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FINAL

REPORT OF INTERIM SITE INVESTIGATIONS NAVY FUEL FARM - WILLOW GROVE NAS

Contract N62472-91-D-1449
Project No. 15, Amendment No. 12

Prepared for:

United States Navy
Northern Division
Naval Facilities Engineering Command
Philadelphia, Pennsylvania 19142-5094

Prepared by:

EA Mid-Atlantic Regional Operations
EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, Maryland 21152

September, 1993
EA Project 12197.06

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1. INTRODUCTION

1.1 SCOPE OF WORK

Under contract number N62472-91-D-1449, project number 15, amendment 12, EA was tasked by NORTHERN DIVISION (NORTHDIV), NAVAL FACILITIES ENGINEERING (NAVFAC) to undertake the following tasks at the Navy Fuel Farm for the Naval Air Station at Willow Grove, Pennsylvania:

- Install six 4-in diameter bedrock monitoring wells at the Navy Fuel Farm. Collect soil samples for headspace analysis and descriptive purposes.

- Sample all existing and new monitoring wells at the site which were determined not to have measurable non aqueous phase product (NAPL) for the following sample parameters: TCL volatile organic compounds (VOC) and total petroleum hydrocarbon (TPH) for gasoline and jet fuel.

- Properly containerize and characterize for disposal any soil or water produced as investigation derived waste (IDW). Arrange for appropriate disposal.

- Generate a report summarizing field and analytical results and characterizing the site conditions at this time.

Drilling began at the site on 22 May 1993 after a delay due to ongoing construction at the Navy Fuel Farm. The wells were installed and developed by 26 May 1993. Sampling began on 10 June, but was not fully completed until 21 June because construction activities around Air National Guard Building 340 prevented access to several wells. Final analytical results became available on 16 July 1993. The draft report was issued to NORTHDIV on 30 July 1993.

1.2 SITE HISTORY

The Navy Fuel Farm is located along the north side of Privet Road and immediately south of the Air National Guard Facility (Figure 1-1). Figure 1-2 shows the site as it appeared prior to

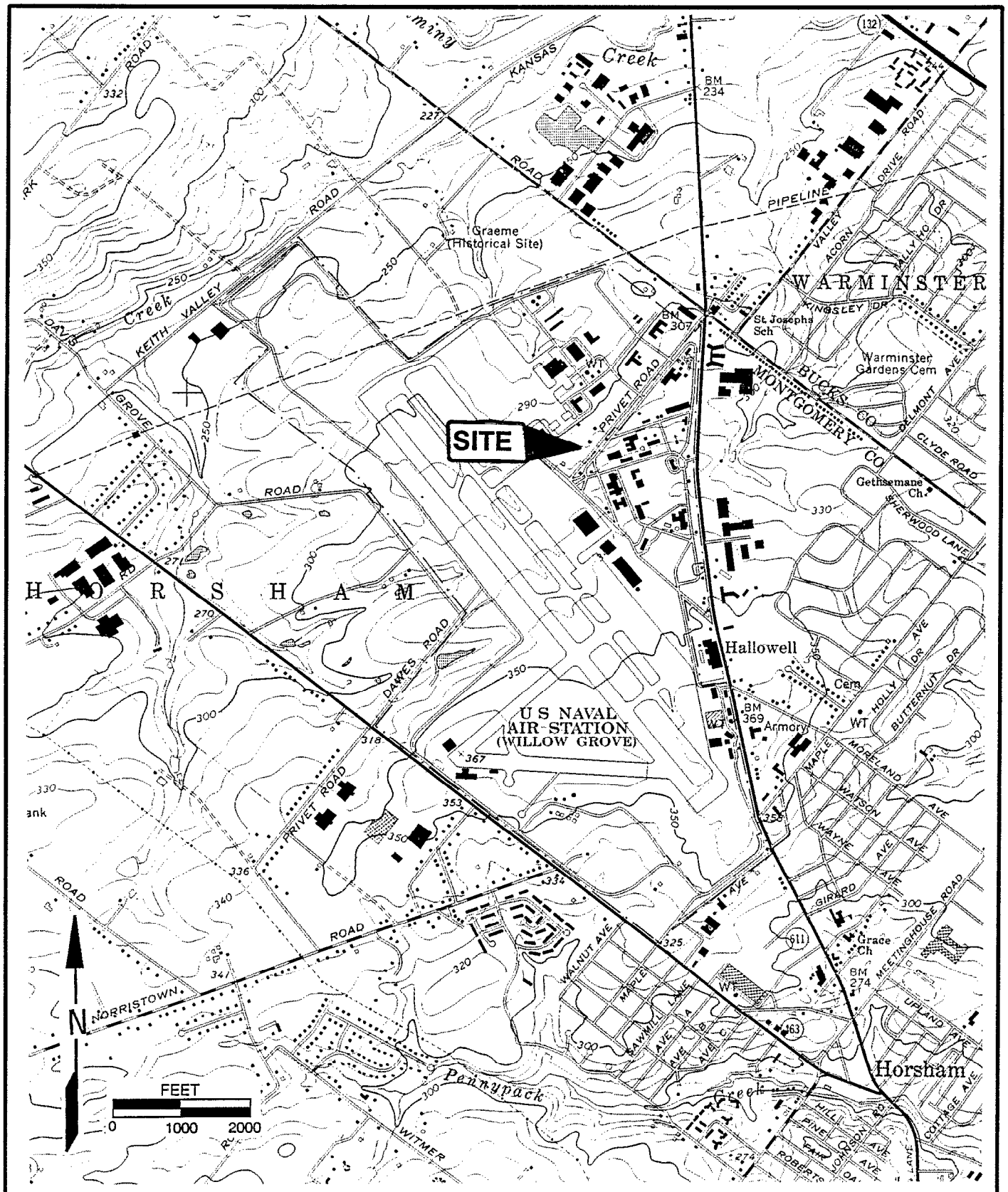


Figure 1-1. Site location map, Willow Grove NAS, Navy Fuel Farm

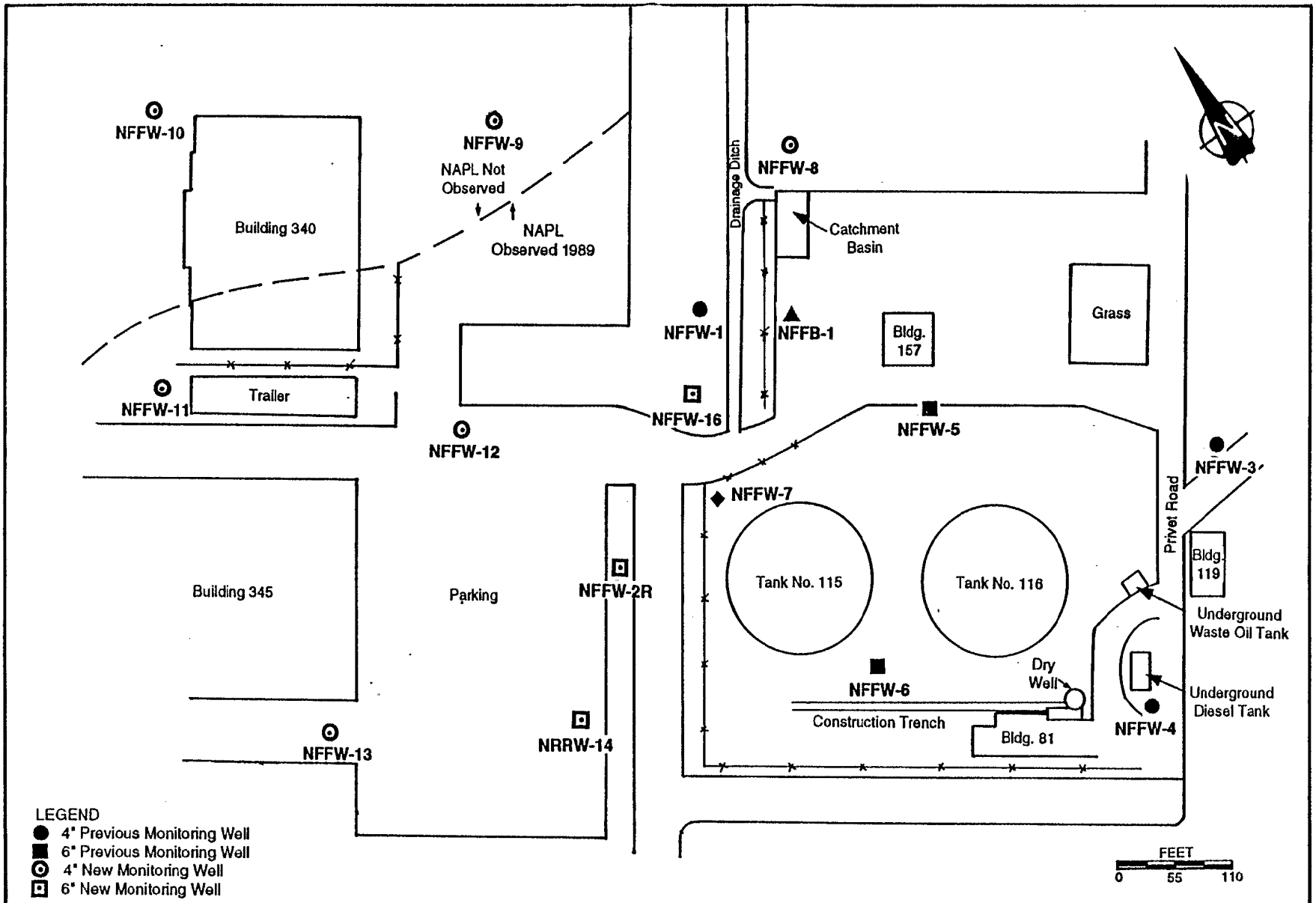


Figure 1-2. Site map prior to 1991, Willow Grove NAS, Navy Fuel Farm

1991. From 1950 to 1991, two partially buried 210,000-gal JP-4/JP-5 aviation fuel tanks were located at the site. A 500-gal underground waste oil tank and an underground diesel tank were also located at the southwestern corner of the site. Subsequent to excavation of a utility trench along the west side of the site, NAPL was observed on top of the water within the utility trench. The NAPL was immediately adjacent to a dry well into which effluent water from the bottom of the jet fuel tanks was periodically siphoned. Areas of dead grass along the west side of Tank 115 also suggested that this tank may have leaked. It was decided to empty and remove the tanks prior to replacing the facility with a new fuel farm. Tank removal began in 1991 and was completed in 1992. During this time, the underground waste oil tank in the southwest portion of the site was removed. Inspection of the tank revealed holes of up to one inch in diameter were present. New above ground fuel storage tanks were installed within a bermed enclosure due east of the site in 1992 on the previous location of Building 157. The Navy Fuel Farm facility is currently inactive. Figure 1-3 shows the site as it appears in July of 1993.

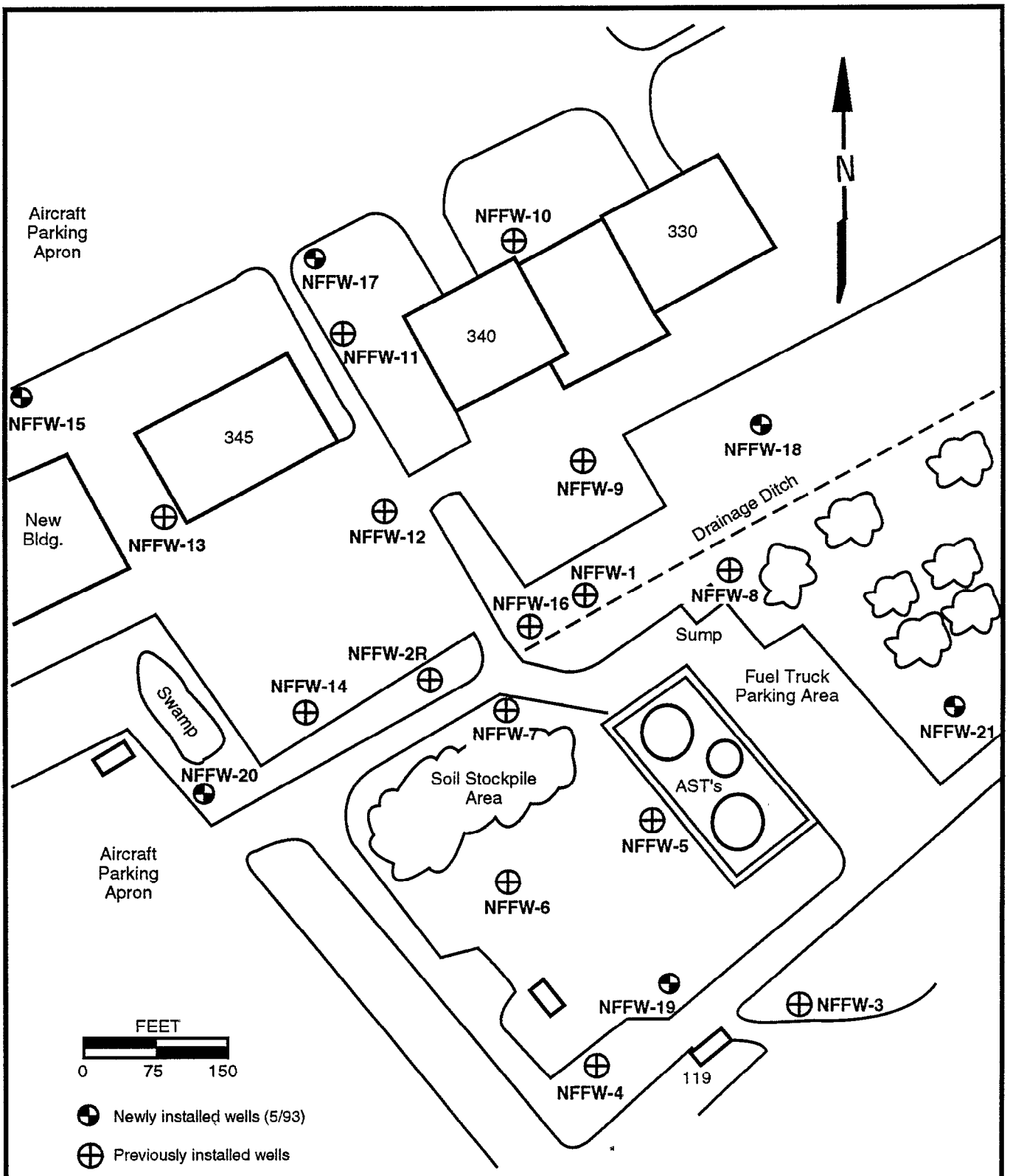


Figure 1-3. Site map - 1993,Willow Grove NAS, Navy Fuel Farm.

