCD	NA	20	NA	5.4	0.8	ND	260	ND	ND
SEEP	8606051905	OCD	<0.1	<0.1	0.024	5.4	0.4	<0.1	160	<0.1	<0.1
SEEP	8606051905	GCL	NA	NA	NA	NA	NA	NA	NA	NA	NA
SEEP	8510241435	GCL	<0.05	NA	<0.05	NA	<1.0	NA	NA	<0.01	NA

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Si	Sn	Sr	V	Zn
GBR-05	8611201640	OCD	<0.1	<0.1	0.1	NA	105	3.9	<0.1	<0.1	<0.1	NA	16	<0.1	<0.1	<0.1	<0.1
GBR-09	8611210620	OCD	<0.1	<0.1	<0.1	NA	36	1.1	<0.1	<0.1	<0.1	NA	6.3	<0.1	10	<0.1	<0.1
GBR-11	8605291615	GCL	NA	NA	NA	NA	NA	NA	NA	NA	0.066	NA	NA	NA	NA	NA	NA
GBR-11	8606051705	OCD	<0.1	<0.1	6.9	<0.0005	100	7.1	<0.1	0.2	<0.1	0	7.86	<0.1	19	<0.1	7.3
GBR-11	8606051705	GCL	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-11	8611201515	OCD	<0.1	<0.1	2.8	NA	57	5.7	<0.1	<0.1	<0.1	NA	8.5	<0.1	9.6	<0.1	8.0
GBR-13	8611201735	OCD	<0.1	<0.1	6.5	NA	130	4.0	<0.1	0.6	<0.1	NA	7.0	<0.1	30	<0.1	<0.1
GBR-17	8605290830	GCL	NA	NA	NA	NA	NA	NA	NA	NA	0.076	NA	NA	NA	NA	NA	NA
GBR-17	8606051230	OCD	<0.1	<0.1	<0.1	<0.0005	60	<0.05	<0.1	<0.1	<0.1	0	5.9	<0.1	12	<0.1	<0.1
GBR-17	8611211450	OCD	<0.1	<0.1	<0.1	NA	54	<0.05	<0.1	0.1	<0.1	NA	6.2	<0.1	11	<0.1	<0.1
GBR-19	8611211510	OCD	<0.1	<0.1	0.7	NA	35	5.2	<0.1	<0.1	<0.1	NA	8.5	<0.1	7.4	<0.1	<0.1
GBR-24S	8611210945	OCD	<0.1	<0.1	<0.1	NA	68	4.4	<0.1	<0.1	<0.1	NA	6.0	<0.1	12	<0.1	<0.1
GBR-24D	8611211105	OCD	<0.1	<0.1	<0.1	NA	43	0.6	<0.1	<0.1	<0.1	NA	7.5	<0.1	7.1	<0.1	<0.1
GBR-27	8606052000	GCL	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-27	8606052000	GCL	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-27	8611211220	OCD	<0.1	<0.1	<0.1	NA	55	4.3	<0.1	<0.1	<0.1	NA	6.6	<0.1	12	<0.1	<0.1
GBR-29	8605300945	GCL	NA	NA	NA	NA	NA	NA	NA	NA	0.14	NA	NA	NA	NA	NA	NA
GBR-29	8606051525	OCD	<0.1	<0.1	<0.1	<0.0005	83	3.8	<0.1	<0.1	<0.1	<0.1	9.0	<0.1	15	<0.1	<0.1
GBR-29	8606051525	GCL	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
GBR-30	8611210930	OCD	<0.1	<0.1	<0.1	NA	15	2.2	<0.1	<0.1	<0.1	NA	7.8	<0.1	3.4	<0.1	<0.1
GBR-31	8611211205	OCD	<0.1	<0.1	0.2	NA	105	2.3	<0.1	0.6	<0.1	NA	7.3	<0.1	26	<0.1	<0.1
SEEP	8510241430	OCD	ND	ND	56	NA	36	7.2	ND	ND	ND	NA	2.1	ND	4.6	ND	0.1
SEEP	8606051905	OCD	<0.1	<0.1	24	NA	22	3.5	<0.1	<0.1	<0.1	NA	30.0	<0.1	5.9	<0.1	0.2
SEEP	8606051905	GCL	ND	NA	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA
SEEP	8510241435	GCL	<0.05	<0.01	32	<0.002	NA	1.19	NA	NA	<0.05	<0.01	NA	NA	NA	NA	NA

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed for this parameter

TABLE 6-4

GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

ORGANIC PARAMETERS

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	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	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	5611211510	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
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

TABLE 6-4 (Cont.)

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	BENZENE	TOLUENE	ETHYL BENZENE	XYLENES PARA	XYLENES META	XYLENES ORTHO	XYLENES TOTAL
STEEL WELL	8605091140	GCL	ND	ND	ND	-	-	-	ND
STEEL WELL	8610171330	GCL	144	148	179	-	-	-	356
SEEP	8606051905	OCD	28000	18000	1200	2200	5500	3000	10700
SEEP	8606051905	GCL	15500	11900	NA	-	-	-	ND
SEEP	8604011435	GCL	511000	103	48	-	-	-	1518
SEEP	8510241413	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

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed for this parameter
ND = not detected

TABLE 6-5

GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

POLYNUCLEAR AROMATIC HYDROCARBONS

CONCENTRATIONS LISTED IN PARTS PER BILLION

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	NAPH	1-METHYL NAPH	2-METHYL NAPH	ACENAPTH -ALENE	ACENAPTHENE	FLUORENE	ANTHRACENE	PHENAN-THRACENE	FLOUR-ANTHENE	PYRENE	BENZO(A) ANTHRACENE	CHRYSENE	BENZO(B) FLUORANTHENE	BENZO(K) FLUORANTHENE	BENZO(A) PYRENE	DIBENZO(A,H) ANTHRACENE	INDENO (1.2.3-CD) PYRENE	BENZO (G.H.I) PERYLENE
GBR-07	8610171550	GCL	ND	NA	NA	7	22	ND	ND	7	10	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-08	8610171615	GCL	50	NA	NA	244	473	78	69	4	ND	ND	3	ND	ND	ND	ND	ND	ND	ND
GBR-09	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	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-27	SPLIT	GCL	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
STEEL WELL	8610171330	GCL	ND	NA	NA	ND	6	ND	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed
ND = not detected

TABLE 5-6
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

CHLORINATED HYDROCARBONS

CONCENTRATIONS LISTED IN PARTS PER BILLION

EDC

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	ACROLEIN	ACRYLON-ITRILE	BROMOFORM	CCl4	DIBROMO-METHANE	DICHLORO-METHANE	DICHLORO-BROMOMETHANE	CHLORODI-BROMOMETHANE	CHLOROETHANE	2-CHLOROETHYL-VINYL ETHER	CHCl3	1.1-DCA	1.2-DCA	1.1-DCE	1.2-DCE
GBR-05	8608051745	OCD	NA	NA	ND	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	ND
GBR-06	8611201545	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	ND
GBR-07	8611201615	OCD	NA	NA	ND	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	ND
GBR-10	8611210845	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	150	ND	ND
GBR-11	8606051705	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND
GBR-11	8611201515	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	ND
GBR-13	8606051900	OCD	NA	NA	ND	ND	ND	25	ND	ND	ND	ND	ND	25	58	ND	10
GBR-13	8611201735	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	44	32	ND	23
GBR-14	8610171215	GCL	ND	ND	ND	ND	NA	ND	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	ND
GBR-15	8610171315	GCL	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	78	ND	ND
GBR-17	8606051230	OCD	NA	NA	ND	ND	ND	15	ND	ND	ND	ND	ND	20	ND	ND	1
GBR-17	8607150730	GCL	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND	ND	NA	ND	ND
GBR-17	8611211450	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	6	ND	ND	ND
GBR-18	8606051435	OCD	NA	NA	ND	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	ND
GBR-19	8610171515	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	12	5.9	ND	14
GBR-19	8611211510	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	10	ND	4
GBR-20	8606051730	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND
GBR-20	8611201711	OCD	NA	NA	ND	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	ND
GBR-24S	8611210945	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	60	ND	ND
GBR-24D	8611211105	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	69	ND	ND
GBR-26	8610171230	GCL	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	66	ND	ND
GBR-27	8606052000A	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
~~GBR-27~~	~~8606052000B~~	~~OCD~~	[illegible]	[illegible]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6	ND	ND
GBR-27	8510241435	GCL	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	NA
GBR-27	8611211220	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	ND
GBR-28	8607151900	GCL	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND	ND	NA	ND	ND
GBR-29	8606051525	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	36	ND	30
GBR-29	8611201440	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	34	ND	ND	14
GBR-30	8610171155	GCL	ND	ND	ND	ND	NA	NA	ND	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	ND
GBR-31	8610171350	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	11	ND	ND	21
GBR-31	8611211205	DCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	22	ND	ND	33
STEEL WELL	8610171330	GCL	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	31	ND	ND
SEEP	8606051905	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	50	ND	49	ND	ND
SEEP	8611211535	OCD	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed
ND = not detected

TABLE 5-6 (Cont.)
GIANT INDUSTRIES BLOOMFIELD REFINERY
GROUND WATER SAMPLES
CHEMICAL ANALYSIS

CHLORINATED HYDROCARBONS

CONCENTRATIONS LISTED IN PARTS PER BILLION

Same compound

WELL NO.	SAMPLE NO.	ANALYTICAL LAB	1,2-DICHLORO-PROPANE	1,3-DICHLORO-PROPYLENE	MEHTYL BROMIDE	METHYL CHLORIDE	1,1,2,2-TCA	TETRACHLORO-ETHENE	TCA	TCE	VINYL CHLORIDE	TRICHLORO-ETHENE	METHYLENE CHLORIDE
GBR-05	8608051745	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-05	8611201640	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-06	8611201545	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-07	8611201615	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-09	8611210820	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-10	8611210845	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-11	8606051705	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-11	8611201515	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-13	8606051900	OCD	ND	ND	ND	ND	ND	ND	23	ND	ND	NA	NA
GBR-13	8611201735	OCD	ND	ND	ND	ND	ND	19	16	12	ND	NA	NA
GBR-14	8610171215	GCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-14	8611211135	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-15	8610171315	GCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-17	8606051230	OCD	ND	ND	ND	ND	ND	1	14	1	ND	NA	NA
GBR-17	8607150730	GCL	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA	NA
GBR-17	8611211450	OCD	ND	ND	ND	ND	ND	ND	7	ND	ND	NA	NA
GBR-18	8606051435	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-18	8611211425	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-19	8610171515	GCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.3	ND
GBR-19	8611211510	OCD	ND	ND	ND	ND	ND	ND	ND	11	ND	NA	NA
GBR-20	8606051730	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-20	8611201711	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-24	8606052040	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-24S	8611210945	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-24D	8611211105	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-26	8610171230	GCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-27	8606052000A	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-27	8606052000B	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-27	8510241435	GCL	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND	ND
GBR-27	8611211220	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-28	8607151900	GCL	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA	NA
GBR-29	8606051525	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-29	8611201440	OCD	ND	ND	ND	ND	ND	NA	8	12	ND	NA	NA
GBR-30	8610171155	GCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GBR-30	8611210930	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
GBR-31	8610171350	GCL	ND	ND	ND	ND	ND	11	7.3	ND	ND	ND	7.0
GBR-31	8611211205	OCD	ND	ND	ND	ND	ND	16	12	12	ND	NA	NA
STEEL WELL	8610171330	GCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SEEP	8606051905	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
SEEP	8611211535	OCD	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

GCL = GEOSCIENCE CONSULTANTS, LTD.
OCD = OIL CONSERVATION DIVISION
NA = not analyzed
ND = not detected

The presence of these contaminants may also be associated with the Lee Acres Landfill plume as evidenced by BTEX contamination found in well GBR-18 upgradient to the refinery.

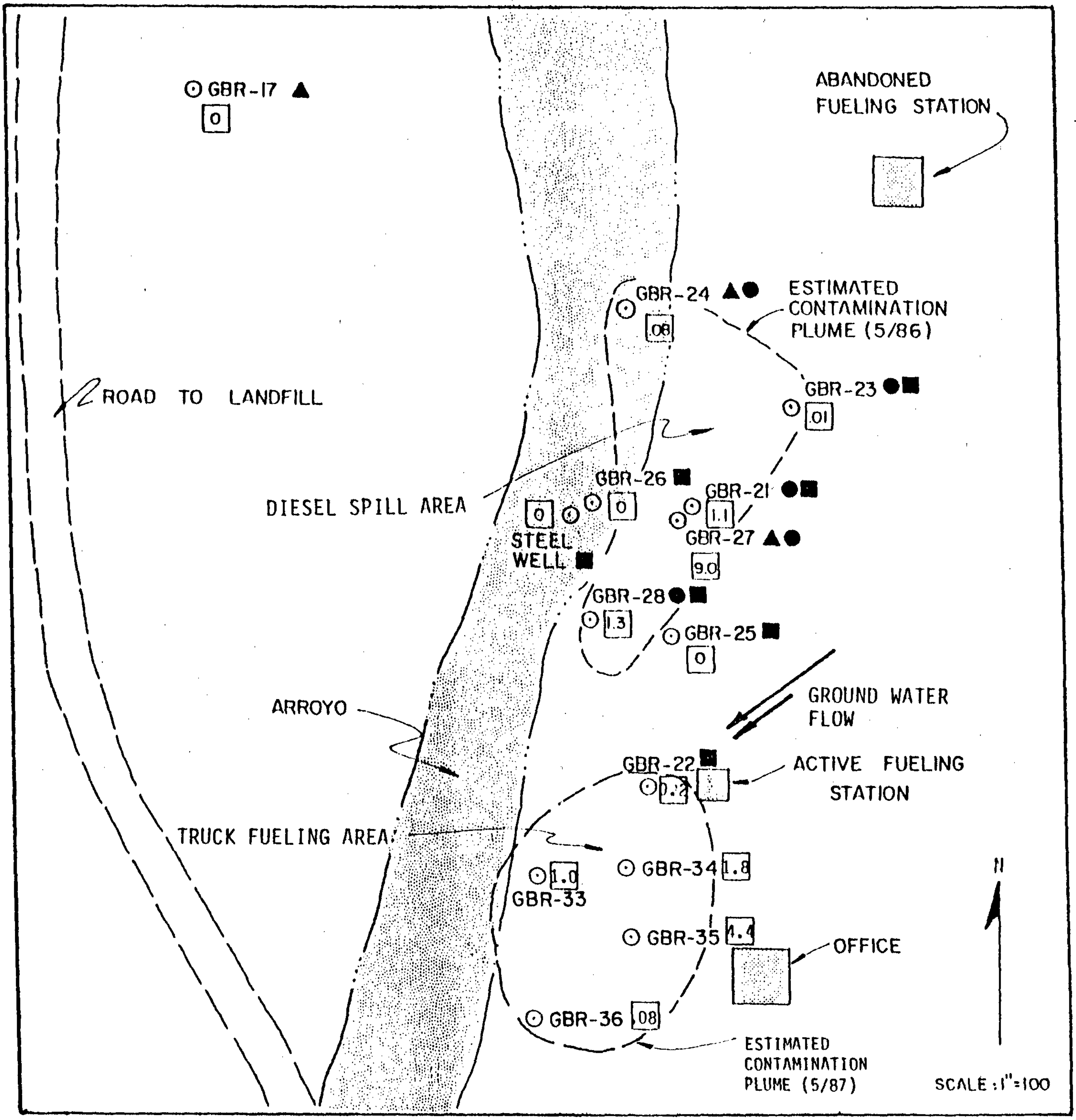
Another group of contaminants, shown in Table 6-6, consists of a number of chlorinated solvents that apparently were not utilized in refinery processes, with the exception of 1,1-DCA and 1,2-DCA, which were used as gasoline additives. The detection of these contaminants in GBR-13, GBR-17, GBR-19, GBR-29, and GBR-31 indicates the presence of a plume emanating from Lee Acres Landfill. This is so because these compounds were known to exist in wastewater at the landfill but were not in use nor discharged from refinery operations. This conclusion is further supported by the presence of chlorinated solvents in GBR-17, which is located upgradient from all refinery activities and directly downgradient from the Lee Acres Landfill.

6.2 DIESEL SPILL AREA

6.2.1 Plume Identification

GCL used the earliest available information from the monitor wells to estimate the extent of the product and dissolved-contamination plumes at the refinery site in order to provide a baseline for future evaluations. Analysis of the data resulted in the estimated product-plume boundary shown in Figure 6-1. This map is based on the measured floating-product thicknesses and ground water sample analyses from all existing wells (except GBR-22) in the area on May 30, 1986. Floating product was found in GBR-27 (9 feet), GBR-21 (1 foot), GBR-23 (1 inch) and GBR-28 (1 foot). These thicknesses have since been significantly reduced by pumping from the three recovery wells in the area, as discussed below. Another nearby down-gradient well (GBR-22) did not show any floating product, which indicates that the plume was localized. Since that time, floating product has appeared in GBR-22 as a result of a recent leak in the Truck Fueling Area.

GCL generally found dissolved-phase petroleum hydrocarbon products (benzene, toluene, xylenes and ethylbenzene) only in wells containing



LEGEND

- APPROXIMATE EXTENT OF PRODUCT PLUME
- ● – DISSOLVED BTEX DETECTED IN WELL
- ■ – NOT ANALYZED FOR HALOGENATED HYDROCARBONS
- [0] – UNCORRECTED BOREHOLE PRODUCT THICKNESS (FT.)
- ▲ – HALOGENATED HYDROCARBONS PRESENT IN WELL

FLOATING PRODUCT THICKNESSES AND PRESENCE OF DISSOLVED PHASE PRODUCTS IN WELLS BEFORE PRODUCT RECOVERY

DIESEL SPILL AND TRUCK FUELING AREAS

GIANT - BLOOMFIELD

FIGURE 6-1

floating product. Initially none were found in nearby GBR-22 and the old "Steel Well". This association indicates that the dissolved-product plume closely coincides with the floating-product plume and the areal extent of both can be characterized by similar methods.

6.2.2 Plume Characteristics

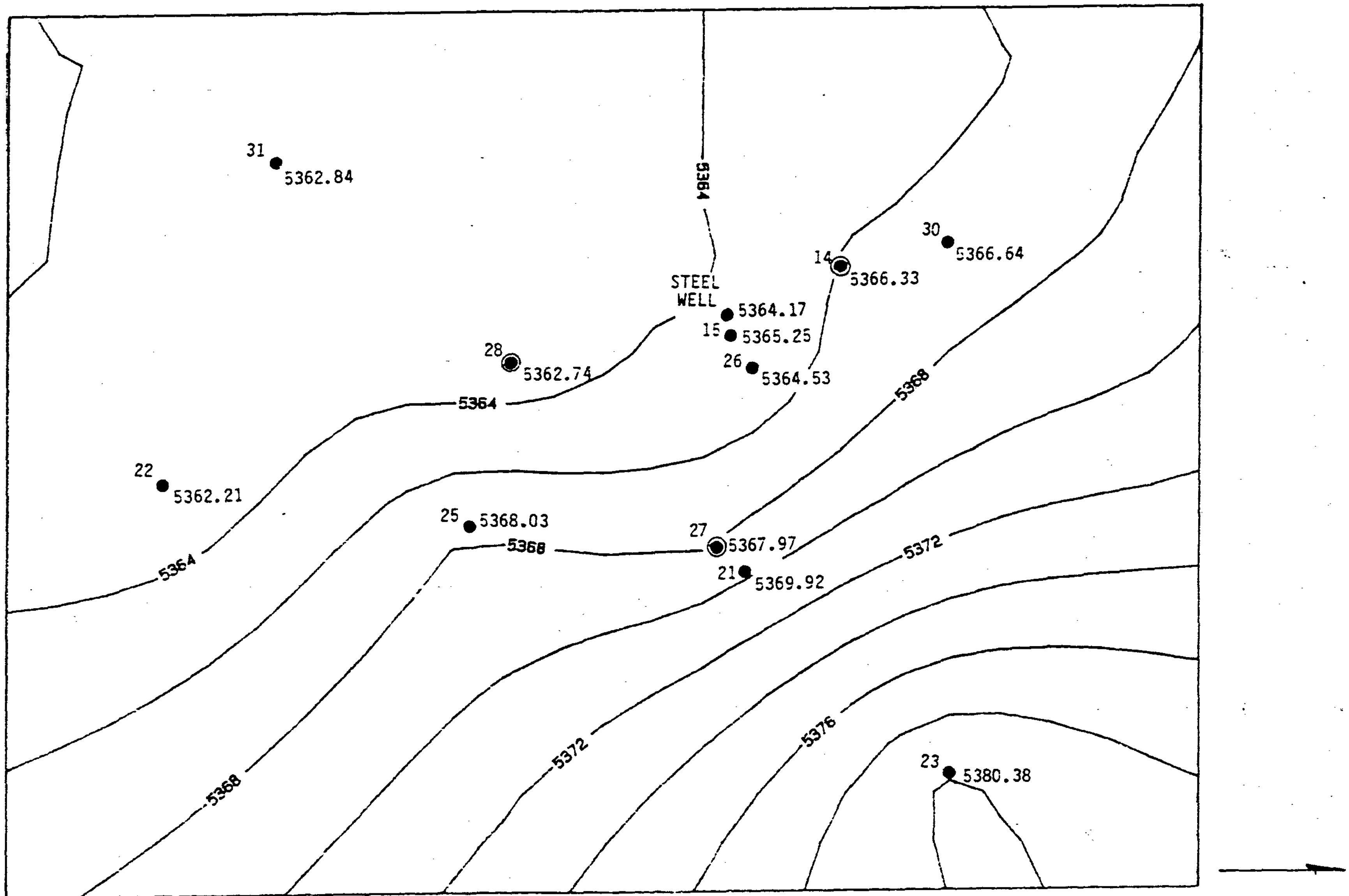
Based on the water level and floating product thickness measurements listed in Table 4-1 (in Section 4.0), GCL has prepared a series of contour maps showing water levels and product thickness for different conditions and different time periods. These are presented in Figures 6-2 through 6-7. These plots were generated by computer and represent existing conditions based on the observed values shown at each measuring point (well) from which the contours were generated.

Figure 6-2 was constructed by the same method as Figure 4-2 (discussed in Section 4.0) and displays water table relationships beneath the Diesel Spill Area in more detail. Again, it should be noted that ground water slopes and flows west and southwest toward the arroyo, then south down the arroyo. Southward deflection of flow lines in the arroyo suggest a high transmissivity of arroyo alluvium relative to units in the eastern part of the site.

Figure 6-3 is a contour map of the floating product according to measurements taken on May 30, 1986. It shows the plume to be centered around GBR-27 and restricted to a relatively small area. This is the baseline condition before any product pumping commenced.

Beginning in June 1986, GCL conducted experimental and pilot-scale pumping that reduced the floating product as demonstrated by subsequent measurements. Figure 6-4 is a contour map of the floating product as measured on October 7, 1986, after 4-1/2 months of intermittent pilot-scale pumping. It should be noted that the shape and distribution of the floating product plume is similar to what it was in May 1986 (compare with Figure 6-3), but the thickness of the plume is much less. The fact that the shape of the plume has been maintained indicates that the

yeh! Same computer drew both!



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

Scale: 1" = 50'

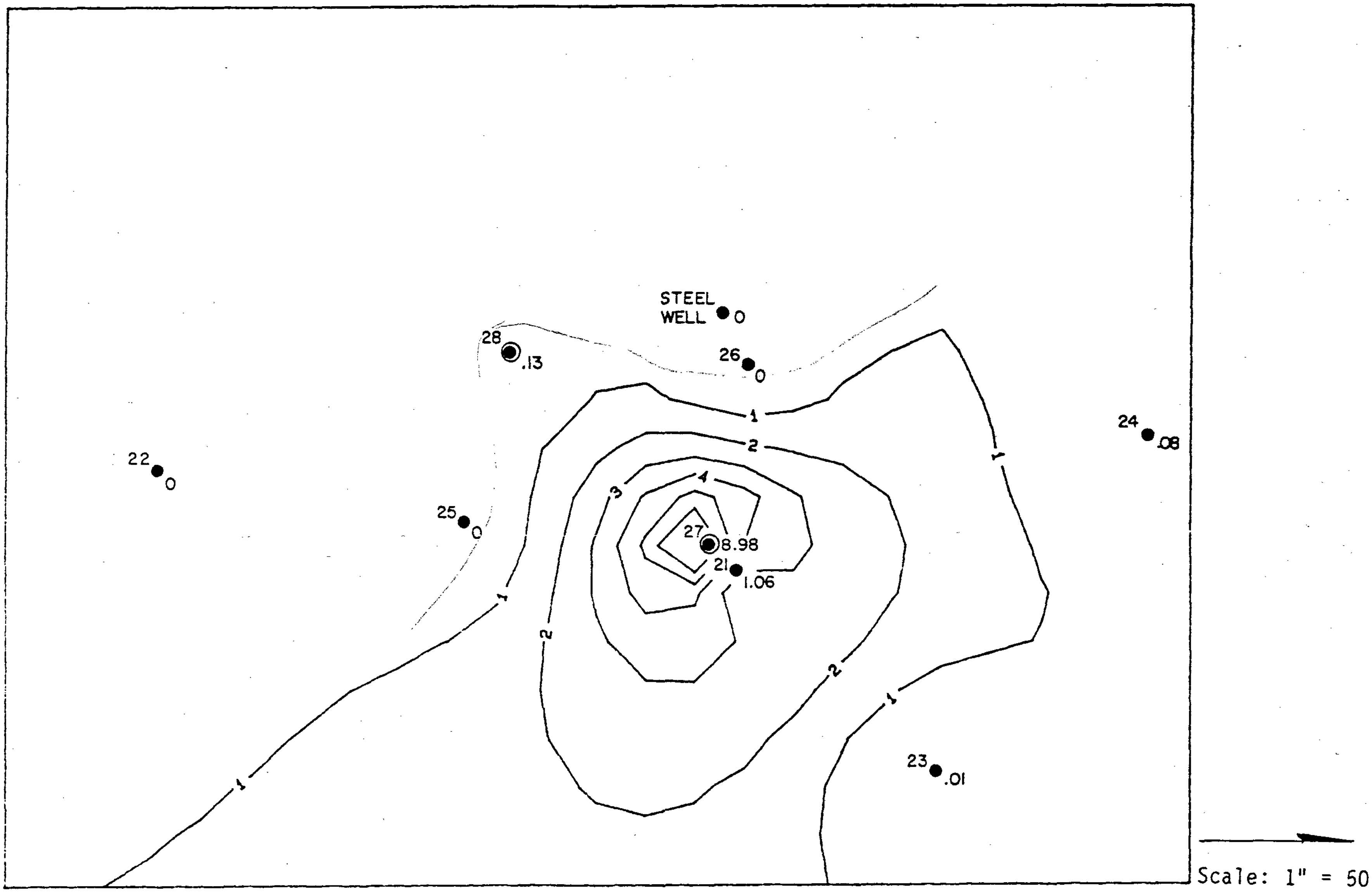
◉ RECOVERY WELL

● MONITOR WELL

FIGURE 6-2

GROUND WATER LEVEL CONTOUR MAP - DIESEL SPILL AREA

(BEFORE PUMPING BEGAN) 5/30/86 Date?



Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

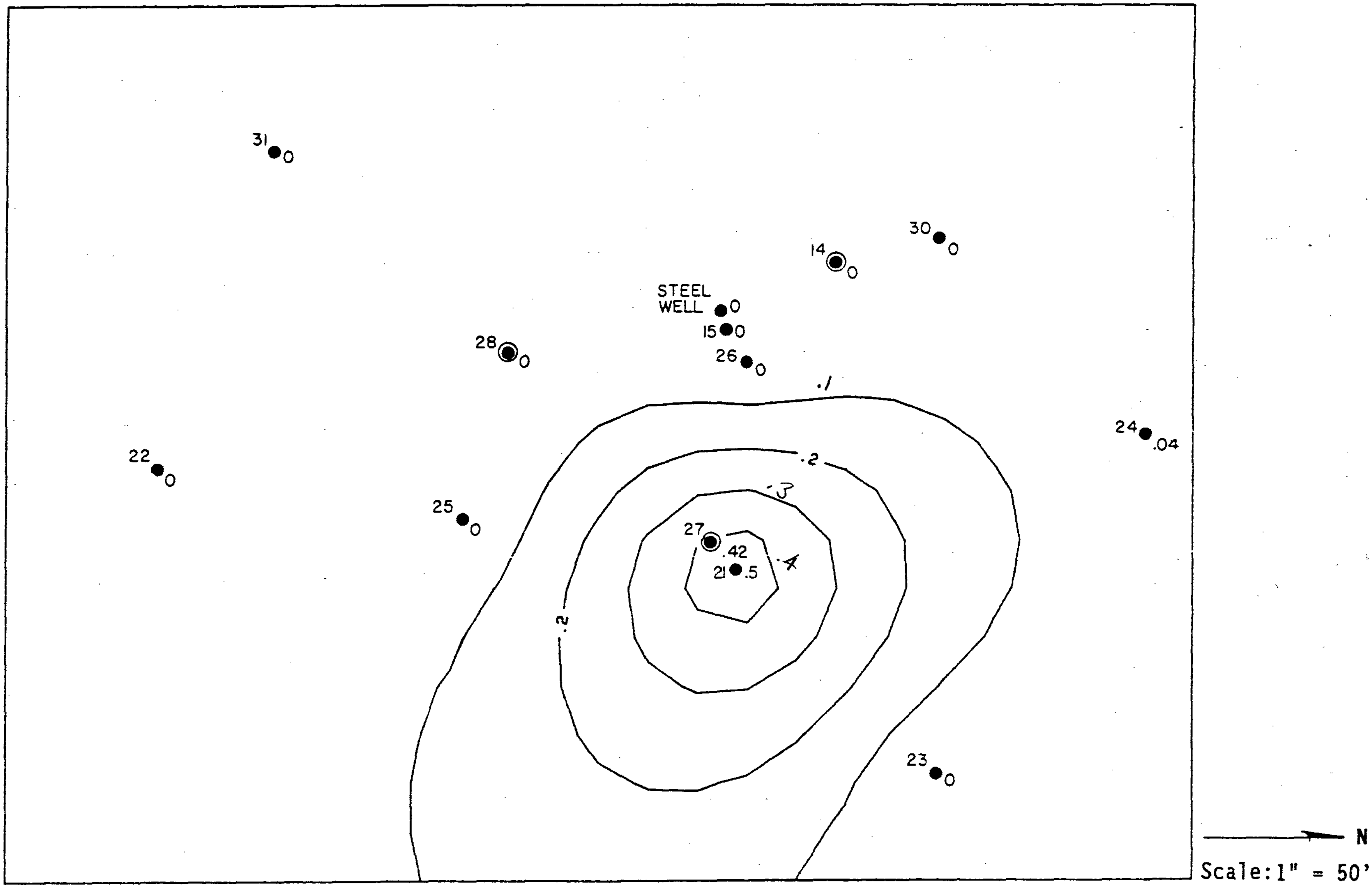
◉ RECOVERY WELL

● MONITOR WELL

FIGURE 6-3

FLOATING PRODUCT PLUME CONTOUR MAP - DIESEL SPILL AREA, MAY 1986

(BEFORE PUMPING BEGAN)

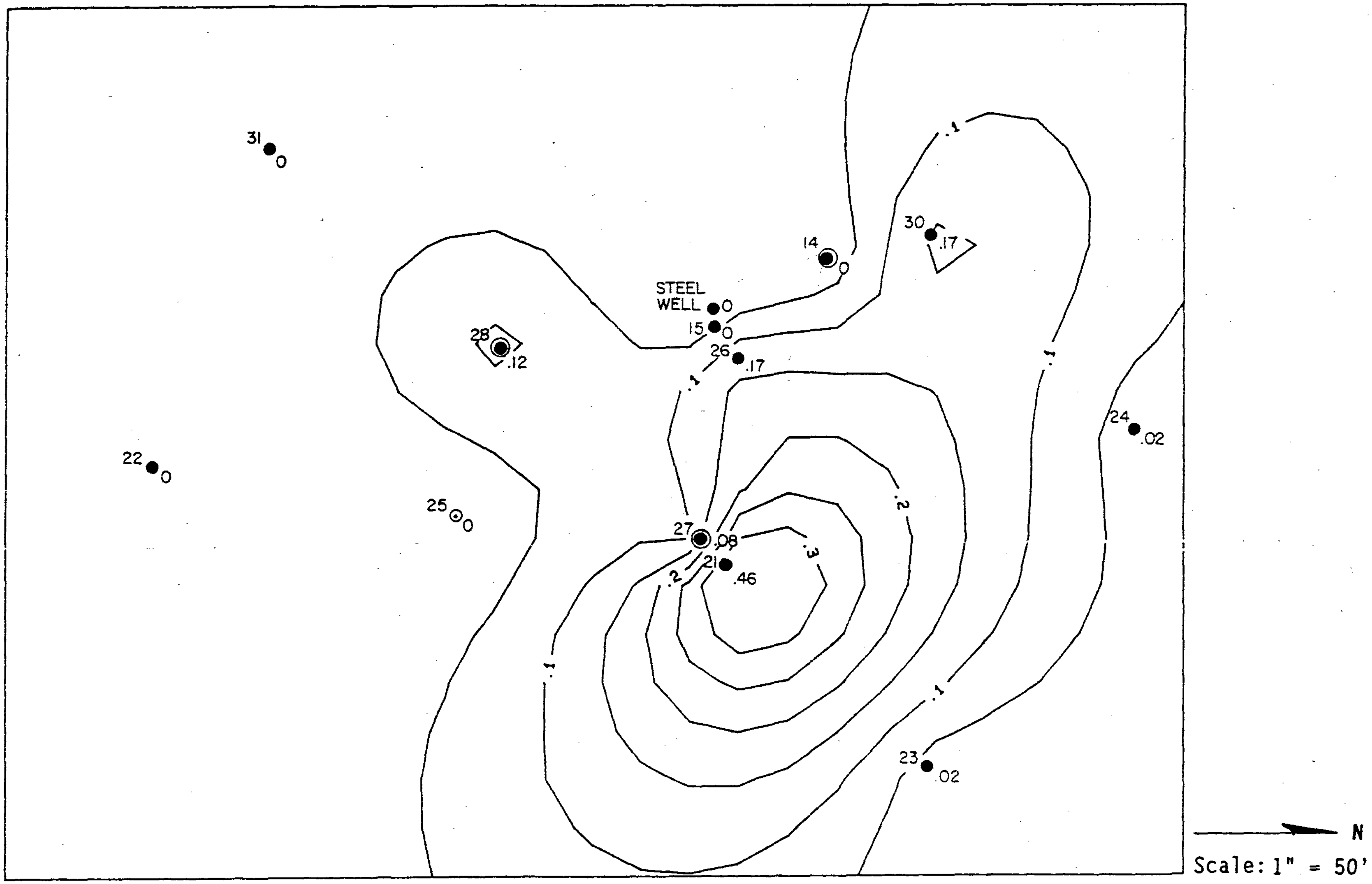


Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

FIGURE 6-4

FLOATING PRODUCT PLUME CONTOUR MAP - DIESEL SPILL AREA, OCT. 1986 10/7/86

(AFTER PILOT SCALE PUMPING FOR 4½ MONTHS)



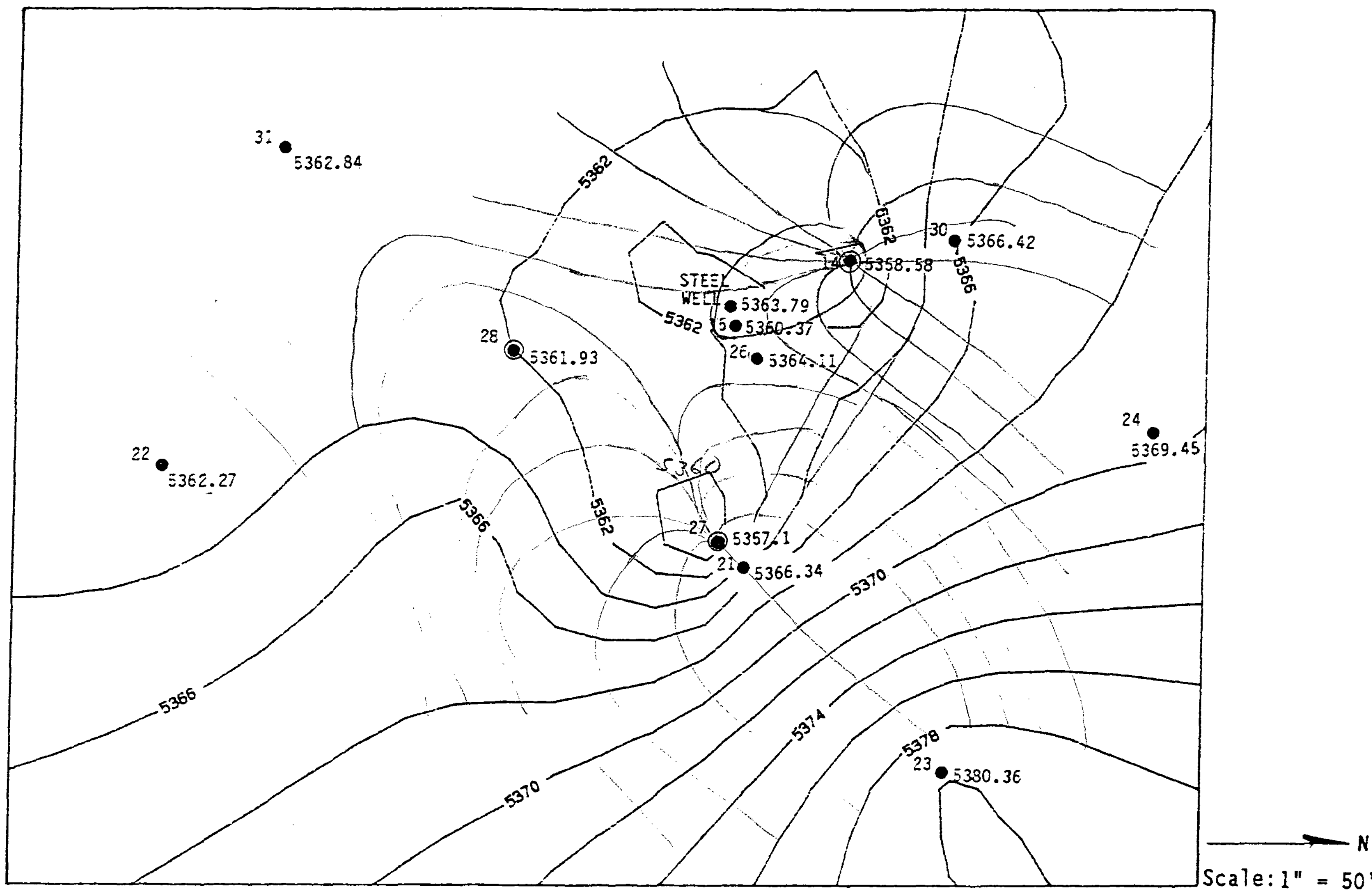
Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

FIGURE 6-5

FLOATING PRODUCT PLUME CONTOUR MAP - DIESEL SPILL AREA, NOV. 1986

(AFTER PUMPING STOPPED FOR 2 WEEKS) ~11/7/86

Why ~~increase~~ product in wells not previously contam? eg. 26-30

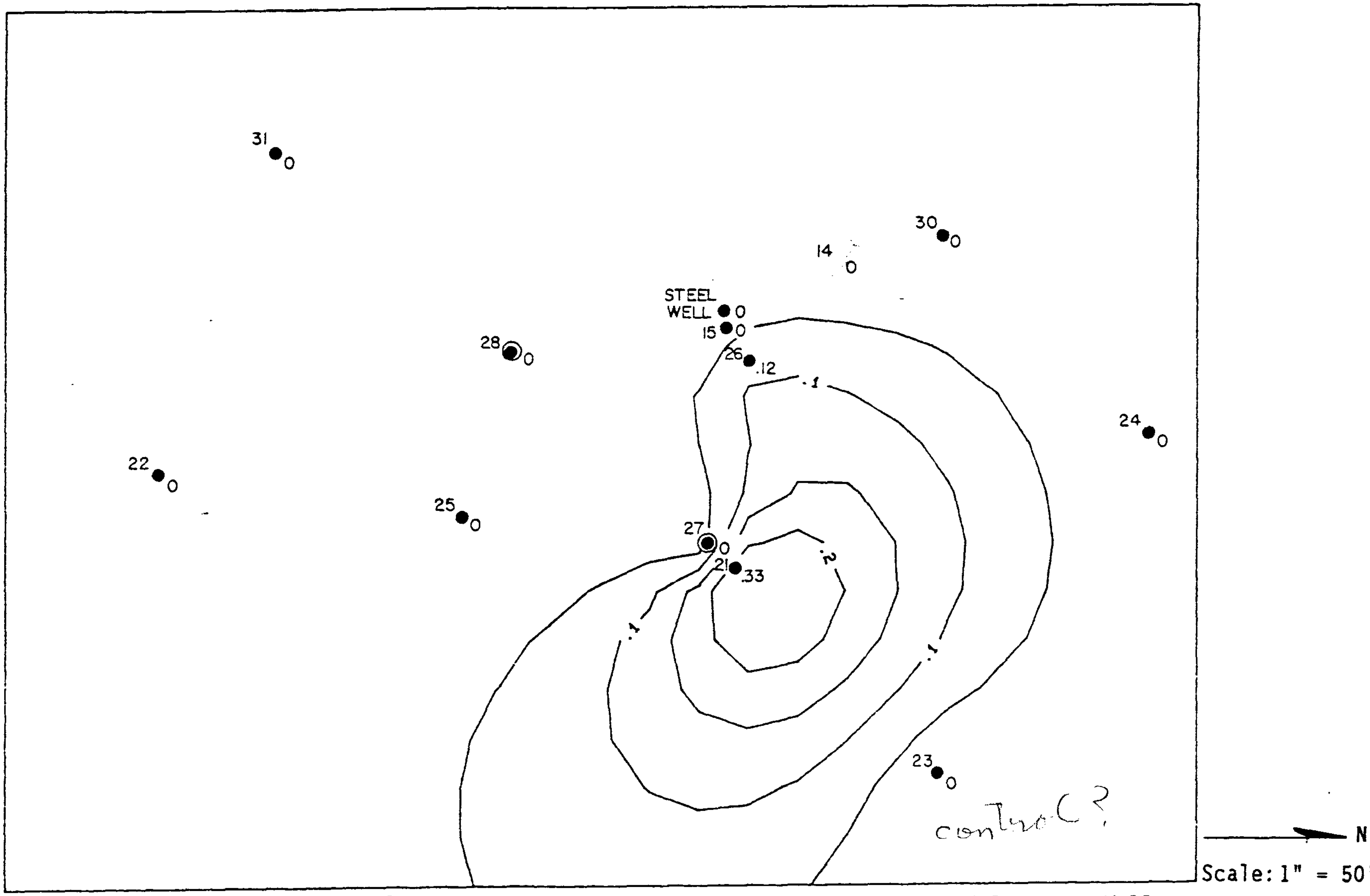


Elevations in Feet above Sea Level, Measured in Monitor and Recovery Wells and Corrected for Floating Product, if Present.

◉ RECOVERY WELL
● MONITOR WELL

FIGURE 6-6
GROUND WATER LEVEL CONTOUR MAP - DIESEL SPILL AREA, NOV. 1986

(WELLS GBR 14, 27, AND 28 PUMPED FOR 2½ DAYS AT 1 GPM - COMPARE WITH FIGURE 6-2)



Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

Need Dates to make clear sequence

FIGURE 6-7

FLOATING PRODUCT PLUME CONTOUR MAP - DIESEL SPILL AREA, NOV. 1986

(AFTER LONG TERM PUMP TEST - COMPARE WITH WATER LEVEL CONTOURS IN FIGURE 6-5) recovery well is equally efficient in removing distant product as in removing product close to the well.

After beginning full-scale pumping in October 1986, GCL discontinued pumping for two weeks in November to prepare for an aquifer pump test in the area. Floating product measurements taken after this two week period of non-pumping are depicted in Figure 6-5, which represents the status of the floating product plume approximately one month after that of Figure 6-4. The plume is still centered around GBR-21 but now displays two pronounced lobes to the west and southwest. These lobes probably correspond to the major ground water and product flow directions, indicating that the floating product plume will tend to migrate slowly downgradient when the recovery pumps are not operating. The existence of these lobes suggests that product tends to migrate around an area of low conductivity on the west side of the Diesel Spill Area.

GCL performed a pump test of the recovery system in the Diesel Spill Area by continuously pumping all three recovery wells simultaneously at approximately 1 gpm each for 2-1/2 days. The influence of this pumping on the ground water elevations is shown in Figure 6-6. This pumping produced substantial local cones of depression centered on GBR-14 and GBR-27 and an overall cone of depression which is effective in controlling movement of the floating product plume as shown in Figure 6-7.

A comparison of the plume before pumping (in Figure 6-5) and after pumping (in Figure 6-7) demonstrates that the pumping has affected the plume in several ways:

- the product plume is still centered on GBR-21 where it has thinned from .46 ft to .33 ft.;
- floating product has disappeared from recovery wells GBR-27 and 28 and monitor wells GBR-23, 24 and 30; and
- the areal extent of the plume has decreased and the prominent lobes to the west and southwest have disappeared.

GCL believes that the pumping of the three recovery wells is effective in containing the spreading of floating product in the Diesel Spill Area. As shown by Figures 6-2 through 6-7, the depression produced by pumping acts as a barrier to the movement of floating product and serves to change the direction of local ground water flow so as to allow this product to be retrieved.

6.3 SOUTHERN REFINERY AREA

6.3.1 Plume Identification

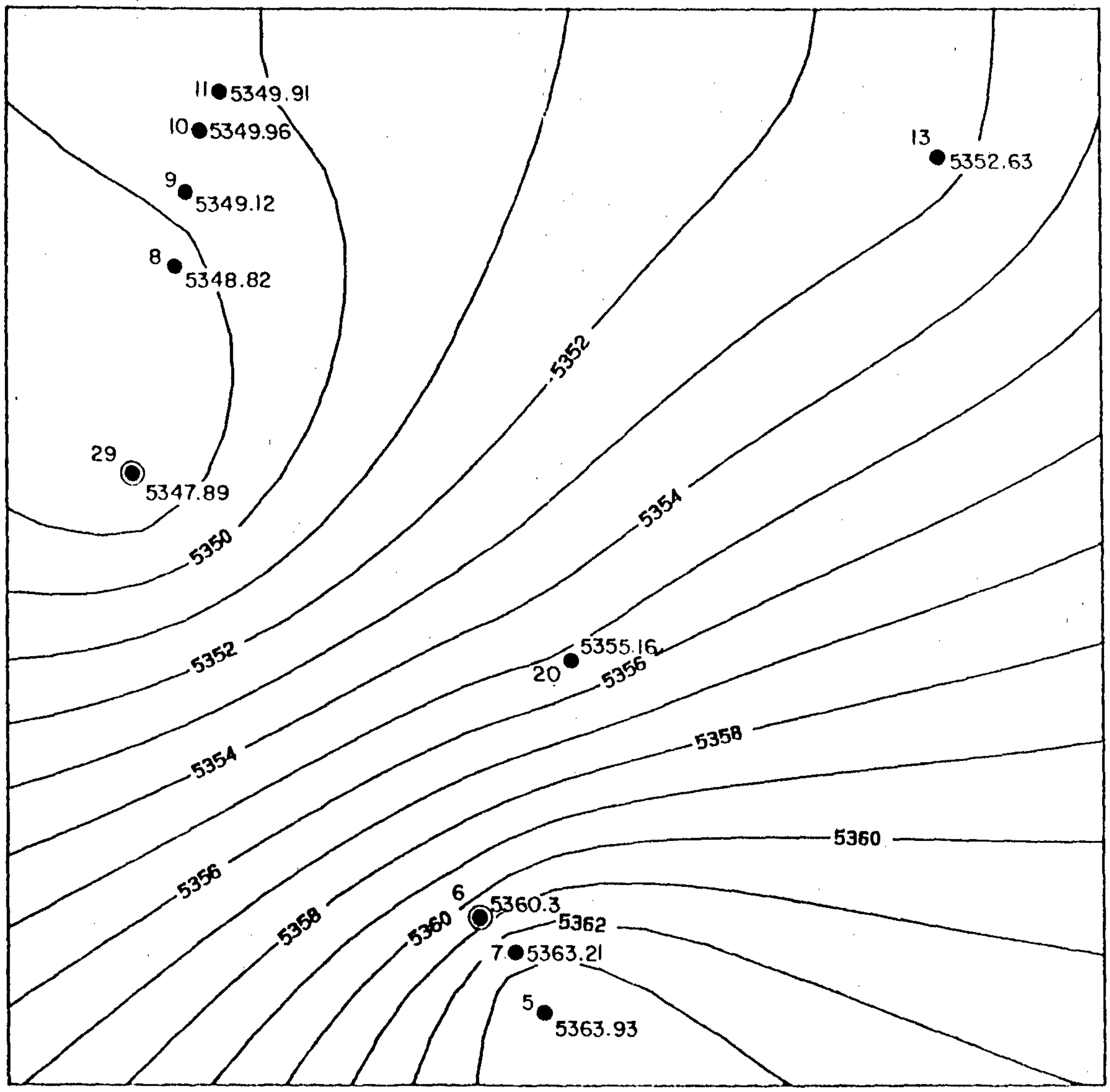
GCL has not yet fully defined the contamination plume in the Southern Refinery Area. In August 1986, GCL found floating product in GBR-5 (11 feet), GBR-29 (7 feet), GBR-11 (5 inches) and GBR-13 (1 foot), but none in nearby GBR-20. GCL has subsequently reduced these floating-product thicknesses in most of these wells by pumping from recovery wells in the area.

6.3.2 Plume Characteristics

Figures 6-8 through 6-11 are maps showing water levels and floating product thicknesses in the Southern Refinery Area at different points in time. Figure 6-8 displays the elevations of ground water beneath the area in more detail than Figure 4-2 (Section 4.0), which covered the entire refinery site. It should be noted that ground water flows southwest toward the arroyo and south within the arroyo.

Figure 6-9 presents the earliest complete data available for floating product levels in the Southern Refinery Area. These data were collected in August 1986 prior to any pumping of wells in the area. Floating product shown on this map is thickest at GBR-5 (greater than 11 feet) and underlies much of the Southern Refinery Area.

Figure 6-10 presents the levels of floating product measured in the Southern Refinery Area in October 1986. GCL had drilled several additional wells in the area since the data presented in Figure 6-9 had been collected in August 1986. Some recently-drilled wells are excluded from Figure 6-10, however, because they are deep-level piezometers



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

N

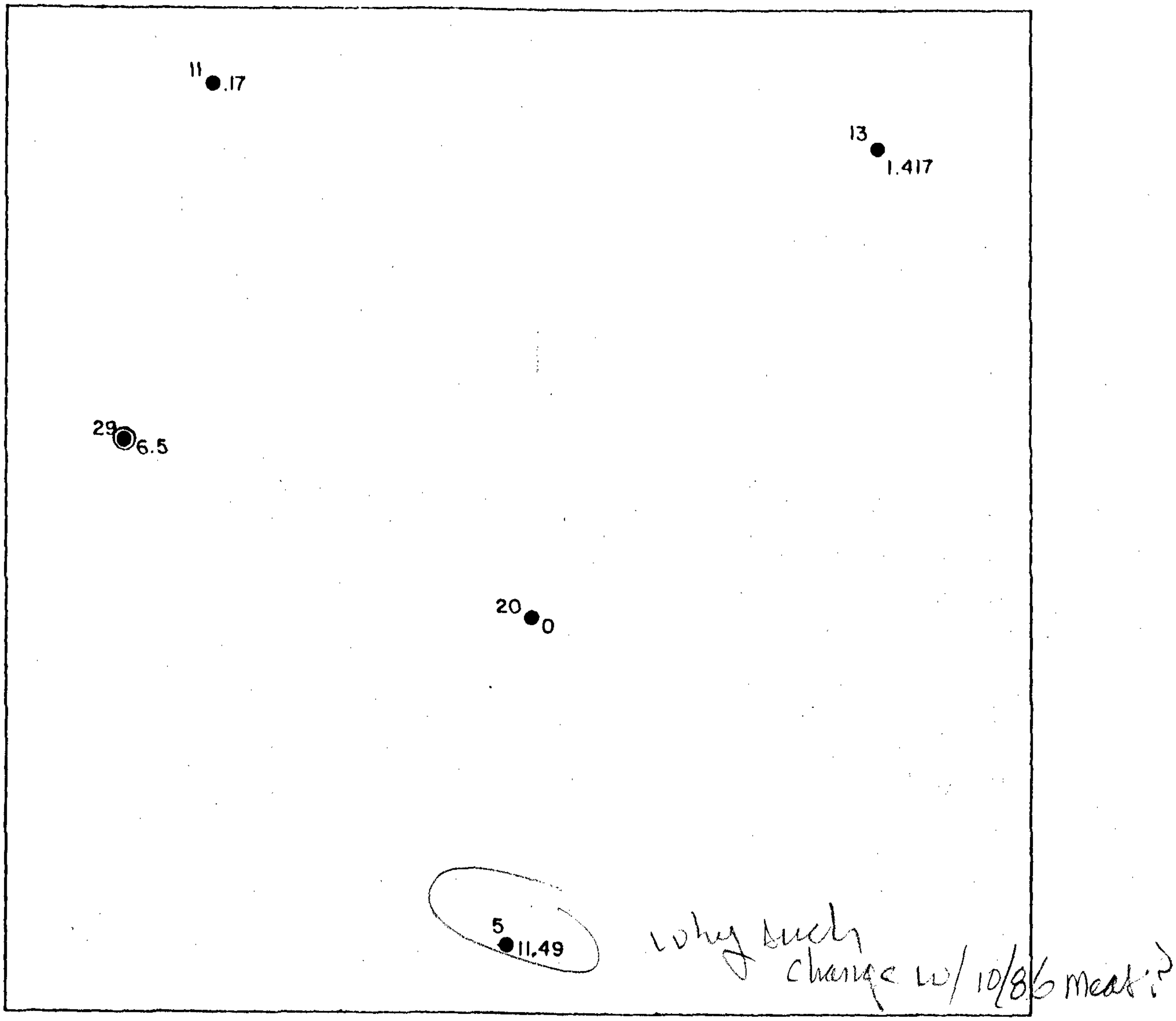
Scale: 1" = 50'

RECOVERY WELL

MONITOR WELL

FIGURE 6-8

GROUND WATER LEVEL CONTOUR MAP - SOUTHERN REFINERY AREA, NOV. 1986



Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

N

Scale: 1" = 50'

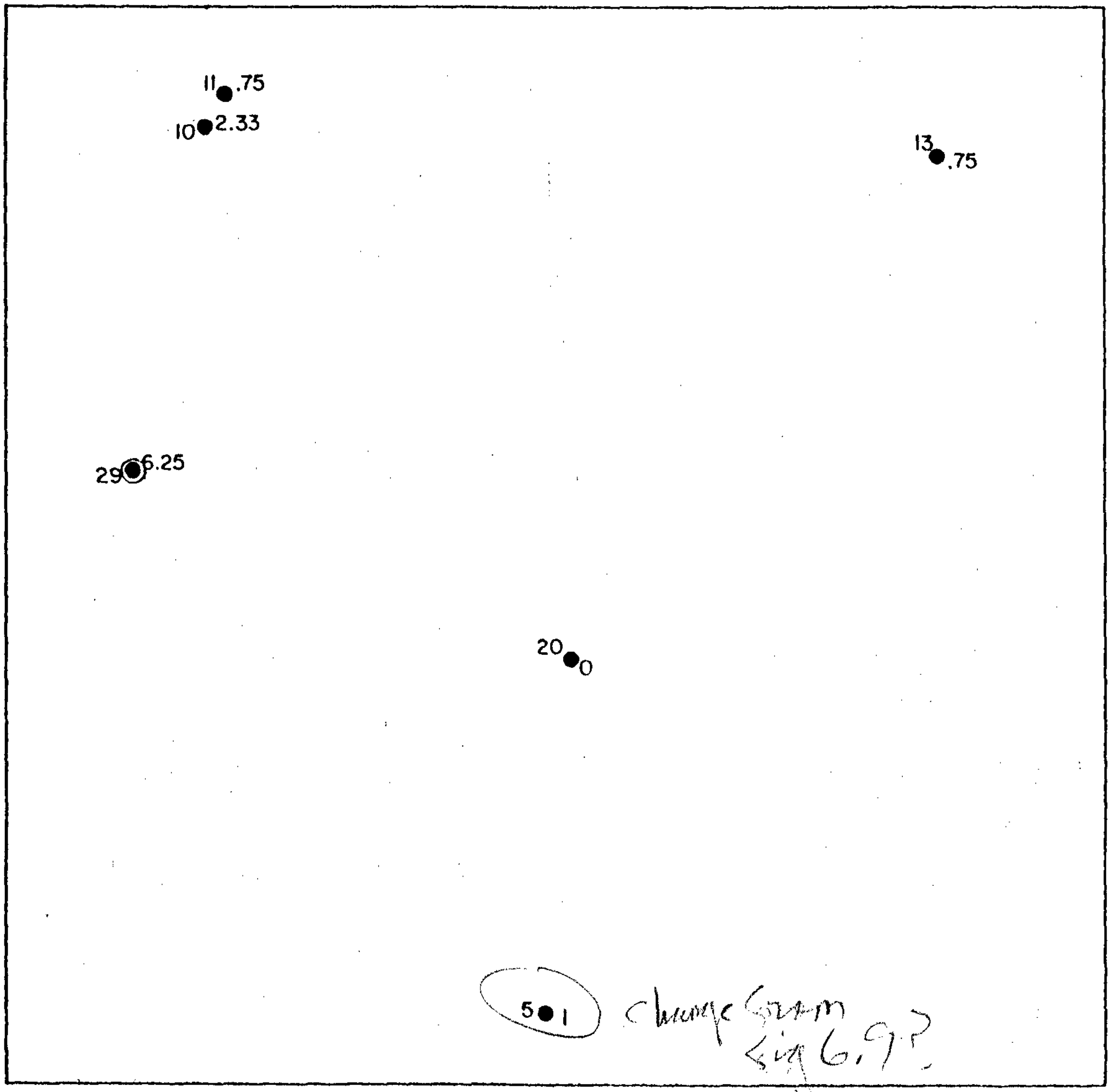
◉ RECOVERY WELL

● MONITOR WELL

FIGURE 6-9

FLOATING PRODUCT MEASUREMENTS - SOUTHERN REFINERY AREA, AUG. 1986

(INITIAL CONDITIONS - COMPARE WITH FIGURES 6-10 AND 6-11)



Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

N

Scale: 1" = 50'

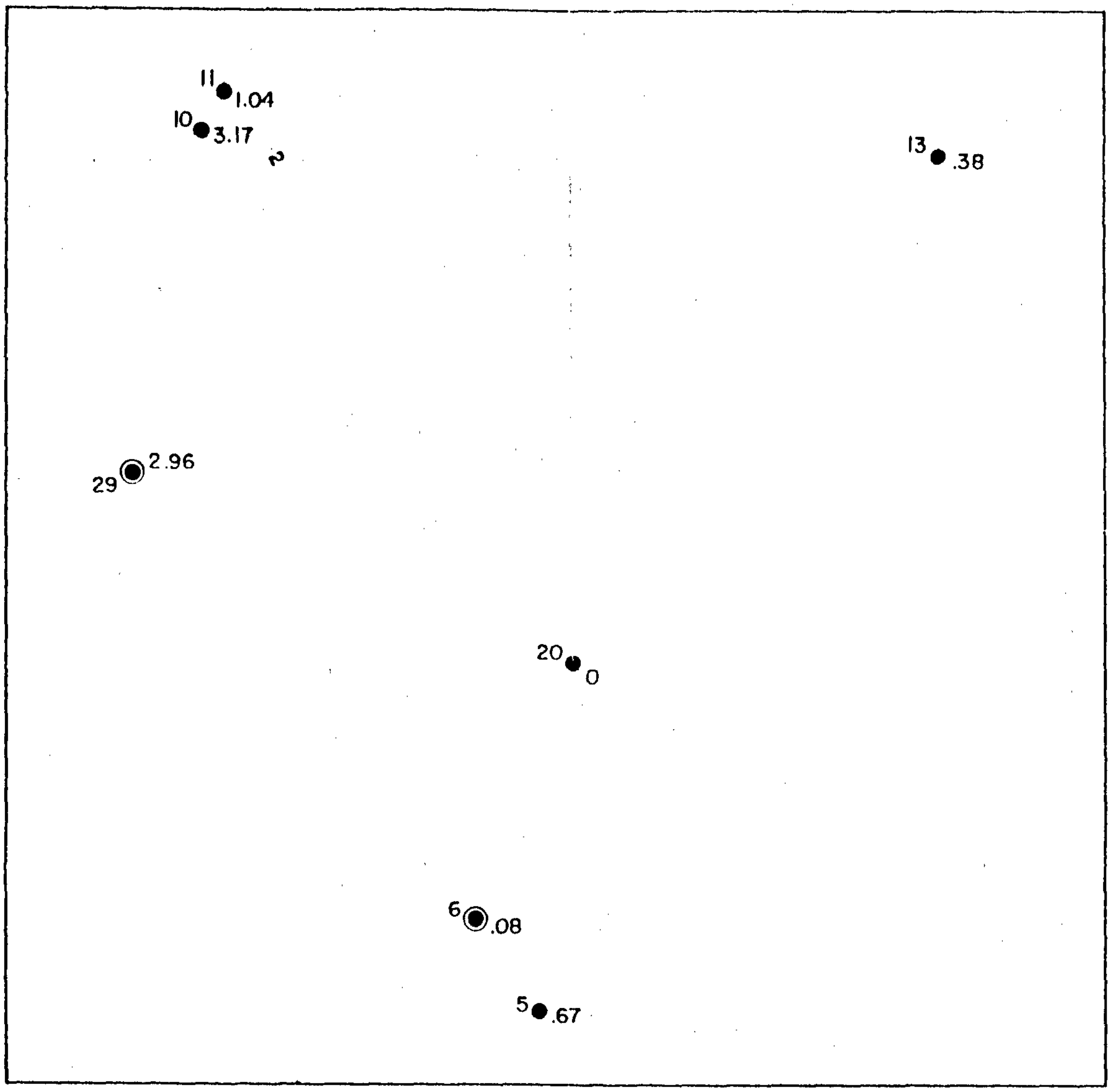
◉ RECOVERY WELL

● MONITOR WELL

FIGURE 6-10

FLOATING PRODUCT MEASUREMENTS - SOUTHERN REFINERY AREA, OCT. 1986

(BEFORE PILOT SCALE PUMPING IN GBR 29 - COMPARE WITH FIGURES 6-9 AND 6-11)



Uncorrected Feet of Product Floating on Water Table, Measured in Monitor and Recovery Wells.

