REPORT OF GEOTECHNICAL SERVICES
EAST PASCO FUEL TERMINAL
PASCO, WASHINGTON
FOR
CHEVRON U.S.A., INC.

GeoEngineers
Incorporated

GeoEngineers
Incorporated

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Consulting Geotechnical
Engineers and Geologists

June 22, 1987

Chevron U.S.A., Inc.
P.O. Box 220
Seattle, Washington 98111

Attention: Mr. Mel Knutson

Gentlemen:

We are submitting four copies of our final report regarding our geotechnical services at your fuel terminal in Pasco, Washington. Our services were authorized by Mr. Knutson on November 10, 1986. Our services were performed under the terms of Contract No. M66CNW00696X, Release No. 3.

We appreciate the opportunity to be of service to Chevron U.S.A. Please call if you have questions regarding our report or if we may be of additional assistance.

Yours very truly,

GeoEngineers, Inc.

James A. Miller

James A. Miller
Associate

JHB:JAM:cs

File No. 0372-18-4

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REPORT OF GEOTECHNICAL SERVICES
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PASCO, WASHINGTON
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INTRODUCTION

The results of our geotechnical services at the East Pasco Fuel Terminal are presented in this report. The terminal is located at 3000 Sacajawea Park Road in Pasco, Washington. The site location relative to surrounding physical features is indicated in Figure 1. The general layout of a portion of the facility is shown in Figure 2.

Four monitor wells, MW-1 through MW-4, were completed at the site during 1983 by Environmental Emergency Services. An additional monitor well, MW-5, was completed by Chevron U.S.A. during the summer of 1986. Locations of Wells MW-1 through MW-5 are shown in Figure 2.

We understand that free (floating) product was detected in Well MW-2 on July 14, 1986 during a regularly scheduled round of well measurements by Chevron personnel. Chevron personnel also observed a fuel product sheen along the bank of the Snake River and deployed a sea curtain to contain the sheen. The approximate location of the sheen is shown in Figure 2.

Terminal-related pipelines and one of the two Salt Lake pipelines were located near the area of the sheen, as shown in Figure 2. The terminal-related and Salt Lake pipelines were exposed during excavation by Chevron USA during August 1986. A terminal-related pipeline which was dedicated to aviation fuel was found to be leaking and all of the terminal-related pipelines were removed from the subsurface in the area near the sheen. Soil contaminated by fuel products was also removed from the subsurface and replaced with "clean" soil during the pipeline abandonment activity.

The removal of the terminal-related pipelines and fuel-contaminated soil did not eliminate the sheen on the surface of the Snake River.

We visited the terminal on October 28, 1986 with Messrs. Mel Knutson and Dave Feiglstok to conduct a preliminary reconnaissance of the site. Samples of free product were collected from Well MW-2 and from the sorbent pads in the sheen area during our initial October 28 site visit.

PURPOSE AND SCOPE

The purpose of our services is to explore subsurface conditions and to develop recommendations for remedial measures aimed at eliminating the fuel product sheen on the river and for the recovery of free product from Well MW-2. Specifically, our scope of services includes:

1. Subcontracting the drilling of four soil borings.
2. Installing 2-inch-diameter PVC monitor wells in each boring.
3. Determining the elevation of all of the monitor well casings to an accuracy of 0.01 feet.
4. Measuring water and free product levels in the four new and five existing monitor wells to determine water table elevations and free product thicknesses.
5. Evaluating the direction of ground water flow based on our field measurements.
6. Assessing whether free product near Well MW-2 is the source of the sheen based on an analysis of ground water flow direction, our findings during drilling and sampling of the four monitor wells, and the results of the "fingerprinting" of product samples collected on October 28, 1986.
7. Developing recommendations and specifications for remedial measures aimed at eliminating the fuel product sheen on the Snake River.
8. Monitoring the construction and effectiveness of remedial actions aimed at eliminating the fuel product sheen on the Snake River.
9. Developing recommendations for the recovery of free product from Well MW-2.

SITE CONDITIONS

GENERAL

The East Pasco Terminal is located on a bluff about 80 feet higher than the Snake River. The facility has been in operation since September 1950 and is used for bulk storage of refined fuel products which are delivered through the Salt Lake Pipelines and by barge. A barge loading/unloading facility and boat house are located at the river. Pipelines are used to transfer product between the terminal and barge facility.

SUBSURFACE CONDITIONS

Subsurface soil conditions beneath portions of the site were explored by drilling four test borings, MW-6 through MW-9, at the locations indicated in Figure 2. Details of the field exploration program and the boring logs are presented in the Appendix. Logs are not available for Borings MW-1 through MW-5.

Borings MW-6 through MW-9 encountered approximately 14 to 65 feet of fine to medium sand which extends from the ground surface downward to about Elevations 335 to 345 (the water surface elevation of the Snake River normally ranges between 335 and 340). The thickness of the sand unit increases from the river toward the terminal as ground surface elevations increase.

Borings MW-6 and MW-9, which are located near the river, encountered silty sand and sandy silt beneath the upper sand unit. Borings MW-7 and MW-8, which are located on the slope between the river and the terminal, encountered gravelly sand and sandy gravel beneath the upper sand unit. Gravelly sand was also encountered beneath the sandy silt at Boring MW-9.

GROUND WATER CONDITIONS

Ground water conditions at the site were explored by installing a monitor well in Borings MW-6 through MW-9. Construction details for the wells are included in the Appendix. Construction details for Wells MW-1 through MW-5 are not available.

We determined the water table depth and elevation in Wells MW-1 through MW-9 on November 26, 1986 and January 8, 1987. Measurements were conducted in a portion of the monitor wells on other dates. The depth to ground water varies from about 75 feet at the top of bluff, near the bulk storage area, to about 15 feet along the top of the river bank. A summary of water table elevations is given in Table 1.

Water table elevations and contours based on our November 26, 1986 measurements are shown in Figure 3. Ground water appears to flow in a southerly direction from the terminal area toward the river, as indicated in Figure 3.

SUBSURFACE CONTAMINATION

Subsurface fuel-related contamination at the site was evaluated by:

1. Physical examination of soil samples and noting the presence of petroleum odor in the samples.
2. Measuring the air space within the monitor well casings for hydrocarbon vapors.
3. Sampling the water table interface in each well for the presence of free (floating) hydrocarbons.
4. Analyzing fuel collected from Well MW-2 and from sorbent pads in the area of the sheen.

We detected a moderate odor of fuel in several soil samples obtained from Boring MW-7. Fuel product odors were not detected in soil samples obtained from Borings MW-6, MW-8 and MW-9.

Hydrocarbon vapors were detected in Wells MW-2 and MW-7. Hydrocarbon vapors were not detected in the remaining seven monitor wells. Hydrocarbon vapor measurements are given in Table 2.

As much as 0.20 feet of free product has been detected in Well MW-2 during our field measurements. Free product thickness in Well MW-2, as measured on several dates, is summarized in Table 3.

Table 3

Summary of Free Product Thickness in Well MW-2

Date	Free Product Thickness (feet)
11/17/86	0.20
11/26/86	0.12
12/15/86	0.06
1/8/87	0.17
3/16/87	0.08

We understand that trace amounts of free product were occasionally detected in Well MW-5 by Chevron personnel during their past measurements. We detected a trace of fuel product in Well MW-5 on November 26, 1986. We used water- and gas-finding paste to make our fluid level measurements. We obtained a positive indication (color change) with the gas-finding paste in Well MW-5 but could not detect a difference in water and product levels (not

a measurable thickness of product) on November 26, 1986. The positive indication in Well MW-5 may have been caused by a sheen or a globule of product on the water surface. We did not detect fuel product in Well MW-5 during later measurements.

Samples of free product were collected from Well MW-2 and from the sorbent pads in the sheen area during our initial October 28 site visit. The results of Chevron's "fingerprinting" of the product samples indicated that the free product in Well MW-2 consisted of unleaded gasoline while the product collected from the sheen consisted of aviation fuel.