2. SITE ASSESSMENT

Six new ground-water monitoring wells (NFFW-15, 17, 18, 19, 20 and 21) were installed at the locations shown in Figure 2-1. The purpose of these wells was to further assess the extent of the contaminant plume detected at the Navy Fuel Farm site during previous investigations. Test borings made preparatory to well installation were continuously sampled to bedrock and the samples retained for description and VOC headspace analysis. Two weeks after the new wells were installed and developed all wells at the site were gauged and those which did not contain measurable NAPL were sampled for TCL VOC and TPH for gasoline and jet fuel.

2.1 SOIL BORINGS

Test borings were made at the selected locations with a Mobile Drill B-80 drilling rig equipped with 8.5-in O.D. hollow stem augers. Soil samples were obtained with a 24-in long 2-in O.D. hammer driven split spoon. Soil borings logs are provided in Appendix A. Depth to bedrock ranged from 6 to 21 ft with an average depth to bedrock of 11.4 ft. The soil type ranged from clayey silt to silty clay and reddish brown to light tan in color depending on the underlying bedrock of red siltstone or tan sandstone respectively.

Table 2-1 summarizes headspace readings for VOC taken for each soil interval collected. Four of the soil borings did not show any high (< 3 ppm) readings. The headspace data from boring NFFW-17 suggests that soil contamination at 6-8 ft is from a product smear zone associated with water table fluctuations since this depth interval brackets the water table at this location and readings from 0 to 6 ft depths were relatively lower. Conversely, the data from NFFW-20 suggests a possible surface spill remnant since the highest readings are near the surface and they taper off rapidly with depth. A swampy area is located adjacent to the boring which may have served to retard the migration of spills and allow them to infiltrate the ground surface at this location. This boring is located immediately adjacent to the west parking apron.

2.2 MONITORING WELL INSTALLATION

After the overburden soil was sampled the boring was advanced into bedrock using an 8-in O.D. air hammer until a depth of 10 ft below the water table. The borehole was reamed out and a

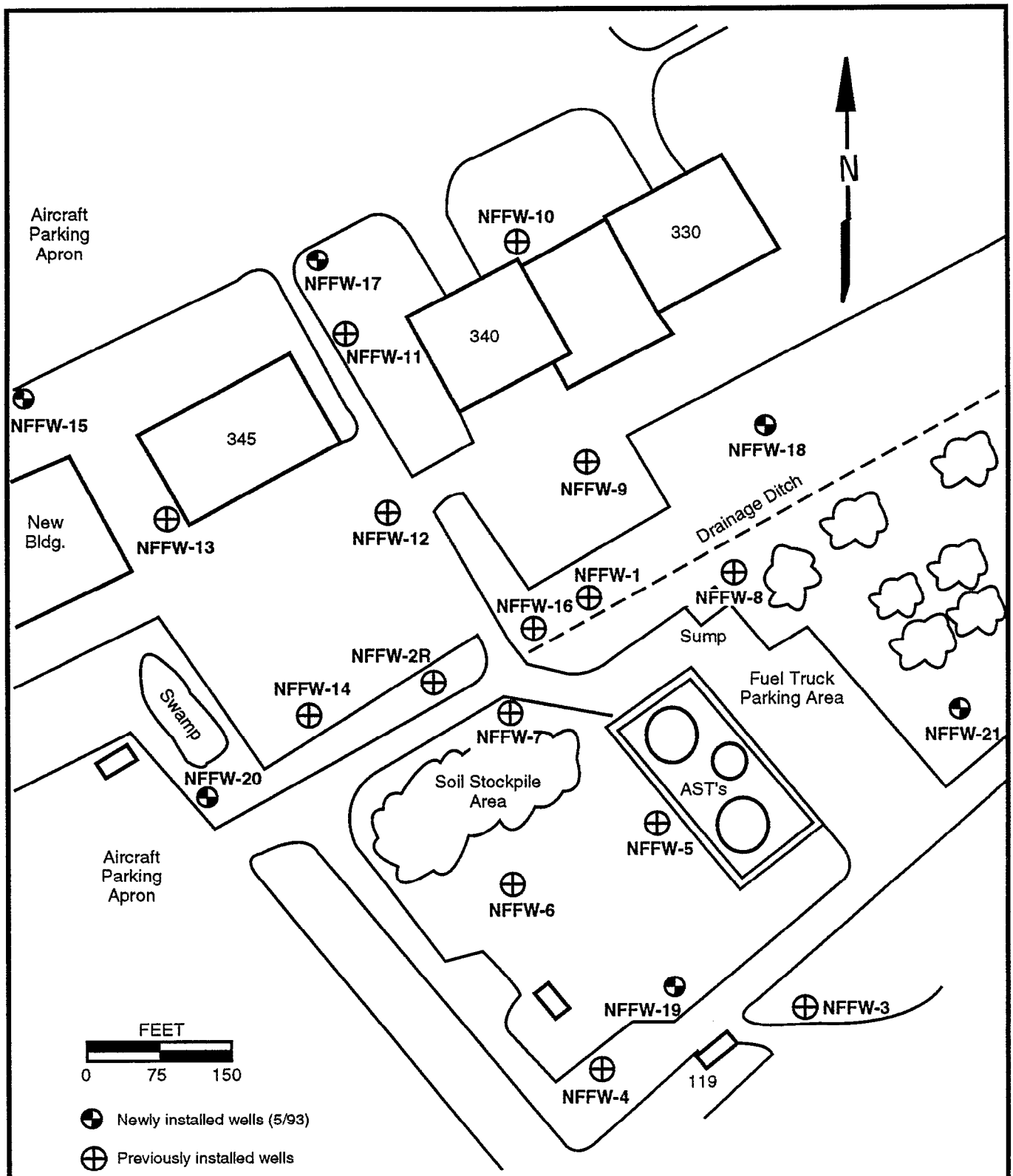


Figure 2-1. Monitoring well locations, Willow Grove NAS, Navy Fuel Farm.

TABLE 2-1: VOC HEADSPACE READINGS (ppm) FOR SOIL SAMPLES FROM MONITORING WELL BORINGS AT WILLOW GROVE NAS - MAY, 1993

Depth (ft)	NFFW-15 May-93	NFFW-17 May-93	NFFW-18 May-93	NFFW-19 May-93	NFFW-20 May-93	NFFW-21 May-93
0-2	1	-	0	5	140	0
2-4	1	20	0	0	550	2
4-6	1	50	0	0	65	2
6-8	2	700	-	0	15	0
8-10	1	5	-	-	11	0
10-12	-	-	-	-	8	0
12-14	-	-	-	-	4	0
14-16	-	-	-	-	3	0
16-18	-	-	-	-	2	-
18-20	-	-	-	-	2	-
20-22	-	-	-	-	1	-

4-in O.D. Schedule 40 PVC monitoring well with 20 ft of 0.01 slot size screen installed. The screened interval was placed to extend 10 ft above and 10 ft below the water table. Past experience at the site has shown that a wide screened interval is necessary due to large water level fluctuations at the site. Well construction diagrams for each well are presented with the associated test boring in Appendix A.

Each well was developed with a submersible pump to remove turbidity and insure adequate flow of ground water into the well. Temperature, pH, and conductivity were monitored per well volume removed from each well until three consecutive readings of each parameter agreed within 10 per cent. Well volumes removed ranged from four to six depending on turbidity, well yield, and water quality readings. Development records for each well are presented in Appendix B. Development water was filtered through an activated carbon canister and discharged to the installation storm/sanitary system.

2.3 INVESTIGATION DERIVED WASTE

Drilling cuttings generated during well installation were drummed in 55-gal drums, sealed, and labeled with a paint pen as to content and well location. Grab samples from each drum were collected before closing, composited, and submitted for analysis of the following waste disposal parameters (analytical methods in parentheses): BTEX (8020), TPH (418.1), TCLP Metals, PCBs (8080), Total Organic Halogens (TOX 9020), Corrosivity, Ignitability, and Paint Filters Liquids Test. These disposal parameters are required by Pennsylvania Department of Environmental Resources (PADER) to characterize potentially petroleum-contaminated soils.

2.4 GROUND-WATER SAMPLING

The results of well gauging on 21 June are shown in Table 2-2. NAPL was detected in eight of the 21 wells. Well NFFW-20 contained a green translucent substance after purging which was not sensed by the interface probe. Although the color suggested ethylene glycol, this could not be determined with the analyses performed. Ethylene glycol is used as a coolant in vehicles which service the planes; this compound has not been analyzed previously in any sampling performed at the site. Well NFFW-13 did not show any product thickness upon gauging, but product entered the well when it was purged for sampling which precluded sample collection.

TABLE 2-2: NAVY FUEL FARM - WILLOW GROVE NAS - MONITORING WELL GAUGING DATA

WELL #/ CASING ELEV.	GAUGE DATE	WELL DEPTH (FT)	WATER COLUMN (FT)	DEPTH TO PRODUCT (FT)	DEPTH TO WATER (FT)	PRODUCT THICKNESS (FT)	CORR. WTR. ELEVATION (FT)
NFFW-1	14-Jun-93	29.00	12.61	16.37	16.39	0.02	293.47
309.84							
NFFW-2R	21-Jun-93	37.50	16.65	20.58	20.85	0.27	292.52
313.15							
NFFW-3	14-Jun-93	28.20	7.90	-	20.30	0.00	300.94
321.24	21-Jun-93	28.20	3.93	-	24.27	0.00	296.97
NFFW-4	14-Jun-93	24.25	5.00	-	19.25	0.00	303.27
322.52	21-Jun-93	28.10	6.36	-	21.74	0.00	300.78
NFFW-5	21-Jun-93	27.75	11.98	-	15.77	0.00	299.77
315.54							
NFFW-6	14-Jun-93	28.00	5.70	21.10	22.30	1.20	296.94
318.28							
NFFW-7	14-Jun-93	28.50	10.66	17.23	17.84	0.61	295.39
312.74							
NFFW-8	14-Jun-93	30.40	14.00	-	16.40	0.00	291.67
308.07	21-Jun-93	30.40	13.73	-	16.67	0.00	291.40
NFFW-9	21-Jun-93	25.50	18.50	-	7.00	0.00	291.61
298.61							
NFFW-10	14-Jun-93	37.00	27.90	-	9.10	0.00	289.91
299.01	21-Jun-93	37.00	27.90	-	9.10	0.00	289.91
NFFW-11	14-Jun-93	24.00	15.10	-	8.90	0.00	292.59
301.49	21-Jun-93	24.00	4.80	-	19.20	0.00	282.29
NFFW-12	21-Jun-93	26.50	11.62	14.87	14.88	0.01	292.49
307.36							
NFFW-13	14-Jun-93	30.00	15.90	-	14.10	0.00	291.00
305.1							
NFFW-14	14-Jun-93	37.50	20.22	16.90	17.28	0.38	294.18
311.16							