N

Scale: 1" = 50'

◉ RECOVERY WELL

● MONITOR WELL

FIGURE 6-11

FLOATING PRODUCT MEASUREMENTS - SOUTHERN REFINERY AREA, NOV. 1986

(AFTER PILOT SCALE PUMPING IN GBR 29 - COMPARE WITH FIGURES 6-9 AND 6-10) screened below the depth at which floating product occurs (GBR-9) or because they were drilled so recently that floating product, if present, had not yet been able to enter the boreholes (GBR-6, 7 and 8).

Figure 6-11 presents the levels of floating product beneath the Southern Refinery Area in November 1986, approximately one month later than those depicted in Figure 6-10. A recovery pump had been operating intermittently in GBR-29 for approximately 2 months. Deep-level piezometers GBR-7, 8 and 9 are excluded from this map because they are screened below depths at which floating product occurs.

Pilot scale pumping performed in GBR-29 was effective in removing some floating product and reducing its thickness in the vicinity of the well. GCL believes that continued pumping of GBR-29 and of the two additional recently installed recovery wells (GBR-37 and GBR-38) will be effective in controlling the movement of floating product offsite, as described further in Section 8.2. Such a conclusion is supported by the hydrogeologic analysis presented in Section 4.2 and Appendix C. Since the time of this pilot scale pumping, GBR-6 has been and continues to be pumped as a recovery well. Also recovery wells GBR-37 and GBR-38 have been drilled and pumps have been installed in them.

6.4 TRUCK FUELING AREA

In early November 1986, Giant discovered and repaired a leak in a diesel fuel delivery line near the currently used fueling station. Giant estimated that approximately 15,000 gallons of diesel fuel had been lost. On November 21, 1986, GCL measured a floating product thickness of 3 feet in GBR-22, which is within 15 feet of the fueling station. Floating product had not previously been found in this well.

The extent of the product plume in this area was recently defined through the installation of exploratory boreholes. GCL drilled 5 boreholes and developed three of them (GBR-33, GBR-34, and GBR-35) into observation wells (Figure 6-1). GCL also drilled a 6-inch recovery well (GBR-36) in the area.

[illegible] [illegible] !

10 [illegible] [illegible]

[illegible] [illegible]

GCL has estimated the thickness of the floating product in the aquifer to be 0.75 feet, which is 25% of the product thickness observed in the GBR-22 borehole on November 21, 1986 (see equation in Section 6.6). GBR-36 is currently being pumped and the water table is being depressed.

6.5 LEE ACRES LANDFILL PLUME

The NMEID (McQuillan and Longmire, 1986) has conducted an investigation of the ground water contamination caused by the Lee Acres Landfill. The NMEID found the soils in the area to be highly susceptible to contamination by the hazardous liquid and solid wastes that previously had been dumped in the liquid waste pits at the landfill. The study found that some of the soils or bottom materials in the arroyo near the site have been contaminated and that the probable source of such contamination was uncontrolled releases of wastes from the liquid waste pits. Contamination was documented in two domestic water wells in the Lee Acres Subdivision located downgradient from the landfill. The shallow ground water in the subdivision was found to contain low levels of benzene, tetrachloroethylene (PCE), trichloroethane (TCA), trichlorethylene (TCE), 1,1-dichloroethene, 1,2-dichloroethene, and 1,1,1-trichloroethane, most of which are also present at elevated concentrations in the surface water and liquid waste samples by the NMEID taken from the landfill.

The NMEID conducted and AEPCO analyzed a terrain electromagnetic conductivity survey (McQuillan and Longmire, 1986), that identified two ground water zones with high terrain conductivity anomalies. The survey indicates that the first zone is probably a leachate plume originating from the liquid waste pits at the landfill. The second zone appears to be near or in the Giant Refining Company's property and GCL believes it is associated with poor quality ground water due to naturally occurring minerals in the old arroyo channel which was buried during refinery construction. The on-site investigations by GCL did not reveal a corresponding contamination plume in this area. Both zones flow southward toward the Lee Acres Subdivision and appear to overlap in an area approximately 1500 feet north of the Bloomfield highway (Route 64) between the arroyo and Giant Refining Company. Terrain conductivity

→ Probably due to leaching of salts from surface sediments beneath fire water pond - Surface shows large areas of such salts decreased away from these two areas and resumed normal background values near the Lee Acres Subdivision, immediately south of the Bloomfield highway.

Tracer Research Corporation conducted a soil gas survey in the area of the landfill and detected high concentrations of contaminants. A total of 46 soil gas samples were analyzed for TCA, TCE, PCE, chloroform and total hydrocarbons, all of which were found in significant concentrations near the landfill. The results of the investigation indicate that the Lee Acres Landfill is a source of both halocarbon and hydrocarbon contamination. These contaminants were shown to be migrating in a southerly direction toward wells in the subdivision that have been shown to be contaminated.

High concentrations of contaminants found in the source areas indicate that the soil underlying the landfill is contaminated. That is, the soil actually contains the contaminant, not just its vapors. Knowing this fact, it is possible that the contamination is still diffusing downward in those areas, actively contaminating the groundwater.

Based upon its investigations to date, GCL does not believe there were any sources of chlorinated solvents (with the exception of DCA) on the Bloomfield Refinery site. Consequently, GCL would not expect to find such contaminants in the soil or ground water at this site. However, GCL found chlorinated solvents similar to those found at the landfill both in ground water along the western edge of the refinery site and also in GBR-17 which is located completely outside of the influence of any potential contamination from the refinery and directly downgradient from the Lee Acres Landfill. Benzene, toluene and xylenes which were found at the landfill were also detected in GBR-18, which is located downgradient from the Lee Acres Landfill and upgradient from the Refinery area. It is apparent to GCL that the contamination found in both GBR-17 and GBR-18 must have come from the landfill and that this contamination is also present in the ground water underlying at the refinery site.

Maybe not - Maybe Amoco

Chlorinated solvents found in the ground water at the Lee Acres Subdivision can also reasonably be assumed to have emanated from the Lee Acres Landfill, because the solvents detected in the subdivision match the contaminant profile detected at the landfill. Benzene, toluene and xylenes were found in the subdivision in addition to chlorinated solvents; all of these compounds were also found at the landfill.

Until the USGS began their studies in January 1987, there had been no wells drilled in the Lee Acres Subdivision or Landfill to investigate the ground water situation, and data from the USGS studies are not yet available for this report. Therefore, the extent of the Lee Acres Landfill plume is presently not fully known. However, it is apparent that this plume is widespread and overshadows the localized contamination sources that GCL has identified on Giant's property. The corrective actions that Giant has initiated are complicated by the continuing influx of the Lee Acres Landfill leachate plume.

6.6 HYDROCARBON PLUME CHARACTERISTICS

Transport of spilled petroleum products in the ground occurs as a multiphase flow involving volatile, soluble, and free-floating transport. Volatile components primarily migrate as vapor through pore spaces within the vadose zone; soluble components migrate as dissolved contaminants within ground water; and free-floating components migrate directly above the ground water. This free-floating product movement represents the primary means of transport for most of the components of a hydrocarbon spill.

The floating product in a hydrocarbon spill generally moves downward and downgradient until it reaches the top of the ground water. At this point the floating product spreads along the water surface until it reaches a critical thickness determined by density, viscosity and surface tension and typically becomes immobile. The lighter fractions, however, can still become dissolved in and be transported by the ground water.

The thickness of a hydrocarbon layer on ground water is usually greatly overestimated by measuring the amount of product which collects in a borehole. This results in an overestimation of the recoverable volume since free-product depth in a well can be typically four times greater than the hydrocarbon thickness in the surrounding ground water-soil matrix. This is expressed by the following equation:

$$\frac{H}{h} = \frac{Pwo}{Pwa} \times \frac{(d_o - d_a)}{(d_w - d_o)} \leq 4$$

Where: H = depth of oil in borehole
h = depth of oil in soil
P_{wa} & P_{wo} = capillary pressure difference between water and air and between water and oil
d_o, d_a, d_w = respective densities of oil, air, and water

It should be noted that the floating product thicknesses presented in this report are not corrected by the above equation and may represent up to 4 times the actual expected thicknesses in the surrounding aquifer (Cooper and Sprague, 1986).

7.0 REMEDIAL ACTION ADDRESSING SOIL CONTAMINATION

Soil that has been contaminated with hydrocarbon product usually retains a significant amount of product suspended in the vadose zone. Because natural degradation is very slow, this product can be a continuous source of ground water contamination. Removal of the contamination is most effectively done by excavating the contaminated soil, spreading it on the surface, and adding water and nutrients to facilitate microbiological degradation. Treatment of soil in place is much more difficult and requires a much longer time.

7.1 REMEDIAL ACTIONS COMPLETED

GCL began a remedial action program soon after discovery of the contaminated soils. Approximately 4,500 cubic yards of soil were removed from four locations at the Bloomfield Refinery and transported to two vacant, bermed areas located in the northeast portion of the refinery property. The two areas have an approximate surface area of 3.1 acres and can effectively hold 5,000 cubic yards of material spread 1 foot thick. These sites were chosen as storage/biodegradation sites because:

- usable ground water in this area is estimated to be greater than 75 feet below land surface; borehole and outcrop data demonstrate that this source of water is protected from any surface contamination by a layer of shale bedrock;
- the berms will effectively prevent run-off and run-on of stormwater; and
- the effectiveness of the proposed biodegradation can be monitored by obtaining shallow soil samples, since these areas have not been used in any refinery operation.

During the last week of April 1986, excavation and removal of hydrocarbon-stained soils began at four locations at the Bloomfield Refinery; the results of the soil samples taken from these areas were previously presented in Tables 5-1 and 5-2. These excavated sites include the storage tank water drain areas, the storage tank bottom containment areas, the underground catch tank excavation in the truck loading area located just to the east of the north loading rack, and the abandoned fire fighting drill area. Giant, under GCL supervision, removed visibly and organoleptically-detectable hydrocarbon-stained soil with earth-moving equipment (backhoes, front-end loaders and bulldozers) and transported it by dump truck to the two bermed storage areas on the east side of the refinery property. After removal of as much stained material as possible, the excavations were inspected and sampled. The following is a more detailed discussion of the excavation, removal and sampling of contaminated soil from each site.

7.1.1 Storage Tank Water Drain Areas

Excavations by Giant at the storage tank water drain area to the west of Crude Tank 1 have completely removed all evidence of staining. Samples were collected from soil remaining at the base of the southern wall of the pit and in the bottom of the excavation. A sample of water that was encountered at a depth of about 15 feet was also collected. Analyses of these samples, presented in Tables 5-1 and 5-2, indicate that an insignificant amount of the contaminated soil remains in place.

Excavations by Giant of the storage tank water drain area between Tanks 23 and 2 also have succeeded in removing significant volumes of stained soil. There are, however, stringers of stained material that could not be removed from the southern edge of the pit. These stringers extend under the foundation of Tank 2 on the eastern side of the pit. Samples were collected from the southern, eastern and western walls of the pit in areas of varying or no visible staining in order to determine the range of residual hydrocarbon concentration. Analyses of samples taken from the west and south walls indicate that all the contaminated soil has been removed. However, samples taken next to the foundation of Tank 2 indicate that contaminated soil extends under the foundation of the tank. The foundation will remain in place, preventing infiltration of precipitation and subsequent leaching of any contamination to ground water. Results of the chemical analyses of these samples are presented in Tables 5-1 and 5-2. GCL believes it is not practical, feasible or necessary to totally remove all evidence of contaminated soil in this area.

7.1.2 Underground Catch Tank in Truck Loading Area

Excavation by Giant of the underground tank in the truck loading area has resulted in the removal of the vast majority of hydrocarbon-stained soils. Some hydrocarbon-stained material was left in place because it extends underneath the concrete slab at the loading rack and beneath the piping networks that service the loading rack. Samples were collected along the northwest corner, the center of the northern pit wall and the center of the southern pit wall in an attempt to provide data on possible ranges of hydrocarbon concentration. Analyses of these samples, shown in Tables 5-1 and 5-2, indicate that soil contaminated with high concentrations of volatile compounds still remains in the northwest corner and along the south wall of the pit. This material does not pose a threat to ground water quality because the concrete slab prevents infiltration of precipitation and subsequent leaching of contaminants to ground water.

7.1.3 Fire Fighting Drill Area

Giant began to remove soil at the fire fighting drill area on May 1, 1986. Excavation started at the seep and removed hydrocarbon-stained soils, moving eastward toward the main pit area. The material had a noticeable hydrocarbon odor. Excavation of the fire fighting drill area was completed by May 9, 1986. Analyses of samples of remaining soils, shown in Tables 5-1 and 5-2, indicate that the vast majority of contaminated soil has been removed. Stained soil containing low levels of xylenes still remains in the east wall of the excavated area where pipelines prevented further excavation.

7.1.4 Oil/Water Separator

GCL did not consider the sludge from the abandoned oil/water separator to be a soil contaminant because it was contained in the concrete vessel. Nevertheless, Giant removed this sludge to prevent possibility of it becoming a source of contamination in the future. Approximately 700 gallons of sludge were transferred to 10 drums and temporarily stored at the soil treatment site pending the results of chemical analysis. The results of the analyses are shown in Tables 7-1 and 7-2. All of the parameters evaluated were below detection or below EP Toxicity limits with the exception of mercury, which was found to exceed the limits in one sample. In order to be certain that waste that may be considered hazardous was not stored permanently on the site, Giant has shipped these 13 drums to an approved hazardous waste disposal site operated by USPCI, Inc. where ?

7.2 PLANNED BIOLOGICAL TREATMENT OF REMOVED SOIL

In July 1986, GCL obtained samples from the soil that had been excavated from the areas described in Section 7.1 and moved to the bermed areas. One sample was taken of stained soil from each bermed area and a composite sample of unstained soil was taken from both areas. These samples, therefore, represent the range of concentrations that were present. GCL then analyzed the samples for the following constituents:

- o Total Metals
- o Halogenated and Aromatic Volatiles
- o Phenols
- o Polynuclear Aromatic Hydrocarbons (PAH's)

The analyses of these samples are presented in Tables 7-3 through 7-7. Detectable concentrations of arsenic, barium, chromium and lead were found in samples from the east and west bermed areas, as well as in the composite sample (Table 7-3). Of the halogenated volatile compounds, only methylene chloride and trichlorofluoromethane were detected (Table 7-4); however, these values are unreasonable and were probably caused by laboratory contamination. GCL found no evidence that these compounds were ever used at the refinery. The east bermed area did have detectable concentrations of some aromatic volatile compounds (Table 7-5). No phenolic or polynuclear aromatic hydrocarbon compounds were detected in any of the samples (Tables 7-6 and 7-7).

Although analysis of the soil stored in the bermed areas shows the material to be non-hazardous and non-threatening to ground water quality, visibly stained soil is present at the site. GCL believes that natural Typo

TABLE 7-1

GIANT BLOOMFIELD REFINERY
SLUDGE SAMPLES FROM ABANDONED OIL/WATER SEPARATOR
EP TOXICITY ANALYSIS

	8610071100	8610071105	8610071110	8610071115	EP TOXICITY LIMITS
Antimony	ND	ND	ND	ND	
Arsenic	ND	0.05	ND	ND	5.0
Barium	1.3	0.13	0.45	0.59	100.0
Beryllium	ND	ND	ND	ND	
Cadmium	ND	ND	ND	ND	1.0
Chromium	1.6	0.46	0.47	0.52	5.0
Cobalt	0.07	0.07	0.07	ND	
Lead	ND	ND	ND	ND	5.0
Mercury	0.004	0.02	0.004	0.34	0.2
Nickel	0.63	0.64	0.41	ND	
Selenium	ND	0.06	ND	ND	1.0
Silver	ND	ND	ND	ND	5.0
Vanadium	ND	ND	ND	ND	

DETECTION LIMITS
FOR ABOVE SAMPLES

	8610071100	8610071105	8610071110	8610071115
Antimony	(0.03)	(0.03)	(0.03)	(0.025)
Arsenic	(0.03)	(0.03)	(0.055)	(0.025)
Barium	(0.07)	(0.07)	(0.065)	(0.065)
Beryllium	(0.015)	(0.015)	(0.015)	(0.015)
Cadmium	(0.055)	(0.55)	(0.055)	(0.05)
Chromium	(0.07)	(0.07)	(0.065)	(0.065)
Cobalt	(0.055)	(0.055)	(0.055)	(0.05)
Lead	(0.35)	(0.35)	(0.35)	(0.35)
Mercury	(0.003)	(0.003)	(0.003)	(0.002)
Nickel	(0.15)	(0.15)	(0.15)	(0.15)
Selenium	(0.15)	(0.05)	(0.15)	(0.15)
Silver	(0.045)	(0.04)	(0.04)	(0.04)
Vanadium	(0.03)	(0.03)	(0.03)	(0.025)

units in mg/L
detection limits in parentheses
ND = not detected

TABLE 7-2

GIANT BLOOMFIELD REFINERY
SLUDGE SAMPLES FROM ABANDONED OIL/WATER SEPARATOR
INORGANIC PARAMETERS

	Units	8610071100		8610071105		861007110		NEW SAMPLES 861007115	
Corrosivity	ph units	7.50	(0.01)	7.16	(0.01)	7.87	(0.01)	7.74	(0.01)
Reactive Sulfide	mg/kg	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Total Cyanide	mg/kg	ND	(0.03)	0.01	(0.01)	ND	(0.01)	ND	(0.01)
Flash Point	°F	99	(200)	111	(200)	131	(200)	115	(200)
Oil	%	14.1	(0.1)	14.0	(0.1)	7.7	(0.1)	11.5	(0.1)
Solids	%	56.5	(0.1)	62.2	(0.1)	73.5	(0.1)	83.5	(0.1)

ND = not detected
limits of detection in parentheses

TABLE 7-3

GIANT BLOOMFIELD REFINERY
COMPOSITE SAMPLES OF REMOVED SOIL
TOTAL METALS

	8607151335 WEST BERMED AREA		8607151330 EAST & WEST BERMED AREAS		8607151315 WEST BERMED AREA		8607151230 EAST BERMED AREA	
Arsenic	1.1	(0.2)	1.3	(0.2)	1.2	(0.2)	1.6	(0.2)
Barium	43	(0.5)	35	(0.5)	43	(0.5)	60	(0.5)
Cadmium	ND	(0.4)	ND	(0.4)	ND	(0.4)	ND	(0.4)
Chromium	59	(0.5)	2.6	(0.5)	39	(0.5)	1.6	(0.5)
Lead	11	(2)	3.7	(2)	12	(2)	8.4	(2)
Mercury	ND	(0.05)	ND	(0.05)	ND	(0.05)	ND	(0.05)
Selenium	ND	(0.4)	ND	(2)	ND	(0.4)	ND	(2)
Silver	ND	(0.3)	ND	(0.3)	ND	(0.3)	ND	(0.3)

units in mg/kg
ND = not detected
detection limits in parentheses

TABLE 7-4

GIANT BLOOMFIELD REFINERY
COMPOSITE SAMPLES OF REMOVED SOIL
HALOGENATED VOLATILES

	8607151330 EAST & WEST BERMED AREA		8607151315 WEST BERMED AREA		8607151230 EAST BERMED AREA	
Bromoform	ND	(290)	ND	(77)	ND	(200)
Carbon tetrachloride	ND	(9.8)	ND	(2.6)	ND	(6.6)
Chlorobenzene	ND	(9.8)	ND	(2.6)	ND	(7)
Chloroethane	ND	(98)	ND	(26)	ND	(66)
2-Chloroethylvinyl	ND	(39)	ND	(5.2)	ND	(26)
Chloroform	ND	(9.8)	ND	(2.6)	ND	(6.6)
Dibromochloromethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,2-Dichlorobenzene	ND	(9.8)	ND	(2.6)	ND	(20)
1,3-Dichlorobenzene	ND	(9.8)	ND	(2.6)	ND	(20)
1,4-Dichlorobenzene	ND	(9.8)	ND	(2.6)	ND	(20)
Dichlorobromomethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
Dichlorodifluoromethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,1-Dichloroethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,2-Dichloroethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,1-Dichloroethylene	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,2-Dichloropropane	ND	(9.8)	ND	(2.6)	ND	(6.6)
cis-1,3-Dichloropropylene	ND	(9.8)	ND	(2.6)	ND	(6.6)
trans-1,3-Dichloropropylene	ND	(9.8)	ND	(2.6)	ND	(6.6)
Methylbromide	ND	(98)	ND	(52)	ND	(70)
Methylchloride	ND	(200)	ND	(52)	ND	(130)
Methylene chloride	1300*#	(820)	770*#	(760)	830*#	(57)
1,1,2,2-Tetrachloroethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
Tetrachloroethylene	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,2-trans-Dichloroethylene	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,1,1-Trichloroethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
1,1,2-Trichloroethane	ND	(9.8)	ND	(2.6)	ND	(6.6)
Trichloroethylene	ND	(20)	ND	(2.6)	ND	(13)
Trichlorofluoromethane	ND	(98)	ND	(2.6)	110*	(66)
Vinyl Chloride	ND	(9.8)	ND	(2.6)	ND	(6.6)

units in ug/kg except where noted
# units in mg/kg
ND = not detected
detection limits in parentheses
*value suspect due to possible sample contamination at laboratory

TABLE 7-5

GIANT BLOOMFIELD REFINERY
COMPOSITE SAMPLES OF REMOVED SOIL
AROMATIC VOLATILES

	860715130 EAST & WEST BERMED AREA		8607151315 WEST BERMED AREA		8607151230 EAST BERMED AREA	
Benzene	ND	(4.9)	ND	(2.6)	ND	(20)
Ethylbenzene	ND	(9.8)	ND	(2.6)	18	(7)
Toluene	ND	(9.8)	ND	(2.6)	ND	(10)
Xylene, m	ND	(9.8)	ND	(2.6)	82	(7)
Xylenes, o & p	ND	(19)	ND	(5.2)	59	(15)

units in ug/kg
ND = not detected
detection limits in parentheses

TABLE 7-6

GIANT BLOOMFIELD REFINERY
COMPOSITE SAMPLES OF REMOVED SOIL
PHENOLS

	8607151330 EAST & WEST BERMED AREA		8607151315 WEST BERMED AREA		8607151230 EAST BERMED AREA	
4-Chloro-3-methylphenol	ND	(100)	ND	(500)	ND	(2000)
2-Chlorophenol	ND	(100)	ND	(500)	ND	(2000)
2,4-Dichlorophenol	ND	(100)	ND	(500)	ND	(2000)
2,4-Dimethylphenol	ND	(100)	ND	(500)	ND	(2000)
2,4-Dinitrophenol	ND	(500)	ND	(2000)	ND	(10000)
2-Methyl-4,6-dinitrophenol	ND	(250)	ND	(1000)	ND	(5000)
2-Nitrophenol	ND	(100)	ND	(500)	ND	(2000)
4-Nitrophenol	ND	(250)	ND	(1000)	ND	(5000)
Pentachlorophenol	ND	(250)	ND	(1000)	ND	(5000)
Phenol	ND	(100)	ND	(500)	ND	(2000)
2,4,6-Trichlorophenol	ND	(100)	ND	(500)	ND	(2000)

units in ug/kg
ND = not detected
detection limits in parentheses

TABLE 7-7

ANALYTICAL RESULTS OF
GIANT BLOOMFIELD REFINERY
COMPOSITE SAMPLES OF REMOVED SOIL
POLYNUCLEAR AROMATIC HYDROCARBONS

	8607151330 EAST & WEST BERMED AREA		8607151315 WEST BERMED AREA		8607151230 EAST BERMED AREA	
Acenaphthene	ND	(50)	ND	(1500)	ND	(1500)
Acenaphthylene	ND	(50)	ND	(1500)	ND	(1500)
Anthracene	ND	(1)	ND	(15)	ND	(15)
Benzo(a)anthracene	ND	(5)	ND	(150)	ND	(150)
Benzo(a)pyrene	ND	(1)	ND	(50)	ND	(50)
Benzo(b)fluoranthene	ND	(1)	ND	(30)	ND	(30)
Benzo(g,h,i)perylene	ND	(5)	ND	(50)	ND	(80)
Benzo(k)fluoranthene	ND	(1)	ND	(20)	ND	(30)
Chrysene	ND	(5)	ND	(150)	ND	(150)
Dibenzo(a,h)anthracene	ND	(10)	ND	(250)	ND	(300)
Fluoranthene	ND	(5)	ND	(150)	ND	(150)
Fluorene	ND	(10)	ND	(200)	ND	(250)
Indeno(1,2,3-cd)pyrene	ND	(5)	ND	(150)	ND	(150)
Naphthalene	ND	(50)	ND	(1500)	ND	(1500)
Phenanthrene	ND	(5)	ND	(150)	ND	(150)
Pyrene	ND	(5)	ND	(150)	ND	(150)

units in ug/kg
ND = not detected
detection limits in parentheses

Although analysis of the soil stored in the bermed areas shows the material to be non-hazardous and non-threatening to ground water quality, visibly stained soil is present at the site. GCL believes that natural biodegradation processes will be effective in abating any remaining organic contamination and that the metals will remain immobilized in the soil.

Biodegradation of oily wastes has had a long and successful history in the petroleum refinery industry. It has been well established by the American Petroleum Institute and others that naturally occurring soil-microbes have the capability of degrading oily waste fractions under a variety of mass loadings and climatological and site conditions (Hornick and others, 1983). Many of these studies have been conducted to examine the kinetics and pathways of biodegradation of specific organic constituents that are commonly encountered in petroleum wastes and have focused on compounds that are considered to be recalcitrant to biodegradation and extremely persistent in the environment. In all cases, the evidence has shown that even these resistant compounds can be degraded by naturally occurring organisms in relatively short periods, albeit, often with adjustment of soil moisture and nutrient content. These studies also show that biodegradation of oily wastes will occur without the addition of any nutrients or water, although at a slower rate.

It is apparent that natural biodegradation processes have been successful at the site. Samples of excavated soil at the time of removal ranged from grossly contaminated to marginally contaminated. Samples taken from the bermed storage area 2 1/2 months after removal showed little organic contamination. The actions of excavating and moving the soil exposed it to conditions favorable for natural biodegradation of organics, leaving only low levels of relatively immobile metals in the soil.

GCL believes that further treatment of this soil is not necessary. The soil will be kept in the bermed areas, isolated from any ground water contact, and has been spread to depths of about 1 foot to promote complete aeration and microbiological degradation of any remaining organic constituents.

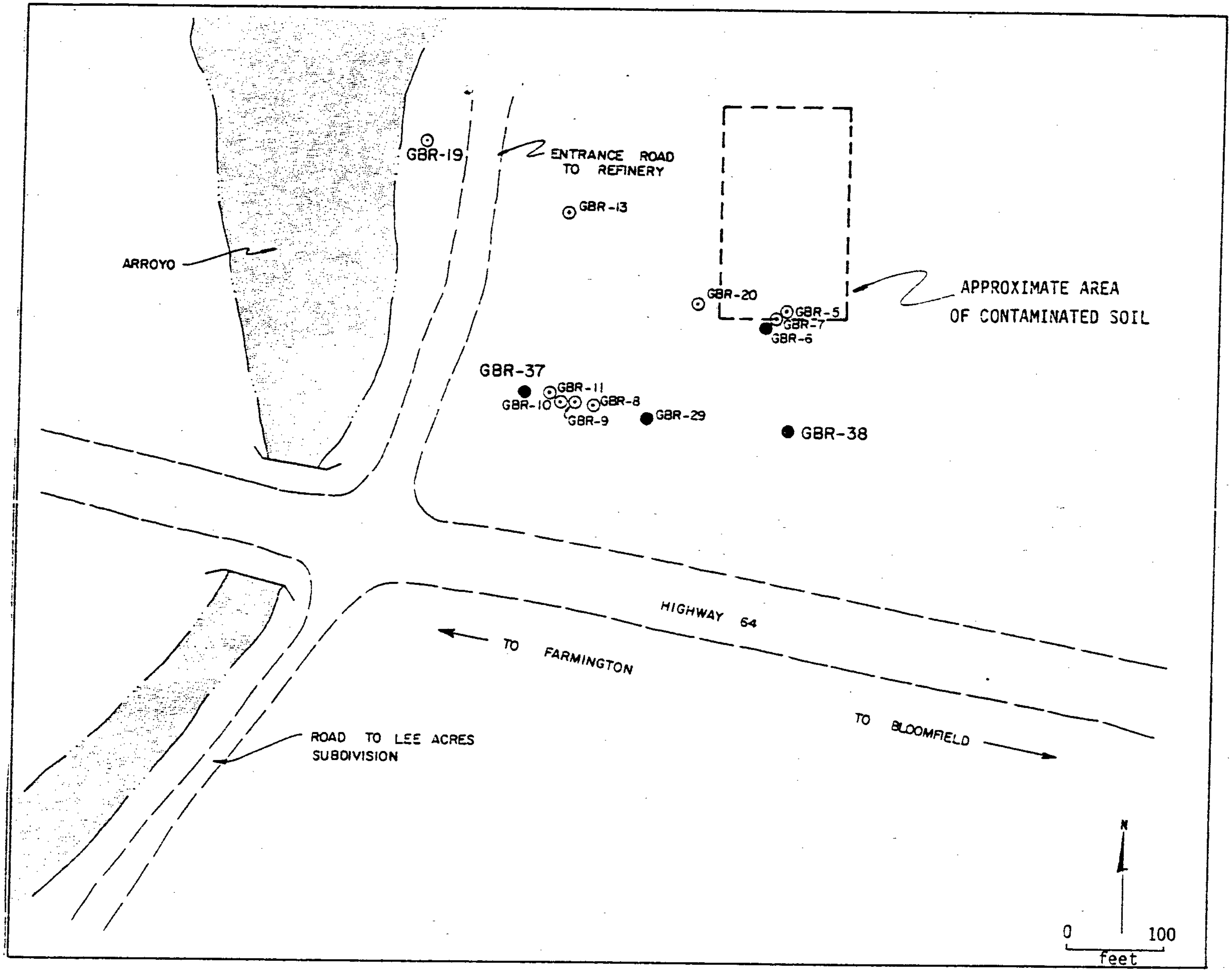
Because of the relatively clean condition of the soil in the bermed storage areas, it would be acceptable as a medium for treating contaminated ground water that will be produced from remedial actions at the refinery (Section 8.5). Contaminated water from ground water reclamation activities could be treated effectively by sprinkling it onto the soil where aeration and microbiological degradation would take place. Land treatment of wastewater in this manner is an accepted method which would be well suited to this application.

7.3 TREATMENT OF SOIL IN-PLACE

GCL has removed all soil containing concentrated contamination that could feasibly be removed. In most areas, remaining contamination will be left to degrade naturally over time. These locations contain small volumes of contaminated soil and pose no threat to the underlying ground water.

However, the Southern Refinery Area, near the former stormwater containment areas, appears still to contain a significant amount of contaminated soil that is infeasible to remove (Figure 7-1). Because this soil contamination may be a continuing source of ground water contamination in the area, it is practical to approach the treatment of both media as a system. As described in detail in Section 8.2, floating product and contaminated water will be pumped from GBR-6, GBR-29, GBR-37 and GBR-38 in order to keep potential contamination from moving off the site. Any ground water contaminated by this soil will be intercepted as well.

Precipitation falling on the ground will provide occasional wetting of the soil and some downward migration of water through the contaminated zone. To provide for clean-up of the contaminated soil, it will be necessary to augment natural wetting of the soil with a controlled



LEGEND

⊙ MONITOR WELLS

● RECOVERY WELLS

FIGURE 7-1

REMAINING IN-PLACE CONTAMINATED SOIL

SOUTHERN REFINERY AREA
GIANT - BLOOMFIELD

application of water. As the moisture in the soil is increased above naturally occurring levels, contamination in the soil will be flushed into the ground water and captured by the ground-water recovery system.

How?

What about capture of salts?

During the frost-free period (April-October), reclaimed ground water will be applied to the contaminated soil in the Southern Refinery Area. Tests conducted on this soil (Appendix E) 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 hydrocarbons) 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.

GCL proposes to approach this upper limit of water application through a series of test applications. Eighteen inches of reclaimed ground water (about 25% of the maximum calculated open pore space) will be applied to the area of concern after a period of 2 weeks during which total precipitation was less than 0.1 inch and at a rate that does not result in ponding on the area. The area will be disked to facilitate infiltration of applied water. A 6-inch high berm will be constructed around the site to prevent any runoff. 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.

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 hydrocarbons 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 contaminants. More detailed plans and specifications for this proposed in-situ treatment of soil will be developed prior to initiation of the program.

The tests described above will be performed only after all the required product recovery wells are in place and operational in the Southern Refinery Area. Since the transport of contaminants in the unsaturated zone cannot always be predicted with theoretical models, it is imperative that the recovery wells collect any contamination that may be dislodged by the flushing action of the water. The recovery wells are designed to capture any floating product and immediately underlying dissolved-phase product contamination that may appear before it can migrate off Giant's property in Southern Refinery Area.

8.0 REMEDIAL ACTION ADDRESSING GROUND WATER CONTAMINATION

Giant began remedial actions promptly upon GCL's discovery of the ground water contamination zones at the Bloomfield Refinery and has continued to assess the effects of all contamination sources on the site.

8.1 DIESEL SPILL AREA PLAN

8.1.1 Remedial Actions Completed

Based on the results of the pump test conducted in GBR-27 (Section 4.1.1) and data from existing wells, GCL drilled two additional exploratory wells, constructed an additional recovery well, and installed a piezometer cluster.

The exploratory wells were drilled in order to identify more accurately the extent of the plume. One exploratory well (GBR-30) was installed 100 feet southwest and downgradient of GBR-24; the other (GBR-31) was installed 100 feet southwest of GBR-28. The locations of both wells are shown in Figure 8-1. Although these 2-inch PVC wells did not encounter any floating product when drilled, a small amount appeared in GBR-30 after several weeks.

A 3-level well cluster was installed inside the contamination area, using two existing wells and one new well, to provide precise monitoring of ground water quality at specific depths and to monitor the effects of the remedial actions. The piezometer nest utilizes the Steel Well, GBR-15 and GBR-26. GBR-15 is constructed of stainless steel, as shown in Figure 8-2, and serves also as a monitor well. GBR-26 is screened at the top of the aquifer from 25 to 35 feet; the Steel Well has an open bottom at 40 feet in the middle of the aquifer, and GBR-15 is screened at the bottom of the aquifer from 45 to 55 feet.

But GBR-26 and steel well showed no draw-down

Three recovery wells are now in place: GBR-14 (6-inch diam.), GBR-27 (5-inch diam.), and GBR-28 (6-inch diam.). They have been spaced so that their cones of influence intersect each other and cover the entire estimated down-gradient edge of the plume (Figure 8-1). These wells were constructed of PVC casing as shown in Figure 8-3.

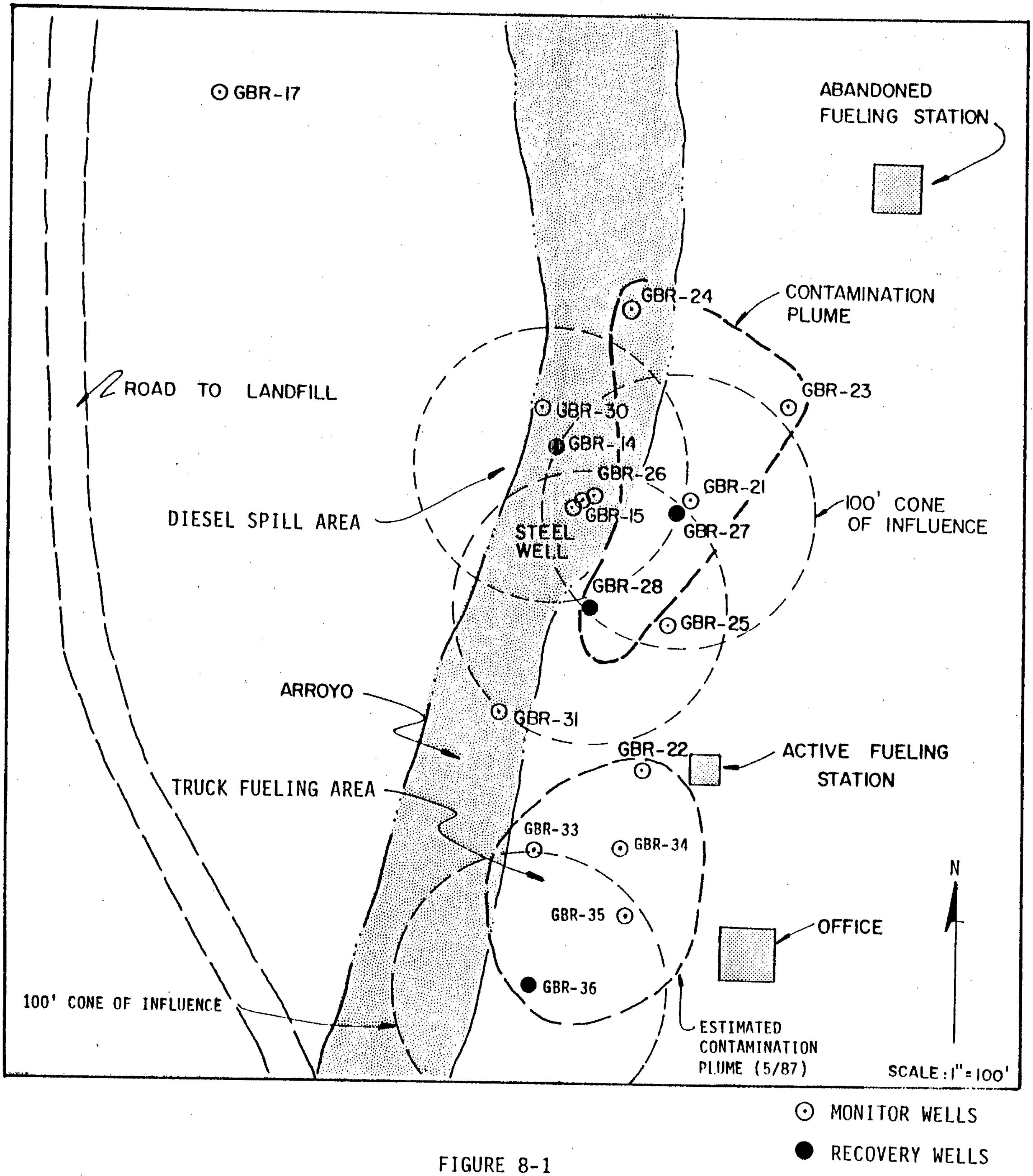
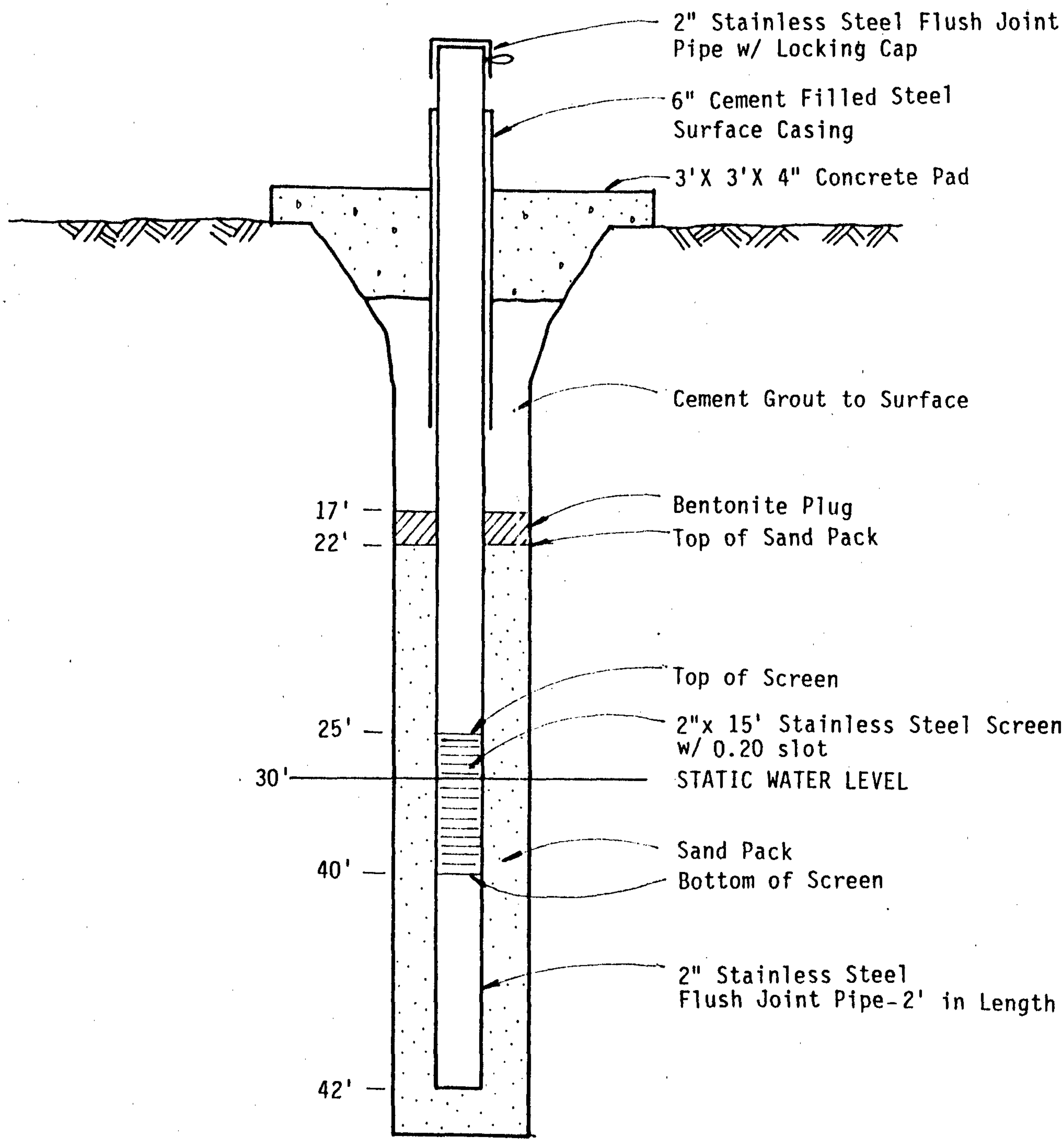


FIGURE 8-1

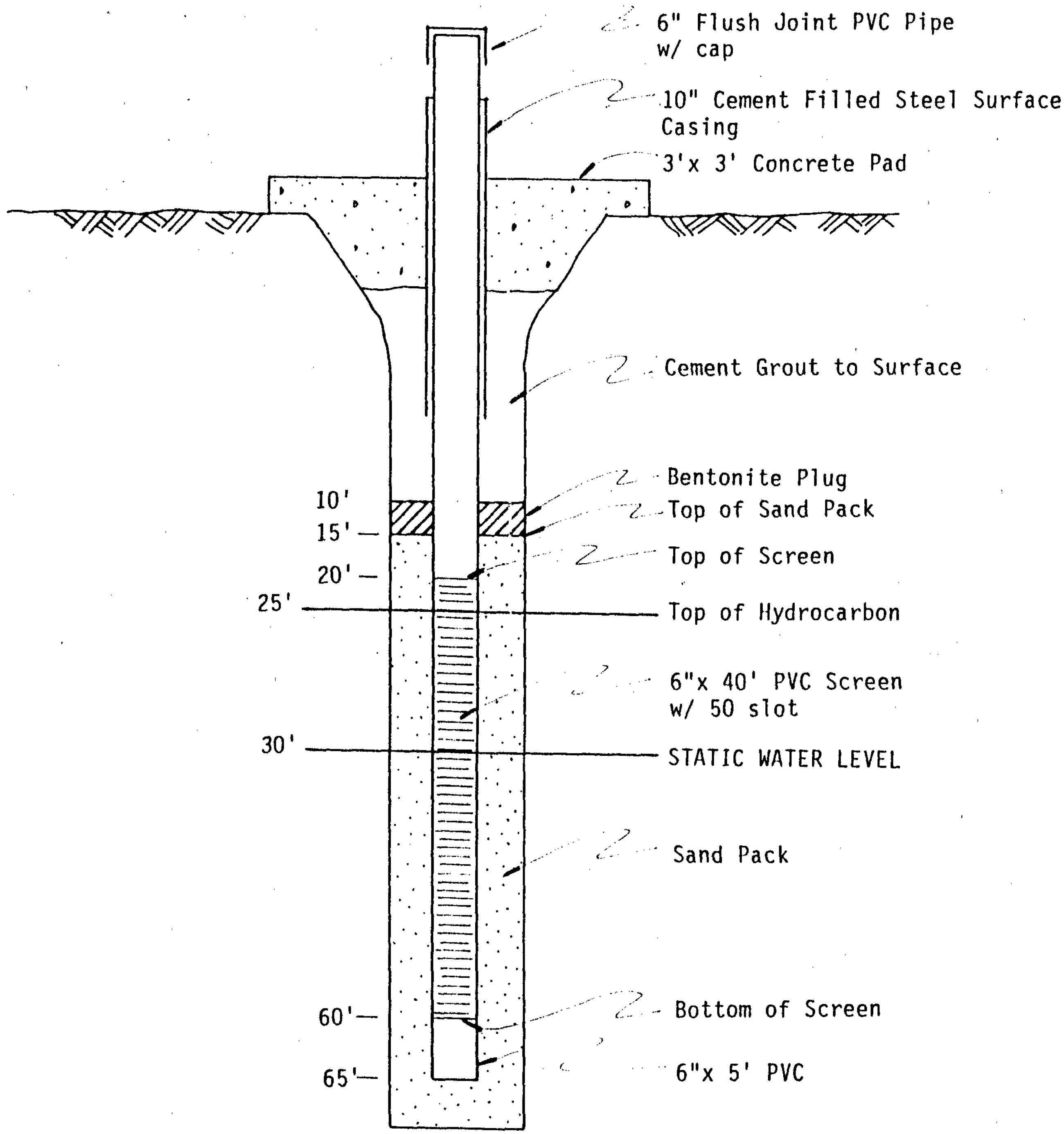
RECOVERY AND MONITOR WELLS
DIESEL SPILL AND TRUCK FUELING AREAS
GIANT - BLOOMFIELD



NOTE: The dimensions shown are typical. The actual values are shown on individual well logs.

TYPICAL MONITOR WELL

FIGURE 8-2



NOTE: The dimensions shown are typical. The actual values are shown on individual well logs.

TYPICAL RECOVERY WELL

FIGURE 8-3

Recovery pumps were installed in the three wells on October 7, 1986. With the exception of intermittent down time, the pumps have been pumping continuously since that time. The pumps currently discharge into a 500 barrel storage tank located near the wells, from which the water is periodically transferred to large storage tanks by truck. Because large quantities of water must be removed in order to also remove the floating product, most of the pumped liquid has consisted of water.

The recovery pump is a specially designed unit that operates by compressed air, as shown in Figure 8-4. It fills from the top of the pump so that, when the inlet is placed at the water level, any product floating on top of the water is skimmed off into the pump. When the pump becomes full it is automatically emptied and then is reset to fill again. This method of operation is well suited to the recovery wells in the Diesel Spill Area because of the low transmissivity of the underlying aquifer. When properly placed, the pumps remove not only floating product, but also enough water to depress the water level, which induces the flow of floating product into the well and effectively contains the plume.

Using the transmissivities and storativities obtained from pump test analyses, GCL designed a remedial action plan based upon a ground water model calibrated to the refinery site. The model is fully discussed in Appendix E of this report. Plate 4 is a representation of the predicted water table elevations during the planned remedial action. These elevations indicate that the floating hydrocarbon contamination present in the Diesel Spill Area is contained and removed through this plan. Field evidence also demonstrates that pumping of the three recovery wells does indeed result in containment and removal of both floating hydrocarbons and dissolved-phase hydrocarbons associated with the floating product.

Model may not be calibrated rightly T/S's are incorrect

GCL has determined that optimal design, based on field testing, requires pumping rates of approximately 1 gpm from each well. Because the pumps fill from the top and discharge only when full, the distance of the pump

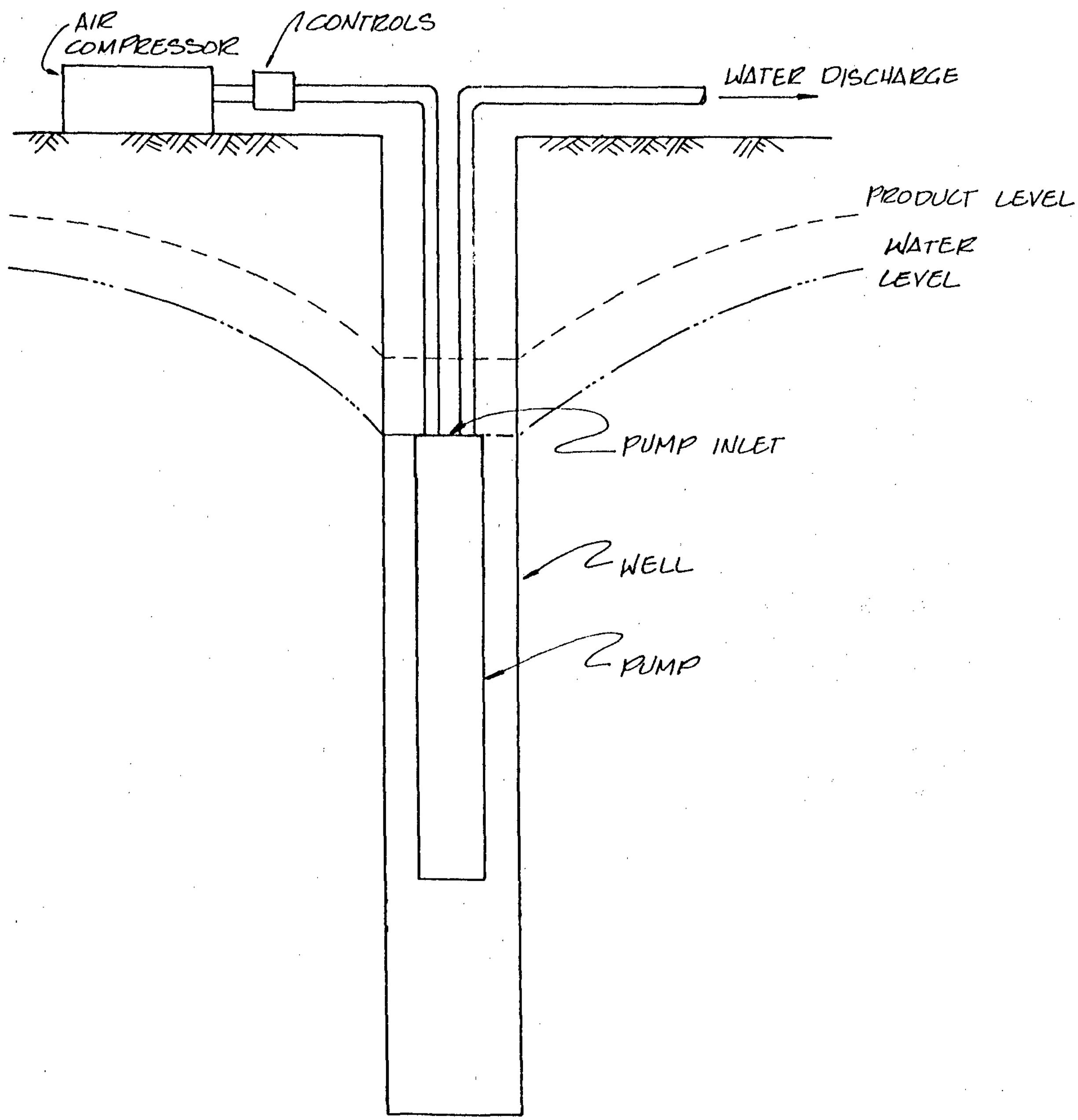


FIGURE 8-4

TYPICAL RECOVERY WELL AND PUMP INSTALLATION below static water levels determines the rate of pumping. In the Diesel Spill Area the optimal pump distance below static water level is:

GBR-14	7.5 feet
GBR-27	8.0 feet
GBR-28	0.6 feet

8.1.2 Further Remedial Actions Planned

The remedial actions already taken in the Diesel Spill Area, as described in Section 8.1.1, have demonstrated that the existing recovery system will be effective in removing the floating product and associated dissolved phase plume in that area. To eliminate unexpected down time, GCL plans to make some improvements to the existing system. To assure long term, reliable operation, Giant will install a large capacity air compressor and direct piping from the 500-barrel storage tank to long-term storage tanks, eliminating the necessity of truck transfer.

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

Tank 23	5,000 barrels capacity
Tank 24	20,000 barrel capacity
Tank 27	5,000 barrels capacity
Tank 32	5,000 barrels capacity
Tank 37	10,000 barrel capacity

Where located? Need to be on plat!

After one tank is filled, the stored water will be sampled and chemically analyzed (see Section 9.0) using EPA methods for purgeable organic compounds, acid-extractable compounds and base-neutral compounds. The results of the testing will determine the appropriate level of treatment required prior to discharge. Figure 8-5 shows the conceptual design of the ground water remedial action plan for the Diesel Spill and Southern Refinery Areas.

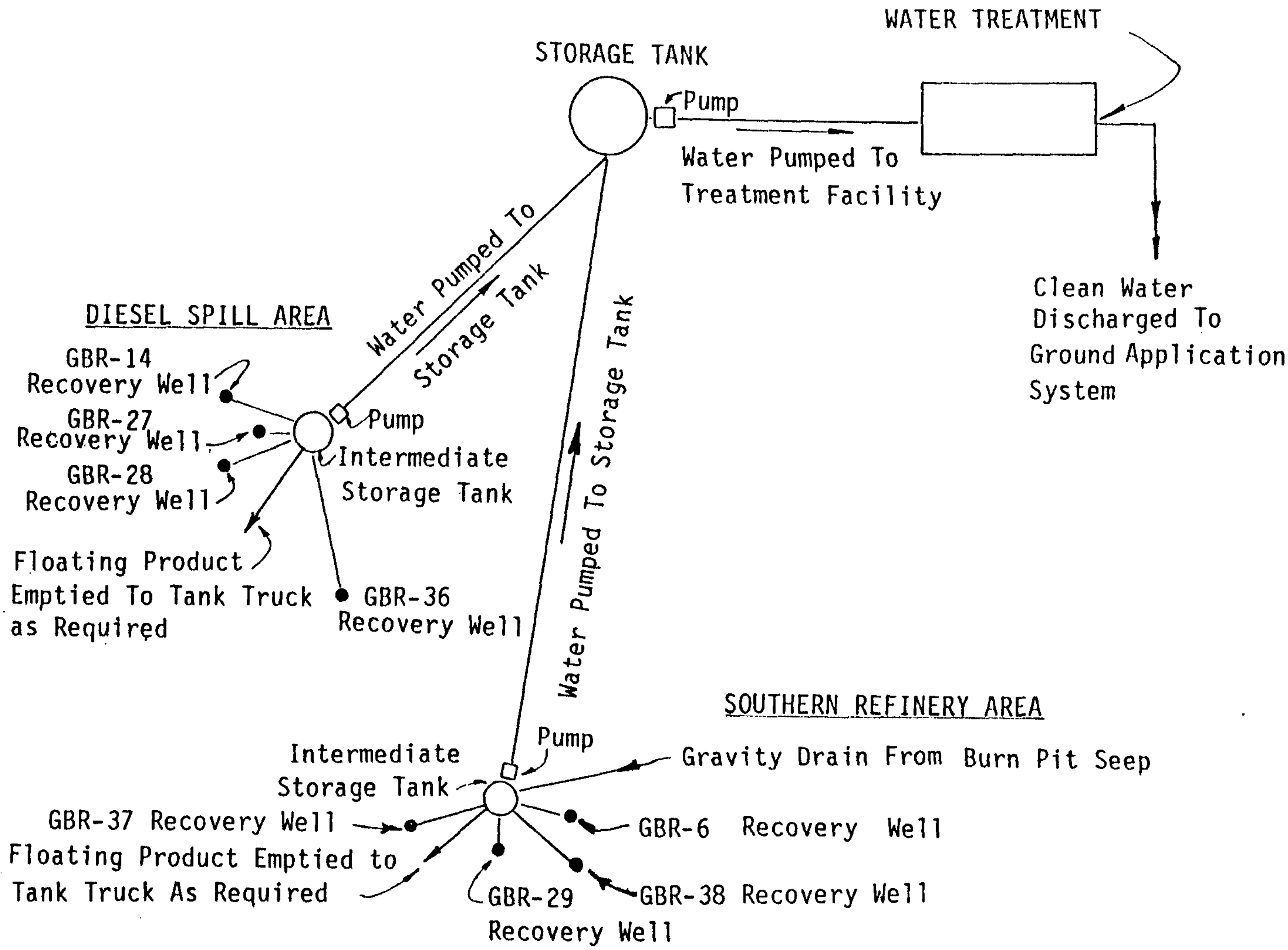


FIGURE 8-5

SCHEMATIC DIAGRAM OF GROUND WATER RECLAMATION SYSTEM

FOR THE GIANT BLOOMFIELD REFINERY

Pumping will be continued until floating product is no longer observable in any of the wells in the Diesel Spill Area. It is expected that at least a year of pumping will be required in order to achieve this result.

8.2 SOUTHERN REFINERY AREA PLAN

8.2.1 Remedial Actions Completed

GCL installed a 3-level well cluster utilizing the existing GBR-11 as one level and two new adjacent 2-inch wells (GBR-9 and GBR-10) for the other levels. GBR-10 is screened at the top of the aquifer from 29 to 39 feet; GBR-11 is screened at the middle of the aquifer from 40 to 50 feet; and GBR-9 is screened at the bottom of the aquifer from 50 to 60 feet. Each well in the cluster is constructed similarly to the wells clustered in the Diesel Spill Area. The purpose of this cluster is to monitor the effects of remedial action in the Southern Refinery Area.

A recovery pump similar to those being used in the Diesel Spill Area was operated intermittently in GBR-29 since October 7, 1986; and a similar pump was operated in GBR-6 since November 21, 1986. Because GBR-6 is a low-yield well, the system proved suitable for it. However, because the aquifer adjacent to GBR-29 is more transmissive, wells in this area require a higher rate of pumping to achieve enough drawdown to fully contain the product plume. Therefore, a larger capacity pump (10 gpm) was installed in GBR-29. In the interim, the pilot scale pumping using a low capacity (1 gpm) pump has been successful in removing a considerable amount of floating product in GBR-29. A higher capacity pump was also installed in GBR-6 in order to provide a greater pumping capability during periods of water application to the soil in that area.

8.2.2 Further Remedial Actions Planned

Interception of contaminated ground water in the Southern Refinery Area will require a higher rate of ground water pumping than in the Diesel Spill Area because of higher-conductivity 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 of the

Diesel Spill Area. As a result, a greater discharge rate is required to control the migration of the plume and recover contaminated ground water. Figure 8-6 shows the optimal recovery-well network based upon the results of ground water modeling performed by GCL. The projected water table elevations resulting from pumping these wells are presented in Plate 4, and a complete discussion of the model utilized by GCL is presented in Appendix E. GCL concludes from this model that the documented floating product plume can be controlled and recovered by pumping from this proposed recovery-well network. This pumping, by removing large quantities of water underlying the floating product, will also remove virtually all of the associated dissolved phase contamination.

