REPORT OF PHASE 4 HYDROGEOLOGIC SERVICES
SPRING CHINOOK HATCHERY
AND REARING FACILITY
WINTHROP, WASHINGTON
FOR
DOUGLAS COUNTY PUBLIC UTILITY DISTRICT

GeoEngineers

July 19, 1991

FishPro, Inc.
3780 Southeast State Highway 160
Port Orchard, Washington 98366

Attention: Mr. Ed Donahue, P.E.

We are submitting 15 copies (10 bound and 5 unbound) of our report of Phase 4 hydrogeologic services for ground water supply at the Spring Chinook Hatchery and Rearing Facility near Winthrop, Washington. Our services for development of technical specifications for well construction were requested by Douglas County Public Utility District on August 1, 1990. The scope of our services for this project was expanded in accordance with our proposal dated August 15, 1990. Our services were authorized by Mr. Ed Donahue of FishPro, Inc.

We appreciate the opportunity to be of service to FishPro, Inc. and the Douglas County Public Utility District on this project. Please call if you have questions regarding this report.

Yours very truly,

GeoEngineers, Inc.

for James A. Miller, P.E.
Principal

TTF:JAM:wd

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REPORT OF PHASE 4 HYDROGEOLOGIC SERVICES
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INTRODUCTION

The results of our Phase 4 hydrogeologic services at the site of the Spring Chinook Hatchery and Rearing Facility near Winthrop, Washington are presented in this report. The site is located adjacent to the Methow River, within the western half of Section 3, Township 34 North, Range 21 East. The location of the site relative to regional topographic conditions is shown in Figure 1.

A combination of surface water and ground water are proposed for use as the water supply for the facility. We understand that a ground water supply of 10 cfs (cubic feet per second) is needed periodically for operation of the facility. We further understand that the highest ground water flows are planned for the summer months. Structures planned for the facility include (but are not limited to) a hatchery building, raceways, a rearing pond and two new residences. The general layout of selected hatchery facilities planned for the site is shown in Figure 2.

GeoEngineers previously conducted three phases of hydrogeologic studies at the site. The Phase 1 and 2 studies, completed in 1988, included shallow subsurface explorations, the installation of observation wells, and one aquifer pumping test. The purpose of our Phase 1 and 2 studies was to provide information for the preliminary design of an infiltration gallery capable of supplying 5 to 6 cfs of ground water. The results of Phase 1 and Phase 2 studies are presented in separate reports dated October 5, 1988. The Phase 3 study, completed in 1989, included the installation of observation wells, the construction of a high capacity test well, and two aquifer pumping tests. The purpose of our Phase 3 services was to provide preliminary design parameters for either production wells or an infiltration gallery capable of supplying 10 cfs of ground water. The results of our Phase 3 study are presented in our report dated March 6, 1990.

GeoEngineers also conducted a geotechnical engineering study at the site in August 1990. The purpose of the study was to develop geotechnical design criteria for the planned structures at the site. The results of our geotechnical study are presented in our report dated September 25, 1990.

DCPUD (Douglas County Public Utility District) plans to supply ground water to the facility using three new production wells located in the southern portion of the site. One new domestic well is planned for residential use at the site (Figure 2). We understand that the test well completed during our Phase 3 studies will be used as a fourth production well for the facilities. Our Phase 3 report identified the test well as TW-10; this well has since been designated as production well PW-4 by DCPUD and FishPro, and is referred to as PW-4 in this report.

PURPOSE AND SCOPE

The purpose of our Phase 4 services is to (1) provide technical support during construction and testing of the three new production wells and the new domestic well, and (2) provide final recommendations for safe yield and long-term pumping rates in the production wells. Our specific scope of services completed during Phase 4 includes the following:

1. Prepare well construction specifications, assist in selection of the well drilling contractor, and provide bid and invoice review services.
2. Observe critical portions of the production well drilling activities and prepare a geologic log of each boring. Prepare a geologic log of the domestic well boring using the drilling contractors well log.
3. Develop recommendations for well screen location(s), length and slot size for the three new production wells and the domestic well based on field observations and mechanical grain-size analyses of aquifer materials.
4. Observe and evaluate well screen installation and development activities in production well PW-3. Maintain daily contact with the drilling contractor during development of the well screens in wells PW-1, PW-2, and the domestic well.

5. Record time-drawdown data during 48-hour pumping tests in the new production wells, and during a 4-hour pumping test in the domestic well. Record water level recovery data for about 12 hours after completion of each pumping test.
6. Monitor the temperature, pH, electrical conductance and dissolved oxygen content of ground water at the site during the pumping tests.
7. Submit a ground water sample collected from one new production well for detailed chemical analyses of water quality parameters. Water samples from the other new production wells and the domestic well were submitted for analysis of dissolved iron and zinc.
8. Provide estimates of the safe yield from each new production well and the domestic well and estimates of drawdown during pumping at anticipated production rates in each well, based on the 48-hour pumping tests.
9. Provide estimates of interference drawdowns in the production wells and the domestic well during long-term, simultaneous pumping from all of the production wells.

SITE CONDITIONS

SURFACE CONDITIONS

The Methow River flows along the northern boundary of the site and Wolf Creek Road forms the southern boundary of the site. Relatively undeveloped pasture land is located adjacent to the eastern and western borders of the site. Two residences are located on the adjacent property to the west. A domestic well located immediately west of the site provides ground water for one or both of the off-site residences. An existing residence and storage building are located near Wolf Creek Road on the upper terrace of the site. Water is diverted from the Methow River into Foghorn Ditch at a location west (upstream) of the site. Foghorn Ditch crosses the central portion of the site as shown in Figure 2. Foghorn Ditch supplies surface water for use at the existing Winthrop National Fish Hatchery facility, located east of the site.

Site topography consists of three relatively level terraces. The lower terrace, located adjacent to the Methow River, has ground surface elevations ranging between about 1766 to 1770 feet. The middle terrace, located north of Foghorn Ditch, is at a ground surface elevation of about 1773 feet. The elevation of the upper terrace, located between the Foghorn Ditch and Wolf Creek Road, is generally about 1783 feet. Vegetation consists mainly of grass, low brush and cottonwood trees on the lower terrace. Grass and weeds are present on the middle and upper terraces at the site. The general locations of the lower, middle and upper terraces are shown in Figure 2.

SUBSURFACE SOIL CONDITIONS

Subsurface soil conditions in the lower and middle terrace areas were explored during our Phase 1, 2 and 3 studies. The explorations consisted of test pit excavations and borings. Soil encountered in our previous explorations generally consists of medium to coarse sand with gravel and fine to coarse gravel with sand. Cobbles were present near the surface at many of the exploration locations. Bedrock consisting of black shale was encountered at a depth of 119 feet in PW-4, and at shallower depths in three of the observation wells drilled during Phase 3 explorations. Detailed descriptions of the soil conditions encountered in the northern portion of the site are presented in our previous reports.

Subsurface conditions beneath the upper terrace were explored during our Phase 4 study by drilling three production wells (PW-1, PW-2 and PW-3) and one domestic well at the locations shown in Figure 2. Wells PW-1, PW-2 and PW-3 were drilled to depths of 150, 125 and 140 feet, respectively. The domestic well was drilled to a depth of 72 feet. Details of the field exploration program are presented in Appendix A of this report. Geologic logs of each boring are shown in Figures 3 through 6.

Soil encountered in the borings drilled during the Phase 4 activities generally consists of medium to coarse sand with gravel, and fine to coarse gravel with sand. Cobbles were encountered at various depths in all of the borings. Significant zones of finer sand with varying amounts of gravel were encountered between the depths of about 94 to 111 feet in boring PW-1, and 38 to 78 feet in boring PW-2. A thin lens (about 3 feet thick) of fine sand was encountered between the depths of 119 and 122 feet in boring PW-3.

Fine sand was reported by the drilling contractor between the depths of 33 to 58 feet in the domestic well. Bedrock was not encountered in the production wells or the domestic well.

GROUND WATER CONDITIONS

Ground water conditions at the site were explored by constructing and testing three production wells and one domestic well. Fourteen-inch-diameter stainless steel well screen was installed in each of the production wells. Six-inch-diameter stainless steel telescoping well screen was installed in the domestic well. Specifics regarding the length of screen installed in each well, the variations in well screen slot size and corresponding screened intervals for each well are included in Appendix A of this report. Well construction schematics are shown in Figures 3 through 6.

The static water table depth was measured in the wells at the site on April 2, 1991 prior to beginning the pumping tests. Wells installed during previous studies (PW-4, OW-7, OW-9, OW-11, OW-12 and TP-4) were included in our measurements to provide additional information with respect to ground water conditions. A domestic well located immediately west of the site was also included in our measurements. Well locations are shown in Figure 2.

The depth to ground water in the observation wells located on the lower and middle terraces ranged from about 3.5 to 4 feet. Ground water was encountered at depths between about 8 to 13 feet below ground surface in the wells located on the upper terrace. Ground water elevations at the observation well locations generally were about 0.5 feet higher in April 1991, compared to October 1989. Ground water elevations at the well locations and water table contours for measurements made on April 2, 1991 are shown in Figure 7. Ground water beneath the site appears to flow toward the northeast based on our April 2, 1991 measurements. This flow direction is consistent with the flow direction determined during our Phase 3 studies during September and October 1989.

The elevation of the water table appears to decrease by about 10 feet from the location of PW-1 on the upper terrace to the location of OW-11 on the lower terrace. This is equivalent to a water table slope (hydraulic gradient) of approximately 0.0062 (33 feet per mile).

Water level and river level measurements conducted on January 8, 1991 during drilling of the production wells indicated that the Methow River was gaining water from the aquifer beneath the site. Site measurements during September and October 1989 also indicated that the Methow River was gaining water from the aquifer. Site measurements during August 1988 indicated that the Methow River was losing water into the aquifer beneath the site. It appears that the Methow River gains water from the aquifer beneath the site during most of the year. However, during drier late summer months, the Methow River may lose water to the aquifer in local areas. We expect that the river would lose water to the aquifer only in areas immediately adjacent to the river, based on the observed hydraulic gradient.

AQUIFER TESTING

GENERAL

Aquifer pumping tests were conducted (in succession) in PW-1, PW-2, PW-3 and the domestic well between April 2 and 12, 1991. A 48-hour stepped pumping test was conducted in each of the production wells. A 4-hour test was conducted in the domestic well following the production well tests. Water levels were allowed to recover to static conditions (about 24 hours) prior to beginning another pumping test. Water level drawdown and recovery in the production wells, domestic well and the observation wells were monitored during each pumping test and as water levels recovered after pumping was terminated. Water levels in the Methow River and the Foghorn Ditch were also monitored during the pumping tests. Water was discharged to the Methow River downstream from the site via an overflow channel from Foghorn Ditch during the pumping tests.

PW-1 Pumping Test: The pumping test in PW-1 was conducted between April 2 and 4, 1991. PW-1 was pumped initially at a rate of 875 gpm; after 100 minutes the pumping rate was increased to 1,100 gpm. The pumping rate was increased to 1,500 gpm approximately 200 minutes into the test. The pumping rate was reduced to about 1,300 gpm after about 400 minutes (6.5 hours) of pumping because the water level in the well casing was drawing down toward the top of the pump bowls. The pumping rate fluctuated between about 1,100 and 1,300 gpm during the last 8 hours of the test because of mechanical difficulties with the pump motor.

Water level drawdown in the well stabilized at about 33.5 feet during pumping at a rate of 1,300 gpm. A plot of the water level versus time in PW-1 during the pumping test is shown in Figure 8.

PW-2 Pumping Test: The pumping test in PW-2 was conducted between April 5 and 7, 1991. PW-2 was pumped initially at a rate of 600 gpm; after 100 minutes the pumping rate was increased to 850 gpm and then to 1,000 gpm. The pumping rate was increased to 1,500 gpm approximately 200 minutes into the test and remained at 1,500 gpm for the duration of the test.

Water level drawdown in the well stabilized at about 16.5 feet during pumping at a rate of 1,500 gpm. A plot of the water level versus time in PW-2 during the pumping test is shown in Figure 9.

PW-3 Pumping Test: The pumping test in PW-3 was conducted between April 8 and 10, 1991. PW-3 was pumped initially at a rate of 700 gpm; after 100 minutes the pumping rate was increased to 1,100 gpm. The pumping rate was increased to 1,500 gpm approximately 200 minutes into the test and remained at 1,500 gpm for the duration of the test.

Water level drawdown in the well stabilized at about 17.5 feet during pumping at a rate of 1,500 gpm. A plot of the water level versus time in PW-3 during the pumping test is shown in Figure 10.

Domestic Well Pumping Test: The pumping test in the domestic well was conducted on April 12, 1991. The domestic well was pumped at a rate of about 80 gpm for a period of 4 hours.

Water level drawdown in the well stabilized at 10 feet during pumping at a rate of 80 gpm. A plot of the water level versus time in the domestic well during the pumping test is shown in Figure 11.

AQUIFER PARAMETERS

Analysis of the Phase 4 pumping test data indicates that the average hydraulic conductivity of the aquifer beneath the site is approximately 0.80 to 0.90 feet per minute. The average hydraulic conductivity value calculated for the Phase 4 pumping tests compares favorably with the average hydraulic conductivity value calculated for the aquifer between the depths of 95 and 120 feet during our Phase 3 pumping test data (about 0.70 feet per minute). The average transmissivity of the aquifer was calculated as approximately 1,200,000 to 1,350,000 gallons per day per foot, based on the Phase 4 pumping test data.

The hydraulic conductivity and transmissivity values presented above are averages. Our observations during the pumping tests and analysis of the data indicate that the hydraulic conductivity values at the site may range between about 0.40 and 2.5 feet per minute. Transmissivity values may range between about 600,000 and 3,750,000 gallons per day per foot. The observed range of values are related to natural variations in the aquifer materials and the different locations of the pumping and observation wells at the site.

The specific capacity (pumping rate divided by total drawdown) of the production wells was relatively consistent with the exception of PW-1. At pumping rates between 600 and 875 gpm (the initial pumping rates) the specific capacity of each production well was about 115 gpm/ft (gallons per minute per foot of drawdown). At pumping rates between 1,000 and 1,100 gpm (the pumping rates during the second step) the specific capacity of PW-1 was about 90 gpm/ft and the specific capacity of PW-2 and PW-3 ranged from 106 to 111 gpm/ft. At a pumping rate of 1,300 gpm the specific capacity of PW-1 was about 40 gpm/ft. At 1,500 gpm the specific capacities of PW-2 and PW-3 were about 86 and 90 gpm/ft, respectively.

GROUND WATER QUALITY

Field Measurements: The temperature, pH and electrical conductance of ground water from the wells were measured periodically during each pumping test. The dissolved oxygen content of water from PW-3 and the domestic well was also measured periodically during the tests of these wells. The dissolved oxygen meter did not operate properly during the tests of PW-1 and PW-2. The results of the field measurements are summarized in Table 1.

The temperatures of ground water from the production wells varied between 39°F (degrees Fahrenheit) and 51°F during the pumping tests. The lowest temperatures were generally recorded in the early morning hours of the tests. Ground water temperatures near the end of the tests ranged between 43°F and 49°F. Ground water temperatures from the domestic well ranged between about 53°F and 54°F. Ground water temperatures during our Phase 4 pumping tests were generally slightly lower than the temperatures recorded during our Phase 3 tests in September and October 1989.

The pH of ground water from the production wells ranged from 5.95 to 7.45 during the pumping tests. Ground water pH values tended to stabilize between 6.5 and 7.0 near the end of each production well test. The pH of ground water from in the domestic well ranged between 6.69 and 6.88 during the pumping test.

The electrical conductance of ground water from the production wells ranged from 177 to 400 μmhos/cm (micromhos per centimeter) during the pumping tests. The electrical conductance generally stabilized at values between 190 and 210 μmhos/cm in the later stages of the production well pumping tests. Electrical conductance ranged from 185 to 207 μmhos/cm during the pumping test of the domestic well.

The concentration of dissolved oxygen in ground water from PW-3 ranged between 4.4 and 8.0 mg/l (milligrams per liter) during the pumping test. Dissolved oxygen values recorded during the domestic well pumping test ranged from 4.0 to 4.4 mg/l. The percent of saturation represented by the dissolved oxygen values ranges from 40 percent to 74 percent, based on an average ground water temperature of 48°F and an elevation of 1,700 feet above sea level. Because the dissolved oxygen meter did not work during the tests in PW-1 and PW-2, the values recorded during the tests in PW-3 and the domestic well are presented for relative comparison purposes only.

Laboratory Analytical Results: Ground water samples were collected from each production well and the domestic well near the end of the respective pumping tests and submitted for laboratory chemical analyses. Ground water samples from PW-1, PW-3 and the domestic well were analyzed for dissolved iron and dissolved zinc. The ground water sample from PW-2 was analyzed for typical drinking water and fishery-related parameters in addition to dissolved iron and zinc. The water samples intended for analysis of metals were filtered in the field immediately before placement in the sample containers. The results of the analyses are summarized in Table 2. The laboratory reports for each water sample are presented in Appendix B.

Concentrations of dissolved iron in water samples from production wells PW-1, PW-2 and PW-3 were 0.32 mg/l, 0.33 mg/l and 0.15 mg/l, respectively. The WDF (Washington Department of Fisheries) recommended standard for iron is less than 0.15 mg/l. Concentrations of dissolved zinc in water samples from production wells PW-1, PW-2 and PW-3 were 0.027 mg/l, 0.091 mg/l and 0.077 mg/l, respectively. The WDF recommended standards for zinc range between less than 0.03 mg/l and less than 0.005 mg/l. Analytical results for the other parameters tested (Table 2) indicate that the ground water from the aquifer would be suitable for fishery-related purposes.

Information provided by the analytical laboratory indicates that iron and zinc are present in most or all commercially available filters, with the exception of teflon filters (the laboratory makes its own teflon filters). GeoEngineers prepared filter blanks in the field using deionized distilled water provided by the laboratory. The blanks were submitted with the water samples intended for analysis of iron and zinc. The analytical results indicated that the concentrations of iron in the filter blanks exceeded the concentration of iron reported for the water samples from PW-1 and PW-2. The concentration of zinc in the filter blanks exceeded the concentration of zinc reported for the water samples from all of the production wells.

DISCUSSION

GENERAL

The results of our field studies at the site indicate that production wells PW-1, PW-2, PW-3 and PW-4 can provide the 10 cfs ground water required for the hatchery facility. As indicated in our report of Phase 3 services, a considerable flux of ground water passes beneath the site. We calculated the ground water flux to be about 13 cfs, based on the pumping tests completed for the Phase 3 study. Our recently completed field studies indicate that the ground water flux beneath the site is approximately 14.5 cfs. The ground water flux calculation for the Phase 4 pumping tests is based on a radius of influence of about 1,000 feet, an aquifer thickness of 140 feet, a mean hydraulic conductivity of 0.50 feet per minute (less than the calculated average), and a water table gradient of 0.0062.