TABLE 2-2: NAVY FUEL FARM - WILLOW GROVE NAS - MONITORING WELL GAUGING DATA

WELL #/ CASING ELEV.	GAUGE DATE	WELL DEPTH (FT)	WATER COLUMN (FT)	DEPTH TO PRODUCT (FT)	DEPTH TO WATER (FT)	PRODUCT THICKNESS (FT)	CORR. WTR. ELEVATION (FT)
NFFW-15	26-May-93	34.90	21.26	-	13.64	0.00	293.23
306.87	10-Jun-93	34.90	19.20	-	15.70	0.00	291.17
	21-Jun-93	34.90	27.41	-	7.49	0.00	299.38
NFFW-16	20-May-93	39.00	24.87	14.01	14.13	0.12	296.91
310.94	10-Jun-93	39.00	22.42	16.38	16.58	0.20	294.52
NFFW-17	26-May-93	22.60	17.12	-	5.48	0.00	294.04
299.52	10-Jun-93	22.60	14.75	-	7.85	0.00	291.67
	21-Jun-93	22.60	13.75	-	8.85	0.00	290.67
NFFW-18	26-May-93	28.80	14.58	-	14.22	0.00	292.72
306.94	10-Jun-93	28.80	13.64	-	15.16	0.00	291.78
	21-Jun-93	28.80	13.07	-	15.73	0.00	291.21
NFFW-19	20-May-93	34.90	17.69	-	17.21	0.00	304.23
321.44	26-May-93	34.90	17.68	-	17.22	0.00	304.22
	10-Jun-93	34.90	14.80	-	20.10	0.00	301.34
	21-Jun-93	34.90	12.55	20.35	22.35	2.00	300.69
NFFW-20	20-May-93	36.95	9.53	-	27.42	0.00	297.13
324.55	26-May-93	36.95	9.43	-	27.52	0.00	297.03
	10-Jun-93	36.95	6.70	-	30.25	0.00	294.30
	21-Jun-93	36.95	5.11	-	31.84	0.00	292.71
NFFW-21	20-May-93	36.70	16.46	-	20.24	0.00	294.23
314.47	26-May-93	36.70	16.41	-	20.29	0.00	294.18
	10-Jun-93	36.70	12.59	-	24.11	0.00	290.36
	21-Jun-93	36.70	10.10	-	26.60	0.00	287.87

- = NOT PRESENT

NAPL continues to be present as in the past on the water table immediately northwest of the main fuel tank area at levels between 0.1-2 ft. Comparison with previous gauging results suggests that NAPL migration continues to be primarily along a series of parallel west-northwest trending fractures. These primary fractures are connected by intersecting secondary fractures which trend northeast-southwest. This fracture orientation was detected during the aquifer testing done in 1991. The alignment of wells NFFW-6, 14, 13, 15 and NFFW-16, 12, 11, 17 approximate the primary fracture alignment.

Figure 2-2 shows the ground-water contours derived from the water level data. Flow direction is towards the north-northwest which is consistent with previous investigations. At the time of this sampling, water levels were generally lower than in past sampling events.

2.4 ANALYTICAL RESULTS

2.4.1 Ground Water

The analytical results of the ground-water sampling are summarized in Table 2-3. Acetone was detected in the method and trip blanks at similar concentrations to the field samples which is indicative of laboratory-analysis artifact.

Of the newly installed wells, sample results indicate that wells NFFW-15 and NFFW-21 are beyond the leading edge of the aqueous VOC plume. Wells NFFW-17 and NFFW-18 show only traces of TCL VOC and comparatively low TPH values suggesting that they lie on the very edge of the migrating plume. The sample results from NFFW-20 show somewhat higher levels of TCL VOC including a previously undetected compound, carbon disulfide at 17 ug/L. The headspace readings in the soil from this well and the close proximity to the runway suggest that the contamination observed in this well is related to surface spills from the fueling of aircraft. The sample showing the highest levels of VOC was NFFW-19 which was collected from the well located immediately downgradient of the removed waste oil tank . The higher proportion of the heavier BTEX compounds suggest that the waste oil tank did leak and contribute to the contaminant plume although jet fuel from Tank 116 appears to be present as well.

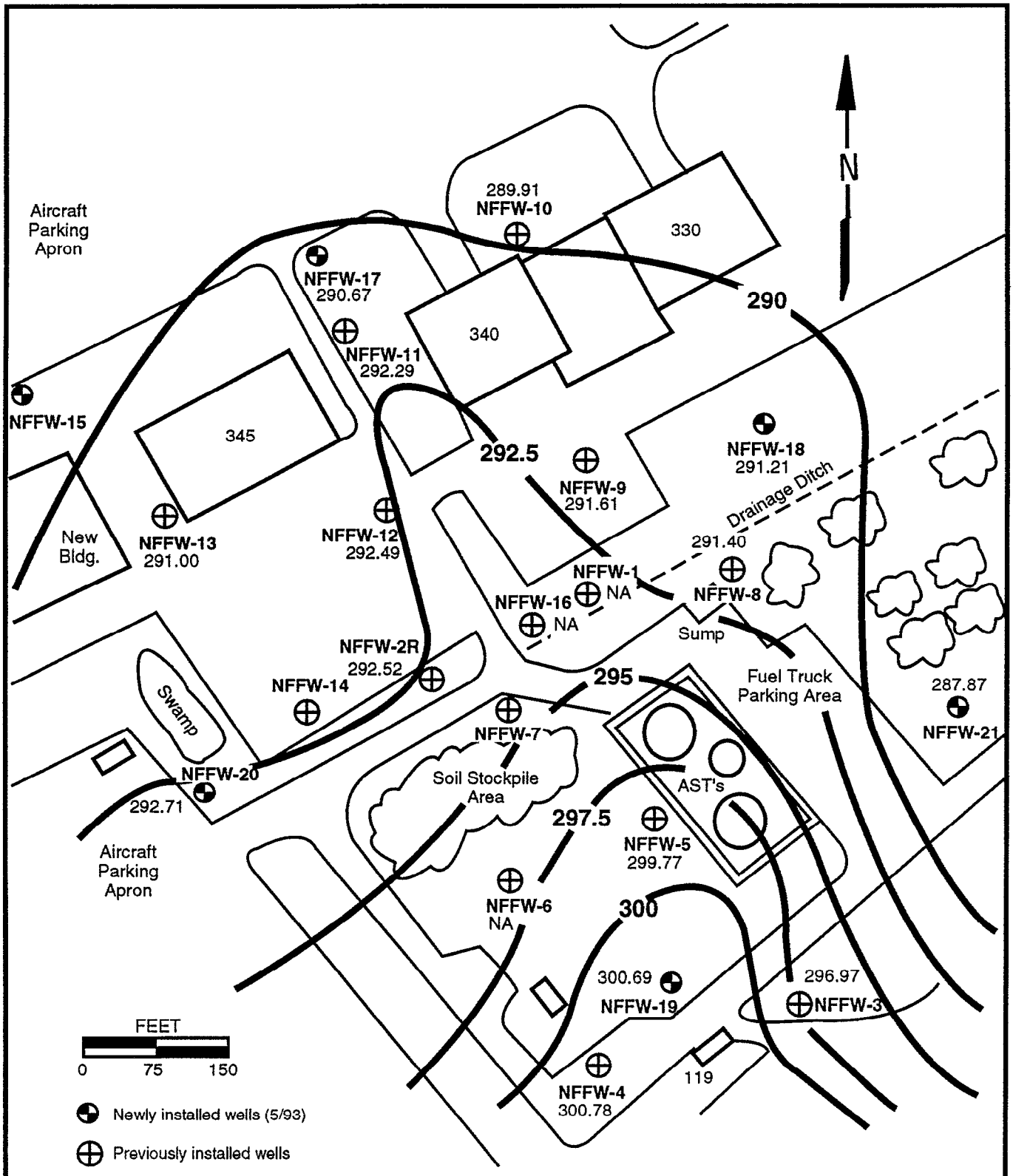


Figure 2-2. Site map Willow Grove NAS, Navy Fuel Farm area showing groundwater elevations (ft) in monitoring wells for 21 June gauging event.

TABLE 2-3: Analytical Results Ground-water Samples - Willow Grove NAS - Navy Fuel Farm

Lab ID #	NFFW-3 5842	NFFW-4 5841	NFFW-5	NFFW-5DUP	NFFW-8 5840	NFFW-9	NFFW-10 5839	NFFW-11 5843
VOLATILES (ppb)								
Acetone	-	-	-	77	59 B	-	14 B	-
Carbon Disulfide	-	-	14	12	-	-	-	-
Trichloroethene	-	-	-	-	-	-	-	-
Benzene	-	-	53	52	-	29	-	16
Toluene	-	-	-	-	-	-	-	-
Chlorobenzene	-	-	-	-	-	5 J	-	-
Ethylbenzene	-	-	23	21	30	-	-	70
Xylenes (total)	-	-	12	11	9 J	-	-	-
TPH- Gasoline	1,600	-	1600	1,700	8,800	1,300	360	8,300
TPH- JP-4	-	-	-	-	3,200	-	-	40,000

Lab ID #	NFFW-15 5698	NFFW-17 5697	NFFW-18 5696	NFFW-19 5693	NFFW-20 5694	NFFW-21 5695	Trip Blk. 5699	Trip Blk.
VOLATILES (ppb)								
Acetone	13 B	15 B	27 B	24 B	19 B	13 B	16 B	-
Carbon Disulfide	-	-	-	-	17	-	-	-
Trichloroethene	3 J	-	-	-	2 J	-	-	-
Benzene	-	6 J	2 J	67	6 J	1 J	-	-
Toluene	-	-	1 J	17 J	2 J	1 J	-	-
Chlorobenzene	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	320	-	-	-	-
Xylenes (total)	-	-	-	500	46	-	-	-
TPH- Gasoline	-	530	6800	6900	5900	-	NA	NA
TPH- JP-4	-	8,400	-	3,600,000	1,600,000	-	NA	NA

- = NOT DETECTED
NA = NOT ANALYZED

Benzene exceeded the NPDWR in six of the 13 wells tested, NFFW-5, 9, 11, 19, 17, and 20, although the latter two concentrations are estimated because they are so close to the quantitation limit. The NPDWR for benzene is 5 ug/L.

The analytical results for the existing wells are comparable to previous sampling rounds. The upgradient wells NFFW-3 and 4 show no VOC detections, although NFFW-3 did show a trace gasoline TPH detection at 1.6 mg/L. Overall what is most noticeable in comparison with previous reports is that MEK was absent during this round of sampling whereas in the past this compound was widespread in the wells sampled. This suggests that the source for this compound has been removed or environmentally degraded.

2.4.2 Waste Characterization

Table 2-4 shows the analytical results of the waste disposal characterization sample. The results show that the composite sample is not hazardous and meets all criteria for classification as Level A soil under the Pennsylvania virgin fuel contaminated soil guidelines with the exception of TPH which was greater than 10 ppm. Consequently, most of the soil was disposed of on the installation by EA personnel at a site selected by the installation environmental officer. The site was selected so as to qualify for disposal of Level B waste. One drum of soil cuttings and associated drilling sludge from NFFW-20 test boring were disposed of at the fuel-contaminated soil stockpile remaining from the tank excavations because headspace readings had shown this soil to be contaminated at a level that might qualify it to be residual waste.

Water separated from the drilling sludge after settling was decanted and filtered through an activated carbon canister and discharged to the installation storm water drainage system.

Table 2-4: Waste Characterization Analytical Results

Analyte	Units	Soil-Composite
VOC's		
Benzene	ug/kg	ND
Toluene	ug/kg	ND
Ethylbenzene	ug/kg	0.64 J
Total Xylenes	ug/kg	9.3
Total BTEX	ug/kg	10
Misc. Analytes		
TPH	mg/kg	24.0
Total Org. Halides	mg/kg	ND
PCB's/Pesticides		
Aroclor-1016	ug/kg	ND
Aroclor-1221	ug/kg	ND
Aroclor-1232	ug/kg	ND
Aroclor-1242	ug/kg	ND
Aroclor-1248	ug/kg	ND
Aroclor-1254	ug/kg	ND
Aroclor-1260	ug/kg	ND
Disposal Parameters		
Ignitable	None	non-ignitable
Paint Filter	None	negative
Percent Solids	%	83
Corrosivity	pH	9.7
Metals*		
Arsenic	mg/l	ND
Barium	mg/l	1.2
Cadmium	mg/l	ND
Chromium	mg/l	ND
Lead	mg/l	ND
Mercury	mg/l	ND
Selenium	mg/l	ND
Silver	mg/l	ND

ND = not detected

3. CONCLUSIONS

Overall, the location of the new monitoring wells has been successful in delineating the edge of the aqueous contaminant plume migrating from the Navy Fuel Farm site. With this current round of data the lateral extent of the NAPL and aqueous plume can now be tentatively mapped as shown in Figure 3-1. Several important conclusions can be made with this current round of data:

- Two additional potential source areas have been discovered during this study: spills from the runway and the removed waste oil tank in the southwest corner of the site.