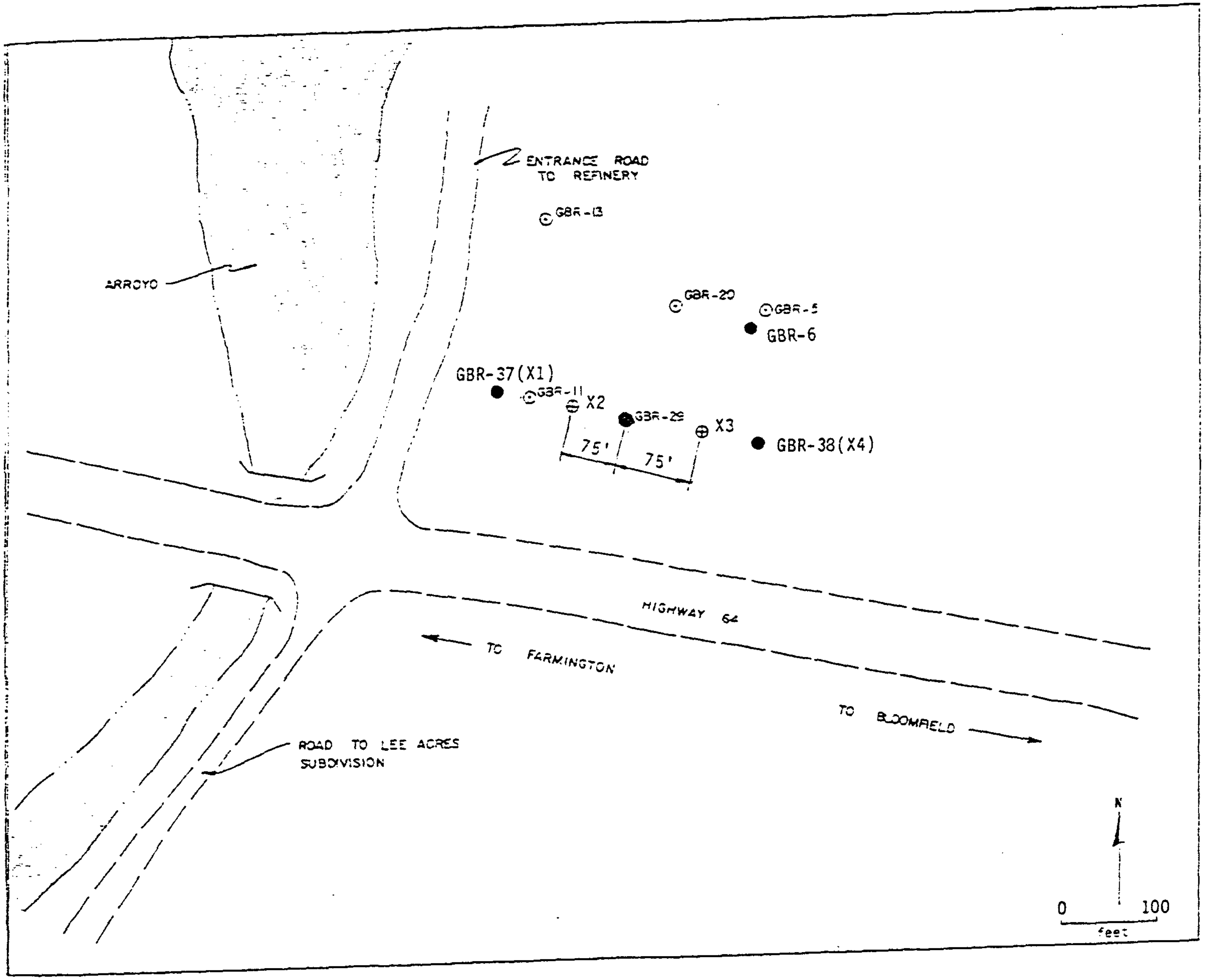
Check w/ new text data

Unlike the Diesel Spill Area, long-term pumping data are not available for this area. Proper recovery-well placement depends on the quality of the data. Therefore, installation of the recovery system in the Southern Refinery Area will proceed incrementally on the basis of observed well yield. This phased approach is outlined below.

Wells X1 and X4, shown in Figure 8-6, have been drilled and completed as 6-inch PVC recovery wells. Well X1 was completed in the high-transmissivity valley sediment and Well X4 was completed in the same sandstone bedrock aquifer in which GBR-29 is located.

These wells will be pumped simultaneously with each well maintaining a pre-set pumping water level which will be determined by field testing. Water levels and product thickness will be monitored over a period of two months. The steady-state model used to design the well network will then be recalibrated with this long-term data. If field evidence and the recalibrated model determine that additional recovery wells are required, the wells will be installed at the optimum locations.

Because of the high yield of GBR-29 and the expected high yields of other planned recovery wells, the model has indicated that a pumping rate of 10-15 gpm will be necessary to achieve control over the plume. This rate



LEGEND

⊗ PROPOSED RECOVERY WELLS

● EXISTING RECOVERY WELLS

FIGURE 8-6

LOCATIONS OF RECOVERY WELLS

SOUTHERN REFINERY AREA

GIANT - BLOOMFIELD

is beyond the capacity of the top-filling, air-driven pumps currently used in the Diesel Spill Area. Therefore, GCL installed higher capacity pumps in the Southern Refinery Area that will produce the necessary drawdown and remove floating product by pumping water from the upper portion of the aquifer.

As Figure 8-7 shows, a submersible pump is fitted with a 4-inch diameter sleeve, called a shroud, before being lowered down the 6-inch well. The bottom of the sleeve is sealed around the pump casing and the top of the sleeve is open to allow the entrance of floating product and water into the pump. The pump will maintain a drawdown in the well down to the top of the shroud by means of appropriate pump controls. This method of pumping will maintain the well water levels required to produce sufficient cones of depression and effectively remove the floating product plume.

Produced water will be pumped to the intermediate storage tank located near GBR-29, where floating product will be removed and the remaining water subsequently pumped to long-term storage tanks on the site. Piping will be installed to permanently connect these tanks.

8.3 TRUCK FUELING AREA PLAN

8.3.1 Remedial Actions Completed

GCL installed a small-diameter recovery pump in GBR-22 on December 4, 1986, to begin immediate recovery action in that area. The pump fits in a 2-inch diameter well and is, therefore, smaller than the other recovery pumps in use at the refinery. This pump uses compressed air and operates on an adjustable, timed cycle. Because trial pumping of GBR-22 produced only a small volume of product and water, it became evident that a larger, thoroughly developed well will be required for effective recovery.

GCL drilled five exploratory boreholes in order to determine the extent of the plume in this area, three of which were cased with 2-inch PVC

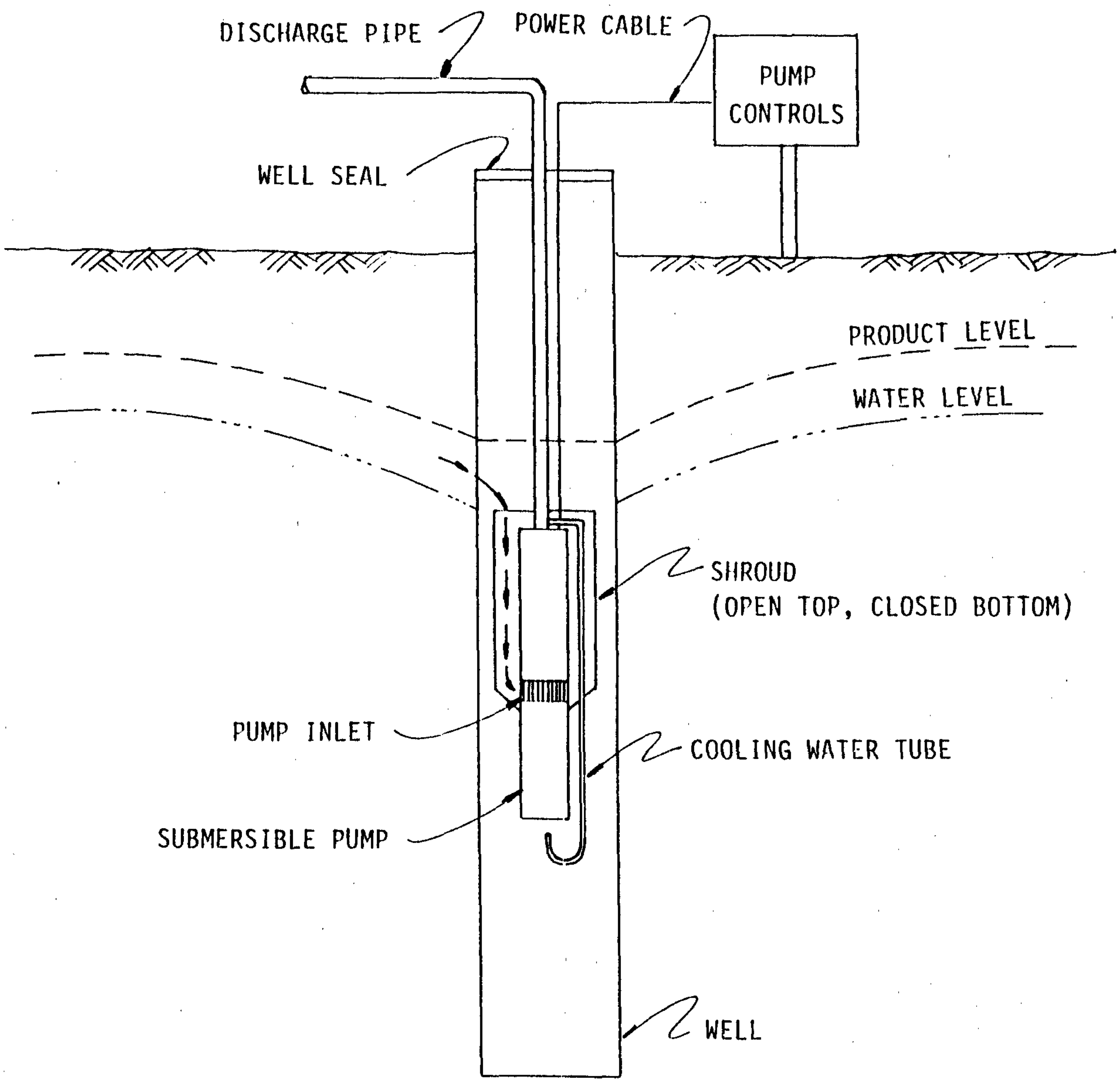


FIGURE 8-7

SUBMERSIBLE PUMP ADAPTED FOR FLOATING PRODUCT REMOVAL pipe to be used as observation wells. These wells are identified as GBR-33, GBR-34 and GBR-35. GCL also installed one 6-inch recovery well (GBR-36) in the lower part of the identified plume at the location shown in Figure 8-1.

8.3.2 Further Remedial Actions Planned

GCL has temporarily installed an air operated recovery pump, similar to those used in the Diesel Spill Area, in recovery well GBR-36. This pump will discharge into the intermediate storage tank in the Diesel Spill Area at a rate of about 1 gpm. Also, a small-diameter, air-operated pump has been temporarily installed in GBR-35 and will produce about 1/2 gpm. These pumps will be permanently connected to the system in the Diesel Spill Area and be similarly pumped.

8.4 FIRE FIGHTING DRILL AREA SEEP

The fire fighting drill area seep in the Southern Refinery Area does not present a hazard to the environment. Water from the seep is currently being collected by a perforated PVC pipe laid in a gravel filled trench (Figure 8-8), and piped by gravity to an intermediate storage tank that is periodically emptied by tank truck.

8.5 WATER TREATMENT AND DISPOSAL

Most of the water pumped from the recovery systems will contain contaminant concentrations in the low ppm or ppb range. Samples taken from the Diesel Spill Area indicate that most dissolved organics are removed by the action of pumping and discharging into the intermediate storage tank. Samples of water from this tank have shown no detectable contamination in most cases and are below New Mexico ground water standards. GCL expects that water from the Southern Refinery Area will likewise be rendered acceptable after moderate exposure to the air.

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

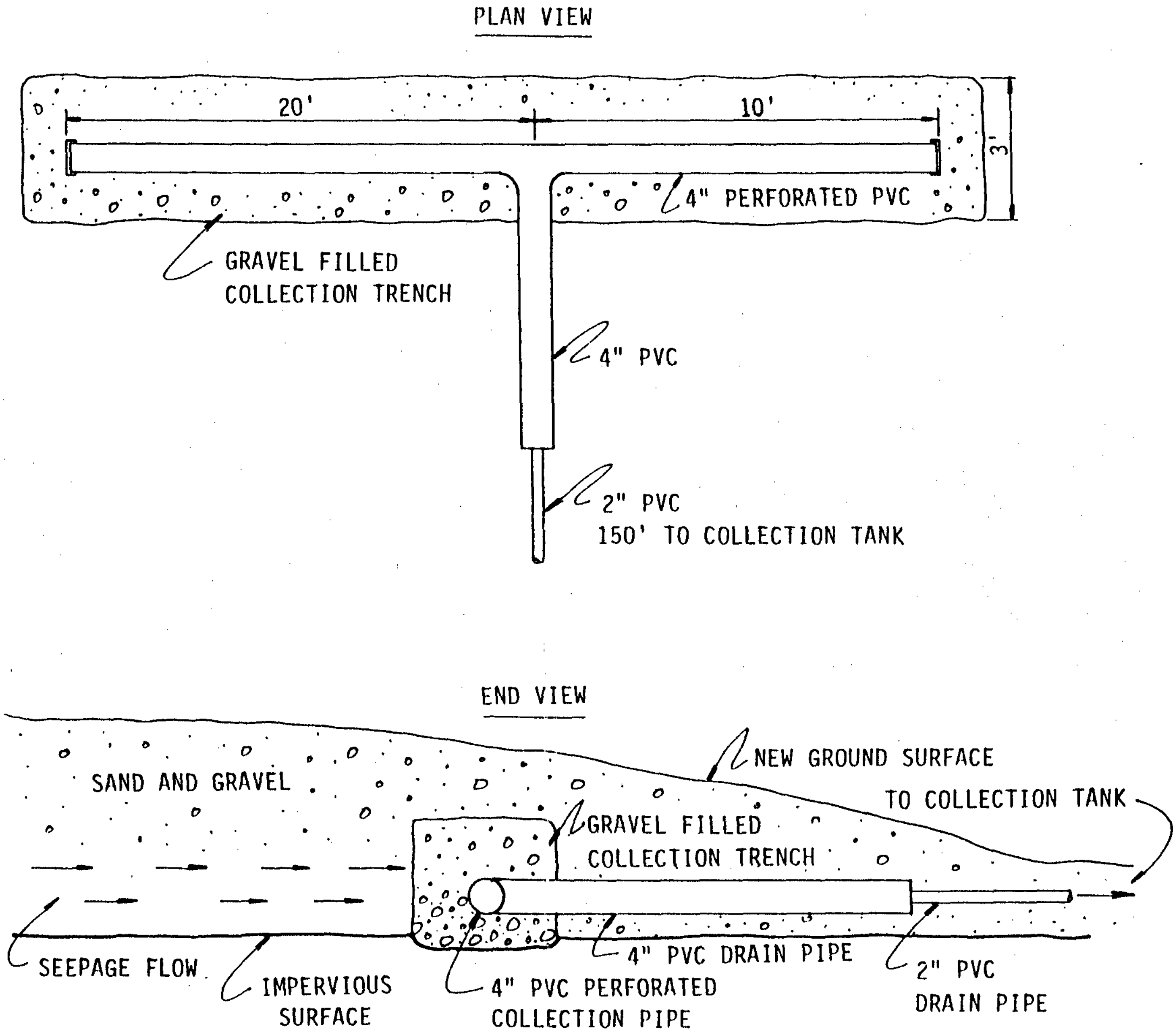


FIGURE 8-8

SEEPAGE COLLECTOR NEAR FIRE FIGHTING DRILL AREA

GIANT BLOOMFIELD REFINERY

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 required. Floating hydrocarbons will be removed from the long-term storage tanks as well. A schematic diagram of the planned collection system is shown in Figure 8-5.

It is likely that the agitation of pumping and exposure to air in the storage tanks will cause much of the dissolved hydrocarbons to volatilize. Limited storage is available at the refinery. With a total pumping rate of about 36 gpm, the residence time of produced water stored at the refinery site is approximately 25-30 days. Produced water may require air-stripping prior to discharge in order to meet state of New Mexico ground water standards. Air stripping, if required, will be achieved through the use of sprinklers as air stripping devices, while applying water to the ground.

GCL conducted a test on November 7, 1986 to determine the extent of hydrocarbon volatilization that would occur through application of contaminated water to soil using a standard impulse-type irrigation sprinkler. It has been reported that this procedure reduces volatile organics by at least 90% (Hazardous Waste Consultant, 1983). Water for the sprinkler test was taken from the intermediate storage tank in the Diesel Spill Area that had received contaminated 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 8-1 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-DCA 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 "not detected" after sprinkling.

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 possible, and since there is a significant overall reduction of benzene in the water when passing through the system, this appears to be a spurious result caused by analytical variance or errors.

The most important result of the sprinkler test is the demonstration of significant reductions of contamination when well water samples are compared to tank discharge samples. Such a comparison indicates that the pumping of the water from the wells into the intermediate storage tank by air-driven pumps and the storage of the water in the tank are sufficient to reduce the levels of BTEX and other organic compounds to levels that may be acceptable for direct discharge to the ground or subsurface.

The sprinkler test did not show large reductions in contamination caused by sprinkling because most contaminants had already been reduced below the limits of detection during storage in the intermediate storage tank. If this contaminant reduction continues to be observed, sprinkling will not be necessary, and direct application to the soil will be used. specified?

Water will be applied to the ground only after it meets applicable ground water quality standards of the State of New Mexico (after storage or after air-stripping). Most of the water (except that which may be applied by sprinkling) will be applied to the ground through an infiltration trench to be located in the contaminated soil area of the Southern Refinery Area. Application in this manner will assist in flushing

TDS
Cl

concentration of Cl, TDS?

TABLE 8-1
GIANT INDUSTRIES BLOOMFIELD REFINERY
SPRINKLER TEST RESULTS
BTEX AND CHLORINATED HYDROCARBONS

CONCENTRATIONS IN PARTS PER BILLION

	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	NOMINAL DETECTION LIMIT
BENZENE	2	ND	7	410	50	2419	319	1
CHLOROBENZENE	ND	ND	ND					1
1,2-DICHLOROBENZENE	ND	ND	ND					1
1,3-DICHLOROBENZENE	ND	ND	ND					1
1,4-DICHLOROBENZENE	ND	ND	ND					1
ETHYLBENZENE	ND	ND	ND					1
TOLUENE	ND	ND	ND	120	74	819	143	1
XYLENES	ND	ND	ND	506	457	4019	224	1
ACROLEIN	ND	ND	ND					25
ACRYLONITRILE	ND	ND	ND					25
BROMOFORM	ND	ND	ND					5
CCl4	ND	ND	ND					5
CHLORODIBROMEMETHANE	ND	ND	ND					5
CHLOROETHANE	ND	ND	ND					5
2-CHLOROETHYLVINYL ETHER	ND	ND	ND					5
CHCl3	ND	ND	ND					5
DICHLOROBROMOMETHANE	ND	ND	ND					5
1,1-DCA	ND	ND	ND					5
1,2-DCA	7.1	6.3	ND	6				5
1,3-DICHLOROPROPYLENE	ND	ND	ND					5
METHYL BROMIDE	ND	ND	ND					5
METHYL CHLORIDE	ND	ND	ND					5
METHYLENE CHLORIDE	ND	ND	ND					5
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND					5
TETRACHLOROETHENE	ND	ND	ND					5
TRANS-1,2-DICHLOROETHENE	ND	ND	ND					5
1,1,1-TCA	ND	ND	ND					5
1,1,2-TCA	ND	ND	ND					5
TRICHLOROETHENE	ND	ND	ND					5
VINYL CHLORIDE	ND	ND	ND					5

ND = not detected

weather conditions
- temperature = 0°C
- wind variable, 10-15 mph
- cloudy

sprinkler conditions
- discharge = 3.5 gpm
- spray length = 30 feet
- spray arc ht = 10 feet

contaminants from the soil, which will then be removed by the line of recovery wells along the southern edge of the site. The infiltration trench will be constructed according to New Mexico State requirements for septic tank effluent trenches. It will be 2-feet deep by 2-feet wide and filled with gravel. Perforated PVC pipe will be laid in the bottom of the trench through which water will be discharged. The length of the trench 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 of the trench.

9.0 MONITORING AND REPORTING

To ensure that the product recovery and containment system in each area is operating properly, it will be necessary to monitor the effects of pumping on ground water. For this purpose, ground water monitor wells are located within and outside of the product plume in each area.

On a bi-weekly basis, Giant will monitor and record the water level and product thickness in selected representative wells (GBR-7, 8, 10, 15, 19, 21, 22, 24, 25, 33, 35) in the Southern Refinery Area, the Diesel Spill Area and the Diesel Fueling Area. Giant will employ an electronic oil and water probe for such monitoring.

GCL will collect water quality data from the burn pit seep, all recovery wells (GBR-6, 14, 27, 28, 29, 36, 37, 38) and from 10 observation and monitor wells (GBR-7, 8, 9, 15, 17, 22, 24D, 25, 26, 33). Prior to discharging any water to the proposed infiltration trench, GCL will conduct a complete chemical analysis of such water for organic constituents. Prior to discharging from a specific storage tank, a sample from the tank will be obtained and analyzed for parameters subject to ground water standards at Section 3-103 of WQCC regulations. If the water to be discharged shows no contaminant level above the standards, it will be discharged directly to the infiltration trench. If contaminant levels exceed the standards, the water will be air-stripped and, if required, treated with granular activated charcoal to achieve the required reductions.

GCL will oversee a program of continued surveillance to assure that the pumping systems operate properly. A daily log (kept on work days only) will be maintained by Giant personnel listing discharge meter readings, general observations and any repair actions taken. Water levels in all storage tanks will also be obtained and recorded in the log. Pipelines will be visually inspected for leaks.

GCL will conduct monthly inspections during the active pumping phases that will include measurement of water levels and product thicknesses. in all wells. Every quarter a report will be prepared listing:

- o ground water elevations;
- o product thicknesses on ground water;
- o quantities pumped;
- o quantities discharged;
- o analytical results of discharge water samples; and
- o all significant actions during the period.

By analyzing these data, GCL will continually evaluate the progress of the remedial action program and Giant will keep NMOCD informed of all significant developments.

10.0 BIBLIOGRAPHY

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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	

SCALE IN FEET
100 50 0 100 200
SCALE 1"=100'(1:1200)

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JUL 17 1987
OIL CONSERVATION DIVISION
SANTA FE

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

SITE LOCATION MAP
GIANT BLOOMFIELD REFINERY

CLIENT: GIANT BLOOMFIELD REFINERY
DATE: 8-21-86
DRAWN BY: KJK
CHECKED BY:
REVISED:
SCALE: 1" = 100'
PLATE I

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

1987 July single copy

1987 July Single copy


D
WEST
D'
EAST
ELEVATION (FEET)
GBR-30 E.L. 5396 2" PVC,SS
GBR-14 E.L. 5395 6" PVC
GBR-15 E.L. 5394 2" PVC,SS
GBR-26 E.L. 5394 2" PVC
GBR-27 E.L. 5397 5" PVC
GBR-21 E.L. 5398 2" PVC
GBR-23 E.L. 5401 2" PVC
UNCONSOLIDATED ALLUVIAL SEDIMENTS
CONSOLIDATED SHALE
CONSOLIDATED SANDSTONE
E
WEST
E'
EAST
GBR-31 E.L. 5393 2" PVC,SS
GBR-28 E.L. 5395 6" PVC
UNCONSOLIDATED ALLUVIAL SEDIMENTS
F
WEST
F'
WEST
GBR-11 E.L. 5388 2" GALV.
GBR-10 E.L. 5388 2" PVC,SS
GBR-9 E.L. 5388 2" PVC,SS
GBR-8 E.L. 5388 2" PVC,SS
GBR-29 E.L. 5382 6" PVC
G
WEST
G'
EAST
GBR-20 E.L. 5392 2" PVC
GBR-7 E.L. 5393 2" PVC,SS
GBR-6 E.L. 5394 6" PVC
GBR-5 E.L. 5393 2" PVC
NOTE : I. WATER LEVELS AND PRODUCT THICKNESSES MEASURED 11/86
(Feet)
RECEIVED JUL 17 1987 OIL CONSERVATION DIVISION SANTA FE
GCL
HYDROGEOLOGIC CROSS SECTIONS (CONT'D.)
GIANT BLOOMFIELD REFINERY
CLIENT:
DATE: 3-2-87
DRAWN BY: KJK, EO
CHECKED BY:
REVISED:
SCALE: VERT. 1"=15' HORZ. 1"=10'
PLATE 2B

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

INTERMEDIATE CONTOUR

DEPRESSION CONTOUR

SPOT ELEVATION

HORIZONTAL / VERTICAL CONTROL POINT

SCALE IN FEET

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

TRM

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SANTA FE

TOPOGRAPHIC / PHOTOBASE MAP
OF THE
GIANT REFINERY
SAN JUAN COUNTY, NEW MEXICO

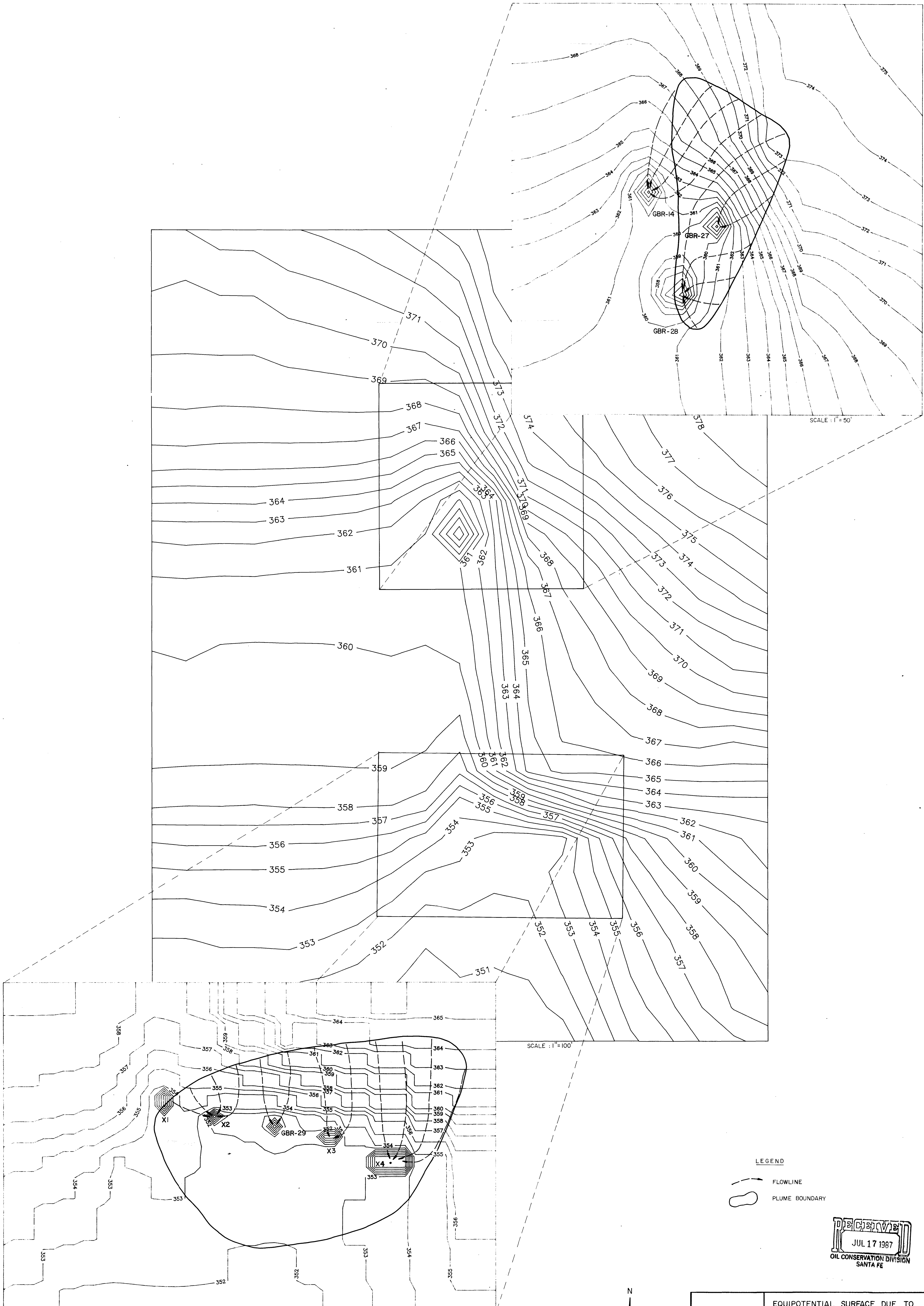
SCALE: 1"= 100' (1:1200)
CONTOUR INTERVAL: 2'
VERTICAL DATUM: MEAN SEA LEVEL

1978

GCL

LOCATION MAP FOR HYDROGEOLOGIC CROSS SECTIONS

CLIENT: GIANT BLOOMFIELD REFINERY
DATE: 8-21-86
DRAWN BY: KJK
CHECKED BY:
REVISED:
SCALE: 1" = 100'



GCL

EQUIPOTENTIAL SURFACE DUE TO PROPOSED PUMPING STRATEGY

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

PLATE 4/E3

Plate 4. Tules 87 Single copy

SOIL AND GROUND WATER INVESTIGATIONS AND REMEDIAL ACTION PLAN

GIANT INDUSTRIES, INC.
BLOOMFIELD REFINERY
BLOOMFIELD, NEW MEXICO

APPENDICES A-C

June 1987

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APPENDIX A
RESULTS OF WATER SAMPLE ANALYSES FROM LEE ACRES LANDFILL AND LEE ACRES SUBDIVISION

APPENDIX A - Results of Chemical Analyses of Water and Wastewater - Lee Acres Landfill

All concentrations are mg/L except for pH units. If no entry is made for the trace elements (aluminum through zinc) then the element was not detected with the detection limit of 0.1 mg/L.

Abbreviations Used in Appendix A and in the text

CH_2Cl_2	Methylene Chloride
1,1-DCA	1,1-Dichloroethane
1,1-DCE	1,1-Dichloroethylene
1,2-DCE	1,2-Dichloroethylene
PCE	Tetrachloroethylene
R	Reported Well Depth
1,1,1-TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TD	Total (Well) Depth
TDS	Total Dissolved Solids (if filtered through 0.45 um membrane) or Total Solids (if not filtered through 0.45 um membrane)
Tr	Trace (<0.001 mg/L)
VOCs	Volatile Organic Compounds

Source of Appendix A: "Water Quality Investigations at the Lee Acres Landfill and Vicinity, San Juan County, NM", Environmental Improvement Division, State of New Mexico, Santa Fe, NM, 87504

Lagoon Water		W. Side	E. Side	S. Side*
Sampling Date	1/11/85	2/27/85	2/27/85	5/2/85
Calcium	204./170.	267/230.	234/200.	224/240.
Magnesium	26.8/19.	18.7/19.	18.5/16.	36.6/25.
Sodium	1,507.	1,833.	1,263.	1790.
Potassium	885.	848.	548.	390.
Bicarbonate	--	417.	625.	476.
Sulfate	430.	1,881.	1,086.	40.2
Chloride	2,759.	3,577.	2,251.	4,474.
Phosphate	--	--	--	0.92
Nitrate-N	--	--	--	< 0.01
Ammonia-N	--	--	--	6.8
TKN	--	--	--	11.1
Aluminum	2.3	1.8	1.5	0.30
Arsenic	0.022	--	--	0.009
Barium	0.74	0.60	0.37	0.5
Beryllium	<0.10	<0.10	<0.10	<0.1
Boron	0.61	0.58	0.48	1.6
Cadmium	<0.10	<0.10	<0.10	<0.10
Chromium	0.28	0.23	0.15	<0.10
Cobalt	<0.10	<0.10	<0.10	<0.10
Copper	<0.10	<0.10	<0.10	<0.10
Iron	6.9	7.8	6.8	75.
Lead	<0.10	0.21	0.10	<0.10
Manganese	1.5	0.83	0.80	2.1
Mercury	--	--	--	--
Molybdenum	<0.10	<0.10	<0.10	<0.10
Nickel	<0.10	<0.10	<0.10	<0.10
Selenium	0.026	--	--	0.025
Silicon	1.2	2.0	2.0	14.0
Silver	<0.10	<0.10	<0.10	<0.10
Strontium	4.4	6.0	4.5	7.3
Tin	<0.10	<0.10	<0.10	<0.10
Vanadium	<0.10	<0.10	<0.10	<0.10
Yttrium	<0.10	<0.10	<0.10	<0.10
Zinc	0.29	0.24	0.54	<0.10
TDS	6,308.	7,695.	5,268.	9018.
pH	7.14	8.08	7.64	6.14
Benzene	0.44	1.03	0.89	0.120
Toluene	0.95	1.98	1.94	0.330
Ethylbenzene	0.1	0.16	0.17	0.025
Xylenes	0.71	1.21	1.34	0.205
CH_2Cl_2	2.0	0.18	0.21	--
1,1,1-TCA	0.4	0.19	0.23	0.010
TCE	0.004	--	--	--
PCE	--	0.016	0.007	--
Acetone	--	--	--	--
2-Propanol	--	--	--	--

* After the addition of $FeCl_3$

Baldwin Well	TD = 50'-60'R
Sampling Date	5/2/85
Calcium	360./400.
Magnesium	46.4/47.
Sodium	311.
Potassium	55.4
Bicarbonate	148.8
Sulfate	1464.
Chloride	69.0
Nitrate-N	<0.01
Ammonia-N	0.02
TKN	0.19
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.24
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	18.
Lead	
Manganese	0.77
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	9.0
Silver	
Strontium	6.3
Tin	
Vanadium	
Yttrium	
Zinc	0.15
TDS	2345.
pH	7.11
Filtration (0.45 um)	No
VOCs	ND

Chacon Well	TD = 55'R
Sampling Date	5/1/85
Calcium	352./410.
Magnesium	51.4/39.
Sodium	506.0
Potassium	3.9
Bicarbonate	127.6
Sulfate	2073.
Chloride	53.2
Nitrate-N	0.04
Ammonia-N	0.15
TKN	0.31
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.32
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	26.
Lead	
Manganese	0.63
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	6.6
Silver	
Strontium	7.1
Tin	
Vanadium	
Yttrium	
Zinc	0.80
TDS	3118.
pH	6.66
Filtration (0.45 um)	No
VOCs	
1,1,1-TCA	0.001
TCE	0.001

Duggins Well

Sampling Date	4/30/85
Calcium	448./430.
Magnesium	43.9/24.
Sodium	610.
Potassium	5.46
Bicarbonate	125.2
Sulfate	2452.
Chloride	40.2
Nitrate-N	1.39
Ammonia-N	0.32
TKN	0.39
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.30
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	0.19
Lead	
Manganese	0.30
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	7.4
Silver	
Strontium	8.8
Tin	
Vanadium	
Yttrium	
Zinc	0.40
TDS	3773.
pH	7.04
Filtration (0.45 um)	No
VOCs	ND

Duncan Well	TD = 40'R
Sampling Date	4/22/85
Calcium	413./430.
Magnesium	69.3/51.
Sodium	508.
Potassium	5.46
Bicarbonate	119.0
Sulfate	2041.
Chloride	81.7
Nitrate-N	<0.01
Ammonia-N	
TKN	
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.42
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	15.
Lead	
Manganese	0.45
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	7.7
Silver	
Strontium	7.7
Tin	
Vanadium	
Yttrium	
Zinc	
TDS	3250.
pH	7.59
Filtration (0.45 um)	No
VOCs	ND

Haines "Cinderblock" Well

Sampling Date	4/30/85
Calcium	117./110.
Magnesium	22.0/24.
Sodium	273.7
Potassium	3.12
Bicarbonate	69.9
Sulfate	871.9
Chloride	20.2
Nitrate-N	0.00
Ammonia-N	0.12
TKN	0.36
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.17
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	16.
Lead	
Manganese	0.15
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	1.7
Silver	
Strontium	3.6
Tin	
Vanadium	
Yttrium	
Zinc	
TDS	1398.
pH	7.02
Filtration (0.45 um)	No
VOCs	ND

Mulliken Well

Sampling Date	4/30/85
Calcium	378./450.
Magnesium	42.5/48.
Sodium	345.
Potassium	3.12
Bicarbonate	155.7
Sulfate	1759.
Chloride	34.1
Nitrate-N	0.08
Ammonia-N	0.01
TKN	<0.1
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.26
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	0.58
Lead	
Manganese	0.43
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	12.
Silver	
Strontium	7.4
Tin	
Vanadium	
Yttrium	
Zinc	
TDS	2278.
pH	7.21
Filtration (0.45 um)	No
VOCs	ND

Nace Well	TD = 13.5'R
Sampling Date	5/1/85
Calcium	148./130.
Magnesium	14.
Sodium	101.2
Potassium	2.73
Bicarbonate	151.4
Sulfate	471.9
Chloride	13.2
Nitrate-N	<0.01
Ammonia-N	0.07
TKN	<0.1
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	<0.1
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	0.44
Lead	
Manganese	2.1
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	6.7
Silver	
Strontium	2.0
Tin	
Vanadium	
Yttrium	
Zinc	0.13
TDS	855.
pH	6.60
Filtration (0.45 um)	No
VOCs	0.001 PCE

Piersall Well

Sampling Date	4/29/85
Calcium	224./280.
Magnesium	46.4/32.
Sodium	145.
Potassium	2.73
Bicarbonate	169.
Sulfate	814.7
Chloride	37.7
Nitrate-N	<0.01
Ammonia-N	0.12
TKN	<0.1
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.18
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	1.7
Lead	
Manganese	0.90
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	10.
Silver	
Strontium	4.3
Tin	
Vanadium	
Yttrium	
Zinc	0.13
TDS	1428.
pH	6.93
Filtration (0.45 um)	No
VOCs	ND

Reynolds Well TD = 50'R

Sampling Date	4/22/85	4/26/85	10/23/85	10/24/85	10/24/85
Calcium	677.	710.		816.8/810.	762.4/810.
Magnesium	73.0	53.		120.5/61.	86.4/61.
Sodium	393.			418.6	414.0
Potassium	2.34			1.17	1.56
Bicarbonate	171.6			228.9	218.7
Sulfate	1231.			1262.	1212.
Chloride	1002.9			1221.8	1320.8
Nitrate-N	3.06			2.31	2.38
Ammonia-N				<0.10	<0.10
TKN				0.62	<0.10
Aluminum					
Arsenic					
Barium					
Beryllium					
Boron		0.19		0.2	0.2
Cadmium					
Chromium					
Cobalt					
Copper					
Iron		<0.10		0.2	<0.10
Lead					
Manganese		<0.05		<0.05	<0.05
Mercury	Not Analyzed		Not Analyzed		
Molybdenum					
Nickel					
Selenium					
Silicon		6.6		6.3	6.2
Silver					
Strontium		13.		14.	14.
Tin					
Vanadium					
Yttrium					
Zinc		1.1		0.7	0.7
TDS	4313.			4343.	4308
pH	6.85			6.38	6.38
Filtration (0.45 um)	No	No	No	No	Yes
VOCs					
Benzene	0.008	Tr			
1,1-DCA	0.006	0.002			
1,1,1-TCA	0.022	0.02			
vinylchloride	--	--		?	
1,1-DCE	0.001	Tr	0.002		
1,2-DCE	0.001	Tr	0.011	0.01	
TCE	0.002	0.002	0.0015	Tr	
PCE	0.01	0.004	0.001	0.001	

Stark Well	TD = 55'R
Sampling Date	4/30/85
Calcium	140./180.
Magnesium	24.4/26.
Sodium	80.5
Potassium	3.9
Bicarbonate	121.4
Sulfate	441.6
Chloride	19.2
Nitrate-N	0.05
Ammonia-N	0.03
TKN	<0.1
Aluminum	
Arsenic	
Barium	
Beryllium	
Boron	0.10
Cadmium	
Chromium	
Cobalt	
Copper	
Iron	4.2
Lead	
Manganese	4.9
Mercury	
Molybdenum	
Nickel	
Selenium	
Silicon	8.2
Silver	
Strontium	2.7
Tin	
Vanadium	
Yttrium	
Zinc	0.15
TDS	828.
pH	6.69
Filtration (0.45 um)	No
VOCs	ND

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.
5				
10			8512200850/10.0'	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'
			8512200900/15.0'	dryer with no odor 15.0'-20.0'.
15				
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				
30				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.
				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 Technolgy

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
0–5				0.0'-5.0' (5.0') FILL: Very coarse cobbles and small boulde brown-gray; dry, faint hydrocarbon odor; no stain.
5–25 (water level ▼? ~10)				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 fron 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'.
TD=25.0' refused auger				Located 97.0', 138° to south hydrant; backfilled with cuttings and bentonite plug @ bottom.

Depth scale: 0, 5, 10, 15, 20, 25, 30

Geoscience Consultants, Ltd

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

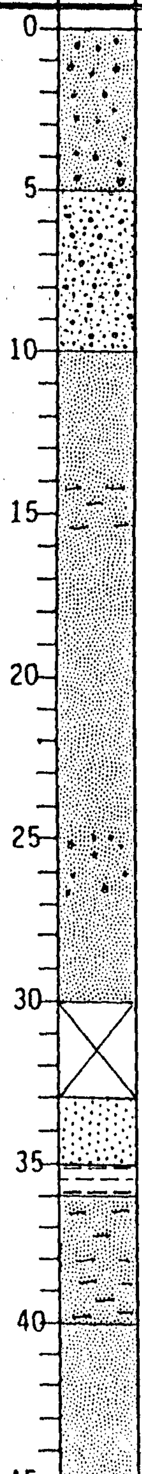
County: San Juan — Contractor: Western Technologies

Spud Date: — Completion Date: 9-24-86

Logs Run: Lithology — Logged By: Martin

Elevation: — Spud In (Fm.):

Remarks: Drilled with Hollow Stem Auger



DEPTH	RUN	FROM	TO	SAMPLE DEPTH	REMARKS	
					0-5'	COBBLES AND SAND, 1/8"-5" in diam w/minor sand; fn-co gr; mod ylsh brn 10YR5/4
					5-7.5'	SAND AND GRAVEL, dusky ylsh 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
					10-12.5'	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
					15-16'	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
					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
					25-27'	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
					33-35'	SANDSTONE, weathered lt olive brn 5Y5/6; fn-med gr w/some silt; no hydrocarbon odor, no moisture
					35-36'	CLAY, olive gry 5Y3/2; hydrocarbon odor; moist; minor sand
					36-40'	SAND AND SOME SILT, fn gr dusky yel 5Y6/4
					40-41'	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

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
40							38.33-39.17' SILTY SAND, fn-med gr olive gry color 5Y4/1 strong hydrocarbon odor
							39.17-39.5' SAND, co gr olive gry color 5Y4/1, strong hydrocarbon odor
45							

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

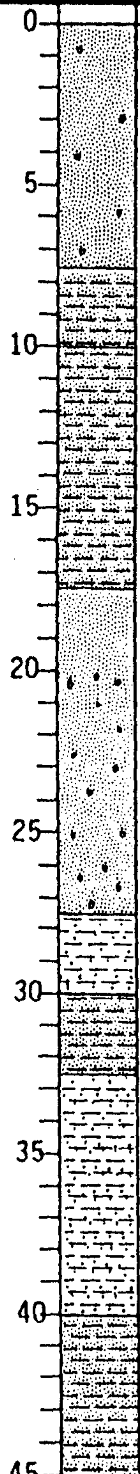
County San Juan Contractor Western Technologies

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	
0–45							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
							5-7.5'	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
							10-12.5'	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
							15-17.5'	same as above
							17.5-20'	SAND, med gr; mod yelsh brn 10YR5/4
							20-22.5'	SAND, med gr, w/occasional pebbles; mod yelsh brn 10YR5/4
							22.5-25'	same as above
							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
							30-32.5'	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
							40-45'	CLAY AND SAND, fn gr sand, dk yelsh orng 10YR6/6; clay is lt olive gry 5Y5/2
							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

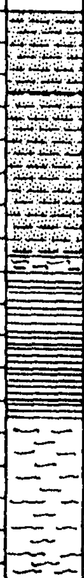
County: San Juan | Contractor: Western Technologies

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	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	

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

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

Page 2 of 2

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							

WELL LOGGING FORM

Geoscience Consultants, Ltd.

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
5', 10, 15, 20, 25, 30, 35, 40, 45, 50, 55		

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

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

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			0-5' GRAVEL: ½" -12" cobbles predominately qaurtzite, poorly sorted, subrounded to sub-angular.
5			
10			
15			5'-15' SILTY SAND: moderate yellowish brown, (10yr 5/4), fine to med grained, moderately well sorted.
20			
25			15'-25', CLAYED SILTY SAND: light olive gray, (5y6/1), fine to med. grained, moderately well sorted.
30			
35			25'-35' SILTY CLAY: dark yellowish brown, (10yr 4/2)
40			
TD=42'			No cuttings would come up hole after 35' Auger Refused at 42'

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page ____ of ____

Client: Montgomery & Andrews | Well Number: GBR 13

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

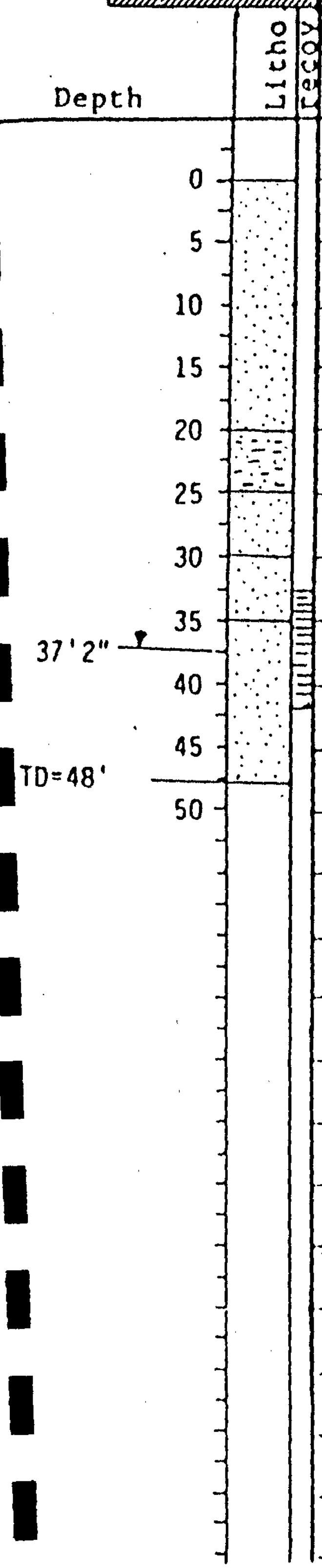
County: San Juan | Contractor: Western Technologies

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



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

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

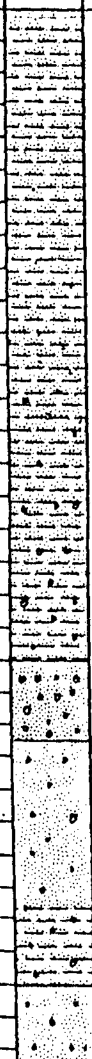
County: San Juan Contractor: Beeman Bros. Drilling Co.

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

Logs Run: Lith from cuttings Logged By: Martin

Elevation: 53[illegible] Spud In (Fm.): ____

Remarks: Drilled with Air Rotary

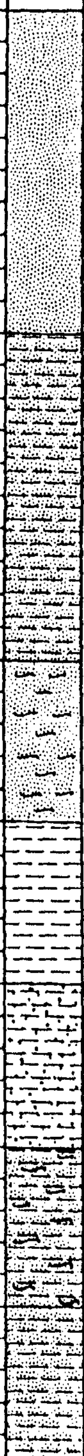


DEPTH	LITHO.	RECOV.	RUN	FROM	TO	SAMPLE DEPTH	REMARKS
0'							0'-coarse-grained, poorly-sorted sandy; medium brown.
10'							10'-coarse-grained, well-sorted clayey sand; mixed medium brown/dark gray-black; stained; strong hydrocarbon odor
20'							20'-coarse-grained, poorly-sorted clayey sand; light 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.
							Sat Thick ~25 - 60 = 35'

WELL LOGGING FORM

GCL

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
							15-20' CLAYEY SAND, med gr w/2-5% gravels; olive gry color 5Y4/1, HC odor
15							
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							

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page ____ of ____

Client: Montgomery & Andrews   Well Number: GBR 16

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

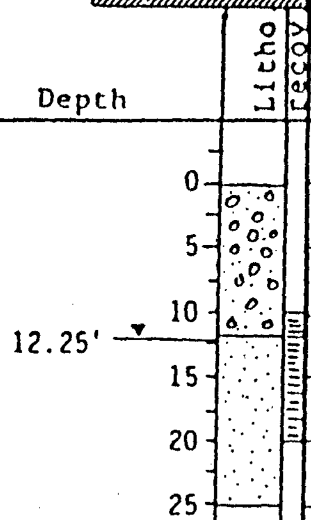
County: San Juan   Contractor: Western Technologies

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



0-12' Fill: Gray to brn gry, very coarse boulders, cobbles and sand, local HC stain & odor

12-25' Sandstone: mod yel brn, fine gr, very poor sorted, subrounded, mod HC odor

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

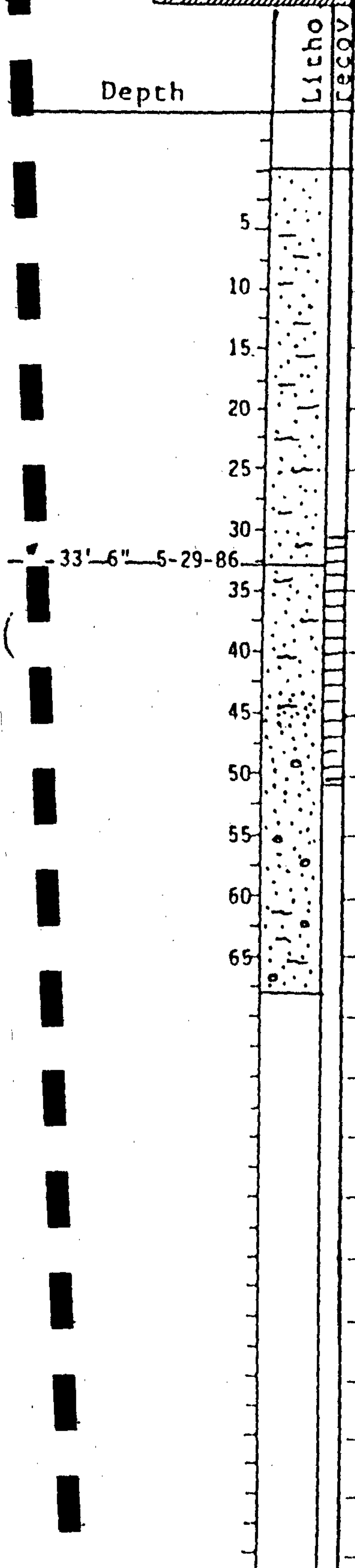
County San Juan Contractor Beeman Bros. Drilling Co.

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



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

WELL LOGGING FORM

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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

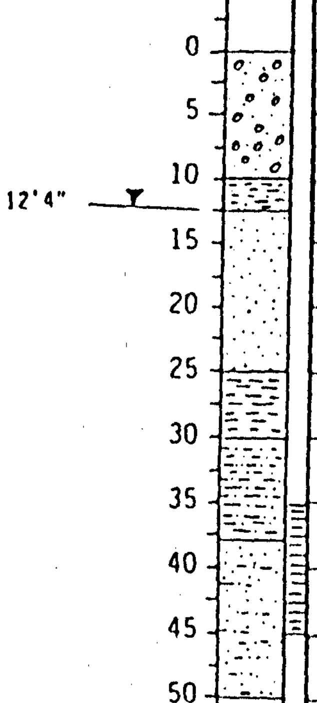
Spud Date: ____ Completion Date: ____

Logs Run: Lith from cuttings and cores — Logged By: ____

Elevation: ____ Spud In (Fm.): ____

Remarks: drilled w/ HSA

Depth | Litho | Recov



0-10' (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

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

DEPTH	LITHO.	RECOV.	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

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							

Geoscience Consultants, Ltd.

WELL LOGGING FORM

Page 1 of 1

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

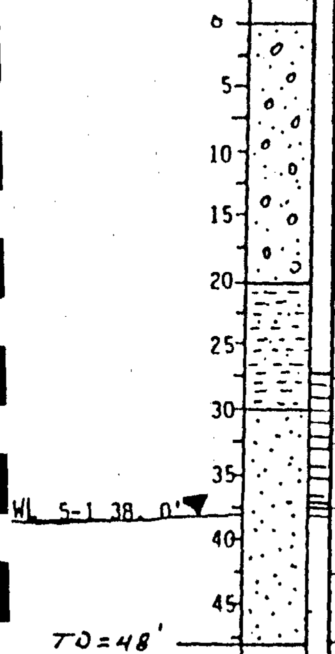
Spud Date 4/18/86 Completion Date 4/18/86

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' (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' (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' (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.

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'

Geoscience Consultants, Ltd.

WELL LOGGING FORM

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

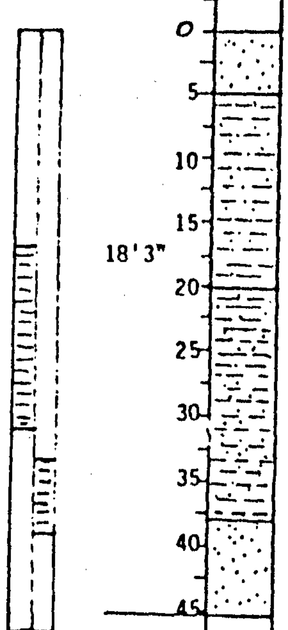
Spud Date 4/15/86 Completion Date 4/16/86

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

Depth | Litho | recov



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 (½Bag)@ 2'

Geoscience Consultants, Ltd.

WELL LOGGING FORM

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

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

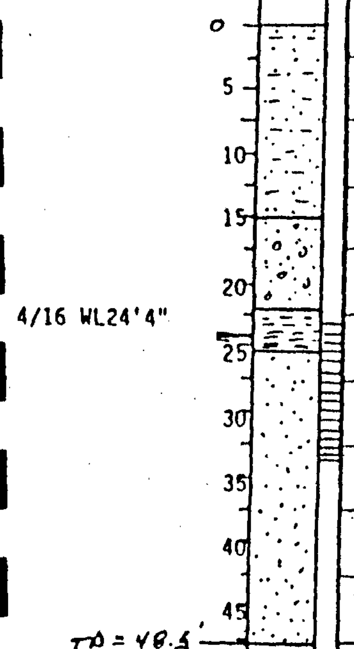
Spud Date 4/16/86 Completion Date 4/16/86

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



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

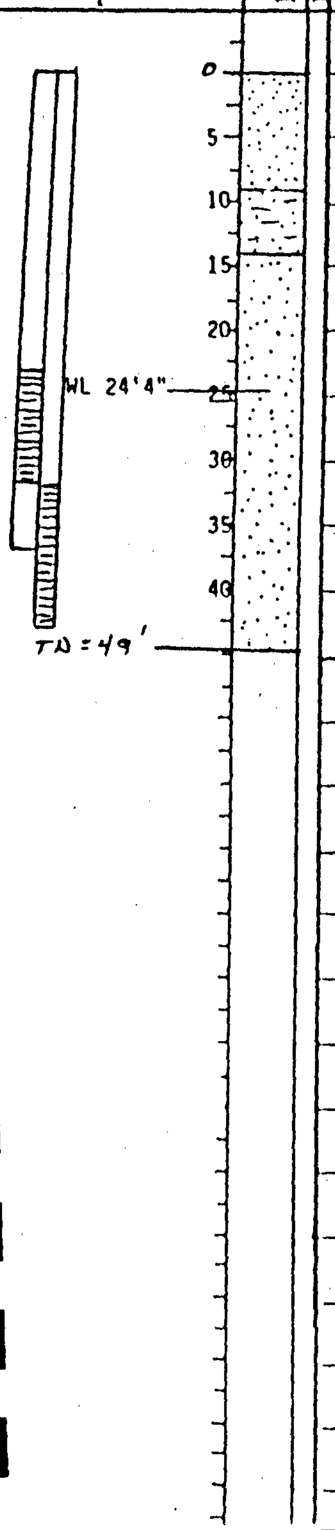
Logs Run lithology from cuttings Logged By Nicholas

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

Client Montgomery & Andrews Well Number GRP 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

WL 32'

TD = 48'

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	Description
0	0-7' (7') SAND : moderate yellowish brown (10yr5/4), med to fine grained, well sorted, no HC odor
7	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	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.
30 (4/23 WL 31'4")	
35	35'-50' (15') SANDSTONE: med dark gray (N4), fine to med grained with some clay, wet HC odor.
50 (TD = 50')	

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

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

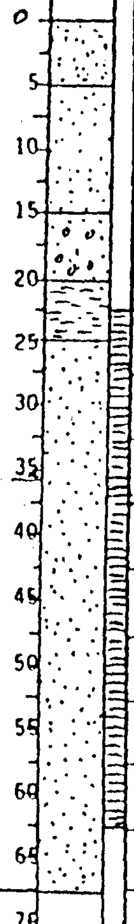
Spud Date 4/23/86 Completion Date 4/23/86

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'

Sat Thick ~ 35-62 = 27'

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.

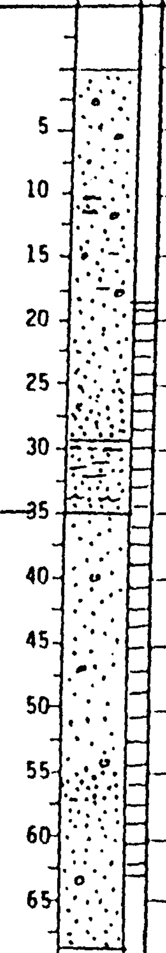
Spud Date: 5/27/86   Completion Date: 5/27/86

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

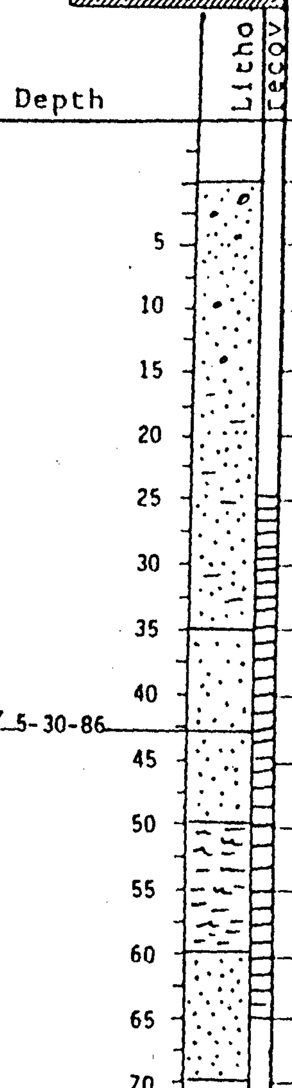
County: San Juan   Contractor: Beeman Bros. Drilling Co.

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

Logs Run: Lith. from cuttings   Logged By: NICHOLAS

Elevation: 5387.9   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

Sat Thick ~43-65 = 22'

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: 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	X						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							

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

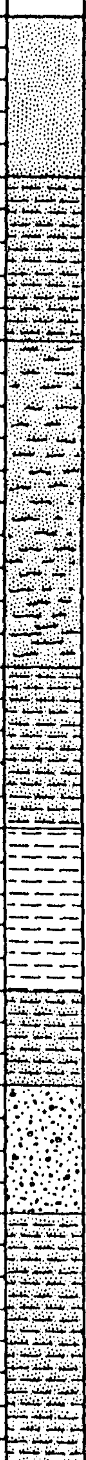
County: San Juan Contractor: Western Technologies

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

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
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.
30				5	28	33				28.0-30.3' No Returns.

BOREHOLE LOG (WELL)

GCL

LOCATION MAP:

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

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

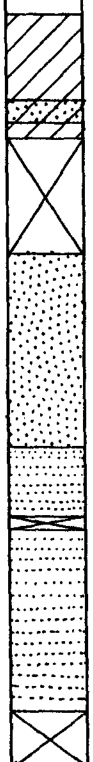
DRILLING CONTR.: WESTERN TECH.

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.

LOCATION DESCRIPTION: ________



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.
										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.
40										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.
				7	38	43				38.0-39.6' No Returns.
45										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										

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-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

LOCATION MAP:

___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.
										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.
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-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										

BORHOLE 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

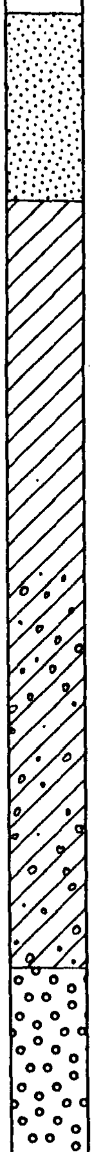
DRILLING CONTR.: SAME

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:

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

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%). Sub-rounded, ≤ 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:

___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:

___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:

__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%). Subrounded 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:

__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:

___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										

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-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
AQUIFER HYDROGEOLOGIC 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

PUMP TEST

DIESEL SPILL AREA

GBR-27

PUMP TEST - DIESEL SPILL AREA - GBR-27

Water level measurements obtained during the April/May pump test in the consolidated sandstone aquifer underlying the site 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 the pump well.

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 pump test.

CORRECTION OF WATER LEVELS FOR FLOATING PRODUCT

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 $[M/LT^2]$
dproduct= density of the product $[M/L^3]$
$dH_2O=$ density of water $[M/L^3]$
$g=$ the gravitational constant $[L/T^2]$

The expression P/(dproduct.g) is equivalent to the pressure head of the product in units of length (eg. feet) of product, and must be converted to length of water through multiplication by the ratio Pproduct/PH_2O.