DISCUSSION

The results of the product "fingerprinting" and our field observations indicate that free product at Well MW-2 was not the source of the fuel product sheen on the Snake River. Contamination related to the free product at Well MW-2 appears to have moved downgradient to the area near Well MW-7 but has not yet reached the area near Well MW-8. The extent of the free product plume north of Well MW-2 has not been determined.

The terminal-related pipelines were suspected as a source of the sheen and were removed from the subsurface during the summer of 1986. We understand that a hole was found within the aviation fuel pipeline during the pipeline abandonment operation and that a limited amount of contaminated soil was observed in the vicinity of the hole in the pipeline. The contaminated soil was removed in 1986 and the excavation was backfilled with clean soil. We understand that free product was not observed on the water table during pipeline abandonment. We also understand that the excavation extended only a portion of the way down the river embankment.

We understand that the Salt Lake Pipeline has been pressure-tested and found not to be leaking. The pipeline carries several types of product and we understand from Chevron Pipeline personnel that a mixture of product types would be expected to be found in the sheen if the Salt Lake Pipeline was leaking. We understand that only aviation fuel was found in the product sample that was collected from the sheen area.

Wells MW-5 and MW-9 are located in the area of the former terminal-rated pipelines and near one of the Salt Lake Pipeline river crossings. Free product was not detected in Well MW-9 and hydrocarbon vapors were not detected in either Wells MW-5 or MW-9. Soil contamination was not detected while drilling and sampling Boring MW-9. Trace amounts of free product (sheen and/or globules) occasionally appear to be present in MW-5.

The results of our explorations indicate that the source of the sheen was fuel-contaminated soil located along the shoreline between the river and the vicinity of Well MW-5.

REMEDIAL MEASURES

FUEL PRODUCT SHEEN

General: Remedial measures aimed at eliminating the fuel product sheen have included, in order of occurrence, the removal of the terminal-related pipelines (by Chevron), pumping of water from Well MW-5, and the excavation of fuel- contaminated soil from along the shoreline of the river.

Recovery Well: Water was pumped from Well MW-5 in an attempt to produce a cone of depression in the water table and a localized reversal in the direction of ground water flow. The pumping system, an oil/water separator and water exfiltration gallery were installed by Crowley Environmental Services during early January 1987 at the locations shown in Figure 4. The pumping system was operational between January 9, 1987 and April 2, 1987.

Prior to installation of the pumping system, we estimated that a pumping rate of 15 gpm would be necessary to cause ground water to flow to the well instead of the river. Well MW-5 was found to be capable of yielding only 8 gpm during system operation. The cone of depression created in the water table was not large enough to cause an extensive reversal in ground water flow direction. As a result, the sheen persisted during the pumping program. Free product did not accumulate in Well MW-5 during the operation of the pumping system.

Removal of Fuel-Contaminated Soil: We recommended that fuel-contaminated soil be removed from along the shoreline based on the persistence of the sheen during the pumping program. Specifications for the soil removal project are presented in our letter dated February 20, 1987. The

location of the excavation, the area used to stockpile the fuel-contaminated soil, and the area used as a borrow source for "clean" fill are shown on Figure 5. Application for construction permits were made to the Franklin County Planner and the U.S. Army Corps of Engineers.

Excavation of soil from the shoreline occurred between May 5 and May 15, 1987. The general contractor for the project was 3-D Tank & Petroleum Equipment Co., Inc. Olympus Contracting, Inc. was on site for emergency spill control during the time the Salt Lake Pipeline was exposed.

Approximately 1900 cubic yards of soil was excavated and approximately 500 cubic yards of soil was judged to be contaminated by fuel. The contaminated soil was stockpiled in Chevron's Marketing Terminal and replaced with clean sand from the borrow area.

The fuel-contaminated soil consisted of fine to medium sand stained with fuel product. The thickness of the fuel-contaminated layer of soil was as great as 24 inches and the layer of contaminated soil was generally found at the base of the upper sand unit, immediately above the silt unit. The point source of the leak was not located; however, a cone of contaminated soil was noted extending from within 3 feet of existing surface grades downward to the silt. This cone occurred approximately 30 feet west of Well MW-5. The configuration and occurrence of the contamination suggest that this was the source location. The nature of the source of the fuel product is not known.

Wells MW-9 and MW-5 were destroyed during excavation. MW-5 was replaced with a 24-inch corrugated metal pipe. The location of the replacement well is shown in Figure 5. Slots were cut in the pipe with an abrasive power saw. Backfill around the pipe consisted of washed pea gravel. The well was developed by withdrawing approximately 8 gpm of water over a period of four hours with a 3-inch diaphragm pump.

The Salt Lake Pipeline was exposed during the soil excavation program and it was found that approximately 25 feet of the asphalt coating on the line had deteriorated in the presence of the fuel-contaminated soil. Chevron Pipeline took this opportunity to recoat the pipeline. A small cofferdam was built to expose a section of line beneath the river. The excavation was dewatered with a portable pump and a vacuum truck. The

softened asphalt coating was replaced with an asphalt/fiberglass wrap and chemically resistant plastic tape was placed over the new coating for additional protection.

Summary: Our observations during the soil excavation program suggest that the point source for the fuel product sheen on the Snake River was located about 30 feet west of Well MW-5. The nature of the point source of fuel product is not known.

The removal of the contaminated soil appears to have eliminated the source of fuel product which caused the sheen. The sheen has abated and is no longer visible on the surface of the Snake River.

FREE PRODUCT RECOVERY

General: Free product has been detected in Well MW-2 since July 1986. The extent of the free product plume is not well defined as a result of the absence of wells in the area north of Well MW-2.

Free Product Recovery: We recommend that a free product recovery program be initiated at Well MW-2. Recovery equipment could consist of the Ejector Systems, Inc. (ESI) single-pump recovery system. Recovered fluids could be routed through an existing oil/water separator. The decanted water from the separator could then be routed to the existing lined pond at the Pasco Terminal. Other methods of water disposal such as an exfiltration gallery could be used if the lined pond is not available.

The quantity and rate of product recovery should reflect the extent of the free product plume in the area north of Well MW-2. We recommend that additional monitor wells be installed in the area north of Well MW-2 if free product is detected in Well MW-2 after one month of continuous operation of the proposed recovery system.

LIMITATIONS

We have prepared this report for use by Chevron U.S.A. in the evaluation of subsurface conditions at the existing bulk fuel terminal in Pasco, Washington. This report is not intended for use by others and the information contained herein may not be applicable to other sites.

Our conclusions are based on limited subsurface data and are subject to modification based on the results of future monitoring and/or additional explorations at the site.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No other conditions, express or implied, should be understood.

- o O o -

We appreciate the opportunity to be of service. Please call if you have any questions regarding our report.

Respectfully submitted,

GeoEngineers, Inc.

John H. Biggane
Geological Engineer/Hydrogeologist

James A. Miller
Associate

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Table 1

Summary of Water Table Elevations

Monitor Well	Elevation of Water Table						
	11-17-87	11-16-86	12-15-86	1-8-87	1-29-87	2-4-87	3-16-87
MW-1	343.20	343.24	-	343.58	-	-	-
MW-2	342.24	342.19	342.31	342.60	-	-	342.86
MW-3	343.22	343.28	-	343.61	-	-	-
MW-4	341.98	342.00	-	342.32	-	-	-
MW-5	340.40	339.89	340.12	340.41	337.10(1)	336.48(1)	340.58
MW-6	340.99	340.84	-	341.14	340.90	340.90	341.43
MW-7	-	342.34	347.38	342.56	-	-	342.80
MW-8	-	342.14	-	342.46	-	-	342.69
MW-9	-	339.75	339.87	340.36	339.33	339.02	340.55