- Product is continuing to migrate in a generally northwest direction away from the site source areas. The NAPL plume has not moved appreciably since 1991 except perhaps in the western edge of the site along the NFFW-14,13,15 fracture line. Product migration may now be primarily through advective/dispersive flow of the remnant plume and by continued solubilization of the NAPL phase currently present in the bedrock fractures. Additional product from fuel spills on the runway which may be also contributing which could account for the NAPL migration noted along the most western fracture line sidegradient to the Navy Fuel Farm.

- MEK was not a detected component of the contaminant plume during this round of sampling. This suggests that the source has been removed or environmentally degraded.

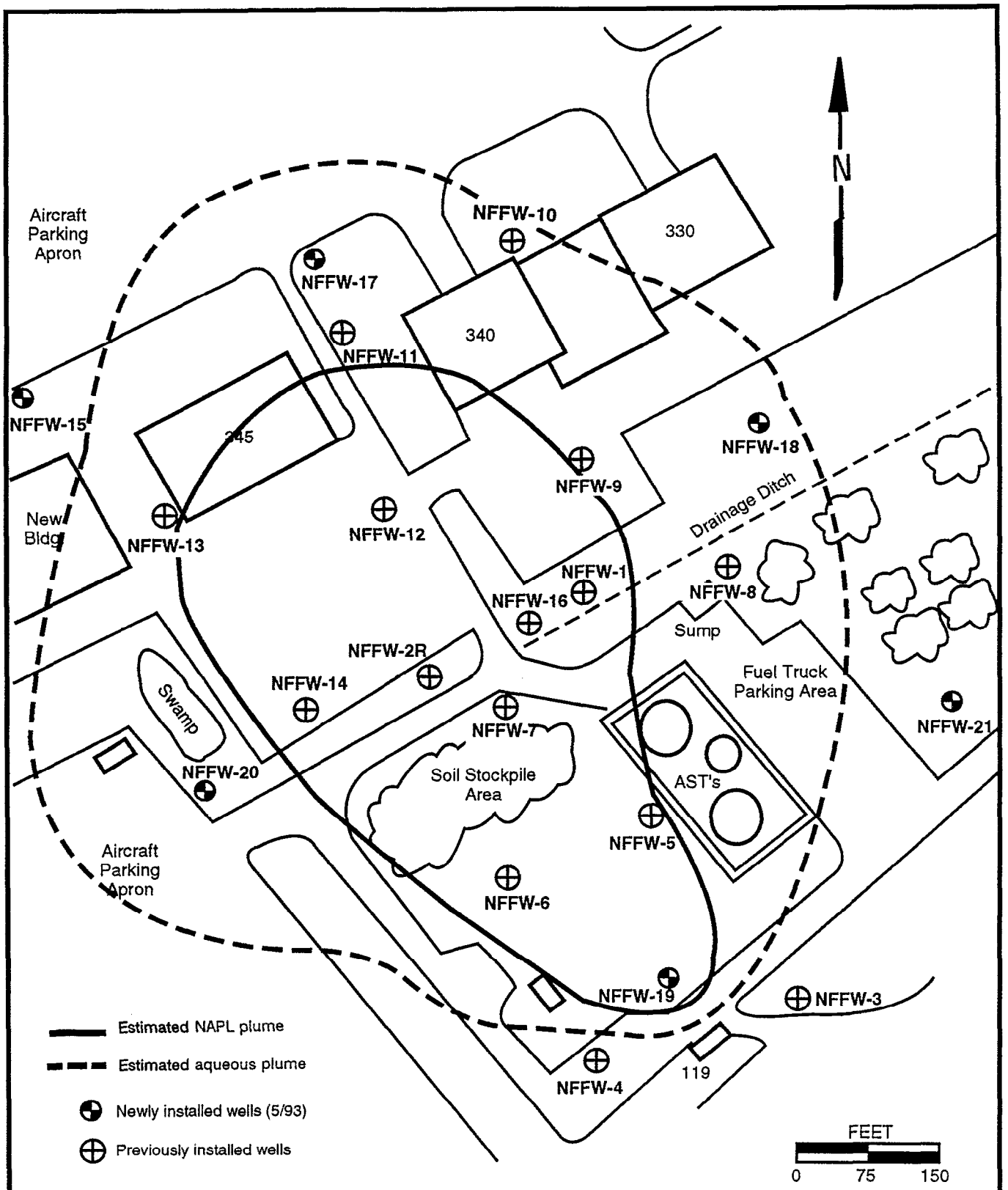


Figure 3-1. VOC plume distribution at Navy Fuel Farm,Willow Grove NAS.

APPENDIX A

SOIL BORING LOGS AND WELL COMPLETION DIAGRAMS

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-15

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet 1 of 1

					Drilling Start	Drilling Finish
Water Lev.						
Time					14:45	9:00
Date					5-19-93	5-21-93
Reference						

Surface Conditions: Grassy area west of Bldg. 345, adjacent to new building

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	HNU (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
SS	24 / 6		1 / 0	1	9, 19	0	CL	brown organics/silty clay (soil), lg. rock in spoon at 6-in - poor recovery, dry, no odor
					32, 33	1		
SS	24 / 20		2 / 2	1	39, 35	2	ML/ CL	brown-tan organic silt and clay, trace sand, dry, no odor
					35, 39	3		
SS	24 / 24		3 / 4	1	12, 23	4	ML	med.- dark brown silt, some clay, trace fine sand, trace lithic fragments, dry, no odor
					23, 21	5		
SS	24 / 12		4 / 6	2	21, 46	6	ML	reddish brown weathered siltstone with clayey layers, micaceous (silt), trace sand in some zones, dry, hard, no odor
					50/1	7		
SS	24 / 1		5 / 8	1	8, 41	8	ML	as above - spoon refusal at 9.5-ft
					50/5	9		
						10		
							SS	10-15 ft - weathered red-brown siltstone/sandstone
							SS	15-21 ft - as above, but harder (less weathered)
							SS	21-32.5 ft - tan-brown silty sandstone - very hard/wet

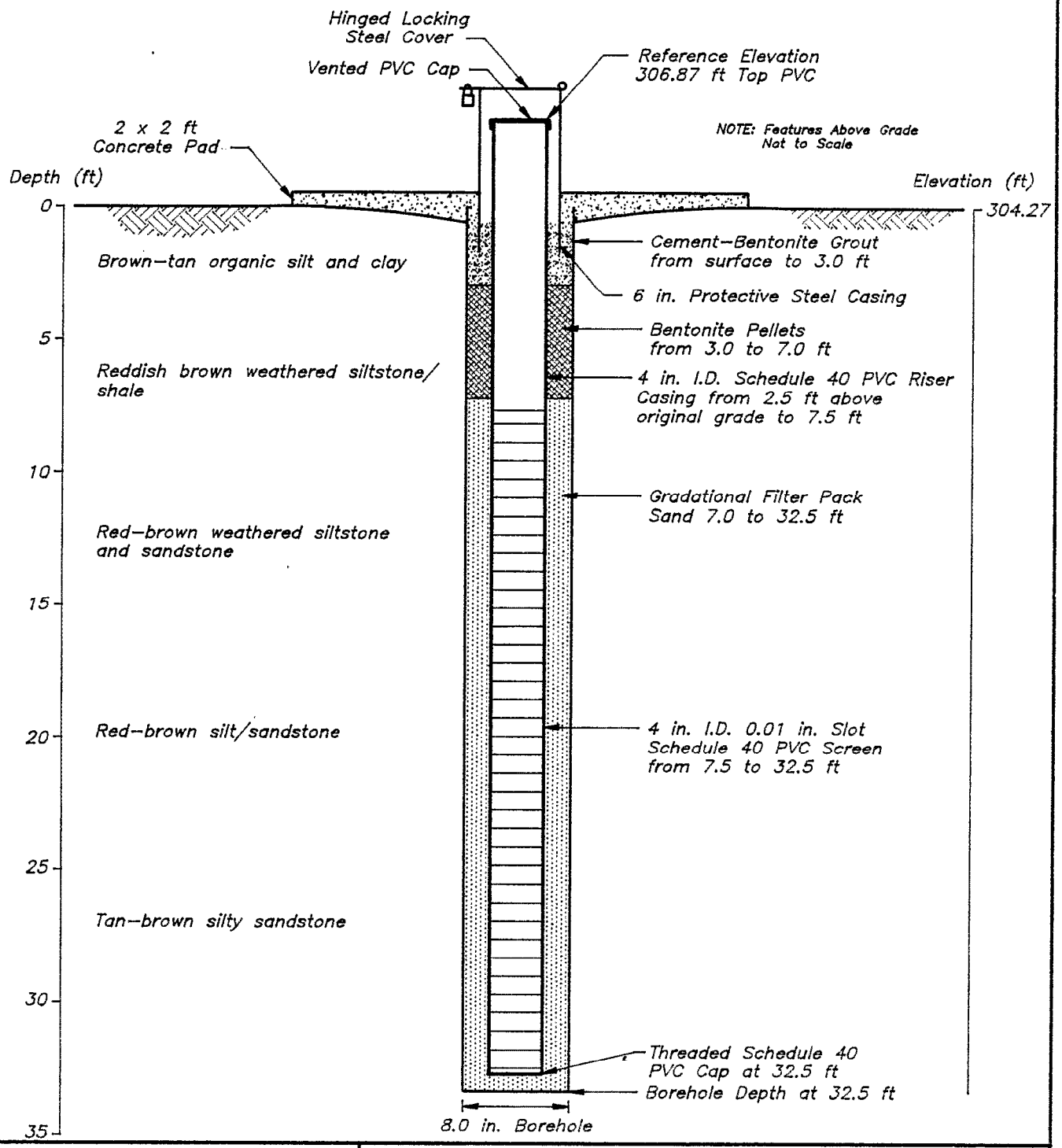
Logged by: Bradley C. Blase Date: 19 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	32.5 - 7.5 ft	Sandpack:	32.5 - 7.0 ft	Grout:	3.0 - 0.0 ft
BOH:	32.5-ft	Riser Interval:	7.5 - (+2.5) ft	Bentonite:	7.0 - 3.0 ft	Cover:	Steel stickup

WELL NO: NFFW-15
WELL COMPLETION DIAGRAM



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	Client: U.S. Navy	Location: Willow Grove NAS
	Job No. 12197.06	Coordinates X: 2,726,322.15 Y: 328,852.40

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-17

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet 1 of 1

					Drilling Start	Drilling Finish
Water Lev.	6.85 ft					
Time	17:45				13:15	17:30
Date	5-20-93				5-19-93	5-20-93
Reference	surface					

Surface Conditions: Asphalt next to airfield/apron, NW of Bldg. 340

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	PID (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
--	- -		- 0	-		0		
						1		
SS	24 24		1 2	20	6 16	2	CL	12" mixed brown clay/silt/fill 4" red silty clay w/ lithic fragments, dry
					16 33	3	ML	8" grayish brown silt, little clay, dry, no odor
SS	24 6		2 4	50	17 24	4	CL	poor sample - rock in spoon mixed red clay/silt, and gray clayey silt, trace sand, dry
					27 34	5		
SS	24 12		3 6	700	18 33	6	CL	greenish gray-brown-reddish brown silty clay, relic tecture near bottom dry, moderate petroleum odor
					35 48	7		
SS	24 20		4 8	5	5 17	8	ML	4" gray-yellow motlled silty clay 16" reddish brown clayey silt w/ lithic fragments, dry, no odor
					25 50/1	9		
SS	.5 --		5 10	-	50/0.5	10	----	spoon refusal atfer 1/2" - at 10-ft
							SH	10 - 16 ft - brittle/soft reddish brown siltstone/shale
							SS	16 - 24 ft - hard brown siltstone/sandstone
								- water with heavy sheen was coming from borehole - use mud-tub to contain water and cuttings - pumped water into nine 55-gal drums to be treated later