The resulting expression

$$h = z + \frac{p}{dH_2O \cdot g}$$

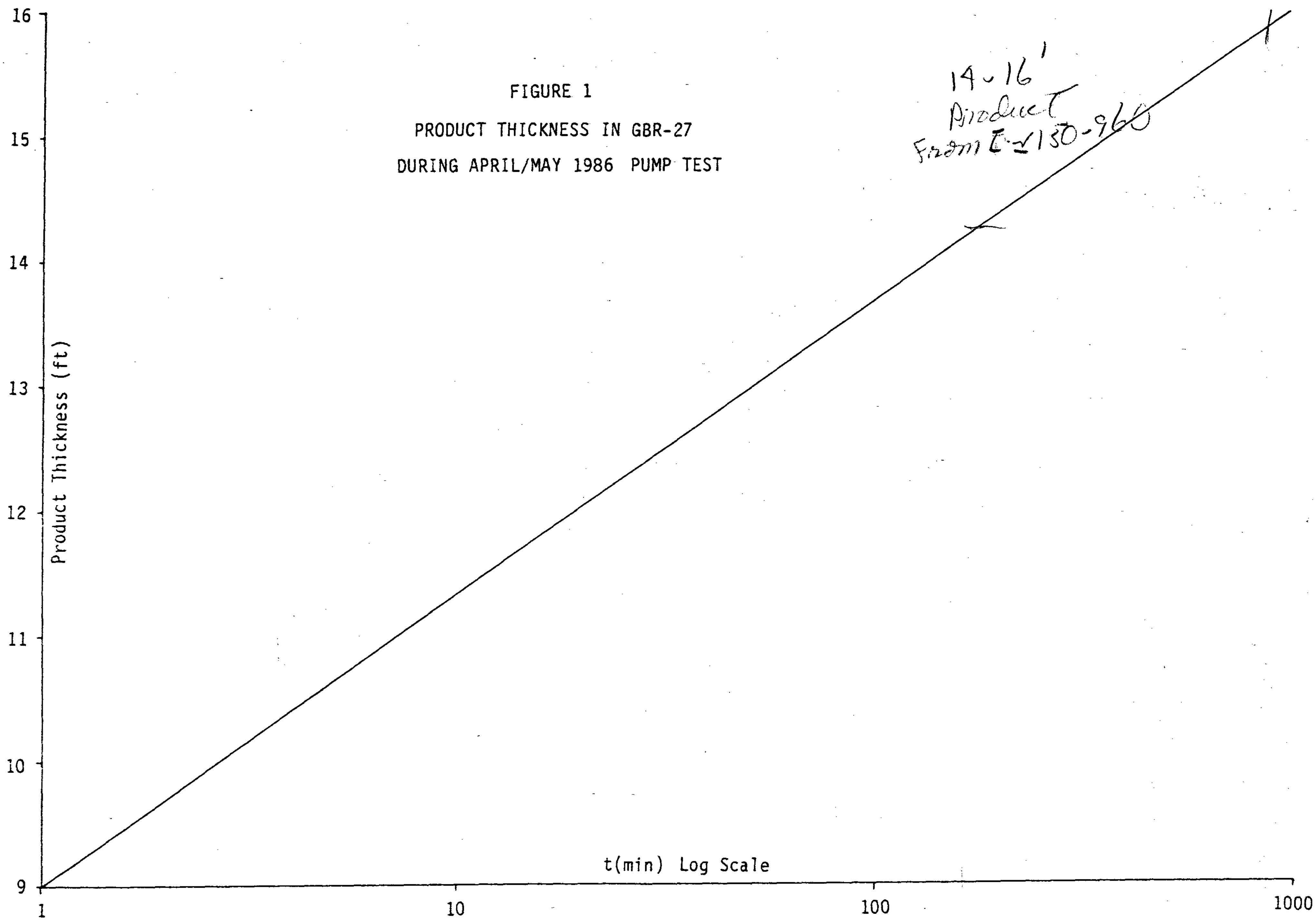
can easily be seen as the familiar Bernoulli equation for the hydraulic head of water, neglecting a velocity head term. The actual hydraulic head h of the water, in the absence of product, can therefore be determined by simply multiplying the observed product thickness (P/Pproduct·g) by an estimate of dproduct/dH_2O 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 log t (see Figure 1). Use of this plot for estimating product thickness at GBR-27 for intermediate times of the pump 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. The attached plot 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. Ideally, product thickness should be determined more accurately through periodic measurement during the pump test, but the logistical problems relating to such measurements would probably be difficult to overcome.

FIGURE 1

PRODUCT THICKNESS IN GBR-27

DURING APRIL/MAY 1986 PUMP TEST



It should be noted that there is no need to reduce product thickness by a factor of 4 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.

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 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.

PUMP-TEST DATA ANALYSIS

Jacob Analysis of Data from GBR-27

Drawdown data observed at pump well GBR-27 was analyzed using a straight-line semi-log Jacob plot. The change in slope of the water level vs. log t plot at t=100 minutes (see Figure 3) could be due to a low-permeability lateral boundary encountered by the expanding cone of depression at GBR-27 or could be the result of partial-penetration effects. Both possibilities can theoretically be addressed using Stallman and Hantush modified Theis analyses with log-log plots of the drawdown data versus time (Kruseman and DeRidder, 1970).

Casing storage or delayed yield

As indicated in the attached plot of water level vs. log t/t' (Figure 4), the rate of recovery is much smaller during early recovery times (i.e.,

not much change at low Q

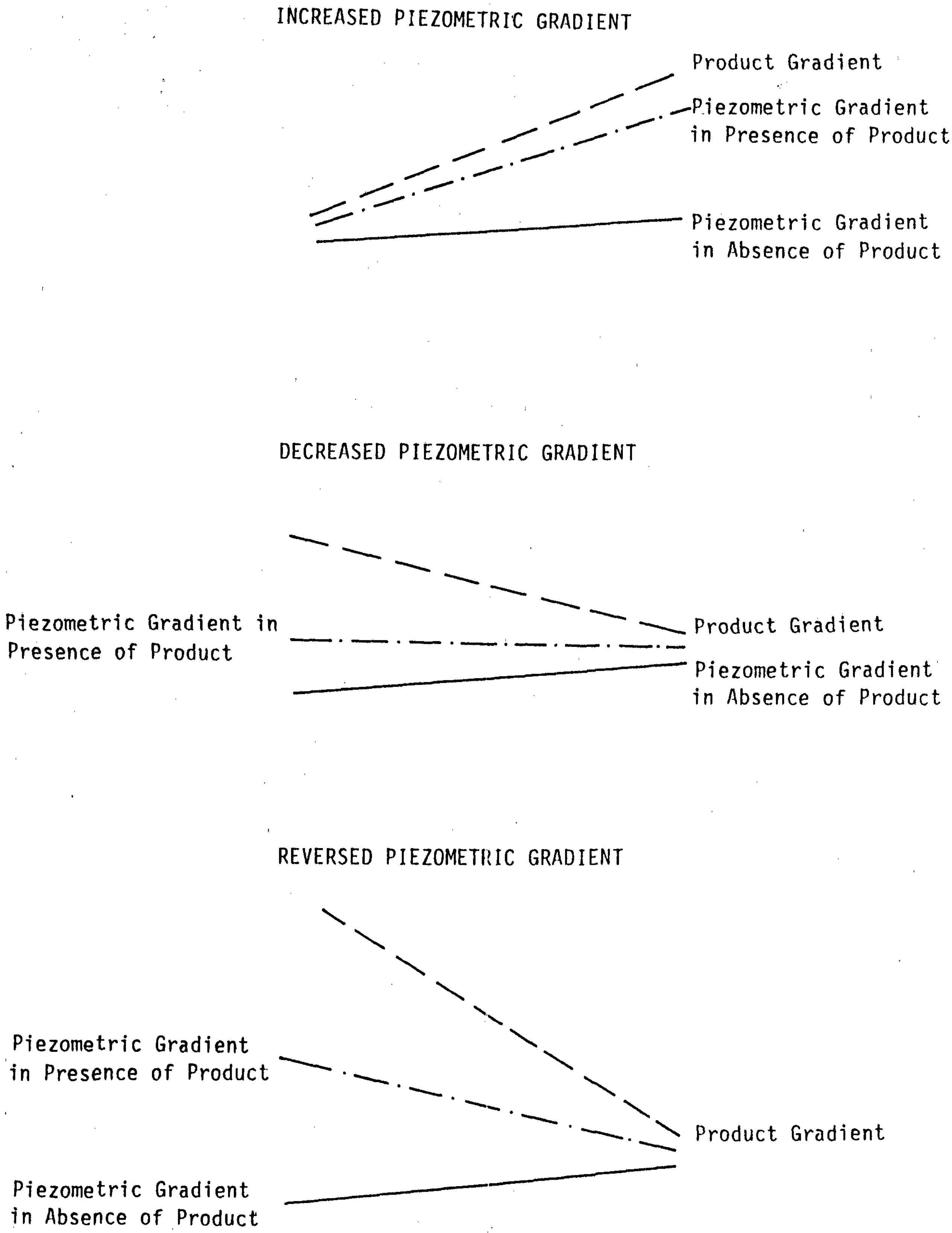
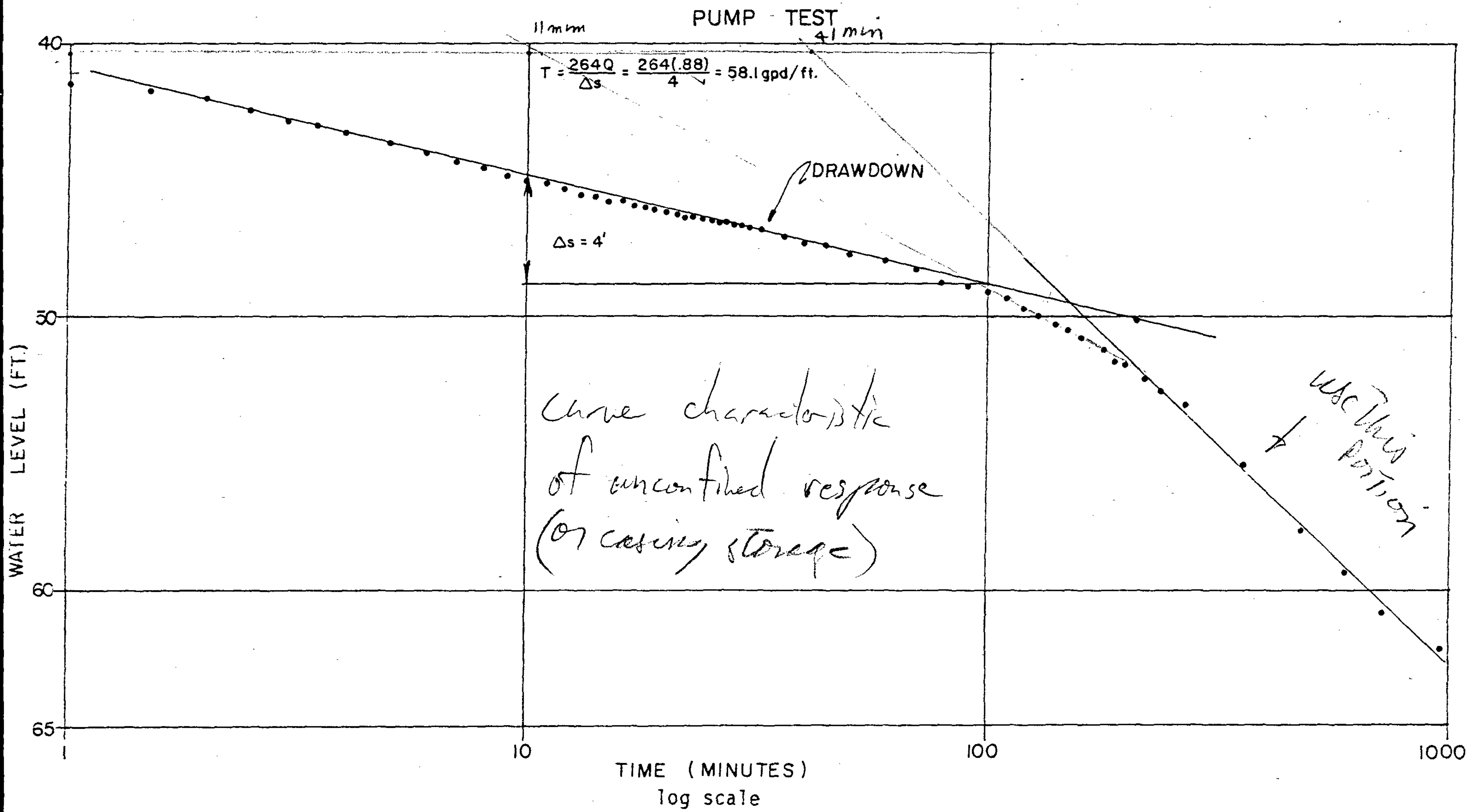


FIGURE 2

SCHEMATIC REPRESENTATION OF THE EFFECTS OF PRODUCT GRADIENT ON THE PIEZOMETRIC GRADIENT

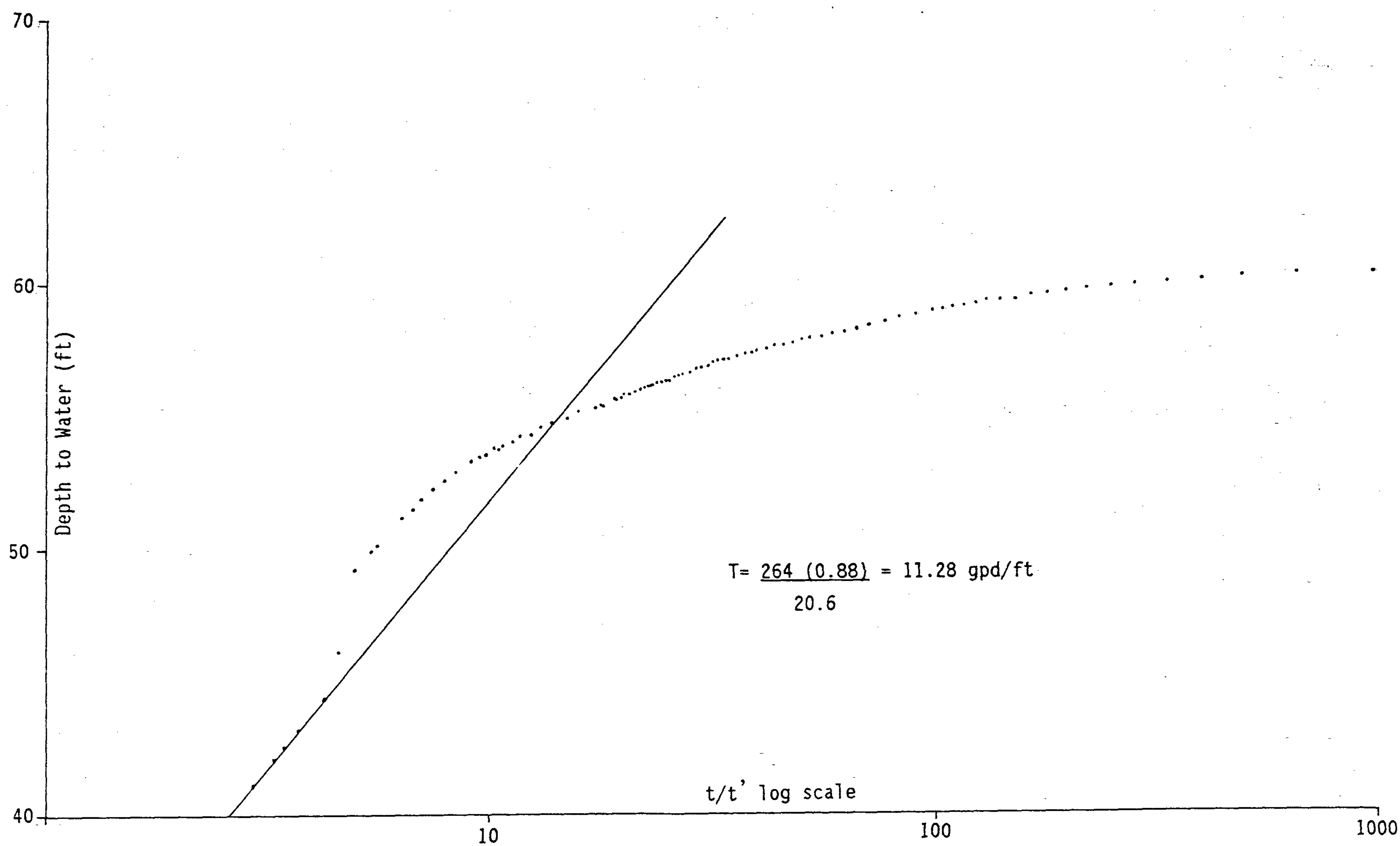


GIANT - BLOOMFIELD
PUMPED WELL
WELL NO. 27

FIGURE 3

4/30/86
C.S.

FIGURE 4
GBR-27
RECOVERY DATA 5/1/86



large valves of t/t') than during later recovery times (t/t'<5). This is the opposite of the usual case of recovery for which the water table rebounds rapidly during initial stages of recovery as water surges back to the well under the pump-induced gradient, with slower recovery as the gradient towards the well decreases at later times. It appears that the large amount of product that accumulated in GBR-27 during pumping was effectively dampening the rate of water level recovery during early stages. The rate of recovery increased somewhat during intermediate stages, but was still significantly smaller than the rate associated with late recovery stages. This behavior would seem typical of water overlain by an initially thick layer of accumulated product that migrates away from the well in response to a decrease in the piezometric gradient, allowing the water table to ultimately rebound to its initial level. The slow rate of rebound during early recovery stages can be attributed to the low conductivity of the aquifer with respect to the low-density, high-viscosity product and the resulting slow rate of product migration. As the water table slowly rebounded and the gradient decreased towards the well, product was gradually removed and the water table rebounded at progressively faster rates. Since no data were available to describe the change in product thickness during recovery stages, no attempt was made to evaluate the effects of product thickness on water recovery at GBR-27. When a straight line was fitted to the recovery data at large recovery time (t/t' small), the calculated transmissivity was equal to 11.3 gpd/ft. Clearly, abrupt recovery during late recovery stages when large quantities of product have migrated away from the vicinity of the well caused the small estimated transmissivity. More gradual late-stage recovery normally associated with recovery in the absence of product pressure head would have produced a higher estimate of transmissivity.

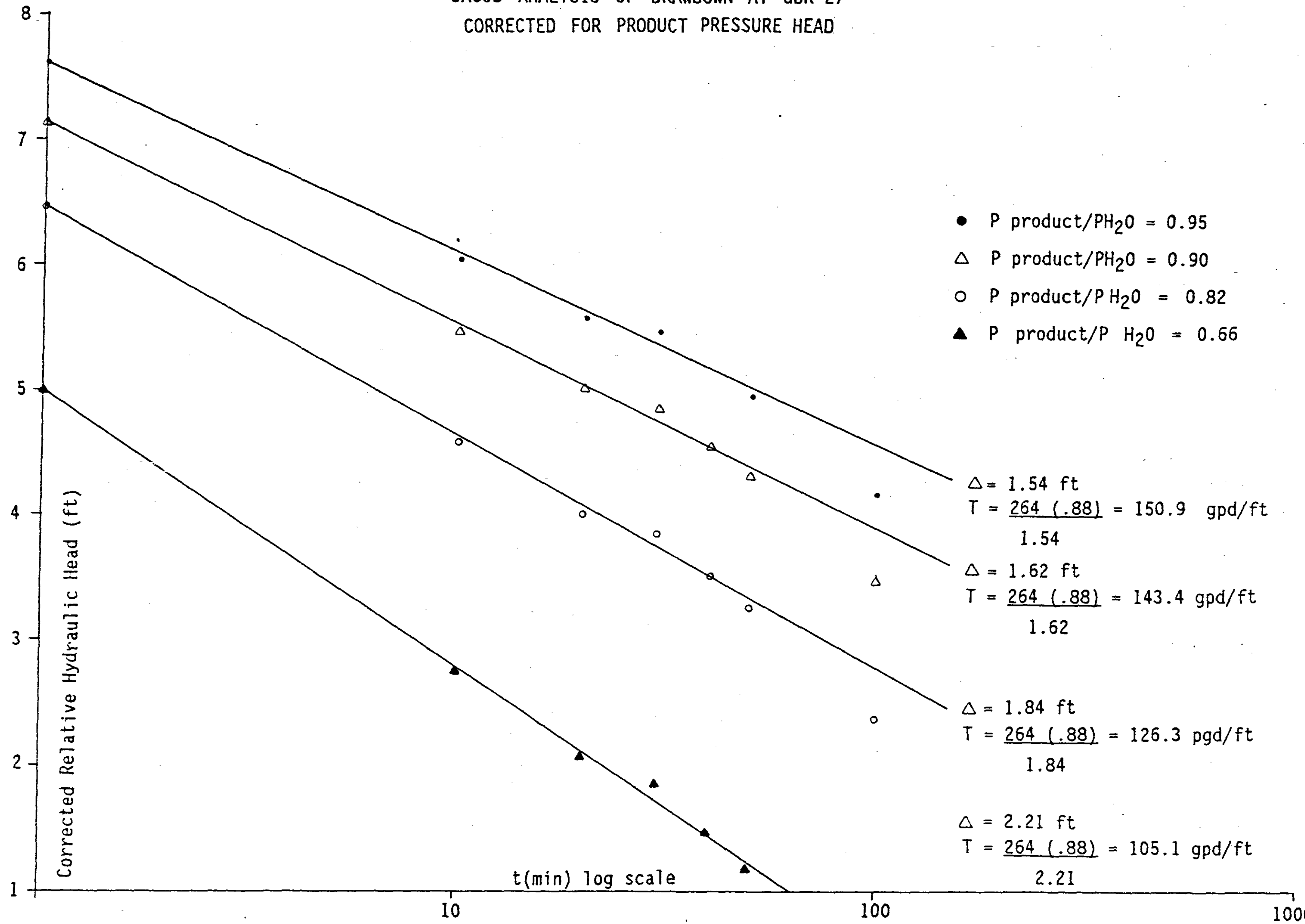
Jacob analysis of GBR-27 drawdown corrected for product pressure head using a density ratio of 0.82 typical of kerosene (CRC Handbook of Chemistry and Physics, p. F-3) yielded a transmissivity of 126.3 gpd/ft. (see Figure 5). This transmissivity estimate was significantly higher than the transmissivity obtained with uncorrected pump-well drawdown because 'removal' of the product pressure head effectively reduced the rate of drawdown during pumping.

is the same ballpark as values I calculated for the GBR-14 pumptest

FIGURE 5

JACOB ANALYSIS OF DRAWDOWN AT GBR-27

CORRECTED FOR PRODUCT PRESSURE HEAD



THEIS ANALYSIS OF DATA FROM GBR-27

The Stallman modified Theis analysis was applied to the drawdown data from pump well GBR-27 in order to determine the position of a low-permeability lateral boundary which might give rise to the observed increase in drawdown at t=100 minutes. The occurrence of low-conductivity clay lenses in the adjacent arroyo alluvium may have been responsible for such boundary effects, causing increased drawdown at GBR-27 as the expanding come of depression intercepted alluvial deposits. Data both corrected and uncorrected for product thickness were used in the analysis, as indicated in Figure 6. The analysis involved utilizing type curves equal to the sum of well functions associated with the pump well and discharging image wells that would produce the shape of the observed log s versus log t plot (see Figure 7).

The match point for the uncorrected drawdown data occurred at s=0.23 ft. and t=0.63 minutes. Using these values, transmissivity was calculated to be 43.9 gpd/ft when the drawdown was corrected for product thickness. The transmissivity was estimated to equal 118.7 gpd/ft. Again, the larger transmissivity for corrected drawdown was expected on the basis of the reduced rate of drawdown that occurred when product was essentially removed during the analysis.

Use of the Stallman method of images to identify the location of a possible low-permeability barrier affecting drawdown at GBR-27 was not considered successful. For the case of GBR-27 acting as its own observation well, the analysis became indeterminate. The analysis yielded estimates of the boundary location at anywhere between 1.0 and 4.2 feet from GBR-27 for both corrected and uncorrected data. Given the moderate aquifer transmissivity estimated from Jacob and modified Theis analyses, any low-permeability barrier observed at t=100 minutes is more likely to be much further from the pump well than 1 to 4 feet. The match point, and thus the estimate of transmissivity obtained from the Stallman modified Theis method, were not affected by the indeterminate value of r_r.

FIGURE 6
THEIS PLOT OF DRAWDOWN VS. TIME AT GBR-27

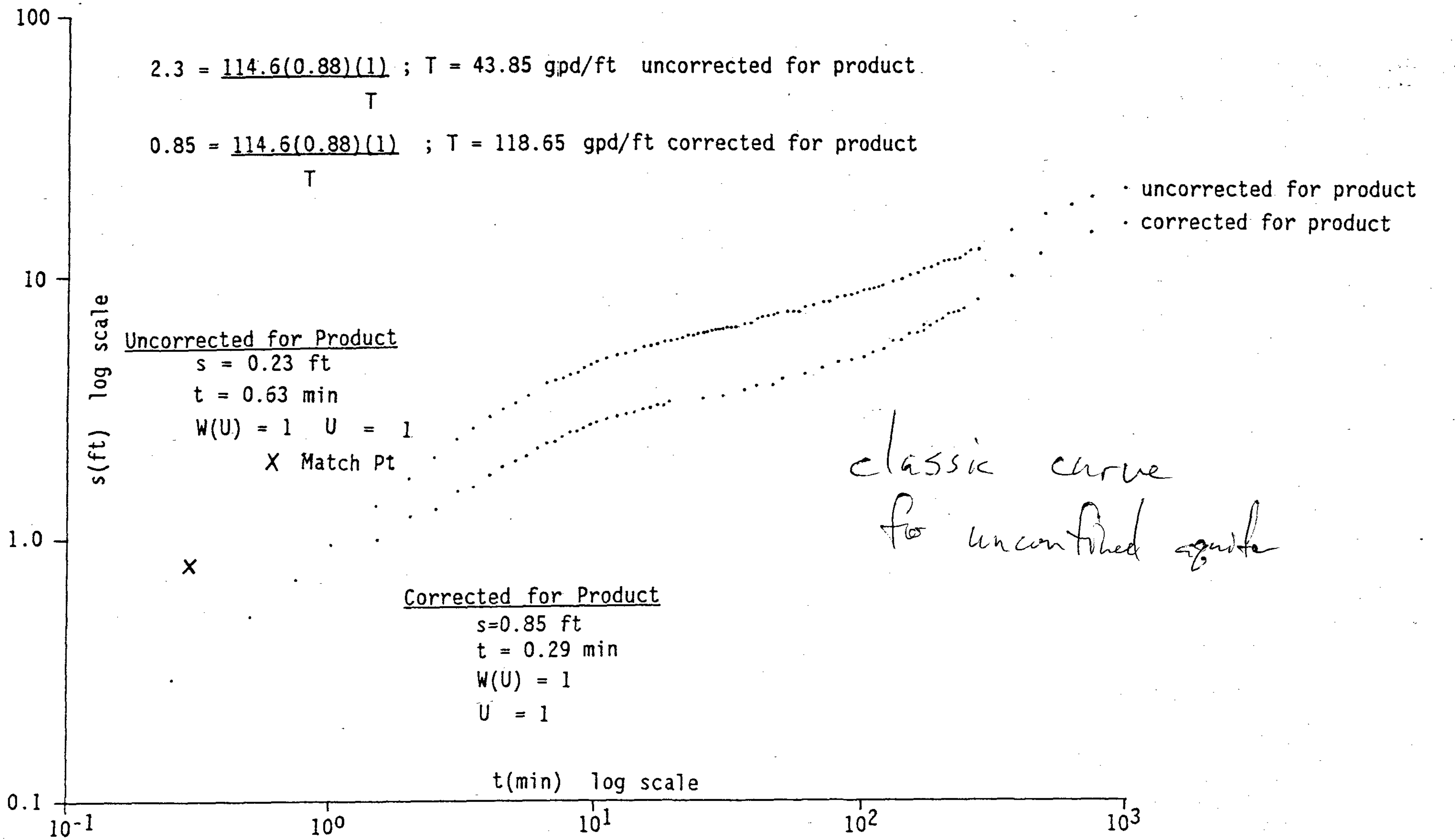
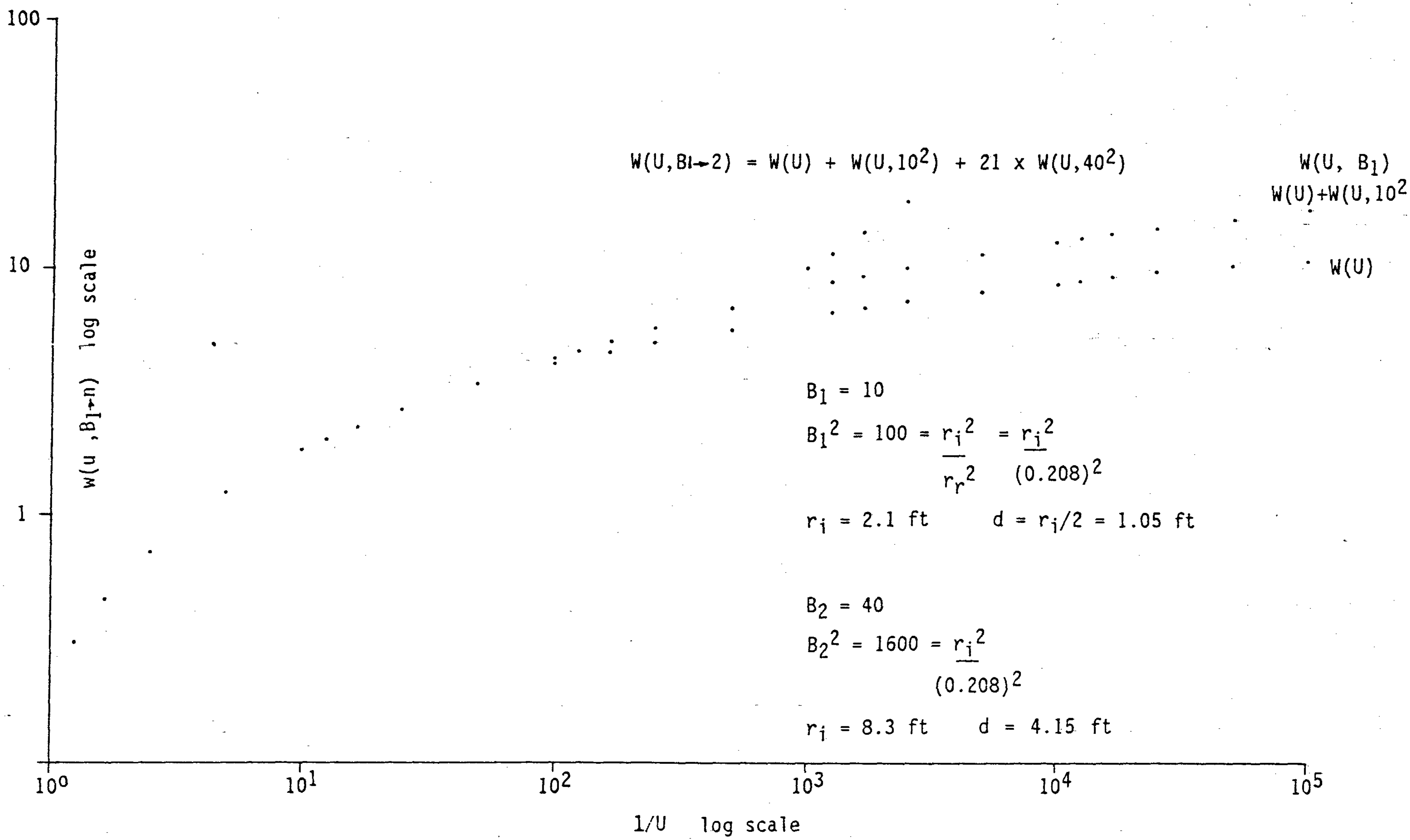


FIGURE 7
STALLMAN MODIFIED THIEIS CURVE W(U, BI→N) vs. 1/U



The upward deviation of drawdown from the Theis curve may be attributed to the effects of a partially-penetrating pump well under conditions of dewatering rather than to low-permeability boundary effects. As the pump-well became dewatered, the effective screen area would have been reduced and the velocity of water entering the well would have greatly increased. This increased velocity would produce large head losses in the well and significantly increased drawdown. The likelihood that the observed drawdown behavior at GBR-27 reflects partial-penetration head losses is somewhat substantiated by the fact that, when drawdown data from GBR-25 are plotted on double-log paper, an upward deviation is not apparent; head losses due to vertical flow at a distance of 80 feet from a partially-penetrating pump well would tend to be minor. Analysis of drawdown data from GBR-27 for potential effects of partial-penetration could not be performed without information pertaining to the thickness of the consolidated sandstone aquifer.

JACOB ANALYSIS OF DATA FROM 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 the straight-line semi-log analysis 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, assuming T, S, and r values of 422.4 gpd/ft (0.0392 ft^2/min), 0.00017, and 80 feet was less than 0.01 only for t > 694 minutes. Ideally, analysis would be performed by using data for t > 694 min., 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. Good

It should be noted that a single straight line could conceivably be fit to drawdown data on the semi-log plot for GBR-25 (Figure 8). The increased drawdown observed at t = 220 minutes was sufficiently slight to substantiate use of a single straight-line fit. Using this single-line fit, transmissivity was estimated to equal 387.2 gpd/ft., with storativity remaining essentially unchanged at 0.00016. However, since the

PUMP TEST

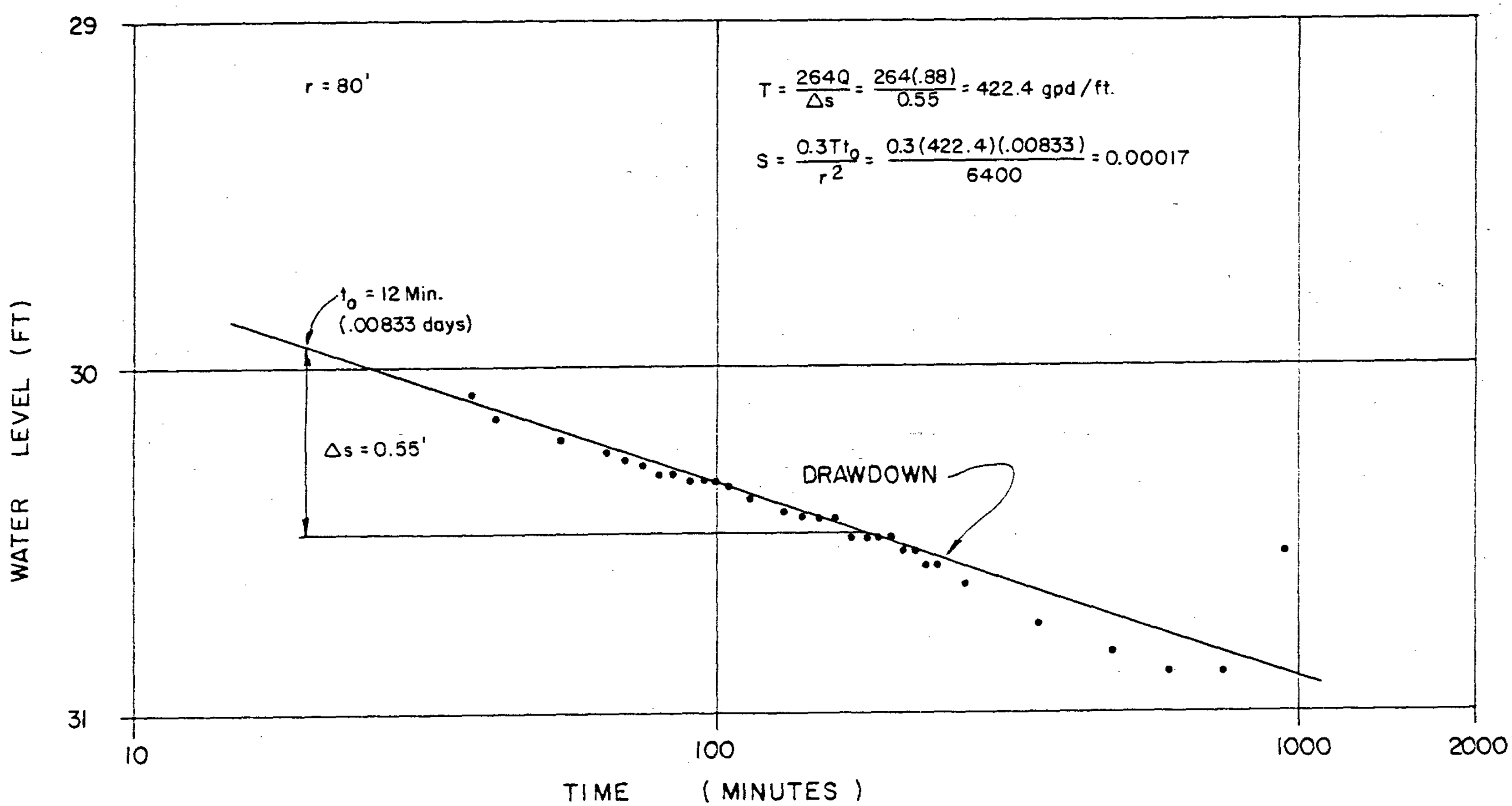


FIGURE 8

GIANT - BLOOMFIELD
OBSERVATION WELL
WELL NO. GBR 25
4/30/86

4/30/86
C.S.

value of u remains too large for valid Jacob analysis, these values should be considered less reliable than those obtained using Theis analysis. Correction for product pressure head at GBR-25 was not possible because no data related to changing product thickness at the well were available.

THEIS ANALYSIS OF DATA FROM GBR-25

Using a double logarithmic plot of drawdown vs. t for GBR-25, a match point of W(u)=1, u=1, s=0.3 feet, and t=14.5 minutes was obtained. These values yielded estimates of T = 336.2 gpd/ft. and S = 0.00028, which were both of the same order of magnitude as parameters estimated from Jacob analysis (see Figure 9). 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.

Deviations of drawdown from the Theis curve at large times were not as pronounced at GBR-25 as they were for GBR-27. This lack of deviation brought into question whether a low-permeability lateral boundary did, in fact, exist in the area affected by the pump test. Deviation of data from Theis-predicted behavior at GBR-27, and the lack of deviation at GBR-25, imply that the source of non-ideal behavior is located in the vicinity of GBR-27. Partial-penetration effects would tend to be localized at the pump well, but would not be as evident at GBR-25 where vertical flow components induced by the partially-penetrating pump well would be negligible simply by virtue of the large distance from pumping.

Yes, and therefore could be due to delayed yield

EVALUATION OF DATA FROM 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 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,

FIGURE 9

THEIS PLOT OF DRAWDOWN DATA FROM GBR-25

r = 80, not 150 (as on data sheets)

$$0.3 = \frac{114.6(0.88)(1)}{T} \; ; \; T = 336.2 \text{ gpd/ft} = 0.0312 \text{ ft}^2/\text{min}$$

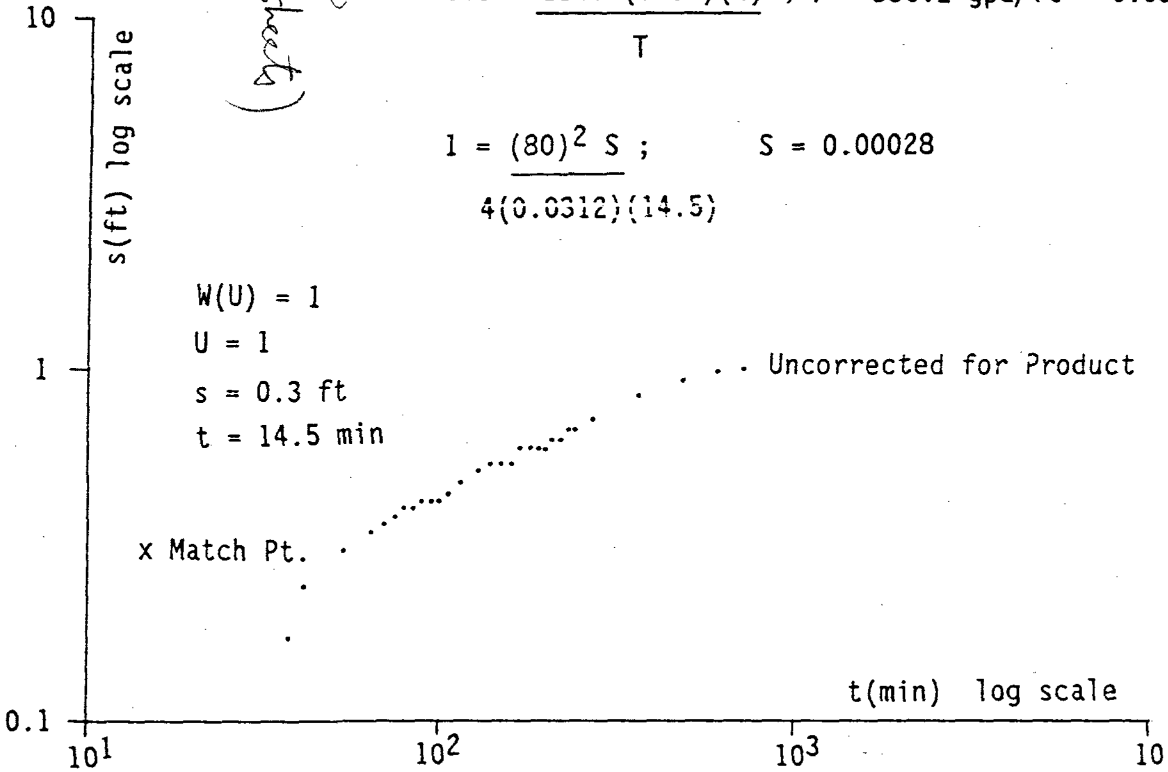
$$1 = \frac{(80)^2 S}{4(0.0312)(14.5)} \; ; \qquad S = 0.00028$$

W(U) = 1

U = 1

s = 0.3 ft

t = 14.5 min



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 GBR-21 data.

SUMMARY OF AQUIFER PARAMETERS

Aquifer parameters obtained on the basis of drawdown data from wells GBR-27 and GBR-25 are summarized 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 storativity analysis.

WELL AND TYPE OF ANALYSIS	T(gpd/ft)	Sy
GBR-27		
Jacob w/uncorrected drawdown	58.1	NA
w/corrected drawdown	126.3	NA
Jacob recovery	ND	NA
Stallman modified Theis (low-k barrier)		
w/uncorrected drawdown	43.9	NA
w/corrected drawdown	118.7	NA
Hantush modified Theis (partial penetration)	ND	NA
GBR-25		
Jacob w/uncorrected drawdown	~~387~~.2	0.00016
w/corrected drawdown	ND	ND
Stallman modified Theis (low-k barrier)	ND	ND
Theis w/uncorrected drawdown	336.2	0.00028
w/corrected drawdown	ND	ND

Don't make sense 40' sandstone

→ u is not less than 0.01 invalid

$K = \frac{T}{b} = \frac{336.2}{40'} = 8.4\ gpd/ft^2$

↑ m at GBR-27

NA = not applicable
ND = no data available

CONCLUSIONS

If drawdown data obtained at GBR-25 are not significantly affected by product pressure head, calculated transmissivities and storativities from analysis of uncorrected drawdown data can be assumed to be reliable estimates of consolidated aquifer parameters. The 336-387 gpd/ft range of transmissivities is somewhat higher than the range of 119-126 gpd/ft estimated using corrected drawdown at GBR-27, where the presence of floating product was considered to be much more of an influence on observed drawdown response. This discrepancy may be attributed to partial-penetration effects that are much more dominant at GBR-27. The continual dewatering of the pump well may have resulted in decreasing screen area, increased velocity of withdrawn water, greater vertical flow components, and significant head losses at the pump well. These head losses would be manifested by drawdown in excess of that which would occur under fully-penetrating conditions, resulting in reduced transmissivity estimates. Although the presence of a low-permeability boundary within the expanding cone of depression could be responsible for the abrupt increase in drawdown at t=100 minutes, image-well analysis did not yield conclusive results due to insensitivity of the analysis to drawdown at the pump well. Since the presence of a low-permeability boundary was not indicated by drawdown data obtained at the GBR-25 observation well, the possibility of partial-penetration effects should not be discounted. Lack of data relating to consolidated aquifer thickness made it impossible to explicitly address the likelihood that partial-penetration of the pump well was responsible for the observed deviations from ideal behavior and the low transmissivities encountered at GBR-27.

Storativities estimated on the basis of uncorrected data from observation well GBR-25 ranged from 0.00016 to 0.00028. These estimates were well within the range of storativities generally associated with confined to partially-confined flow. If the pump test had been of longer duration, it is possible that leakage from localized shale units along the eastern edge of the Diesel Spill Area would have become evident.

RECOMMENDATIONS

In order to account for all effects of non-ideal behavior during pump testing, it is essential that sufficient information related to the causes of such non-ideal behavior be acquired. Floating product thicknesses should be monitored throughout the duration of pump testing at all pump and observation wells. This will make it possible to correct for product pressure head without resorting to speculative semi-log plots of product thickness vs. log t (see Figure 1). In addition, test pumping should be conducted for at least 24 hours by ensuring that the pump well has been completed at a depth sufficient to avoid dewatering and consequent partial-penetration effects. Long-duration tests would make it possible to more thoroughly investigate the possibility of low-permeability lateral boundaries, vertical leakage, and other sources of non-ideal behavior. A longer duration test at GBR-27 would have made it possible to determine whether the effects of a proposed low-permeability

exactly what we were saying

boundary would have eventually become evident at observation well GBR-25. If a significant increase in drawdown did not occur at GBR-25 after 2 to 3 days of pumping, the abrupt drawdown increase at GBR-27 at t=100 minutes would clearly be ascribed to partial-penetration influences. A final source of inadequate data was related to lack of a specified consolidated sandstone aquifer thickness. Geophysical studies may have the potential for yielding estimates of aquifer thickness for the deep consolidated aquifer. Alternatively, at least one borehole should be drilled to several hundred feet in order to ascertain the depth to contiguous shale and the minimum aquifer thickness. For large estimates of minimum aquifer thickness, many methods of analysis are insensitive to this parameter. For example, in correcting for partial penetration effects, it may make little difference whether aquifer thickness is 500 or 2000 feet when compared to the depth of the pump well. However, if aquifer thickness is only 100 feet, such an analysis would be sensitive to the estimated thickness.

All ND (no data) entries in the aquifer parameter summary table can be ascribed to lack of data relating to product thickness and consolidated aquifer thickness and to testing of insufficient duration.

Given the constraints associated with pumping in contaminated areas affected by product pressure head, excessive costs of drilling to large depths for aquifer thickness determination, and general problems relating to non-ideal aquifer behavior, the use of slug or bailer tests and laboratory testing of core samples for purposes of defining hydraulic conductivity should be considered. When properly conducted, these methods can produce inexpensive and reliable estimates of aquifer transmissivity without the problems inherent to field testing methods.

TABLE C-1
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 (corrected levels?)

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (t_o) Pump off: Date 5/1 Time ___ (t'_o) 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		Comments
4/[illegible]/86	1530	0				40'4.5"		40.38		9'	33.00	=Static		
		: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 C-1 (Cont.)
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 ____ Time ____ (t'_o)
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		15.0				45'9"		45.75'						
		16.0				10"		45.83'						
		17.0				11.5"		45.96'						
		18.0				46'0"		46.00'						
		19.0				1.5"		46.13'						
		20.0				2.5"		46.21'						
		21.0				3.5"		46.29'						
		22.0				4.5"		46.38'						
		23.0				4.5"		46.38'						
		24.0				5.25"		46.44'						
		25.0				6"		46.50'						
		26.0				7"		46.58'						
		27.0				7.5"		46.63'						
		28.0				8"		46.67'						
		29.0				8.5"		46.71'						
		30.0				9"		46.75'						
		31.0				10"		46.83'						
		32.0				10"		46.83'						
		33.0				-		-						
		34.0				-		-						
		36.0				47'1"		47.08'						
		38.0				-		-						
		40.0				47'4"		47.33'	6.95					
		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 C-1 (Cont.)

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 (t_o)
Pump off: Date ____ Time ____ (t_o')
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 ____

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 on factors affecting test data
4/30/86		52.0				-		-						
		54.0				-		-						
		56.0				-		-						
		58.0				-		-						
	1630	60.0				48'.5"		48.04		13.18	37.23	4.23		
		65.0				2.75"		48.23						
		70.0				4.5"		48.38		13.32	37.46	4.46		
		75.0				6.25"		48.52						
		80.0				9"		48.75		13.45	37.72	4.72		
		85.0				10"		48.83						
		90.0				11.5"		48.96						
		95.0				49'2"		49.17						
		100.0				2.5"		49.21		13.6	38.06	5.06		
		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					corrected WL =	
		140.0				3.5"		50.29	Δ	PT	CWL	Δc	WL - (PT)(.82)	
		150.0				6.75"		50.56	10.18	14.1	39.00	6.00		
		160.0				9"		50.75	10.37	14.18	39.12	6.12		
		170.0				51'3"		51.25	10.87	14.22	39.59	6.59		
	1830	180.0				3.5"		51.29	10.91	14.3	39.56	6.56		
		190.0				7"		51.58	11.2	14.35	39.81	6.81		
		200.0				9.5"		51.79	11.41	14.4	39.98	6.98		
		210.0				52.5"		52.08	11.7	14.45	40.23	7.23		
		220.0				3"		52.25	11.87	14.5	40.36	7.36		

TABLE C-1 (Cont.)
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_o) Pump off: Date ____ Time ____ (t'_o) 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'	PT	CWL Discharge measurement	δc Rate	
4/30/86		230.0				52'4"		52.33	11.95	14.54	40.41	7.41	
	1930	240.0				7"		52.58	12.2	14.58	40.32	7.32	
	2000	270				53'2.5"		53.21	12.83	14.7	41.16	8.16	
		360				55'5.5"		55.46	15.08	14.98	43.18	10.18	
5/[illegible]86	0000	480				57'11"		57.92	17.54	15.28	45.39	12.39	
	0200	600				59'4.5"		59.38	19.00	15.5	46.67	13.67	
	0400	720				60'10"		60.83	20.45	15.69	47.96	14.96	
	0800	960				62'1.5"		62.13	21.75	15.97	49.03	16.63	

TABLE C-2

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 (t_0) Pump off: Date 5/1 Time 800 (t_0') 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	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		
4/30/86	0					25'7"		25.58'						
	11.0					25'?								
	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 C-2 (Cont.)

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

Pump on: Date 4/30 Time 1530 (t_o)
Pump off: Date ______ Time ______ (t_o')
Duration of aquifer test:
Pumping 16 hrs. Recovery ______

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 ______

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 on factors affecting test data
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'						
5/1/86	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 C-3
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~~ 80' ft. Type of test Pump Test No. 1

Measuring equipment Powers W.L. Indicator

Time Data
Pump on: Date 4/30 Time 1530 (t_0)
Pump off: Date 5/1 Time 0800 (t_0')
Duration 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

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		0				29'11"	29.91		0				
		38				30'1"	30.08		0.17				
		42				30'1.75"	30.15		0.24				
		54				30'2.5"	30.21		0.30				
		65				30'3"	30.25		0.34				
		70				30'3.25"	30.27		0.36				
		75				30'3.5"	30.29		0.38				
		80				30'3.75"	30.31		0.40				
		85				30'3.75"	30.31		0.40				
		90				30'4"	30.33		0.42				
		95				30'4"	30.33		0.42				
		100				30'4"	30.33		0.42				
		105				30'4.25"	30.35		0.44				
		115				30'4.5"	30.78		0.87				
		130				30'5"	30.42		0.51				
		140				30'5.25"	30.44		0.53				
		150				30'5.25"	30.44		0.53				
		160				30'5.25"	30.44		0.53				
		170				30'6"	30.50		0.59				
		180				30'6"	30.50		0.59				
		190				30'6"	30.50		0.59				
		200				30'6"	30.50		0.59				
		210				30'6.5"	30.54		0.63				
		220				30'6.5"	30.54		0.63				
		230				30'7"	30.58		0.67				
		240				30'7"	30.58		0.67				
		270				30'7.5"	30.63		0.72				
		360				30'9"	30.75		0.84				

TABLE C-3 (Cont.)

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~~ 80' 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_o) Pump off: Date 5/1 Time 0800 (t_o') 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 on factors affecting test data
		480				30'10"	30.83		0.92					
		600				30'10.5"	30.88		0.97					
		720				30'10.5"	30.88		0.97					
		960				30'6.5"	30.54		0.63					

TABLE C-4
AQUIFER TEST DATA

wner Giant Address Bloomfield County San Juan State NM

ate 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

easuring 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_0) ump off: Date 5/1 Time 0800 (t'_0) uration 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 ___	

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		
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 C-4 (Cont.)

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_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[illegible]/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 C-4 (Cont.)
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_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
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 C-4 (Cont.)
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	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (t_0) Pump off: Date 5/1 Time 0800 (t_0') 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	

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 C-5
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_0)
Pump off: Date 5/1 Time 0800 (t'_0)
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 on factors affecting test data
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 C-5 (Cont.)
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	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date 4/30 Time 1530 (t_0) Pump off: Date 5/1 Time 0800 (t_0') Duration of aquifer test: Pumping 16 hrs. Recovery 8 hrs	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
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						

PUMP TEST

DIESEL SPILL AREA

GBR-14

Note: Because of the large number of figures and tables in this section, they are grouped together at the end of the text.

PUMP TEST - DIESEL SPILL AREA - GBR-14

ANALYSIS OF DRAWDOWN DATA AT GBR-14

When drawdown observations obtained at pump well GBR-14 were plotted on double-log paper, as many as 3 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 data because changes in drawdown were more evident when plotted on an arithmetic scale rather than a log scale (see Figures 10, 13 and 16).

Initially, it was believed that the abrupt changes in slope on the semi-log plots and the corresponding deviations from the Theis curve on double-log plots resulted solely from interception of the expanding cone of depression at GBR-14, which was completed in the arroyo alluvium, with lower-conductivity sandstone occurring along the edges of the arroyo or low-conductivity clay lenses in the arroyo. However, the maximum semi-log slope change which would occur when a completely impermeable boundary was encountered would be 2. Slopes on the semilog plots changed by a factor of 4 and 3 for pump tests #1 and #3, respectively. Given that the adjacent sandstone or interlayed clay lenses are not completely impermeable relative to the alluvial fill, even slope changes of 2 would not be expected solely on the basis of boundary effects. The excessive slope changes were probably due to superposition of lower-conductivity sandstone or clay boundary effects and partial-penetration effects that become progressively more evident as pumping dewatered the alluvial aquifer.

change occurs at t = 33 min. I doubt you would see these effects at such early times

Unfortunately, analysis of pump test results on the basis of these non-ideal influences could not be performed using drawdown data observed at the pump well; the relevant equations become indeterminate at small radial distances from the pump well. Rather, drawdown data observed at observation well GBR-15, which was completed in the arroyo alluvium, was relied on to perform quantitative analysis relating to boundary and partial-penetration influences.

Since deviations from ideal behavior at the pump well were not evident during early pumping times, presumably prior to the interception of sandstone or clay boundaries or the occurrence of significant dewatering, drawdown observed at GBR-14 during early stages of pumping was useful in defining the transmissivity which would occur at a fully-penetrating well in an infinite aquifer. Prior to analysis of the data, 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):

$$S' = S - \frac{S^2}{2D}$$

Where S' = drawdown which would occur in an equivalent confined aquifer under conditions of constant transmissivity [L]

S = observed drawdown in the unconfined alluvial aquifer under conditions of decreasing transmissivity [L]

D = the estimated average aquifer saturated thickness at the well at which drawdown is observed [L]

The correction did not substantially alter the plots when aquifer thicknesses of 70 and 100 feet were assumed, even during pump test #3 when large water level declines were observed in response to pumpage of 5 gpm (see Figure 14).

Transmissivities obtained on the basis of early drawdown data at pump well GBR-14 are shown calculated in Figures 10, 11, 13, 14,16 and 17 and are summarized below:

ESTIMATED TRANSMISSIVITY OF THE ALLUVIAL AQUIFER NEAR GBR-14

	T (gpd/ft.)	
Pump Test	Theis Analysis	Jacob Analysis
1 (Q = 1 gpm)	902.4	754.3
3 (Q = 5 gpm)	855.2	1100.0
5 (Q = 2 gpm)	619.5	660.0
average	792.4	838.1

Since the transmissivities obtained using Theis analysis varied over a smaller range than those calculated according to Jacob analysis, it was estimated that the transmissivity of the alluvial aquifer was roughly 790 gpd/ft. This average transmissivity was twice as large as the maximum transmissivity of 387 gpd/ft calculated for the adjacent sandstone aquifer using data from a pump test performed at GBR-27 in the same area.

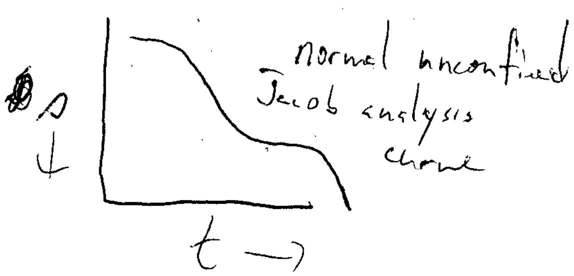
If it is assumed that the sandstone aquifer may be more than 10 times as thick as the alluvial aquifer, the hydraulic conductivity of the alluvial system could be as much as 20 times larger than the conductivity of the consolidated sandstone aquifer. Even this large a difference in conductivity would not be sufficient to cause semi-log slope changes of 2 or greater, further suggesting that abrupt changes in drawdown must be due to some combination of boundary and partial-penetration effects.

obviously conductivity of sand, much greater than sandstone

Although late-time data at GBR-14 could not be used to quantitatively characterize boundaries and partial-penetration effects due to limitations of the methods of analysis for data observed at the pump well, observation of the drawdown data clearly indicates the presence of at least two boundaries within the radius of influence at GBR-14. These boundaries become evident at various times during pumping, depending on the rate of withdrawal. The expanding cone of depression at GBR-14 apparently encounters a clay lens or the boundary at the edge of the arroyo closest to GBR-14, then reaches another clay lens or the sandstone at the side of the arroyo farthest from GBR-14.

cone of depression expands across arroyo in 6 to 7 min (max of 35 min) ?

The table below summarizes the time after pumping at which major deviations from the Theis type curve occurred during each pump test. With the exception of the first deviation noted for pump test #1, which occurred at a time of approximately 1 minute, the data indicate the presence of two sandstone boundaries. The first boundary was encountered most quickly when the aquifer was pumped at a rate of 5 gpm, at t approximately equal to 7 minutes.



breaks could be due to unconfined conditions such as dewatering of aquifer

TIME AFTER PUMPING AT WHICH DEVIATION FROM THEIS CURVE OCCURRED (MIN)

TEST	DISCHARGE (GPM)	DELAYED YIELD	FIRST BOUNDARY	SECOND BOUNDARY
PT #1	1	1-3	12	34
PT #3	5		7	20
PT #5	2		10	40

This same boundary was subsequently encountered at times of approximately 10 minutes and 12 minutes for discharges of 2 and 1 gpm. The second boundary, which was clearly located at a greater distance from the pump well, was encountered at times of 20, 40, and 34 minutes for pumpages of 5, 2, and 1 gpm, respectively. The more rapid response to the smaller discharge rate of 1 gpm compared to the response to discharge of 2 gpm may be attributed to measurement error.

The possibility that delayed yield effects could have contributed to the initial deviation of drawdown between 1 and 3 minutes for Q = 1 gpm was somewhat discounted by the fact that "flattening" of the drawdown vs. time plot did not occur at larger discharges, when delayed yield effects in the unconfined aquifer would have become more dominant. It is much more likely that the small observed changes in drawdown for pump test #1 at early time were related to measurement error and not to any physically-based phenomenon. Therefore no dewatering of the aquifer ?

? what flattening at early times?

As previously mentioned, it was not possible to evaluate the data observed at the GBR-14 pump well for boundary locations because of the mathematical limitations of the analytical methods. The first boundary appears to correspond to the western edge of the arroyo closest to GBR-14 and the second boundary corresponds to the eastern edge of the arroyo located further from the pump well. The fact that the time to respond to the second boundary is more than three times the time to respond to the first boundary suggests, according to the "law of times", that the second boundary is at least 1.7 times farther from GBR-14 than the first boundary (Todd, 1972).

how ?

No attempt was made to incorporate the effects of partial-penetration into the analysis because there are no methods available to account for its effect on drawdown data observed at the pump well. Pump test data observed at GBR-14 are listed in Tables C6, C8 and C10.

ANALYSIS OF RECOVERY DATA AT GBR-14

Recovery data observed at GBR-14 consistently plotted as S-shaped or convex-downward curves on semi-log paper, typical of recovery under partially-penetrating conditions when a low-conductivity barrier is present upgradient of the recovery site (see Figures 12, 15 and 18). During early recovery times (large t/t'), recovery is very slow because replenishment of the aquifer is occurring only from those directions where lateral flow is not inhibited by the presence of boundaries. The extent of distortion of the recovery rate depends on the location of the boundary relative to the natural hydraulic gradient. Moreover, upward vertical flow near the partially-penetrating recovery well produces smaller drawdown than would otherwise be observed under conditions of full penetration. As the well becomes replenished at intermediate values of t/t', vertical flow components diminish and drawdown approaches that which would occur in a fully-penetrating well in a finite aquifer. At later recovery stages, the rate of replenishment is no longer distorted by vertical flow components, but is still dominated by the occurrence of inhibited flow from upgradient barriers. Lack of replenishment from the vicinity of sandstone boundaries along the edges of the arroyo is considered to be the cause of low transmissivities estimated from late-recovery (small t/t') straight-line fits to the recovery data from pump tests 2, 4, and 6. Transmissivities of 95.0, 17.1, and 34.7 gpd/ft estimated on the basis of late recovery data from these tests were not considered to be representative of the alluvial aquifer due to persistent boundary influences. Longer-duration recovery observations would presumably have yielded smaller slopes on the semi-log plots and large corresponding transmissivities. Recovery data observed at GBR-14 are listed in Tables C7, C9 and C11.

ANALYSIS OF DRAWDOWN DATA AT GBR-15

Five drawdown values were obtained at observation well GBR-15 during pump test #5 when GBR-14 was pumped at a rate of 2 gpm. A double-log plot of the data exhibited an overall shape characteristic of drawdown in an aquifer stressed by a partially-penetrating well (see Figure 19). Using parameters related to the geometry of pump and observation well screened intervals, the Hantush modification of the Theis method was used to analyze the drawdown data observed at GBR-15.

Parameters used in defining the modified type curve are shown in Figure 21. Although values of b, b,, d, and z varied during the course of the test as water levels declined, the modified type curve remained essentially unchanged regardless of whether initial or final parameters were used.