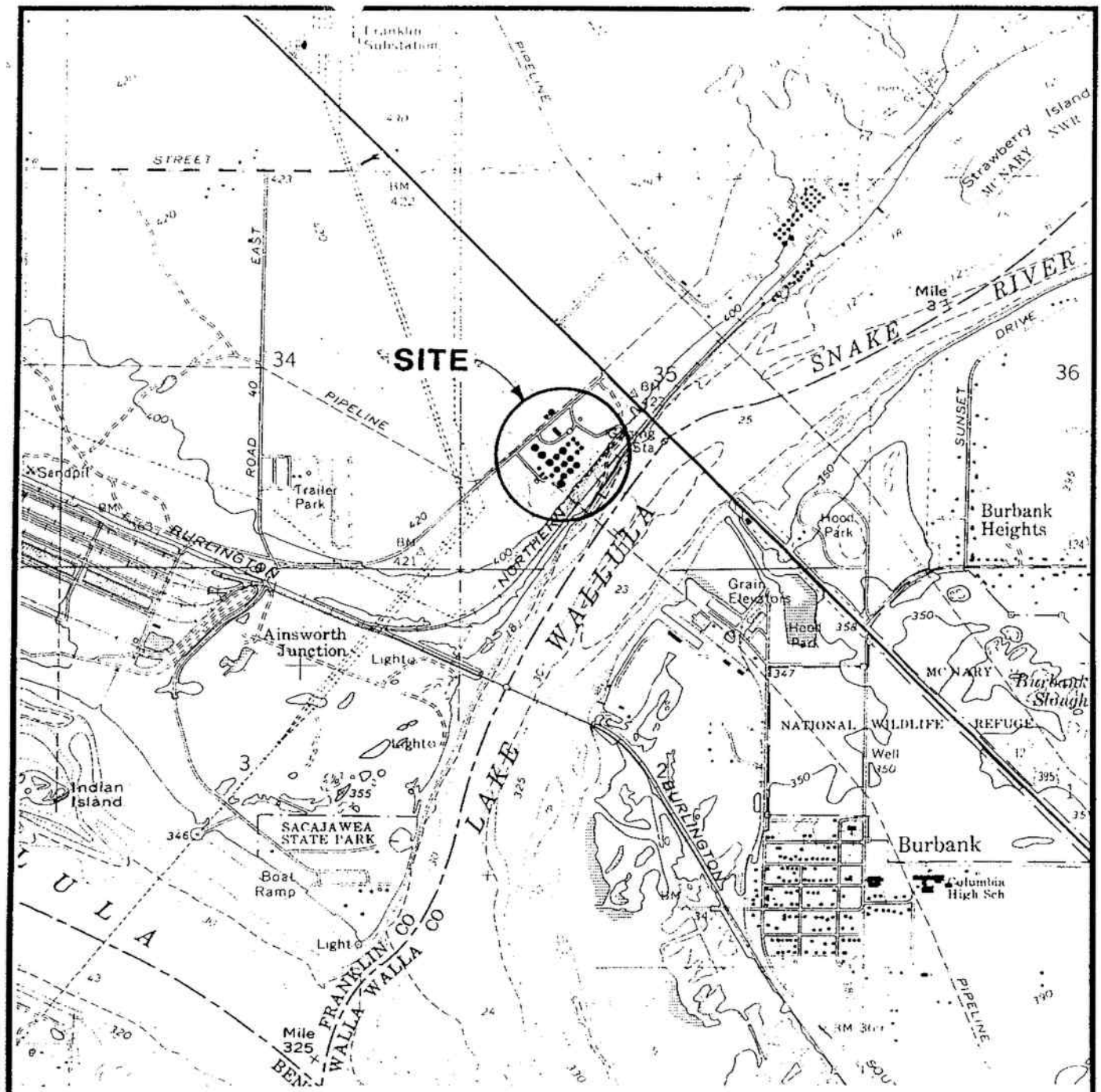
(1) Pumping from Well MW-5 to create water table depression began on 1/9/87 and was terminated on 4/2/87.

TABLE 2

HYDROCARBON VAPOR DATA

Well No.	Date	Percent of Lower Explosive Limit(1)
1	11-17-86	0
2	11-17-86	100
3	11-18-86	0
4	11-18-86	0
5	11-18-86	0
6	11-18-86	0
7	11-20-86	60
8	11-20-86	0
9	11-20-86	0

1. Measurements conducted at a depth of about 8 feet with a Bacharach Model H Explosimeter calibrated to methane.



REFERENCE: USGS 7.5' TOPOGRAPHIC QUADRANGLE MAP, "PASCO, WASH."

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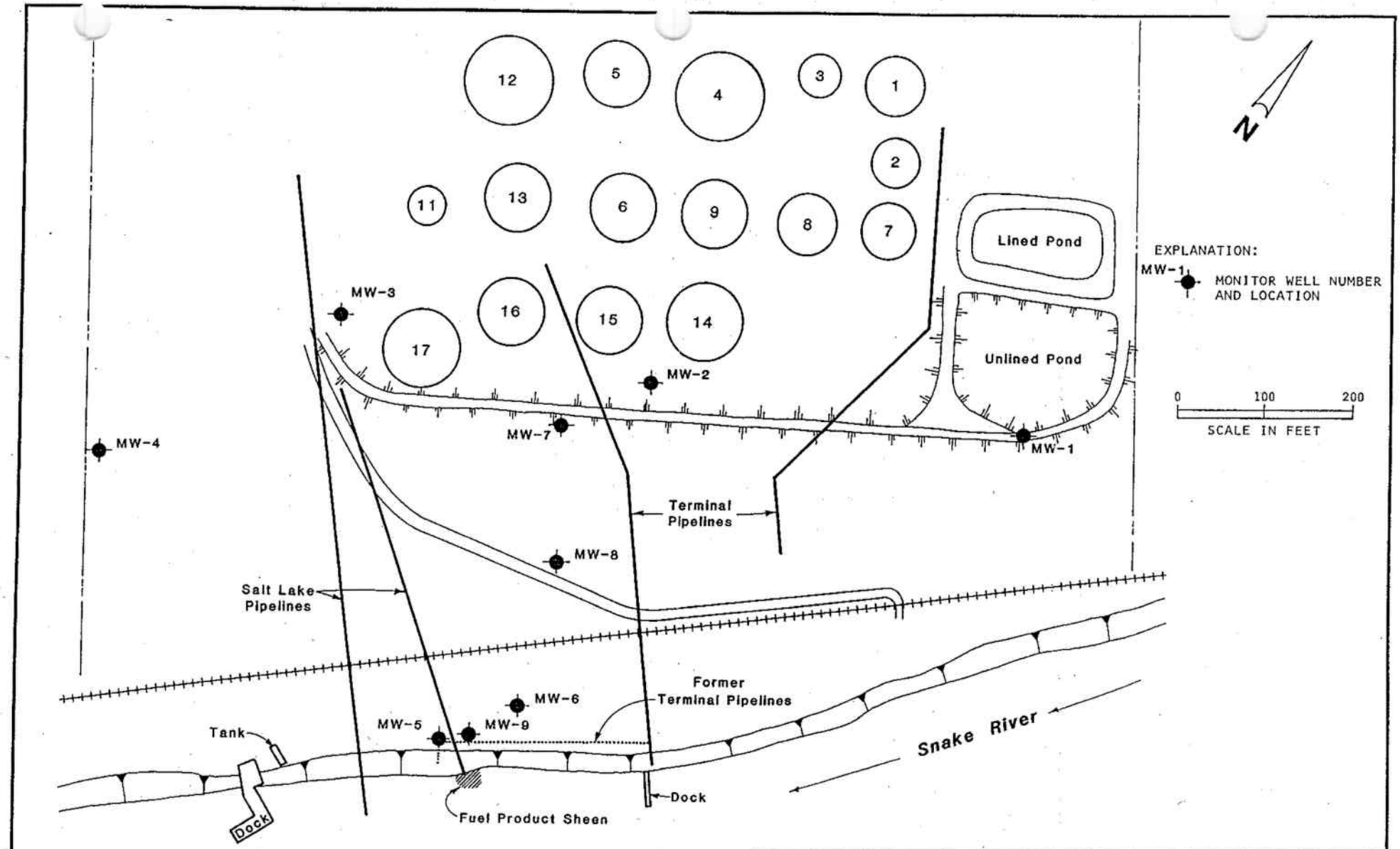
VICINITY MAP

FIGURE 1



REFERENCE: DRAWING ENTITLED "EAST PASCO TERMINAL, WASHINGTON" BY STANDARD OIL COMPANY OF CALIFORNIA, DATED 1/21/52.