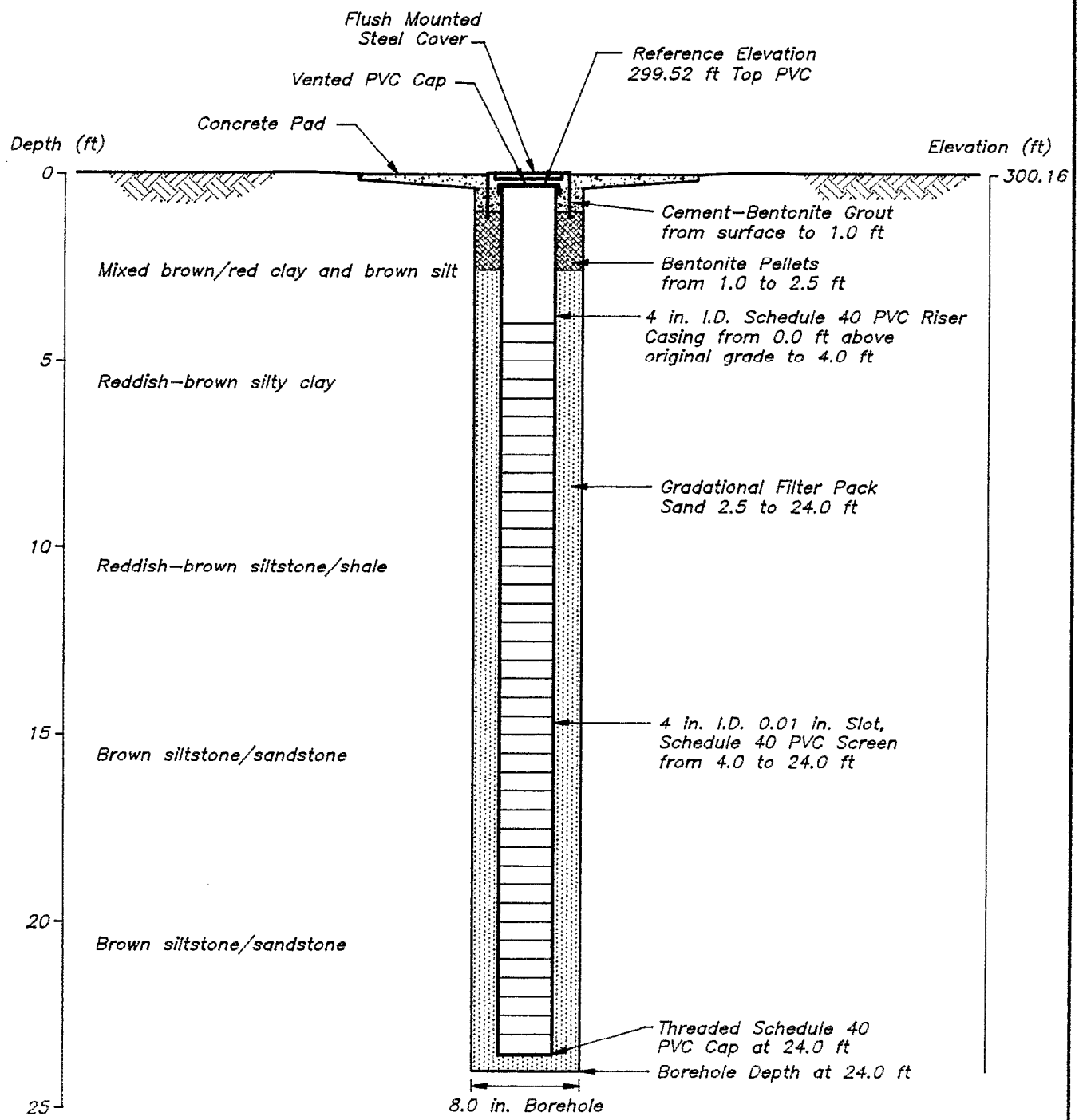
Logged by: Bradley C. Blase Date: 19 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	24 - 4 ft	Sandpack:	24 - 2.5 ft	Grout:	1.0 - 0.0 ft
BOH:	24-ft	Riser Interval:	4 - 0 ft	Bentonite:	2.5 - 1.0 ft	Cover:	steel flushmount

WELL NO: NFFW-17
WELL COMPLETION DIAGRAM



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

Client: U.S. Navy

Job No. 12197.06

Location: Willow Grove NAS

Coordinates X: 2,726,563.66
Y: 329,059.93

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-18

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet of

					Drilling Start	Drilling Finish
Water Lev.	11.20 ft				11:20	14:00
Time	13:30				5-21-93	5-21-93
Date	5-21-93					
Reference	surface					

Surface Conditions: Grass underlain by coarse gray gravel, SE of Bldg. 330

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	PID (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
SS	24 / 18		1 / 0	0	5 / 14	0	CL	4" mixed soil/organics/gravel 14" tan-brown silty clay, some sand, dry, med. hard, no odor
					10 / 10	1		
SS	24 / 12		2 / 2	0	12 / 20	2	CL	6" tan-gray silty clay, trace organics 6" orange mottled sandy clay, some silt, dry, looks disturbed, fine gravel near bottom (lithic frags), no odor
					30 / 30	3		
SS	13 / 12		3 / 4	0	17 / 40	4	SM	6" as above 6" orangish brown silty sand, semi-consolidated, dry, no odor
					50/1	5		
						6		auger refusal at 6-ft
							SS	6 - 16 ft - brown-tan sandstone/siltstone (hit water at 15-ft)
							SH	16 - 20 ft - red-brown siltstone/shale
							SS	20 - 24 - grayish sandstone/siltstone (hard), lg. fracture at 22.5-ft
							SS	24 - 25.5 ft - tan sandstone, fracture at 24.5-ft

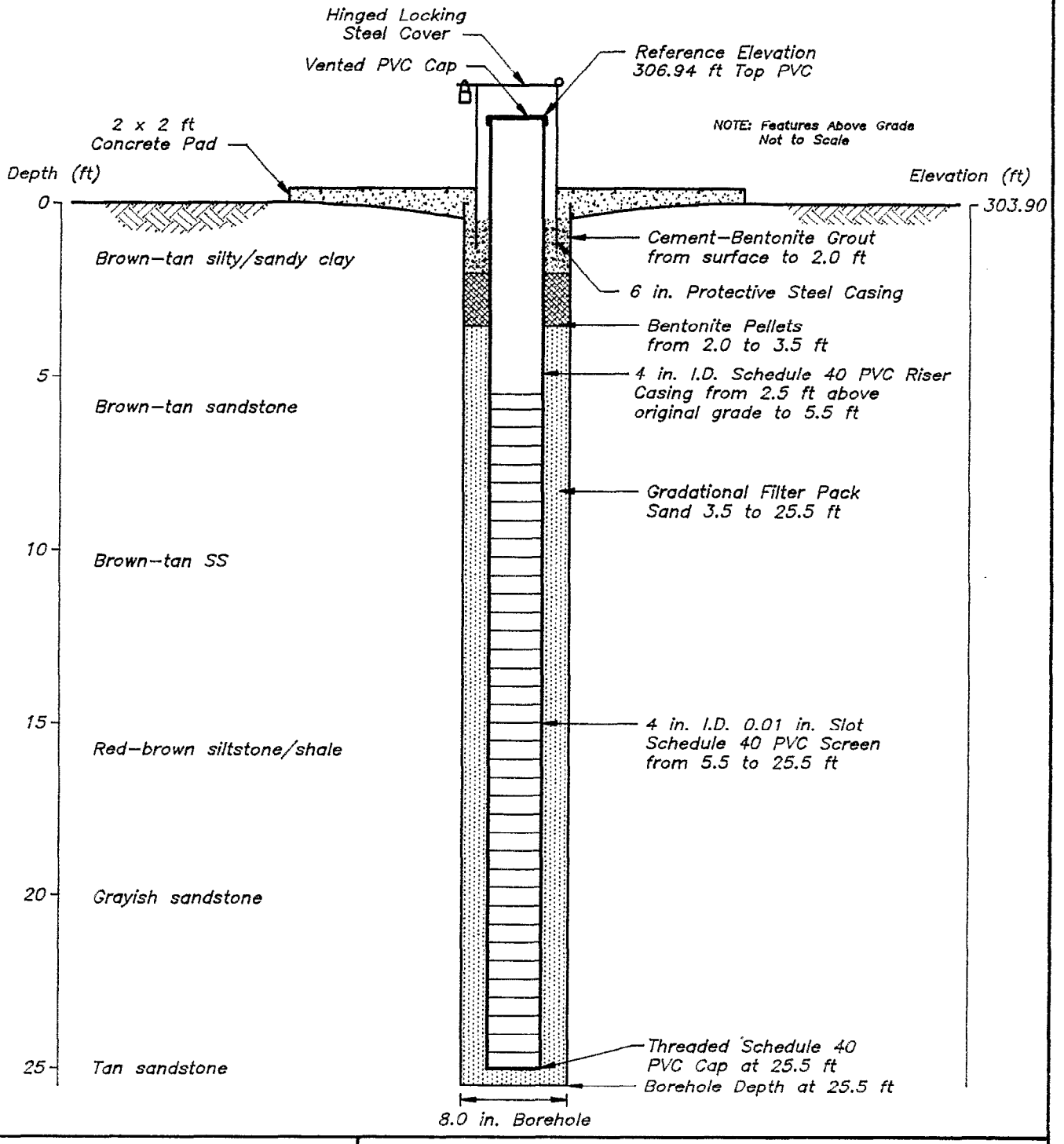
Logged by: Bradley C. Blase Date: 21 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	25.5 - 5.5 ft	Sandpack:	25.5 - 3.5 ft	Grout:	2.0 - 0.0 ft
BOH:	25.5 ft	Riser Interval:	5.5 - (+2.5) ft	Bentonite:	3.5 - 2.0 ft	Cover:	steel stickup

WELL NO: NFFW-18
WELL COMPLETION DIAGRAM



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

Client: U.S. Navy

Location: Willow Grove NAS

Job No. 12197.06

Coordinates X: 2,727,098.29
Y: 328,987.35

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-19

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet 1 of 1

					Drilling	
Water Lev.	25.5 ft	17.21 ft			Start	Finish
Time	8:20	17:45			8:30	9:00
Date	5-20-93	5-20-93			5-19-93	5-20-93
Reference	surface	TOC				

Surface Conditions: Dirt/clay/fill, 75-ft NW of Bldg. 119

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	PID (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
SS	24		1	5	15	0	CL	mixed lt-dk brown clay, tan sand and silt, trace gravel - poor sample
	6		0		40			dry, no odor
					48	1		
					25			
SS	24		2	0	24	2	CL	brown organic silty clay, trace sand and gravel, sl. moist, hard/dense
	20		2		21			no odor
					18	3		
					21			
SS	24		3	0	9	4	CL	20" reddish brown silt/clay, med. hard, dry
	24		4		38			4" tan silty fine sand/weathered sandstone/siltstone, very hard, dry
					50/1	5		
SS	24		4	0	49	6	(SS)	tan-brown weathered sandy siltstone
	6		6		50/2		-----	refusal at 6.5-ft
							SS	6.5 - 25 ft - tan sandstone, hard, dry
								HNU = 5-10 ppm in breathing zone
								HNU = 20 ppm near borehole
							SS	25 - 30 ft - brown-tan sandy cuttings - appears to be slightly moist
								HNU = 1-5 ppm in breathing zone
								HNU = 10 ppm near borehole
							SS	30 - 31 ft - purplish-dk. red siltstone, very hard
								fracture at 31-ft - good water

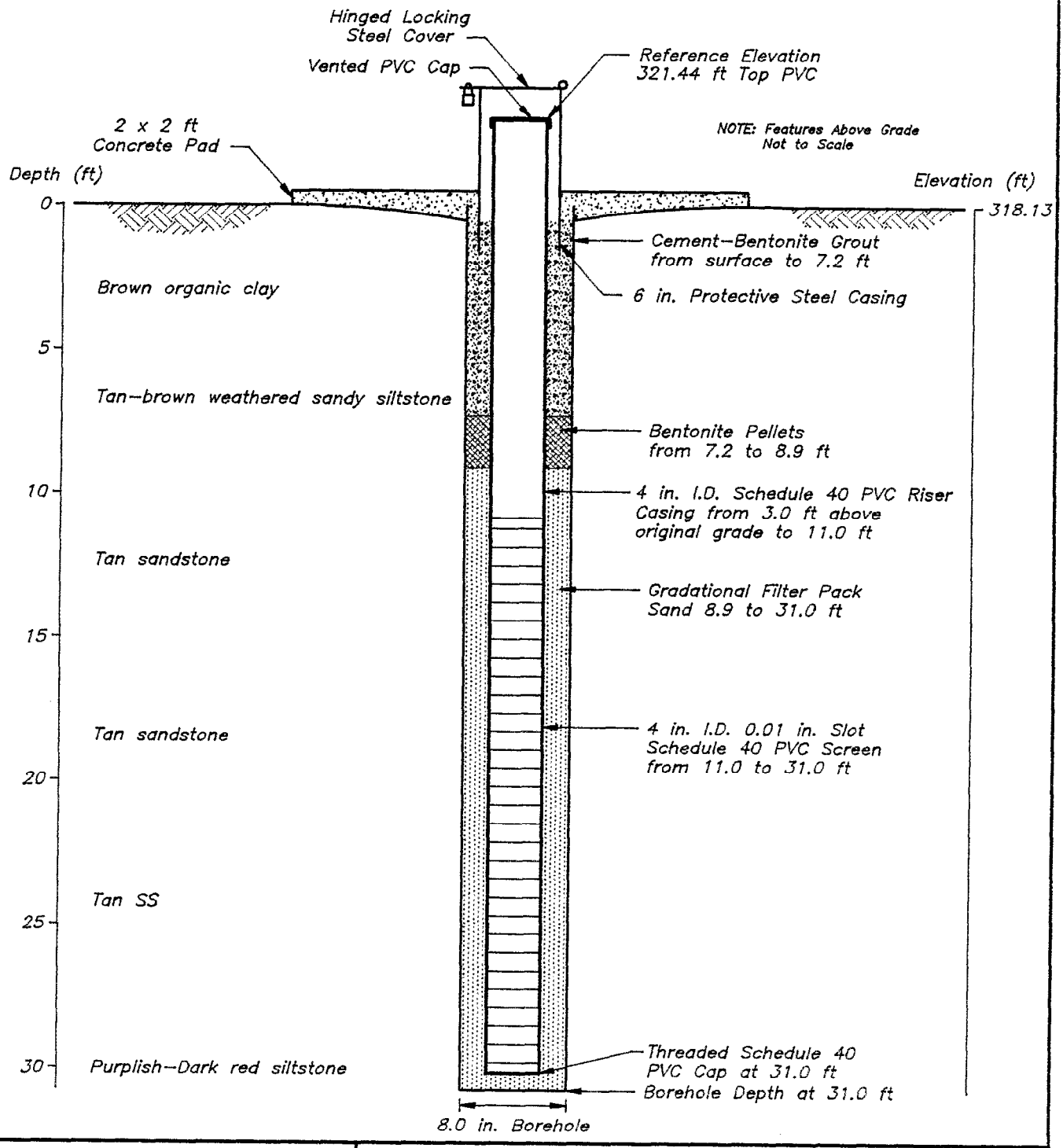
Logged by: Bradley C. Blase Date: 21 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	31 - 11 ft	Sandpack:	31 - 8.9 ft	Grout:	7.2 - 0.0 ft
BOH:	31-ft	Riser Interval:	11 - (+3)	Bentonite:	8.9 - 7.2 ft	Cover:	steel stickup