Transmissivity estimated using the modified type curve was equal to 128.2 gpd/ft, which storativity was estimated as 0.0045. These small values of T and S relative to those observed at GBR-14 are presumably related to the greater predominance of clayey and silty sands and lower percentages of gravel in the vicinity of GBR-15 relative to those near GBR-14.

similar to values calculated from recovery data

Upward deflection of drawdown data from the modified type curve at t=100 minutes (see Figure 19) was probably the result of the interception of a clay lens or sandstone at the edge of the arroyo by the expanding cone of depression at GBR-14. Judging from the rapid increase in drawdown at GBR-15 and the time associated with this increase, this boundary most likely corresponds to the second boundary encountered by the pump well. The distance to this boundary was estimated using the Stallman method to account for a discharging image well situated on the far side of the boundary. The image well was calculated to be located roughly 40 feet from GBR-15. These results agreed with the image-well location obtained using a semi-log plot of the data shown in Figure 20 and the "law of times", which was estimated to be 60 feet from GBR-15. Assuming that the edge of the sandstone was to the east of GBR-15, the boundary was estimated to be located up to 10 feet away from GBR-15. Geologic cross-sections appear, in fact, to indicate a rapid gradation of alluvium into sandstone to the east of this well. More accurate specification of the edge of the alluvium would have been possible on the basis of data from an additional observation well.

Saturated aquifer thickness obtained using the Hantush modification of the Theis curve (Kruseman and DeRidder, 1970) was roughly 75 feet in the vicinity of the pump test site (see Figure 19). Assuming an average depth to water of 33 feet in this area, the alluvium was determined to be approximately 108 feet deep. ?

CONCLUSIONS

Average transmissivity of the unconfined alluvial aquifer in the vicinity of GBR-14 was estimated to be 790 gpd/ft. Assuming an average saturated thickness of 75 feet, this translates into a hydraulic conductivity of 10.5 gpd/ft^2. This is within the range of conductivity representative of silty sand (Freeze and Cherry, 1978). but logs shows sands & gravel

Although transmissivity of the alluvial aquifer was only twice as large as the maximum sandstone transmissivity of the 387 gpd/ft in the diesel spill area, the hydraulic conductivity of the alluvium could be an order of magnitude larger when differences in saturated thicknesses are considered. Thus, the sandstone acts as a low-conductivity barrier when encountered by lateral stresses induced by pumpage of the adjacent alluvium.

Transmissivity of the alluvium near GBR-15 was estimated to be 128 gpd/ft, which was equal to a hydraulic conductivity of 1.7 gpd/ft^2. This value of conductivity is within the lower part of the range normally associated with silty sand (Freeze and Cherry, 1978). Storativity near GBR-15 was estimated as 0.0045, a value indicative of partially-confined conditions which may be encountered in the presence of areally-extensive clay lenses.

Sandstone boundaries on both the eastern and western edges of the arroyo were evident from the drawdown data.

The saturated thickness of the alluvial aquifer near GBR-14 was estimated to be roughly 75 feet, with the total thickness of the alluvium amounting to roughly 108 feet.

ANALYSIS OF DRAWDOWN DATA AT GBR-26, GBR-30, AND THE STEEL WELL No measurable drawdown response was observed in wells GBR-26, GBR-30, and the steel well 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 which was also screened in these layers, it is likely that silt has migrated through the gravel pack and lodged in the screen 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.

RECOMMENDATIONS

Fully-penetrating wells, particularly those intended as pump wells for pump-test analysis, should be constructed whenever economically feasible. Methods do exist for analyzing pump-test data in the presence of a partially-penetrating pump well, but they are not as reliable as the more conventional Theis and Jacob methods of analysis.

As many observation wells as possible should be monitored during pump testing, for as long a duration as possible. Data recorded at the wells can be used to analyze for non-ideal influences relating to boundaries and partial penetration, while data observed at pump wells is usually worthless for characterizing non-ideal behavior because the effective well radius is unknown, well losses distort drawdown data, and many equations become indeterminate when applied to observations from the pump well.

Longer-duration recovery should be allowed in order to minimize problems associated with boundaries and partial-penetration effects. Yes

FIGURES AND TABLES FOR
GBR-14 PUMP TEST

Summary of Pump Tests:

Pump Test 1 - GBR-14 pumped at 1 gpm
Pump Test 2 - Recovery from pump test 1
Pump Test 3 - GBR-14 pumped at 5 gpm
Pump Test 4 - Recovery from pump test 3
Pump Test 5 - GBR-14 pumped at 2 gpm
Pump Test 6 - Recovery from pump test 5

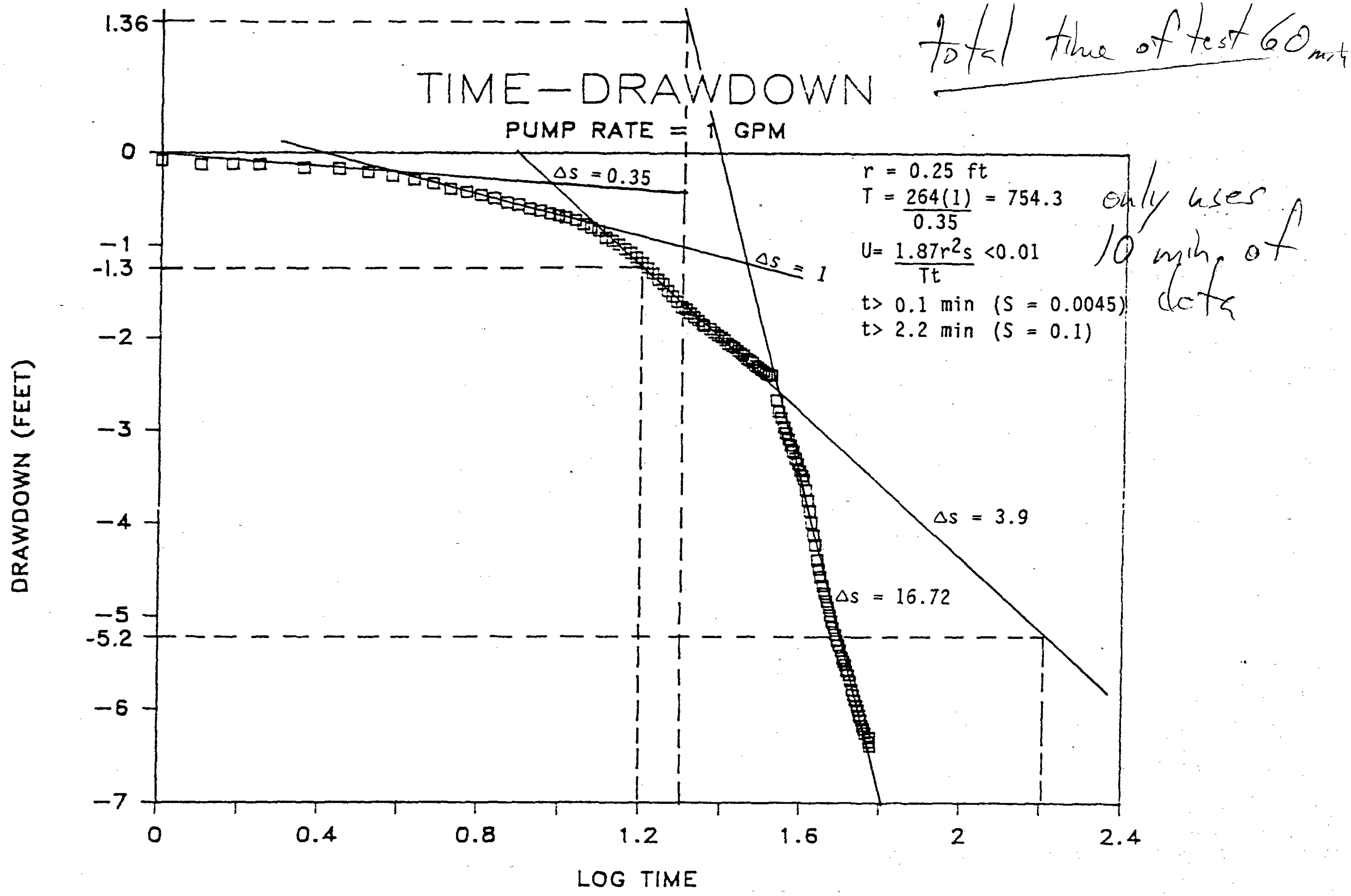


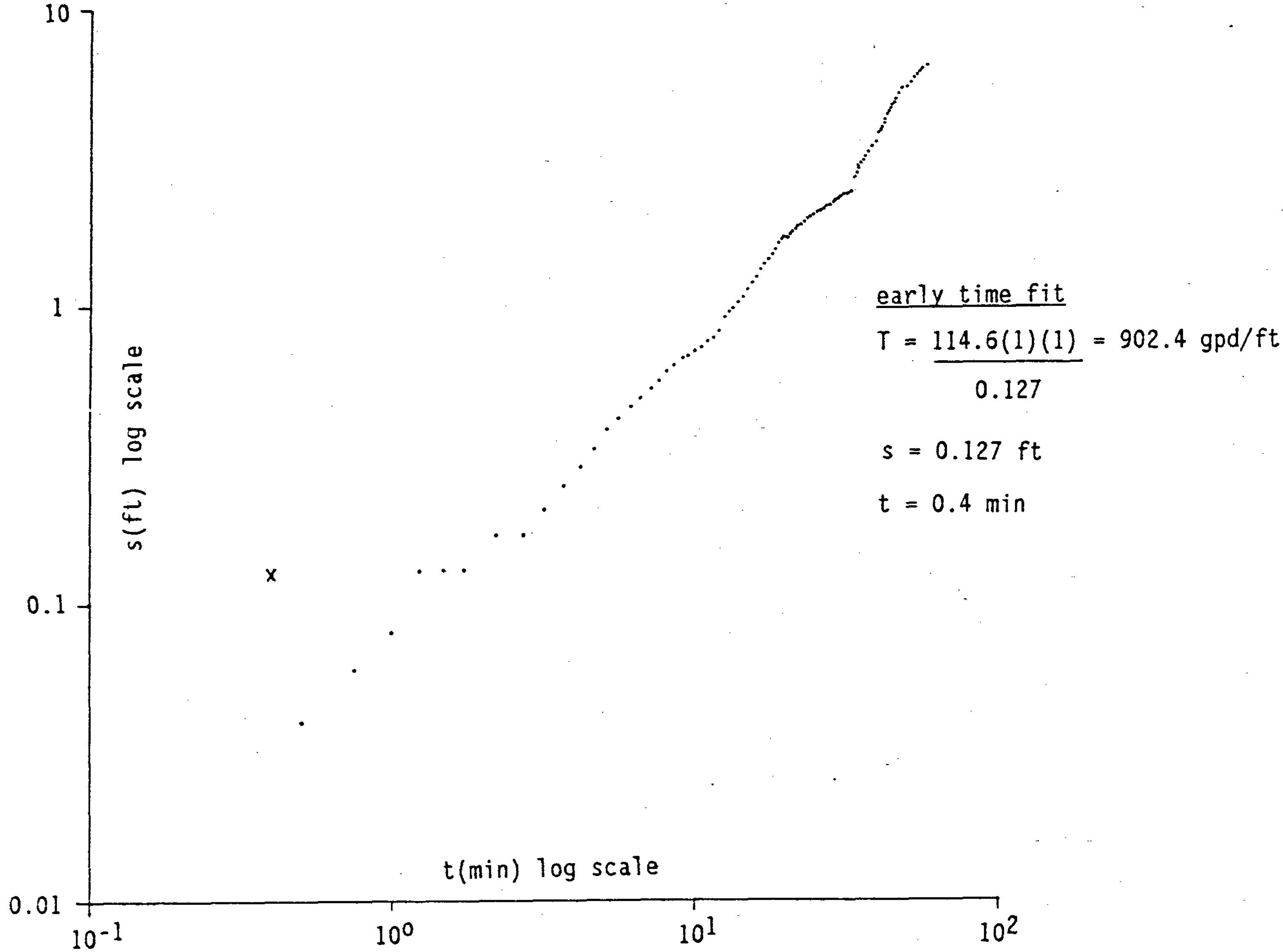
FIGURE 10

SEMILOG PLOT OF DRAWDOWN VS.

TIME FOR PUMP TEST 1 AT GBR - 14

FIGURE 11

DOUBLE LOG PLOT OF DRAWDOWN VS.
TIME FOR PUMP TEST 1 AT GBR – 14



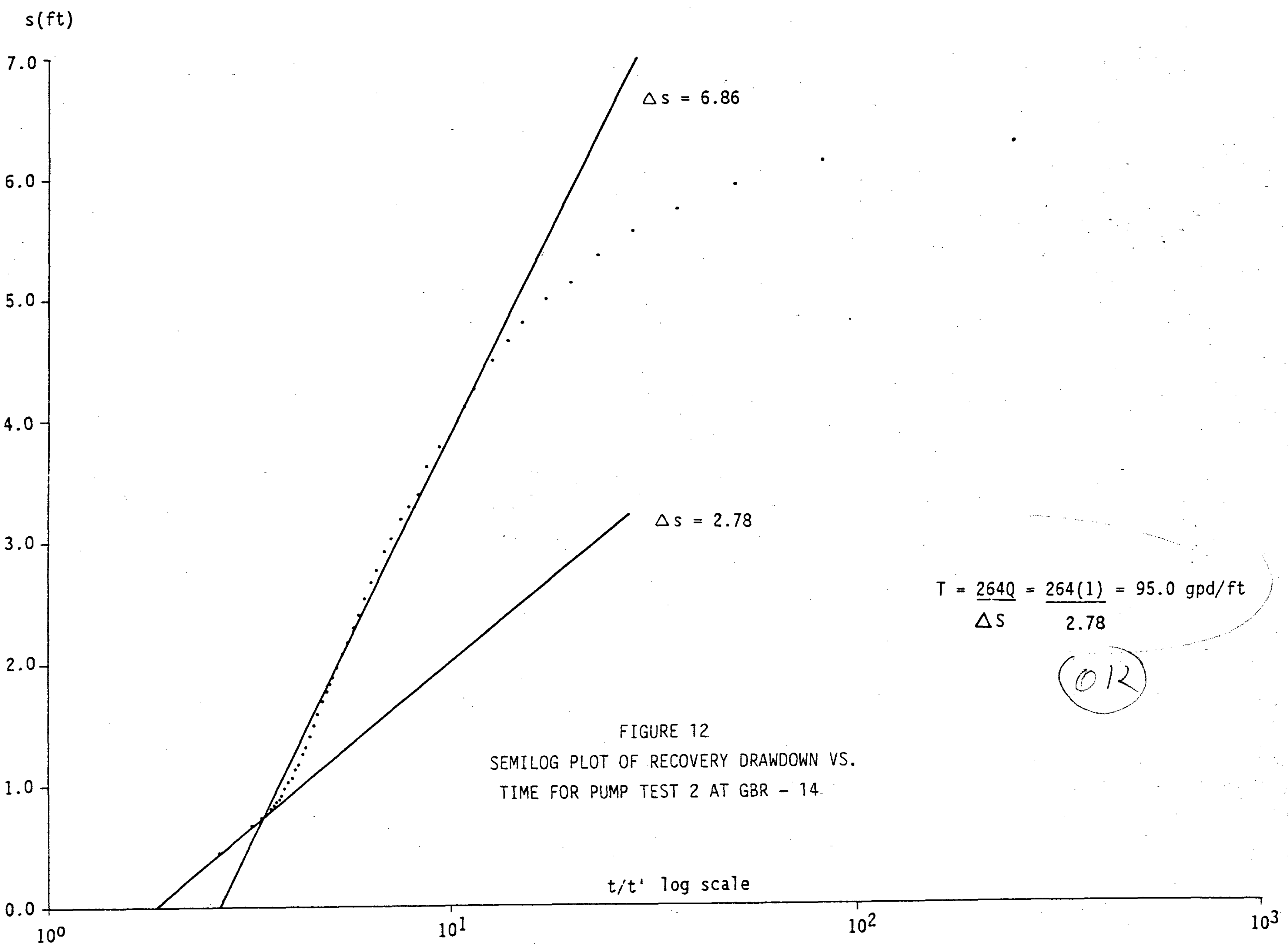


FIGURE 12
SEMILOG PLOT OF RECOVERY DRAWDOWN VS.
TIME FOR PUMP TEST 2 AT GBR - 14

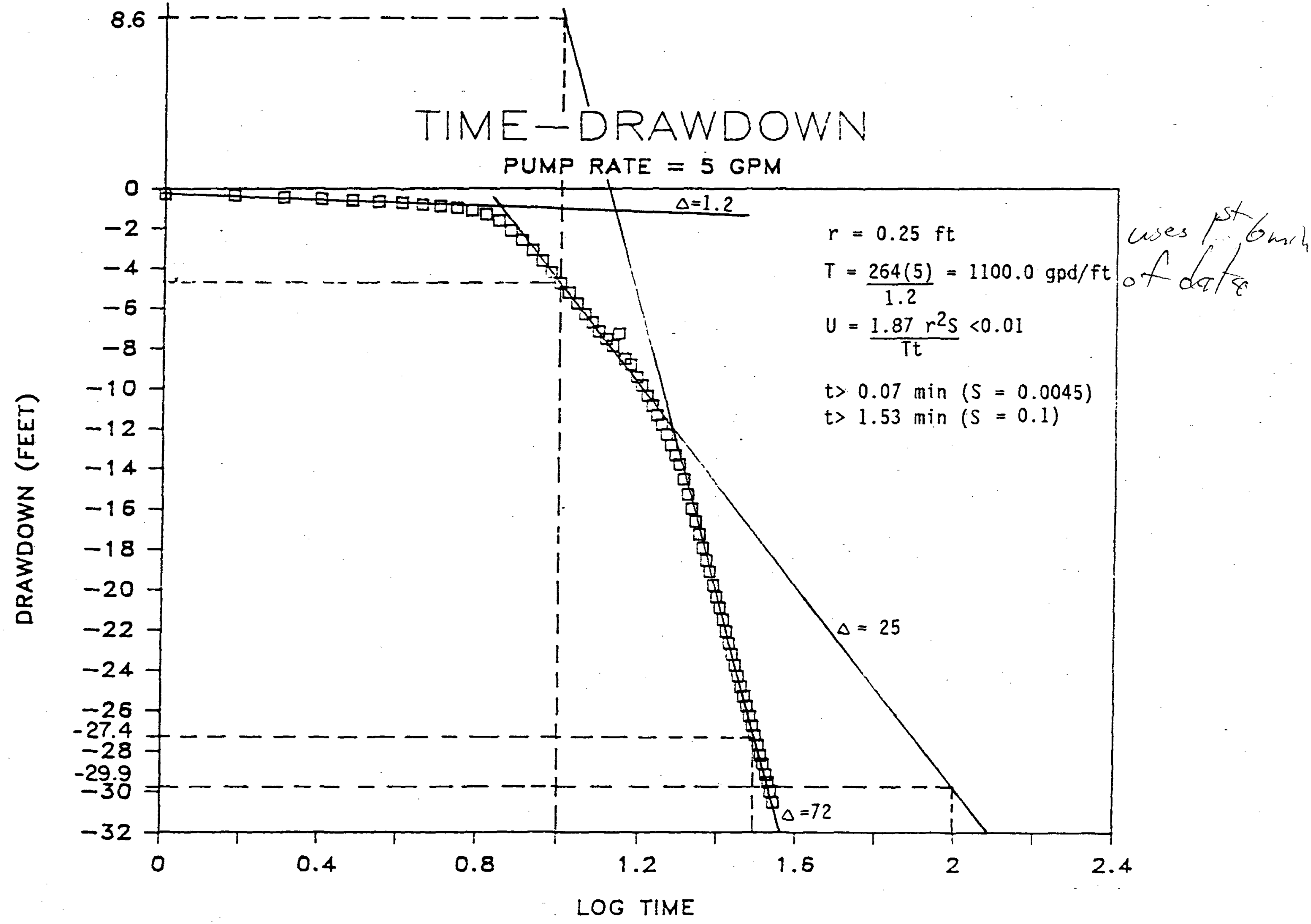


FIGURE 13

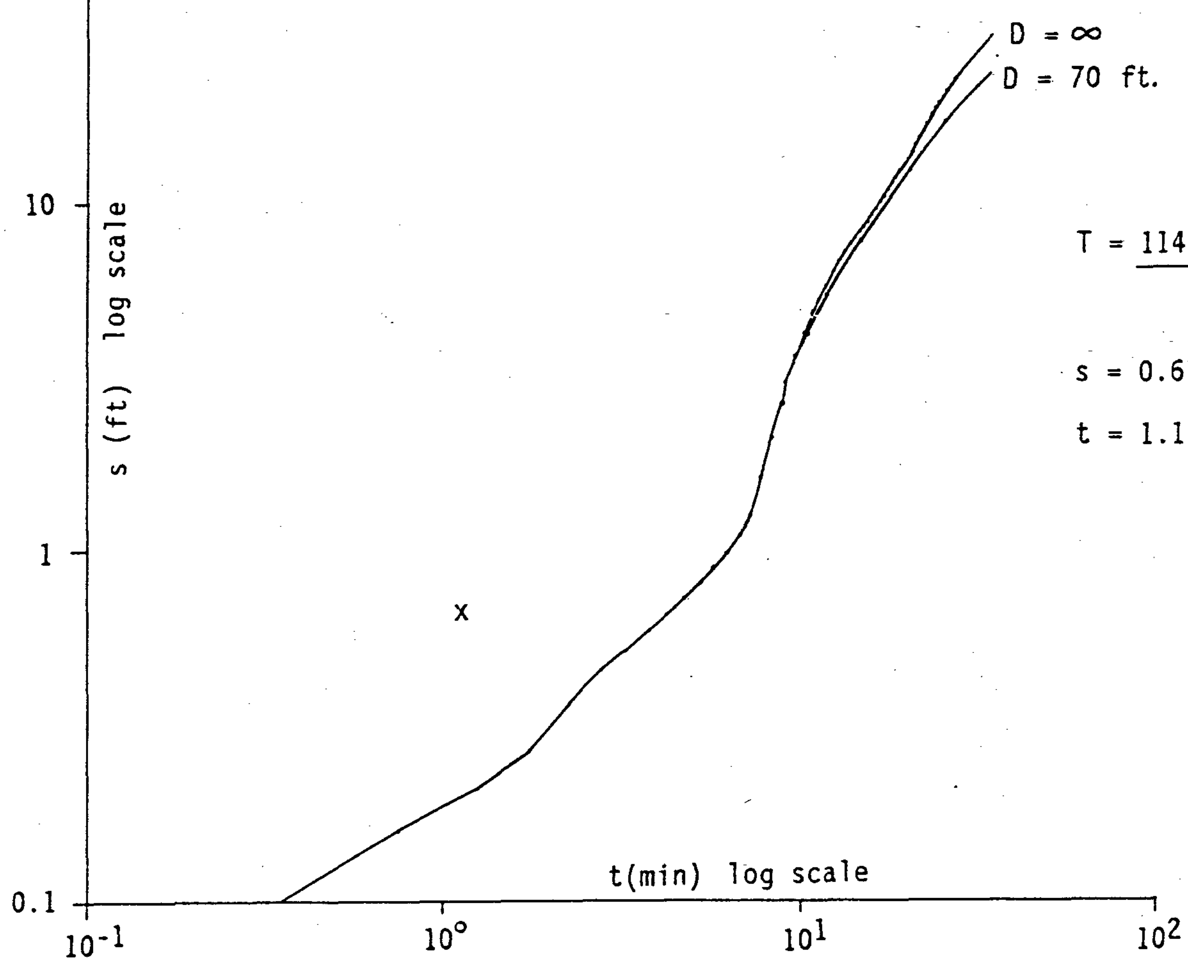
SEMILOG PLOT OF DRAWDOWN VS.

TIME FOR PUMP TEST 3 AT GBR - 14

FIGURE 14

DOUBLE LOG PLOT OF DRAWDOWN VS.

TIME FOR PUMP TEST 3 AT GBR - 14



$$T = \frac{114.6(5)(1)}{0.67} = 8\ 55.2 \text{ gpd/ft}$$

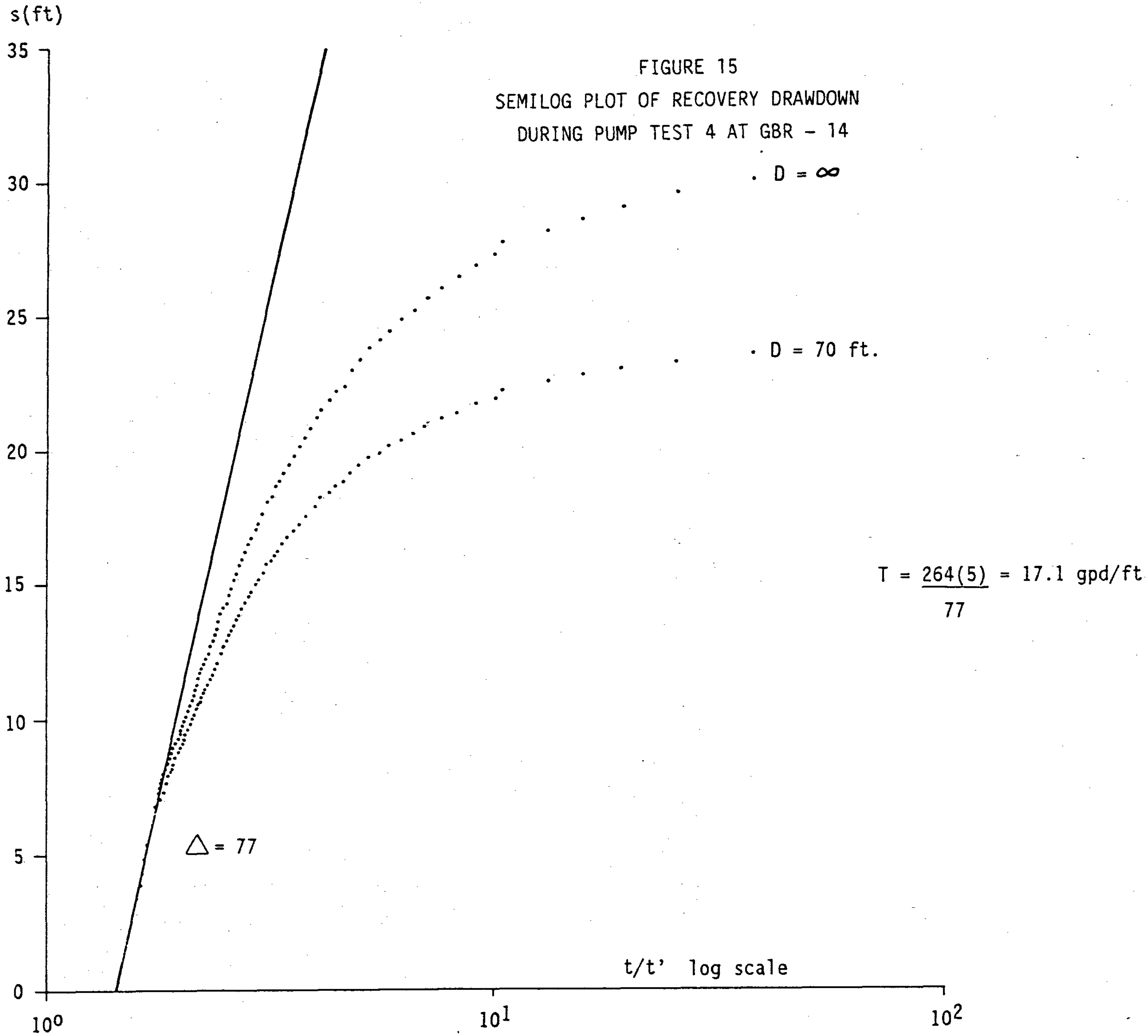
s = 0.67 ft

t = 1.1 min

FIGURE 15

SEMILOG PLOT OF RECOVERY DRAWDOWN

DURING PUMP TEST 4 AT GBR – 14



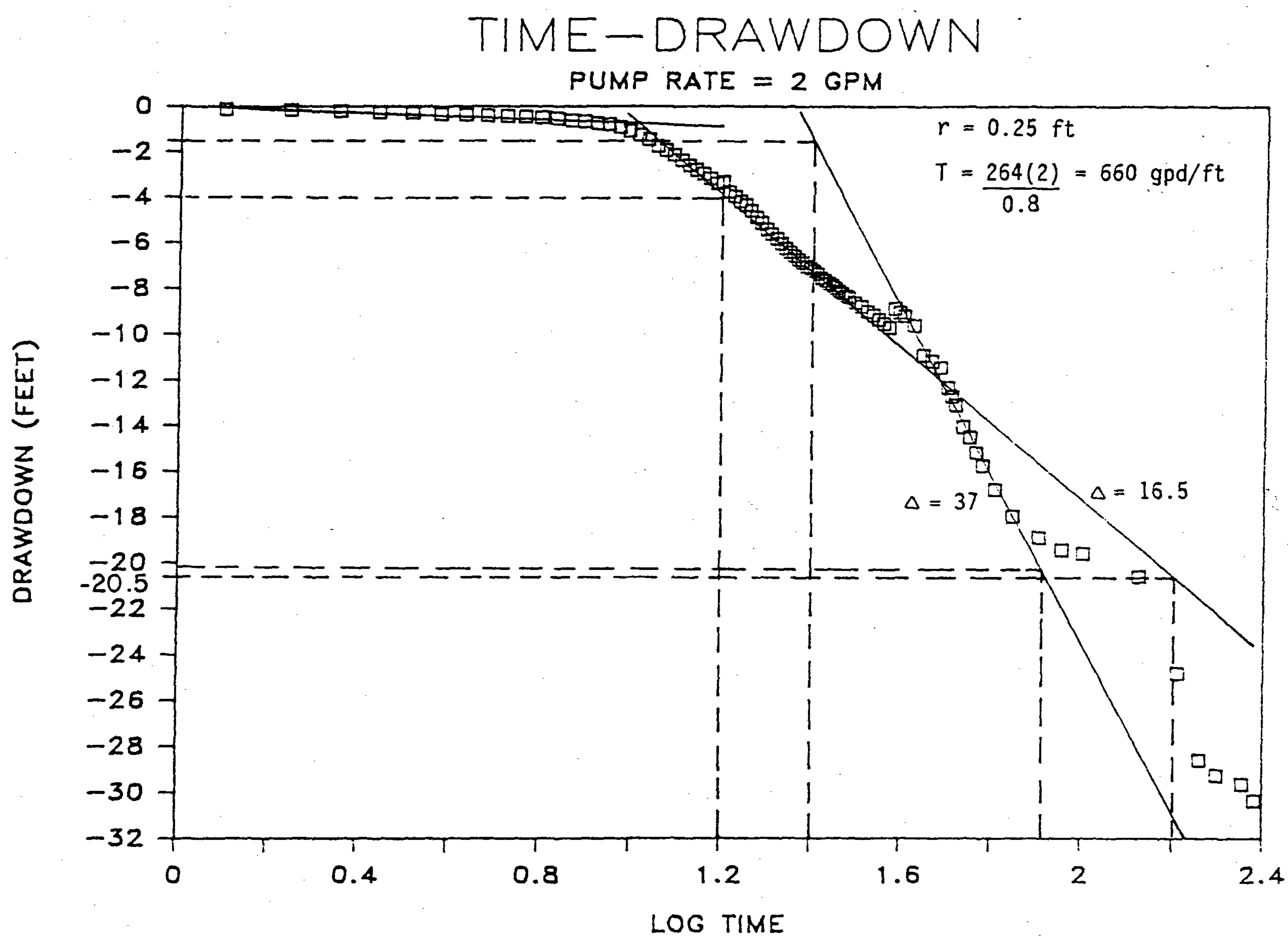


FIGURE 16

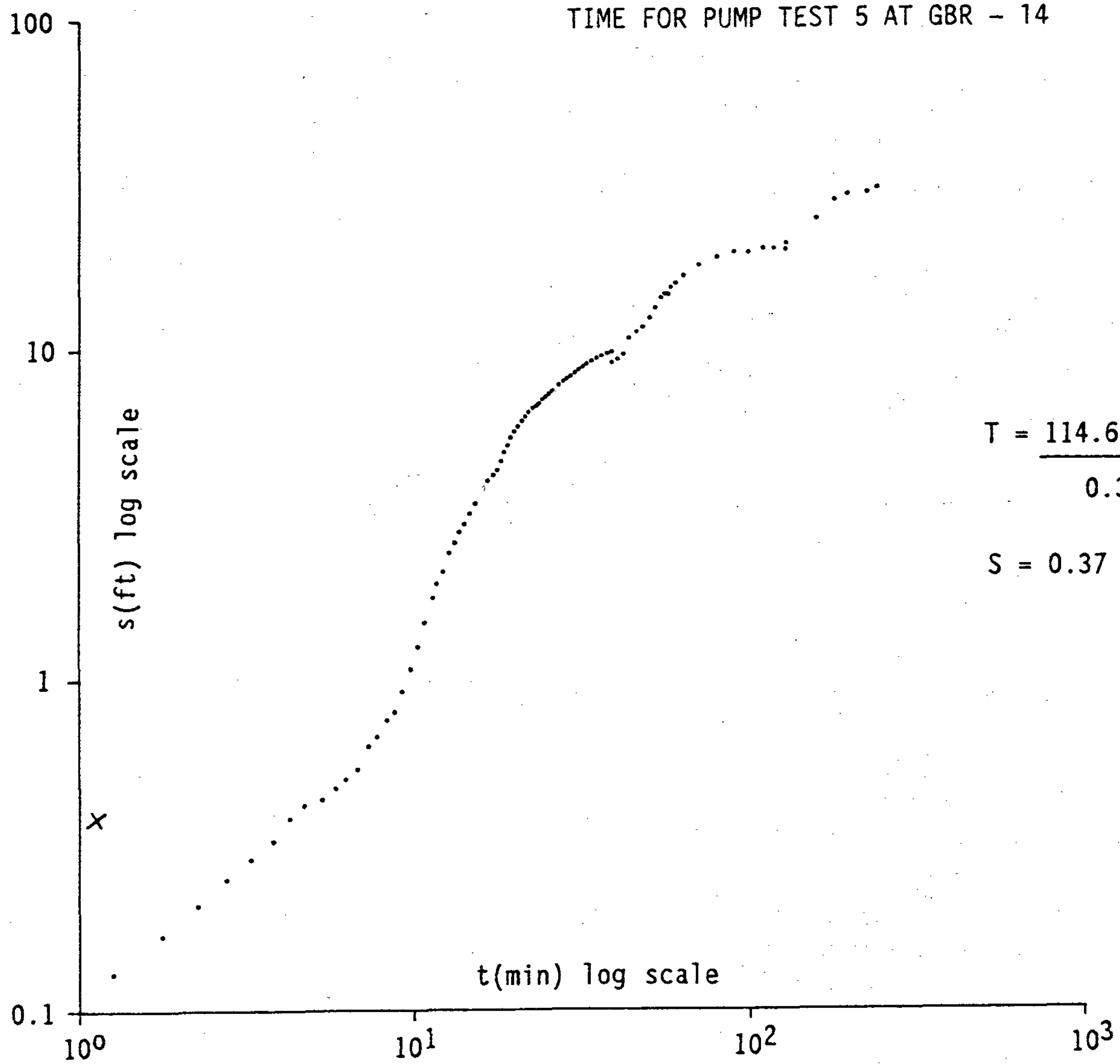
SEMILOG PLOT OF DRAWDOWN VS.

TIME FOR PUMP TEST 5 AT GBR - 14

FIGURE 17

DOUBLE LOG PLOT OF DRAWDOWN VS.

TIME FOR PUMP TEST 5 AT GBR - 14



$$T = \frac{114.6(2)(1)}{0.37} = 619.5 \text{ gpd/ft}$$

$$S = 0.37 \text{ ft}$$

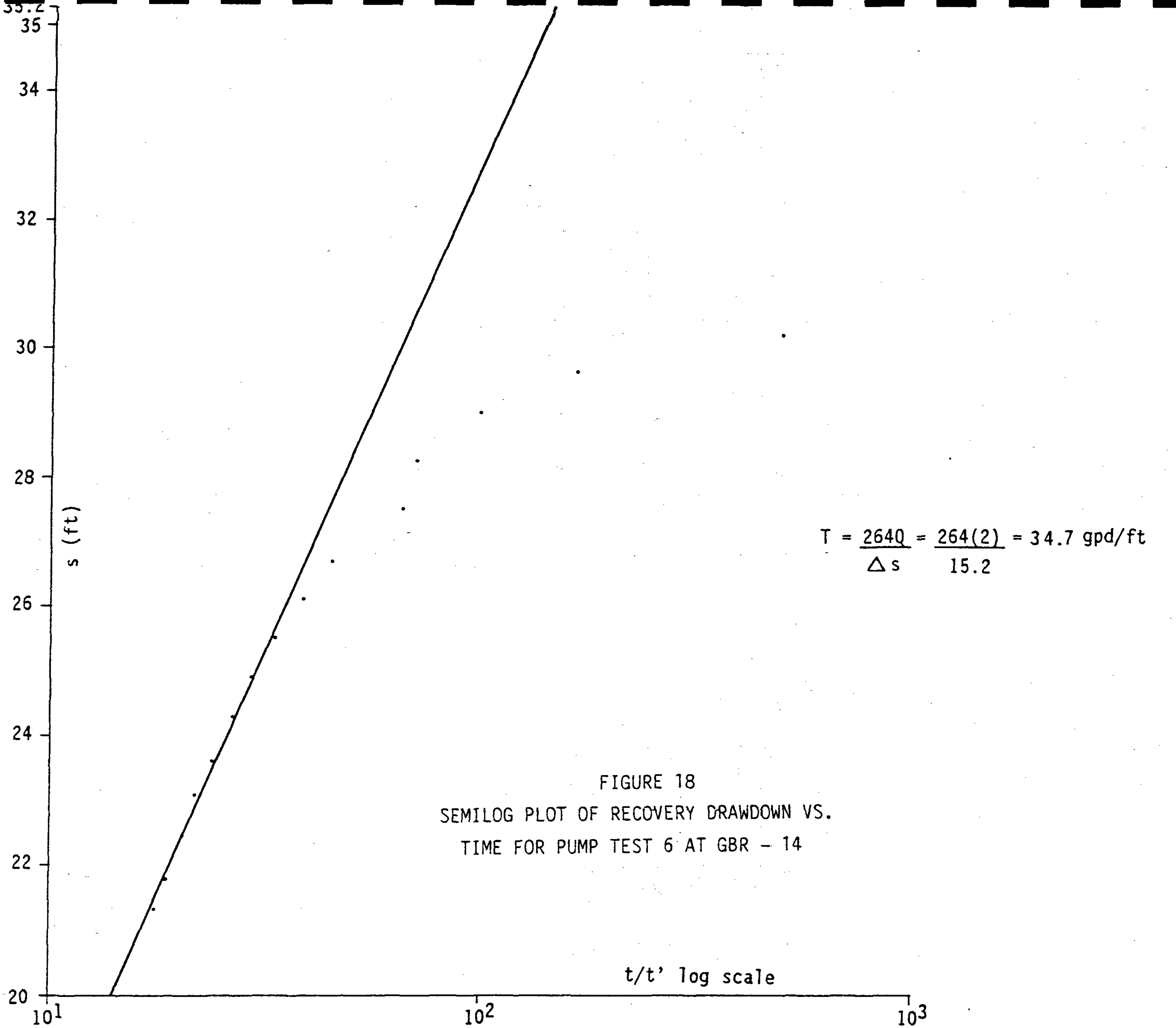
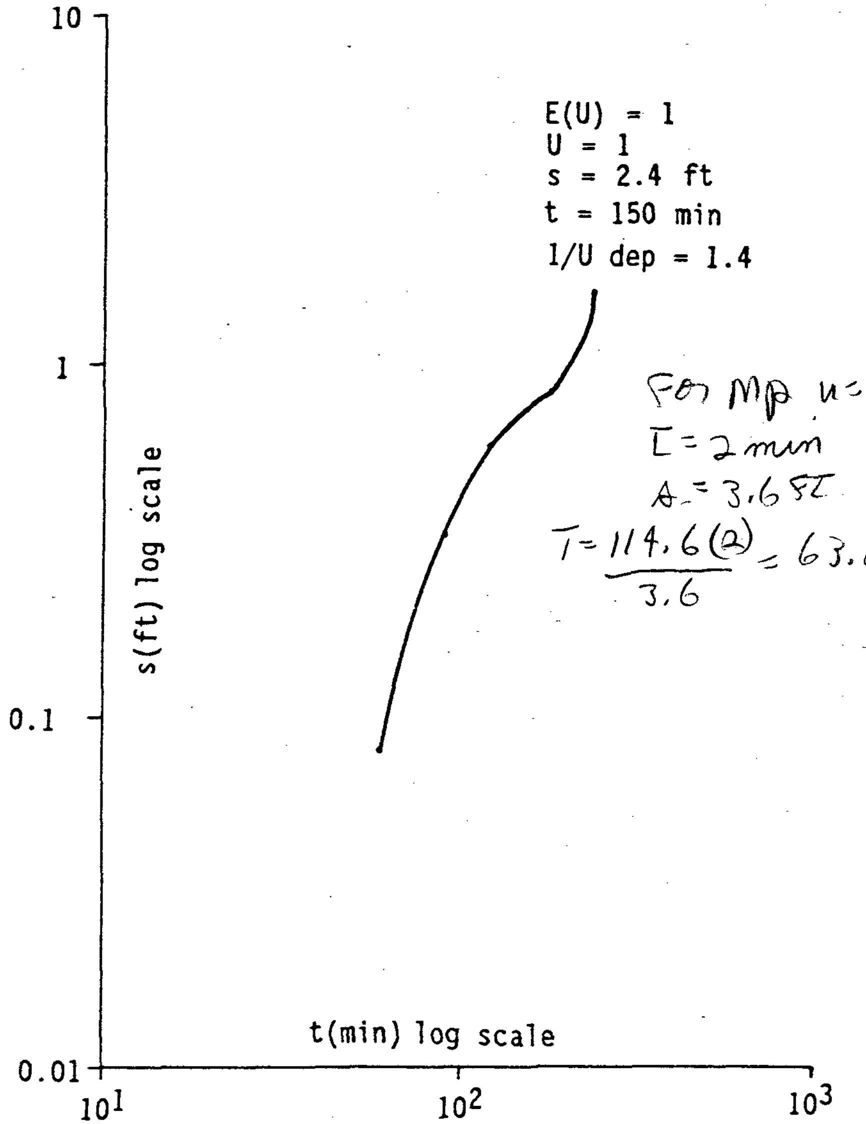


FIGURE 18
SEMILOG PLOT OF RECOVERY DRAWDOWN VS.
TIME FOR PUMP TEST 6 AT GBR – 14

FIGURE 19

DOUBLE LOG PLOT OF DRAWDOWN VS.

TIME FOR PUMP TEST 5 AT GBR – 15



$r = 40$ ft $\quad Q = 2\ \frac{gal}{min}\left(\frac{ft^3}{7.481\ gal}\right) = 0.2673\ ft^3/min$

$S = \frac{Q}{8''K(6-d)}\ E(u)$

$2.4 = \frac{0.2673}{8''K(28-0)}\ (1)$

$K = 1.58 \times 10^{-4}$ ft/min $\times$ 7.48 gal/ft³ $\times$ 1440 min/day = 1.7 gpd/ft²

$D = 0.5\left[b + 2 + r\sqrt{\frac{5}{Udep}}\right] = 0.5\left[28 + 16.75 + 40\sqrt{5(1.4)}\right]$

$= 75.3$ ft

$T = KD = 1.58 \times 10^{-4}\ (75.3) = 1.19 \times 10^{-2}\ ft^2/min,$

$= 1.19 \times 10^{-2}\ \frac{ft^2}{min}\left(\frac{1440\ min}{1\ day}\right)\left(\frac{7.48\ gal}{ft^3}\right),$

$= 128.2$ gpd/ft

$u = \frac{r^2 s}{4Tt}$

$1 = \frac{(40)^2 S}{4\ (1.19 \times 10^{-2})\ (150)}$

$S = 0.0045$

FIGURE 20

SEMILOG PLOT OF DRAWDOWN VS.
TIME FOR PUMP TEST 5 AT GBR - 15

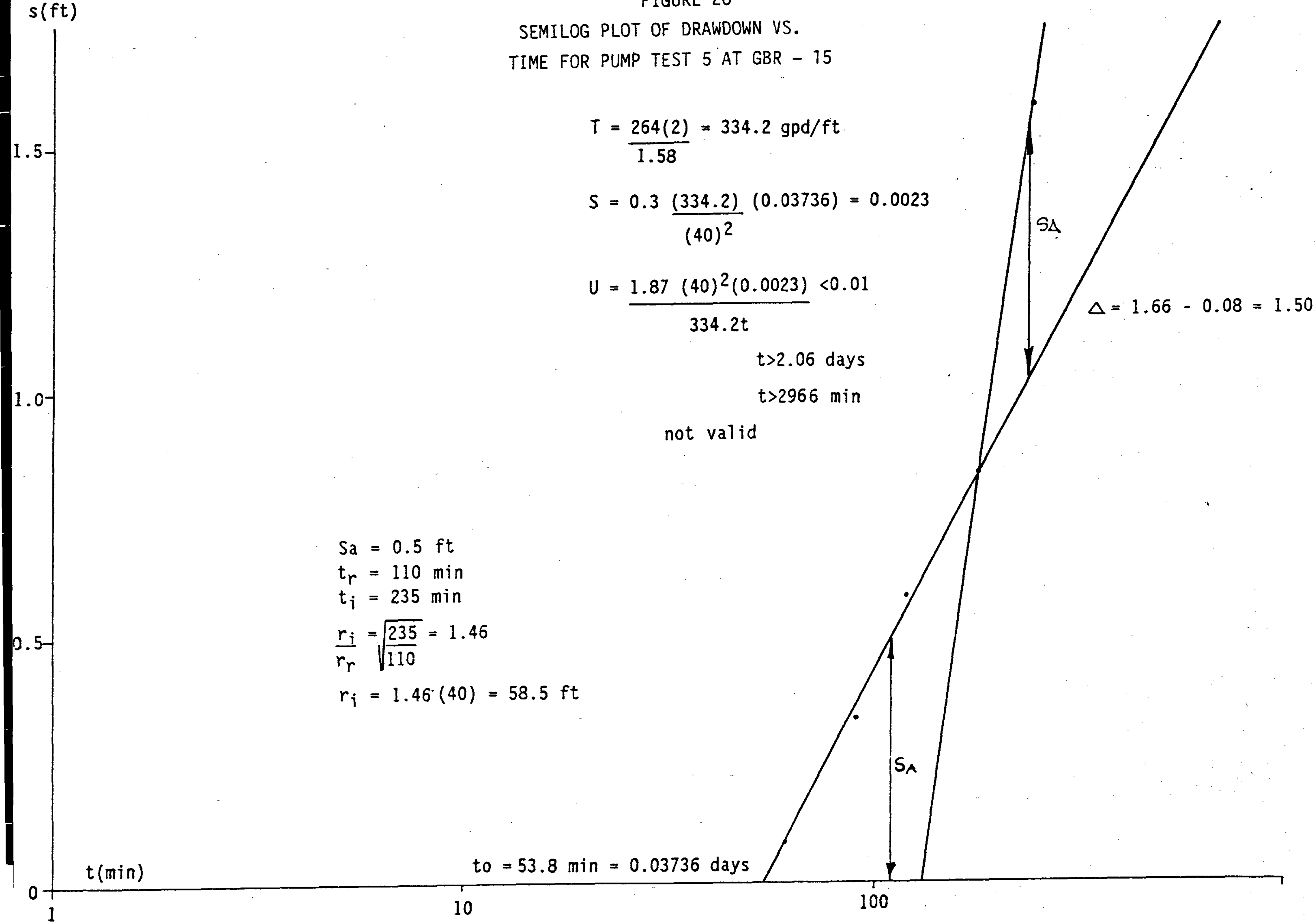


FIGURE 21
COMPLETION DIAGRAM
FOR GBR – 14 AND GBR – 15

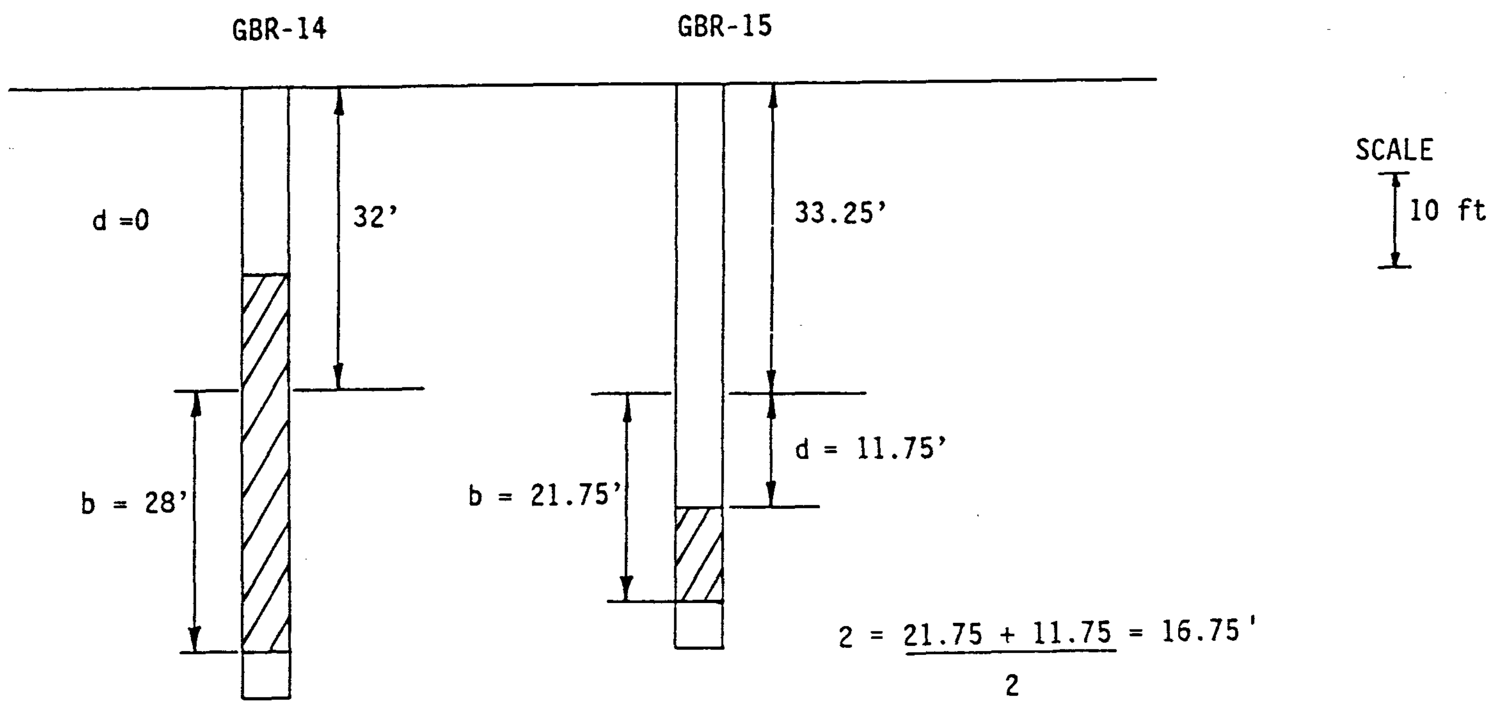


TABLE C6
DRAWDOWN MEASUREMENTS
GBR-14
Q = 1 gpm

PUMPTEST 1

TIME (minutes)	DEPTH TO WATER FEET	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 C6 (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 C6 (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 C7
RECOVERY MEASUREMENTS
GBR-14

PUMPTEST 2

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 C7 (CONT.)
RECOVERY MEASUREMENTS

PUMPTEST 2

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 C8
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 C8 (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 C9
RECOVERY MEASUREMENTS
GBR-14

PUMPTEST 4

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 C9 (CONT.)
RECOVERY MEASUREMENTS

PUMPTEST 4

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER 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 C9 (CONT.)
RECOVERY MEASUREMENTS

PUMPTEST 4

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 C10
DRAWDOWN MEASUREMENTS
GBR-14
Q = 2 gpm

PUMPTEST 5

TIME (minutes)	DEPTH TO WATER FEET	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 C10 (CONT.)
DRAWDOWN MEASUREMENTS

PUMPTEST 5

TIME (minutes)	DEPTH TO WATER FEET	DEPTH TO WATER 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 C10 (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 C11
RECOVERY MEASUREMENTS
GBR-14

PUMPTEST 6

TIME (minutes)	DEPTH TO WATER FEET	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

DIESEL SPILL AREA

GBR-14, GBR-27 AND GBR-28

Note:

1. The 3 wells were pumped simultaneously
2. All figures and tables are grouped together following the text

PUMP TEST - DIESEL SPILL AREA - GBR-14, GBR-27, AND GBR-28

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 shown in Figures 22-34 and Tables C12-C30 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.

Two pump tests had previously been performed in the diesel spill area. Drawdown at GBR-14 and GBR-27 had been observed at GBR-15 and GBR-25, respectively. Extension of drawdown at late times associated with the multiple-well pump test could not be performed for these wells using fitted Theis curves because of the non-ideal boundary effects at these wells. Moreover, drawdown data at all other observation wells due to separate pumpage at the three discharging wells was not available. Due to these limitations, recourse was made to predicting the drawdown at all observation wells using a simple computer program developed in-house and based on the Theis equation. Output from this program was considered to be a first approximation of drawdown generated by 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

$$W(u) = -0.5772 - \ln u + u - \frac{u^2}{2 \times 2!} + \frac{u^3}{3 \times 3!} - \frac{u^4}{4 \times 4!} + \frac{u^5}{5 \times 5!}$$

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. Average T and S estimated in the vicinity of GBR-14 were equal to 790 gpd/ft and 0.0045, while average T and S near GBR-27 were equal to 361.7 gpd/ft and 0.00022. 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 3 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 equal to 7000 gpd/ft and 0.03 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 (see Appendix B).

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.

The small values of T and S observed near GBR-27, the moderate values encountered near GBR-14, and the high values obtained near GBR-28 and near GBR-29 in the southern refinery area 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 (see Appendix B). 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.

Using the transmissivities and storativities obtained from all pump test analyses, it was possible to estimate the radius of influence at each pump well in the diesel spill area after 1 year of pumping at a rate of 1 gpm. Assuming that the cone of depression effectively extends out to all points at which a drawdown of 0.1 feet would occur, the radius of influence was determined using the Theis equation with a drawdown of 0.1 feet. Results of the calculations, assuming a horizontal water table, are listed below:

Well	T (gpd/ft)	S	Effective Radius of Influence (ft)
GBR-14	790.0	0.0045	3610
GBR-27	361.7	0.00022	16600
GBR-28	2100.0	0.02	1150

Not reasonable

The actual radius of influence would tend to be smaller than the predicted radius in the upgradient direction and larger in the downgradient direction, depending on the natural hydraulic gradient. The collective area within these three cones of depression extends well over the area of contamination, indicating that the recovery operation would be successful in intercepting floating product. In fact, pumpage at only GBR-14 and GBR-27 for a period of 15 hours would be sufficient to create an effective cone of depression of 150 feet that would be adequate to intercept the entire plume of floating product as it is currently defined. Steady-state conditions would not be attained at any of the wells after 1 year of recovery; the effective radius of influence would continue to expand for years in the moderately transmissive aquifer. In order to account for a sloping water table, recourse was made to utilizing a finite-difference flow model for defining the actual zone of capture induced by pumping in the diesel spill area.