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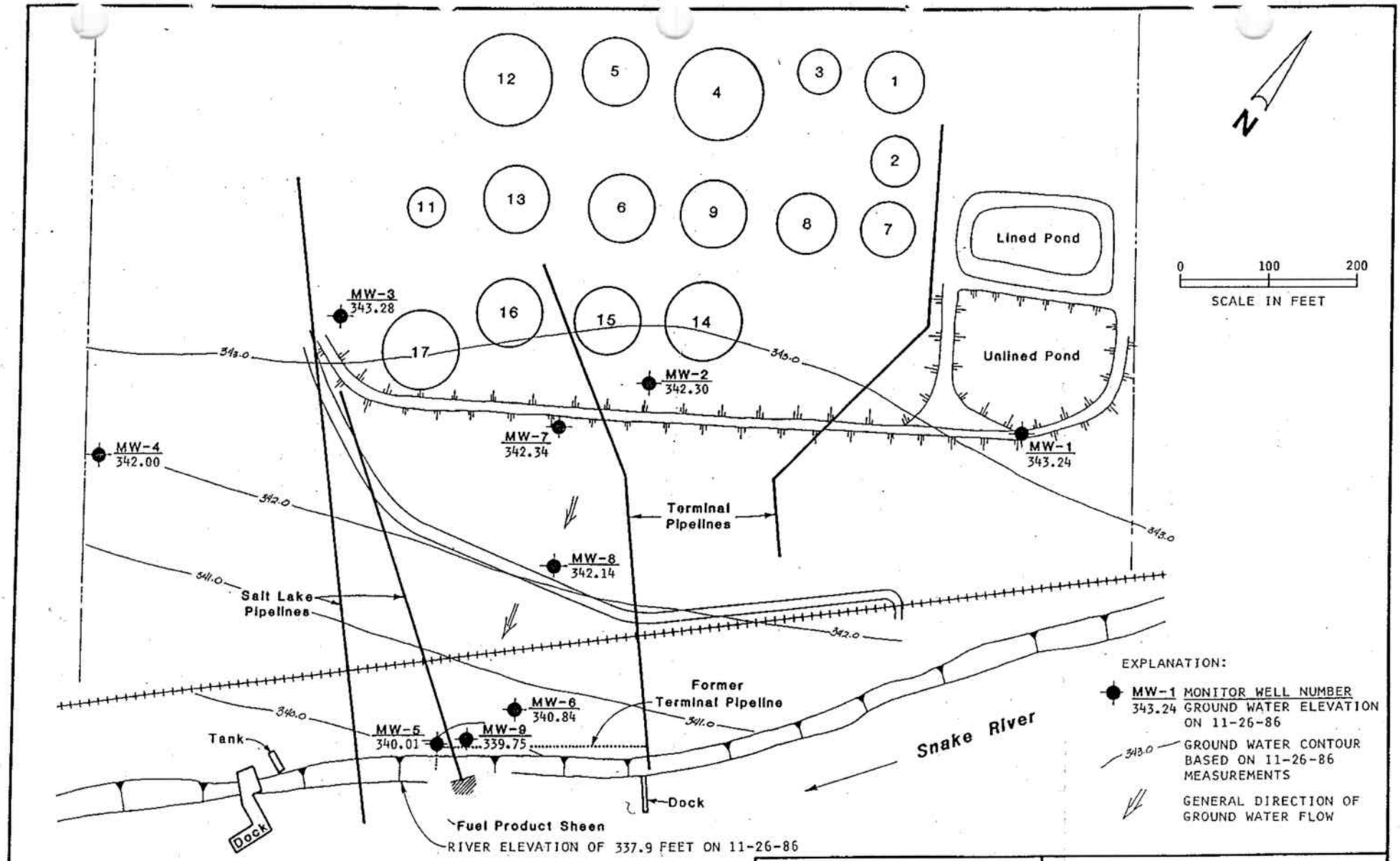
SITE PLAN

FIGURE 2



REFERENCE: DRAWING ENTITLED "EAST PASCO TERMINAL, WASHINGTON" BY STANDARD OIL COMPANY OF CALIFORNIA, DATED 1/21/52.

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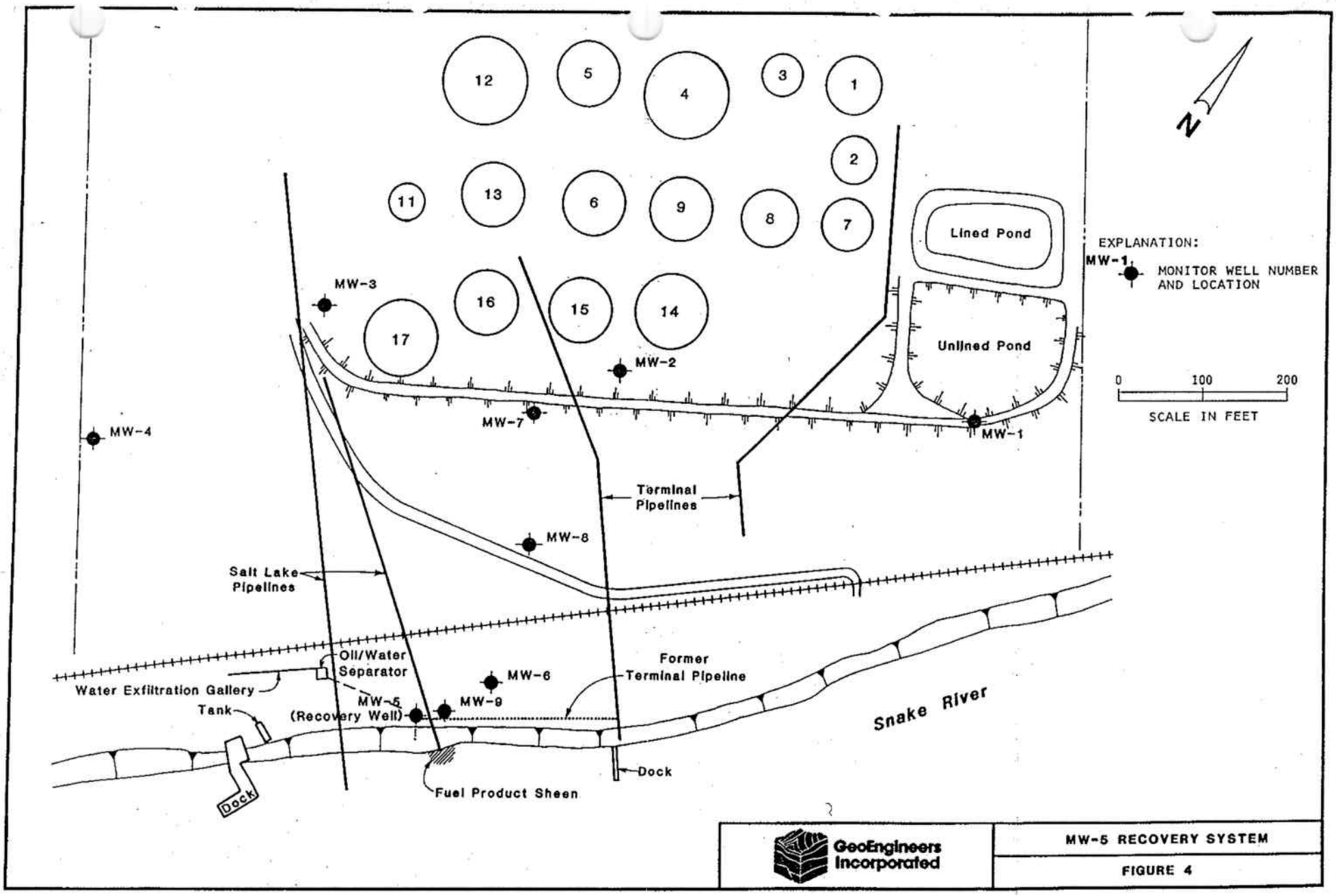
GROUND WATER CONTOUR MAP