The specific capacity of PW-1 decreased from 90 gpm/ft to 40 gpm/ft as the pumping rate was increased from 1,100 gpm to 1,500 gpm. In our opinion, this is a significance decrease in the specific capacity of the well and is of concern relative to long-term production from PW-1. The decrease in specific capacity most likely results from a lower aquifer transmissivity in the vicinity of PW-1. It is also possible that an aquifer boundary, such as bedrock or fine-grained materials, is present in the area influenced by PW-1. No direct evidence of an aquifer boundary was observed during the pumping tests in the production wells. Short-term pumping tests, however, do not always indicate the presence of aquifer boundaries that may affect ground water production after weeks or months of pumping.

SAFE YIELD

The maximum transmitting capacity of the well screens (based on the manufacturers recommendations) installed in PW-1, PW-2, PW-3, PW-4 and the domestic well are shown below.

WELL	SCREEN CAPACITY
PW-1	1,500 gpm
PW-2	1,520 gpm
PW-3	1,360 gpm
PW-4	1,470 gpm
Domestic	200 gpm

We understand that on a preliminary basis the DCPUD is planning to pump production wells PW-1, PW-2 and PW-3 at a rate of about 1,200 gpm, and that PW-4 will be pumped at a rate of about 1,000 gpm. The results of the pumping tests indicate that the planned pumping rates are generally within the long-term production capabilities of the wells.

Pumping from PW-1 at the screen capacity would produce a drawdown of approximately 40 feet, based on the observed specific capacity. The drawdown was significantly less (and specific capacity greater) at pumping rates of 1,100 gpm and less. In our opinion, PW-1 should not be pumped at a rate greater than 1,000 gpm during the initial stages of ground water use at the site. The pumping rate could potentially be increased in the future depending on observed drawdown during extended pumping from the well.

Wells PW-2 and PW-3 were pumped at or slightly above the screen capacities during the Phase 4 pumping tests. The results of the pumping tests indicate that PW-2 and PW-3 could be pumped safely at the respective screen capacities.

We understand that water pumped from PW-4 during sampling attempts in 1990 was turbid. We recommended to FishPro and DCPUD in a letter dated November 8, 1990 that PW-4 be redeveloped and tested prior to installing a permanent pump in the well. Recent information indicates that PW-4 may be used as a dewatering well during construction of the hatchery facilities. Use of PW-4 for dewatering will likely provide sufficient redevelopment of its well screen. If PW-4 is redeveloped adequately, the well could be pumped safely at the screen capacity.

We recommend that the domestic well pumping rate not exceed 100 gpm, based on the expected drawdown in the well when the production wells are operating.

WELL INTERFERENCE

Water level drawdown data from the Phase 3 and Phase 4 pumping tests, and our analysis of aquifer parameters, were used to estimate the well interference for the four production wells and the domestic well. Our estimation of interference drawdowns in the wells is based on DCPUD's planned pumping rate of 1,200 gpm in all of the production wells and 80 gpm in the domestic well. The drawdown estimates assume that all of the wells are pumping at the above rates for a period of 90 to 180 days. Our estimates do not account for the potential presence of aquifer boundaries that may affect long-term drawdowns. A summary of estimated interference drawdowns is presented in Table 3.

As indicated in Table 3, we expect about 22 to 29 feet of drawdown in PW-1 during simultaneous pumping of PW-1 and the other production wells. We estimate that PW-2 and PW-3 would experience total drawdowns of about 14 to 19 feet under similar conditions. The total drawdown in PW-4 is expected to range between 10 and 14 feet. Drawdown in the domestic well is expected to be between 12 and 19 feet. Approximately 60 to 80 feet of water would remain above the top of the well screen in PW-1, PW-2 and PW-3 at the drawdown values listed above. About 40 feet and 25 feet of water would remain above the top of the well screens in PW-4 and the domestic well, respectively, at the expected drawdown levels.

Measurements conducted during the Phase 4 pumping tests indicate that interference effects will be present in the off-site domestic well (Figures 2 and 7) during pumping at the hatchery site. The maximum drawdown observed in this well was about 1.0 feet during the pumping test in PW-2. We estimate that simultaneous pumping from the production wells at the approximate rates listed in Table 3 will cause an increased drawdown in the off-site well ranging between 4 and 6 feet.

Our observations indicate that the pumping tests did not directly affect water levels in the Foghorn Ditch or the Methow River. Water levels in the ditch and river rose slightly (0.03 to 0.16 feet) during the pumping tests in PW-1 and PW-2. Water levels declined slightly (0.01 to 0.02 feet) in the ditch and the river during the pumping test in PW-3.

RECOMMENDATIONS

The results of our ground water supply studies at the hatchery site indicate that conditions are favorable for withdrawal of 10 cfs ground water from the production wells. However, the long-term production capacity of the wells cannot be defined precisely, based on the relatively short-term pumping tests conducted during our Phase 3 and Phase 4 studies. We recommend that the DCPUD institute a permanent monitoring procedure and establish a data base for the wells at the site. Water levels in the production wells and the domestic well should be measured and recorded weekly after the wells are placed in service. We recommend that OW-7 and OW-12 be maintained for use as observation wells, and be included in the measurements. During the first month of operation we recommend that the measurements be conducted on a daily basis. The water levels should be measured with an accuracy of 1/2 inch or less and the depths to water should be referenced to the same datum at the top of each well when a measurement is made. Each time a measurement is made, the time, date, water depth and present production well pumping status should be recorded. Any long term decline of the pumping level in the wells (for a constant pumping rate) may be cause for concern.

Sustainable long-term pumping rates in the individual production wells will depend on the actual ground water drawdown conditions observed during operation of the facilities. The long-term pumping rates should not exceed the screen capacity of the wells. We recommend that the pumping rates in PW-2, PW-3 and PW-4 not exceed the screen capacities for these wells. We recommend that the pumping rate in PW-1 not exceed 1,000 gpm. On a preliminary basis, the initial pumping rates in PW-2 and PW-3 could be set at about 1,500 gpm and 1,300 gpm, respectively. Wells PW-1 and PW-4 could be pumped at initial rates of about 1,000 gpm. We recommend that the pumping rate in the domestic well not exceed 100 gpm.

The water sample analytical data indicate acceptable water quality, with the possible exception of dissolved iron and zinc. We recommend that the wells be resampled for iron and zinc. The water samples should be filtered in the field using teflon filters (if available). Filter blanks that are prepared in the field should be submitted for analysis with the ground water samples. If the water samples are not filtered in the field they should be transmitted immediately to an analytical laboratory for chemical analysis.

LIMITATIONS

We have prepared this report for use by FishPro, Inc. and the Douglas County Public Utility District for their evaluation of the ground water supply potential for the Spring Chinook Hatchery and Rearing Facility. Our conclusions and recommendations are based on field observations and interpretation of the results of our subsurface explorations and pumping tests. The use of wells PW-1, PW-2, PW-3 and PW-4 as permanent ground water supply wells for the site appears to be favorable. Our interpretations, however, should not be construed as a warranty of favorable long-term ground water supply conditions 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.

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

Respectfully submitted,

GeoEngineers, Inc.

Terry T. Fisk
Project Geologist

for James A. Miller, P.E.
Principal

TTF:JAM:wd

TABLE 1
GROUND WATER QUALITY PARAMETERS

Pumping Well[1]	Elapsed Time (hours)	Time of Day	Temperature[2] (degrees Fahrenheit)	pH[2]	Electrical Conductance[2] (µmhos/cm)	Dissolved Oxygen[3] (mg/l)	
						Field	Percent Saturation[4]
PW-1	6.2	16:40	48.2	5.95	177	–	–
	20.6	07:10	39.2	6.10	249	–	–
	26.1	12:35	46.4	6.68	200	–	–
	31.3	17:50	46.4	6.77	190	–	–
	45.1	07:35	46.4	6.45	206	–	–
PW-2	1.3	11:55	49.2	6.93	400	–	–
	5.4	16:00	48.3	6.76	200	–	–
	25.8	12:25	48.0	6.50	203	–	–
	46.6	10:15	48.7	6.74	213	–	–
PW-3	0.9	09:55	48.9	6.54	232	6.0	55
	2.6	11:35	51.1	6.90	202	5.8	53
	4.5	13:30	49.7	6.77	212	8.0	74
	6.0	15:00	50.3	7.45	184	4.4	40
	23.7	08:40	45.4	7.13	223	5.8	53
	30.8	15:50	48.8	6.90	208	6.4	59
	46.5	07:30	43.0	6.93	210	7.8	72
Domestic	1.0	09:45	52.7	6.88	207	4.0	37
	3.5	12:20	54.3	6.69	185	4.4	40

Notes:

[1]Data from PW-1 was collected between April 2 and 4, 1991. Data from PW-2 was collected between April 5 and 7, 1991. Data from PW-3 was collected between April 8 and 10, 1991. Data from the domestic well was collected on April 12, 1991.

[2]Temperature, pH and electrical conductance were measured using a CSI Hydac meter.

[3]Dissolved oxygen was measured using a YSI model 51B meter. The instrument did not operate during the PW-1 and PW-2 pumping tests. The instrument appeared to operate properly during the PW-3 and domestic well pumping tests, however, the data is presented only for relative comparison.

[4]At an average ground water temperature of 48°F and an elevation of 1,700 feet, 100 percent saturation is about 10.85 mg/l.

mg/l = milligrams per liter

TABLE 2
SUMMARY OF GROUND WATER ANALYTICAL DATA

Water Quality Parameter	Units	Water Sample[1]						
		PW-1		PW-2		PW-3		Domestic
		Sample	Blank[2]	Sample	Blank[2]	Sample	Blank[2]	Sample
Dissolved Iron	mg/l	0.32	1.7	0.33	0.84	0.15	<0.01	<0.01
Dissolved Zinc	mg/l	0.027	0.031	0.091	0.143	0.077	0.044	0.021
Dissolved Aluminum	mg/l	–	–	0.12	–	–	–	–
Dissolved Arsenic	mg/l	–	–	<0.03	–	–	–	–
Dissolved Cadmium	mg/l	–	–	<0.002	–	–	–	–
Dissolved Chromium	mg/l	–	–	<0.006	–	–	–	–
Dissolved Copper	mg/l	–	–	<0.002	–	–	–	–
Dissolved Lead	mg/l	–	–	<0.02	–	–	–	–
Dissolved Magnesium	mg/l	–	–	3.8	–	–	–	–
Dissolved Manganese	mg/l	–	–	0.005	–	–	–	–
Dissolved Molybdenum	mg/l	–	–	<0.01	–	–	–	–
Dissolved Potassium	mg/l	–	–	1.5	–	–	–	–
Dissolved Silver	mg/l	–	–	<0.010	–	–	–	–
Dissolved Sodium	mg/l	–	–	7.9	–	–	–	–
Total Coliform	CFU/100 mls	–	–	<2.5	–	–	–	–
Turbidity	NTU	–	–	0.19	–	–	–	–
Hardness	mg/l as C_aCO_3	–	–	77	–	–	–	–
Alkalinity	mg/l as C_aCO_3	–	–	69	–	–	–	–
Total Dissolved Solids	mg/l	–	–	260	–	–	–	–
Total Suspended Solids	mg/l	–	–	<1.0	–	–	–	–
pH		–	–	7.0	–	–	–	–
Dissolved Oxygen[3]	mg/l	–	–	9.4 to 10	–	–	–	–
Total Organic Carbon	mg/l	–	–	14	–	–	–	–
Total Phosphate	mg/l	–	–	<0.010	–	–	–	–
Ortho Phosphate	mg/l	–	–	0.006	–	–	–	–
Ammonia Nitrogen	mg/l	–	–	0.016	–	–	–	–
Total Kjeldahl Nitrogen	mg/l	–	–	<0.50	–	–	–	–
Nitrate + Nitrite Nitrogen	mg/l	–	–	0.228	–	–	–	–
Nitrite Nitrogen	mg/l	–	–	<0.010	–	–	–	–
Chloride	mg/l	–	–	1.5	–	–	–	–
Sulfate	mg/l	–	–	4.6	–	–	–	–
Anaerobic Plate Count	CFU/100 mls	–	–	1.0	–	–	–	–

Notes:

[1]Water samples were collected near the end of each pumping test.

PW-1 sample collected on April 4, 1991

PW-2 sample collected on April 7, 1991

PW-3 sample collected on April 10, 1991

Domestic well sample collected on April 12, 1991

[2]Filter blank obtained by filtering distilled water using the same equipment and methods used to filter the ground water samples collected.

[3]Sample was preserved

CFU = colony-forming units

NTU = nephelometric turbidity units

"<" = less than

mls = milliliters

mg/l = milligrams per liter

TABLE 3
ESTIMATED LONG-TERM WATER LEVEL DRAWDOWN

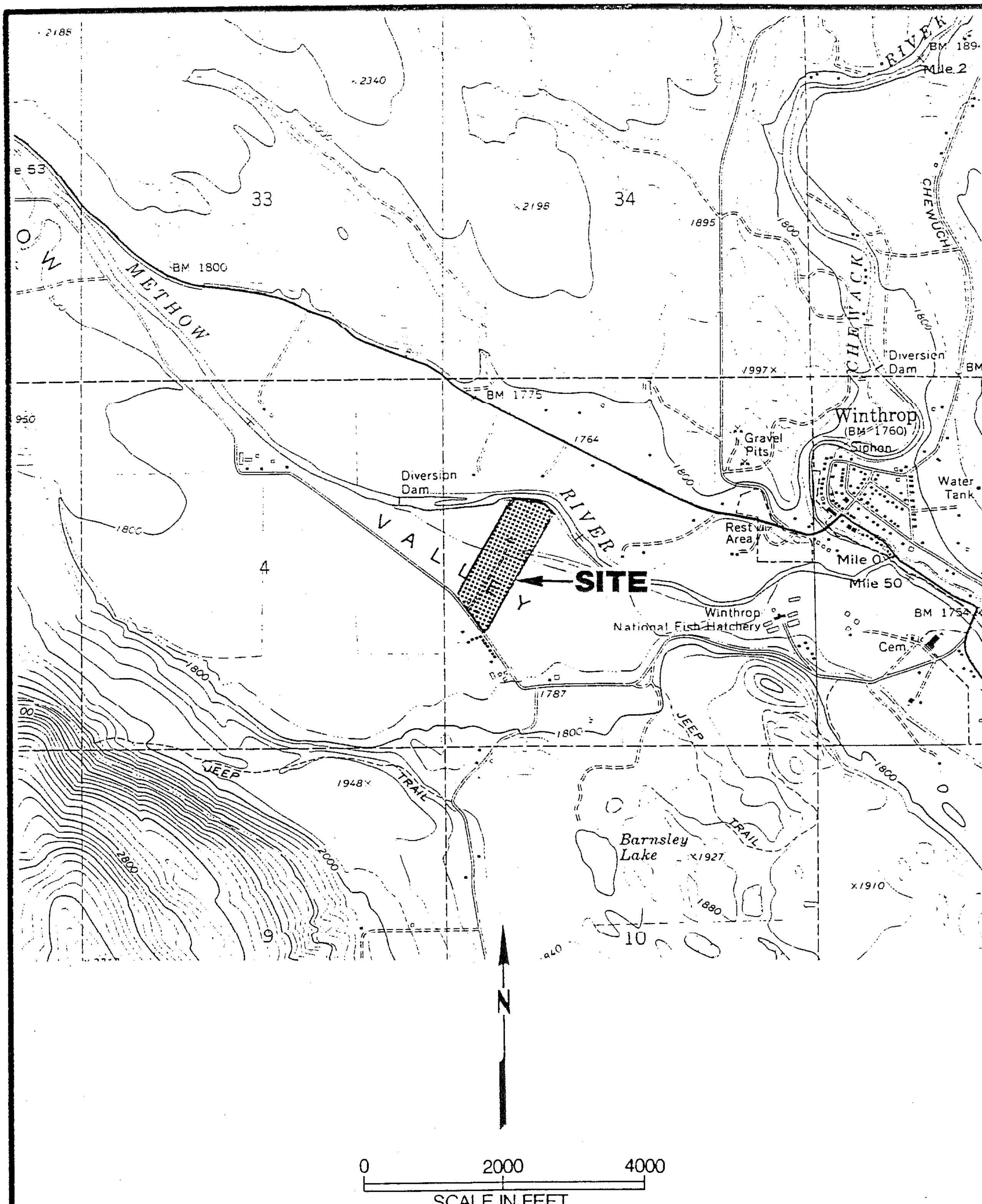
Pumping Well	Pumping Rate (gpm)	Expected Drawdown[1] (feet)				
		PW-1	PW-2	PW-3	PW-4	Domestic
PW-1	1,200	20 to 24	0.75 to 2	0.5 to 1.75	0.5 to 1.5	0.75 to 2
PW-2	1,200	0.75 to 2	12 to 13	0.75 to 2	0.75 to 1.75	1 to 2.25
PW-3	1,200	0.5 to 1.75	0.75 to 2	12 to 13	1 to 2	0.75 to 1.75
PW-4	1,200	0.5 to 1.5	0.75 to 1.75	0.75 to 2	8 to 9	0.75 to 1.75
Domestic[2]	80	–	–	–	–	9 to 11
All Wells	4,880	21.75 to 29.25	14.25 to 18.75	14 to 18.75	10.25 to 14.25	12.25 to 18.75

Notes:

[1]Based on continuous pumping for a period of 90 to 180 days.