Where are capture zone curves

FIGURES AND TABLES FOR

PUMP TEST OF GBR-14, 27 AND 28

Note:

1. Pumped wells - GBR-14, 27 and 28
2. Observation wells - GBR 15, 21S, 21D, 23, 24S, 24D, 25, 26, 30, Steel Well
3. Time-Drawdown Plots are presented followed by the corresponding tables of drawdown measurements

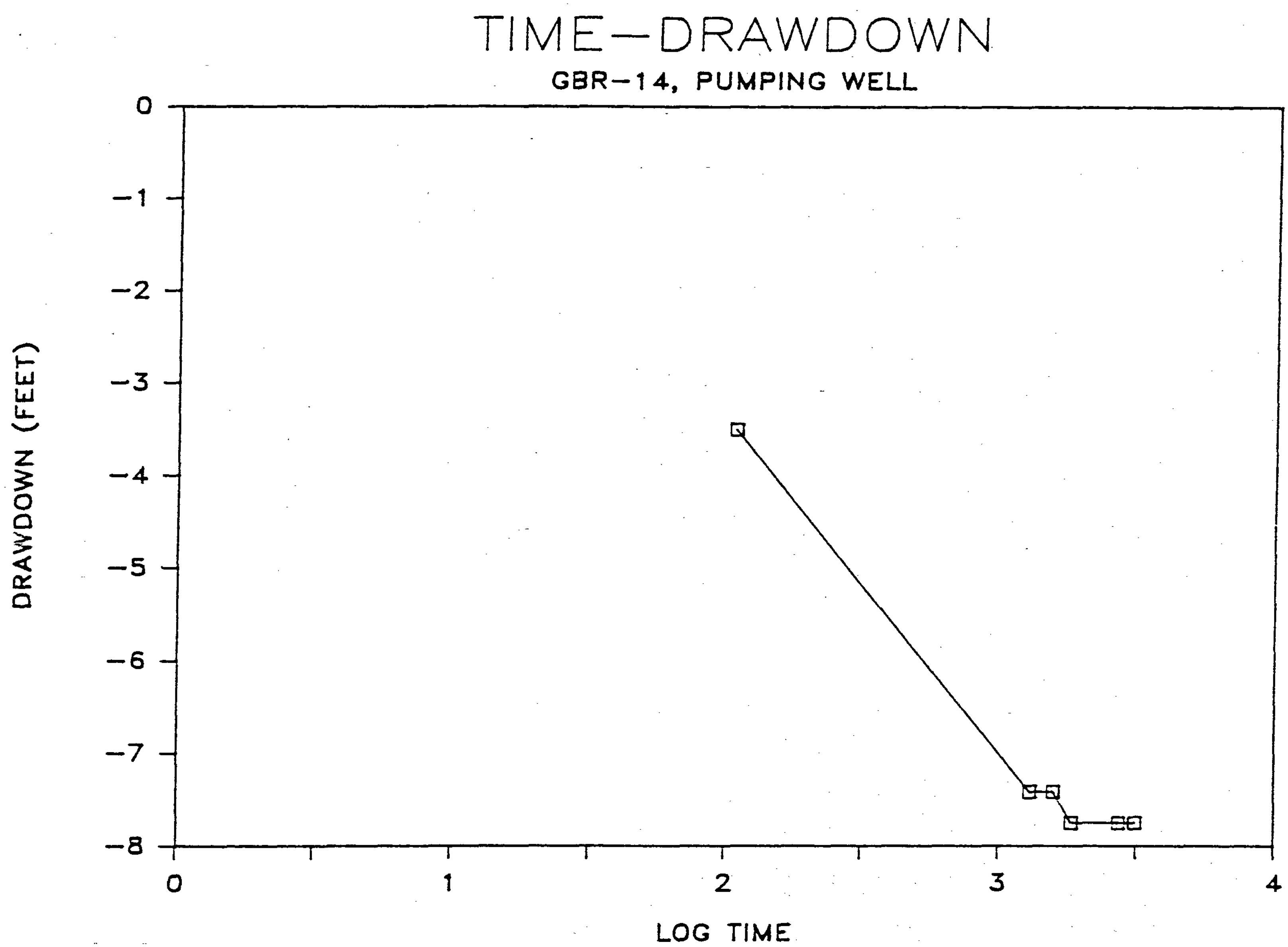

TIME—DRAWDOWN
GBR—14, PUMPING WELL
DRAWDOWN (FEET)
0
−1
−2
−3
−4
−5
−6
−7
−8
0
1
2
3
4
LOG TIME

FIGURE 22

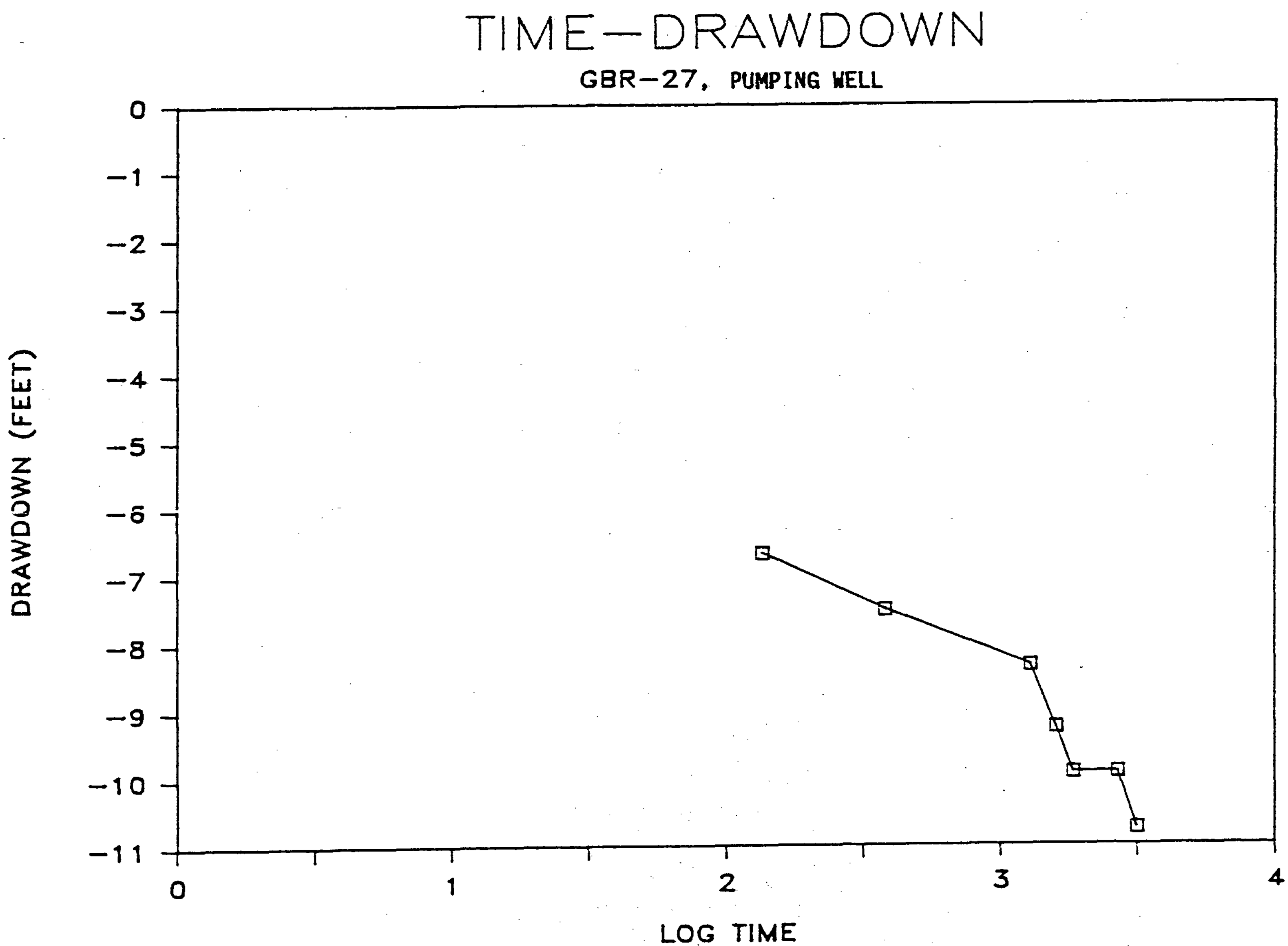

TIME—DRAWDOWN
GBR—27, PUMPING WELL
DRAWDOWN (FEET)
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
−10
−11
0
1
2
3
4
LOG TIME

FIGURE 23

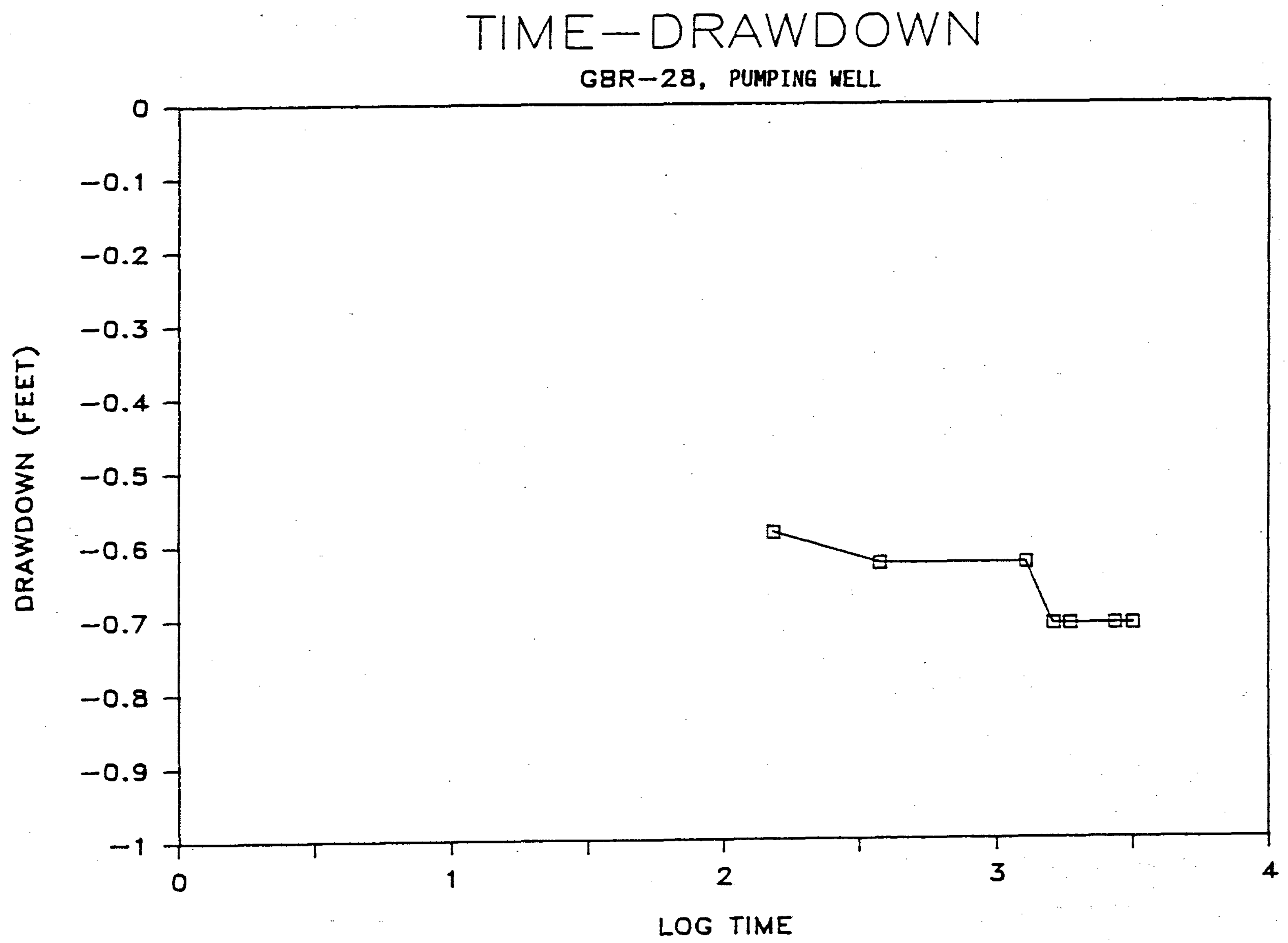
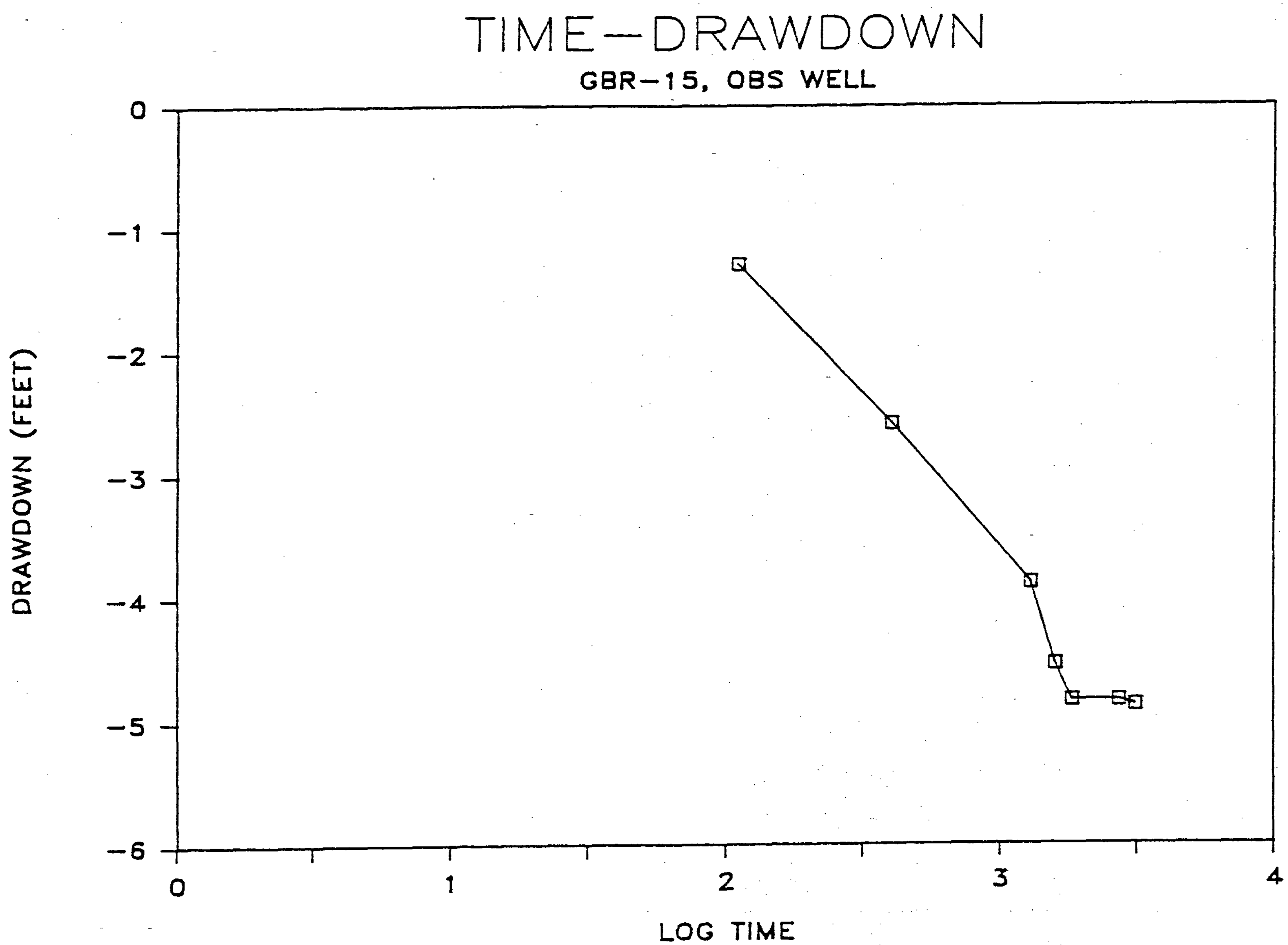
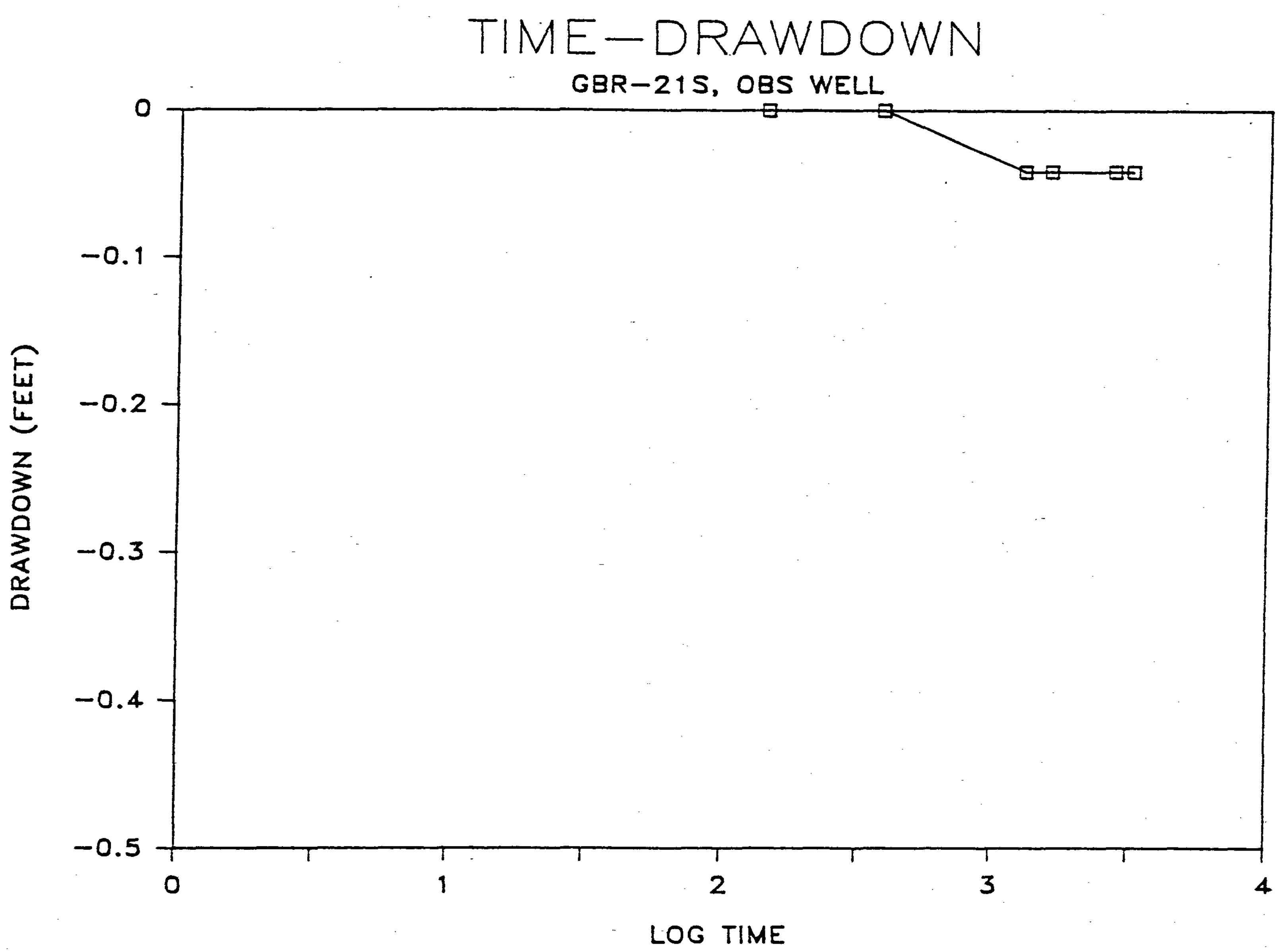

TIME—DRAWDOWN
GBR—28, PUMPING WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1
0
1
2
3
4
LOG TIME

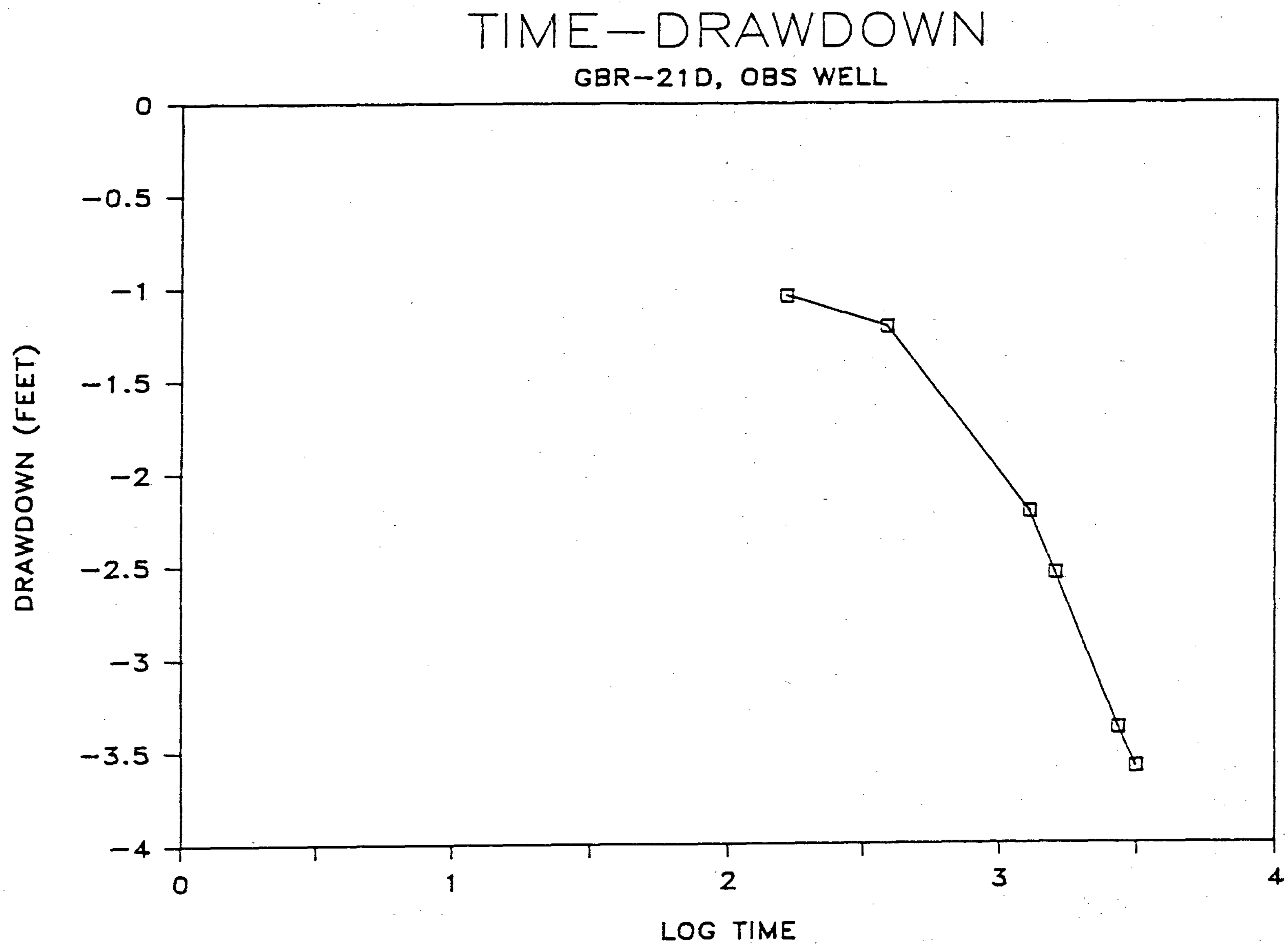
FIGURE 24


TIME—DRAWDOWN
GBR—15, OBS WELL
DRAWDOWN (FEET)
0
−1
−2
−3
−4
−5
−6
0
1
2
3
4
LOG TIME
FIGURE 25



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 26



TIME—DRAWDOWN
GBR—21D, OBS WELL
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4
DRAWDOWN (FEET)
0
1
2
3
4
LOG TIME

FIGURE 27

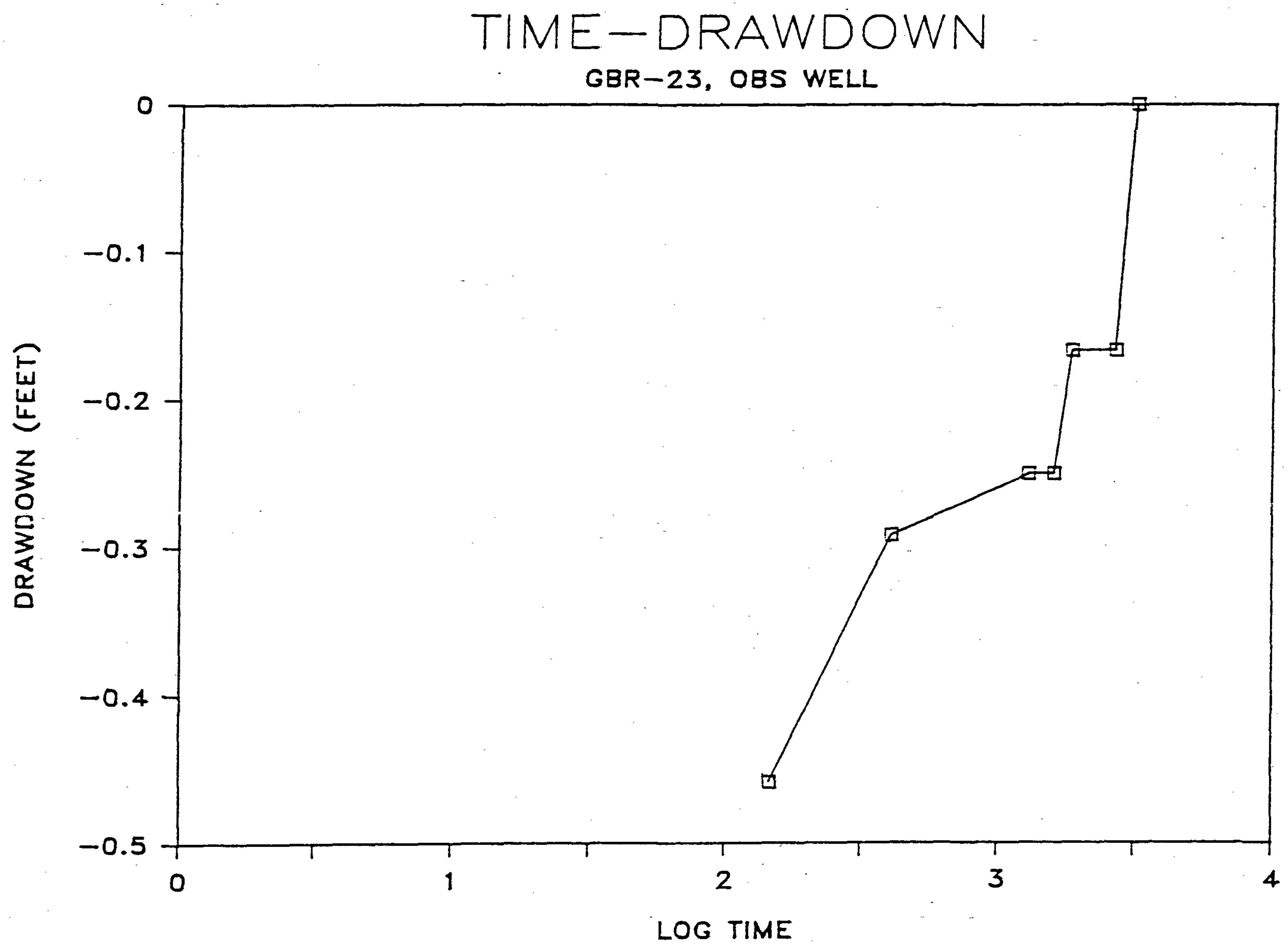

TIME—DRAWDOWN
GBR—23, OBS WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
0
1
2
3
4
LOG TIME

FIGURE 28

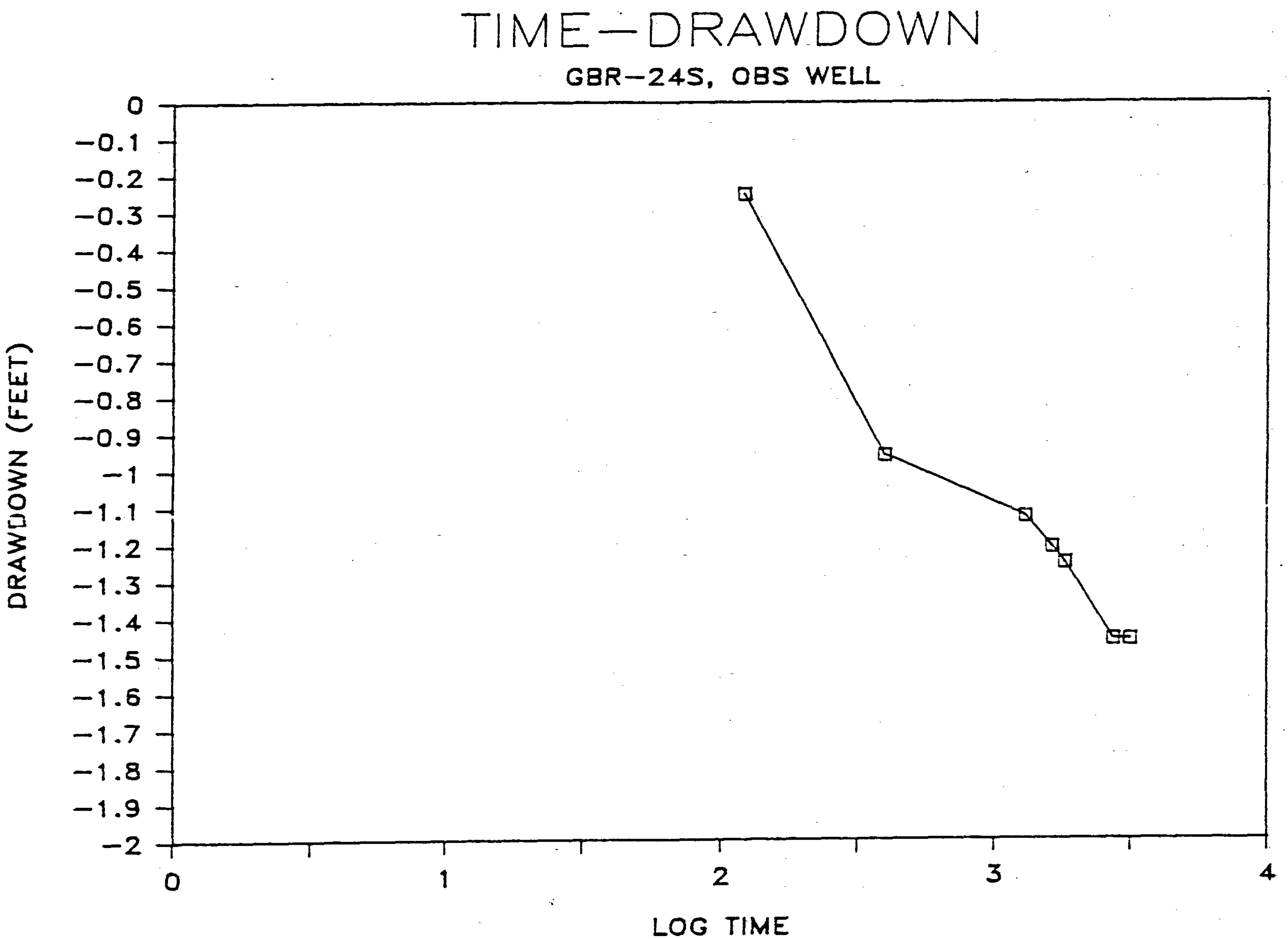
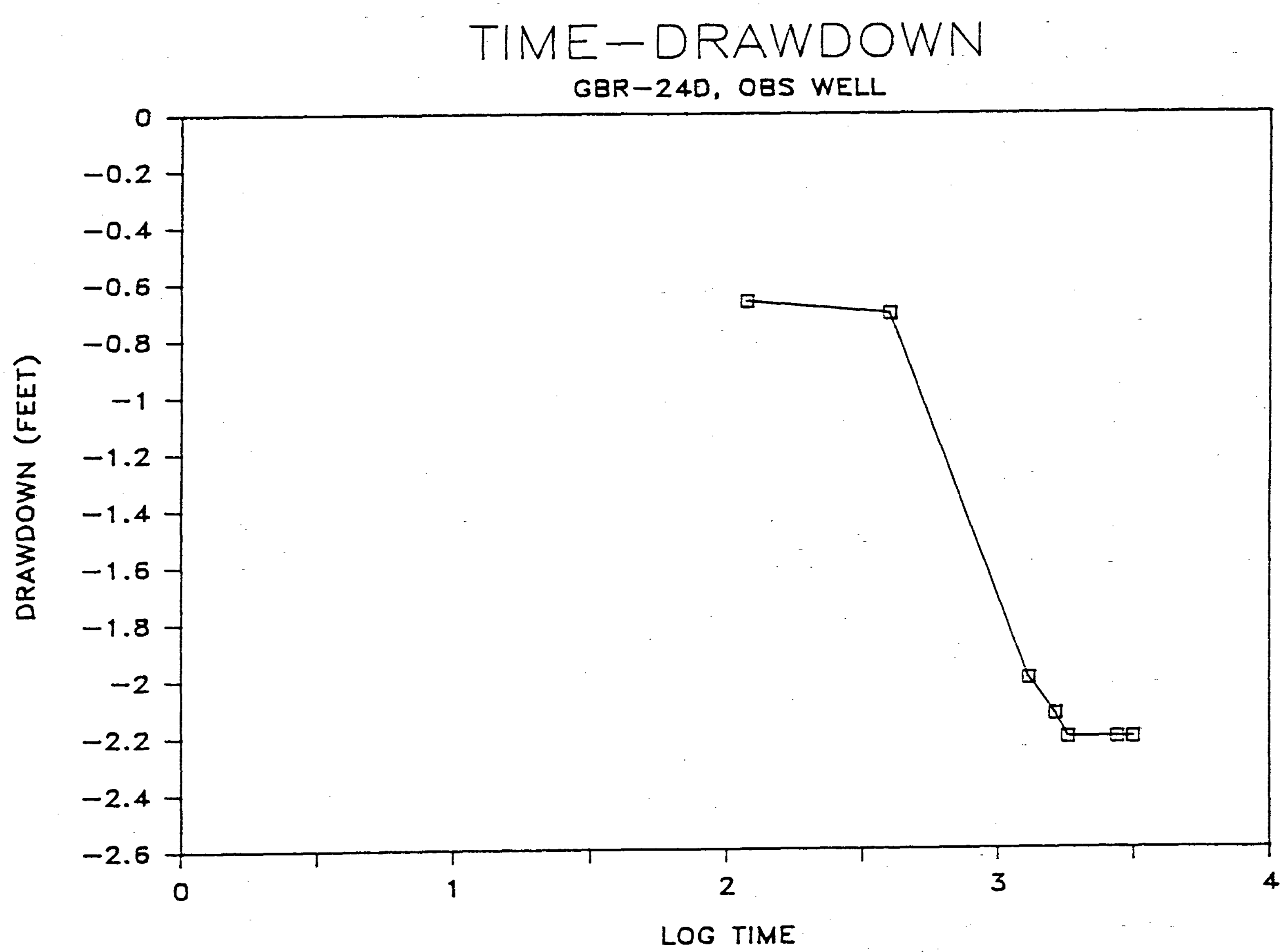
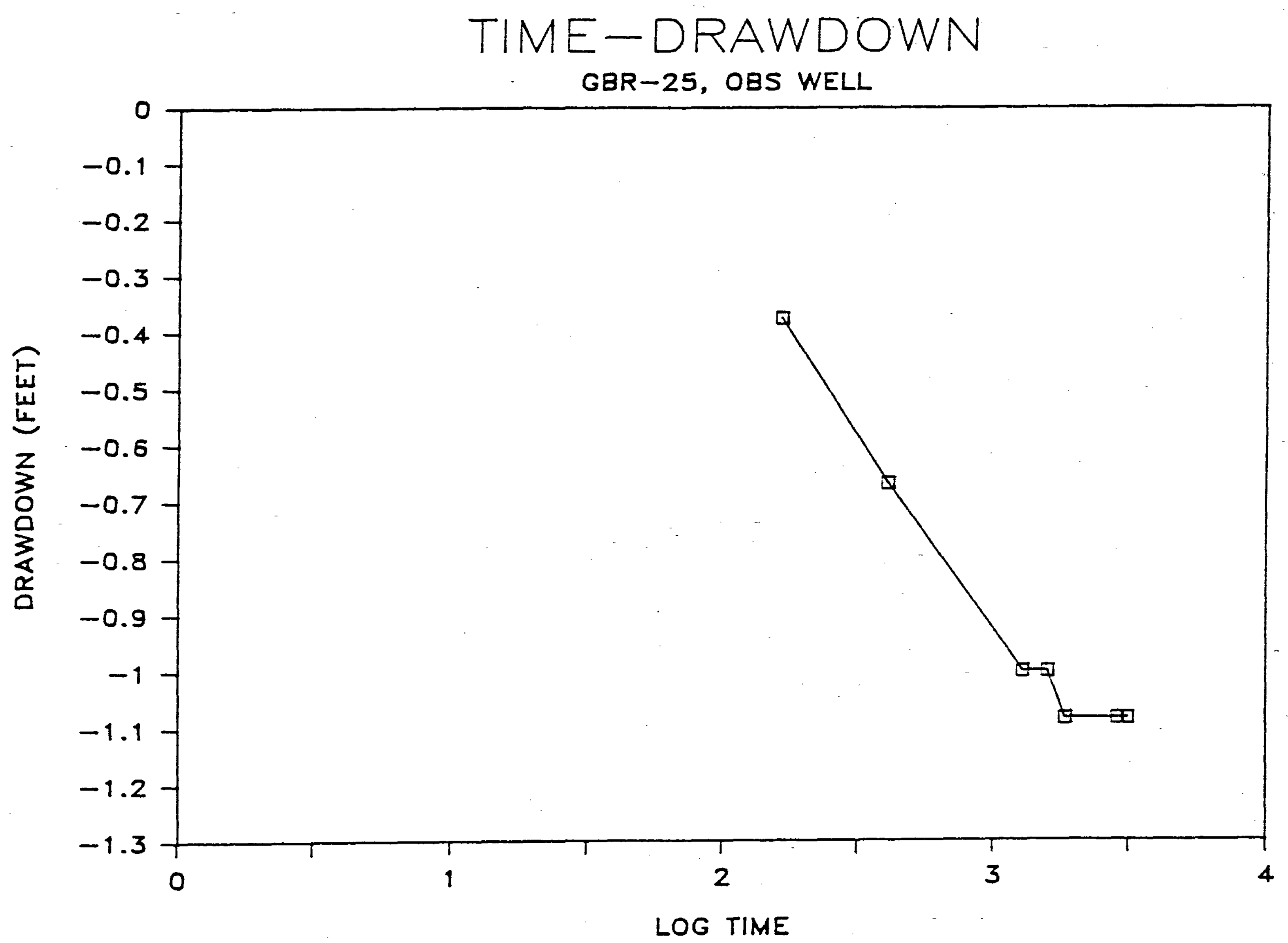

TIME—DRAWDOWN
GBR—24S, OBS WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1
−1.1
−1.2
−1.3
−1.4
−1.5
−1.6
−1.7
−1.8
−1.9
−2
0
1
2
3
4
LOG TIME

FIGURE 29



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 30



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 31

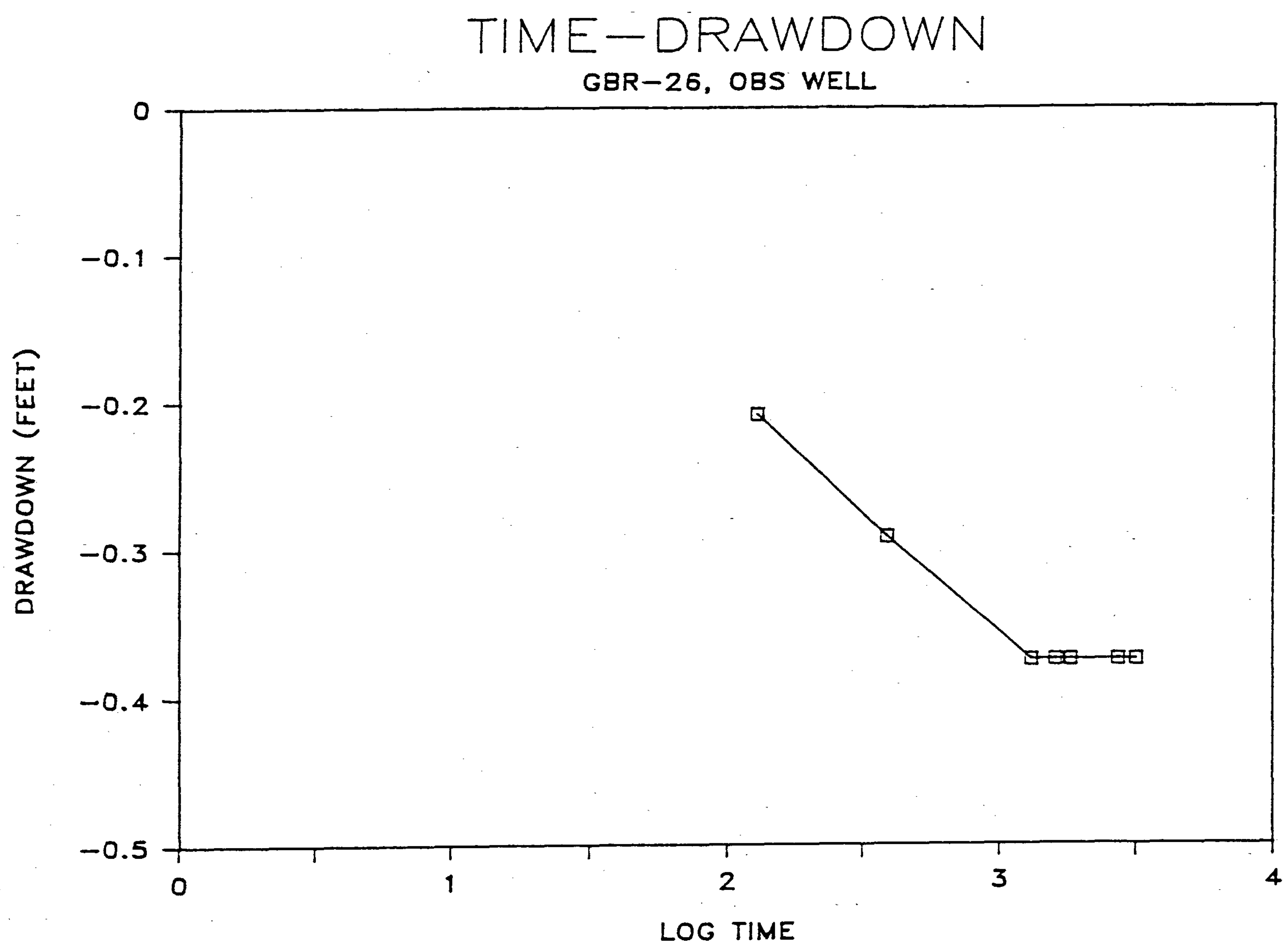

TIME—DRAWDOWN
GBR—26, OBS WELL
0
—0.1
—0.2
—0.3
—0.4
—0.5
DRAWDOWN (FEET)
0
1
2
3
4
LOG TIME

FIGURE 32

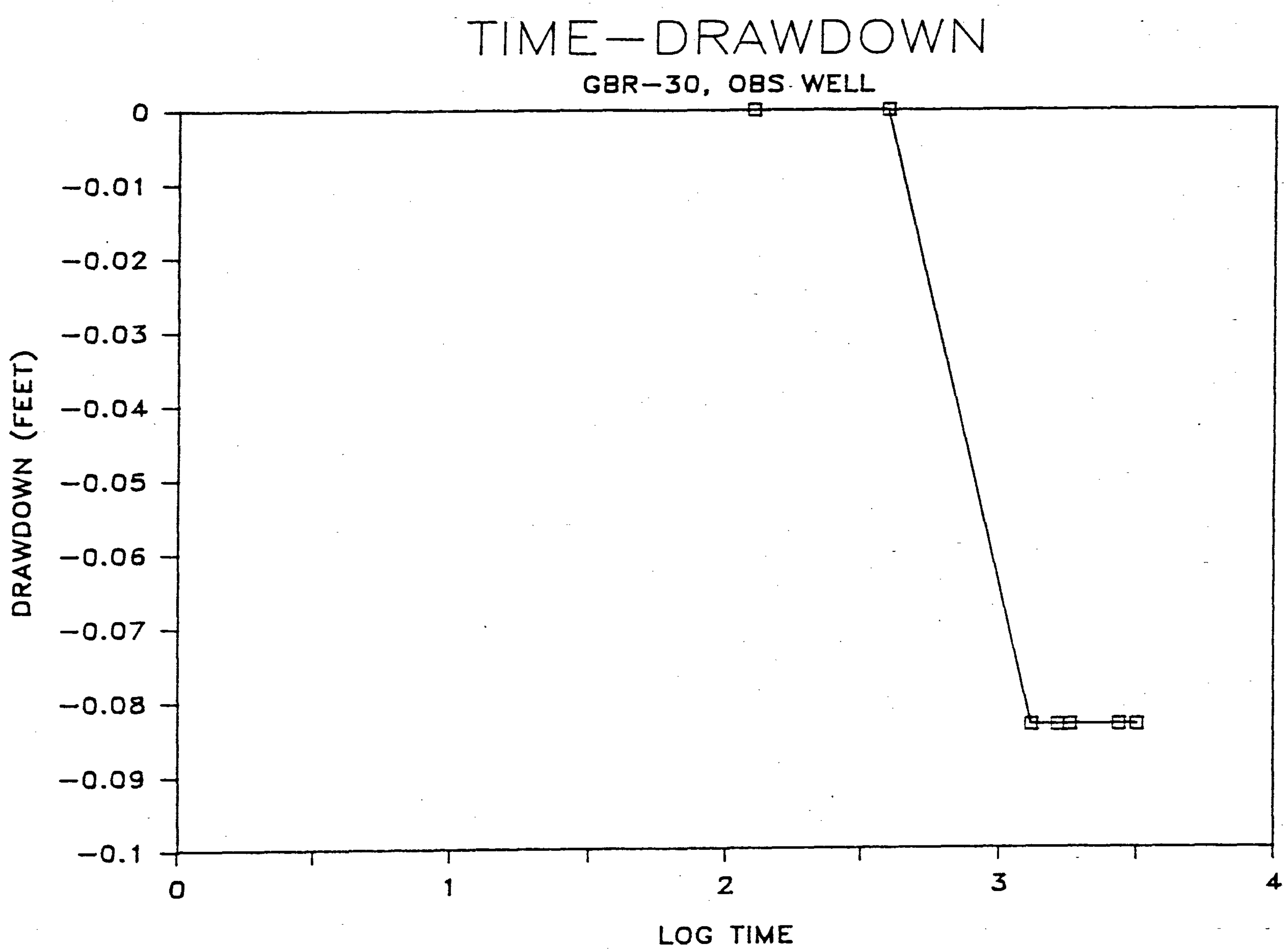

TIME—DRAWDOWN
GBR—30, OBS WELL
0
−0.01
−0.02
−0.03
−0.04
−0.05
−0.06
−0.07
−0.08
−0.09
−0.1
DRAWDOWN (FEET)
0
1
2
3
4
LOG TIME

FIGURE 33

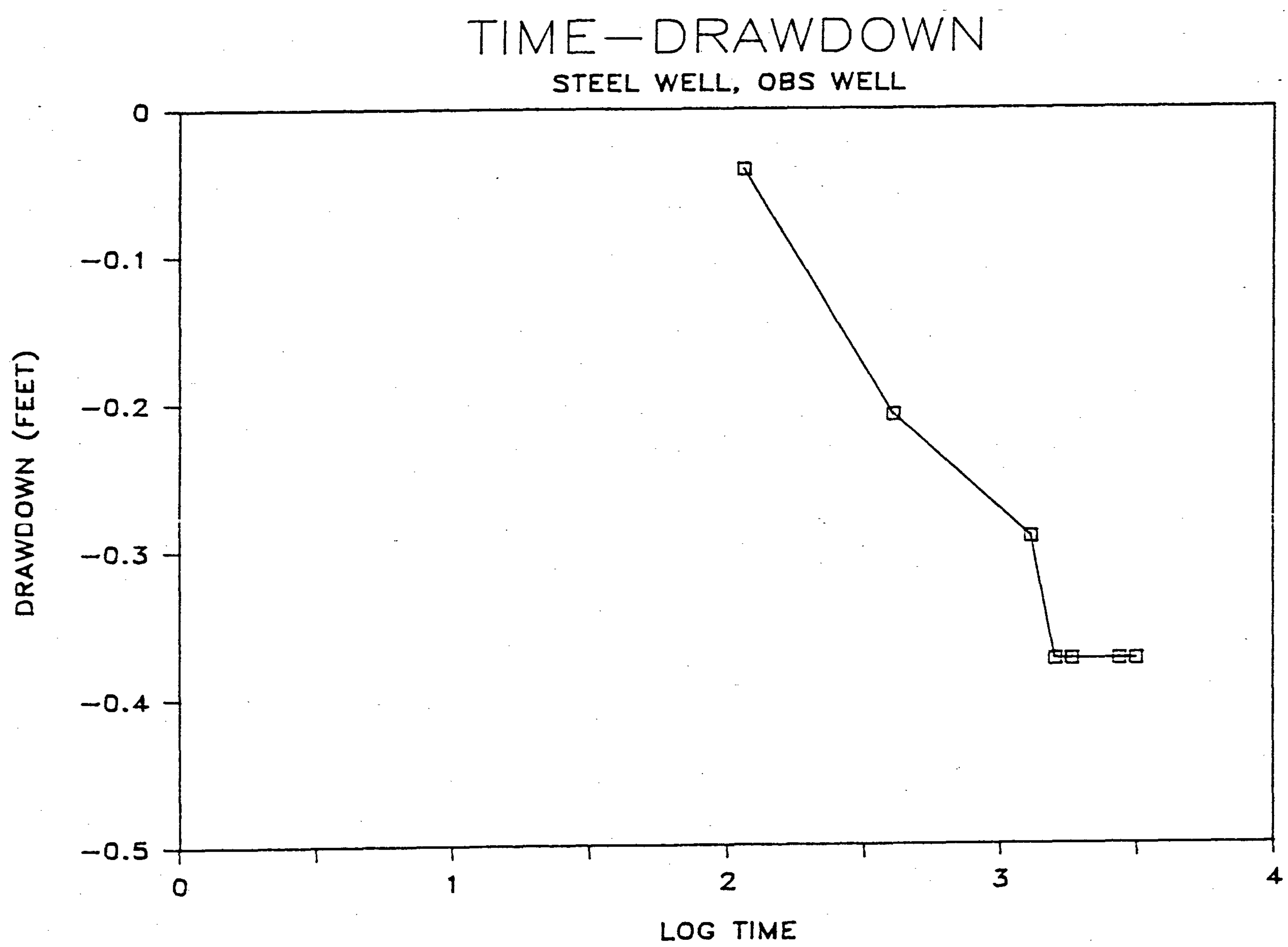

TIME—DRAWDOWN
STEEL WELL, OBS WELL
DRAWDOWN (FEET)
0
−0.1
−0.2
−0.3
−0.4
−0.5
0
1
2
3
4
LOG TIME

FIGURE 34

PUMP TEST DATA
TABLE C12

OBR 17 (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 C13

GPR 17(a) (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO PRODUCT FEET	DEPTH TO PRODUCT INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIME MINUTES	LOG TIME
1200.00	0.00	29.00	7.00	29.50	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 C14

GBR 27 (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	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	1266.00	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 C15

GBR 28(a) (PUMPING WELL)

CLOCK	TIME (min)	DEPTH TO WATER FEET	INCHE	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIM 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	1852.00	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 C16

GBR 28 (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	10.50	33.98	0.00	0.00	ERR
1443.00	153.00	34.00	5.50	34.46	-0.58	15[illegible].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	2700.00	34.00	7.00	34.56	-0.71	854.00	3.43
1635.00	3155.00	34.00	7.00	34.58	0.71	447.00	3.50

PUMP TEST DATA
TABLE C17

BMR 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 C18

SBR 218(D) (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	2.38
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 C19

OBR 210 (303 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	-2.54	308.00	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 C20

GBR 23a (OBS WELL)

CLOCK	TIME (min)	DEPTH TO PRODUCT FEET	DEPTH TO PRODUCT INCHES	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIM MINUTES	LOG TIME
1200.00	0.00	23.00	11.75	23.98	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	1236.00	TRACE	TRACE	----	----	829.00	3.11
1449.00	1609.00	TRACE	TRACE	----	----	373.00	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 C21

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	145.00	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 C22

GBR 248(s) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO PRODUCT FEET	INCHE	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIM 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	180.00	3.26
946.00	2746.00	TRACE	TRACE	----	----	922.00	3.44
1644.00	3164.00	NONE	NONE	----	----	418.00	3.50

PUMP TEST DATA
TABLE C23

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 C24

BRR 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 C25

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 C26

GBR 26(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO PRODUCT FEET	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

GBR 26(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO PRODUCT FEET	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 C27

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	-0.27	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 C28

GBR 30(a) (OBS WELL)

CLOCK	TIME (min)	DEPTH TO FEET	PRODUCT INCHE	TOTAL DEPTH FEET	TOTAL DRAWDOWN FEET	DELTA TIM 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 C29

GDR 30 (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	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 C30

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

PUMP TEST

SOUTHERN REFINERY AREA

GBR-29

PUMP TEST - SOUTHERN REFINERY AREA - GBR-29

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 (see logs, Appendix C). 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.

for same reason should not use data from GBR-8

? On what basis

no definite curve for this data

Since there was no evidence of deviation from ideal Theis behavior for drawdown observed at GBR-29 or GBR-8 within measurement error, straightforward Theis fits were used to analyze the data. Transmissivity calculated on the basis of data from GBR-29 was estimated as 1041.8 gpd/ft, while T and S from data observed at GBR-8 were determined to equal 2338.8 gpd/ft and 0.051 (see Figures 35 & 36). 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 1690.3 gpd/ft can therefore be used to characterize the unconfined system underlying the

I had T = 928 [illegible] using Jacob analysis

this value should not be used due to low confidence in calculations for GBR-8 which should not be averaged in southern refinery area. The estimated value of storativity was well within the range normally encountered in unconfined aquifers.

CONCLUSIONS

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 areally-limited shale units.

No Overall transmissivity of the regionally unconfined system averages 1645.3 gpd/ft. Storativity is approximately equal to 0.05 in unconfined areas of the system.

Why use 0.05 calculated from GBR-8 instead of value from GBR-29 29 is pumped well

DISCHARGE AT GBR-29 REQUIRED TO INTERCEPT PRODUCT AT GIANT BLOOMFIELD REFINERY - 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 37. 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:

$$\left(\frac{dh}{dx}\right)_{max} = \frac{(5350-5351)\ ft}{12.5\ ft} = -0.08$$

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

$$h = \left(\frac{dh}{dx}\right)_{south} \times (300 \text{ ft}) = (-0.04)(300 \text{ ft}) = 12 \text{ ft}$$

yes if $\frac{dh}{dx}$ 300' south is same as in pumped area

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.

should not use (use 1041 gpd/ft)

Using a transmissivity of 1690.3 gpd/ft 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.

$$u = \frac{1.87\ (300)^2\ (0.05)}{1690.3\ (365)} = 1.4 \times 10^{-2}$$

$$w = 3.7054$$

$$s = \frac{114.6\ (9.9)\ (3.705)}{1690.3} = 2.5 \text{ ft}$$

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

This value will be diff. using T = 1041 gpd/ft

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. Larger discharge would be required to actually induce northward-oriented hydraulic gradients which would draw contamination away from the subdivision.

Although larger values of T and S are probably representative of the alluvial valley fill south of the highway, flow to the GBR-29 recovery well will be limited by the transmissivity and storativity of the consolidated sandstone. Therefore, consideration of the effects of higher T and S south of the highway would have little effect on the analysis.

FIGURE-35

DOUBLE LOG PLOT OF
DRAWDOWN AT GBR-29

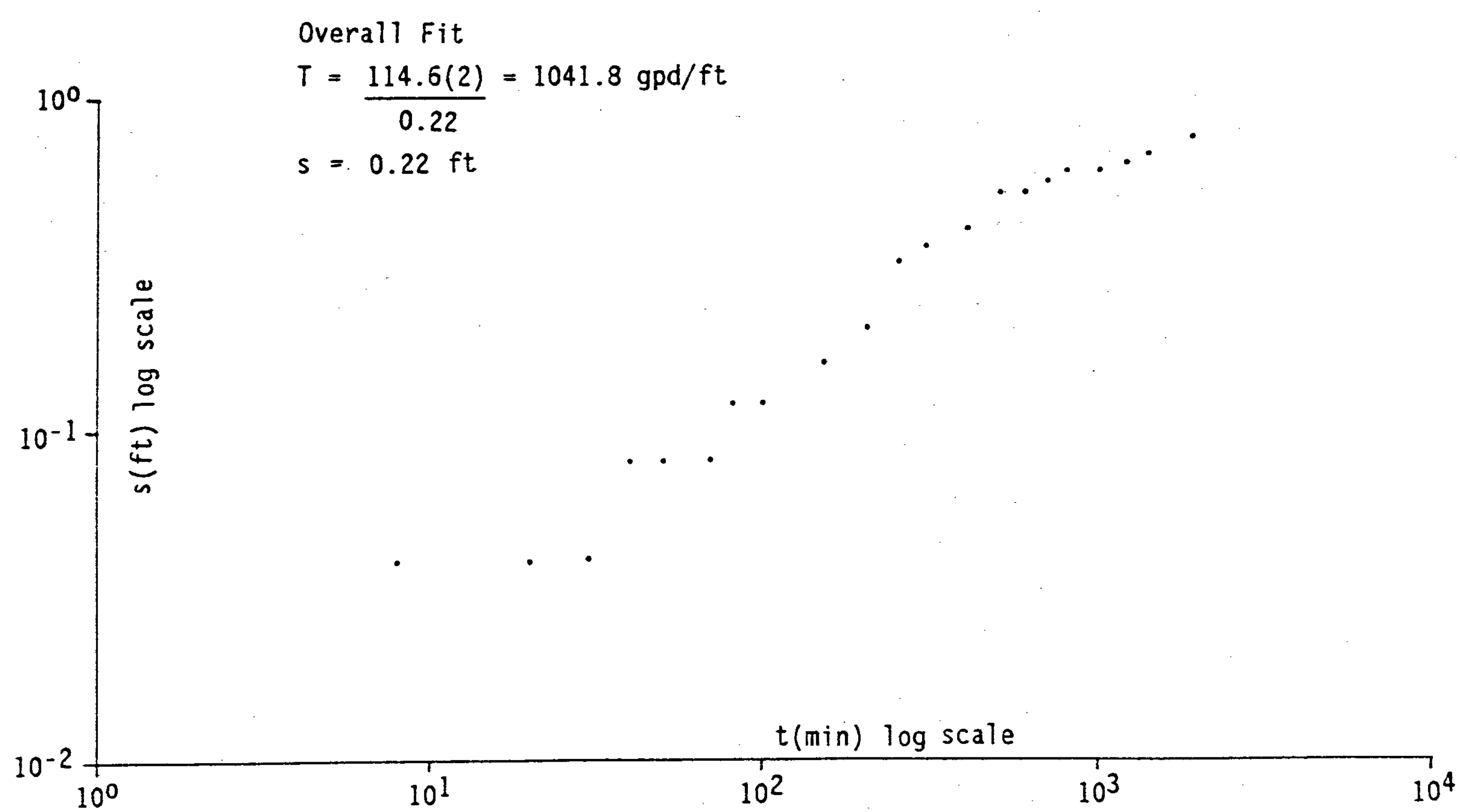
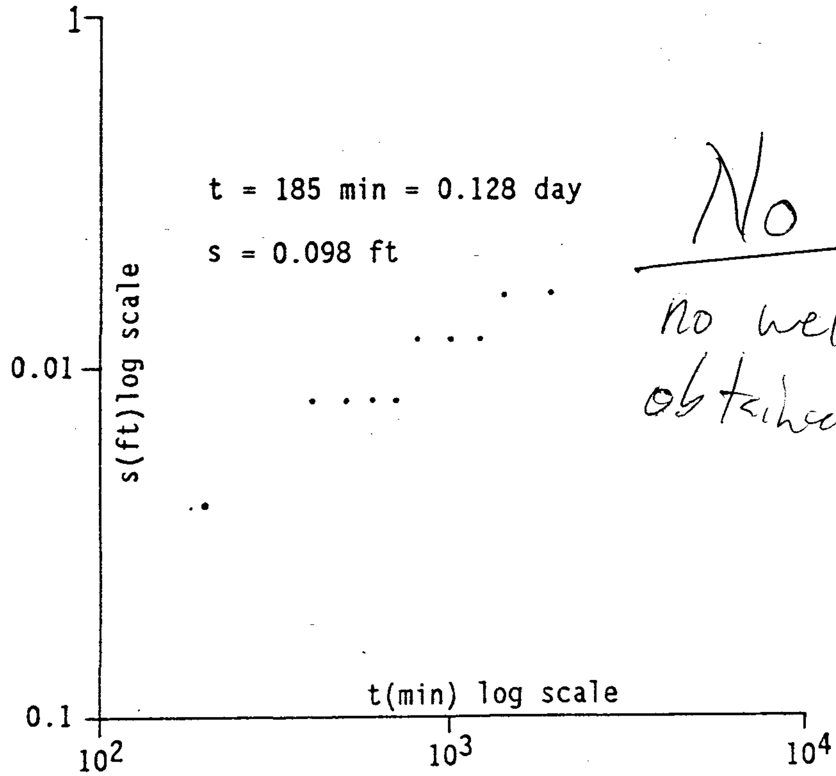


FIGURE - 36

DOUBLE LOG PLOT OF DRAWDOWN AT
GBR-8 DUE TO PUMPING AT GBR-29

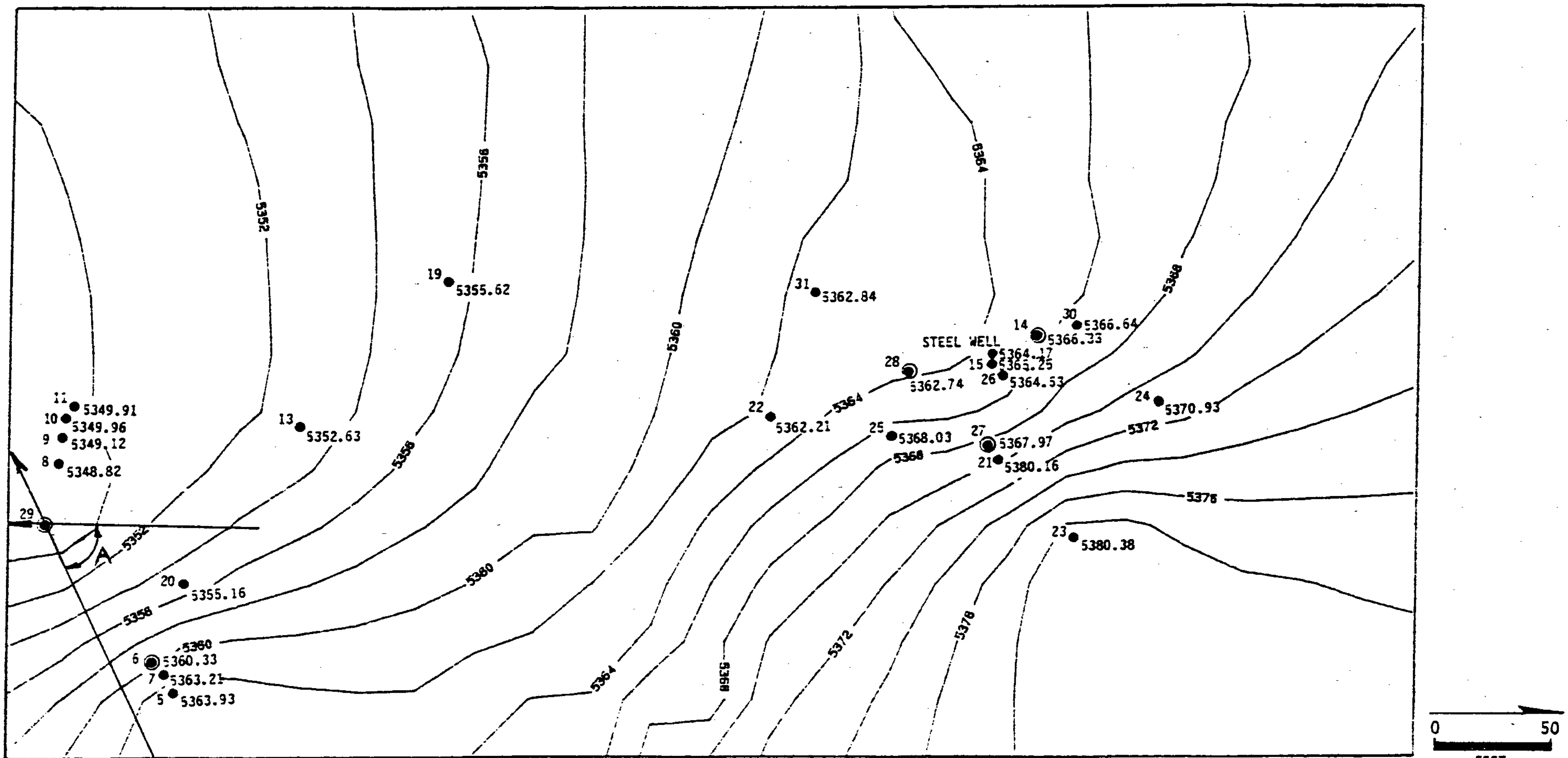
$$T = \frac{114.6(2)}{0.098} = 2338.8 \text{ gpd/ft}$$

$$s = \frac{2338.8(0.128)}{1.87(56.3)^2} = 0.051$$



No Good

no well defined curve can be obtained from this data



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

◉ RECOVERY WELL

● MONITOR WELL

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

FIGURE 37

TABLE C31
GBR-29 PUMP TEST
DRAWDOWN IN FEET (Q=2 gpm)

MINUTES OF PUMPING	PUMPED WELL GBR-29	OBSERVATION WELLS	
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	.04	0	0
9	.04	0	0
10	.04	0	0
20	.04	0	0
30	.04	0	0
40	.08	0	0
50	.08	0	0
70	.08	0	0
80	.12	0	0
100	.12	0	0
150	.16	0	0
200	.20	.04	0
250	.32	.04	0
300	.36	.04	0
400	.40	.08	.04
500	.52	.08	.04
600	.52	.08	.04
700	.56	.08	.04
800	.60	.12	.04
1000	.60	.12	.04
1200	.64	.12	.04
1400	.68	.16	.08
1900	.76	.16	.08

Note: Resolution of readings = .04 ft. by computer hardware

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 D
SOIL HYDRAULIC ANALYSIS

ASSAIGAI ANALYTICAL LABORATORIES

TO: Geoscience/M & A
Attn: Nicholas
Alvarado Square
Albuquerque, NM 87158

DATE: 29 October 1986
1834

% Moistures for GBR-6

ANALYTE: % Water Moisture

SAMPLE ID	ANALYTICAL RESULTS
8609231130 7.5'	5.7 %
8609231200 11.0'	6.9 %
8609231300 15.0'	8.0 %
8609231330 17.5'	6.0 %
8609231400 20.0'	5.3 %
8609231415 22.5'	6.0 %
8609231430 25.0'	10.9 %
8609231500 30.0'	15.7 %
8609231520 32.5'	9.5 %
8609231530 33.0'	7.7 %
8609231545 36.0'	8.7 %
8609231600 37.5'	12.0 %
8609231615 40'	6.0 %
8609231620 43'	8.5 %
8609231630 48'	10.7 %

REFERENCE:" Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", USEPA, SW 846, EMSL-Cincinnati, 1982.

An invoice for services is enclosed. Thank you for contacting Assaigai Labortories.

Sincerely,

Jennifer V. Smith

Jennifer V. Smith, Ph.D.
Laboratory Director

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DANIEL B. STEPHENS & ASSOCIATES, INC.