FIGURE 3



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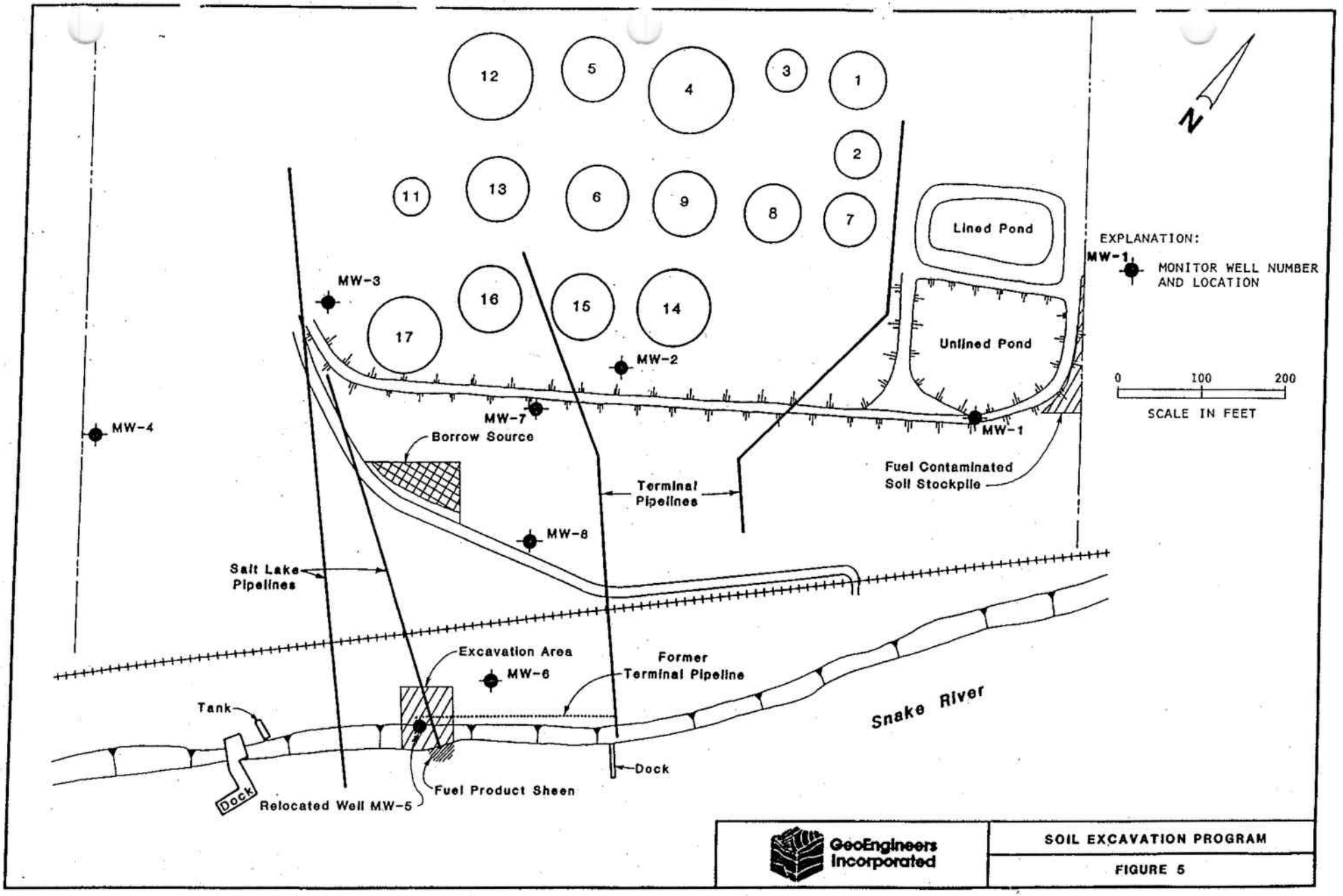
MW-5 RECOVERY SYSTEM

FIGURE 4


12
5
4
3
1
2
11
13
6
9
8
7
16
15
14
17
Lined Pond
Unlined Pond
MW-3
MW-2
MW-7
MW-1
MW-4
MW-8
MW-6
Borrow Source
Terminal Pipelines
Fuel Contaminated Soil Stockpile
Salt Lake Pipelines
Excavation Area
Former Terminal Pipeline
Tank
Dock
Relocated Well MW-5
Fuel Product Sheen
Snake River
N
EXPLANATION:
MW-1
MONITOR WELL NUMBER AND LOCATION
0
100
200
SCALE IN FEET
GeoEngineers Incorporated
SOIL EXCAVATION PROGRAM
FIGURE 5

A P P E N D I X

FIELD EXPLORATIONS

DRILLING AND SOIL SAMPLING PROGRAM

Subsurface conditions at the bulk fuel terminal were explored by drilling Borings MW-6 through MW-9 at the locations indicated in Figure 2. The borings were drilled between November 17, 1986 and November 20, 1986 to depths of 25 to 79 feet using Mobile B-80 hollow-stem auger drilling equipment owned and operated by Soil Sampling Service, Inc.

A hydrogeologist from our staff determined the boring locations, examined and classified the soils encountered, and prepared a detailed log of each boring. Soils encountered were classified visually in general accordance with ASTM D-2487-83, which is described in Figure A-1. An explanation of the boring log symbols is presented in Figure A-2. The logs for Borings MW-6 through MW-9 are given in Figures A-3 through A-8.

Relatively undisturbed soil samples were obtained from each boring using a Dames & Moore split barrel sampler (2.4-inch-ID). The sampler was driven 18 inches by a 300-pound weight falling a vertical distance of approximately 30 inches. The number of blows needed to advance the sampler the final 12 inches is indicated to the left of the corresponding sample notations on the boring logs.

MONITOR WELL CONSTRUCTION

Two-inch-diameter, Schedule 40 PVC pipe was installed in each boring at the completion of drilling. The lower portion of the well casing is machine slotted (0.02-inch slot width) to allow entry of water, floating hydrocarbons, or hydrocarbon vapors into the well casings. Medium to coarse sand was placed in the borehole annulus surrounding the slotted portion of the wells. Bentonite surface seals were installed in annulus of the well bores. Monitor well construction details are indicated in Figures A-3 through A-8.

We determined the elevations of the well casings to the nearest 0.01 foot with an engineer's level on November 25, 1986. An elevation of 421.50 feet at the base of Tank 13 was used as a site datum. Elevation data are included on the monitor well logs.

GROUND WATER ELEVATIONS

The depth to the ground water table was measured from the monitor well casing rims using a fiberglass tape and water-finding paste. Free product thickness was measured with gas-finding paste. Ground water elevations were calculated by subtracting the water table depth from the casing rim elevations and by correcting for the presence of free product when appropriate.

HYDROCARBON VAPOR CONCENTRATIONS

Hydrocarbon vapor concentrations were measured in each monitor well at a depth of about 8 feet between November 17 to November 20, 1986. Vapor concentrations in percent of the lower explosive limit (LEL) were measured with our Bacharach Model H Explosimeter, which is calibrated to methane.

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-83.
2. Soil classification using laboratory tests is based on ASTM D2487-83.
3. Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry – Absence of moisture, dusty, dry to the touch

Moist – Damp, but no visible water

Wet – Visible free water or saturated, usually soil is obtained from below water table

GEI 85-85

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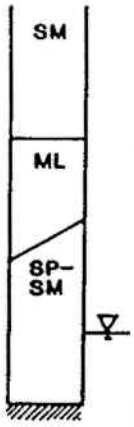
SOIL CLASSIFICATION SYSTEM

FIGURE A-1

LABORATORY TESTS:

AL	Atterberg limits
CP	Compaction
CS	Consolidation
DS	Direct shear
GS	Grain-size analysis
HA	Hydrometer analysis
K	Permeability
M	Moisture content
MD	Moisture and density
SP	Swelling pressure
TX	Triaxial compression
UC	Unconfined compression
CA	Chemical Analysis

SOIL GRAPH:



Soil Group Symbol (See Note 1)

Distinct contact between Soil Strata

Gradual Change between Soil Strata

Water Level

Bottom of Boring

BLOW-COUNT/SAMPLE DATA:

Blows required to drive sampler 12 inches or other indicated distances using 300 pound hammer falling 30 inches.

"P" indicates sampler pushed with weight of hammer or hydraulics of drill rig.