WELL NO: NFFW-19
WELL COMPLETION DIAGRAM



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	Client: U.S. Navy	Location: Willow Grove NAS
	Job No. 12197.06	Coordinates X: 2,727,110.24 Y: 328,413.81

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-20

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet 1 of 2

					Drilling Start	Drilling Finish
Water Lev.	27.42 ft					
Time	17:45				10:00	12:00
Date	5-20-93				5-19-93	5-20-93
Reference	TOC					

Surface Conditions: Grass, west of tankfield, at corner of airfield and access road for fual farm

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	PID (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
SS	24		1	140	15	0		mixed tan-beige clay/silt/organics, dry
	12		0		28		FILL	black sand/gravel, some clay, mod. product odor
					30	1		
					37			
SS	24		2	550	26	2	FILL	6" tan-beige silty sand, dry, strong product odor
	20		2		30			14" reddish brown clay, some silt, hard
					13	3		HNU > 200 ppm in borehole, < 5 ppm in breathing zone
					13			
SS	24		3	65	6	4	FILL	18" red-brown-tan mixed clay/silt, some sand, slight prod. odor in sandy zones, dry
	18		4		8			
					12	5		
					12			
SS	24		4	15	14	6	CL	12" brown-tan mottled organic clay, some silt, sl. moist, soft
	20		6		23			6" brown organic silt/clay (soil), sl. moist
					21	7		2" reddish-brown silty clay, trace lithic fragments, moist
					13			
SS	24		5	11	5	8	CL	6" brown-reddish organic silty clay, moist, no odor
	20		8		18			14" reddish brown silty clay, relic texture, moist
					12	9		
					25			
SS	24		6	8	25	10	CL	22" dark red silty clay, slight relic texture (weathered shale/siltstone)
	22		10		33			
					39	11		
					50/2			
SS	24		7	4	6	12	CL	22" as above
	22		12		12			
					13	13		
					23			
SS	24		8	3	27	14	CL	12" brown-reddish clayey silt, micaceous, med. hard, dry
	24		14		24			12" reddish brown silty clay, mottled with white clay near bottom, dry
					21	15		
					27			
SS	24		9	2	5	16	CL	24" as above
	24		16		15			
					23	17		
					25			
SS	24		10	2	39	18	CL	10" reddish-brown silty clay, very hard (weathered siltstone), dry
	10		18		50/4			
					-	19		
					-			

Logged by: Bradley C. Blase Date: 19 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	34 - 14 ft	Sandpack:	34 - 11 ft	Grout:	9.5 - 0.0 ft
BOH:	34-ft	Riser Interval:	14 - (+3) ft	Bentonite:	11 - 9.5 ft	Cover:	steel stickup

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-20

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet 2 of 2

					Drilling Start	Drilling Finish
Water Lev.	27.42 ft					
Time	17:45				10:00	12:00
Date	5-20-93				5-19-93	5-20-93
Reference	TOC					

Surface Conditions: Grass, west of tankfield, at corner of airfield and access road for fual farm

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	PID (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
SS	24 / 10		11 / 20	1	39 / 50/4	20	CL	reddish-brown silty clay, relic texture, very hard, (weathered siltstone)
						21	-----	spoon refusal at 21-ft
						22		
						23	SH	21 - 26 ft - dark red siltstone/shale
						24	SS	26 - 34 ft - brown silty sandstone, very hard, heavy vapors at 29-ft
						25		
						26		Notes:
						27		@ 29-30 ft - HNU = 50 ppm in breathing zone, HNU = 200 ppm near borehole don respirators at 10:30
						28		
						29		@ 33 ft - HNU = 5-20 ppm in breathing zone, 50-100 ppm near borehole
						30		@ 34 ft - finish borehole, doff respirators at 11:10
						31		
						32		
						33		
						34		
						35		
						36		
						37		
						38		
						39		
						40		

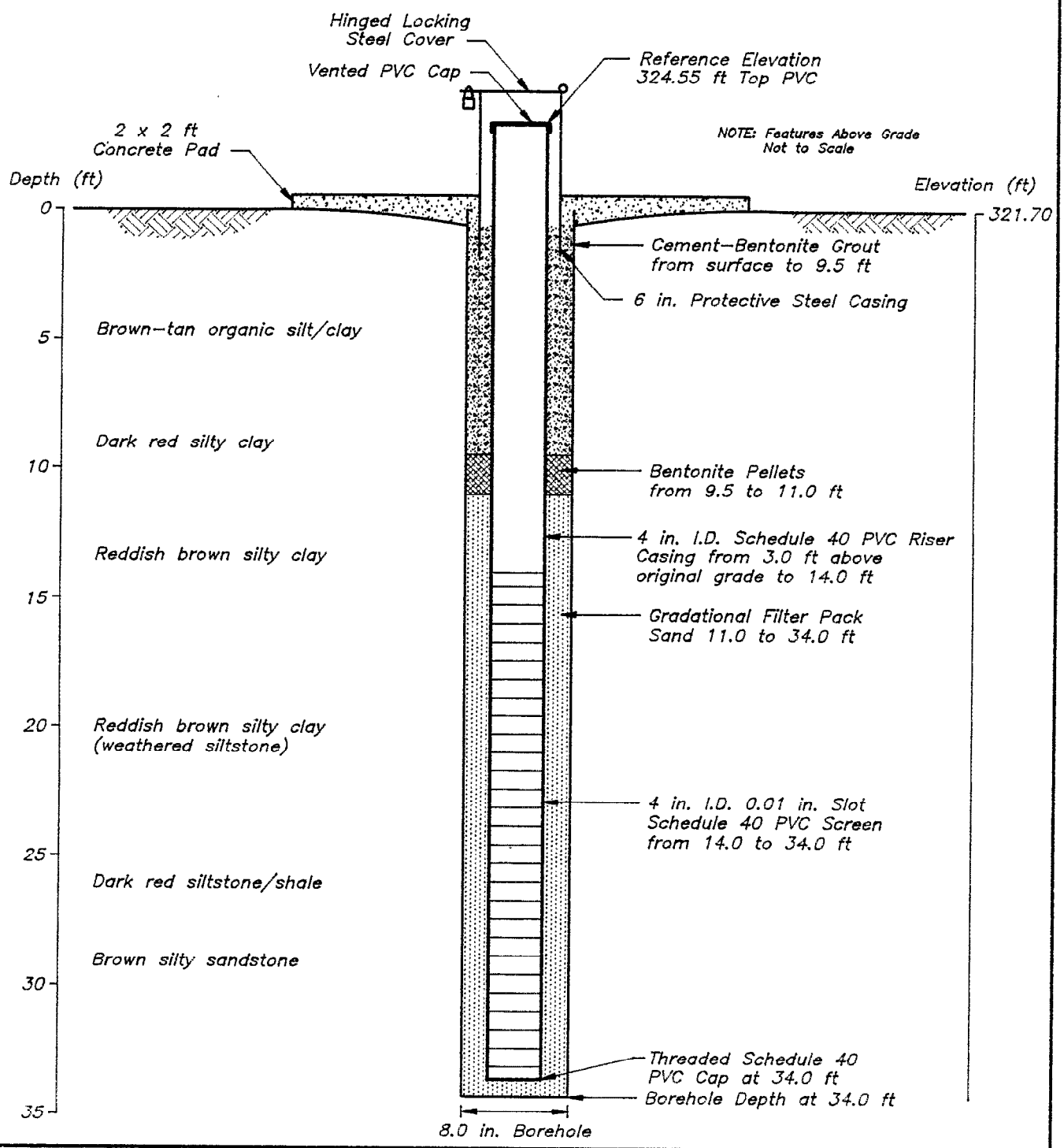
Logged by: Bradley C. Blase Date: 19 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	34 - 14 ft	Sandpack:	34 - 11 ft	Grout:	9.5 - 0.0 ft
BOH:	34-ft	Riser Interval:	14 - (+3) ft	Bentonite:	11 - 9.5 ft	Cover:	steel stickup

WELL NO: NFFW-20
WELL COMPLETION DIAGRAM



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

Client: U.S. Navy

Location: Willow Grove NAS

Job No. 12197.06

Coordinates X: 2,726,579.81
Y: 328,509.71

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

Job. No.	Client	Location
12197.06	U.S. Navy, Willow Grove NAS	W. Grove, PA

Drilling Method: Mobile B-80 - 4.25" HSA to refusal, followed by 8-in air hammer to TD

Boring No. NFFW-21

Sampling Method: HSA - 2" x 24" split spoon driven by 140# hammer. Air rotary - grab samples from cuttings

Sheet 1 of 1

					Drilling Start	Drilling Finish
Water Lev.	20.03					
Time	10:00				11:00	14:40
Date	5-19-93				5-18-93	5-18-93
Reference	TOC					

Surface Conditions: Grass, gravel, fill - 150 ft east of fuel farm

Sample Type	Inches Drvn/In. Recvrd	Dpth Csg.	Samp. /samp. depth	PID (ppm)	Blows per 6 in.	Depth in Feet	USCS Log	
SS	24 / 18		1 / 0	0	8 / 14	0	FILL	mixed brown organic silt/clay, trace sand/gravel/brick, dry, no odor
					14 / 18	1		
SS	24 / 18		2 / 2	2	30 / 25	2	FILL	mixed gray-black-brown silt/sand/organics, some gravel, sl. moist, no odor
					15 / 24	3		
SS	24 / 24		3 / 4	2	10 / 9	4	CL	6" as above 18" light brown clayey silt, trace fine sand, dry, no odor
					10 / 18	5		
SS	24 / 24		4 / 6	0	18 / 18	6	SM	light-med. brown-orange mottled sandy silt, more sand near bottom, trace clay, slightly moist, no odor
					15 / 18	7		
SS	24 / 20		5 / 8	0	9 / 19	8	SM	light brown-tan sandy silt, trace clay, dry, no odor
					24 / 20	9		
SS	24 / 12		6 / 10	0	9 / 17	10	CL	6" brown sandy silt/beige silty clay, dry 6" orange-brown clayey silt, trace sand, dry, no odor
					15 / 13	11		
SS	24 / 24		7 / 12	0	5 / 11	12	CL	8" as above 16" dark purple-reddish silty clay (weathered shale), hard, moist
					13 / 16	13		
SS	24 / 16		8 / 14	0	27 / 30	14	SH	maroon-dark red mudstone/siltstone (weathered), moist, hard
					50/5	15	-----	spoon refusal at 15.4 ft
							SH	15.4 - 20 ft - fractured/weathered maroon/red mud/siltstone (shale)
							SH	20 - 29 ft - hard red mudstone/siltstone (shale)
							SS	29 - 34 ft - gray-tan sandstone,, trace conglomerate, micaceous, hard