CONSULTANTS IN GROUND-WATER HYDROLOGY SOCORRO, NEW MEXICO

FINAL DATA REPORT

ON

LABORATORY ANALYSES

OF

SOIL HYDRAULIC PROPERTIES

PREPARED FOR

GEOSCIENCE CONSULTANTS, LTD.

ALBUQUERQUE, NEW MEXICO

DECEMBER, 1986

DANIEL B. STEPHENS & ASSOCIATES, INC.
CONSULTANTS IN GROUND-WATER HYDROLOGY

• GROUND-WATER CONTAMINATION • UNSATURATED ZONE INVESTIGATIONS • WATER SUPPLY DEVELOPMENT •

December 9, 1986

Mr. Randall T. Hicks
Vice President
GEOSCIENCE CONSULTANTS, LTD.
500 Cooper Avenue N.W., Suite 325
Albuquerque, New Mexico 87102

Dear Mr. Hicks:

Please find enclosed the final data report on the five soil analyses. This report constitutes completion of the analyses requested in your written communication of October 27, 1986.

We have reviewed the data available for each sample, and we believe the parameters are generally reasonable and representative for the soil samples. However, Daniel B. Stephens & Associates, Inc. cannot verify that samples are representative of the soils from which they were collected, and we do not assume any responsibility for interpretations or analyses based on this data.

We are very grateful to provide this service to GEOSCIENCE CONSULTANTS, LTD. Please do not hesitate to call us if you have any questions.

Sincerely Yours,

Warren B. Cox
Laboratory Manager

WBC:bdf
Enclosure

P.O. BOX 740 SOCORRO, NEW MEXICO 87801 (505) 835-3162

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

INTRODUCTION

Daniel B. Stephens & Associates, Inc. was requested to perform the following tasks as outlined in written communication from GEOSCIENCE CONSULTANTS, LTD. on October 27, 1986 and personal communication from Mr. Randall Hicks on November 17, 1986.

Task #1. Conduct laboratory analyses of five (5) soil samples, to include analyses as outlined below for each sample:

DEPTH	SAMPLE NUMBER	ANALYSIS TO BE PERFORMED
12.5'	GC1	Initial moisture content, unsaturated hydraulic conductivity.
29.5'	GC2	Initial moisture content.
37'	GC3	Initial moisture content.
39'	GC4 (Sandstone)	Initial moisture content, unsaturated hydraulic conductivity.
39'	GC5 (Mudstone)	Initial moisture content, unsaturated hydraulic conductivity.

Task # 2. Determine, if possible, the horizontal saturated hydraulic conductivity of the sandstone sample, from 39 feet.

In execution of the foregoing request, Daniel B. Stephens & Associates, Inc. has performed the following work as summarized below and in Table 1.

Task #1. Laboratory analyses of the five (5) soil samples were completed. The method of Mualem (1978) was chosen for determining unsaturated hydraulic conduuctivity, as agreed upon by Mr. Randall Hicks (Personal communication, November 17, 1986). The three parameter fit of the Mualem model was applied to moisture retention-pressure head characteristics of samples GC1, GC4, and GC5 which were obtained by the hanging column and pressure plate methods. The parameters of fit alpha (α), n and residual moisture content, were used by the model to calculate relative unsaturated hydraulic conductivity, as described in Appendix B, Principles and Methods. Saturated hydraulic conductivity was determined for samples GC1, GC4 and GC5, as part of the determination of unsaturated hydraulic conductivity. Graphical representation of the data generated by the model is presented for unsaturated hydraulic conductivity.

Task #2. Horizontal saturated hydraulic conductivity of sample GC4 (Sandstone) could not be measured because there was insufficient soil core for analysis.

Included in this data report are summary tables, graphs, and raw laboratory data. The Appendices describe basic principles of the analyses, methods of calculation, sample preparation, and a chemical analysis of the water used in the laboratory. All calculation results are expressed in metric units according to Table 2, except for sample depths which were reported to us in length units of feet.

Table 1. Summary of Tests

Test \ Sample No.	GC1	GC2	GC3	GC4	GC5
Saturated Hydraulic Conductivity	X			X	X
Unsaturated Hydraulic Conductivity	X			X	X
Moisture Retention	X			X	X
Initial Moisture Content	X	X	X	X	X

Note: GC4 represents the sandstone sample, GC5 represents the mudstone sample.

Table 2. Unit Conventions

Hydraulic Conductivity: cm/sec

Moisture Content: % volume

Bulk Density: g/cc

Porosity: Dimensionless

Note: Unless otherwise stated, lengths are in units of centimeters, and masses are in units of grams.

SATURATED HYDRAULIC CONDUCTIVITY

Table 3. Summary of Saturated Hydraulic Conductivity Test Results

Sample No.	K (cm/sec)	
GC1	1.1×10^{-4}	
GC4	3.1×10^{-5}	(Sandstone)
GC5	9.3×10^{-6}	(Mudstone)

FALLING HEAD TEST DATA

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC1 RING NO: H21 DEPTH: 12.5'

TYPE OF WATER USED: Tap

LENGTH OF SAMPLE: A.9 (cm) RADIUS OF SAMPLE: 2.5 (cm)

CROSS SECTIONAL AREA OF SAMPLE: 19.63 (cm^2)

CROSS SECTIONAL AREA OF STANDPIPE: 20.428 (cm^2)

BEGINNING: Stand Pipe #5

DATE	TIME	TEMP (°C)	RESERVOIR HEAD (cm)	SAMPLE HEAD (cm)	ΔH_1 (cm
11/13	0900	18.5	-41	-17.8	-23.2
11/13	1845	18.5	-41	-14.2	-26.8

ENDING:

DATE	TIME	TEMP (°C)	RESERVOIR HEAD (cm)	SAMPLE HEAD (cm)	ΔH_2 (cm
11/13	1837	18.5	-41	-27.9	-13.1
11/14	0818	18.5	-41	-32.5	- 8.5

ELAPSED TIME = 1st run = 34,620 (sec) 2nd run = 48,780 (sec)

VISCOSITY CORRECTION = 1.038 (both runs)

RUN NO. ______ OF ______ RUNS

CALCULATIONS: 1st run, K sat = 8.7×10^{-5} cm/sec
2nd run, K sat = 12.5×10^{-5} cm/sec

K (SAT) = 1.1×10^{-4} cm/sec = arithmetic average

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: W. Cox

CHECKED BY: L. Williamson

FALLING HEAD TEST DATA

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC4 (Sandstone) RING NO: 21C DEPTH: 39'

TYPE OF WATER USED: Tap

LENGTH OF SAMPLE: 5.1 (cm) RADIUS OF SAMPLE: 2.5 (cm)

CROSS SECTIONAL AREA OF SAMPLE: 19.63 (cm^2)

CROSS SECTIONAL AREA OF STANDPIPE: 20.428 (cm^2)

BEGINNING: Standpipe #4

DATE	TIME	TEMP (°C)	RESERVOIR HEAD (cm)	SAMPLE HEAD (cm)	ΔH_1 (cm)
11/13	0900	17.0	-41.5	-10.2	-31.3
11/13	1839	19.0	-41.5	-14.9	-26.6

ENDING:

DATE	TIME	TEMP (°C)	RESERVOIR HEAD (cm)	SAMPLE HEAD (cm)	ΔH_2 (cm)
11/13	1839	19.0	-41.5	-14.9	-26.6
11/14	0828	19.0	-41.5	-22.1	-19.4

ELAPSED TIME = 1st run = 34,740 (sec) 2nd run = 49,740 (sec)

VISCOSITY CORRECTION = 1st run = 1.051 2nd run = 1.025

RUN NO. ______ OF __________ RUNS

CALCULATIONS: 1st run, K sat = 2.6×10^{-5} cm/sec
2nd run, K sat = 3.5×10^{-5} cm/sec

K (SAT) = 3.1×10^{-5} cm/sec = arithmetic average

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: W. Cox

CHECKED BY: L. Williamson

FALLING HEAD TEST DATA

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC5 (Mudstone) RING NO: H14 DEPTH: 39'

TYPE OF WATER USED: Tap

LENGTH OF SAMPLE: 5.1 (cm) RADIUS OF SAMPLE: 2.5 (cm)

CROSS SECTIONAL AREA OF SAMPLE: 19.63 (cm^2)

CROSS SECTIONAL AREA OF STANDPIPE: 20.428 (cm^2)

BEGINNING: Standpipe #3

DATE	TIME	TEMP (°C)	RESERVOIR HEAD (cm)	SAMPLE HEAD (cm)	ΔH_1 (cm
11/13	0900	18.5	-39.0	-16.3	-22.7
11/13	1841	19.0	-39.0	-17.5	-21.5

ENDING:

DATE	TIME	TEMP (°C)	RESERVOIR HEAD (cm)	SAMPLE HEAD (cm)	ΔH_2 (cm
11/13	1841	19.0	-39.0	-17.5	-21.5
11/14	0829	19.0	-39.0	-19.4	-19.6

ELAPSED TIME = 1st run = 34,860 (sec) 2nd run = 49,680 (sec)

VISCOSITY CORRECTION = 1st run = 1.031 2nd run = 1.025

RUN NO. ______ OF ____________ RUNS

CALCULATIONS: 1st run, K sat = 8.5×10^{-6} cm/sec
2nd run, K sat = 10.1×10^{-6} cm/sec

K (SAT) = 9.3×10^{-6} cm/sec = arithmetic average

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: L. Williamson

CHECKED BY: W. Cox

MOISTURE RETENTION

Table 4. Summary of Moisture Retention-Pressure Head Test Results

Sample No.	Pressure Head (cm of water)	Moisture Content (% volume)
GC1	0.0	39.2
	- 15.8	37.7
	- 37.3	33.2
	- 74.6	29.2
	-105.0	28.1
	-125.0	27.4
	-176.7	26.3
GC4 (Sandstone)	0.0	36.6
	- 24.7	33.4
	- 73.4	30.0
	-102.8	29.8
	-130.4	29.1
	-173.8	28.7
	-202.5	28.7
	-1020.0	19.3
GC5 (Mudstone)	0.0	43.8
	- 28.8	43.2
	-101.0	40.8
	-128.7	40.7
	-156.4	39.7
	-200.8	39.2
	-1020.0	29.4

MOISTURE RETENTION DATA - HANGING COLUMN
(PORE SIZE DISTRIBUTION)

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC1 RING NO.: H21

DEPTH: 12.5' SAMPLE VOLUME: 96.19 (cc)

WEIGHT AT 0 CM TENSION W/CAP AND RING (SATURATED): 287.1 (g)

TARE WEIGHT, RING: 89.6 (g) TARE WEIGHT, CAP: 8.2 (g)

DRY WEIGHT OF SAMPLE: 151.6 (g)

SATURATED MOISTURE CONTENT: 39.2 (% vol)

INITIAL VOLUME OF WATER IN SAMPLE: 37.7 (cc)

	SUCTION (cm)	BURET VOLUME (cc)	VOLUME CHANGE (cc)	VOLUME CHANGES (cc)	MOISTURE CONTENT (%VOL)
DRYING	0.0	45.2	0.0	0.0	39.2
	15.8	43.8	1.4	1.4	37.7
	37.3	39.4	4.4	5.8	33.2
	74.6	35.6	3.8	9.6	29.2
	105.0	34.5	1.1	10.7	28.1
	125.0	33.9	0.6	11.3	27.4
	176.7	32.8	1.1	12.4	26.3
WETTING					

* NOTE: Tension is measured from center of sample to bottom of meniscus

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: L. Williamson

CALCULATIONS MADE BY: W. Cox

CHECKED BY: L. Williamson

MOISTURE RETENTION DATA - HANGING COLUMN
(PORE SIZE DISTRIBUTION)

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC4 (Sandstone) RING NO.: 21C

DEPTH: 39' SAMPLE VOLUME: 100.0 (cc)

WEIGHT AT 0 CM TENSION W/CAP AND RING (SATURATED): 311.5 (g)

TARE WEIGHT, RING: 100.3 (g) TARE WEIGHT, CAP: 7.7 (g)

DRY WEIGHT OF SAMPLE: 166.9 (g)

SATURATED MOISTURE CONTENT: 36.6 (% vol)

INITIAL VOLUME OF WATER IN SAMPLE: 36.6 (cc)

	SUCTION (cm)	BURET VOLUME (cc)	VOLUME CHANGE (cc)	Σ VOLUME CHANGES (cc)	MOISTURE CONTENT (%VOL)
DRYING	0.0	49.4	0.0	0.0	36.6
	24.7	46.2	3.2	3.2	33.4
	73.4	42.8	3.4	6.6	30.0
	102.8	42.6	0.2	6.8	29.8
	130.4	41.9	0.7	7.5	29.1
	173.8	41.5	0.4	7.9	28.7
	202.5	41.5	0.0	7.9	28.7
WETTING					

* NOTE: Tension is measured from center of sample to bottom of meniscus

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: L. Williamson

CALCULATIONS MADE BY: W. Cox

CHECKED BY: L. Williamson

MOISTURE RETENTION DATA - PRESSURE PLATE
(PORE SIZE DISTRIBUTION)

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC4 (Sandstone) RING NO.: 21C

DEPTH = 39' SAMPLE VOLUME: 100.0 (cc)

WEIGHT AT 0 CM TENSION W/CAP AND RING (SATURATED) = 311.5 (g)

TARE WEIGHT, RING = 100.3 (g) TARE WEIGHT, CAP = 7.7 (g)

DRY WEIGHT OF SAMPLE = 166.9 (g)

SATURATED MOISTURE CONTENT = 36.6 (% vol)

INITIAL VOLUME OF WATER IN SAMPLE = 36.6 (cc)

WEIGHT FROM HANGING COLUMN, W/O CAP = 301.0 (g)

FINAL TENSION ON HANGING COLUMN= 202.5 (cm)

DATE	TIME	PRESSURE (BAR)	WEIGHT, WITH Ring(g) +Rubber Ring	CHANGE IN WEIGHT(g)	Σ WEIGHT CHANGES (g)	MOISTURE CONTENT %VOL
11/24	1330	0		Into P.P.		
11/25	2220	1	291.6	9.4	17.3	19.3

COMMENTS: Rubber Ring Mass = 5.19 g

LABORATORY ANALYSES PERFORMED BY: L. Williamson

CALCULATION MADE BY: W. Cox

CHECKED BY: L. Williamson

MOISTURE RETENTION DATA - HANGING COLUMN
(PORE SIZE DISTRIBUTION)

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC5 (Mudstone) RING NO.: H14

DEPTH: 39' SAMPLE VOLUME: 100.0 (cc)

WEIGHT AT 0 CM TENSION W/CAP AND RING (SATURATED): 309.7 (g)

TARE WEIGHT, RING: 93.0 (g) TARE WEIGHT, CAP: 7.5 (g)

DRY WEIGHT OF SAMPLE: 165.4 (g)

SATURATED MOISTURE CONTENT: 43.8 (% vol)

INITIAL VOLUME OF WATER IN SAMPLE: 43.8 (cc)

	SUCTION (cm)	BURET VOLUME (cc)	VOLUME CHANGE (cc)	VOLUME CHANGES (cc)	MOISTURE CONTENT (%VOL)
DRYING	0.0	47.6	0.0	0.0	43.8
	28.8	47.0	0.6	0.6	43.2
	101.0	44.6	2.4	3.0	40.8
	128.7	44.5	0.1	3.1	40.7
	156.4	43.5	1.0	4.1	39.7
	200.8	43.0	0.5	4.6	39.2
WETTING					

* NOTE: Tension is measured from center of sample to bottom of meniscus

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: L. Williamson

CALCULATIONS MADE BY: L. Williamson

CHECKED BY: W. Cox

MOISTURE RETENTION DATA - PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC5 RING NO.: H14

DEPTH = 39' SAMPLE VOLUME: 100.0 (cc)

WEIGHT AT 0 CM TENSION W/CAP AND RING (SATURATED) = 309.7 (g)

TARE WEIGHT, RING = 93.0 (g) TARE WEIGHT, CAP = 7.5 (g)

DRY WEIGHT OF SAMPLE = 165.4 (g)

SATURATED MOISTURE CONTENT = 43.8 (% vol)

INITIAL VOLUME OF WATER IN SAMPLE = 43.8 (cc)

WEIGHT FROM HANGING COLUMN, W/O CAP = 297.7 (g)

FINAL TENSION ON HANGING COLUMN= 200.8 (cm)

DATE	TIME	PRESSURE (BAR)	WEIGHT, WITH RING (g)	CHANGE IN WEIGHT(g)	Σ WEIGHT CHANGES (g)	MOISTURE CONTENT %VOL
11/23	1340	0		Into P.P.		
11/24	2215	1	292.9	9.9	14.4	29.4

COMMENTS: Weights Include Rubber Ring = 5.1 gram

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATION MADE BY: L. Williamson

CHECKED BY: W. Cox

INITIAL MOISTURE CONTENT

Table 5. Summary of Initial Moisture Content Test Results

Sample No.	Initial Moisture Content (% volume)	Comments
GC1	11.2	
GC2	29.4	The sample, upon arrival at the laboratory, gave off strong smell of hydrocarbons. The sample was air dried in a well ventilated area for 3 days before oven drying. In evaluating the initial moisture content result, the density of the pore fluid initially present in the sample should be taken into account. For the laboratory result presented here, pore fluid density is taken to be 1 gram per cubic centimeter
GC3	28.0	
GC4 (Sandstone)	16.5	
GC5 (Mudstone)	24.1	

DATA FOR INITIAL MOISTURE CONTENT, BULK DENSITY AND POROSITY

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC1

RING NO.: H21 DEPTH: 12.5' (cm,m)

TARE WEIGHT, RING = 89.6 (g) PAN NUMBER: 41

TARE WEIGHT, CAP = 8.2 (g) TARE WEIGHT, PAN= Tared Off (g)

FIELD WEIGHT OF SAMPLE W/CAP AND RING = 260.2 (g)

VOLUME OF SAMPLE = 96.19 (cc)

DATE AND TIME INTO/~~OUT OF~~ OVEN: 11/23/86 1930

DATE AND TIME ~~INTO~~/OUT OF OVEN: 11/25/86 2220
(MILITARY TIME)

DRY WEIGHT OF SAMPLE = 151.6 (g)

DRY BULK DENSITY = 1.58 (g/cc)

PARTICLE DENSITY = 2.65 (g/cc)

METHOD: X ASSUME ρ_s = 2.65 g/cm

___ PYCNOMETER (SEE SEPARATE DATA SHEET)

CALCULATED POROSITY = 40.4 (% VOL)

INITIAL MOISTURE CONTENT = 11.2 (% VOL)

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: L. Williamson

CALCULATIONS MADE BY: W. Cox

CHECKED BY : L. Williamson

DATA FOR INITIAL MOISTURE CONTENT, BULK DENSITY AND POROSITY

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC2

RING NO.: N/A DEPTH: 29.5'

TARE WEIGHT, RING = N/A (g) PAN NUMBER: 40

TARE WEIGHT, CAP = N/A (g) TARE WEIGHT, PAN= Tared Off (g)

FIELD WEIGHT OF SAMPLE (Soil Only) = 209.0 (g)

VOLUME OF SAMPLE = 100 (cc)

DATE AND TIME INTO/XXXX Air Dry: 11/10/86 1840

DATE AND TIME INTO/XXXXXOF OVEN: 11/13/86 1920

DATE AND TIME XXXX/OUT OF OVEN: 11/16/86 1810

DRY WEIGHT OF SAMPLE = 179.6 (g)

DRY BULK DENSITY = 1.80 (g/cc)

PARTICLE DENSITY = 2.65 (g/cc)

METHOD: X ASSUME ρ_s = 2.65 g/cm

__ PYCNOMETER (SEE SEPARATE DATA SHEET)

CALCULATED POROSITY = 32.1 (% VOL)

INITIAL MOISTURE CONTENT = 29.4 (% VOL)

COMMENTS: Sample had to be air dried for 3 days before oven drying due to high hydrocarbon content.

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: L. Williamson

CHECKED BY : W. Cox

DATA FOR INITIAL MOISTURE CONTENT, BULK DENSITY AND POROSITY

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC3

RING NO.: N/A DEPTH: 37'

TARE WEIGHT, RING = N/A (g) PAN NUMBER: 18

TARE WEIGHT, CAP = N/A (g) TARE WEIGHT, PAN= Tared Off (g)

FIELD WEIGHT OF SAMPLE (Soil Only) = 215.6 (g)

VOLUME OF SAMPLE = 100.0 (cc)

DATE AND TIME INTO/~~OUT OF~~ OVEN: 11/10/86 1830

DATE AND TIME ~~INTO~~/OUT OF OVEN: 11/13/86 1935
(MILITARY TIME)

DRY WEIGHT OF SAMPLE = 187.6 (g)

DRY BULK DENSITY = 1.88 (g/cc)

PARTICLE DENSITY = 2.65 (g/cc)

METHOD: X ASSUME ρ_s = 2.65 g/cm

___ PYCNOMETER (SEE SEPARATE DATA SHEET)

CALCULATED POROSITY = 29.1 (% VOL)

INITIAL MOISTURE CONTENT = 28.0 (% VOL)

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: W. Cox

CHECKED BY : L. Williamson

DATA FOR INITIAL MOISTURE CONTENT, BULK DENSITY AND POROSITY

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC4 (Sandstone)

RING NO.: 21C DEPTH: 39'

TARE WEIGHT, RING = 100.3 (g) PAN NUMBER: 16

TARE WEIGHT, CAP = 7.7 (g) TARE WEIGHT, PAN= Tared Off (g)

FIELD WEIGHT OF SAMPLE W/CAP AND RING = 291.4 (g)

VOLUME OF SAMPLE = 100.0 (cc)

DATE AND TIME INTO/~~OUT OF~~ OVEN: 11/25/86 2240

DATE AND TIME INTO/OUT OF OVEN: 11/28/86 2115
(MILITARY TIME)

DRY WEIGHT OF SAMPLE = 166.9 (g)

DRY BULK DENSITY = 1.67 (g/cc)

PARTICLE DENSITY = 2.65 (g/cc)

METHOD: X ASSUME ρ_s = 2.65 g/cm

___ PYCNOMETER (SEE SEPARATE DATA SHEET)

CALCULATED POROSITY = 37.0 (% VOL)

INITIAL MOISTURE CONTENT = 16.5 (% VOL)

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: W. Cox

CHECKED BY : L. Williamson

DATA FOR INITIAL MOISTURE CONTENT, BULK DENSITY AND POROSITY

JOB NAME: Geoscience Consultants

JOB NUMBER: 86-L-020

SAMPLE NUMBER: GC5 (Mudstone)

RING NO.: H14 DEPTH: 39'

TARE WEIGHT, RING = 93.0 (g) PAN NUMBER: 30

TARE WEIGHT, CAP = 7.5 (g) TARE WEIGHT, PAN= Tared Off (g)

FIELD WEIGHT OF SAMPLE W/CAP AND RING = 290.0 (g)

VOLUME OF SAMPLE = 100.0 (cc)

DATE AND TIME INTO/~~OUT OF~~ OVEN: 11/25/86 2245

DATE AND TIME ~~INTO~~/OUT OF OVEN: 11/28/86 2110
(MILITARY TIME)

DRY WEIGHT OF SAMPLE = 165.4 (g)

DRY BULK DENSITY = 1.65 (g/cc)

PARTICLE DENSITY = 2.65 (g/cc)

METHOD: x ASSUME ρ_s = 2.65 g/cm

___ PYCNOMETER (SEE SEPARATE DATA SHEET)

CALCULATED POROSITY = 37.7 (% VOL)

INITIAL MOISTURE CONTENT = 24.1 (% VOL)

COMMENTS:

LABORATORY ANALYSES PERFORMED BY: W. Cox

CALCULATIONS MADE BY: W. Cox

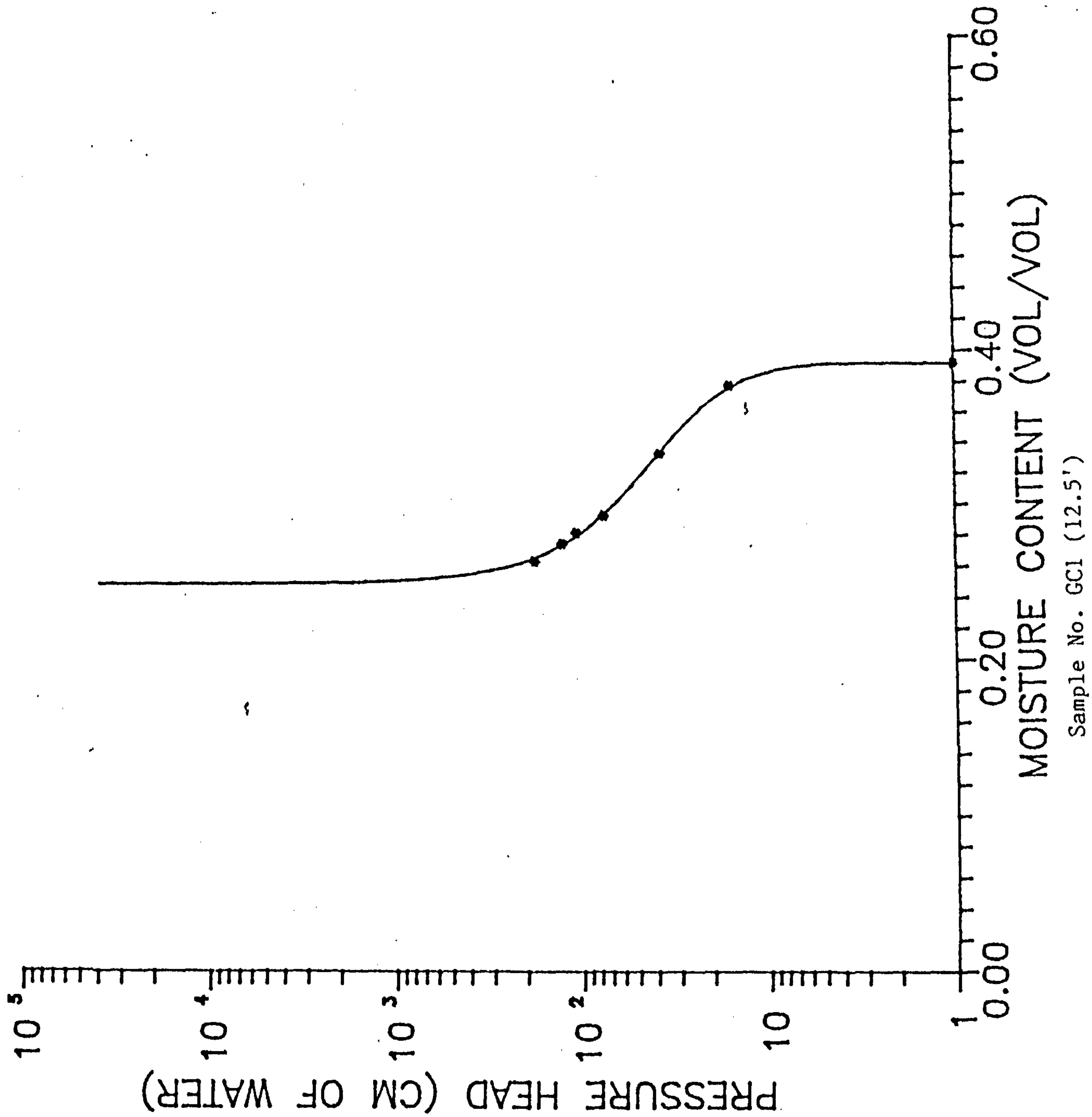
CHECKED BY : L. Williamson

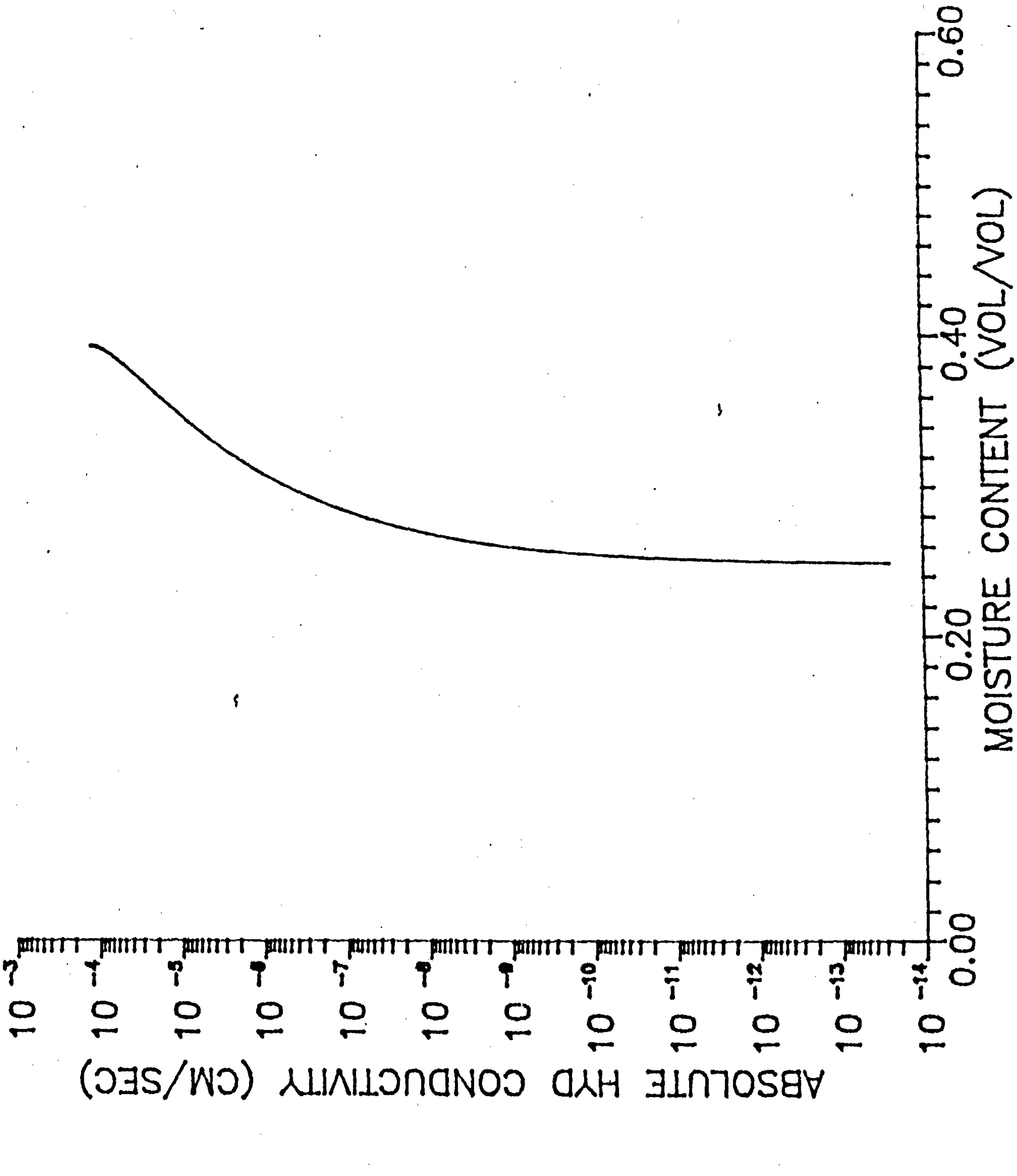
UNSATURATED HYDRAULIC CONDUCTIVITY

Table 6. Summary of Parameters in Mualem Model for Unsaturated Hydraulic Conductivity

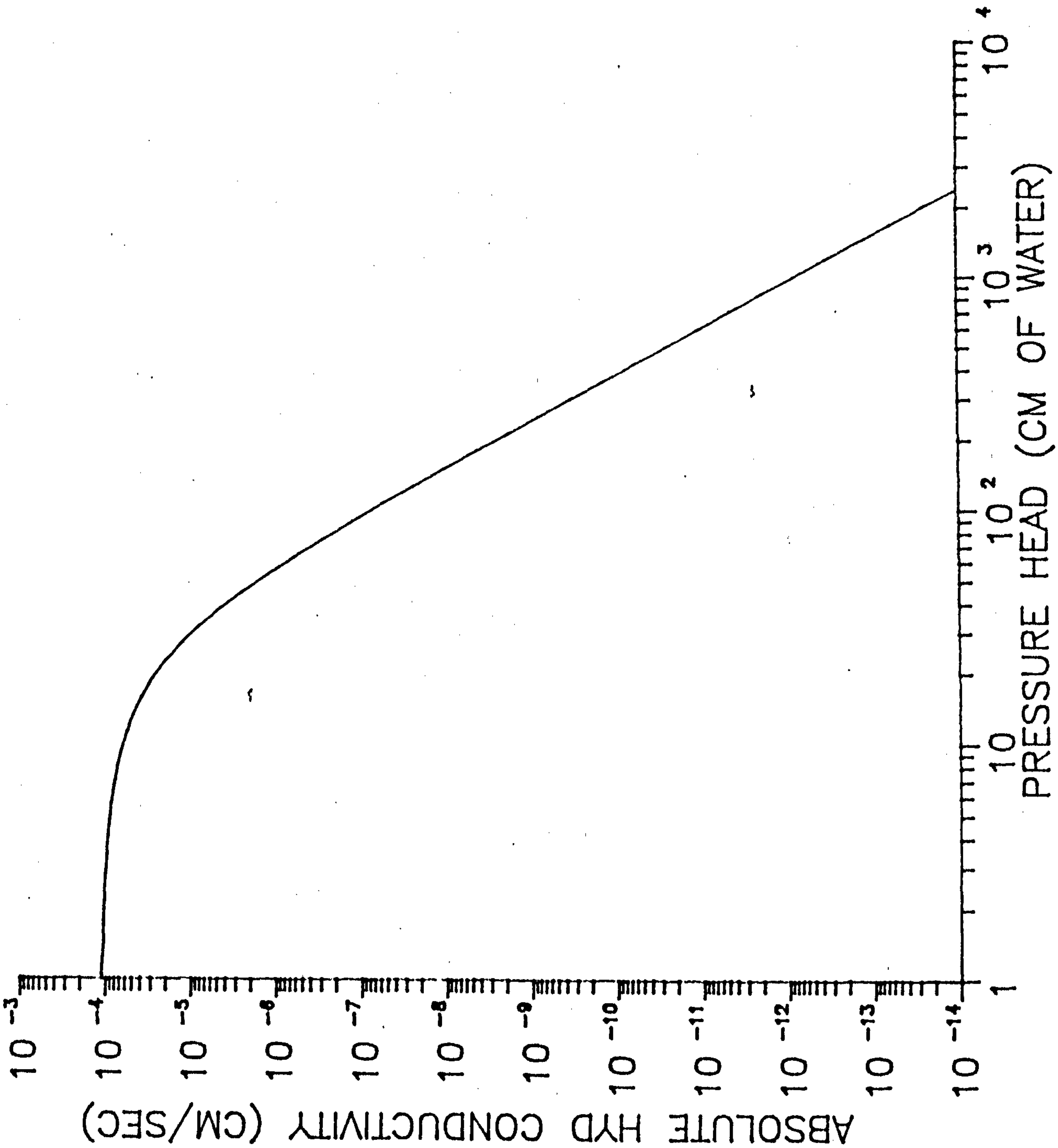
Sample No.	Alpha	N	Saturated Moisture Content (fixed)	Residual Moisture Content (fitted)*
GC1	0.03341	2.19880	0.392	0.24776
GC4 (Sandstone)	0.02080	1.19595	0.366	0.00008
GC5 (Mudstone)	0.00426	1.25027	0.438	0.00001

* Note: Residual moisture content is a parameter obtained by a regression analysis, rather than by measurement. Moisture content at -15 bars is approximately 12 and 15% for samples GC4 (Sandstone) and GC5 (Mudstone), respectively.

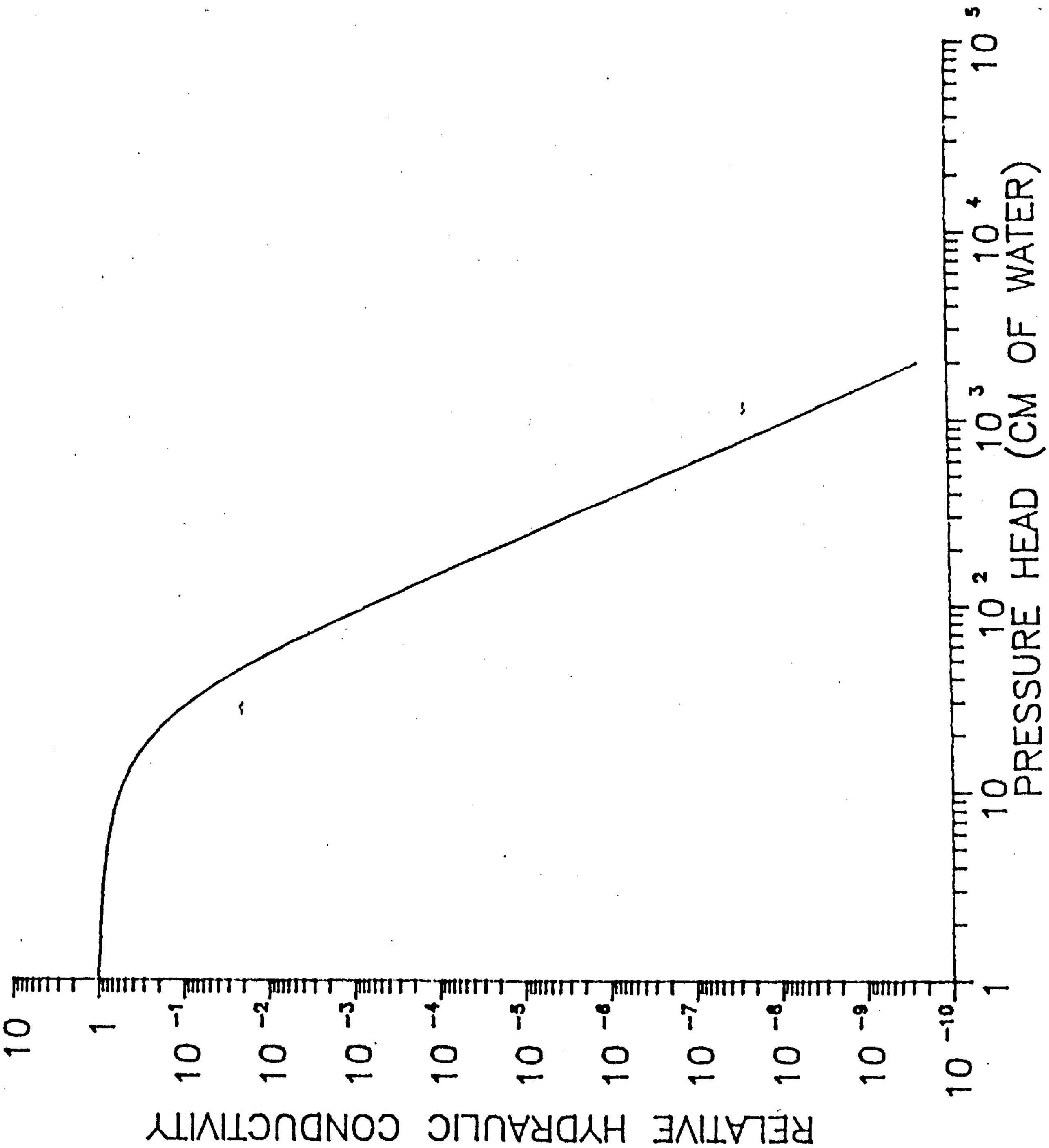

PRESSURE HEAD (CM OF WATER)
10^5
10^4
10^3
10^2
10
1
MOISTURE CONTENT (VOL/VOL)
0.00
0.20
0.40
0.60
Sample No. GC1 (12.5')



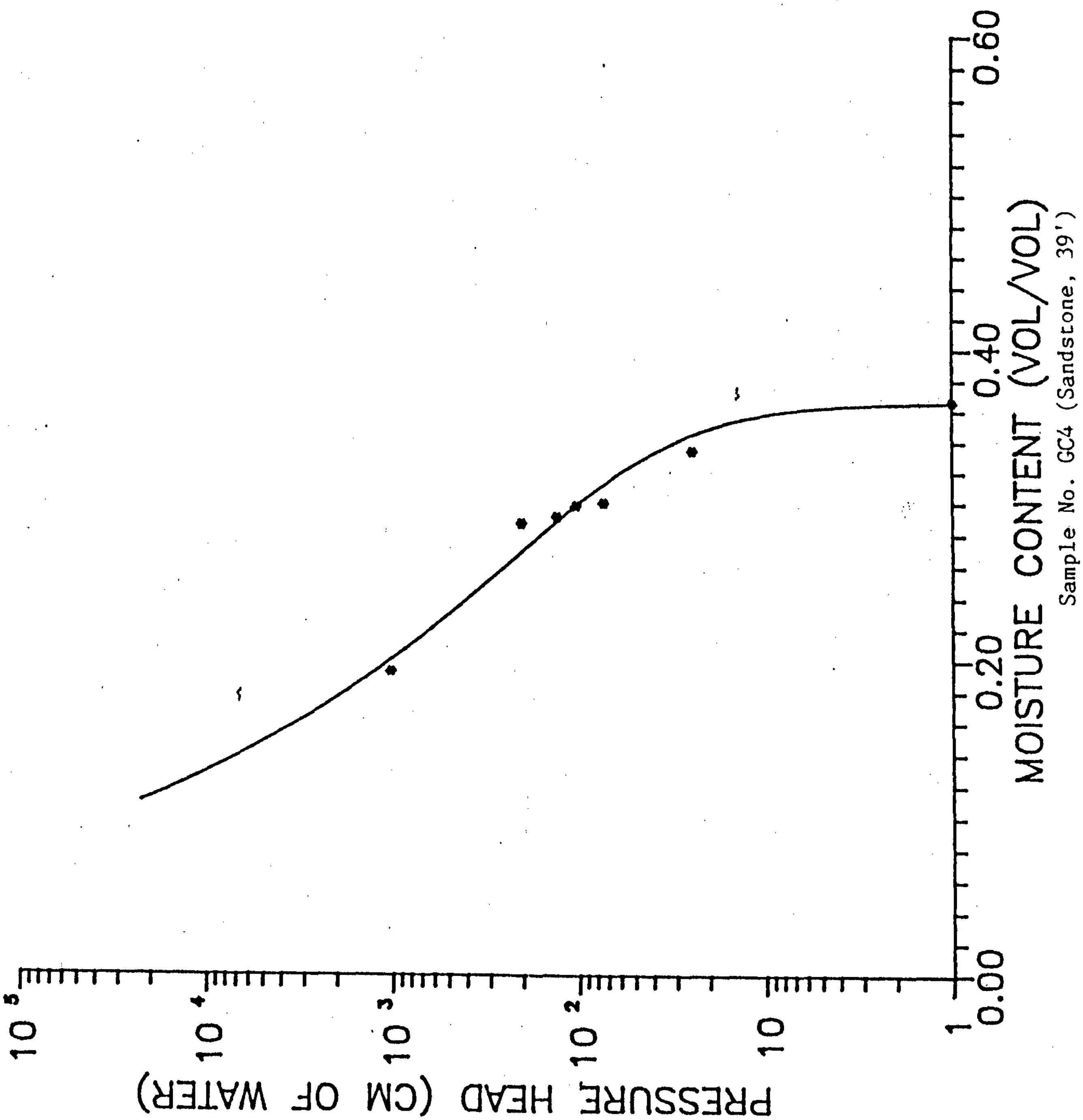
Sample No. GC1 (12.5')

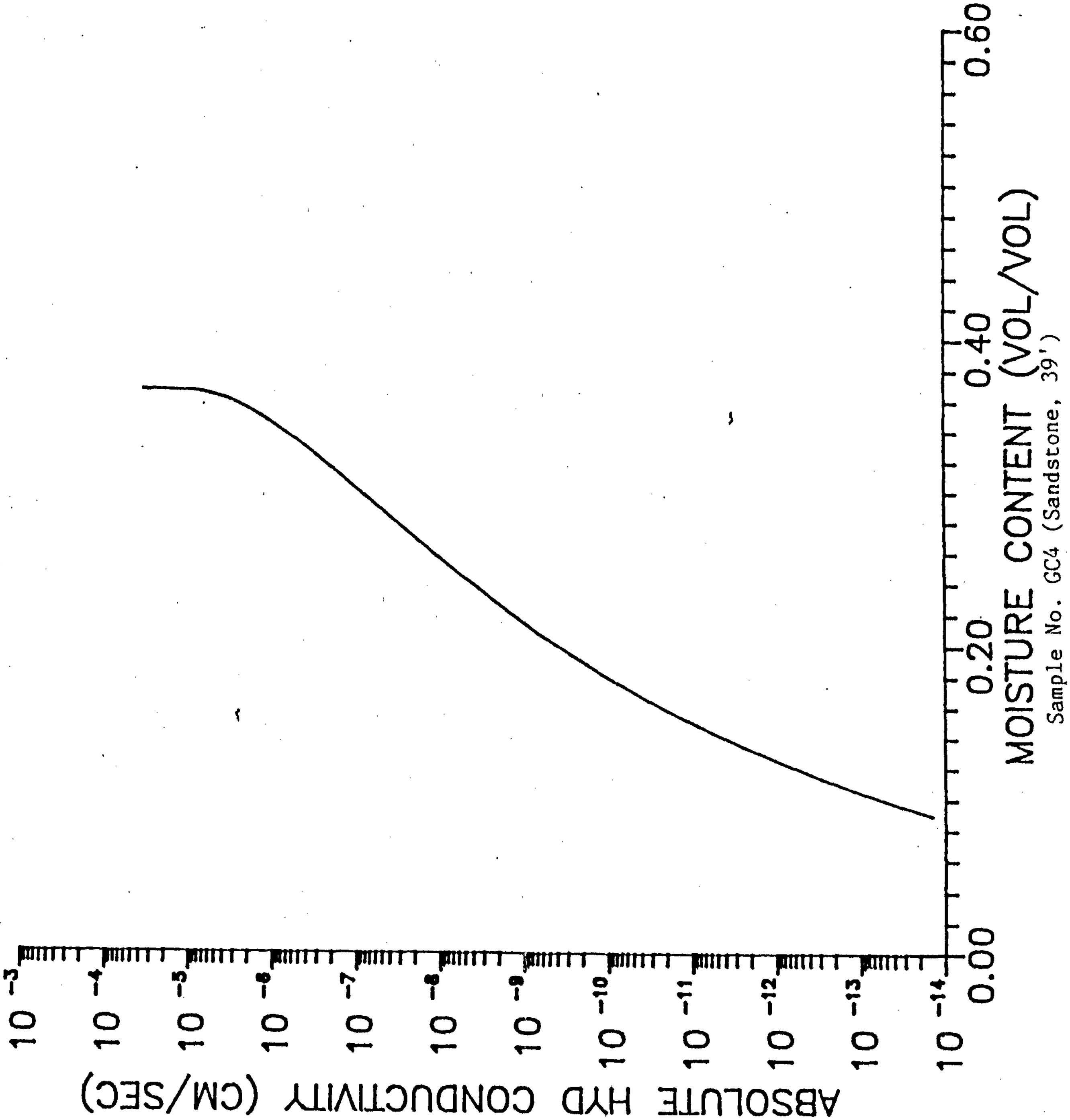


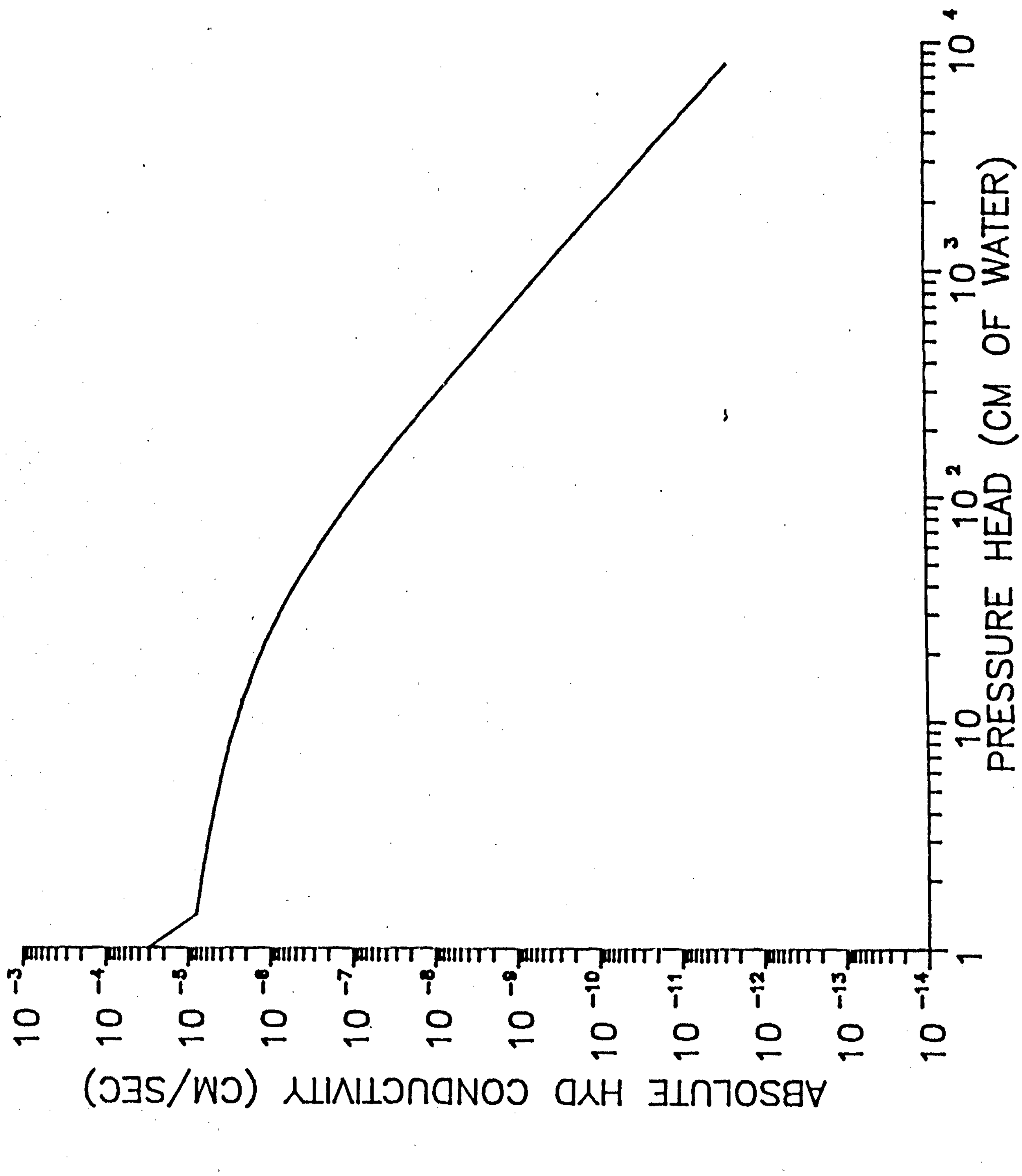
Sample No. GCI (12.5')



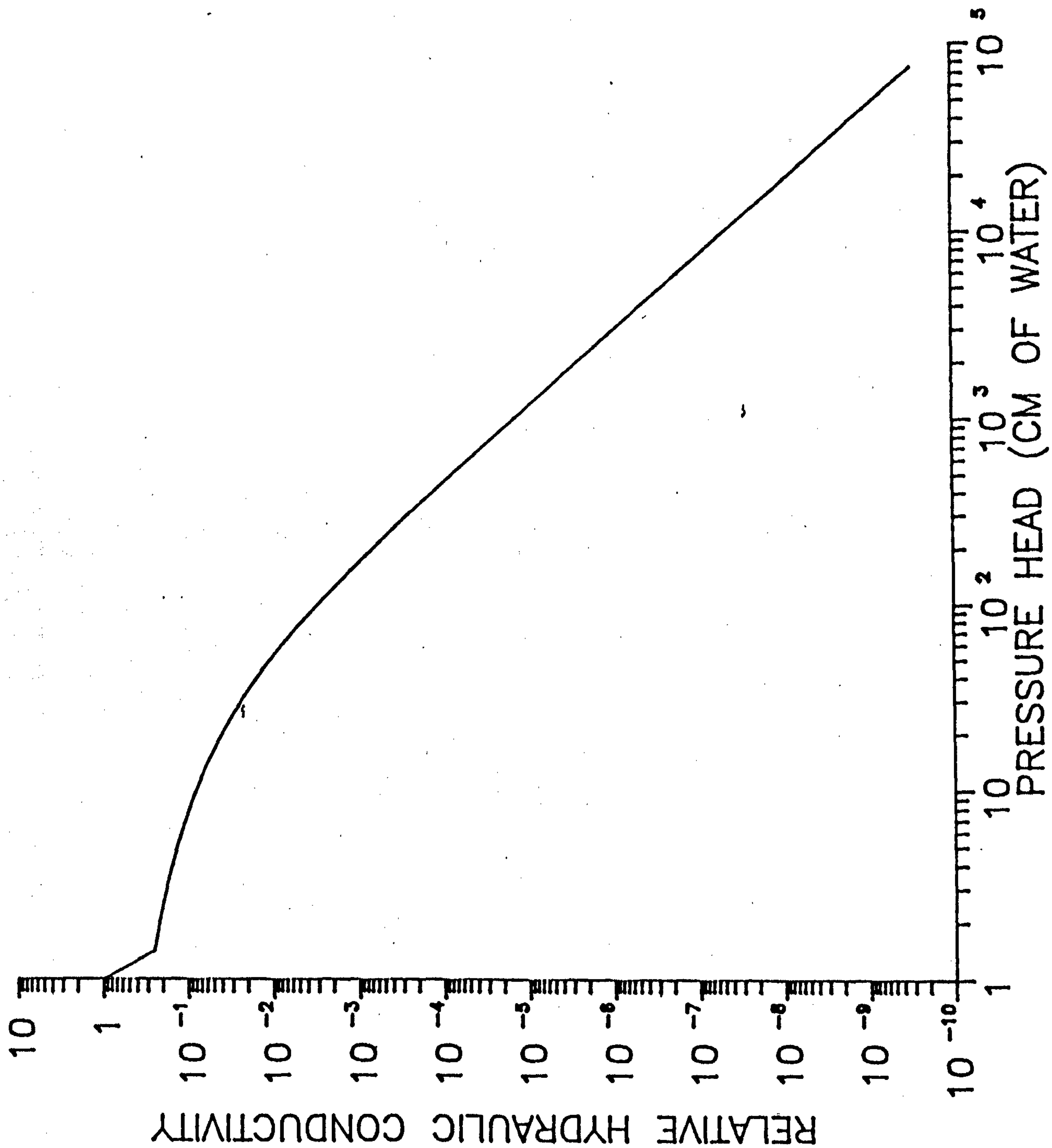
Sample No. GC1 (12.5')


MOISTURE CONTENT (VOL/VOL)
Sample No. GC4 (Sandstone, 39')
0.00
0.20
0.40
0.60
PRESSURE HEAD (CM OF WATER)
1
10
10 2
10 3
10 4
10 5

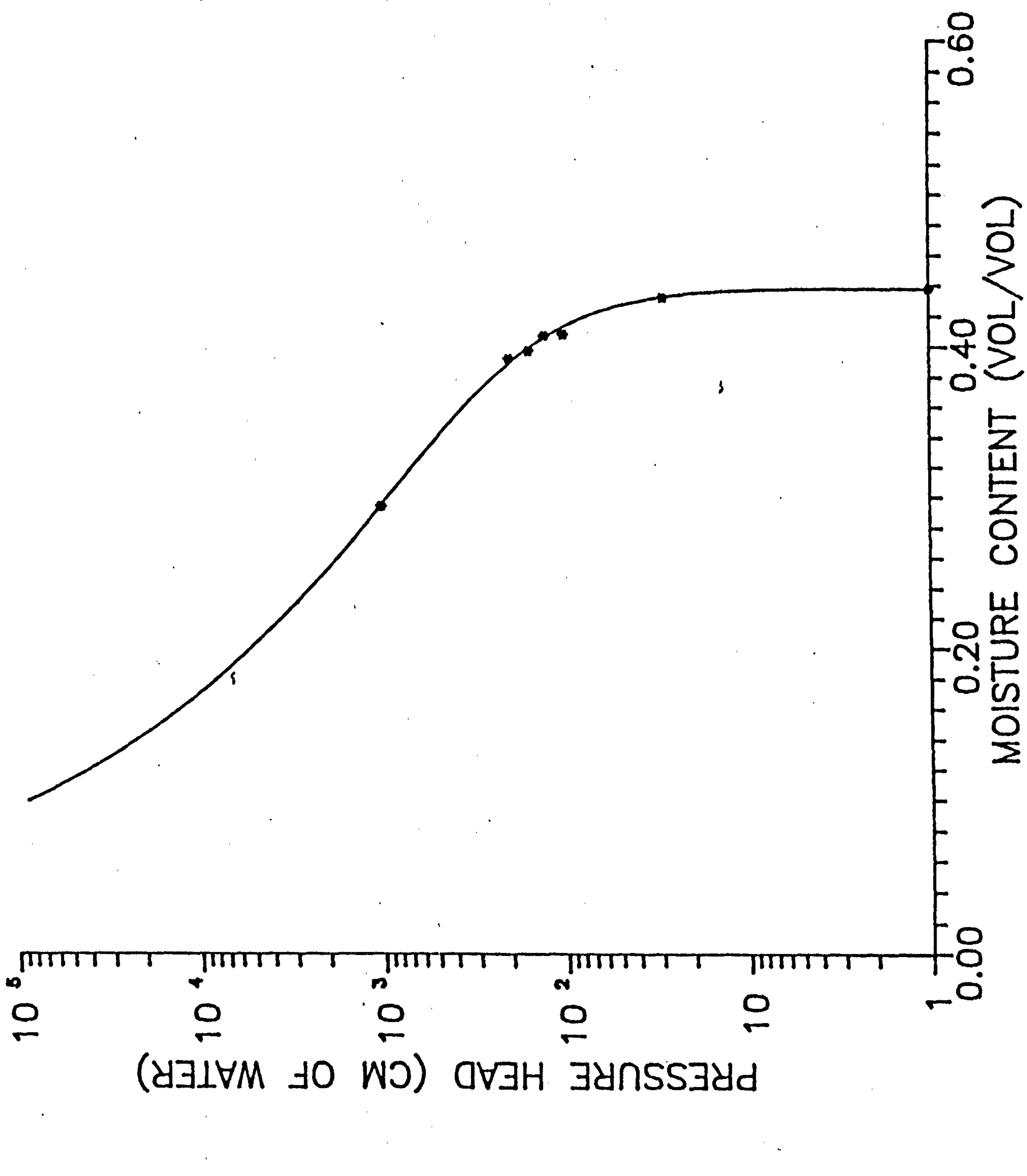

0.00
0.20
0.40
0.60
MOISTURE CONTENT (VOL/VOL)
Sample No. GC4 (Sandstone, 39')
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
10 -9
10 -10
10 -11
10 -12
10 -13
10 -14
ABSOLUTE HYD CONDUCTIVITY (CM/SEC)



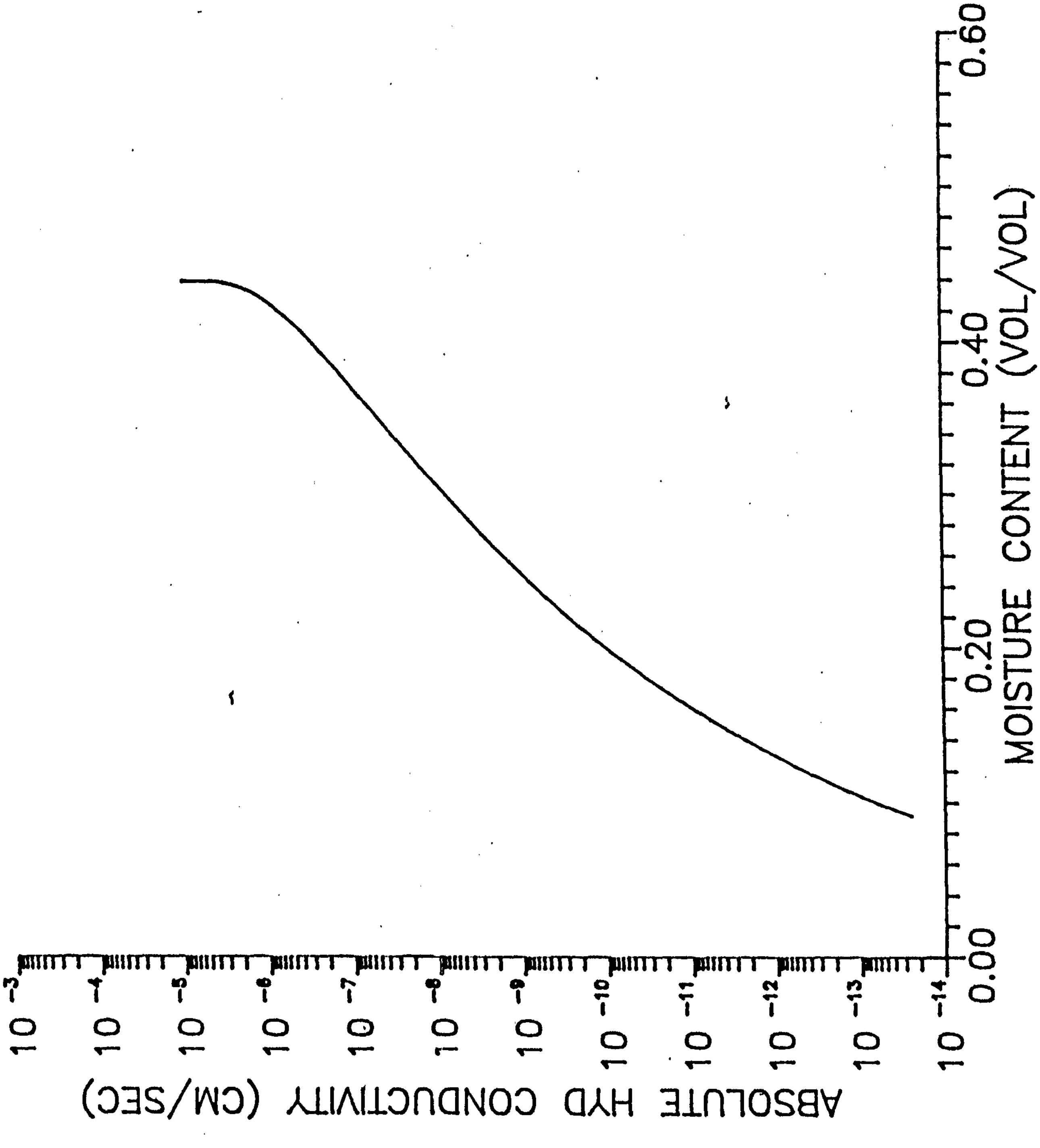
Sample No. GC4 (Sandstone, 39')



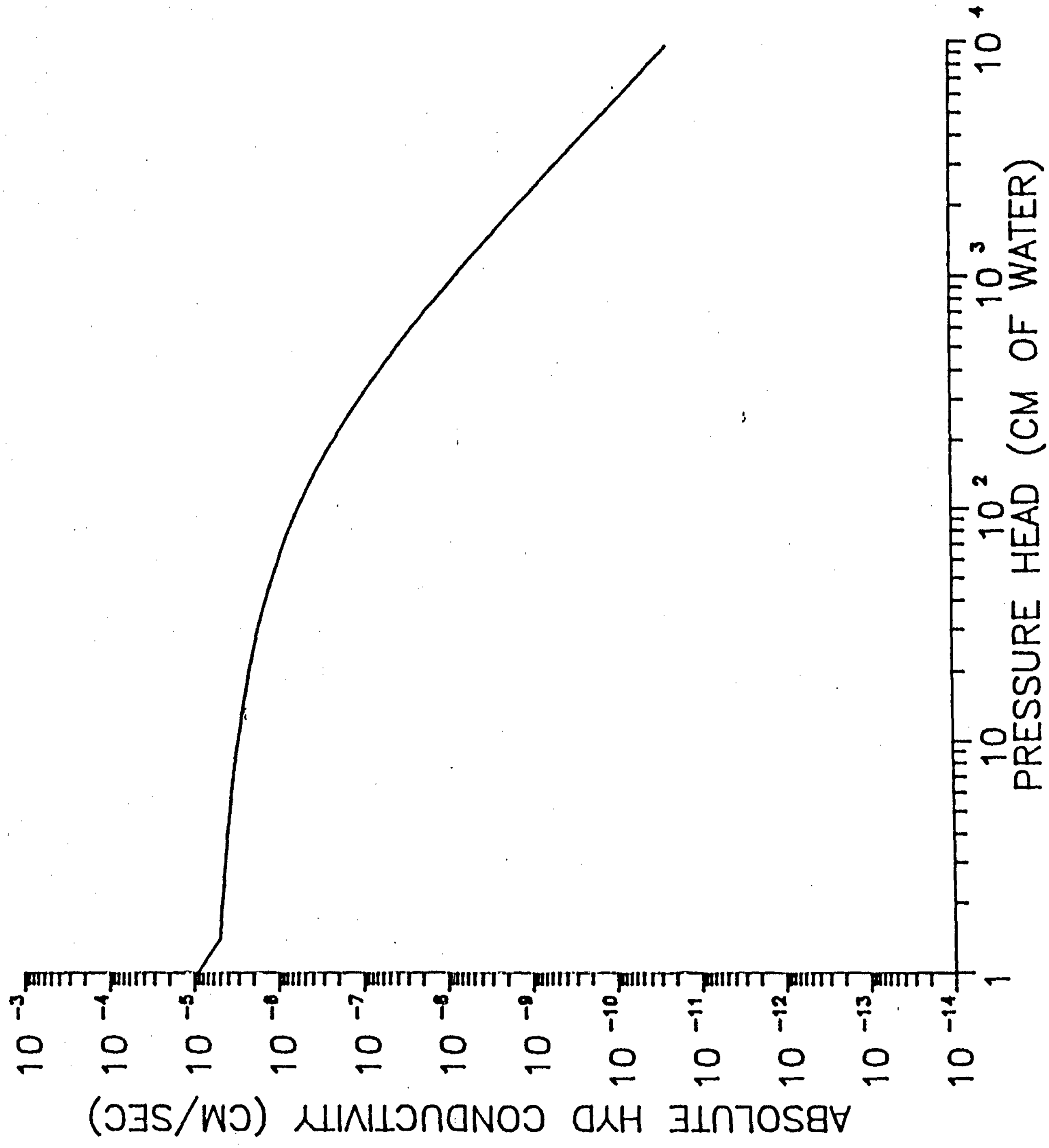
Sample No. GC4 (Sandstone, 39')



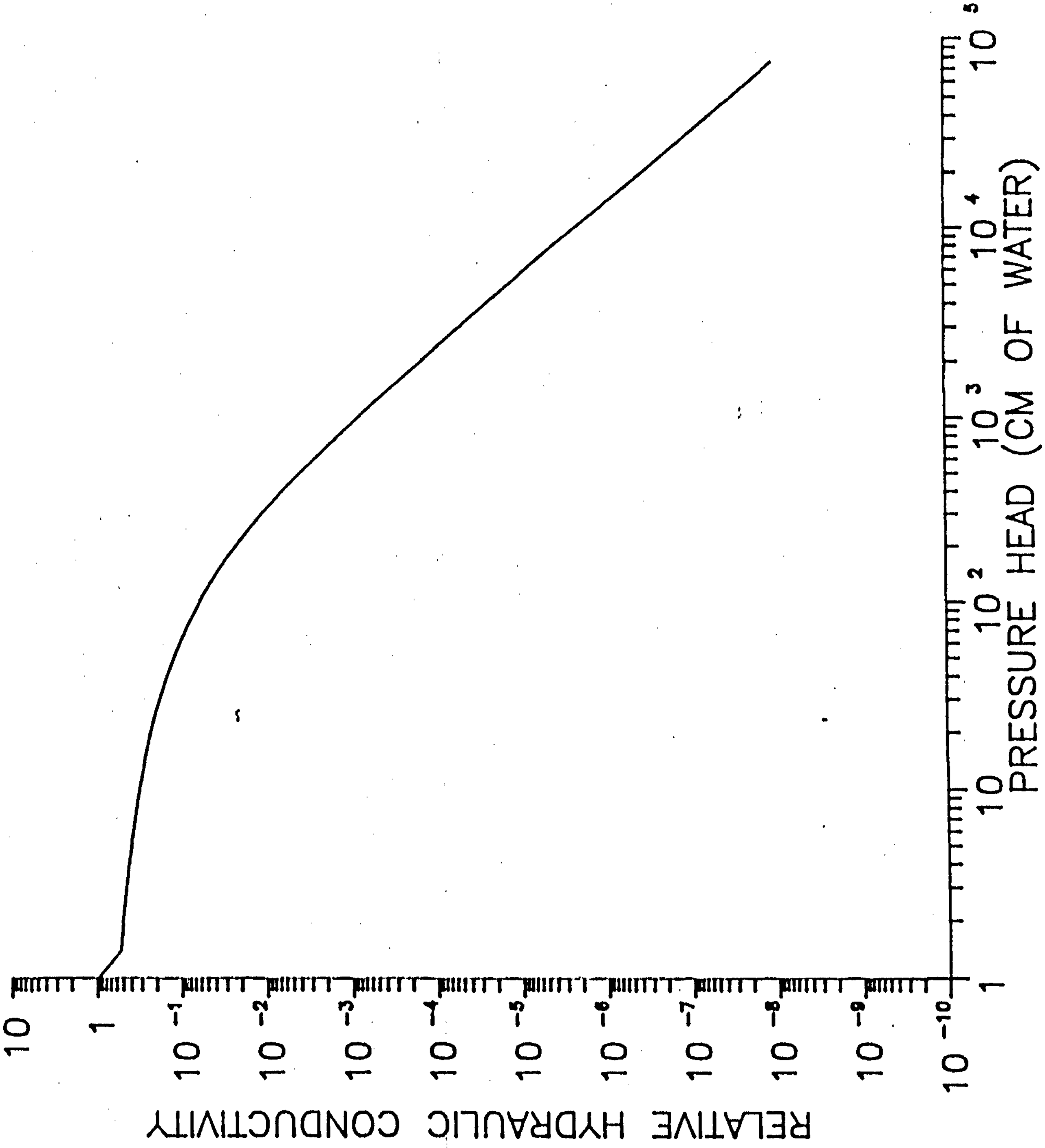
Sample No. GC5 (Mudstone, 39')



Sample No. GC5 (Mudstone, 39')



Sample No. GC5 (Mudstone, 39')



Sample No. GC5 (Mudstone, 39')

APPENDIX A

SAMPLE PREPARATION

SAMPLE PREPARATION

Sample No.	Preparation Performed
GC1	Soil arrived at the laboratory loose in a plastic bag. To achieve a bulk density representative of the field bulk density of the soil, the one piece of the sample that was not broken was carved into a cubic shape 2cm x 2cm x 1.66cm. The mass of this soil cube was determined as well as the volume calculated. A 100cc sample ring was then hand packed to this density (g/cc).
GC2	Soil arrived at the laboratory loose in a plastic bag. The sample had a strong odor of hydrocarbons, and appeared to be close to saturation with the pore fluid present. Only a small portion of the sample was still intact. To achieve a bulk density of the soil, the procedure outlined for sample GCI was employed. After preparation, the soil sample was removed from the 100cc sample ring and placed in an aluminum pan to air dry.

Sample No.	Preparation Performed (Continued)
GC3	Soil arrived at the laboratory in a plastic-bag. The soil was in the form of a cylindrical core, and appeared to be intact. A 100 cc sample ring was slowly pushed over the end of the soil core until the sample ring had been filled. The soil core was then trimmed at both ends flush with the sample ring. The sample was then removed from the ring and placed in an aluminum pan for oven drying.
GC4 (Sandstone)	Soil arrived at the laboratory in a plastic bag. The soil was in the form of a cylindrical core. Some vertical fractures were present in the clay portion of the core which comprised one end of the core. The other end of the soil core consisted of what appeared to be a well cemented sandstone. There appeared to be a thin layer of organics separating the two portions of the core. The sandstone portion of the core was separated from the clay portion. A 100cc sample ring

SAMPLE PREPARATION

Sample No.	Preparation Performed (Continued)
GC4	was slowly pushed over the soil core as the core was carved to a diameter just greater than the sample ring using an exacto knife.
GC5 (Mudstone)	Sample preparation was performed as outlined for sample GC4.

APPENDIX B

PRINCIPLES AND METHODS

SATURATED HYDRAULIC CONDUCTIVITY

Method

The saturated hydraulic conductivity of a soil sample can be measured in two types of laboratory apparatus: a constant head permeameter or a falling head permeameter.

Constant head. The hydraulic conductivity K is defined here as the ratio of q, the volume flux of water passing through a unit cross sectional area of soil per unit time, and (Δh/L) gradient of hydraulic head in the direction of flow, corrected to 20°C:

$$K = (q/[\Delta h/L])(V_T/V_{20}) \qquad (1)$$

where $V_{20,T}$ is the kinematic viscosity at 20 °C and observed temperature, T.

A soil sample of length, L, and cross-sectional area, A, is placed in a sample holder which prevents any loss of soil or change in volume and establishes laminar unidirectional flow through the sample. A constant head differential, Δh, is then set up across the sample and maintained. Periodic readings of volumetric outflow are taken until stable values for conductivity, K are obtained. Temperature of the fluid is measured with a thermometer. Figure B-1 is a diagram of the apparatus used. A constant head system is best suited to samples with conductivities greater than 10^{-4} cm/sec.

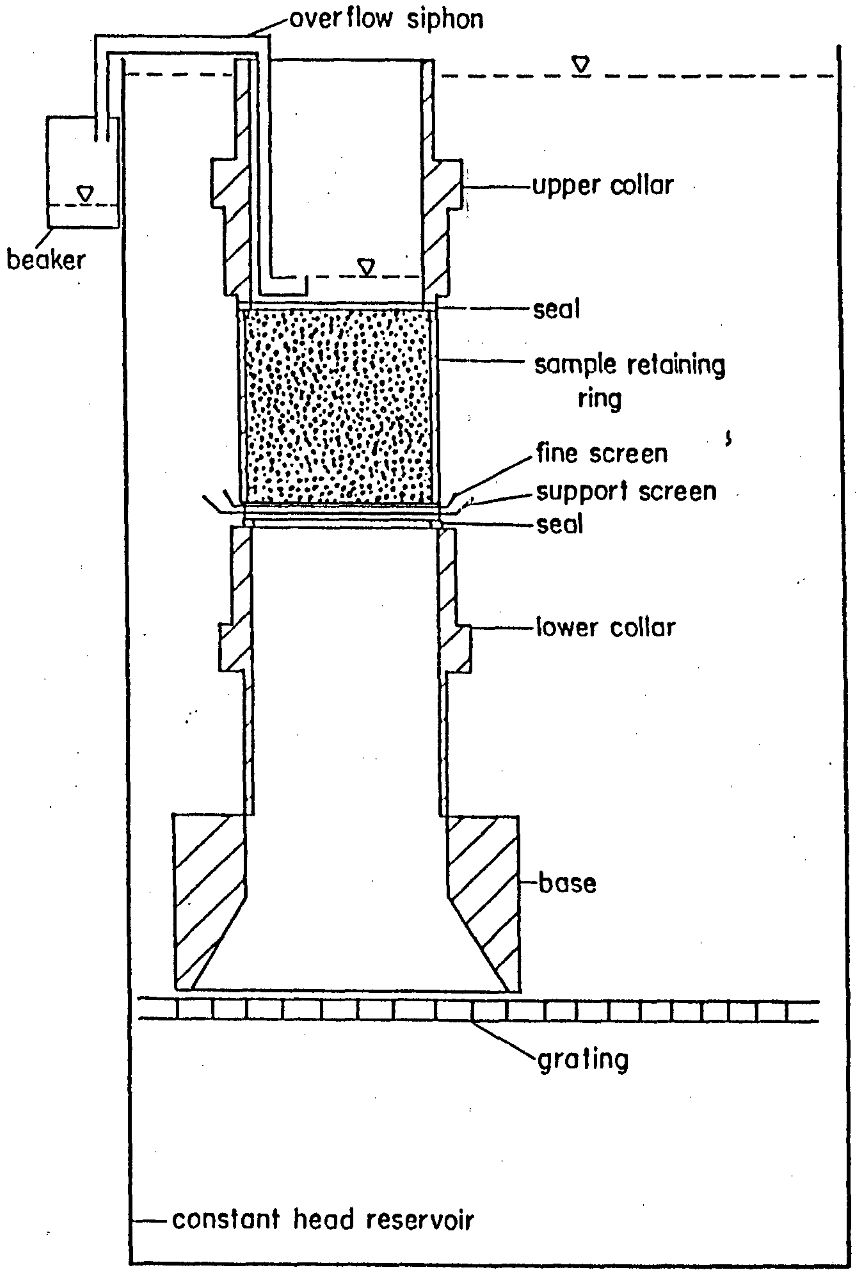


Figure B-1. Constant Head Permeameter

Falling head. A soil sample of length L and cross sectional area, A, is placed in a sample holder which has a standpipe with cross-sectional area, a. A head of H_1, is established in the standpipe above the sample, then the water level is allowed to fall to H_2 in time t. Figure B-2 is a diagram of the apparatus used. A falling head system is best suited to samples with conductivities less than 10^{-4} cm/sec. The hydraulic conductivity, is then defined as:

$$K = (a \times L/A \times t)\ \ell n\,(H_1/H_2)(V_T/V_{20}) \quad (2)$$

Procedures:

Constant head. Cylinders containing the soil sample are covered on both ends with loose fitting caps and placed in a shallow pan containing de-aired water. The samples are allowed to wet slowly from below for 24 hours. The samples are removed from the pan, and two screens are placed over one end; a very stiff one of coarse mesh for support and a fine one of either 80 to 100 mesh to prevent any sample from being washed out. The cylinder, with screens attached, is then clamped into the sample retainer and placed in the permeameter. The level of the water in the permeameter reservoir is then slowly raised over a period of hours. When the level in the reservoir reaches to within a few centimeters above the top of the sample, a siphon is placed in the sample retainer assembly to remove water from above

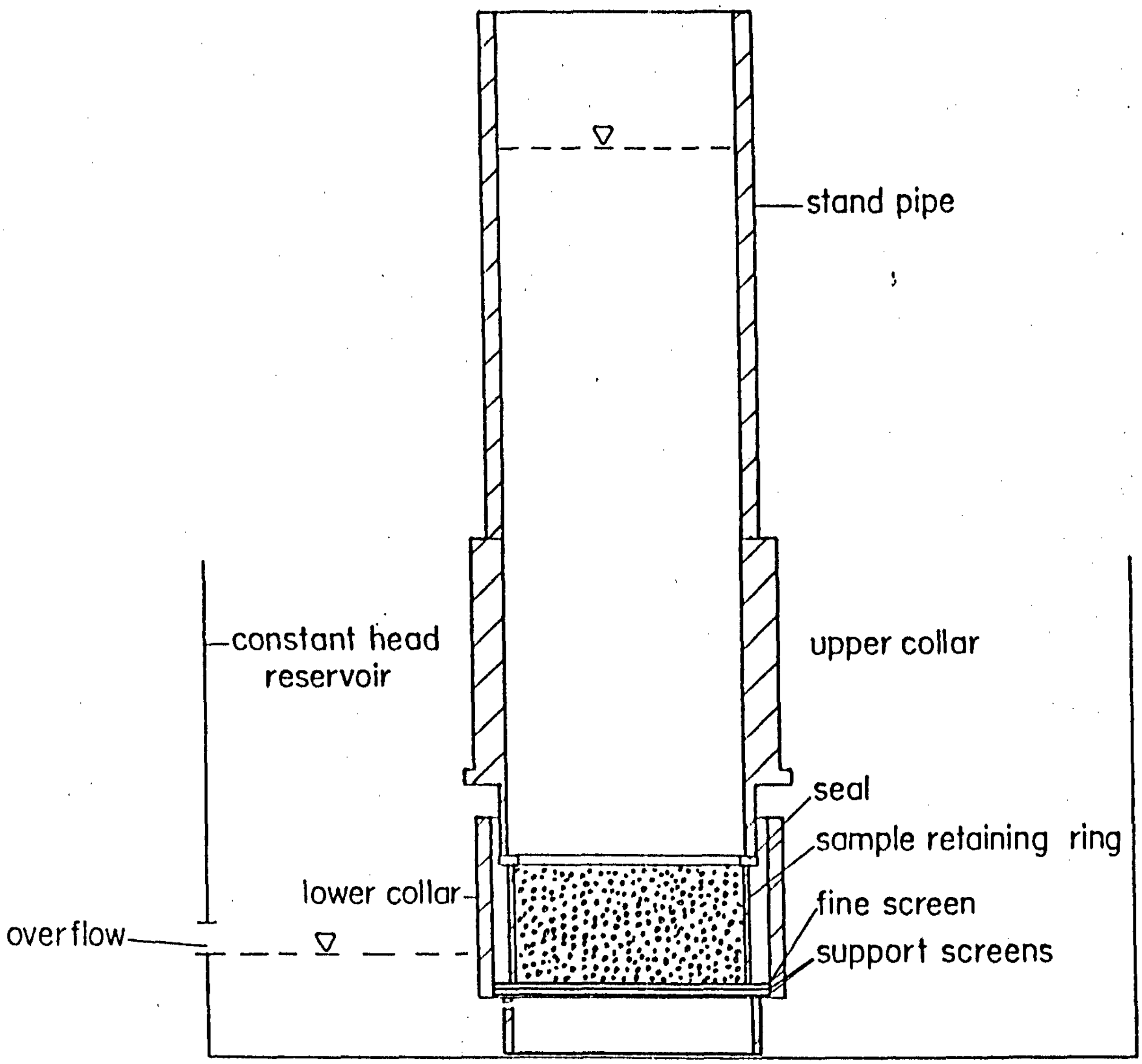


Figure B-2. Falling Head Permeameter

the sample. Water flows upward through the sample due to the hydraulic head difference across the sample. Periodic measurements of discharge and the head difference across the sample are made, and the hydraulic conductivity is calculated. A correction to 20 C is then applied for differences in kinematic viscosity. Measurement continues until the calculated hydraulic conductivity value stabilizes.

Falling head. Saturation of the sample is obtained by the same procedures described under constant head test. Screens are also attached as outlined under constant head test. The ring with screens is then placed in the falling head sample retainer and set in a constant head reservoir. Water is added to the standpipe and the difference between the water level in the standpipe and that in the constant head reservoir are recorded over time. The water level in the standpipe is allowed to fall, while the fluid level in the lower level is constant. After a period of time the difference in water levels between that in the standpipe and that in the constant head reservoir are measured and the elapsed time noted. Correction is applied for kinematic viscosity.

Calculations:

Experimental values are substituted into the appropriate equation as outlined under methods.

MOISTURE RETENTION - HANGING COLUMN

(PORE SIZE DISTRIBUTION)

Principle

Use of pore size distribution as a soil characteristic is based upon acceptance of the capillary model. This model is described by:

$$h' = 2 \cos \gamma / \rho g r \qquad (3)$$

where h' is the height to which a liquid will rise in a clean capillary tube of radius r, γ is the surface tension of the liquid, ρ is its density, and g is acceleration due to gravity. If water is extracted from an initially saturated sample of soil by a tension equal to h', the volume of water extracted is equal to the volume of pores having an effective radius greater than the radius, r. As the tension applied to the sample increases, additional water drains from progressively smaller pores.

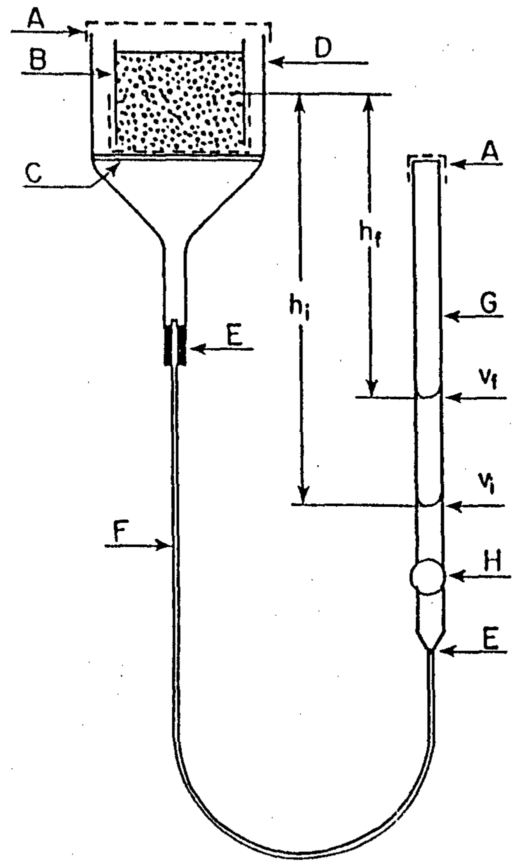
Method

The key component of the apparatus for measuring the retention of moisture at different pressure heads or pore size distribution is a fritted glass porous plate that conducts water, but when wet the plate is impermeable to air. The fritted glass plates have an air-entry pressure of about 300 to 400 cm of water. These plates are affixed in a glass funnel which is connected to a buret with stopcock by means of flexible tubing. A diagram of the apparatus is shown in Figure 3. A soil sample is placed on the plate and tension, h' is applied to the sample by positioning the fluid level in the buret at different levels below the center of the sample. Water flows out of the sample into the buret until equilibrium is achieved. The tension is again increased or decreased to obtain another state of equilibrium between moisture held by capillary forces in the sample and the applied tension.

Laboratory Procedure

Air is first removed from the porous plate by allowing de-aired water to pass continuously through it for 24 hours. The funnel with porous plate and the buret are supported on vertical rods by means of clamps. A saturated sample within its sample ring is then placed on the porous plate, making certain that good hydraulic contact is established between the soil particles and the plate. With the stopcock of the buret closed, the initial level of the water in the buret is recorded.

The buret is then lowered a small increment to about 10 to 15 cm below the center of the soil sample. When the stopcock is opened, the soil may begin to desaturate, and the drainage will flow into the buret. When drainage has ceased, the stopcock is



A Aluminum foil covers
B Sample in cylinder
C Fritted glass porous plate (part of D)
D Büchner funnel with porous plate
E Joints must be secure
F Flexible tubing
G Burette, least division not more than 0.1% sample volume
H Stopcock of burette
h_i cm of water suction, initial
h_f cm of water suction, final
v_i Burette reading, initial
v_f Burette reading, final

Figure B-3. Hanging Column Apparatus

closed and we record the water level in the vuret and the vertical distance from the bottom of the meniscus of the water in the buret to the middle of the soil sample. The procedure is repeated in a stepwise manner until the maximum tension desired is reached. A reversal of the process is used to gather data on the wetting behavior of the sample.

Calculation

Saturated moisture content , θ_{sat} , (volume percent) is determined as follows:

$$\theta\,sat = [M\ sat - M\ dry]/[V_T \times \rho_w] \times 100 \qquad (\%\ vol) \qquad (4)$$

where M sat = mass of sample saturated, M dry = mass of sample, oven dried to a constant weight, V_T = volume of the sample, ρ_w = density of the water at temp when saturated mass was determined. The quantity [M sat - M dry]/ρ_w is the volume, in cubic centimeters, of water initially contained in the sample volume. The drainage is subtracted from the initial volume of water and then divided by the sample volume to arrive at the moisture content in percent volume at the given value of tension.

$$[V_i - V_D]/V_T \times 100 = \theta_{h'} \qquad (\%\ vol) \qquad (5)$$

where V = volume of water initial, V_D = cumulative volume drained from sample, V_T = volume of sample, $\theta_{h'}$ = moisture content at the tension value h'. This gives then a paired set of values of tension, or pressure head, versus volumetric moisture content.

MOISTURE RETENTION - PRESSURE PLATE

Principle

The operation of the pressure plate moisture extractor requires maintaining a pressure difference between the liquid phase of the water in the soil and water on the opposite side of a porous plate which supports the soil sample. The sample and porous plate are sealed in a rigid container so that positive gas pressure applied above the plate causes flow to occur across the plate (Figure B-4). The porous ceramic plate is supported by a fine mesh screen which also provides a passage way for the extracted solution. The water beneath the plate is open to the atmosphere through the outflow tube. The illustration in Figure B-5 shows a magnified view of soil particles in contact with the plate inside the pressure plate extractor during an extraction run.

As soon as air pressure inside the chamber is raised above atmospheric pressure, the higher pressure inside the chamber forces excess water through the microscopic pores in the plate. Air, however, will not flow through the pores of the plate, because the plate remains saturated due to its high air-entry pressure. When the pressure in the chamber increases, water leaves the sample until the tension of the water

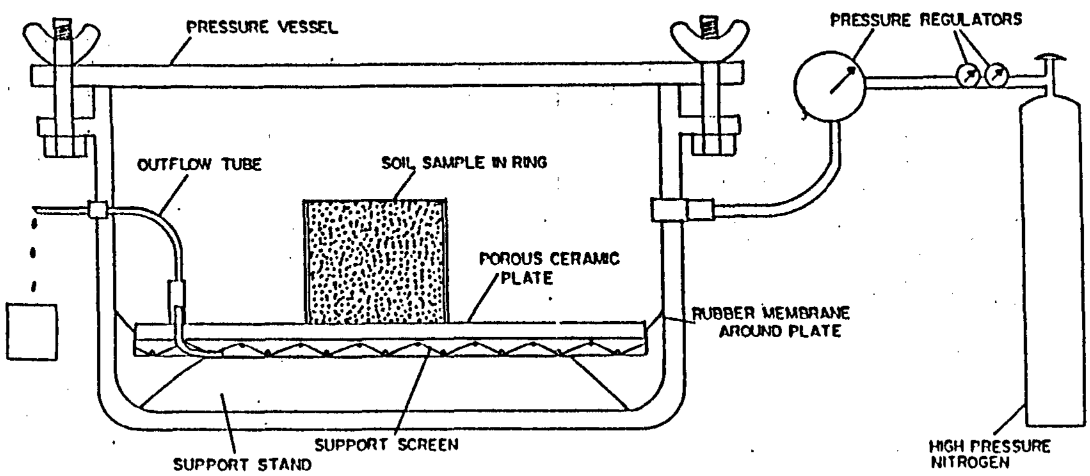


Figure B-4. Pressure Plate Extractor

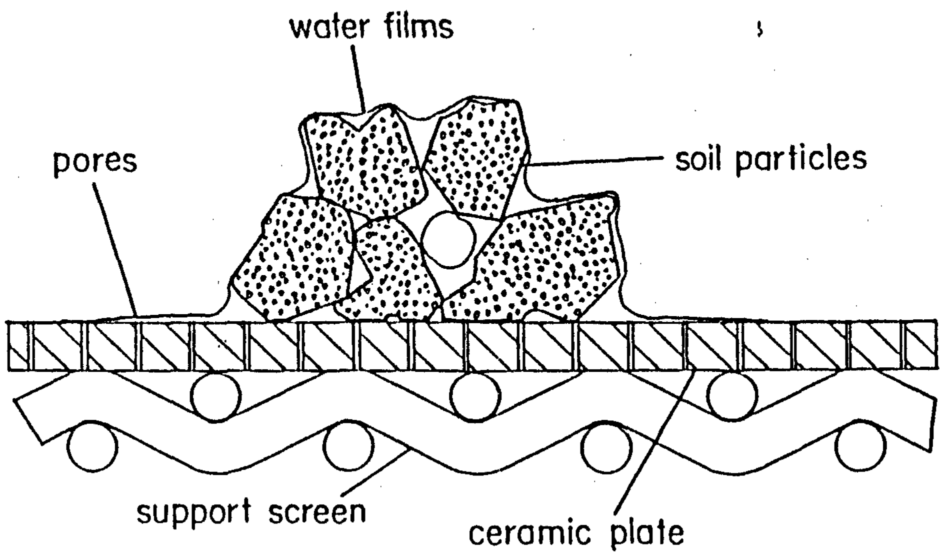


Figure B-5. Magnified View of Soil Particles due to capillary and adsorptive forces is in equilibrium with the applied pressure.

Method

Moisture retention is obtained using a pressure plate extractor (Soil Moisture Inc., Santa Barbara, CA, Model 1500), with 1, 3 and 15 bar ceramic plates. Pressure is provided by high pressure nitrogen from cylinders.

Laboratory Procedure

The porous ceramic plate is placed is a shallow pan with deaired distilled water and allowed to stand overnight. The plate is then removed from the pan and placed in the extractor. De-aired distilled water is poured over the plate to the limit allowed by the rubber skirt, which generally just submerges the plate. The pressure plate is sealed and pressure brought to 50% of the plates maximum rated pressure. This pressure is maintained until outflow ceases. The extractor is opened and any excess water around the plate is removed.

The soil samples in their sample rings are then placed on the plate, making certain good hydraulic contact is established. The extractor is then sealed and the pressure brought to the level desired. The pressure is maintained until outflow ceases. The extractor is then opened and the samples weighed quickly on an electronic top-loading balance. Subsequently, the samples are returned to the extractor, and the pressure is increased to the next increment.

Calculations

The decrease in mass of water in the sample during a period of applied pressure is converted to an equivalent decrease in volume of water according to:

$$V_w = \Delta m/\rho_T \qquad (cc) \qquad (6)$$

where Δm = change in mass of soil sample (g), ρ_T = density of water at temperature of experiment (g/cc), V_w = equivalent volume of water (cc).

Volumes of water calculated from equation 6 are then used to determine the moisture content at that pressure:

$$\theta_p = (V_i - \Sigma\Delta V_w)/V_T \times 100 \qquad (\%\ vol) \qquad (7)$$

where θ_p = moisture content at pressure p (% vol), V_i = initial volume of water in sample (cc), $\Sigma\Delta V_w$ = cumulative water volume change (cc), V_T = total volume of the sample (cc).

INITIAL MOISTURE CONTENT

Method

Core method, with oven drying.

Laboratory Procedure

The field weight of the soil sample is determined as soon as possible after the sample is removed from the packing container. The tare of the ring which holds the sample, as well as the mass of the caps for the ends of the ring, are determined. The volume of soil in the sample ring is also calculated. After all specified analyses have been performed on the sample, the sample is removed from its ring and spread in an aluminum pan. When necessary, soil aggregates are broken up by motar and pestal. Care is taken not to change the natural particle size distribution. The sample is placed in a convection oven at 110° C for at least 24 hours until dried to a constant weight.

Calculations

The initial moisture content is determined on a percent volume basis according to:

$$\theta_i = [M_i - M_f]/[V_T \times \rho] \times 100 \quad (\%vol) \qquad (8)$$

where θ_i = initial moisture content (% vol), M_i = initial mass of soil only (g), M_f = final mass of soil only (g), V_T = total volume of sample (cc), ρ = density of pore fluid in the soil when initial mass was determined (g/cc). The density of the pore fluid initially present in the sample is assumed to be 1.0 g/cc.

BULK DENSITY

Method

Core method, with oven drying.

Laboratory Procedure

The volume of the soil sample is determined from sample geometry measurements, and the sample is dried in the oven at 110 C until no additional mass loss occurs.

Calculations

$$\rho_b = M_D/V_T \qquad (g/cc) \qquad (9)$$

where ρ_b = dry bulk density (g/cc), M_D = mass of oven dried soil sample (g), V_T = total volume of soil sample (cc).

POROSITY

Method

Calculated from bulk density and measured or assumed values of particle density.

Laboratory Procedure

Bulk density, ρ_b, is determined by oven drying, as described in the section outlining the bulk density determination. For this series of analyses particle density, ρ_s, is assumed to be 2.65 g/cc.

Calculation

$$n = [1 - (\rho_b/\rho_s)] \times 100 \qquad \text{(percent)} \qquad (10)$$

UNSATURATED HYDRAULIC CONDUCTIVITY

Method

Mualem (1976) described the theoretical basis for a procedure used to estimate unsaturated hydraulic conductivity from the soil-water release curve according to the following equations;

$$K_r = S_e^{\frac{1}{2}} \left[\int_0^{S_e} 1/h(x)dx / \int_0^1 1/h(x)dx \right]^2 \quad , \qquad (11)$$

where K_r = relative hydraulic conductivity, $h = h(S_e)$ is the negative pressure head, given here as a function of dimensionless moisture content:

$$S_e = \theta - \theta_r / \theta_s - \theta_r \qquad (12)$$

where subscripts s and r indicate saturated and residual values of the soil moisture (θ). The expression relating dimensionless moisture content to the pressure head, and thus the soil moisture release curve is given by:

$$S_e = [1/1 + (\alpha h)^n]^m \qquad m = 1 \div 1/n \qquad (13)$$

where , and n are obtained by a non-linear least squares numerical procedure applied to measured moisture retention data using the technique developed by Van Genuchten (1978).

Laboratory procedure

The data input to the computer model of Van Genuchten (1978) consists of the saturated moisture content, residual moisture content and values of observed pressure head versus moisture content. The residual moisture content is taken to be the moisture content at -15 bars. The paired values of observed pressure head and moisture content are obtained as described under the procedures for determining moisture retention by the hanging column and pressure plate methods. Saturated moisture content is determined through gravimetric measurements and sample geometry.

References

Mualem, Y., 1976, A New Model for Predicating the Hydraulic Conductivity of Unsaturated Porous Media, Water Resources Research, vol. 12, no. 3, p. 513-522.

Van Genuchten, R., 1978, Calculating the Unsaturated Hydraulic Conductivity With a New Closed-Form Analytical Model, Research Report No. 78-WR-08, Princeton University, Department of Civil Engineering, September 1978, 65pp.

APPENDIX C

CHEMICAL ANALYSIS OF WATER

TAP WATER CHEMICAL ANALYSIS

ANIONS:	PPM
CARBONATE, $CO_3^{=}$	0
BICARBONATE, HCO_3^{-}	202
CHLORIDE, Cl^{-}	40
SULFATE, $SO_4^{=}$	109
NITRATE, NO_3^{-}	2.44
FLUORIDE, F^{-}	0.69

CATIONS:	
SODIUM, Na^{+}	62.0
POTASSIUM, K^{+}	1.5
MAGNESIUM, Mg^{++}	10
CALCIUM, Ca^{++}	61

TOTAL EPM ANIONS = 6.784

TOTAL EPM CATIONS = 6.602

% ERROR = 2.72

pH = 7.6

HARDNESS = 194 ppm, $CaCO_3$

APPROXIMATE TDS = 455 ppm

CONDUCTIVITY = 650 mmhos

APPENDIX E
FINITE-DIFFERENCE GROUND WATER FLOW MODEL

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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) finite-difference ground water flow model 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 drawdown responses observed during pump testing at the recovery wells, as well as estimated long-term drawdown. 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 four additional recovery wells near the existing recovery well in the Southern Refinery Area should be adequate to intercept all potentially contaminated ground water known or believed to be present north of the four proposed 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 a 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 aquifer. This 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.

This non-Theis behavior became evident during previous pump testing at the site. Results of this testing suggest that cones of depression which develop around recovery wells completed in alluvial and sandstone units encounter lower-permeability sandstone, shale, or clay. The large range of values for transmissivity and storage coefficient obtained from analyses of several pump tests clearly illustrates the extent of heterogeneity in the aquifer. The existence of a sloping water table introduces additional non-ideal behavior to the analysis.

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 groundwater 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 I: An initial steady-state calibration was performed by executing the flow model using various hydraulic conductivity distributions. Since the steady-state model response did not appear to be sensitive to changes in hydraulic conductivity within a reasonable range of variation, a more refined steady-state calibration was performed in Phase II using long-term steady-state drawdowns estimated from previous pump test results.

Phase II: This phase of calibration involved variation of hydraulic conductivity 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. During this phase, as well as during Phase I, 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 water-table map shown in Figure 4-4.

Phase III: 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 II steady-state calibration.

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 I and II, 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 II. 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 pull 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 map shown in Figure 4-4. 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 lateral 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 (see Figure 4-4). This orientation greatly facilitated the modeling study. Subsequent definition of longitudinal and lateral dispersivities, relative to the direction of ground water flow, can be redefined with respect to the orientation of the grid by simply resolving the dispersivity vectors into grid-oriented vectors.

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. This minimized 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. Table 1 lists values of DELX (I) and DELY (J) describing the spacing between columns and rows. These spacings are shown plotted on Plate F1. The northwesternmost corner of the grid was located at a northing of 2500 feet and an easting of 10400 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 (see Figure 4-4). 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

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

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

TABLE 1B
FINITE-DIFFERENCE GRID ROW
SPACING ARRAY DELY(J) (FT)

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

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 are maintained at these boundary nodes, there is no difference between assigning constant-head 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, which 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 Âh/Âl across the nodal element was reproduced according to Darcy's Law:

$$Q = K(x,y)\ A\quad h/\ l$$

Where A equals the cross-sectional flow area of the element.

Constant-head values along the northern, eastern, and southern boundaries were specified on the basis of observed water levels shown in Figure 4-4. 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 F1). 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 water levels corrected for floating product were used to define constant-head values along the inner rectangular boundary (see Plate F1). Table 2 lists 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 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. 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:

TABLE 2A
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 2B
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 2C
CONSTANT HEADS ALONG THE
EASTERN INNER BOUNDARY

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		

$$Kxx \quad hx + \quad Kyy \quad hy = S \frac{dh}{dt}$$

where Kxx = the hydraulic conductivity in the x-direction (along rows) [L/T]

Kyy = the conductivity in the y-direction (along columns) [L/T]

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

hy = 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 node

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:

$$Kxx \quad hx + \quad Kyy \quad hy = 0$$

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 and on the overall flow dynamics of the aquifer. 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 can be 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

Sat Thick 22-32'

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. A uniform steady-state saturated thickness of 62.5 feet could have been generated only through iterative adjustment of depth to bedrock. However, the effort required to iteratively define a uniform saturated thickness of 62.5 feet over the flow domain was not considered warranted at this time.

Use of an average saturated thickness of 62.5 feet made it possible to identify recovery-well nodes that would be incapable of sustaining targeted recovery rates. These nodes would go dry as soon as water levels dropped below the average screened interval bottom depth of 62.5 feet.

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/partially-confined aquifer was unknown. Initial conductivities were assigned on the basis of pump-test transmissivities normalized to the average saturated thickness of 62.5 feet. 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.

In order to permit hydraulic conductivity to conform to observed geologic conditions, the flow domain was subdivided into several zones within which conductivity was assumed to be uniform (see Plate F1). Pump testing at GBR-14 and observation of drawdown at GBR-15, both of which were completed in the arroyo alluvium, yielded transmissivity estimates of 790 and 128 gpd/ft at the pump well and at GBR-15, respectively. These transmissivities translated into conductivities of 12.6 and 2.1 gpd/ft^2 when normalized by the average saturated thickness of the alluvial-sandstone aquifer. The average conductivity of 7.4 gpd/ft^2 was well within the range of the silty sand of 1-1000 gpd/ft^2 which appears to characterize the arroyo sediments (Freeze and Cherry, 1979). Since lithologic descriptions of the fine-to-medium grained clayey sand obtained at GBR-17 appear to closely correspond to descriptions of the alluvium at GBR-14 and GBR-15, this value of hydraulic conductivity was applied everywhere in the zone of arroyo alluvium.

In the zones immediately east and west of the arroyo zone, which were characterized by a fine-to-medium-grained sandstone overlain by unsaturated alluvial fill, results from a pump test performed at GBR-27 were used to identify initial hydraulic conductivity. Transmissivities obtained from this test ranged from 118.7 to 387.2 gpd/ft, the equivalent of 1.9 and 6.2 gpd/ft^2 hydraulic conductivity. The average conductivity of 4.1 gpd./ft^2 was well within the accepted range for sandstone of 0.001 to 50 gpd/ft^2 (Freeze and Cherry, 1979).

A pump test performed at GBR-29, which was completed within the sandstone unit in the southeastern portion of the grid, yielded a transmissivity of 1041.8 gpd/ft, or an equivalent conductivity of 16.7 gpd/ft^2. This conductivity was somewhat higher than that observed in the sandstone near GBR-27, possibly as a result of replenishment from adjacent valley sediments near GBR-8, 9, 10, and 11 during the pump test, but was well within the range normally encountered in sandstone. Values of 4.1 and

16.7 gpd/ft^2 were used to initialize the hydraulic conductivities in the northern sandstone zone and in the southeastern sandstone zone, respectively.

Pump test data obtained at well GBR-8 during pumping at GBR-29 indicated a transmissivity of 2338.8 gpd/ft. The associated conductivity of 37.4 gpd/ft^2 obtained from drawdown data observed at GBR-8, which was completed in San Juan River valley sediments, probably represents a minimum conductivity, because it was the adjacent sandstone actually being stressed. These valley sediments were believed to be somewhat coarser-grained than the arroyo sediments, which were deposited by fluvial processes. River valley sediments appear to have been generated by higher-energy erosional processes caused by incision of the San Juan River and by the resulting increase in the topographic gradient to the south. The conductivity of 37.4 gpd/ft^2 was within the 10 to 10,000 gpd/ft^2 range typical of clean sand (Freeze and Cherry, 1979).

Table 3 lists the hydraulic conductivity estimates used to initialize the calibration in each zone. The conductivity zones were extended out to the edges of the model grid where geologic data were lacking. Further refinement of conductivity zones was limited by the number and location of actual transmissivity measurements and well logs.

There are no known leaking rivers and lakes near the site and the properties of discontinuous confining shale and clay beds are unknown. Therefore, no attempt was made to incorporate leakance into the model calibration.

3.4.4 Iterative Trial-and-Error Calibration

Initial attempts at steady-state calibration focused on variation of hydraulic conductivity until the overall configuration of the observed water table was reproduced. This Phase I calibration was directed at generating the overall characteristics of the potentiometric surface. Phase II calibration involved adjustment of hydraulic conductivity until the anticipated steady-state response to pumping stresses was duplicated.

TABLE 3
INITIAL, MINIMUM, MAXIMUM, AND FINAL MODEL
HYDRAULIC CONDUCTIVITIES (GPD/FT^2)

ZONE	INITIAL CONDUCTIVITY	RANGE OF VARIATION[a]		FINAL CONDUCTIVITY
		MINIMUM	MAXIMUM	
Arroyo Alluvium	7.4	2.1	12.6	1.8
Sandstone (N)	4.1	1.9	6.2	35.
(SE)	16.7	8.	25.	35.
Low-K Sandstone	5.	-	-	1.3
Valley Sediments	37.4	19.	56.	50.

a range defined by minimum and maximum transmissivities from pump test analysis or as ±50% of lithologically estimated conductivity when pump test data not available

The second phase was intended to "fine-tune" the model to facilitate subsequent transient calibration when small errors in conductivity may produce large errors in the estimate of storage coefficient. 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 (see Figure 4-4). In an effort to reproduce these closely-spaced contours, two low-permeability zones were constructed beneath these areas. Conductivities of these low-permeability zones were initially assigned as 5 gpd/ft^2 and were gradually reduced to 1.3 gpd/ft^2 in order to accurately duplicate the observed steep gradients in the rezoned 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 groundwater 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.

Steady-state response of the model was remarkably insensitive to variation in hydraulic conductivity within the ranges defined by pump-test analyses. Although this insensitivity could, to some extent, be attributed to the use of constant-head boundaries along three sides of the flow domain and the resulting pre-definition of the overall head drop across the system, it could also be related to the small range of pump-test conductivity used to perform the calibration (see Table 3).

3.4.4.2 Phase II Calibration

To compensate for this apparent model insensitivity, use was made of the three single-well pump tests performed in the Diesel Spill Area and Southern Refinery Areas. Based on the drawdown versus time plots generated at each pump-test 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 pump node, discharging at the pump-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. This represented a worst-case scenario for the case of recovery operations, because high transmissivities would result in smaller induced gradients. Thus, using these somewhat overestimated conductivities, it was possible to predict overestimated (i.e., maximum) discharges required to intercept 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. Use of underestimated long-term drawdown at pump wells is a means of building a margin-of-error into the recovery-prediction stage of the modeling study.

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):

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

where s = 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 'fine-tune' the steady-state model for long-term pumpage was as follows:

1) Using the estimated transmissivity of the zone containing the well and pump-test discharge, calculate s

2) Add s to the drawdown predicted by the model, s, to obtain simulated drawdown at a point s'=s + s

3) If the value of s' is approximately equal to the extrapolated observed steady-state drawdown at the pump well, the model has been calibrated for transmissivity (and 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 4 lists the pump-test discharges and extrapolated steady-state drawdown at GBR-14, GBR-27, and GBR-29 obtained from Figures C-11, C-6 and C-35, respectively.

TABLE 4 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 he 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 3 lists the final estimates of conductivity obtained on the basis of the two-phase steady-state calibration. With the exception of final conductivity for the sandstone, all final conductivities were within the specified ranges.

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 F4) with the observed water table (Figure 4-4) 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 5. 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.

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 5
PLASM INPUT PARAMETERS FOR GENERATION OF
STEADY-STATE HEAD

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U
Y
N
0

C
1 365 136 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 2299.501 2299.501 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 5
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 5
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 5
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 5
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 5
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 5
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 5
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 5
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 5
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 5
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 5
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 5

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 5
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 5
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	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	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 5
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 5
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 5
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 5

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 5
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 5
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 5
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 5
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 5
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 5

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 5 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 F3 depicts the potentiometric surface in the Southern Refinery Area due to the recovery-well pumpages listed in Table 6. A total of 91,000 gallons per day of water would be pumped under the suggested strategy. A successful recovery strategy 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 F3 would evolve over a long period of time. Clearly, this 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 downgradient 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.

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 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. As a result, greater discharge and a larger number of wells will be required to recover a

Table 5 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 F3 depicts the potentiometric surface in the Southern Refinery Area due to the recovery-well pumpages listed in Table 6. A total of 91,000 gallons per day of water would be pumped under the suggested strategy. A successful recovery strategy 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 F3 would evolve over a long period of time. Clearly, this 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 downgradient portions of the estimated plume could easily be captured by the proposed level of pumping.

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TABLE 6
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

specific volume of contaminated ground water in the Southern Refinery Area compared to the Diesel Spill Area.

Plate F3 shows only one of several possible recovery-well networks that would be capable of capturing the potential plume in the Southern Refinery Area. Installation of more than the four additional recovery wells would, in general, require less pumping from each well to effect the same recovery drawdown. For example, total required discharge from wells X1 and X2, completed in the high-conductivity valley sediments, could be reduced by installing several more wells in the sediments. The total required discharge would tend to be reduced with a greater number of recovery wells because the amount of stress required to intercept water would diminish when it is distributed over a wider area. The actual number of wells required for recovery of all potentially contaminated ground water will be dictated by long-term well yields and by the capacity of the treatment system.

3.6 RECOMMENDATIONS

Since recovery-well placement and number will partly depend on the yield of the aquifer, installation of the recovery system should proceed on the basis of observed well yield. The suggested procedure for recovery-well installation is as follows:

1) Install wells X2 and X3, shown in Plate F3. Optimal placement of these wells are more dominated by the edges of the inferred plume than by aquifer yield.

2) Test the two new wells over a period of one or two months to determine their long-term yields. Assume that all new wells completed in the same materials will have these yields. Estimate potential yields in untested aquifer materials.

3) Run the calibrated steady-state model using observed and estimated long-term yields to determine the precise locations of additional wells needed to prevent contamination from migrating off the site.

The approximate capture zones that would develop under the proposed remedial action pumping strategy are shown in Plate F4. Clearly, much of the anticipated product and dissolved contamination would be intercepted by the recovery wells, given the assumption upon which the numerical models are based.

LEGEND

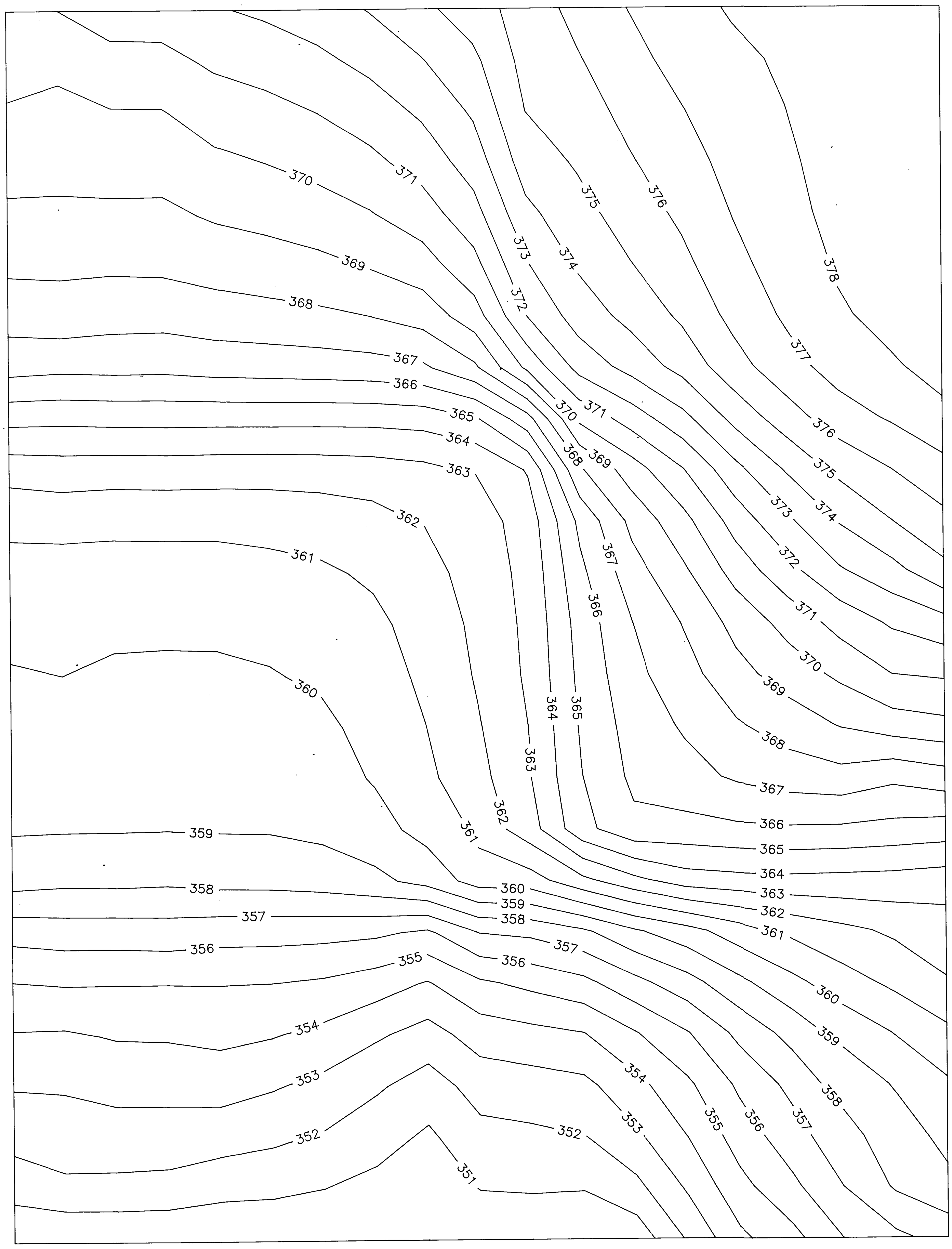
● 6 WELL LOCATIONS

GCL

HYDRAULIC CONDUCTIVITY ZONES

CLIENT:
DATE: 3/20/87
DRAWN BY: KJK
CHECKED BY:
REVISED:
SCALE: 1" = 100'

PLATE E1



LEGEND

356 EQUIPOTENTIAL LINE
(HEAD -5000 ft.)

N

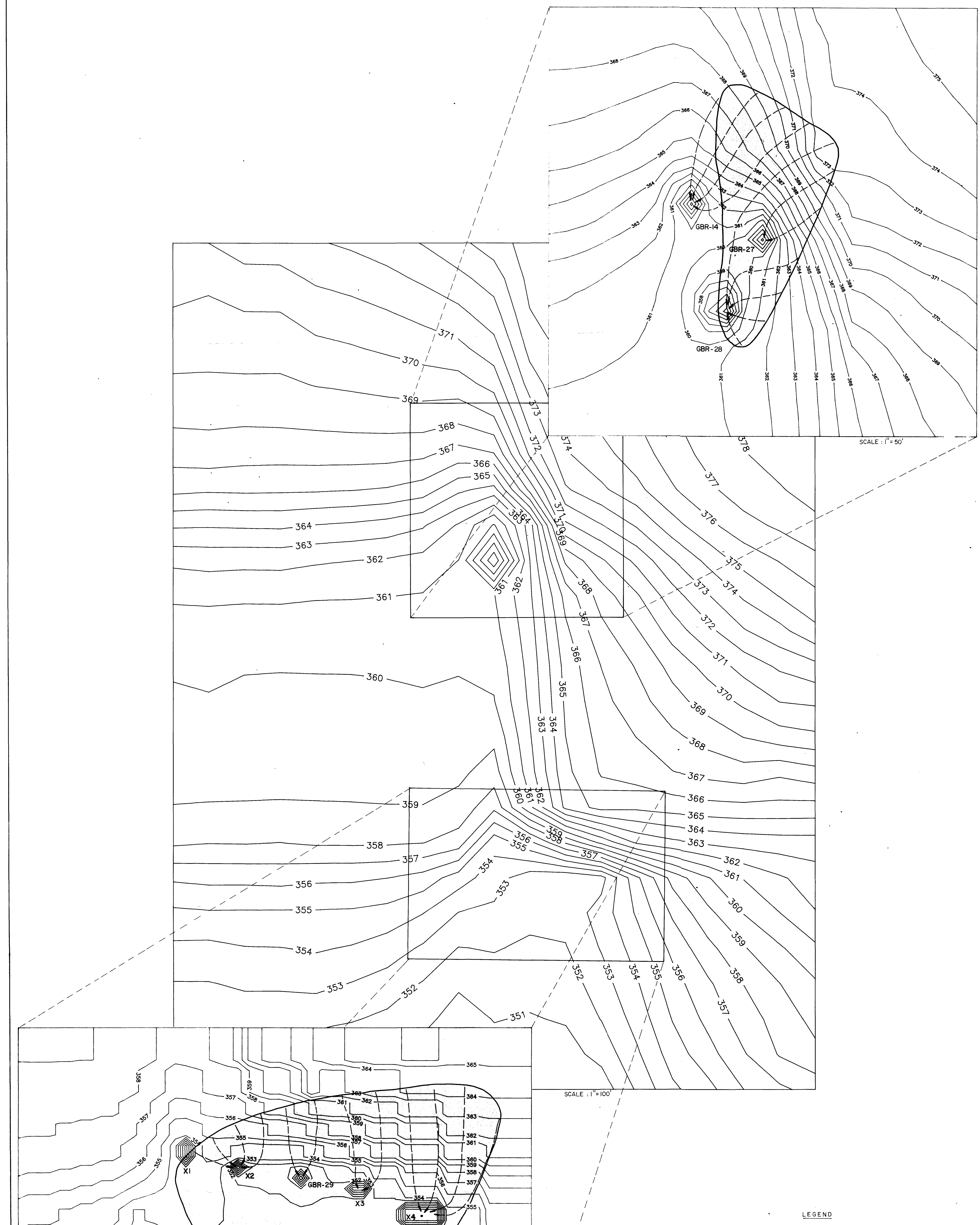
0 100
feet

GCL

SIMULATED EQUIPOTENTIAL SURFACE UNDER STEADY-STATE CONDITIONS

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

PLATE E2



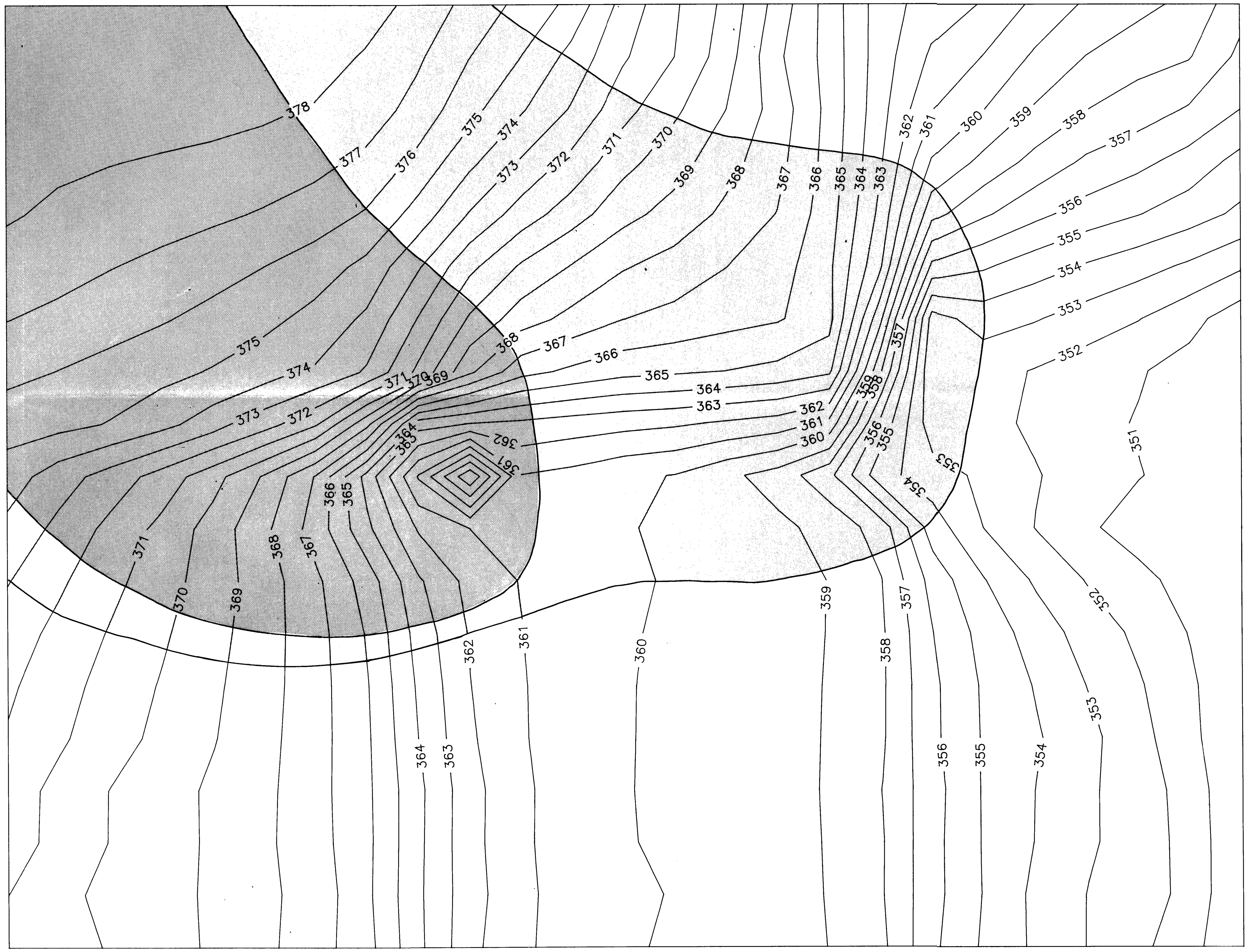
GCL

EQUIPOTENTIAL SURFACE DUE TO PROPOSED PUMPING STRATEGY

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

PLATE 4/E3

Plate E3



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.

N

0 100
feet

GCL

APPROXIMATE CAPTURE ZONES UNDER PROPOSED RECOVERY STRATEGY

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

PLATE E4