22 ■ Location of relatively undisturbed sample

12 ⊠ Location of disturbed sample

P □ Location of sampling attempt with no recovery

10 ◪ Location of sample attempt using Standard Penetration Test procedures

Location of sample using relatively undisturbed Shelby Tube

NOTES:

1. Soil classification system is summarized in Figure A-1.
2. The reader must refer to the discussion in the report text as well as the exploration logs for a proper understanding of subsurface conditions.

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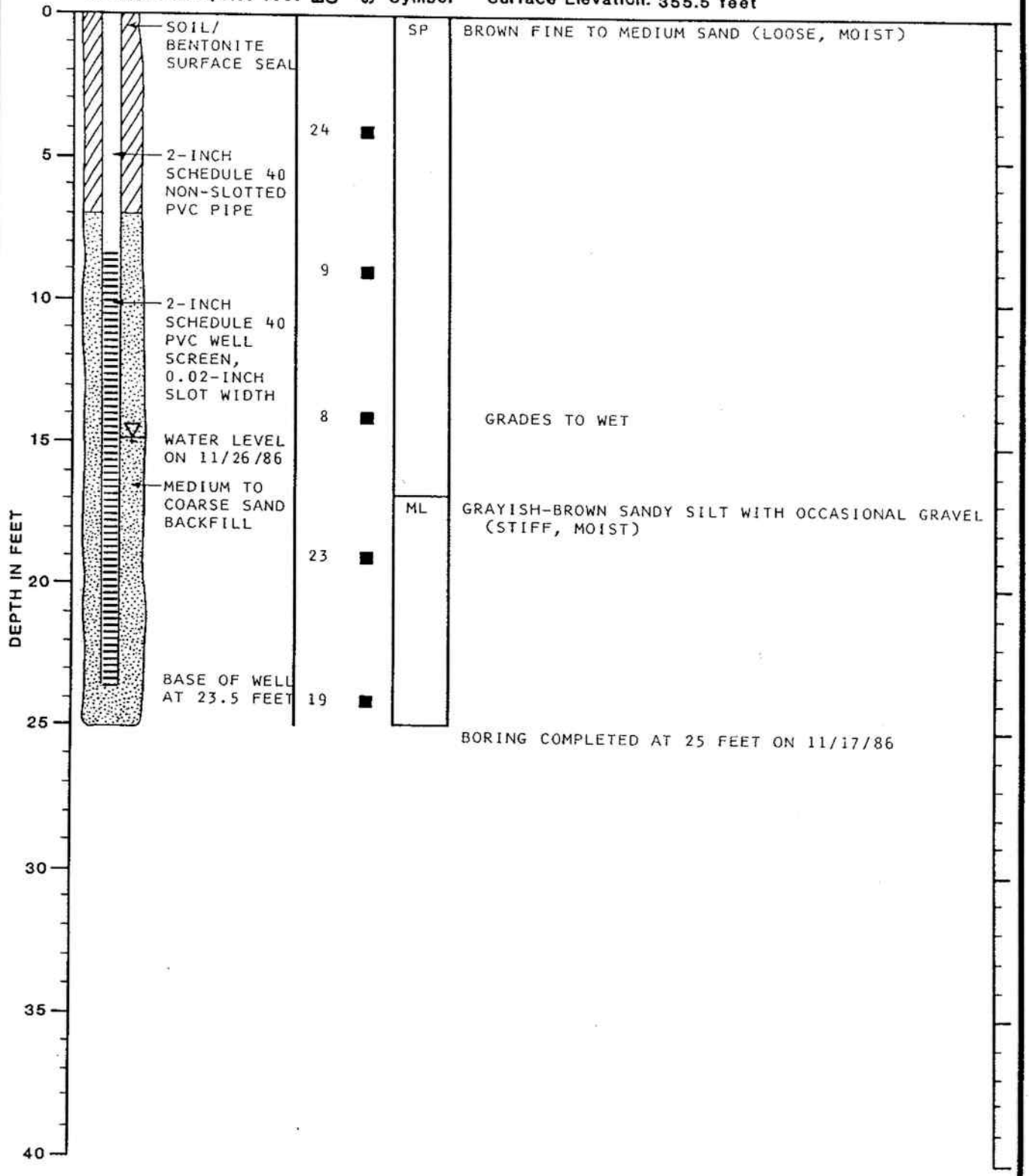
KEY TO BORING LOG SYMBOLS

FIGURE A-2

MONITOR WELL NO. 6



Note: See Figure A-2for Explanation of Symbols

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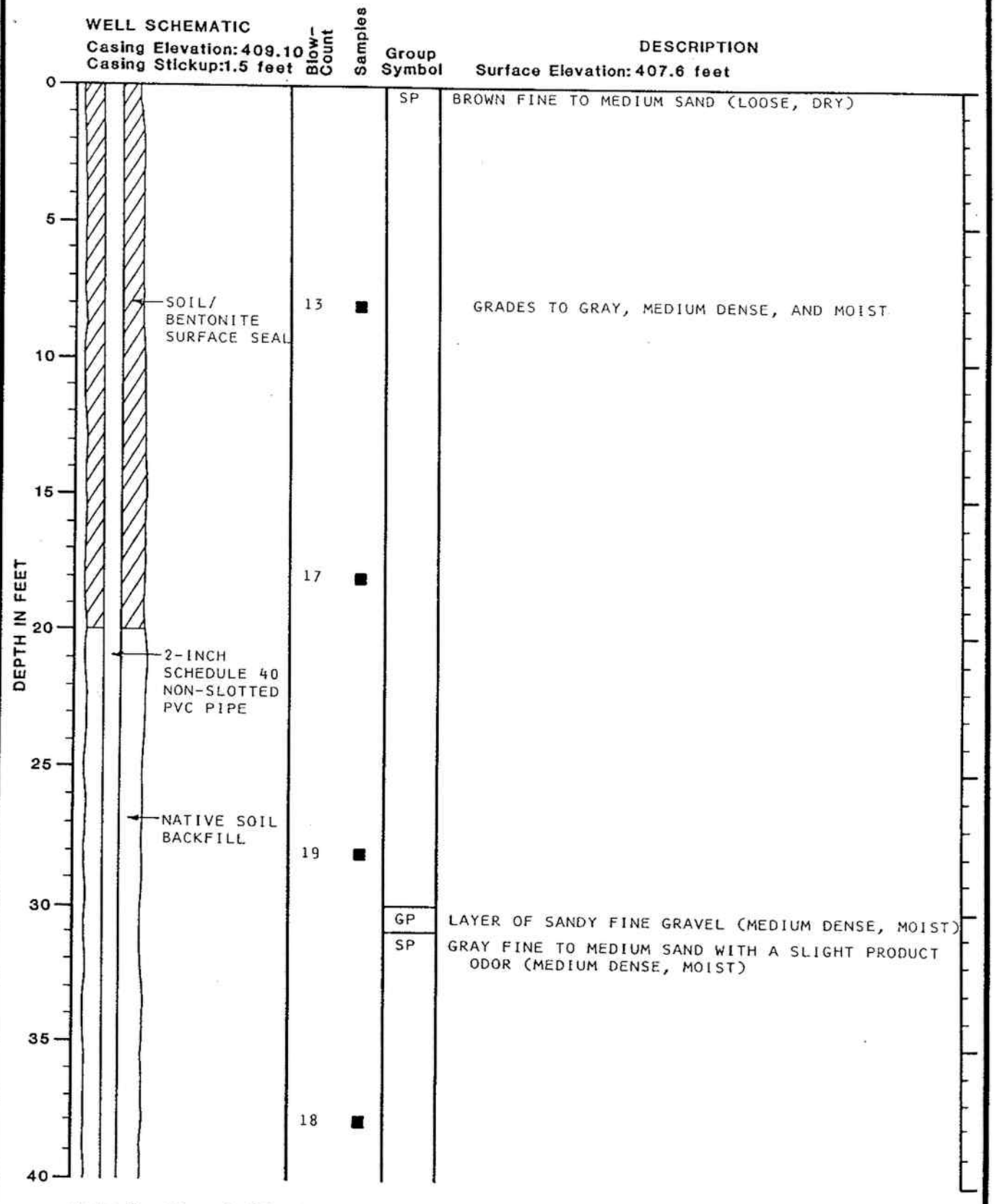
LOG OF MONITOR WELL