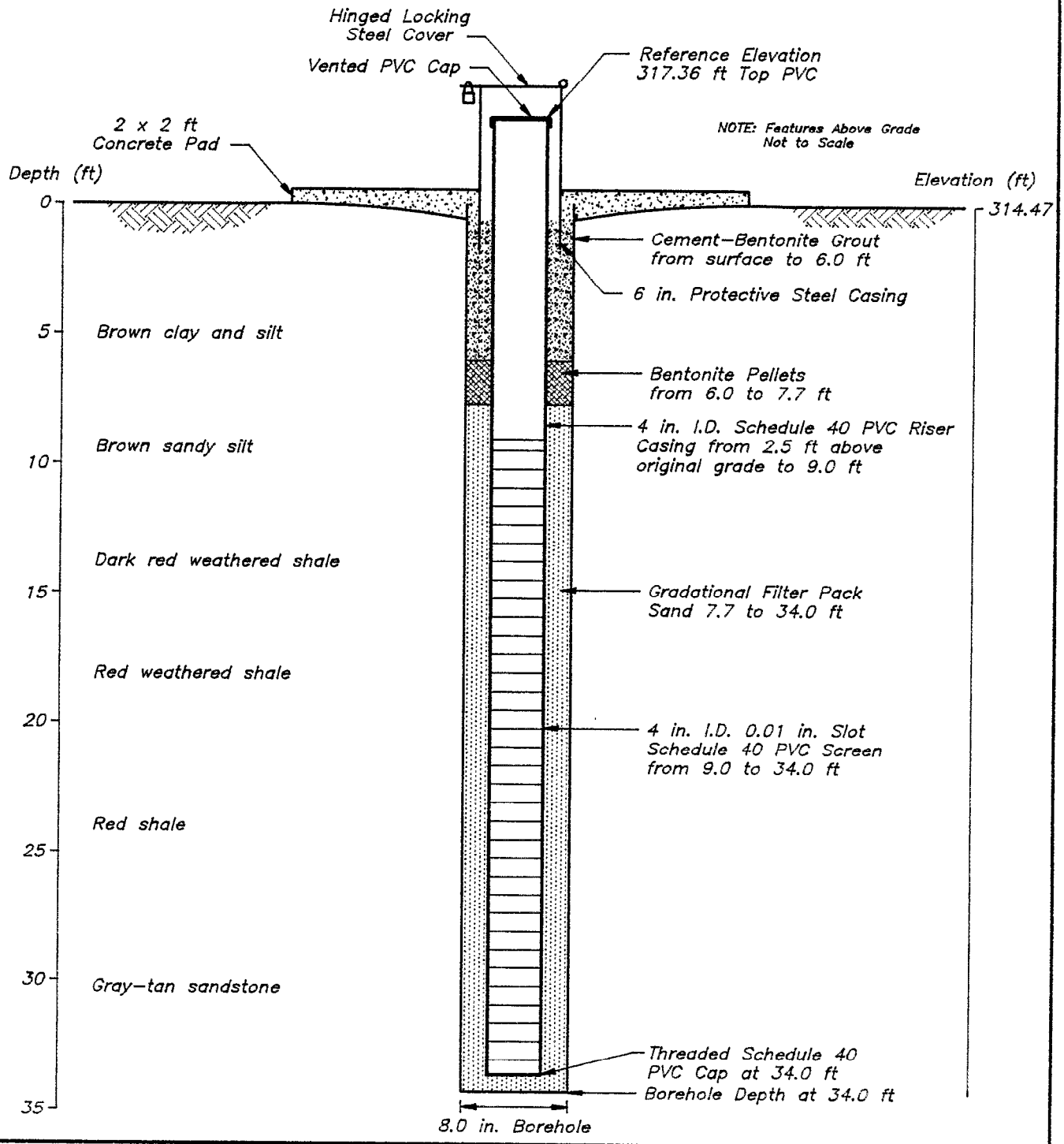
Logged by: Bradley C. Blase Date: 18 May 1993

Drilling Contractor: Environmental Drilling, Inc. Driller: Scott Hauge

WELL SPECIFICATIONS:

Diam. of casing:	4-in PCV	Screen Interval:	34 - 9 ft	Sandpack:	34 - 7.7 ft	Grout:	6.0 - 0.0 ft
BOH:	34-ft	Riser Interval:	9 - (+2.5) ft	Bentonite:	7.7 - 6.0 ft	Cover:	steel stickup

WELL NO: NFFW-21
WELL COMPLETION DIAGRAM



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

Client: U.S. Navy

Job No. 12197.06

Location: Willow Grove NAS

Coordinates X: 2,727,328.79
Y: 328,761.28

APPENDIX B

FIELD SAMPLING SHEETS

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE

Well Number: NFFW - 3 Gauge Date: 6/14/93

Weather: SUNNY 80° C Gauge Time: 1640

Well Condition: GOOD

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 28.10 Purge Date: 6/14/93

(2) Depth to LPH (ft): Purge Start Time:

(3) Depth to Water (ft): 20.30 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 3

(5) Liquid Depth (ft) = [(1) - (3)]: 7.80 Total Purge Time (min): 13.0

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 38.5

Did Well Pump Dry? Describe: YES 5 MIN'S WAITED 15 MIN'S PURGED 4 MIN'S

Description of Purged Water Odor: TOTAL 27 GALS

Sampler:

Sampling Date:

Sample Type (grab or composite): Split? With Whom?

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1		6.80	330	18	
2		6.18	300	17	
3		6.45	370	17	
4		6.55	200	17	
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE 12197.06

Well Number: NFFW - 4 Gauge Date: 14 / JUNE 93

Weather: SUNNY 80° Gauge Time: 1705

Well Condition: GOOD

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: I.F.P. Measurement Reference: T.O.C.

(1) Well Depth (ft): 24.25 Purge Date: 14 / JUNE / 93

(2) Depth to LPH (ft): Purge Start Time: 1715

(3) Depth to Water (ft): 19.25 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 1.5

(5) Liquid Depth (ft) = [(1) - (3)]: 5.0 Total Purge Time (min):

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume:

Did Well Pump Dry? Describe: YES, 5 MIN'S / WAITED 18 MIN'S Purged 2 MINS / waited 18 mins Purged 2 min

Description of Purged Water Odor: YES → PETROLEUM

Sampler: JLW

Sampling Date: 14 / JUNE 93

Sample Type (grab or composite): GRAB Split? With Whom? NO

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1715	6.24	360	20	
2	1725	6.24	300	18	
3	1735	6.14	290	18	
4	1740	6.15	300	18	
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE

Well Number: NFFW. 4 Gauge Date: 6/14/93

Weather: SUNNY 80° Gauge Time: 1300

Well Condition: GOOD

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 24.25 Purge Date: 6/14/93

(2) Depth to LPH (ft): Purge Start Time: 18.00

(3) Depth to Water (ft): 19.25 Purge Method: 2" SUB

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 1 gpm

(5) Liquid Depth (ft) = [(1) - (3)]: 5.0 Total Purge Time (min): 14.0

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 14.2

Did Well Pump Dry? Describe: YES

Description of Purged Water Odor:

Sampler:

Sampling Date:

Sample Type (grab or composite): Split? With Whom?

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1805	6.54	360	20	
2	1815	6.34	300	18	
3	1825	6.14	290	18	
4	1835	6.15	300	18	
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE

Well Number: NFFW-8 Gauge Date: 6/14/93

Weather: SUNNY Gauge Time:

Well Condition: GOOD NO LOCK

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: TFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 30.40 Purge Date: 6/14/93

(2) Depth to LPH (ft): Purge Start Time: 1450

(3) Depth to Water (ft): 16.40 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 4 GPM

(5) Liquid Depth (ft) = [(1) - (3)]: 1400 Total Purge Time (min): 17.3

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 69.3

Did Well Pump Dry? Describe: YES 6 MINS WAITED 15 MINS DRY 5 MINS

Description of Purged Water Odor: WAITED 15 MINS PUMPED 5 MINS

Sampler:

Sampling Date:

Sample Type (grab or composite): Split? With Whom?

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1		6.64	412	19.5	
2		6.75	422	19.5	
3		6.69	380	18.0	
4		6.82	385	18.0	
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE

Well Number: NFFW-10 Gauge Date: 6/14/93

Weather: SUNNY Gauge Time: 1600

Well Condition: GOOD

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: I.F.P. Measurement Reference: T.O.C

(1) Well Depth (ft): 37.0 Purge Date: 6/14/93

(2) Depth to LPH (ft): Purge Start Time: 1605

(3) Depth to Water (ft): 9.10 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 7

(5) Liquid Depth (ft) = [(1) - (3)]: 27.90 Total Purge Time (min): 19.7

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 138

Did Well Pump Dry? Describe: YES 10 MIN'S 70 GAL / DECREASED PUMPING RATE

Description of Purged Water Odor: 4 GPM PURGED 10 MINS

Sampler:

Sampling Date:

Sample Type (grab or composite): Split? With Whom?

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1605	6.25	405	18	
2	1620	6.44	445	18	
3	1630	6.61	348	18	
4	1640	6.66	430	18	
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE

Well Number: NFFW-11 Gauge Date: 6/14/93

Weather: SUNNY 80°C Gauge Time: 1300

Well Condition: GOOD LOCK #2406

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 24.0 Purge Date: 6/14/93

(2) Depth to LPH (ft): Purge Start Time: 1515

(3) Depth to Water (ft): 8.90 Purge Method: 5" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 7

(5) Liquid Depth (ft) = [(1) - (3)]: 15.10 Total Purge Time (min): 10 MINS

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 74.7

Did Well Pump Dry? Describe: NO

Description of Purged Water Odor:

Sampler:

Sampling Date:

Sample Type (grab or composite): Split? With Whom?

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1515	6.47	370	19.5	
2	1520	6.60	322	17.5	
3	1525	6.61	312	17.5	
4	1530	6.55	320	17.5	
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE

Well Number: NFFW-13 Gauge Date: 6/14/93

Weather: SUNNY 80°C Gauge Time: 0955

Well Condition: GOOD

Well Diameter (inches): 4" (Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 30.00 Purge Date:

(2) Depth to LPH (ft): Purge Start Time: 1030

(3) Depth to Water (ft): 14.10 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 4

(5) Liquid Depth (ft) = [(1) - (3)]: 15.90 Total Purge Time (min):

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume:

Did Well Pump Dry? Describe: YES-4 min's / decreased Pump 1.5 gpm

Description of Purged Water Odor: YES

Sampler: 22.05 → PRODUCT

Sampling Date: 22.06 → WATER

Sample Type (grab or composite): Split? With Whom?

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1030	6.52	258	17.5	
2	1050	6.28	235	16.5	
3					
4					
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: Willow Grove 12197.06

Well Number: NFFW-15 Gauge Date: 10/June/93

Weather: Sunny 80° Gauge Time: 1005

Well Condition: New #2402

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 34.90 Purge Date: 10/June/93

(2) Depth to LPH (ft): Purge Start Time: 1000

(3) Depth to Water (ft): 15.70 Purge Method: 2" Sub Pump

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 7 gpm

(5) Liquid Depth (ft) = [(1) - (3)]: 19.20 Total Purge Time (min): 14.0

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 95 gal

Did Well Pump Dry? Describe: No

Description of Purged Water Odor: YES

Sampler: JLW

Sampling Date: 10/June/93 1430

Sample Type (grab or composite): GRAB Split? With Whom? No

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1010	5.74	152	22	
2	1015	5.94	142	18	
3	1020	5.98	148	17.5	
4	1025	5.92	150	17.5	
5	1030	5.98	152	17.5	
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: Willow Grove 12197.06

Well Number: NFFW-17 Gauge Date: 10/June/93

Weather: Sunny 80° Gauge Time: 1050

Well Condition: New Lock # 2402

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 22.60 Purge Date: 10/June/93

(2) Depth to LPH (ft): Purge Start Time: 1055

(3) Depth to Water (ft): 7.85 Purge Method: 2" Sub Pump

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 7 gpm

(5) Liquid Depth (ft) = [(1) - (3)]: 14.75 Total Purge Time (min): 10.60

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 74.21

Did Well Pump Dry? Describe: No

Description of Purged Water Odor:

Sampler: JLW

Sampling Date: 10/June/93 1440

Sample Type (grab or composite): GRAB Split? With Whom? No

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1055	6.27	408	25	
2	1100	6.54	298	17.5	
3	1105	6.60	292	17.5	
4	1110	6.58	278	17.5	
5	1115	6.60	276	17.5	
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE 12197.06

Well Number: NFFW-18 Gauge Date: 10/JUNE/93

Weather: SUNNY 80° Gauge Time: 1120

Well Condition: NEW LOCK # 2402

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 38.80 Purge Date: 10/JUNE/93

(2) Depth to LPH (ft): Purge Start Time: 1125

(3) Depth to Water (ft): 15.16 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 7 gpm

(5) Liquid Depth (ft) = [(1) - (3)]: 23.64 Total Purge Time (min): 17 MIN'S

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 117 0

Did Well Pump Dry? Describe: NO

Description of Purged Water Odor:

Sampler: JLW

Sampling Date: 10/JUNE/93 1530

Sample Type (grab or composite): GRAB Split? With Whom? NO

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1125	6.37	348	26	
2	1130	6.52	335	17	
3	1135	6.53	335	15.5	
4	1140	6.50	332	15.5	
5	1145	6.54	334	15.5	
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE 12197.06

Well Number: NFFW - 19 Gauge Date: 10/JUNE/93

Weather: SUNNY 80° Gauge Time: 1320

Well Condition: NEW LOCK # 2402

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 34.90 Purge Date: 10/JUNE/93

(2) Depth to LPH (ft): Purge Start Time: 1325

(3) Depth to Water (ft): 20.10 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 2 gpm

(5) Liquid Depth (ft) = [(1) - (3)]: 14.80 Total Purge Time (min):

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 73.28

Did Well Pump Dry? Describe: YES, 5 MIN'S / WAITED 15 MIN'S / PURGED 1.5 MIN'S / WAITED 15 MIN'S

Description of Purged Water Odor: PURGED 1.0 MIN.