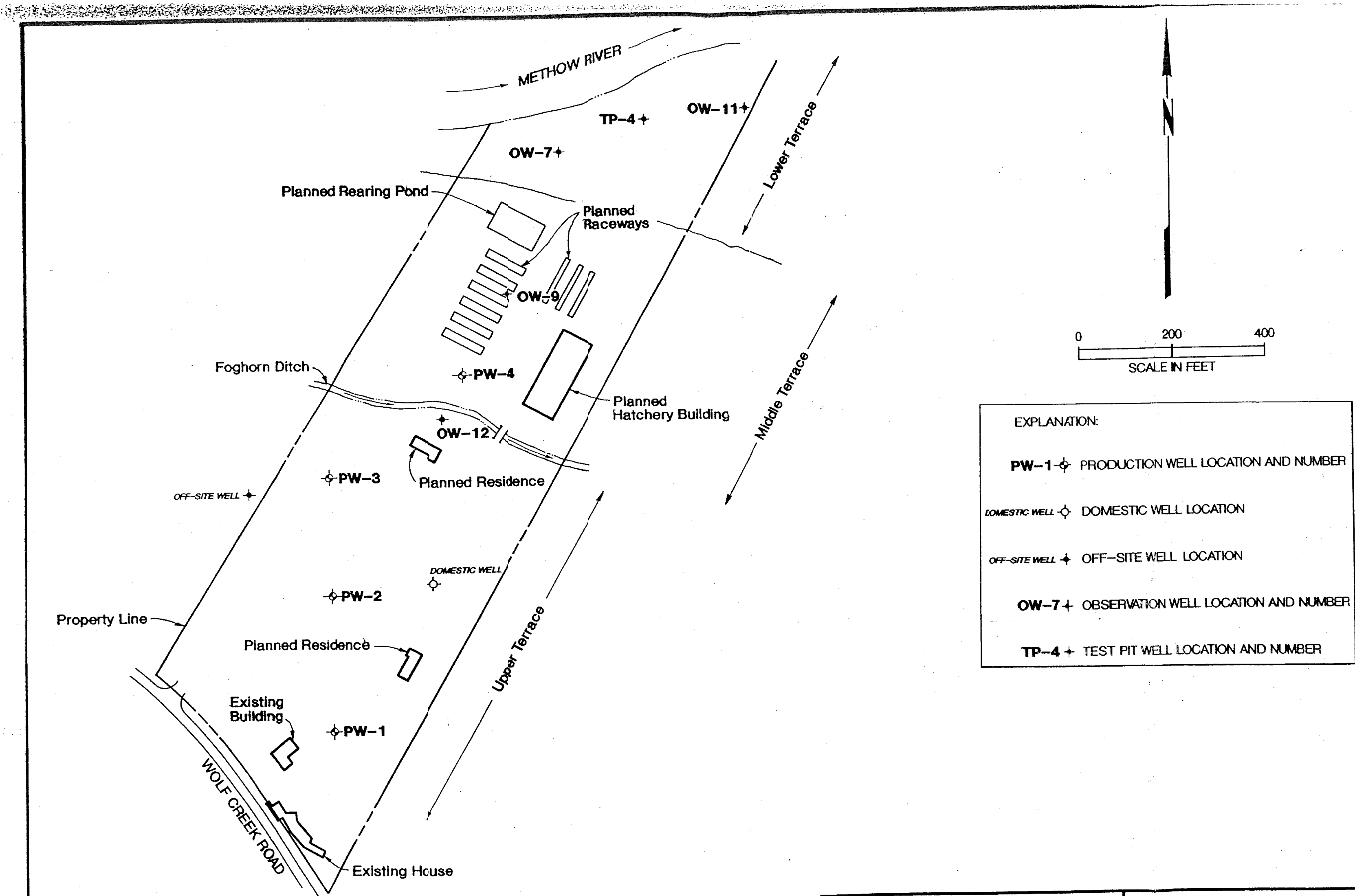
[2]Pumping from the domestic well at 80 gpm has negligible long-term effect on the production wells.

gpm = gallons per minute



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

GeoEngineers	**VICINITY MAP**
	FIGURE 1



REFERENCE: DRAWING ENTITLED "HATCHERY SITE PLAN," BY FISHPRO, INC., DATED 02/04/91.

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SITE PLAN

FIGURE 2

1317-013-B04 TTT:BDH 5.30.91 (B)

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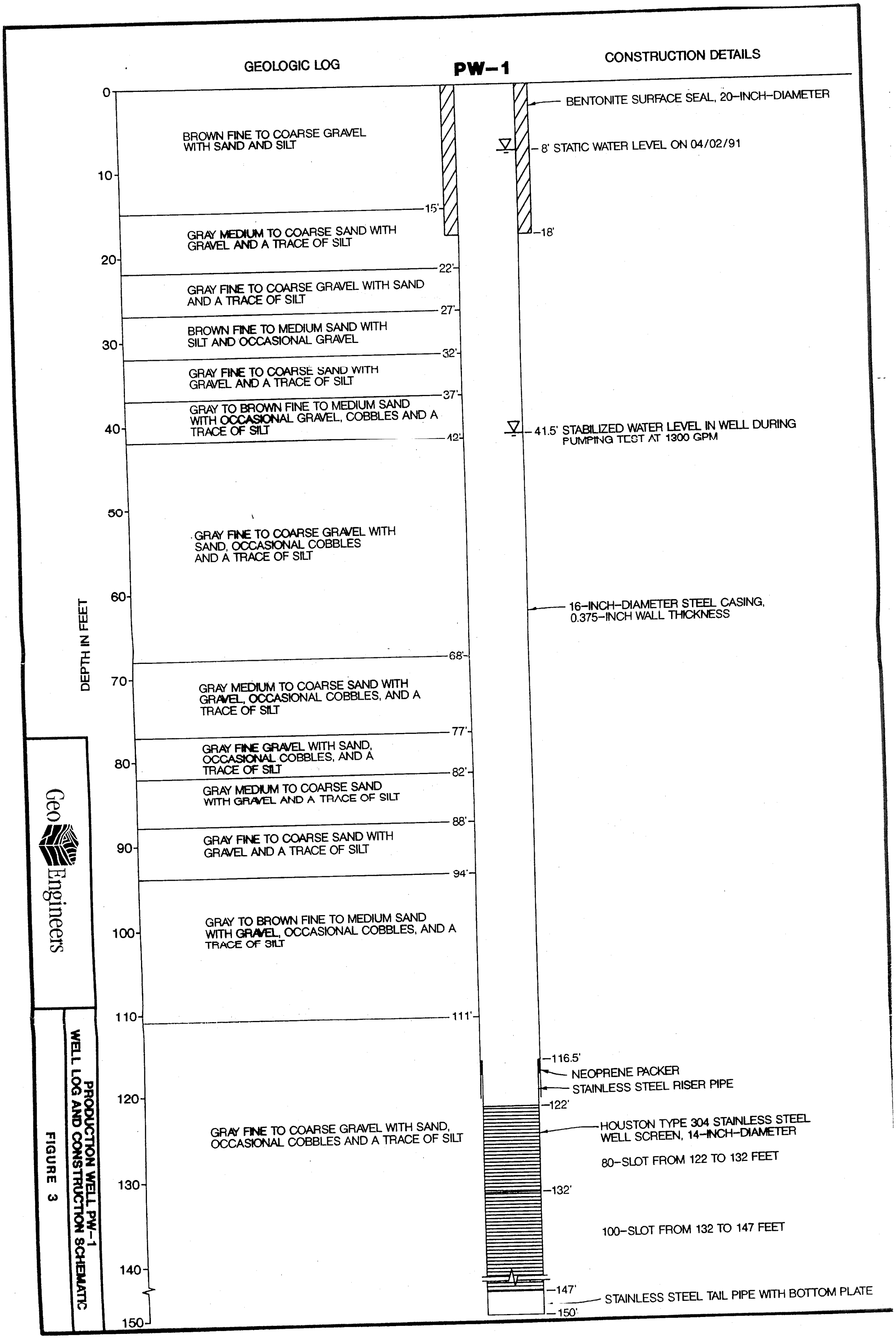
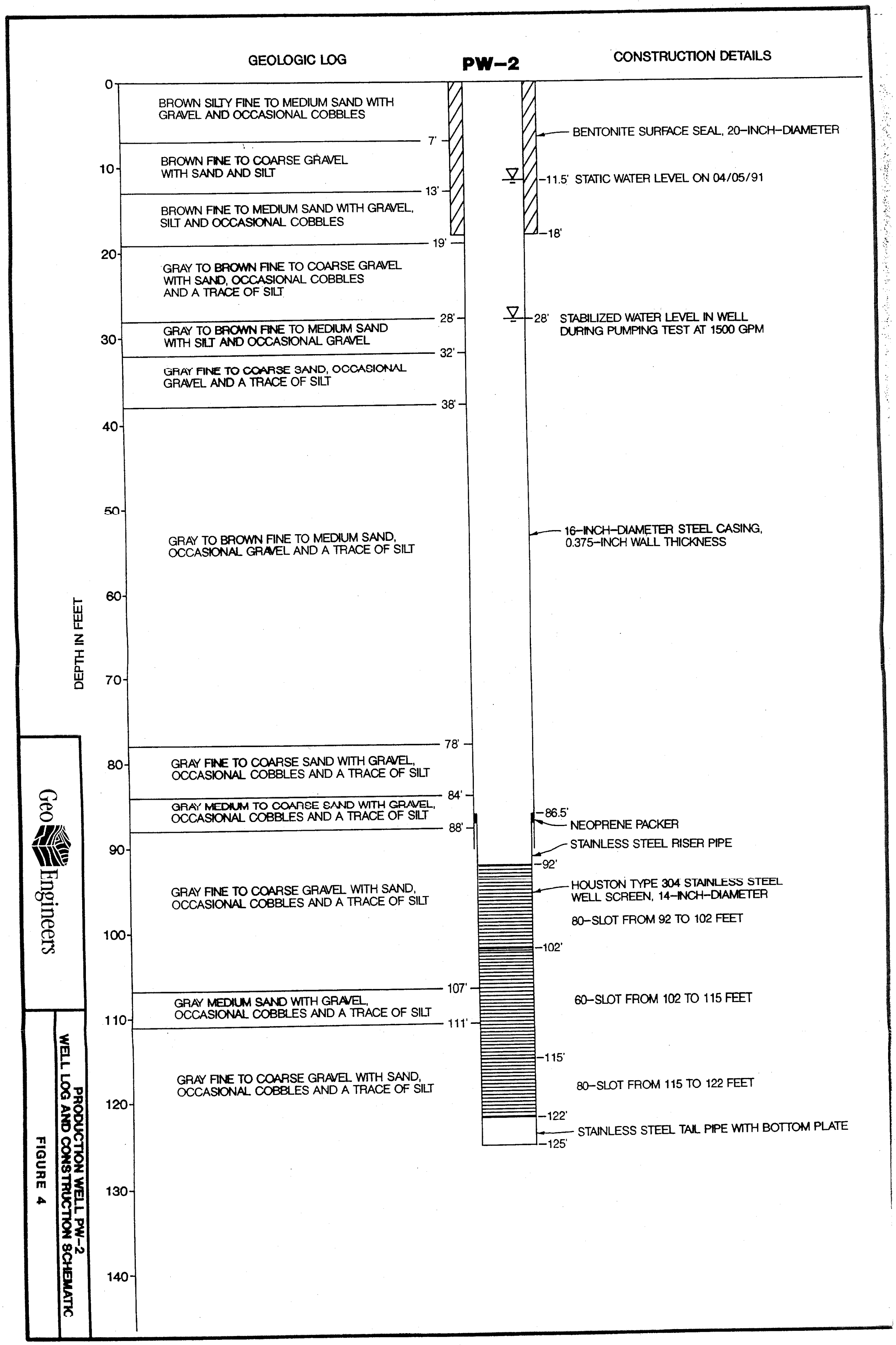
1317·013·B04 TTF:BDH 5.30.91



PRODUCTION WELL PW-1
WELL LOG AND CONSTRUCTION SCHEMATIC

FIGURE 3

1317·013·B04 TTF:BDH 5.30.91



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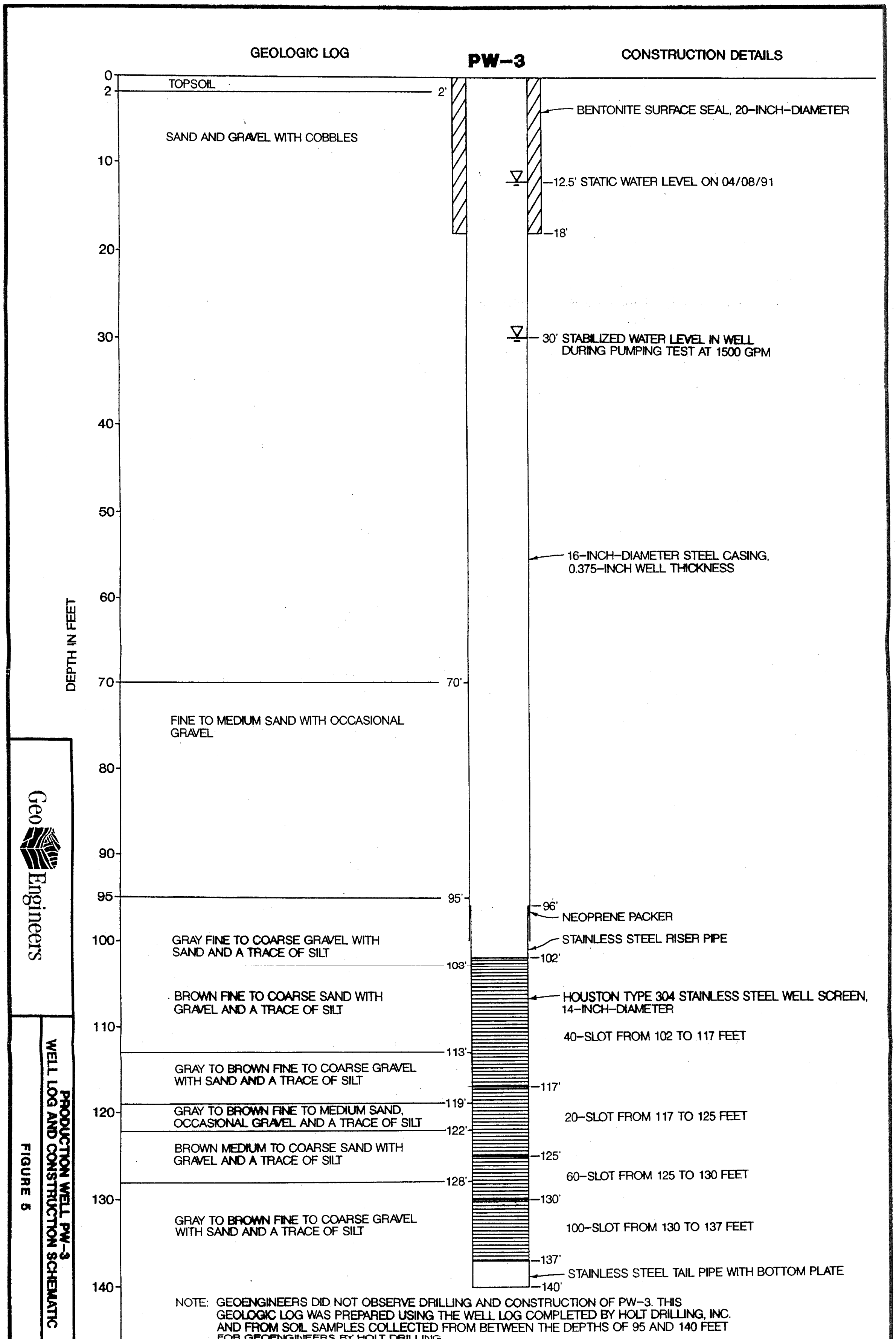
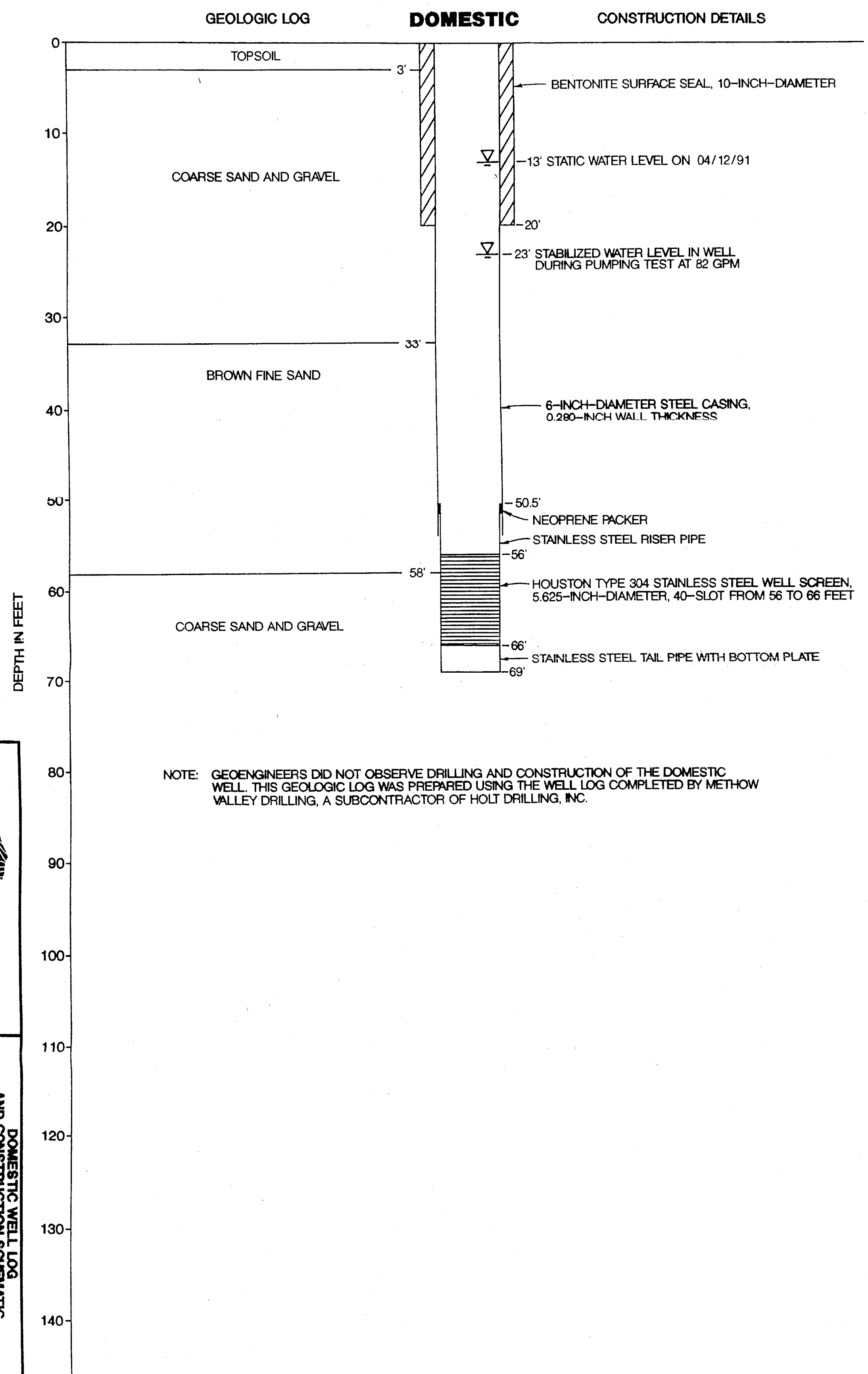
1317-013-B04 TTF:BDH 5.30.91



PRODUCTION WELL PW-3
WELL LOG AND CONSTRUCTION SCHEMATIC

FIGURE 5

1317-013-B04 TTF:BDH 5.30.91



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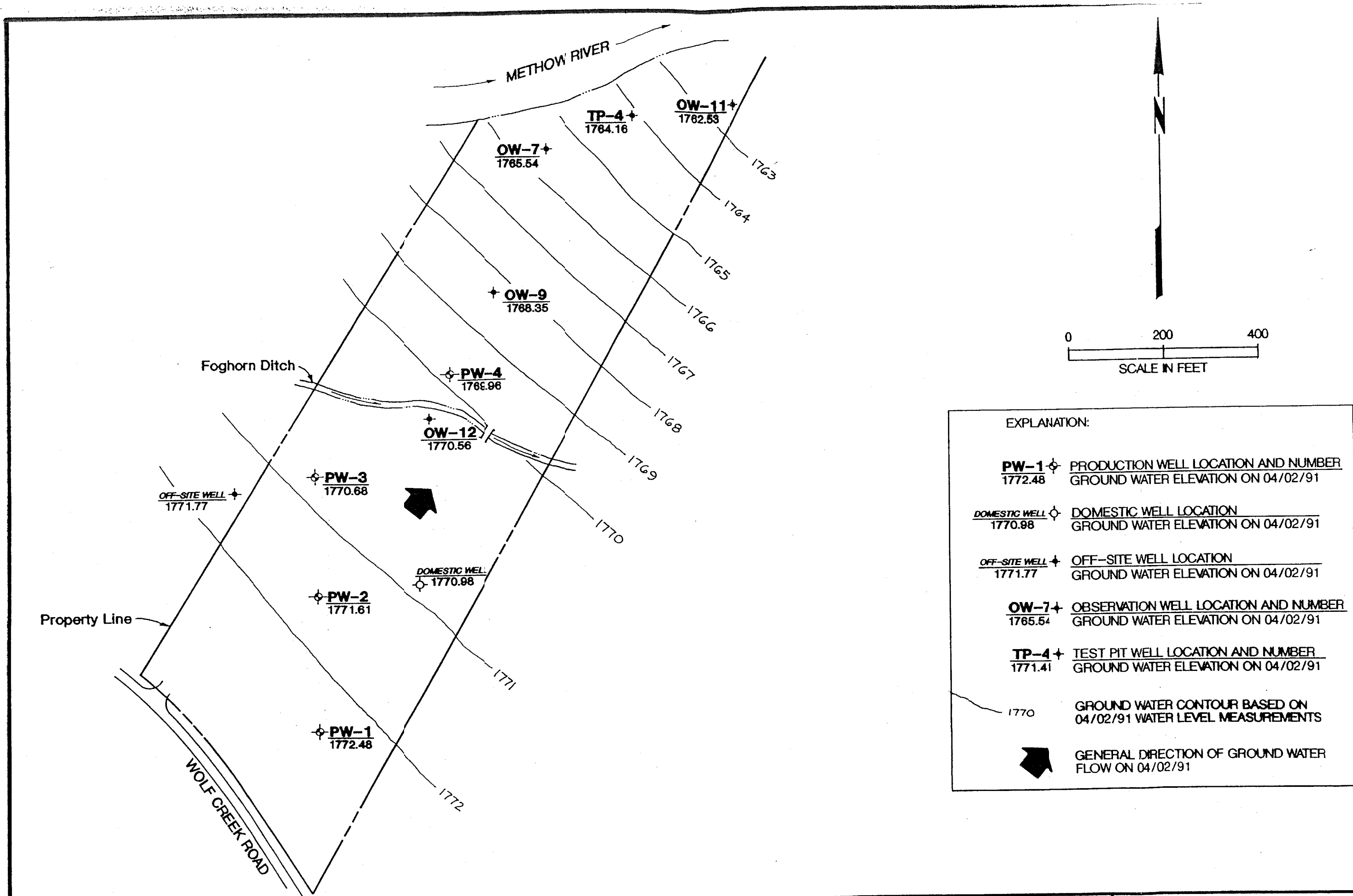
DOMESTIC WELL LOG AND CONSTRUCTION SCHEMATIC

FIGURE 6



REFERENCE: DRAWING ENTITLED "HATCHERY SITE PLAN," BY FISHPRO, INC., DATED 02/04/91.

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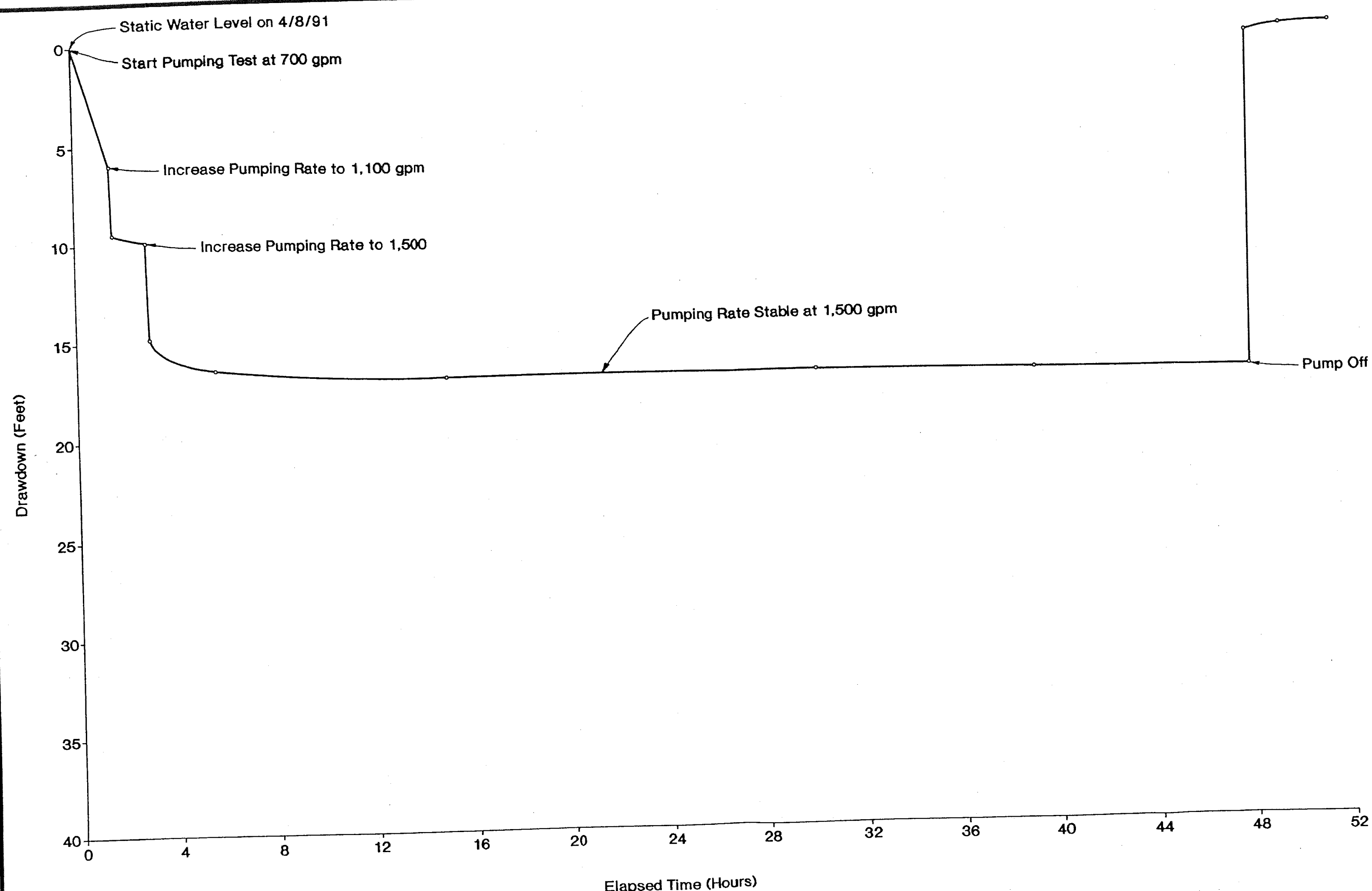
GROUND WATER CONTOURS (STATIC CONDITIONS)

FIGURE 7

1317-013-B04 TTF:BDH 5.30.91 (a)

DOC020.max



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PRODUCTION WELL PW-3
WATER LEVEL VS. TIME

FIGURE 10

1317-013-B04 CRW:BDH 4.25.91

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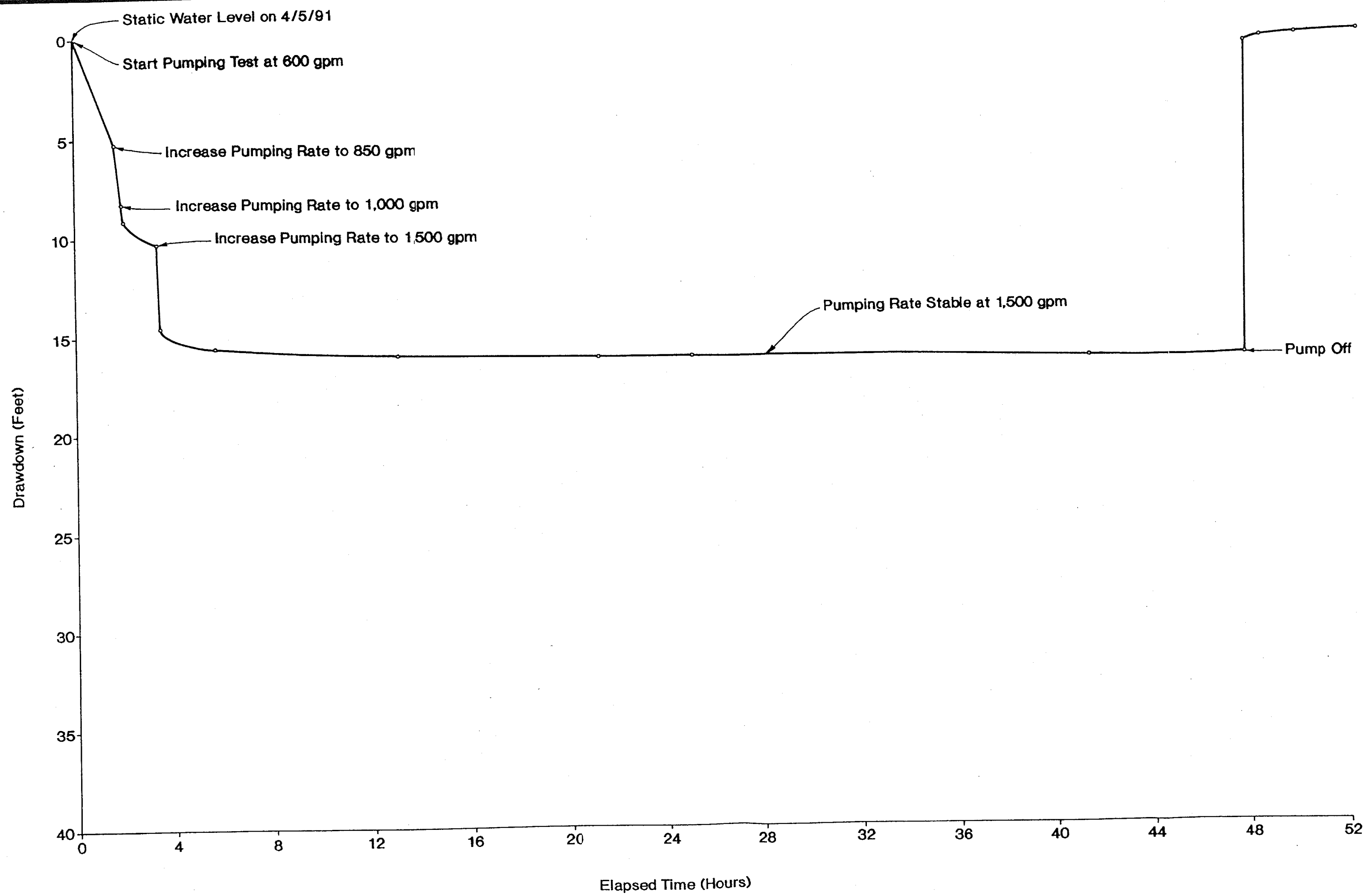

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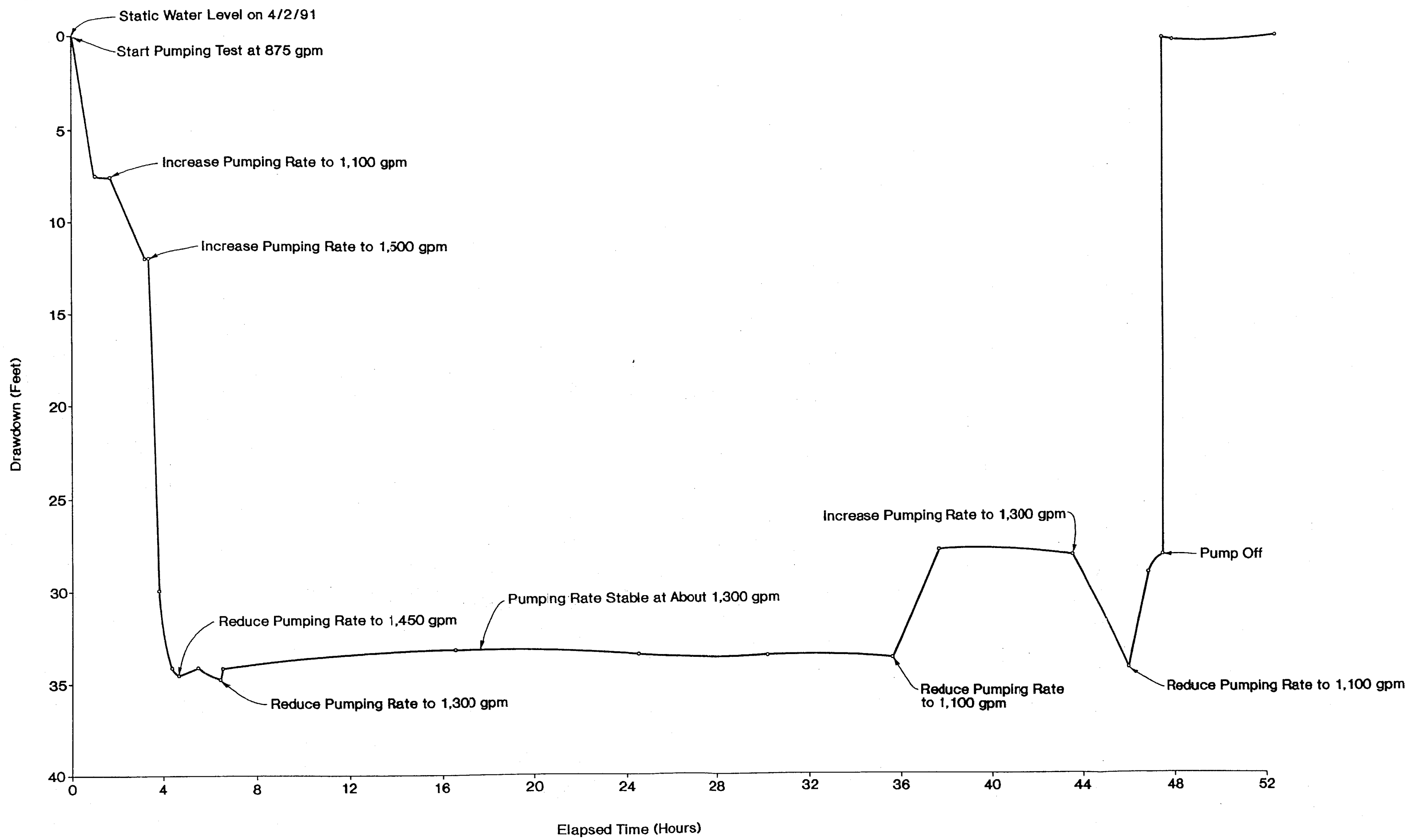
PRODUCTION WELL PW-2
WATER LEVEL VS. TIME

FIGURE 9

1317-013-B04 CRW:BDH 4.25.91



NOTE: THE FLUCTUATIONS IN THE PUMPING RATE AFTER ABOUT HOUR 36 WERE CAUSED BY MECHANICAL DIFFICULTIES WITH THE PUMP MOTOR.

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PRODUCTION WELL PW-1
WATER LEVEL VS. TIME

FIGURE 8

1317.013.B04 CRW:BDH 4.25.91

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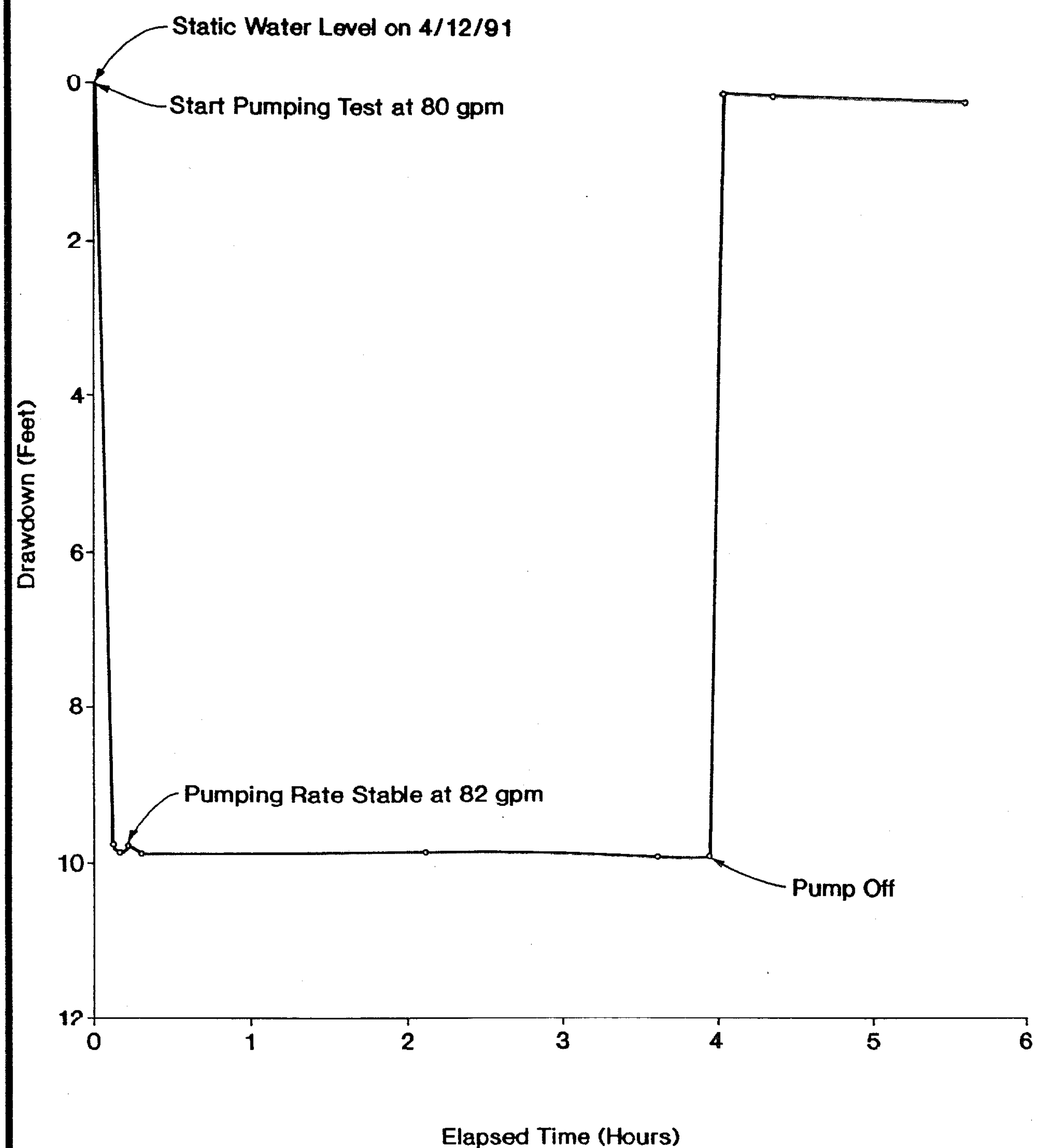

1317-013-B04 CRW:BDH 4.25.91

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**DOMESTIC WELL
WATER LEVEL VS. TIME**

FIGURE 11

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

DRILLING AND SOIL SAMPLING PROGRAM

Subsurface conditions in the southern (upper terrace) portion of the Spring Chinook Hatchery and Rearing Facility site were explored during our Phase 4 studies by drilling four borings at the locations indicated in Figures 2 and 7. The borings include three production well borings (PW-1, PW-2 and PW-3) and one domestic well boring. The 16-inch-diameter production well borings were drilled between January 1 and January 18, 1991 to depths ranging between 125 and 150 feet. The production well borings were completed using cable tool drilling equipment owned and operated by Holt Drilling, Inc. of Puyallup, Washington. GeoEngineers personnel observed the drilling of PW-1 and PW-2. GeoEngineers did not observe the drilling of PW-3 or the domestic well.

The 6-inch-diameter domestic well boring was drilled to a depth of 72 feet on March 8 and 9, 1991 using air-rotary drilling equipment owned and operated by Methow Valley Drilling of Twisp, Washington. Methow Valley Drilling was subcontracted to Holt Drilling, Inc.

The boring locations were selected by DCPUD (Douglas County Public Utility District) in general accordance with the recommendations included in our report of Phase 3 services dated March 6, 1990. Geologists from our staff examined and classified the soils encountered in borings PW-1 and PW-2, and prepared a detailed log of these borings. Soil samples obtained from below a depth of 95 feet in PW-3 were collected by Holt Drilling and submitted to GeoEngineers for classification in our soils laboratory. GeoEngineers did not observe soil samples collected from the domestic well. The logs of PW-3 and the domestic well were developed using water well reports prepared by the drilling contractors and soil samples from PW-3. Soils encountered were classified visually in general accordance with ASTM D-2488-83, which is described in Figure A-1. The boring logs are presented in Figures 3 through 6 in the text of this report.

Soil samples were obtained from the production wells at approximately 5-foot intervals using a down hole steel sediment bailer. The soil grain-size distributions of the samples obtained from PW-1 and PW-2 were determined by dry sieving in the field. The soil grain-size distributions of the samples obtained from PW-3 below a depth of 95 feet were determined by dry and wet sieving in our laboratory. Plots of grain-size distribution for samples from the lower portions of the three production wells are shown in Figures A-2 through A-16.

WELL CONSTRUCTION

Production wells PW-1, PW-2 and PW-3 were drilled and cased as 16-inch-diameter bores to depths of 150, 125 and 140 feet, respectively. Fourteen-inch-diameter, Type 304 stainless steel well screens were installed in each well following completion of drilling. The domestic well was drilled and cased as a 6-inch-diameter bore to a depth of 72 feet. Six-inch-diameter, Type 304 stainless steel telescoping well screen was installed following completion of drilling. The total length of screen, screen slot size and depth interval for each well screen are shown below.

WELL	SCREEN LENGTH (feet)	SLOT SIZE (inches)	DEPTH INTERVAL (feet)
PW-1	25	0.080 0.100	122-132 132-147
PW-2	30	0.080 0.060 0.080	92-102 102-115 115-122
PW-3	35	0.040 0.020 0.060 0.100	102-117 117-125 125-130 130-137
Domestic	10	0.040	56-66

A riser pipe 5 feet in length, and a tail pipe 3 feet in length were attached to the top and bottom, respectively, of each screen. A neoprene packer is attached to the top of each riser pipe. Well construction details are shown in Figures 3 through 6.

The production well screens were developed using surge block methods. Development of the production well screens was conducted using cable tool drilling equipment owned and operated by Holt Drilling. The domestic well screen was developed with air lift methods using air-rotary drilling equipment owned and operated by Methow Valley Drilling.

PUMPING TESTS

A pumping test was completed in each production well using a vertical line-shaft turbine pump powered by a truck-mounted diesel engine. The pump assembly consisted of 8-inch-diameter column and 10-inch-diameter bowls. The production well pumping tests were conducted between April 2 and April 10, 1991 using equipment owned and operated by Holt Drilling, Inc.

Each production well pumping test was conducted for a period of about 48 hours. Water levels were allowed to recover for about 24 hours prior to starting the next pumping test. The pumping tests were conducted as stepped tests. Each production well was pumped at a rate of approximately 700 gpm (gallons per minute) for the first 100 minutes of the test, about 1,000 gpm for the second 100 minutes, and approximately 1,300 gpm to 1,500 gpm for the remainder of the test. Flow rates were determined using a circular orifice weir. Water was discharged through a flexible synthetic pipe into an overflow channel for Foghorn Ditch that returns water directly to the Methow River.

The domestic well pumping test was conducted with an electric submersible pump owned and operated by Winthrop Pump of Winthrop, Washington. Winthrop Pump was subcontracted to Holt Drilling, Inc. The domestic well was pumped at a rate of approximately 80 gpm for 4 hours on April 12, 1991. The flow rate from the domestic well was measured directly with a 55-gallon drum. Water was discharged onto the ground surface approximately 200 feet east (downgradient) of the domestic well.

GROUND WATER AND SURFACE WATER ELEVATIONS

The elevation of the ground water table during the pumping tests was measured using pressure transducers and a hand held electric sounder. Ground water elevations were determined relative to the casing rims of the pumping wells, the domestic well, the off-site well, and selected observation wells. The wells used to obtain water level measurements are shown in Figures 2 and 7. Casing rim elevations for the production wells, the domestic well and the off-site well were determined using an engineers level relative to the casing elevation of observation well OW-12, previously determined by Erlandsen and Associates of Brewster, Washington.

Water levels in the Methow River and Foghorn Ditch were measured relative to temporary benchmarks placed in their channels.

GROUND WATER QUALITY PARAMETERS

The temperature, pH and electrical conductance of the ground water from the production wells and domestic well were measured with a Hydac temperature, pH and conductance meter manufactured by Cambridge Scientific Industries. The meter consists of sensors that are immersed in a water sample, and a digital readout. The calibration of the Hydac meter was checked prior to obtaining the field measurements.

Dissolved oxygen was measured using a meter manufactured by Yellow Springs Instruments. The meter consists of a probe with a permeable membrane that is immersed in a water sample. Difficulties with the membrane of the dissolved oxygen meter prevented measurement of dissolved oxygen during the pumping tests in PW-1 and PW-2. The difficulties suggest that the measurements recorded during the tests in PW-3 and the domestic well should be used only for relative indications of dissolved oxygen content.

The measurements were obtained by periodically collecting samples of the ground water during the pumping tests. The samples were obtained at the location of the discharge to the Foghorn Ditch overflow channel. The ground water quality data are summarized in Table 1 in the text of this report.

GROUND WATER ANALYTICAL PROGRAM

Ground water samples were obtained from each of the production wells and the domestic well during the later stages of the respective pumping tests. The water samples were submitted to AMTest, Inc. for chemical analyses. The ground water sample from PW-2 was analyzed for drinking water quality parameters, dissolved iron and zinc, plus other selected parameters. The ground water samples from PW-1, PW-3 and the domestic well were analyzed for dissolved iron and zinc. The water samples intended for analysis of metals were filtered in the field prior to placement in bottles provided by the laboratory. Filter blanks were prepared by GeoEngineers at the site using distilled water. The filter blanks were submitted with the ground water samples for analysis of dissolved iron and zinc. The laboratory reports are presented in Appendix B and summarized in Table 2.

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

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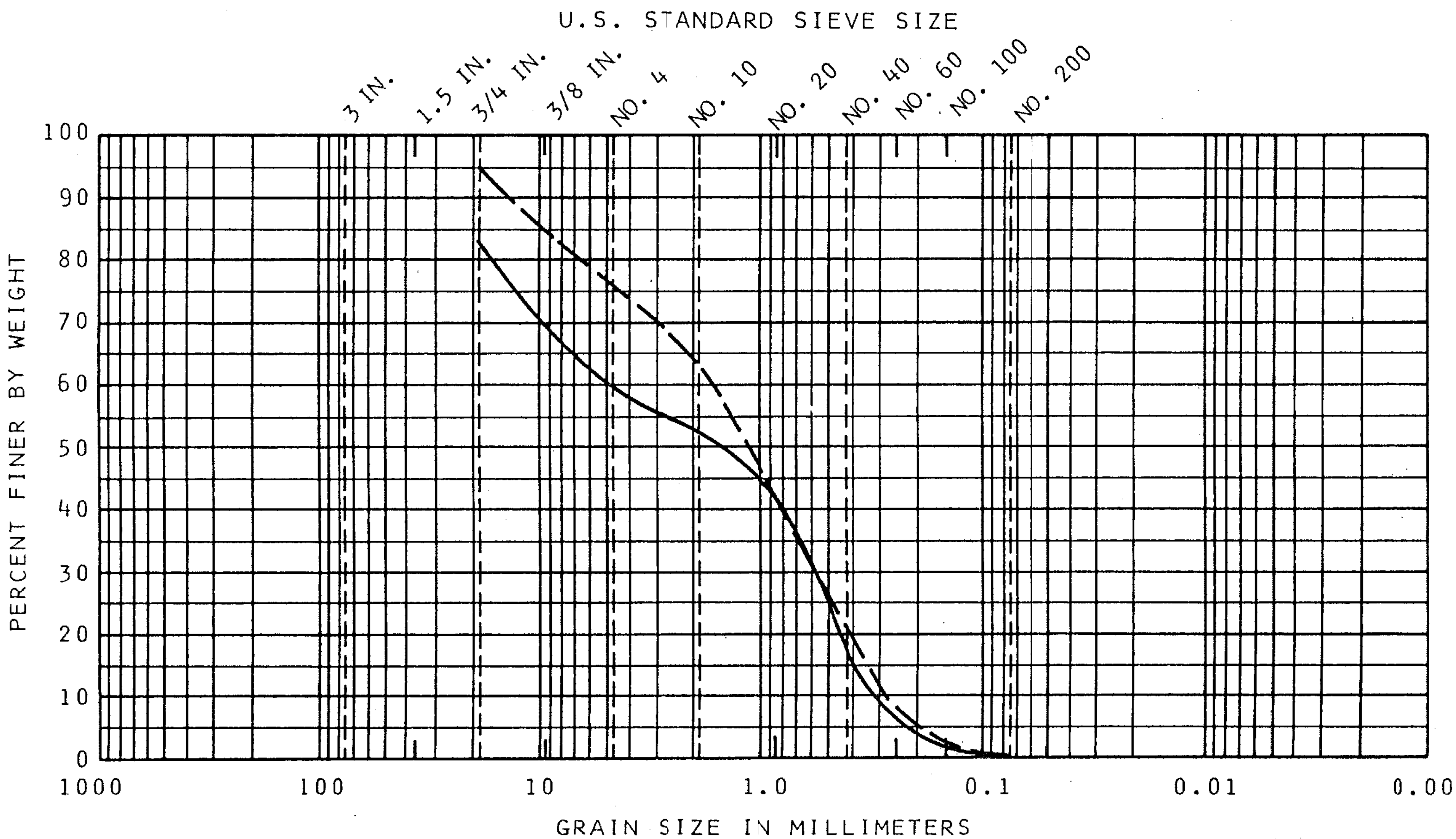
SOIL CLASSIFICATION SYSTEM

FIGURE A-1

GEI 85-88

GEI 30-88



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———————	PW-1	105'	GRAY FINE-TO-MEDIUM SAND WITH GRAVEL AND OCCASIONAL COBBLES (SP)
— — — —	PW-1	110'	GRAY FINE TO MEDIUM SAND WITH GRAVEL AND OCCASIONAL COBBLES (SP)

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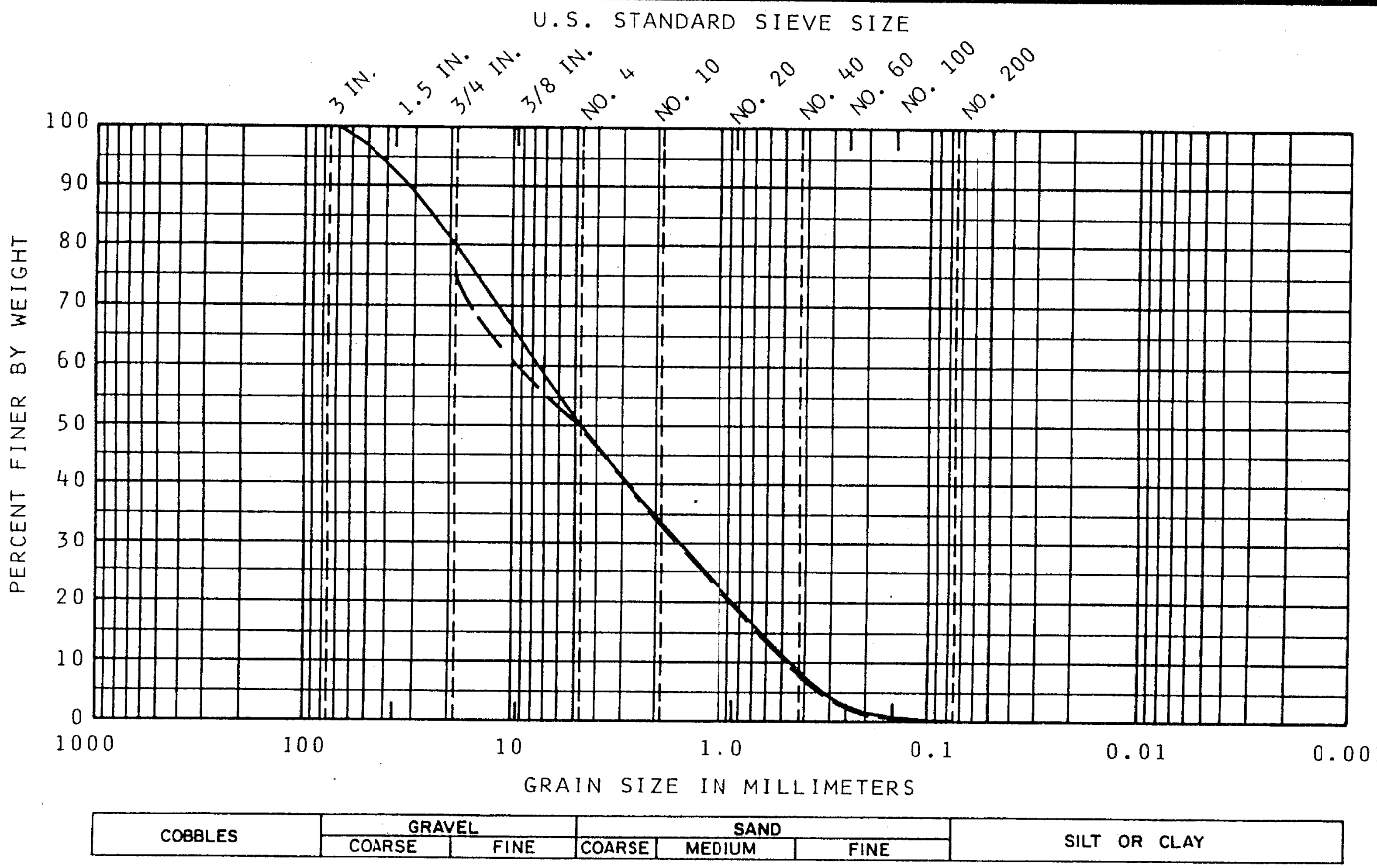
PW-1 GRADATION CURVES

FIGURE A-2



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——————— (solid)	PW-1	115'	GRAY FINE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GP)
— — — — (dashed)	PW-1	120'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)

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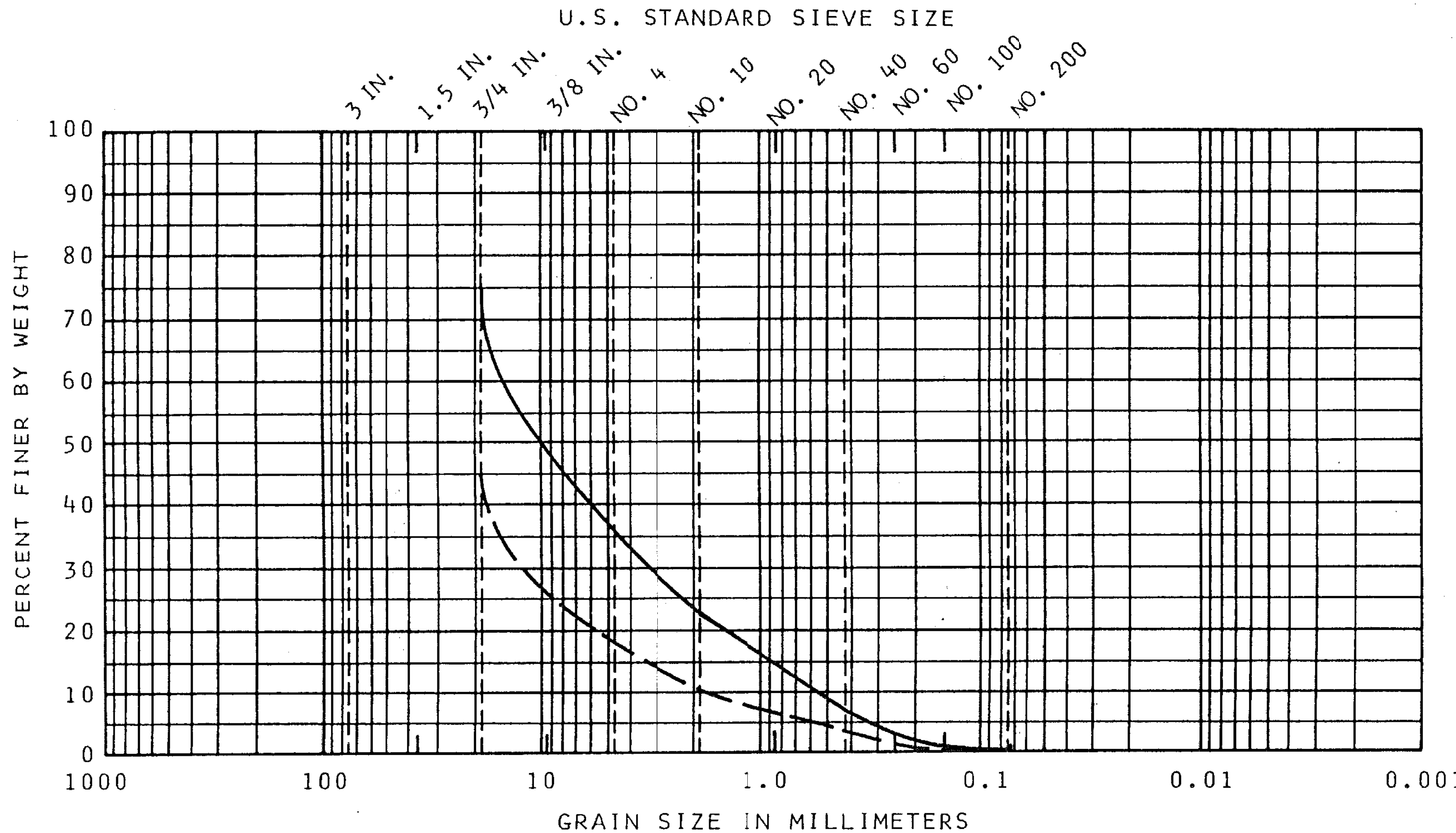
PW-1 GRADATION CURVES

FIGURE A-3



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
————	PW-1	125'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)
— — — —	PW-1	130'	GRAY COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GP)

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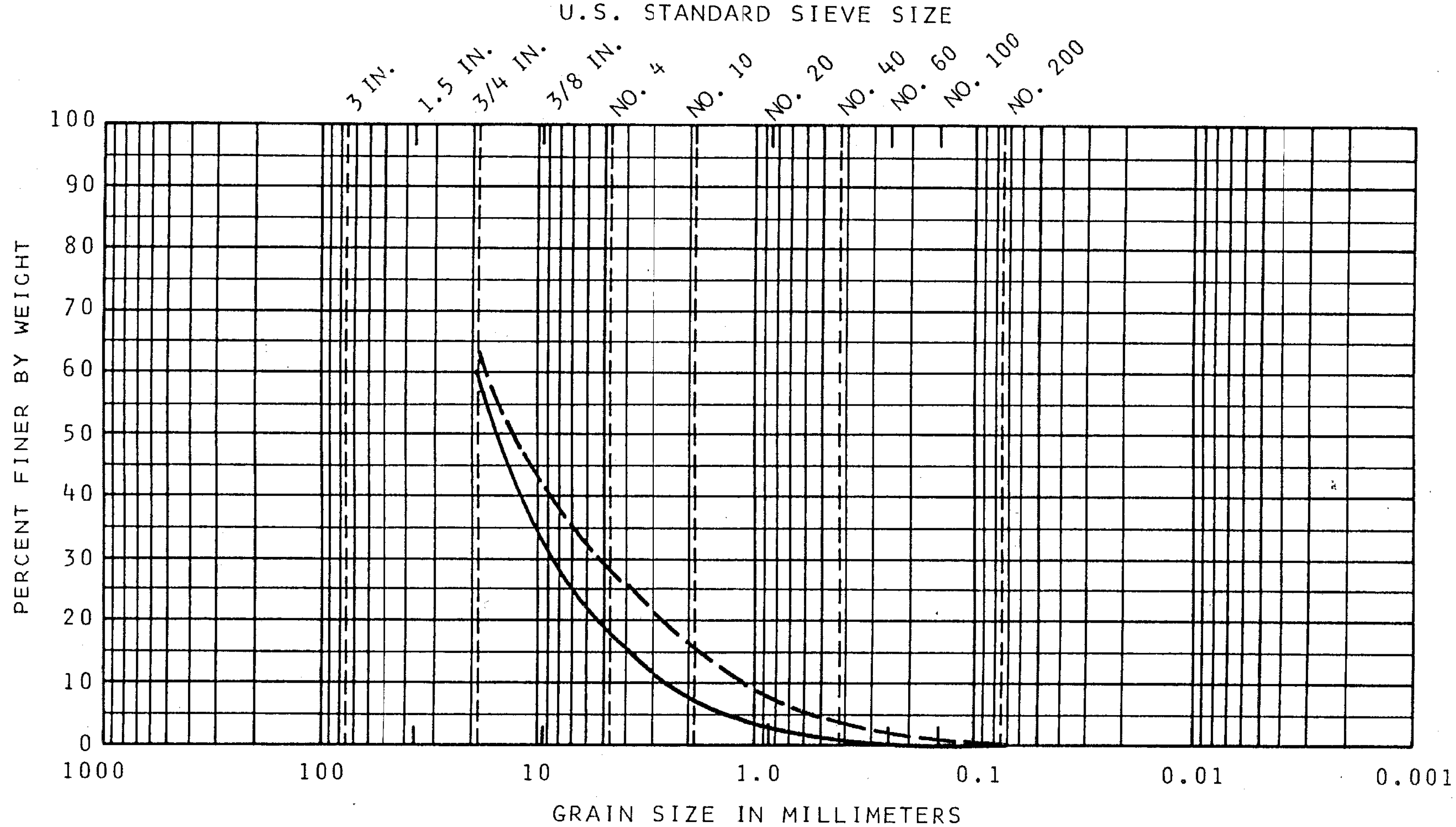
PW-1 GRADATION CURVES

FIGURE A-4

GEI 30-88



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———— (solid line)	PW-1	135'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)
— — — (dashed line)	PW-1	140'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)

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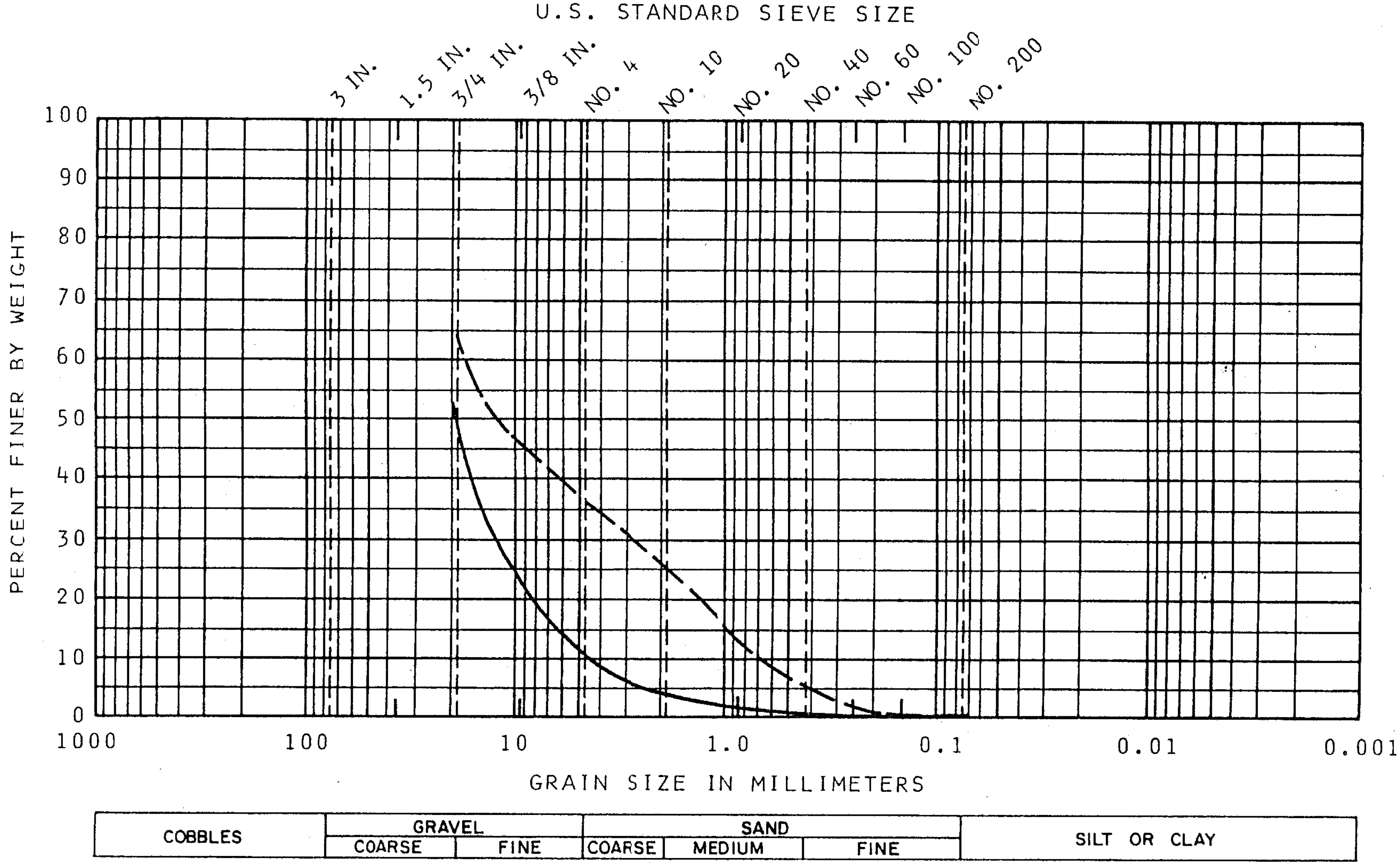
PW-1 GRADATION CURVES

FIGURE A-5

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——— (solid)	PW-1	145'	GRAY FINE TO COARSE GRAVEL WITH SAND AND CCCASIONAL COBBLES (GW)
— — — (dashed)	PW-1	150'	GRAY COARSE GRAVEL WITH SAND AND CCCASIONAL COBBLES (GP)

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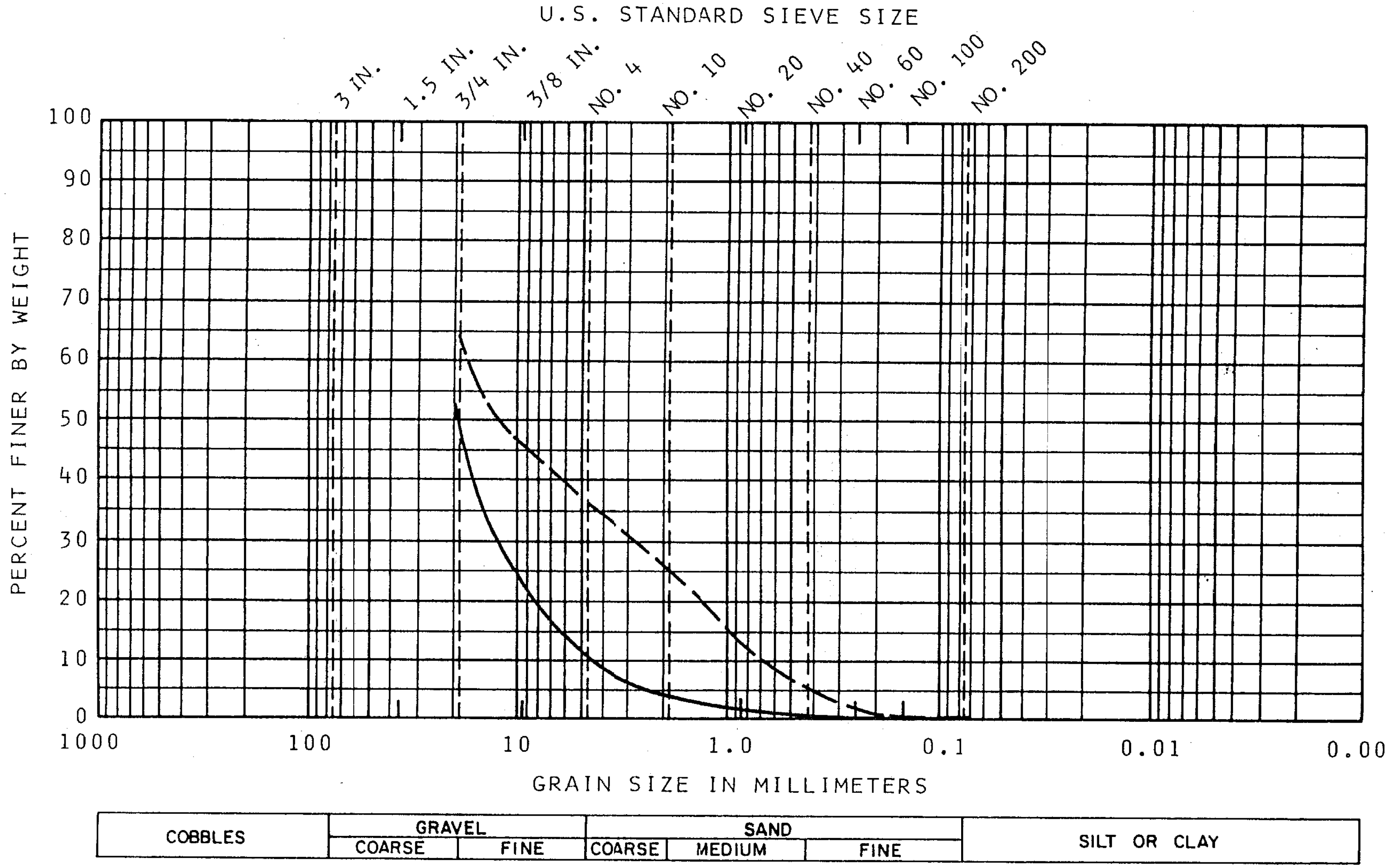
PW–1 GRADATION CURVES

FIGURE A–6

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——————— (solid line)	PW-1	145'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)
— — — — (dashed line)	PW-1	150'	GRAY COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GP)

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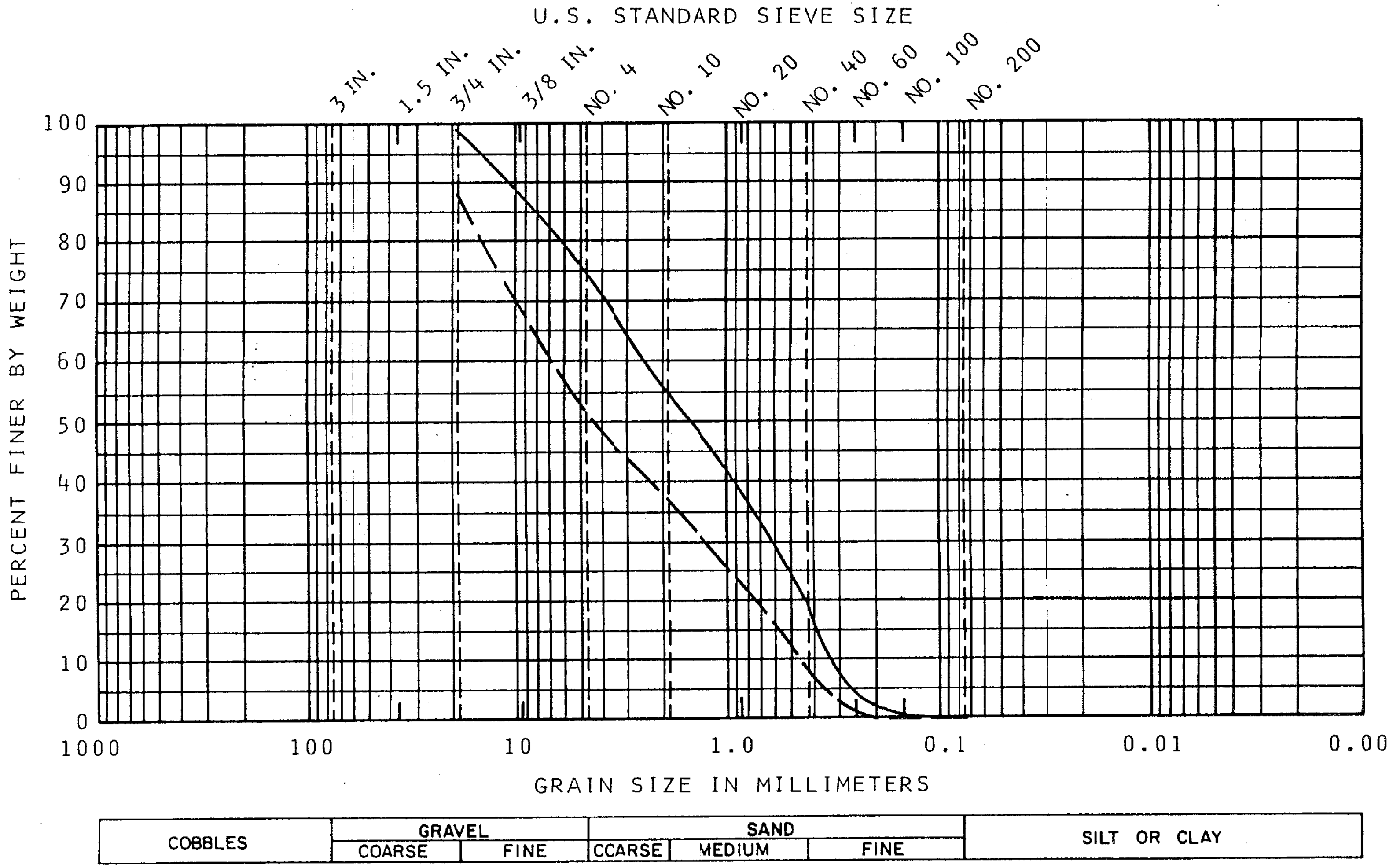
PW-1 GRADATION CURVES

FIGURE A-6

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———— (solid line)	PW-2	80'	GRAY FINE TO MEDIUM SAND WITH GRAVEL AND OCCASIONAL COBBLES (SP)
— — — — (dashed line)	PW-2	85'	GRAY MEDIUM TO COARSE SAND WITH GRAVEL AND OCCASIONAL COBBLES (SP)

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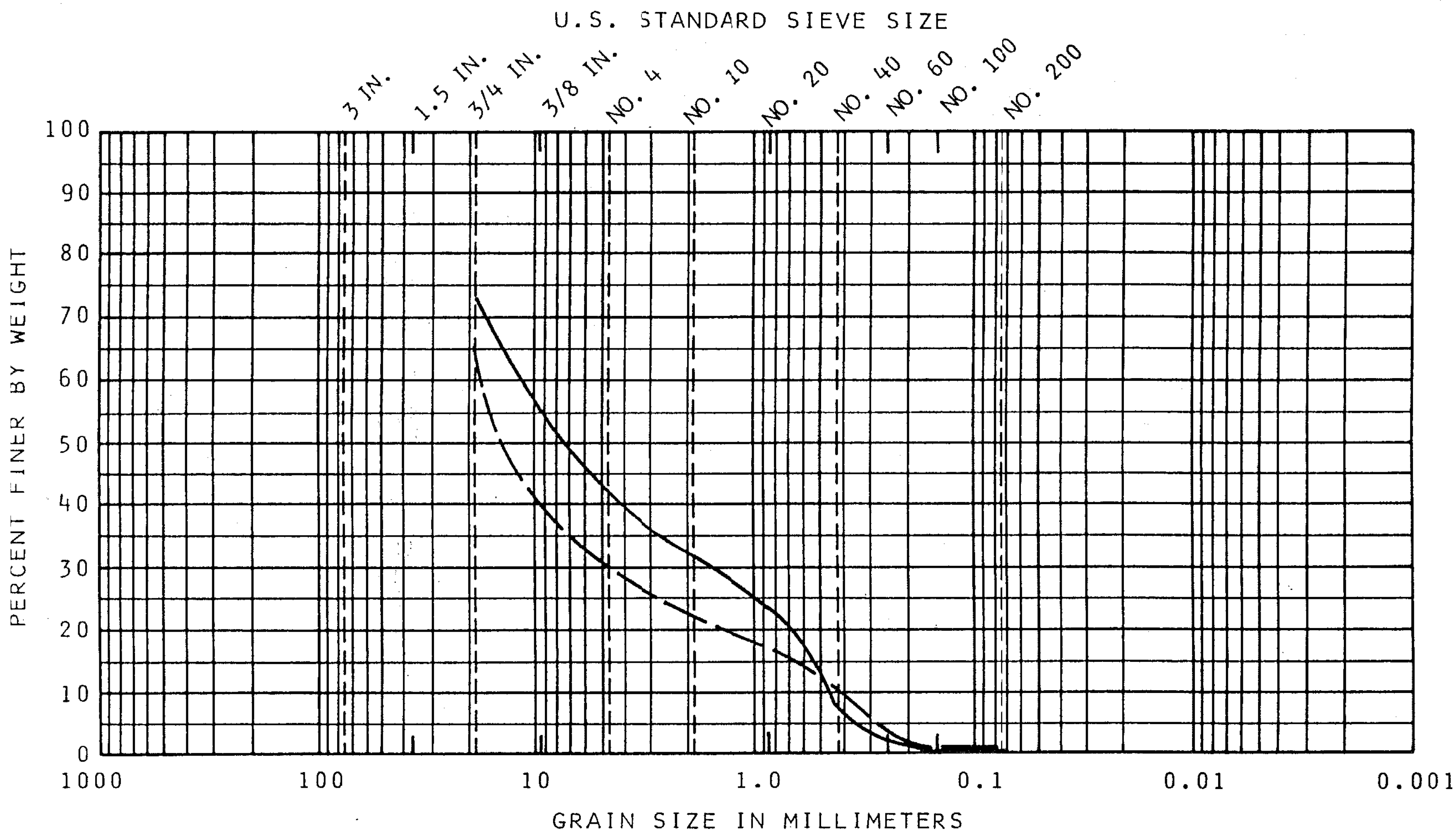
PW-2 GRADATION CURVES

FIGURE A-7

GEI 30-88



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

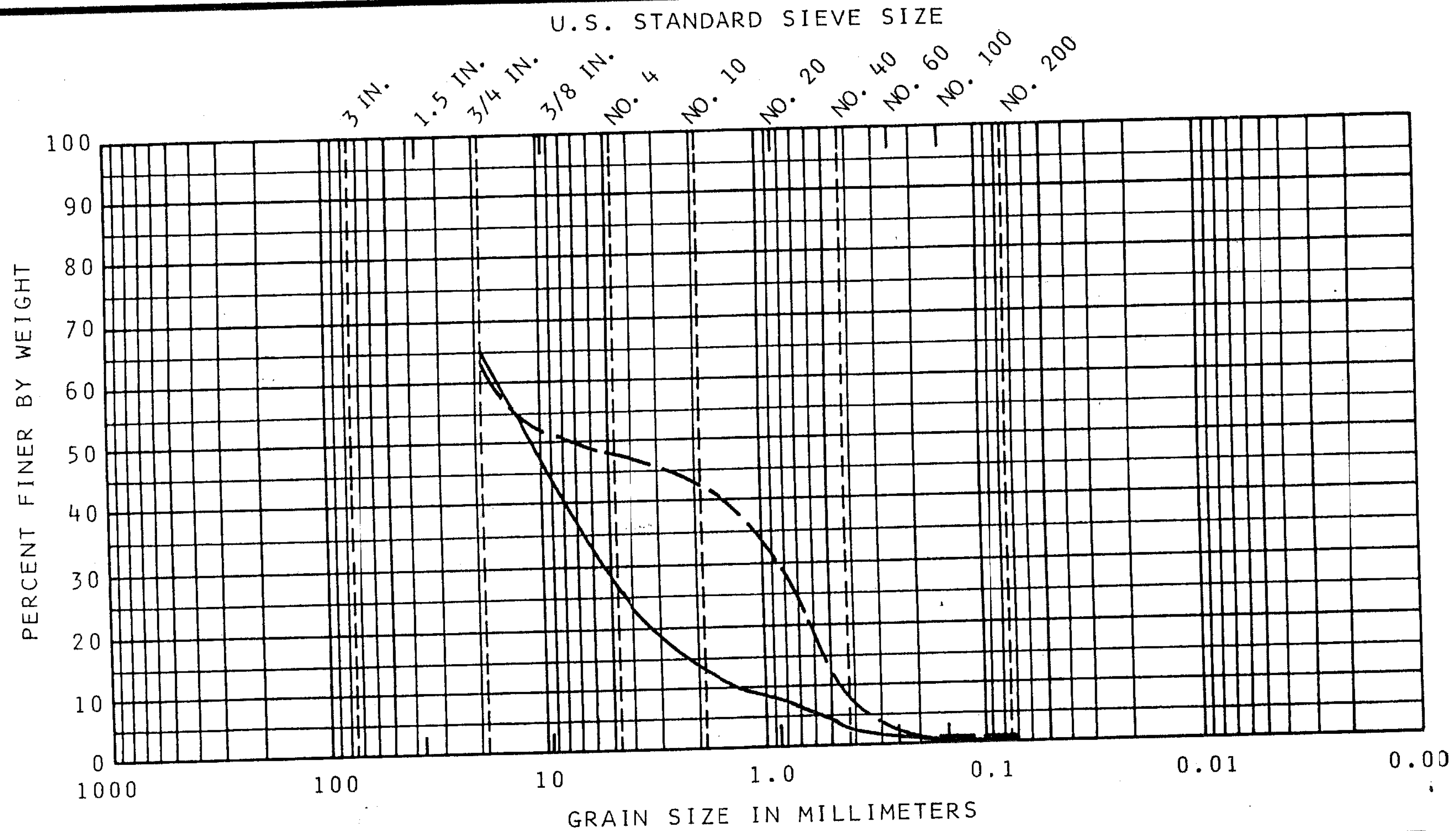
SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——————— (solid)	PW-2	90'	GRAY FINE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GP)
— — — — (dashed)	PW-2	95'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)

GeoEngineers

PW-2 GRADATION CURVES

FIGURE A-8

GEI 30-88



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———————	PW-2	101'	GRAY FINE TO COARSE GRAVEL WITH SAND AND COBBLES (GW)
— — — —	PW-2	105'	GRAY COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GP)

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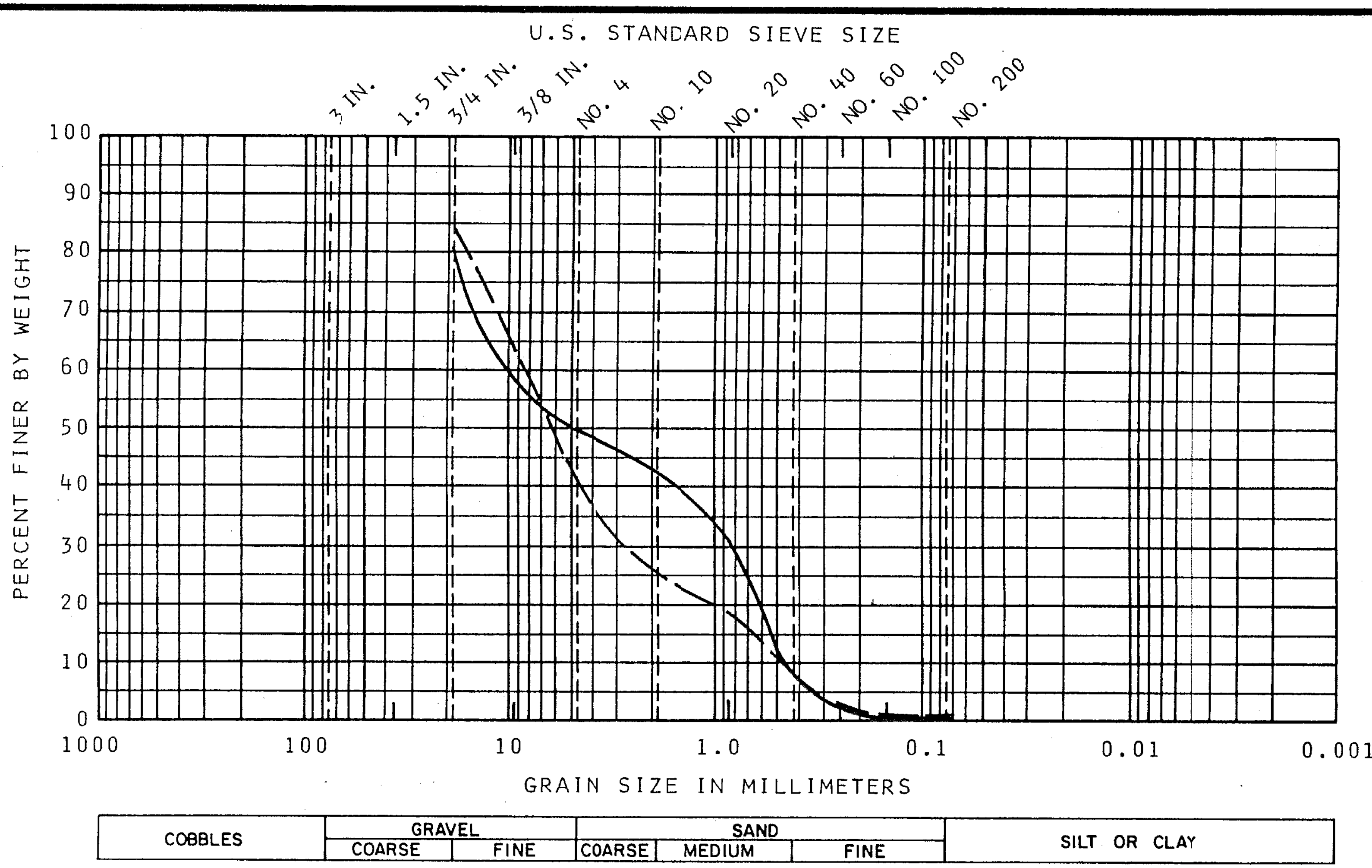
PW-2 GRADATION CURVES

FIGURE A-9

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
————	PW-2	110'	GRAY MEDIUM TO CAORSE SAND WITH GRAVEL AND OCCASIONAL COBBLES (SP)
— — — —	PW-2	115'	GRAY FINE TO CAORSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)

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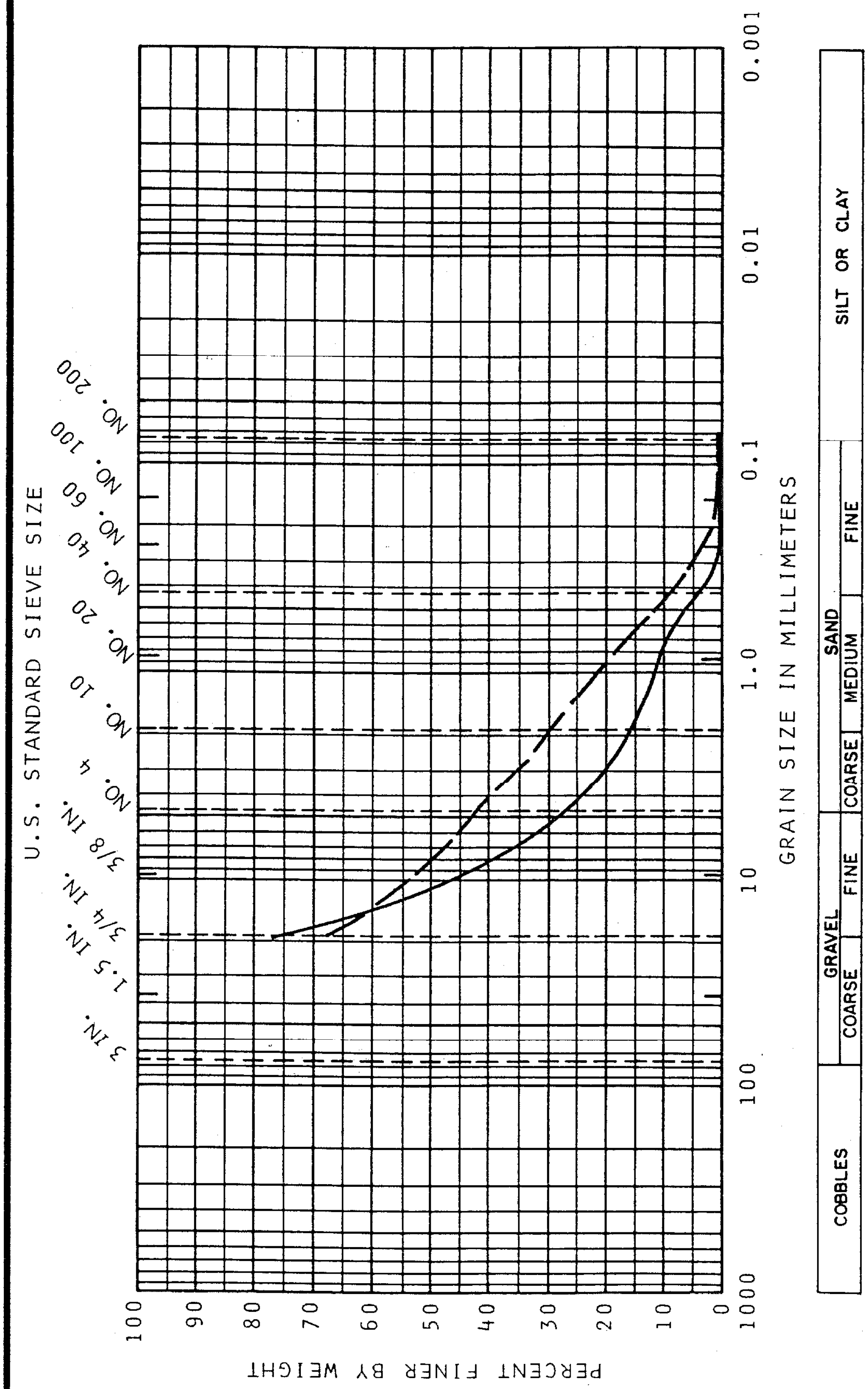
PW-2 GRADATION CURVES

FIGURE A-10

DOC020.max



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——— (solid line)	PW-2	120'	GRAY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GW)
— — — (dashed line)	PW-2	125'	GRAY COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (GP)

GEI 30-88

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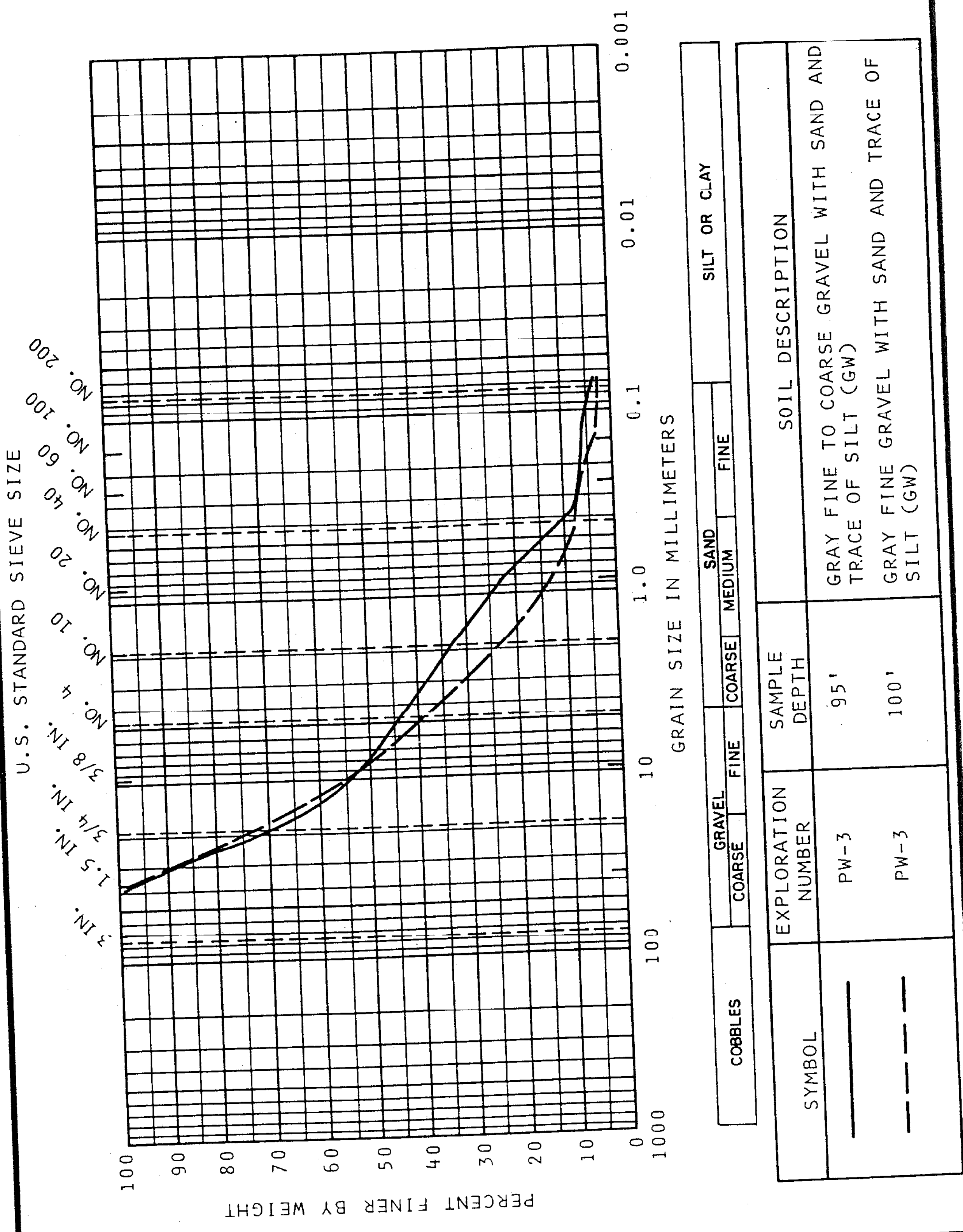
PW-2 GRADATION CURVES

FIGURE A-11



GEI 30-88

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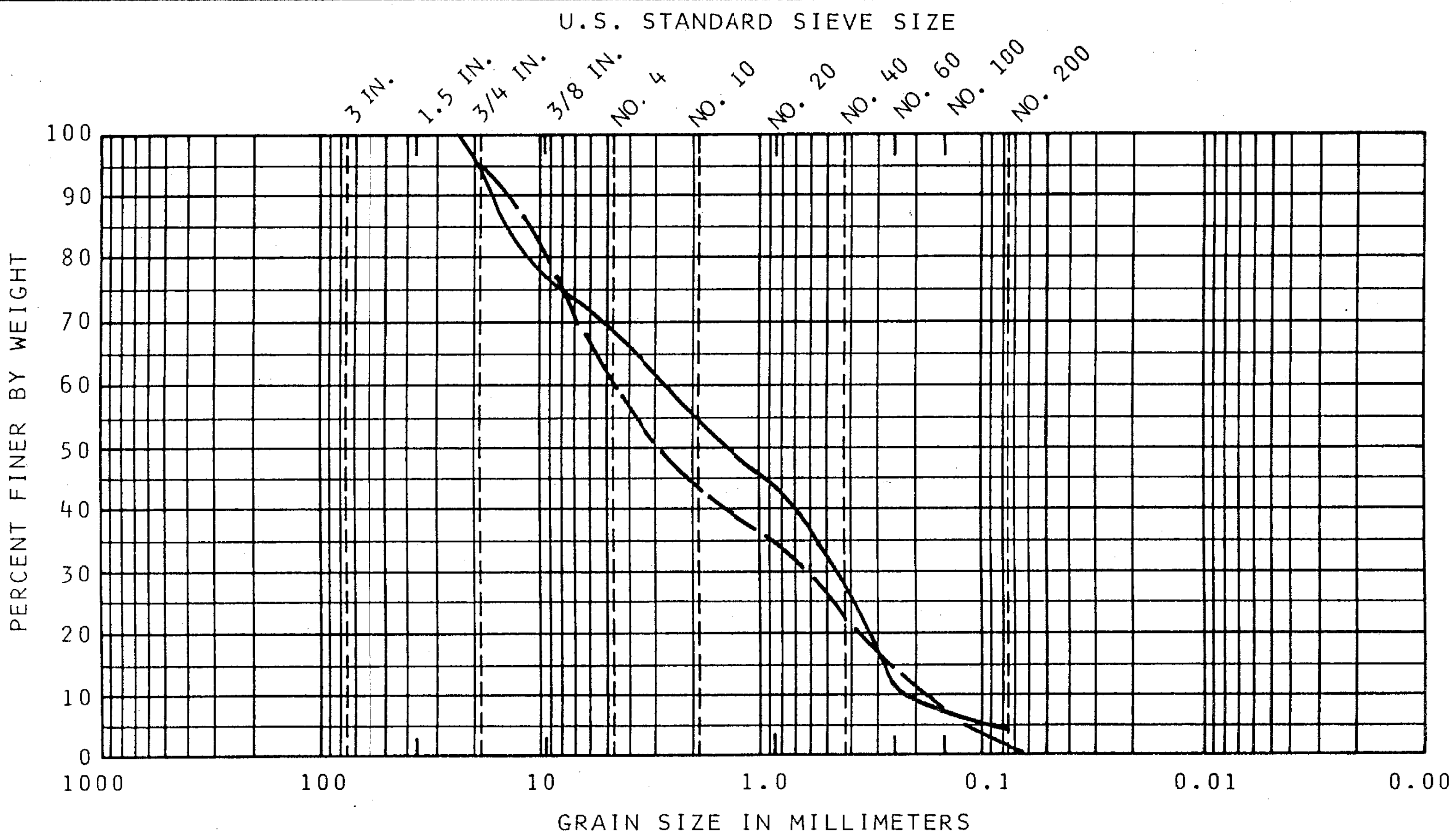
PW-3 GRADATION CURVES

FIGURE A-12

GEI 30-88



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——————— (solid)	PW-3	105'	BROWN MEDIUM COARSE SAND WITH GRAVEL AND TRACE OF SILT (SP)
— — — — (dashed)	PW-3	110'	BROWN FINE TO MEDIUM SAND WITH GRAVEL AND TRACE OF SILT (SP)

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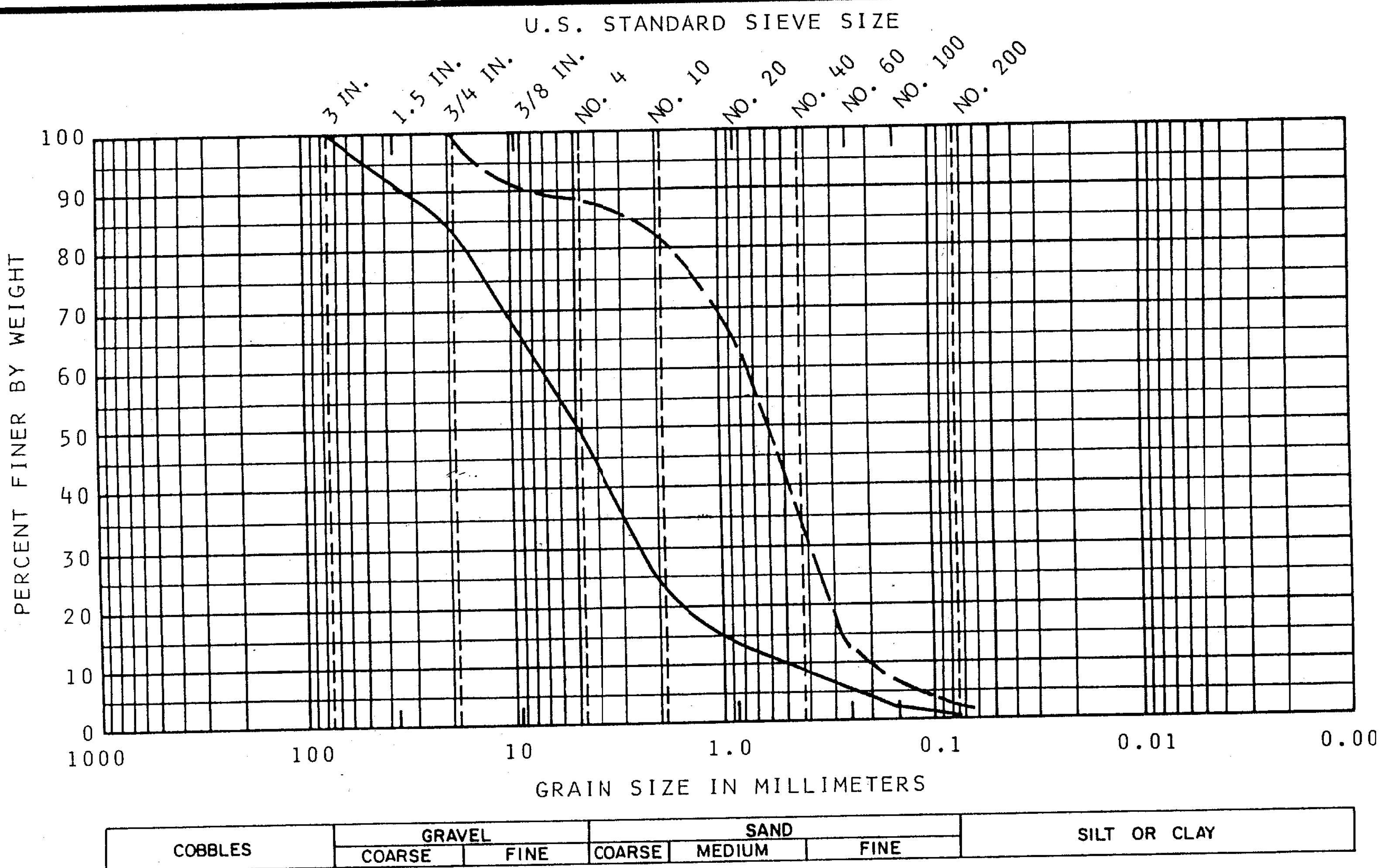
PW-3 GRADATION CURVES

FIGURE A-13

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
————	PW-3	115'	GRAY-BROWN FINE TO COARSE GRAVEL WITH SAND (GW)
— — — —	PW-3	120'	GRAY-BROWN FINE TO MEDIUM SAND WITH OCCASIONAL FINE GRAVEL (SP)

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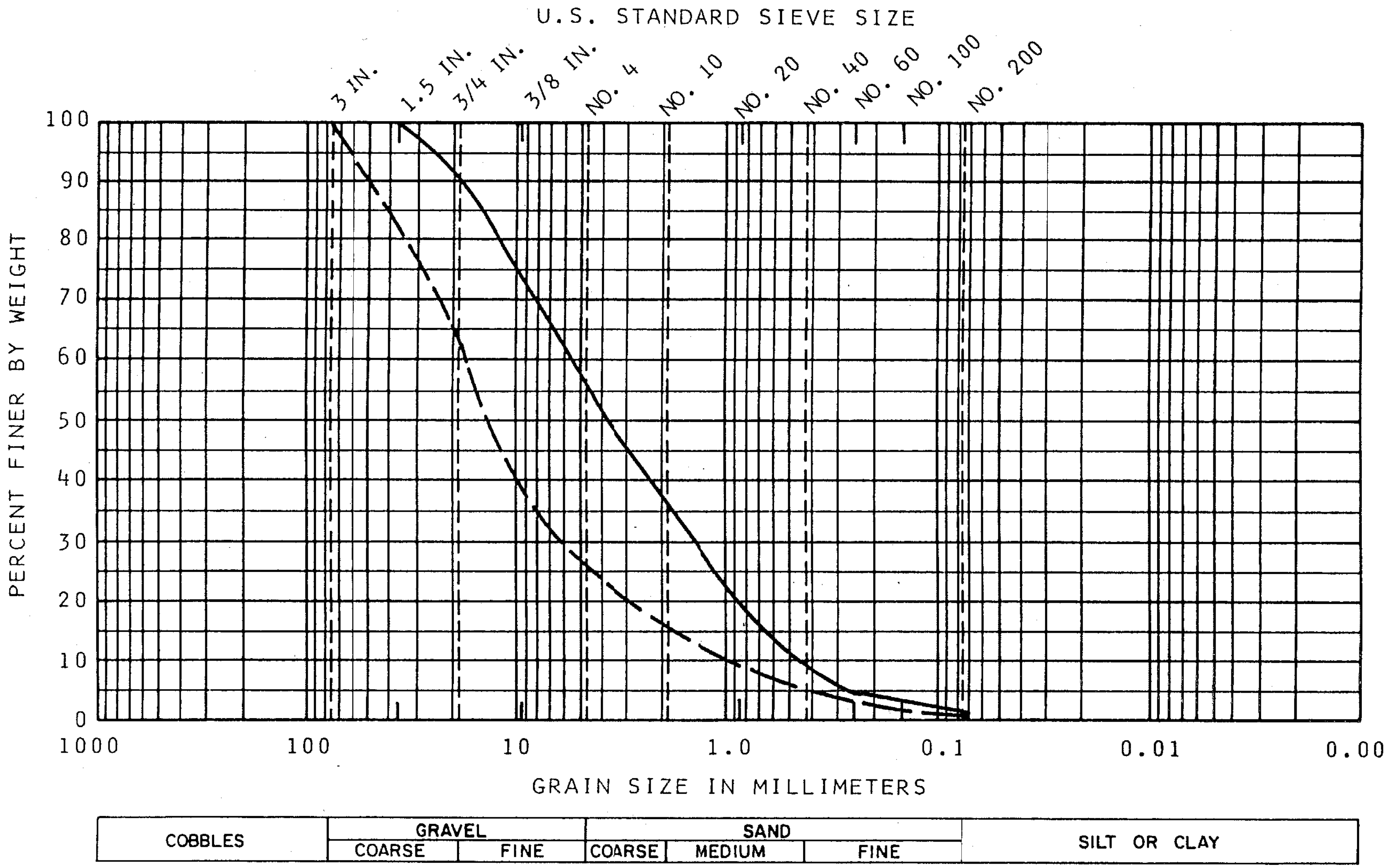
PW-3 GRADATION CURVES

FIGURE A-14

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———	PW-3	125'	BROWN MEDIUM TO COARSE SAND WITH GRAVEL (SP)
— — —	PW-3	130'	GRAY-BROWN FINE TO COARSE GRAVEL WITH SAND (GW)

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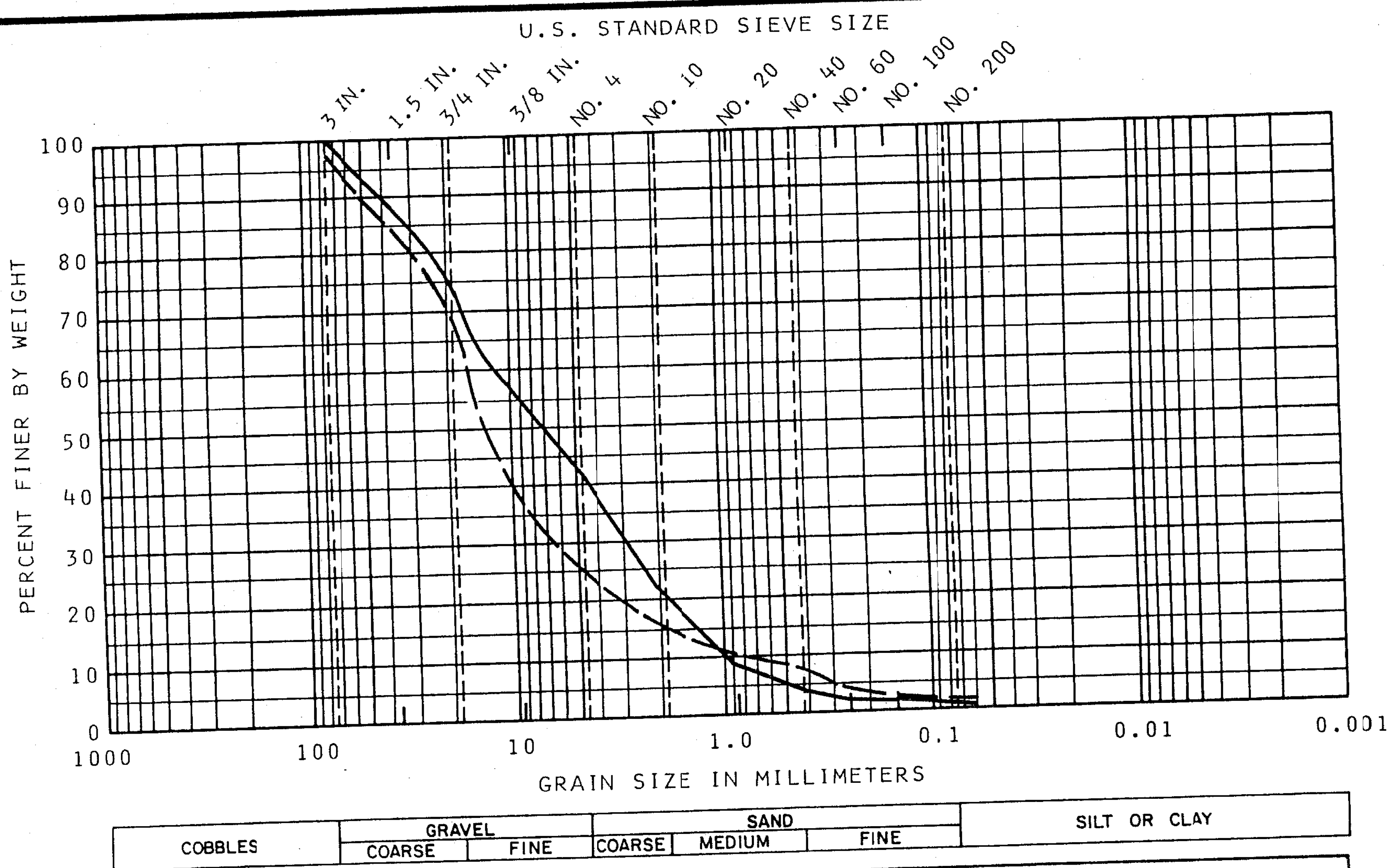
PW-3 GRADATION CURVES

FIGURE A-15

GEI 30-88



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——— (solid)	PW-3	135'	GRAY-BROWN FINE GRAVEL WITH SAND (GW)
— — — (dashed)	PW-3	140'	GRAY-BROWN FINE TO COARSE GRAVEL WITH SAND (GW)

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PW-3 GRADATION CURVES

FIGURE A-16

APPENDIX B

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Routing TTF

File 1317-013-B04

AMTEST

AmTest Inc.
Professional Analytical Services
14603 N.E. 87th St.
Redmond, WA 98052
Fax: 206 883 3495
Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Geo Engineers

REPORT TO: Terry Fisk
8410 - 154th Avenue NE
Redmond, WA 98052

DATE RECEIVED: 04/08/91

DATE REPORTED: 04/25/91

PROJECT NO.: 1317-013-B04

DOUGLAS COUNTY P.U.D.

Laboratory Sample Nos.	107341	107342
Client Identification	PW-1-A	PW-1-B
Dissolved Iron (mg/L)	0.32	1.7
Dissolved Zinc (mg/L)	0.027	0.031

KF/pb

REPORTED BY Kathy Fugiel

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AMTEST

AmTest Inc.

Professional
Analytical
Services

14603 N.E. 87th St.
Redmond, WA
98052

Fax: 206 883 3495

Tel: 206 885 1664

MAY 30 1991

Routing TTF

ANALYSIS REPORT

CLIENT: GeoEngineers, Inc.

REPORT TO: Terry Fisk
8410 - 154th Avenue NE
Redmond, WA 98052

DATE RECEIVED: 04/09/91

DATE REPORTED: 05/20/91

PROJECT NO.: 1317-013-4

DOUGLAS COUNTY P.U.D. - WINTHROP

Laboratory Sample Number	107529
Client Identification	DI
Dissolved Iron (ug/ml)	0.84
Dissolved Zinc (ug/ml)	0.143

AMTEST

CLIENT: GeoEngineers, Inc.

REPORT TO: Terry Fisk

DATE RECEIVED: 04/09/91
DATE REPORTED: 05/20/91
PROJECT NO.: 1317-013-4

DOUGLAS COUNTY P.U.D. - WINTHROP

Laboratory Sample Number	107530
Client Identification	PW2
Dissolved Iron (ug/ml)	0.33
Dissolved Zinc (ug/ml)	0.091
Dissolved Aluminum (ug/ml)	0.12
Dissolved Arsenic (ug/ml)	<0.03
Dissolved Cadmium (ug/ml)	<0.002
Dissolved Chromium (ug/ml)	<0.006
Dissolved Copper (ug/ml)	<0.002
Dissolved Lead (ug/ml)	<0.02
Dissolved Magnesium (ug/ml)	3.8
Dissolved Manganese (ug/ml)	0.005
Dissolved Molybdenum (ug/ml)	<0.01
Dissolved Potassium (ug/ml)	1.5
Dissolved Silver (ug/ml)	<0.010
Dissolved Sodium (ug/ml)	7.9
Total Coliform (CFU/100 mls)	<2.5
Turbidity (NTU)	0.19
Hardness (mg/L as $CaCO_3$)	77.
Alkalinity (mg/L as $CaCO_3$)	69.
Total Dissolved Solids (mg/L)	260.
Total Suspended Solids (mg/L)	<1.
pH	7.0
Dissolved Oxygen (mg/L)	9.4]
	10.]
Total Organic Carbon (mg/L)	14.
Total Phosphate (mg/L)	<0.010
Ortho Phosphate (mg/L)	0.006
Ammonia Nitrogen (mg/L)	0.016
Total Kjeldahl Nitrogen (mg/L)	<0.50
Nitrate + Nitrite Nitrogen (mg/L)	0.228
Nitrite Nitrogen (mg/L)	<0.010
Chloride (mg/L)	1.5
Sulfate (mg/L)	4.6
Anaerobic Plate Count (CFU/100 mls)	1.0

< = less than
] = duplicate analysis

KF/pb

REPORTED BY Kathy Fugiel

Kathy Fugiel

AMTEST

AmTest Inc.
Professional Analytical Services
14603 N.E. 87th St.
Redmond, WA
98052
Fax: 206 883 3495
Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Geo Engineers, Inc.

REPORT TO: Terry Fisk
8410 - 154th Avenue NE
Redmond, WA 98052

DATE RECEIVED: 04/11/91

DATE REPORTED: 04/30/91

PROJECT NO.: 1317-013-4

DOUGLAS COUNTY PUD - WINTHROP

Laboratory Sample No.	107764	107765
Client Identification	PW-3-A	PW-3-B
Dissolved Iron	0.15	< 0.01
Dissolved Zinc	0.077	0.044

< = less than

91-L-646

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GeoEngineers

MAY 08 1991

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File

AMTEST

AmTest Inc.

Professional Analytical Services

14603 N.E. 87th St.
Redmond, WA
98052

Fax: 206 883 3495

Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Geo Engineers, Inc.

REPORT TO: Terry Fisk
8410 - 154th Avenue NE
Redmond, WA 98052

DATE RECEIVED: 04/11/91

DATE REPORTED: 04/30/91

PROJECT NO.: 1317-013-4

DOUGLAS COUNTY PUD - WINTHROP

Laboratory Sample No.	107943
Client Identification	Domestic
Dissolved Iron	< 0.01
Dissolved Zinc	0.021

All results are expressed in (ug/mL).

< = less than

91-L-647

REPORTED BY Kathy Fugiel

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