FIGURE A-3

MONITOR WELL NO. 7



Note: See Figure A-2 for Explanation of Symbols

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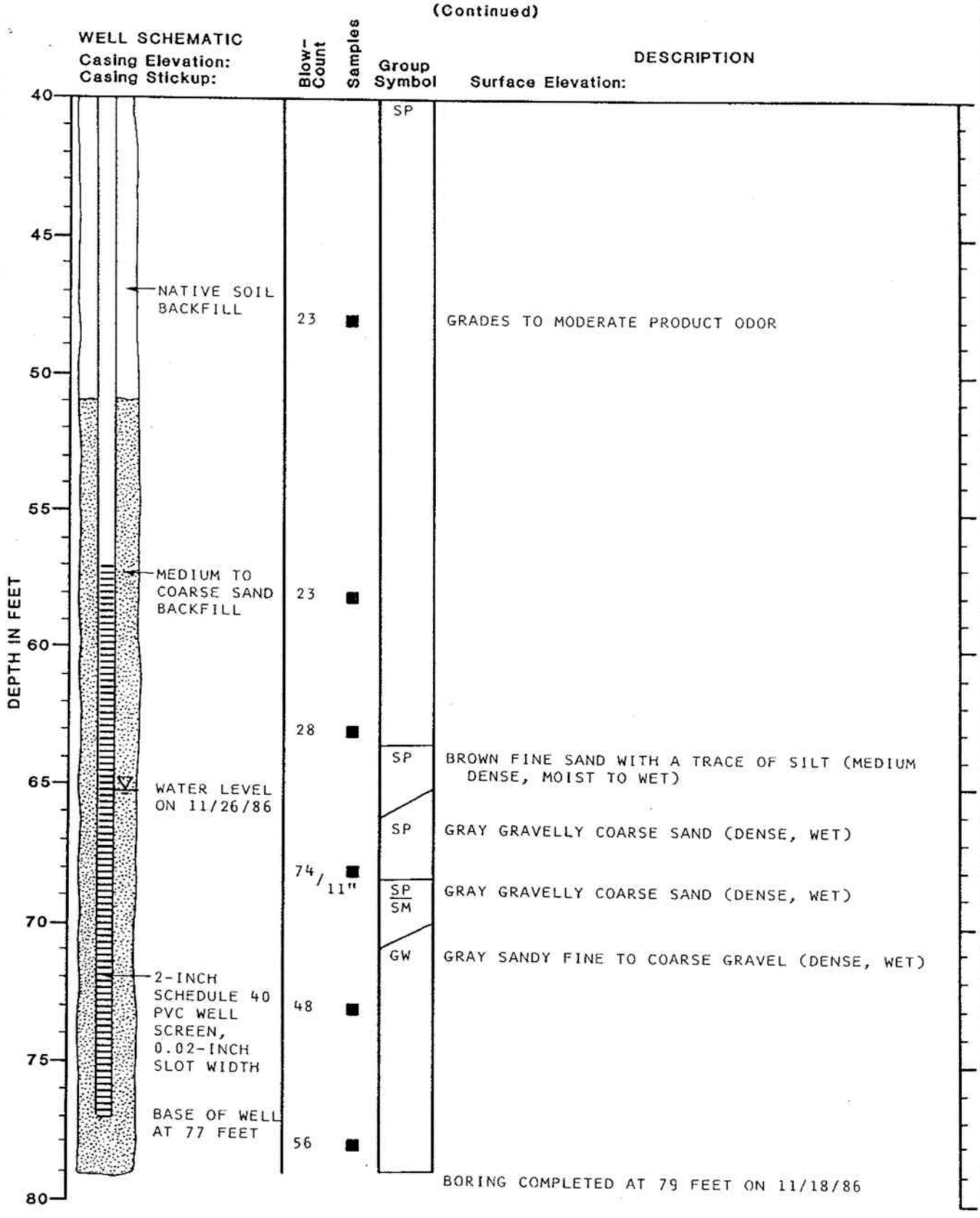
LOG OF MONITOR WELL

FIGURE A-4

MONITOR WELL NO. 7
(Continued)



Note: See Figure A-2 for Explanation of Symbols

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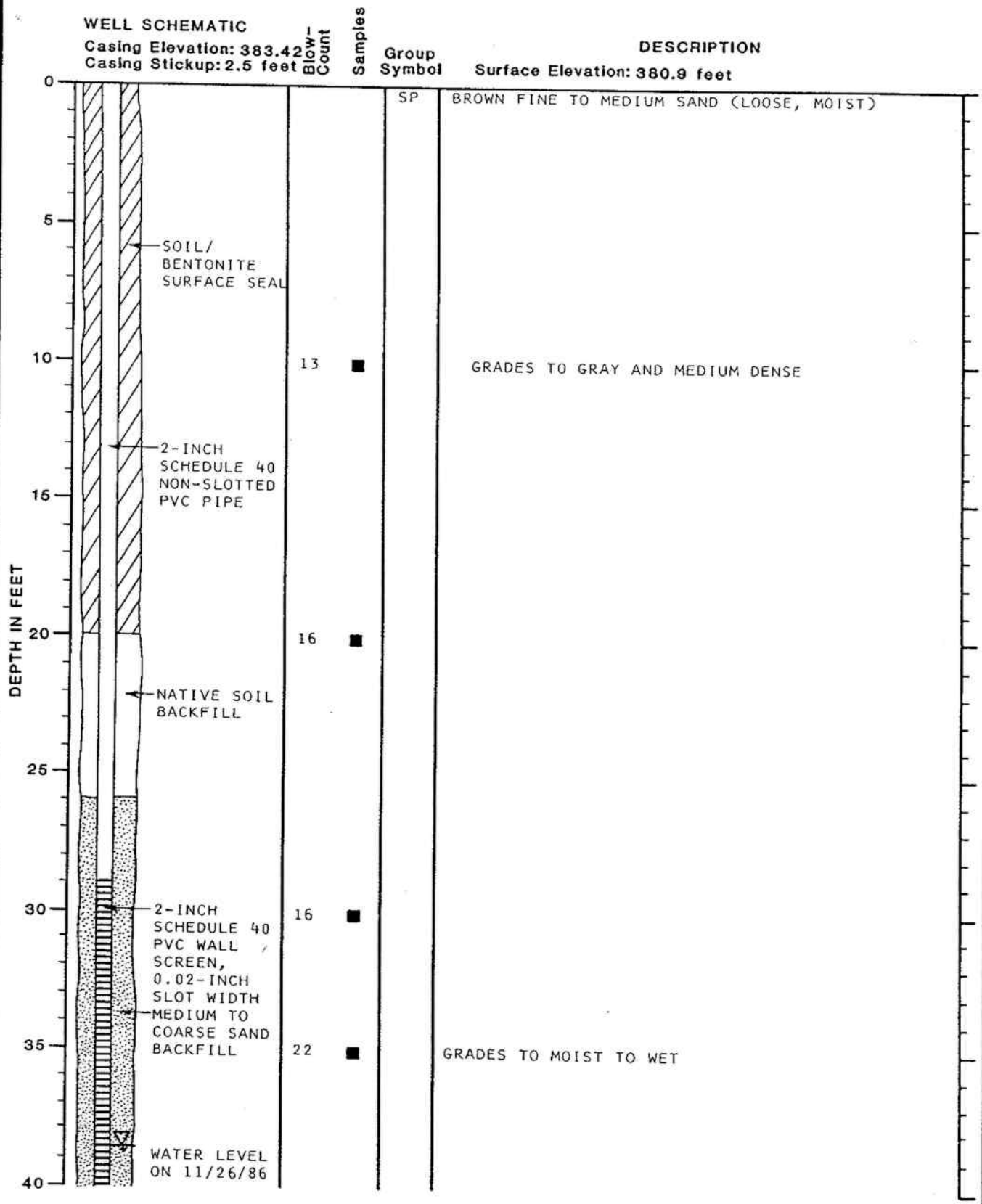
LOG OF MONITOR WELL

FIGURE A-5

MONITOR WELL NO. 8



Note: See Figure A-2 for Explanation of Symbols

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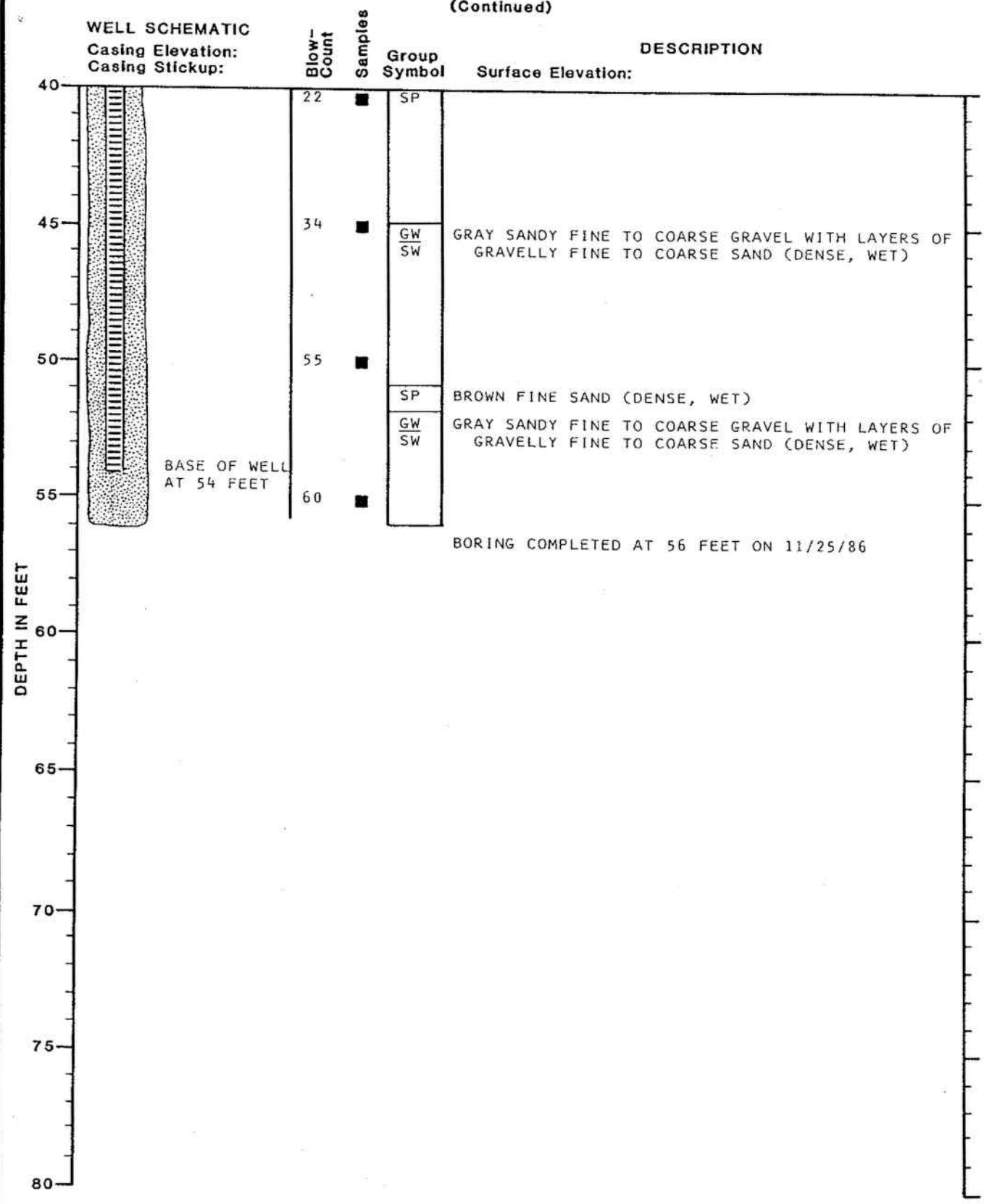
LOG OF MONITOR WELL

FIGURE A-6

MONITOR WELL NO. 8

(Continued)



Note: See Figure A-2 for Explanation of Symbols

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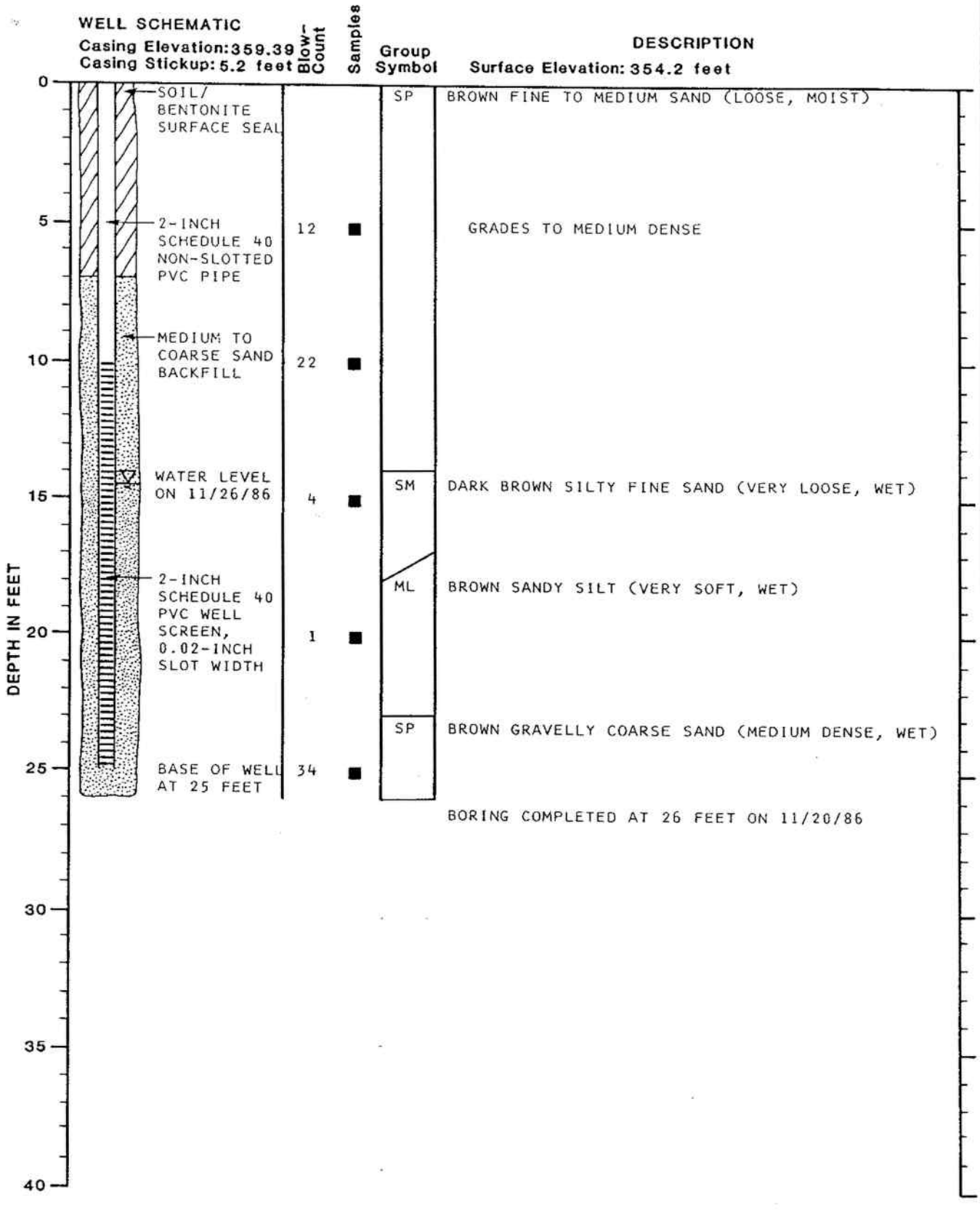
LOG OF MONITOR WELL

FIGURE A-7

MONITOR WELL NO.9



Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

FIGURE A-8