Sampler: JLW

Sampling Date: 10/JUNE/93

Sample Type (grab or composite): GRAB Split? With Whom? NO

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1330	6.35	388	25	
2	1345	6.37	340	18	
3	1410	6.48	382	18.5	
4					
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE 12197.06

Well Number: NFFW-20 Gauge Date: 10/JUNE/93

Weather: SUNNY 75° Gauge Time: 1310

Well Condition: NEW LOOK # 2402

Well Diameter (inches): 4" Stick Up or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C

(1) Well Depth (ft): 36.95 Purge Date: 10/JUNE/93

(2) Depth to LPH (ft): Purge Start Time: 1315

(3) Depth to Water (ft): 30.25 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 3

(5) Liquid Depth (ft) = [(1) - (3)]: 6.70 Total Purge Time (min): 10 min's

(6) Liquid Volume (gall) = [(5) * Conversion]: 8.28x4 Total Purge Volume: 33.15

Did Well Pump Dry? Describe: YES AFTER 2 min's WAITED 15 min's PURGED 1 min 8 GALLONS

Description of Purged Water Odor:

Sampler: JLW

Sampling Date: 10/JUNE/93 1500

Sample Type (grab or composite): GRAB Split? With Whom? NO

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1240	6.03	342	27	
2	1300	6.24	480	22	
3					
4					
5					
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field Record of Well Gauging, Purging, and Sampling

Site: WILLOW GROVE 12197.06

Well Number: NFFW-21 Gauge Date: 10/JUNE/93

Weather: SUNNY 75°C Gauge Time: 1155

Well Condition: NEW LOCK #2402

Well Diameter (inches): 4" (Stick Up) or Down (ft):

Gauging Method: IFP Measurement Reference: T.O.C.

(1) Well Depth (ft): 36.70 Purge Date: 10/JUNE/93

(2) Depth to LPH (ft): Purge Start Time: 1200

(3) Depth to Water (ft): 24.11 Purge Method: 2" SUB PUMP

(4) LPH Thickness (ft) = [(3) - (2)]: Purge Rate (gall/min): 6 gpm

(5) Liquid Depth (ft) = [(1) - (3)]: 12.59 Total Purge Time (min): 10 min's

(6) Liquid Volume (gall) = [(5) * Conversion]: Total Purge Volume: 62.0

Did Well Pump Dry? Describe: NO

Description of Purged Water Odor:

Sampler: JLW

Sampling Date: 10/JUNE/93 1510

Sample Type (grab or composite): GRAB Split? With Whom? NO

Comments and Observations:

Well Borehole Volumes Removed	Time	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Turbidity (NTU)
1	1205	6.11	332	24	
2	1210	5.93	252	17.5	
3	1215	5.94	250	17.0	
4	1220	5.92	248	17.0	
5	1225	5.96	250	17.0	
6					
7					
8					
9					
10					

Conversions from Liquid Depth to Volume:

Well Diameter	Gallons/Foot
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove Date: 21 June 92

Well No.: NFW-3 Well Diam. 4 Time: 1145

Weather: Overcast 85°

Well condition: Good Sounding Method: I.F.S.

Stickup/Flush? Stick up Reference: Top of casing

Odor (if any): None

1. Well Depth: 28.20 Purge Method: 2" submersible
2. Depth to Liquid: Purge rate: 4 gpm
3. Depth to Water: 24.27 Purge Time: 5 min
4. Liquid Column: 3.93
5. Liquid Volume: 4.87 Purge Volume: 20

Pump Dry? Yes

Describe: After 6 gal, wait 15 min, dry after 5 gal.

Sampler(s): SHO

Sample date: 21 June 92 Sample Time: 1547

Sample Type: Grab TPH Split? NO

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 93

Well No.: NFFW-4

Well Diam. 4"

Time:

Weather: OVERCAST 85°

Well condition: good

Sounding Method: I.F.P.

Stickup/Flush? Flush

Reference: top of casing

Odor (if any): strong

1. Well Depth: 28.10

Purge Method:

2. Depth to Liquid:

Purge rate:

3. Depth to Water: 21.74

Purge Time:

4. Liquid Column: 6.36

5. Liquid Volume: 7.89

Purge Volume: 31.5

Pump Dry? YES

Describe: AFTER 4 GAL, WAIT 15 MIN PURGED 1 GAL, 5 GAL TOTA

Samplers: SHD

Sample date: 21 JUNE 93

Sample Time: 1535

Sample Type: GRAB TOP

Split? NO

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 93

Well No.: NFFW-5 Well Diam. 6"

Time: 1100

Weather: overcast 85°

Well condition: Good

Sounding Method: I.F.P.

Stickup/Flush? stickup

Reference: Top of casing

Odor (if any): slight

1. Well Depth: 27.75

Purge Method: 2" submersible

2. Depth to Liquid:

Purge rate: 4 gpm

3. Depth to Water: 15.77

Purge Time: 22 min

4. Liquid Column: 11.98

5. Liquid Volume: 21.68

Purge Volume: 86.72

Pump Dry? yes

Describe: after 56 gal, wait 15 min purged 10 gal 69 gal

Samplers: SHO

Sample date: 21 June 93

Sample Time: 1524

Sample Type: Grab TPH

Split? no

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: Willow Grove NAS Date: 6-21-93

Well No.: NFFW-8 Well Diam. 4 Time: 1008

Weather: Sunny Humid 95°

Well condition: Good, no lock Sounding Method: I.F.A.

Stickup/Flush? Stick-up Reference: Top of casing

Odor (if any):

1. Well Depth: 30.40 Purge Method: 2" submersible
2. Depth to Liquid: Purge rate: 2 gpm
3. Depth to Water: 16.67 Purge Time: 34
4. Liquid Column: 13.73
5. Liquid Volume: 17 Purge Volume: 68

Pump Dry? yes

Describe: After 46 gal, wait 15 min purged 22 gal, 68 total

:: 55

Sample date: 21 June 93 Sample Time: 1520

Sample Type: Grab Split? no

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 93

Well No.: NFFW-9 Well Diam. 4"

Time: 1445

Weather: Overcast 85°

Well condition: Good Locked

Sounding Method: I.E.P.

Stickup/Flush? Flush

Reference: Top of casing

Odor (if any): None

1. Well Depth: 25.50

Purge Method: 2" submersible

2. Depth to Liquid:

Purge rate: 5 gpm

3. Depth to Water: 7.00

Purge Time: 20 min

4. Liquid Column: 18.5

5. Liquid Volume: 22.94

Purge Volume: 92

Pump Dry? No

Describe:

Samplers: SKD

Sample date: 21 June 93

Sample Time: 1515

Sample Type: Grab

Split? No

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove Date: 21 JUN 93

Well No.: NFFW-10 Well Diam. 4" Time: 1320

Weather: OVERCAST 85°

Well condition: Good Sounding Method: I.E.P.

Stickup/Flush? Flush Reference: Top of casing

Odor (if any): Slight

1. Well Depth: ~~37.00~~ 37.00 Purge Method: 2" Submersible

2. Depth to Liquid: - Purge rate: 5 gpm

3. Depth to Water: 9.10 Purge Time: 28 min

4. Liquid Column: 27.90

5. Liquid Volume: 34.59 Purge Volume: 138

Pump Dry? NO

Describe: pumped slow at the end

Samplers: SKD

Sample date: 21 JUN 93 Sample Time: 1429

Sample Type: Grab Tot Split? NO

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21

Well No.: NFFW-11 Well Diam. 4"

Time: 1314

Weather: Overcast 90°

Well condition: Good, locked

Sounding Method: I.F.P.

Stickup/Flush? Stickup 3"

Reference: Top of casing

Odor (if any): none

1. Well Depth: 24.0

Purge Method: 2" submersible

2. Depth to Liquid:

Purge rate: 3 gpm

3. Depth to Water: 19.20

Purge Time: 8 min

4. Liquid Column: 4.8

5. Liquid Volume: 5.95

Purge Volume: 24

Pump Dry? No

Describe:

Samplers: TS

Sample date: 21 June 93

Sample Time: 1426

Sample Type: Grab Tpff

Split? No

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 93

Well No.: NFFW-15 Well Diam. 4"

Time: 1410

Weather: OVERCAST 85°

Well condition: Good LOCKED

Sounding Method: I.F.P.

Stickup/Flush? STICKUP

Reference: Top of casing

Odor (if any): NONE

1. Well Depth: 34.90

Purge Method: 2" SUBMERSIBLE

2. Depth to Liquid:

Purge rate: 6 gpm

3. Depth to Water: 7.49

Purge Time: 23

4. Liquid Column: 27.41

5. Liquid Volume: 33.99

Purge Volume: 136

Pump Dry? NO

Samplers: SHO

Sample date: 21 JUN 93

Sample Time: 1445

Sample Type: GRAB

Split? NO

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 93

Well No.: NFFW-17

Well Diam. 4"

Time: 1414

Weather: Overcast 90°

Condition: Good

Sounding Method: I.F.P

Stickup/Flush? Flush

Reference: Top of casing

Odor (if any): None

1. Well Depth: 22.60

Purge Method: 2" Submersible

2. Depth to Liquid:

Purge rate: 5

3. Depth to Water: 8.85

Purge Time: 14

4. Liquid Column: 13.75

5. Liquid Volume: 17.05

Purge Volume: 69

Pump Dry? No

Describe:

Samplers: TS

Sample date: 21 June 93

Sample Time: 1441

Sample Type: GRAB TPH

Split? No

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: willow Grove NAS Date: 21 June 93

Well No.: NFFW 18 Well Diam. 4" Time: 1114

Weather: Sunny Humid 90°

Well condition: Good Sounding Method:

Stickup/Flush? Reference:

Odor (if any):

1. Well Depth: 38.80 Purge Method: 2" Submersible

2. Liquid: Purge rate: 5 gpm

3. Depth to Water: 15.73 Purge Time: 20

4. Liquid Column: 23.07

5. Liquid Volume: 28.61 Purge Volume: 114.4

Pump Dry? NO

Describe:

Samplers: JS

Sample date: 21 June 93 Sample Time: 1525

Sample Type: Grab Split? NO

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 97

Well No.: NFFW-19

Well Diam. 4"

Time: 1251

Weather: overcast 90°

Well condition: Good, locked

Sounding Method: I.F.P

Stickup/Flush? Stickup

Reference: Top of casing

Odor (if any): Strong petroleum

1. Well Depth:

Purge Method:

2. Depth to Liquid: 22.35

Purge rate:

3. Depth to Water: 20.35

Purge Time:

4. Liquid Column:

5. Liquid Volume:

Purge Volume:

Pump Dry?

Describe: well not purged due to product

TS

Date: 21 June 97

Sample Time: 1526

Sample Type: Grab TPH

Split? no

With Whom?

Comments:

Field record of well gauging, purging, and sampling

Location: WILLOW GROVE NAS

Date: 21 JUNE 92

Well No.: NFFW-20 Well Diam. 4

Time: 1209

Weather: SUNNY HUMID 90°

Well condition: Good

Sounding Method: I.F.P

Stickup/Flush? STICK up

Reference: TOP OF CASING

Odor (if any): NONE

1. Well Depth: 36.95

Purge Method: 2" SUBMERSIBLE

2. Depth to Liquid:

Purge rate: 2 gpm

3. Depth to Water: 31.84

Purge Time: 15 min

4. Liquid Column: 5.11

5. Liquid Volume: 6.34

Purge Volume: 26

Pump Dry? YES

Describe: AFTER 4 GAL, WAIT 15 min, PURGED 2 GAL 6 GAL TOTAL

Samplers: JS

Sample date: 21 JUNE 92

Sample Time: 1526

Sample Type: GRAB

Split? NO

With Whom?

Comments: WELL RECOVERED FROM PURGING WITH PRODUCT IN IT.

Field record of well gauging, purging, and sampling

Location: NAS Willow Grove

Date: 21 June 93

Well No.: NFFW-21

Well Diam. 4"

Time: 1030

Weather: OVERCAST 85°

Well condition: Good, Locked

Sounding Method: I.R.P.

Stickup/Flush? Stickup

Reference: Top of casing

Odor (if any): NONE

1. Well Depth: 36.70

Purge Method: 2" submersible pump

2. Depth to Liquid:

Purge rate: 7 gpm

3. Depth to Water: 26.60

Purge Time: 8 min

4. Liquid Column: 10.10

5. Liquid Volume: 12.52

Purge Volume: 51 gal

Pump Dry? No

Describe:

Samplers: SMD

Sample date: 21 June 93

Sample Time: 1530

Sample Type: Gamma Tom

Split? No

With Whom?

Comments: