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RESPONSE TO NOTICE OF VIOLATION (NOV) NUMBER 4 ISSUED FEBRUARY 4, 1992

03/03/92

DOE-1305-92

DOE-FN/OEPA

3556

LETTER

[redacted]

[redacted]

Department of Energy
Fernald Environmental Management Project
P.O. Box 398705
Cincinnati, Ohio 45239-8705
(513) 738-6357

3065

APR 0 3 1992

DOE-1305-92

Mr. Phil Harris
Division of Hazardous Waste
Ohio Environmental Protection Agency
40 South Main Street
Dayton, Ohio 45402-2086

Dear Mr. Harris:

RESPONSE TO NOTICE OF VIOLATION (NOV) NUMBER 4 ISSUED FEBRUARY 4, 1992

Reference: Letter, P. E. Harris to R. E. Tiller, "Notice of Violations regarding the Groundwater Quality Assessment Annual Reports," dated February 4, 1992

This letter serves to transmit a report on the suitability of two monitoring wells in the Shandon Flow System (Monitoring Wells 2066 and 3066) located upgradient of the Waste Pit Area. The report was requested by the Ohio Environmental Protection Agency (Ohio EPA) in a NOV issued on February 4, 1992 (reference), regarding the Resource Conservation and Recovery Act (RCRA) Groundwater Quality Assessment of Waste Pit 4. The violation alleged that monitoring wells 2066 and 3066 may not be suitable upgradient wells due to "questionable" water quality when compared with monitoring well 3043. The remaining response to other allegations in the NOV of February 4, 1992, will be addressed under separate cover.

The Fernald Environmental Management Project (FEMP) is an EPA National Priority Listed Site (NPL) under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). A CERCLA Remedial Investigation and Feasibility Study (RI/FS) is ongoing at the site and includes Waste Pit 4. Waste Pit 4 received radioactive waste containing Barium Salts from 1980 to 1983. RCRA is considered an Applicable or Relevant and Appropriate Requirement (ARAR) of CERCLA.

The enclosed report concludes that monitoring wells 2066 and 3066 are properly constructed and are located upgradient to the Waste Pit Area. Three flow systems within the Great Miami Aquifer converge in the vicinity of the FEMP. The Dry Fork and Shandon Flow system converge near the Waste Pit Area. Monitoring Wells 2066 and 3066 are completed in the Shandon Flow System. Monitoring wells 2043 and 3043 are completed in the Dry Fork Flow System.

The chemistry of each flow system is distinctly different from that of the other flow system. If a direct comparison of water chemistry is made between the 0043 and 0066 monitoring wells, without regard to the fact that they are completed in different flow streams with different degrees of lithologic heterogeneity (the Shandon contains more clay), one could conclude that the results are questionable.

The allegations in the NOV involve the current RCRA Groundwater Assessment Program for Waste Pit 4, as defined by the RCRA Groundwater Quality Assessment Program Plan (GQAPP) for Waste Pit 4. An upgradient to downgradient comparison of water quality for assessment monitoring is not a regulatory requirement, but it is a requirement of the GQAPP. This method of evaluation was selected to aid in the determination of rate and extent of contaminant migration, which is a requirement of an assessment monitoring program. In the February 4, 1992, letter, the Ohio EPA expressed concern over the FEMP's determination of the rate and extent of migration based on statistical methods, and recommended that best professional judgement be employed in the determination.

To resolve this concern as well as the concern with the use of the 066 cluster as upgradient wells, the FEMP proposes to immediately employ a time versus concentration tracking method as part of the RCRA GQAPP instead of the upgradient to downgradient tests. The FEMP believes that the statistical tests performed as part of the GQAPP in the past were instrumental in identifying the contaminants of concern, and best professional judgement has been successfully employed to determine the extent of contamination. The upgradient to downgradient comparison of water quality is therefore no longer necessary. The time versus concentration method will better identify changes and trends in contaminant concentrations.

On December 20, 1991, the FEMP submitted to the Ohio EPA the RCRA Groundwater Monitoring Plan (GMP), which identified groundwater monitoring for eight potential units at the site. The status of these units is still under discussion with the Ohio EPA. The RCRA GMP proposed the time versus concentration tracking method and comparison of water quality to action levels in place of an upgradient to downgradient concentration comparison. The FEMP proposes to begin the time versus concentration tracking immediately as part of the GQAPP.

This letter will be enclosed as an addendum to the GQAPP as documentation that notification was made to the Ohio EPA and United States Environmental Protection Agency (U.S. EPA) as to a modification of the GQAPP.

DOE-FEMP staff are available to meet with Ohio EPA, Southwest District Office (SWDO) representatives to further discuss the enclosed report and assure that Ohio EPA, SWDO concerns have been adequately addressed.

If you have any questions, please contact Ed Skintik at (513) 738-6660.

Sincerely,

R. E. Tiller
Manager

FN:Skintik

Enclosure: As Stated

cc w/enc.:

K. A. Hayes, EM-424, TREV
J. A. Saric, USEPA-V, HRE-8J
R. Bendula, OEPA-Dayton
G. E. Mitchell, OEPA-Dayton
P. Pardi, OEPA-Dayton
M. Proffitt, OEPA-Dayton
T. Schneider, OEPA-Dayton
L. S. Farmer, WEMCO
V. A. Franklin, WEMCO
J. P. Hopper, WEMCO
E. D. Savage, WEMCO
AR Coordinator, WEMCO

bcc w/enc.:

C. J. Fermaintt, DOE, FN
W. S. Sidle, DOE, ORFO
D. J. Brettschneider, WEMCO
D. J. Carr, WEMCO
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J. M. Sattler, WEMCO
S. G. Schneider, WEMCO
B. J. Smith, WEMCO

[redacted]

[redacted]

Report on the Suitability of Monitoring Wells 2066 and 3066
For Determining Background Water Quality
In the Shandon Flow System

Introduction

The Ohio EPA has requested that the US DOE document the suitability of Monitoring Wells 2066 and 3066 for determining background water quality in the Shandon Tributary of the Great Miami Aquifer (OEPA, February 04, 1992). This report is presented in response to that request. Since the suitability of the wells was alleged to be a violation of OAC 3745-65-91(A)(1)(a) and (b), this report will also explain why these wells were chosen to be used for the RCRA Assessment.

Background

The Fernald Environmental Management Project (FEMP) is an EPA National Priority Listed Site (NPL) under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). A CERCLA Remedial Investigation and Feasibility Study (RI/FS) is ongoing at the site and includes Waste Pit 4. Waste Pit 4 received radioactive waste containing Barium Salts from 1980 to 1983. RCRA is considered an Applicable, Relevant and Appropriate Requirement (ARAR) of CERCLA cleanup activities.

Three flow systems within the Great Miami Aquifer converge in the vicinity of the FEMP. The chemistry of groundwater in each flow system is distinctly different from that of the other flow systems. Because of the heterogeneity of upgradient groundwater chemistry, it is not possible to derive a single representative background water chemistry for the Great Miami Aquifer. Background water quality is therefore divided into the Ross, Dry Fork and Shandon Groups. The RI/FS issued a Draft Groundwater Report in 1990 that interprets groundwater quality upgradient of the FEMP (DOE, 1990). Sections 15.1 through 15.2 of that report address background water quality and are included as Appendix 3 to this report.

Monitoring Wells 2050, 2056, 2066, 2105 and 3066 are completed in the Shandon Flow System, upgradient to the FEMP Waste Pit Area. Monitoring Wells 2066 and 3066 were installed on 08-21-87 and 09-22-87 respectively as part of the CERCLA RI/FS investigation for the purpose of determining the nature and extent on any contamination. Construction of both wells was done in compliance to the USEPA approved RI/FS Quality Assurance Program Plan (QAPP).

They were selected for use in the RCRA Assessment Program as background wells for the Shandon Flow System because it can be documented that they are suitable for use as groundwater monitoring wells. All of the other upgradient wells completed in the Shandon Flow System are private wells.

Flow Systems Beneath the Waste Pit Area

The Waste Pit Area is located very close to where the Shandon Flow System and the Dry Fork Flow system converge. Potentiometric surface constructions indicated that flow beneath Waste Pit 4 originates in the Shandon Flow System. Therefore monitoring wells 2066 and 3066 were selected as the background wells for the RCRA Assessment Program.

Observations drawn from the interpretation of groundwater elevation maps indicate that some component of flow beneath Waste Pit 4 could also originate from the Dry Fork Flow System. Therefore Monitoring Wells 2043 and 3043 are also included in the RCRA Assessment for determining background water quality in the Dry Fork Flow System. If a direct comparison of water chemistry is made between the 0043 and 0066 well clusters, without regard to the fact that they represent different flow systems, one could conclude that the results are questionable. Water quality data collected from the upgradient monitoring wells is provided in Table 1 as an average and standard deviation.

Statistics were not calculated for the following parameters because the data was primarily composed of non-detect values: aluminum, antimony, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, mercury, molybdenum, nickel, nitrate, phenols, selenium, silver, thallium, and vanadium.

A comparison of groundwater chemistry between the three tributaries, using the average concentration of 30 metals and water quality parameters, indicates that the Shandon Flow System has the highest averages of 18 metals and water quality parameters, including the highest chloride, iron and specific conductance averages. This comparison indicates that the Shandon tributary contains naturally higher concentrations of many parameters.

A comparison of the groundwater chemistry at monitoring wells 2066 and 3066 with the water chemistry determined from the other private wells in the Shandon tributary indicate that Monitoring Well 2066 has concentrations of potassium, sulfate, and TOX that exceed the RI/FS determined background average by more than two times standard deviation. The comparison also indicates that Monitoring Well 3066 has concentrations of arsenic, calcium, chloride, specific conductivity, iron, magnesium, manganese, phosphorous, potassium, sodium, sulfate, TOC and TOX that exceed the RI/FS background average by more than two times the standard deviation.

This comparison indicates that Monitoring Wells 2066 and 3066 have higher concentrations of many parameters than other background wells in the Shandon Flow System.

Ongoing Work

The hydrogeology and water quality of the Shandon Flow System is still being addressed in the RI/FS. This work will also be used in the RCRA Assessment Program if applicable. Specifically, completion records indicate that lithology of the Shandon Flow System is more heterogeneous than the lithology of the Dry Fork Flow System. Appendix 1 contains installation records for monitoring wells 2066 and 3066. An interpretation of the lithology of the Shandon Flow System, made from soil classification records, is also included in Appendix 1. Monitoring Well 2066 has a 19 foot sand pack and is completed in a 4.5 foot thick sand lens. Monitoring Well 3066 has a 12 foot sand pack and is completed in a 18.5 foot sand lens. Comparatively, boring logs for Monitoring Wells 2043 and 3043 indicate a 90 foot deposit of sands and gravels consistent with other boring logs in the Dry Fork.

Water elevation data collected in Monitoring Wells 2066 and 3066 are provided in Appendix 2. In the Dry Fork Flow System, the potentiometric head difference between the 2000 series and the 3000 series is in the range of 0 to 2 feet. The potentiometric head difference observed between monitoring wells 2066 and 3066 is typically 15 feet. This large pressure difference indicates that flow between the two sands are independent of each other.

The water elevation in Monitoring Well 2066 is usually 12 to 15 feet higher than neighboring 2000-series monitoring wells screened in the Dry Fork Flow System. The water elevations recorded in 3066 are consistent with water elevations recorded in 3000-series monitoring wells in the Dry Fork Flow System. The RI/FS is in the process of installing additional wells east and southeast of the 0066 well pad. Data collected from the installation of the wells will be used to better define the heterogeneous nature of the aquifer lithology in the area.

Water elevation data collected from the wells will be used to better define a potentiometric surface for the area, and water quality data collected from the wells will be used to better define the groundwater chemistry in the area. The wells are being installed and completed according to the USEPA approved RI/FS QAPP. Therefore, upon completion, records will exist that will document the suitability of these wells for the collection of groundwater samples.

References Cited

OEPA, February 04, 1992, Letter from Mr. Phillip C. Harris, Division of Hazardous Waste Management, Ohio Environmental Protection Agency, to Mr. Robert E. Tiller, Manager U.S. DOE-FEMP, regarding U.S. DOE-FEMP HAZARDOUS WASTE OH 689 0008 976 HAMILTON COUNTY TSD-GEN.

DOE, 1990, DRAFT Groundwater Report Feed Materials Production Center Fernald, Ohio Remedial Investigation and Feasibility Study, Volumes 1-13, Prepared by ASI/IT for the US. Department of Energy.

TABLE 1

Summary Water Quality Statistics in RCRA Upgradient Monitoring Wells
(average concentrations recorded in ppm)

Parameter	Monitoring Well 2043 average	Monitoring Well 2043 standard deviation	Monitoring Well 3043 average	Monitoring Well 3043 standard deviation
arsenic	***	***	0.0108	0.0242
barium	0.200	0.0806	0.2815	0.0439
calcium	97.91	21.12	79.81	22.89
chloride	38.71	16.19	18.73	9.39
specific conductivity	353.6	317.8	567.7	93.3
fluoride	0.4993	0.1034	0.3407	0.1014
iron	0.6835	0.4855	2.9987	0.9616
magnesium	33.84	7.4533	24.98	4.7871
manganese	0.2044	0.0893	0.0583	0.0093
pH	7.086	0.241	7.268	0.142
phosphorous	0.83	1.23	0.40	0.08
potassium	1.68	1.27	1.38	1.21
sodium	31.643	10.718	20.586	5.553
sulfate	78.879	66.472	20.483	44.604
TOC	7.005	4.909	6.588	4.530
TOX	***	***	***	***
zinc	***	***	0.0281	0.01296

*** - The number of non-detects in the sample population was greater than the number of detected results, therefore an average and standard deviation was not calculated.

Parameter	Monitoring Well 2066 average	Monitoring Well 2066 standard deviation	Monitoring Well 3066 average	Monitoring Well 3066 standard deviation
arsenic	0.0273	0.0225	0.0705	0.0507
barium	0.6721	0.2042	0.4586	0.1831
calcium	67.26	14.67	149.47	22.28
chloride	67.97	8.40	549.00	221.78
specific conductivity	696.1	179.1	1621.9	554.2
fluoride	0.8067	0.1814	0.1763	0.0903
iron	1.3205	0.5185	12.9013	7.226
magnesium	25.390	7.6335	43.107	12.6678
manganese	0.0373	0.0171	0.1257	0.0650
pH	7.209	0.275	7.063	0.135
phosphorous	0.22	0.13	1.04	0.36
potassium	2.10	1.05	3.75	1.25
sodium	49.508	5.515	261.231	92.483
sulfate	15.596	30.551	34.789	29.722
TOC	7.819	5.260	13.129	9.361
TOX	***	***	0.0465	0.0353
zinc	***	***	0.0288	0.0497

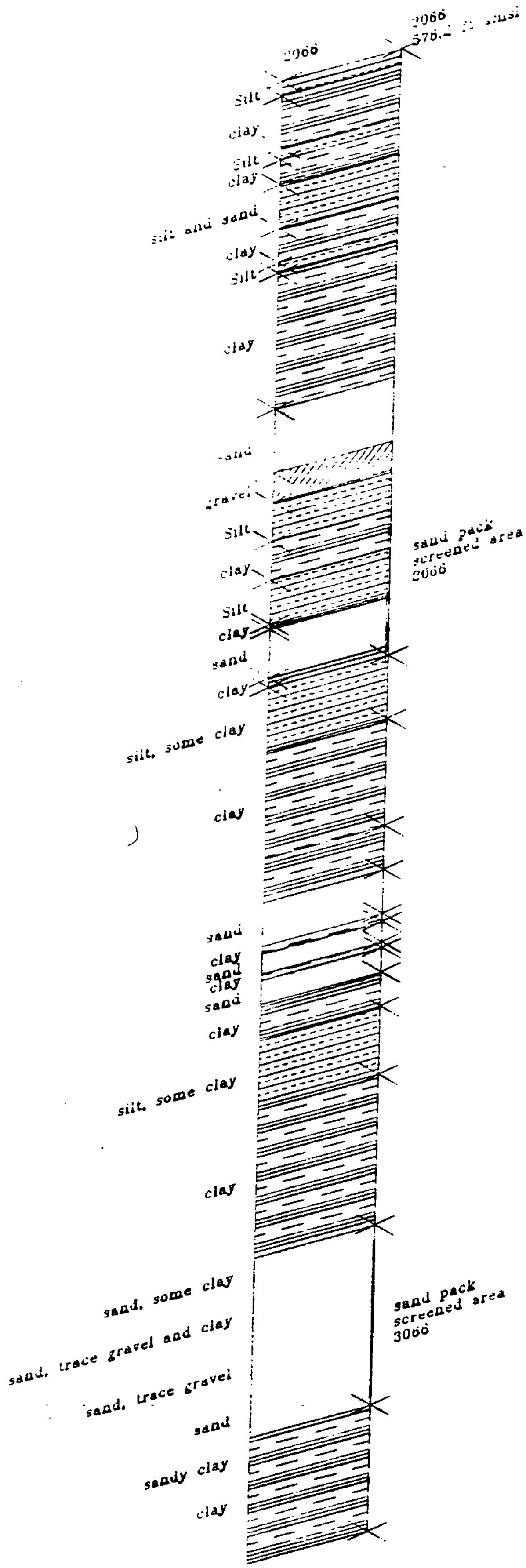
*** - The number of non-detects in the sample population was greater than the number of detected results, therefore an average and standard deviation was not calculated.

[redacted]

APPENDIX 1

[redacted]

Cross Section of Monitoring Wells 2066 and 3066



[redacted]

3065 [redacted]

FERNALD RI/FS — VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: [illegible] — PROJECT NAME: FMPC RI/FS

BORING NUMBER: 2066 — COORDINATES: NORTH 483.938.95 EAST 1.376.703.45 — DATE: 08/25/87

GROUND ELEVATION: 573.2 — GWL: Depth N/A Date/Time N/A — DATE STARTED:

ENGINEER/GEOLOGIST: D. OAKLEY — Depth N/A Date/Time N/A — DATE COMPLETED:

DRILLING METHODS: CABLE-TOOL — PAGE 1 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES	DESCRIPTION	USCS SYMBOL	TSF
1.5	07000 08/25/87 1110	6 6 5	13	STIFF BROWN SILT, TRACE FINE SAND.	ML	N/A
3.0	07001 08/25/87 1150	6 6 6	14	STIFF BROWN SILTY CLAY, TRACE FINE SAND.	CL	
4.5	07002 08/25/87 1500	1 2 3	14	MEDIUM STIFF REDDISH YELLOW CLAY - TRACE SILT. MEDIUM STIFF LIGHT GRAY CLAY, TRACE SAND AND SILT.	CL CL	
6.0	07003 08/25/87 1510	1 2 3	17	MEDIUM STIFF LIGHT GRAY CLAY, TRACE SAND AND SILT.	CL	
7.5	07004 08/25/87 1700	1 1 2	14	SOFT LIGHT YELLOWISH BROWN CLAY. SOFT LIGHT GRAY SILT, TRACE FINE SAND AND CLAY.	CL	
9.0	07005 08/26/87 0800	1 3 2	14	LIGHT YELLOWISH BROWN SILT, SOME CLAY. SOFT LIGHT GRAY CLAY, TRACE SILT. MEDIUM STIFF YELLOWISH BROWN CLAY, SOME SILT, TRACE SAND.	ML CL CL	N/A
10.5	07006 08/26/87 0840	6 7 10	13	MEDIUM DENSE YELLOWISH BROWN, COARSE SAND, TRACE GRAVEL AND SILT.	SP	N/A
12.0	07007 08/26/87 0900	6 7 11	8	VERY STIFF YELLOWISH RED SILT, SOME SAND, TRACE CLAY. REDDISH BROWN SAND MEDIUM DENSE GRAVE, TRACE SILT.	ML SP	N/A N/A
13.5	07008 08/26/87 1345	4 16 17	17	HARD GRAY SANDY SILT, TRACE GRAVEL. LENS REDDISH BROWN MEDIUM SAND, TRACE GRAVEL AND SILT.	ML SP	N/A N/A
15.0	07009 08/26/87 1430	2 5 6	9	STIFF GRAY SILT, TRACE CLAY. STIFF DARK GRAY MEDIUM SAND, SOME SILT, TRACE GRAVEL.	ML SM	N/A N/A

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. DRILLER - HARRY DYKES. ASSISTANT - TIM HARRIS. RIG - CYCLONE 42. SAMPL TAKEN WITH STANDARD SPLIT SPOON SAMPLER - 2.0" O.D.

[redacted] 12

PROJECT NUMBER: 602 [illegible]	PROJECT NAME: FMPC RI/FS		
BORING NUMBER: 2066	COORDINATES: NORTH 483,938.95 EAST 1,376,703.45		DATE: 08/25/87
GROUND ELEVATION: 578.2	GWL: Depth N/A	Date/Time N/A	DATE STARTED: [illegible]
ENGINEER/GEOLOGIST: D. OAKLEY	Depth N/A	Date/Time N/A	DATE COMPLETED:
DRILLING METHODS: CABLE-TOOL			PAGE 2 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	R
16.5	07010 08/26/87 1510	3 6 7	9	STIFF GRAY CLAY, SOME SILT, TRACE SAND AND GRAVEL.	CL		
18.0	07011 08/26/87 1530	5 7 8	13				
19.5	07012 08/26/87 1540	4 5 9	9	STIFF GRAY SILT, SOME CLAY, TRACE GRAVEL.	ML	N/A	
21.0	07013 07014 08/26/87 1555	11 13 22	15	STIFF GRAY SILT, SOME CLAY, TRACE GRAVEL. HARD GRAY CLAY AND SILT, TRACE GRAVEL.	ML CL	N/A	
22.5	07015 08/26/87 1615	8 12 20	13	HARD GRAY SILTY CLAY, TRACE GRAVEL AND SAND.	CL		
24.0	07017 08/27/87 1025	20 15 25	12				
24.0	07016 08/27/87 1025	20 15 25	12				
25.5	07018 08/27/87 1110	9 19 26	13				
27.0	07019 08/27/87 1150	5 26 50	10				
28.5	07020 08/27/87 1330	7 10 50	16				
28.5	07021 08/27/87 1330	7 10 50	16				
30.0	07022 08/27/87 1410	17 27 40	14				

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. SAMPLES TAKEN WITH SANTDARD SPLIT SPOON SAMPLER - 2.0" O.D. DRILLER - HA[illegible] DYKES. ASSISTANT - TIM HARRIS. RIG - CYCLONE 42.

FERNALD RI/FS VISUAL CLASSIFICATION OF SOILS 306[redacted]

PROJECT NUMBER: 602 3.2 PROJECT NAME: FMPC RI/FS

BORING NUMBER: 2066 COORDINATES: NORTH 483,938.95 EAST 1,376,703.451 DATE: 08/25/87

GROUND ELEVATION: 578.2 | GWL: Depth N/A Date/Time N/A | DATE STARTED: (

ENGINEER/GEOLOGIST: D. OAKLEY | Depth N/A Date/Time N/A | DATE COMPLETED:

DRILLING METHODS: CABLE-TOOL | PAGE 3 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS	SYMBOL	TSF	R
30.0	07023 08/27/87 1410	17 27 40	14					

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. SAMPLES TAKEN WITH SANTDARD SPLIT SPOON SAMPLER - 2.0" O.D. DRILLER - DYKES. ASSISTANT - TIM HARRIS. RIG - CYCLONE 42.

[redacted]

PROJECT NUMBER: 602 3.2 PROJECT NAME: FMPC RI/FS

BORING NUMBER: 2066 COORDINATES: NORTH 483,938.95 EAST 1,376,703.45 DATE: 08/25/87

GROUND ELEVATION: 578.2 | GWL: Depth N/A Date/Time N/A | DATE STARTED: C

ENGINEER/GEOLOGIST: D. OAKLEY | Depth N/A Date/Time N/A | DATE COMPLETED:

DRILLING METHODS: CABLE-TOOL | PAGE 4 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	R
31.5	07024 08/27/87 1450	13 17 37	13	HARD GRAY CLAY, SOME SILT AND GRAVEL, TRACE SAND. HARD GRAY SILTY CLAY, TRACE GRAVEL AND SAND.	CL CL		
33.0	07025 08/27/87 1520	5 7 10	10	VERY STIFF GRAY SILTY CLAY, TRACE SAND AND GRAVEL.	CL		
34.5	07026 08/27/87 1550	13 16 40	16	VERY DENSE STRONG BROWN SAND, TRACE GRAVEL AND SILT.	SP	N/A	
36.0	07027 08/28/87 0900	14 51	12	VERY DENSE STRONG BROWN SAND, TRACE GRAVEL.	SP	N/A	
40.0							
41.5	07028 08/28/87 1100	30 50	9	VERY DENSE STRONG BROWN SANDY GRAVEL, TRACE CLAY. HARD GRAY SILT, TRACE CLAY AND SAND.	GP ML	N/A N/A	
45.0							

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. SAMPLES TAKEN WITH SANTOARD SPLIT SPOON SAMPLER - 2.0" O.D. DRILLER - K DYKES. ASSISTANT - TIM HARRIS. RIG - CYCLONE 42.

FERNALD RI/FS — VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: [illegible]	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2066	COORDINATES: NORTH 483,938.95 EAST 1,376,703.45	DATE: 08/25/87
GROUND ELEVATION: 578.2	GWL: Depth N/A Date/Time N/A	DATE STARTED: 08.
ENGINEER/GEOLOGIST: D. OAKLEY	Depth N/A Date/Time N/A	DATE COMPLETED: 0
DRILLING METHODS: CABLE-TOOL		PAGE 5 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REI
46.5	07029 08/31/87 0830	18 25 17	17	HARD GRAY SILT, TRACE CLAY AND SAND, LENS GRAY CLAY.	ML	N/A	
50.0							
51.5	07030 08/31/87 0930	4 20 13	15	HARD GRAY CLAY, TRACE SILT. HARD GRAY SILT, SOME SAND, TRACE CLAY.	CL ML	N/A	
55.0							
56.5	07031 07032 08/31/87 1025		18	VERY STIFF GRAY SILT, SOME SAND, TRACE CLAY. VERY STIFF GRAY CLAY, SOME SAND, TRACE SILT. MEDIUM DENSE GRAY SAND, TRACE CLAY, SOME SILT.	ML CH SM	N/A N/A N/A	
60.0							

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. WET SAND. DRILLER - HARRY DYKES. ASSISTANT - TIM HARRIS. RIG - CYCLONE
SAMPLES TAKEN WITH STANDARD SPLIT SPOON SAMPLER - 2.0" O.D.

FERNALD RI/FS VISUAL CLASSIFICATION OF SOILS 3065[redacted]

PROJECT NUMBER: 602 3.2 PROJECT NAME: FMPC RI/FS

BORING NUMBER: 2066 COORDINATES: NORTH 483,938.95 EAST 1 376,703.45 DATE: 08/25/87

GROUND ELEVATION: 578.2 GWL: Depth N/A Date/Time N/A DATE STARTED: 0

ENGINEER/GEOLOGIST: D. OAKLEY Depth N/A Date/Time N/A DATE COMPLETED: (

DRILLING METHODS: CABLE-TOOL PAGE 6 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY (INCHES)		USCS SYMBOL	TSF	RE
61.5	07033 07034 08/31/87 1420	6 6 10	18	MEDIUM DENSE GRAY SAND, SOME SILT, TRACE CLAY. VERY STIFF GRAY CLAY, TRACE SAND AND SILT.			

BOTTOM OF BORING 63

NOTES:
DRILLER - HARRY DYKES. ASSISTANT - TIM HARRIS. RIG - CYCLONE 42. SPLIT SPOON SAMPLES TAKEN WITH STANDARD TU
2.0" O.D.

[redacted] 17

PROJECT NUMBER: 602 [illegible] PROJECT NAME: [illegible] RI/FS

BORING NUMBER: 3066 COORDINATES: NORTH 483.951.29 EAST 1,376,706.241 DATE: 09/16/87

GROUND ELEVATION: 573.2 | GWL: Depth N/A Date/Time N/A | DATE STARTED: 0

ENGINEER/GEOLOGIST: D. OAKLEY | Depth N/A Date/Time N/A | DATE COMPLETED: (

DRILLING METHODS: CABLE-TOOL | PAGE 1 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY (INCHES)		USCS SYMBOL	TSF	RE
61.5							
63.5	07041 09/16/87 0950		24	FOR DESCRIPTION OF SOILS FROM 0-62.0 FT SEE VISUAL CLASSIFICATION OF SOILS FROM WELL 266.			
65.0							
66.5	07036 07035 09/16/87 1050	6 23 50	14	HARD GRAY SILT, SOME CLAY, MOIST.	ML	N/A	
70.0							
71.5	07038 07037 09/16/87 1300	15 25 40	18	HARD GRAY SILTY CLAY - DRY.	CL	2.25	
75.0							

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. SEE LOG FROM WELL #266 FOR DESCRIPTION OF FIRST 62. RIG - CYCLONE 42. - HARRY DYKES. ASSISTANT - TIM HARRIS. BACKGROUND READINGS - HNU - ZERO. ALPHA - 0 COUNTS/MIN. BETA/GAMMA - COUNTS/MIN.

[redacted]

PROJECT NUMBER: 602 [illegible] | PROJECT NAME: FMPC RI/FS

BORING NUMBER: 3066 | COORDINATES: NORTH 483,951.29 EAST 1,376,706.24 | DATE: 09/16/87

GROUND ELEVATION: 578.2 | GWL: Depth N/A Date/Time N/A | DATE STARTED: 0

ENGINEER/GEOLOGIST: D. OAKLEY | Depth N/A Date/Time N/A | DATE COMPLETED:

DRILLING METHODS: CABLE-TOOL | PAGE 2 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY	INCHES		USCS SYMBOL	TSF	RE
76.5	07039 07040 09/16/87 1340	8 15 19	16		HARD GRAY SILTY CLAY - MOIST.	CL	1.5	
80.5								
81.5	07043 07042 09/16/87 1500	11 22 31	18		HARD GRAY CLAY, TRACE SILT - DRY.	CL	3.0	
87.5								
89.0	07044 07045 09/16/87 1545	6 15 14	18		MEDIUM DENSE GRAY FINE SAND - WET. GRAY CLAY, SOME SAND, TRACE SILT.	SP CL	0.2	
90.0								

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. SEE LOG FROM WELL #266 FOR DESCRIPTION OF FIRST 62. RIG - CYCLONE 42. D - HARRY DYKES. ASSISTANT - TIM HARRIS. BACKGROUND READINGS - HNU-ZERO, ALPHA-0 COUNTS/MIN. BETA/GAMMA - 40- COUNTS/MIN.

[redacted] 19

PROJECT NUMBER: 632 [illegible]	PROJECT NAME: FMPC RI/FS
BORING NUMBER: [illegible]	COORDINATES: NORTH 483,951.29 EAST 1,376,706.24 | DATE: 09/16/87
GROUND ELEVATION: 578.2	GWL: Depth N/A Date/Time N/A | DATE STARTED:
ENGINEER/GEOLOGIST: D. OAKLEY	Depth N/A Date/Time N/A | DATE COMPLETED:
DRILLING METHODS: CABLE-TOOL	PAGE 3 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY (INCHES)		USCS SYMBOL	TSF
91.5	07047 07046 09/17/87 0830	7 9 11	18	MEDIUM DENSE DARK GRAY FINE GRAINED SAND, TRACE CLAY AND SILT - WET. GRAY CLAY, TRACE SAND AND SILT.	SP CL	0.2
95.0						
96.5	07048 09/17/87 0930	30 50	3	HARD DRY CLAY,M SOME SILT, TRACE SAND - DRY.	CL	2.5
100.0						
101.5	07049 09/17/87 1130	9 14 25	13	HARD GRAY SILT, SOME CLAY, TRACE SAND - DRY.	ML	.75
105.0						

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. ADDED 20 GALLONS WATER. SEE LOG FROM WELL #266 FOR FIRST 62. RIG - CY[illegible] 42. DRILLER - HARRY DYKES. ASSISTANT - TIM HARRIS. BACKGROUND READINGS - HNU - 0 ZERO, ALPHA - 0 COUNTS/MI[illegible] BETA/GAMMA - 40-80 COUNTS/

[redacted] 20

FERNALD RI/FS — VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 [illegible] | PROJECT NAME: FMPC RI/FS

BORING NUMBER: 3066 | COORDINATES: NORTH 483,951.29 EAST 1,376,706.24 | DATE: 09/16/87

GROUND ELEVATION: 573.2 | GWL: Depth N/A Date/Time N/A | DATE STARTED: 09/

ENGINEER/GEOLOGIST: D. OAKLEY | Depth N/A Date/Time N/A | DATE COMPLETED: 09

DRILLING METHODS: CABLE-TOOL | PAGE 4 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REM
106.5	07050 07051 09/17/87 1230	27 50 50	16	HARD GRAY SILTY CLAY, TRACE SAND - DRY.	CL	3.0	
110.0							
111.5	07053 07052 09/17/87 1400	11 34 43	13	HARD DRY SILTY CLAY.	CL	2.5	
113.5	07054 09/17/87 1500		23				
115.0							
116.5	07055 09/17/87 1545	11 16 23	12	HARD GRAY SILTY CLAY - DRY.	CL	2.5	
120.0							

NOTES:
SAMPLE SCANNED BACKGROUND READINGS. 7:30 9-18-87. SEE LO FROM WELL #266 FOR FIRST 62. RIG - CYCLONE 42. DRILL HARRY DYKES. ASSISTANT - TIM HARRIS. BACKGROUND READINGS - HNU - ZERO, ALPHA - 0 COUNTS/MIN. BETA/GAMMA - 40- COUNTS/MIN.

PROJECT NUMBER: 532 [illegible] PROJECT NAME: FMPC RI/FS

BORING NUMBER: 3066 COORDINATES: NORTH 483,951.29 EAST 1,376,706.24 DATE: 09/16/87

GROUND ELEVATION: 578.2 GWL: Depth N/A Date/Time N/A | DATE STARTED: 09

ENGINEER/GEOLOGIST: D. OAKLEY Depth N/A Date/Time N/A | DATE COMPLETED: (

DRILLING METHODS: CABLE-TOOL | PAGE 5 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	RE
121.5	07056 07057 09/18/87 0830	12 16 26	18	HARD GRAY CLAY, TRACE SILT - MOIST. DENSE GRAY SAND, SOME CLAY - MOIST. DENSE DARK GRAY SAND, SOME CLAY, TRACE GRAVEL - MOIST.	CL SP SW	2.0 1.0 0.5	
125.0							
126.5	07059 07058 09/18/87 0920	15 25 50	18	VERY DENSE GRAY SAND, TRACE GRAVEL, TRACE CLAY, WET, MEDIUM GRAIN SIZE.	SW	0.2	
130.0							
131.5	07060 07061 09/18/87 1030	17 38 46	18	VERY DENSE GRAY COARSE SAND, SOME GRAVEL - WET.	SW	0.3	
135.0							

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. ADDED 25 GALLONS WATER. (SEE LOG FROM WELL #266 FOR FIRST 62. RIG - CY 42. DRILLER - HARRY DYKES. ASSISTANT - TIM HARRIS. SCREEN SET FROM 125-135. BACKGROUND - HNU - ZERO, ALPHA COUNTS/MIN., BETA/GAMM

[redacted] 22

PROJECT NUMBER: 602 [illegible]	PROJECT NAME: FMPC RI/FS		
BORING NUMBER: 3066	COORDINATES: NORTH 483.951.29 EAST 1,376.706.24		DATE: 09/16/87
GROUND ELEVATION: 573.2	GWL: Depth N/A	Date/Time N/A	DATE STARTED: (
ENGINEER/GEOLOGIST: D. OAKLEY	Depth N/A	Date/Time N/A	DATE COMPLETED:
DRILLING METHODS: CABLE-TOOL			PAGE 6 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	R
136.5	07062 09/18/87 1440	11 17 31	8	VERY DENSE GRAY SAND - WET, MEDIUM GRAIN SIZE.	SP	0.2	
140.0							
141.5	07064 07063 09/18/87 1615	9 13 19	18	HARD DARK GRAY SANDY CLAY, TRACE SILT - MOIST.	CL	1.0	
148.0							
149.5	07066 07065 09/19/87 0840	21 31 35	15	GRAY SANDY CLAY - MOIST. HARD, GRAY CLAY, SOME SILT - MOIST.	CL	.75	
150.0							

NOTES:
SAMPLE SCANNED - BACKGROUND READINGS. SEE LOG FROM WELL #266 FOR FIRST 62. RIG - CYCLONE 42. DRILLER - HARR
ASSISTANT - TIM HARRIS. BACKGROUND - HNU - ZERO, ALPHA - 0 COUNTS/MIN., BETA/GAMMA - 40-80 COUNTS/MIN.

FERNALD RI/FS — VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 [illegible]	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3066	COORDINATES: NORTH 483,951.29 EAST 1,376,706.24	DATE: 09/16/87
GROUND ELEVATION: 573.2	GWL: Depth N/A Date/Time N/A	DATE STARTED: 09
ENGINEER/GEOLOGIST: D. OAKLEY	Depth N/A Date/Time N/A	DATE COMPLETED: C
DRILLING METHODS: CABLE-TOOL		PAGE 7 OF

DEPTH	SAMPLE	DATE	TIME	BLOWS ON	SAMPLE	RECOVERY	INCHES		USCS	SYMBOL	TSF	RE
152.0	07067	09/19/87	1250			20		HARD, GRAY SILTY CLAY, MOIST. SAMPLE TD 152 FT.				

BOTTOM OF BORING 152

NOTES:
SHELBY TUBE. DESCRIPTION BASED ON PREVIOUS SAMPLE AND CLASSIFICATION OF SOILS OBSERVED AT ENDS OF TUBE. SEE L WELL #266 FOR FIRST 62. RIG - CYCLONE 42. DRILLER - HARRY DYKES. ASSISTANT - TIM HARRIS. HOLE TD 150 - SHE TAKEN FROM 150 TO 152

FERNALD RI/FS VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.0 PROJECT NAME: FMPC RI/FS

BORING NUMBER: 3043 COORDINATES: NORTH 481,770.91 EAST 1,377,050.35 DATE: 12/04/87

GROUND ELEVATION: GWL: Depth N/A Date/Time N/A DATE STARTED:

ENGINEER/GEOLOGIST: B. DUNNING Depth N/A Date/Time N/A DATE COMPLETED:

DRILLING METHODS: CABLE-TOOL PAGE 1 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	
1.5	07614 12/04/87 0800	2 6 7	12	VERY SOFT, VERY DARK GRAYISH-BROWN CLAY (2.5Y, 3/2), SILTY AND DRY WITH ROOTLETS.	OL	<.5	Hnu= α = βΓ =
3.0	07615 12/04/87 0810	5 7 8	12	VERY STIFF, GRAYISH-BROWN CLAY (2.5Y, 5/2) DAMP.	CL	3.5	Hnu= α = βΓ =
4.5	07616 12/04/87 0835	11 11 14	12	STIFF, LIGHT OLIVE-BROWN CLAY (2.5Y, 4/4) WITH A TRACE OF VERY FINE GRAVEL, DAMP.	CL	2.0	Hnu= α = βΓ =
6.0	07617 12/04/87 0840	9 11 10	15	SOFT, LIGHT OLIVE-BROWN CLAY (2.5Y, 5/6) SILTY AND DAMP.	CL	.50	Hnu= α = βΓ =
7.5	07618 12/04/87 0850	8 11 7	9	VERY SOFT, LIGHT OLIVE-BROWN CLAY (2.5Y, 5/6), FAIR AMOUNT OF MOISTURE NOTED.	CL	<.25	Hnu= α = βΓ =
9.0	07619 12/04/87 1055	10 10 10	18	VERY SOFT, LIGHT OLIVE-BROWN CLAY (2.5Y, 5/6), FAIR AMOUNT OF MOISTURE NOTED.	CL	<.25	Hnu= (α = (βΓ = 2
10.5	07620 12/04/87 1105	7 8 11	18	MEDIUM STIFF, OLIVE-YELLOW CLAY (2.5Y, 6/8) DAMP. STIFF OLIVE-BROWN CLAY (2.5Y, 4/4) MOIST.	CL CL	1.0 1.0	Hnu= (α = (βΓ = 2
12.0	07621 12/04/87 1120	12 11 13	18	MEDIUM STIFF, LIGHT OLIVE-BROWN CLAY (2.5Y, 5/6) DRY. STIFF, DARK GRAYISH-BROWN CLAY (2.5Y, 4/2). MEDIUM DENSE, LIGHT OLIVE BROWN SILTY SAND (2.5Y, 5/6) DAMP.	CL CL SM	1.5 1.5 N/A	Hnu= 0 α = 0 βΓ = 2
13.5	07622 12/04/87 1130	3 7 4	18	MEDIUM DENSE, LIGHT OLIVE BROWN SILTY SAND (2.5Y, 5/6), DAMP. MEDIUM DENSE, GRAYISH-BROWN SAND (2.5Y, 5/2). MEDIUM DENSE, LIGHT OLIVE-BROWN SAND (2.5Y, 5/6).	SM SC SP	N/A N/A N/A	Hnu= 0 α = 0 βΓ = 2(
15.0	07623 12/04/87 1140	11 13 17	18	VREY STIFF, DARK GRAY CLAY (5Y, 4/1) WITH A TRACE OF FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 α = 0 βΓ = 20

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL COL
ASTM.

PROJECT NUMBER: 602 212	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3043	COORDINATES: NORTH 481,770.91 EAST 1,377,050.35	DATE: 12/04/87
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 12/
ENGINEER/GEOLOGIST: B. DUNNING	Depth N/A Date/Time N/A	DATE COMPLETED: 12
DRILLING METHODS: CABLE-TOOL		PAGE 2 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS	SYMBOL	TSF	REM
16.5	07624 12/04/87 1540	7 8 12	18	STIFF, DARK GRAYISH-BROWN (2.5Y, 4/2) CLAY, SLIGHTLY SILTY, DRY.	CL		1.5	Hnu= 0 α = 0 βΓ = 2(
18.0	07625 12/04/87 1550	7 8 11	12	STIFF, DARK GRAYISH-BROWN (2.5Y, 4/2) CLAY, SLIGHTLY SILTY, DRY. MEDIUM DENSE, DARK GRAY SD (5Y, 4/1), SILTY WITH SOME GRAVEL.	CL SP		1.5 N/A	Hnu= 0 α = 0 βΓ = 2(
19.5	07626 12/05/87 0830	5 7 9	13	STIFF, OLIVE GRAY CLAY (5Y, 5/2) WITH A TRACE OF GRAVEL, DRY.	CL		1.55	Hnu= 0 α = 0 βΓ = 5(
21.0	07627 12/05/87 0841	14 22 27	15	STIFF, OLIVE GRAY CLAY (5Y, 5/2) WITH A TRACE OF GRAVEL, DRY.	CL		1.55	Hnu= 0 α = 0 βΓ = 4(
22.5	07628 12/05/87 0944	8 11 16	6	MEDIUM DENSE, OLIVE GRAY CLAYEY GRAVEL (5Y, 5/2) WITH SOME COARSE GRAVEL AND ROCK FRAGMENTS, MOIST.	GC		N/A	Hnu= 0 α = 0 βΓ = 40
24.0	07629 12/05/87 0950	15 37 29	18	HARD, DARK GRAY CLAY (5Y, 4/1) WITH A TRACE OF FINE TO COARSE GRAVEL, DAMP.	CL		4.5+	Hnu= 0 α = 0 βΓ = 20
25.5	07770 12/05/87 1024	17 22 31	18	STIFF, GRAY CLAY (5Y, 5/1) WITH A TRACE OF GRAVEL, DRY. VERY DENSE, GRAY TO DARK GRAY GRAVEL (5Y, 5/1 TO 4/1), CLAYEY IN PARTS, WET.	CL GC		1.5 N/A	Hnu= 0 α = 0 βΓ = 20-
27.0	07771 12/05/87 1035	17 24 30	6	VERY DENSE, GRAY TO DARK GRAY GRAVEL (5Y, 5/1 TO 4/1), CLAYEY IN PARTS, WET.	GC		N/A	Hnu= 0 α = 0 βΓ = 20-
28.5	07772 12/05/87 1045	5 17 17	18	VERY DENSE, GRAY TO DARK GRAY GRAVEL (5Y, 5/1 TO 4/1), CLAYEY IN PARTS, WET. STIFF, DARK GRAY CLAY (5Y, 4/1) WITH A TRACE OF GRAVEL.	GC CL		N/A 1.5	Hnu= 0 α = 0 βΓ = 20-
30.0	07773 12/05/87 1400	4 11 17	15	STIFF, DARK GRAY CLAY (2.5Y, N/4) WITH A TRACE OF GRAVEL.	CL		1.5	Hnu= 0 α = 0 βΓ = 20-

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL COL ASTM.

FERNALD RI/FS 3065 [redacted]

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 ... PROJECT NAME: FMPC RI/FS

BORING NUMBER: 3043 COORDINATES: NORTH 481,770.91 EAST 1,377,050.35 DATE: 12/04/87

GROUND ELEVATION: GWL: Depth N/A Date/Time N/A DATE STARTED: 12/(

ENGINEER/GEOLOGIST: B. DUNNING Depth N/A Date/Time N/A DATE COMPLETED: 12/

DRILLING METHODS: CABLE-TOOL PAGE 3 OF 7

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REM
31.5	07774 12/05/87 1405	10 13 18	18	MEDIUM STIFF, DARK GRAY CLAY (2.5Y, N4/) WITH A TRACE OF FINE GRAVEL.	CL	.75	Hnu= 0 α = 0 βΓ = 40
33.0	07775 12/05/87 1420	10 14 17	16	MEDIUM STIFF, DARK GRAY CLAY (2.5Y, N4/) WITH A TRACE OF FINE GRAVEL. VERY STIFF, DARK YELLOWISH-BROWN CLAY (10YR, 4/4).	CL CL	.75 3.75	Hnu= 0 α = 0 βΓ = 40
34.5	07776 12/05/87 1440	11 14 15	18	DARK GRAY, DENSE, FINE GRAVEL (2.5Y, N4). MEDIUM DENSE, YELLOWISH-BROWN SAND (10YR, 5/8) WITH A TRACE OF FINE GRAVEL, DRY.	GW	N/A	Hnu= 0 α = 0 βΓ = 40
40.0							
41.5	07777 12/05/87 1657	10 22 33	18	VERY DENSE, MULTICOLORED BROWN, LOOSE, FINE GRAVEL. VERY DENSE, YELLOWISH-BROWN SAND (10YR, 5/6) WITH A TRACE OF FINE GRAVEL, DRY.			Hnu= 0 α = 0 βΓ = 40
45.0							

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL COL
ASTM.

[redacted] 27

PROJECT NUMBER: 602 ...	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 1043	COORDINATES: NORTH 481,770.91 EAST 1,377,050.35	DATE: 12/04/87
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 12/
ENGINEER/GEOLOGIST: B. DUNNING	Depth N/A Date/Time N/A	DATE COMPLETED: 1
DRILLING METHODS: CABLE-TOOL		PAGE 4 OF

DEPTH	SAMPLE / DATE / TIME	BLOWS / 6 IN	SAMPLE RECOVERY INCHES	DESCRIPTION	USCS SYMBOL	TSF	REM
46.5	07778 12/07/87 0940	11 23 30	16	VERY DENSE, YELLOWISH-BROWN SAND (10YR, 5/6), DAMP.	SW	N/A	Hnu= 0 α = 0 βΓ = 2
50.0							
51.5	07779 12/07/87 1006	12 22 25	13	DENSE, YELLOWISH-BROWN SAND (10YR, 5/6). DAMP BUT NOT SATURATED.	SW	N/A	Hnu= 0 α = 0 βΓ = 3
55.0							
56.5	07780 12/07/87 1032	12 23 29	18	DENSE, YELLOWISH-BROWN SAND (10YR, 5/6). DAMP BUT NOT SATURATED. VERY DENSE, DARK GRAYISH-BROWN (2.5Y, 4/2) SAND, GRAY SAND FAIRLY MOIST.	SW SW	N/A N/A	
60.0							

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL CC
ASTM.

ERNALD RI/FS — VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 ... — PROJECT NAME: FMPC RI/FS

BORING NUMBER: 1043 — COORDINATES: NORTH 481,773.91 EAST 1,377,050.351 DATE: 12/04/87

GROUND ELEVATION: — GWL: Depth N/A Date/Time N/A — DATE STARTED: 12.

ENGINEER/GEOLOGIST: B. DUNNING — Depth N/A Date/Time N/A — DATE COMPLETED: 1.

DRILLING METHODS: CABLE-TOOL — PAGE 5 OF

DEPTH	SAMPLE	DATE	TIME	BLOWS ON SAMPLE	RECOVERY INCHES	DESCRIPTION	USCS	SYMBOL	TSF	REMARKS
61.5	07781	12/07/87	1108	9 17 26	16	DENSE, DARK GRAYISH-BROWN (2.5Y, 4/2) SAND W/SOME FINE GRAVEL. MOIST, BUT QUESTIONABLE ABOUT BEING WET.	SW		N/A	Hnu= (α = (βΓ = 4
65.0										
66.5	07782	12/07/87	1316	9 14 17	18	DENSE, DARK GRAYISH-BROWN (10YR, 4/2) COARSE SAND, APPEARS WET DENSE, OLIVE-GRAY (5Y, 4/2) FINE SANDY GRAVEL.	SW GW		N/A N/A	Hnu= (α = (βΓ = 4
70.0										
71.5	07783	12/07/87	1456	50 50	10	VERY DENSE, DARK GRAYISH-BROWN SAND (2.5Y, 4/2), WET. VERY DENSE, DARK GRAY (5Y, 4/1) CLAYEY GRAVEL.	SW GC		N/A N/A	Hnu= 0 α = 0 βΓ = 4
75.0										

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL C
ASTM.

PROJECT NUMBER: [illegible] PROJECT NAME: FMPC RI/FS

BORING NUMBER: [illegible] COORDINATES: NORTH 481,770.91 EAST 1,377,050.35 DATE: 12/04/87

GROUND ELEVATION: GWL: Depth N/A Date/Time N/A DATE STARTED: 1

ENGINEER/GEOLOGIST: B. DUNNING Depth N/A Date/Time N/A DATE COMPLETED:

DRILLING METHODS: CABLE-TOOL PAGE 6 OF

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	R
76.5	07784 12/07/87 1621	19 39 50	18	VERY DENSE, VERY DARK GRAY SAND WITH SOME FINE TO COARSE GRAVEL (5Y, 3/1).	SP	N/A	Hnu= α = βΓ =
80.0							
81.5	07785 12/07/87 1648	10 13 18	14	DENSE, MULTICOLORED (BROWN, GRAYS, WHITE, BLACK) LOOSE, POORLY GRADED FINE TO COARSE GRAVEL.	GP	N/A	Hnu= α = βΓ =
85.0							
86.5	07786 12/08/87 0845	18 39 50	18	MULTICOLORED GRAVEL, GEN A/A. VERY DENSE, DARK GRAY SILTY TO CLAYEY GRAVEL (5Y, 4/1).	GW GM	N/A N/A	Hnu= α = βΓ =
90.0							

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL C ASTM.

[redacted] 30

PROJECT NUMBER: [illegible] PROJECT NAME: FMPC RI/FS

BORING NUMBER: 1043 COORDINATES: NORTH 481,773.91 EAST 1,377,050.35 DATE: 12/04/87

GROUND ELEVATION: | GWL: Depth N/A Date/Time N/A | DATE STARTED: 12

ENGINEER/GEOLOGIST: B. DUNNING | Depth N/A Date/Time N/A | DATE COMPLETED: 1

DRILLING METHODS: CABLE-TOOL | PAGE 7 OF

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	RE
91.5	07787	12/08/87 1006	7 17 29	16	DENSE, DARK GRAYISH-BROWN (2.5Y, 4/2) SAND WITH SOME FINE GRAVEL.	SW	N/A	Hnu= α = ßΓ =
95.0								
96.5	07788	12/08/87 1113	17 25 35	18	VERY DENSE, DARK GRAYISH-BROWN (2.5Y, 4/2) SAND.	SW	N/A	Hnu= α = ßΓ =
100.0								
101.5	07789	12/08/87 1137	23 35 38		VERY DENSE, DARK GRAYISH BROWN SAND (2.5Y, 4/2). VERY DENSE, DARK GRAYISH-BROWN SILTY SAND (2.5Y, 4/2).			Hnu= 0 α = 0 ßΓ = 4
108.0								
109.5	07790	12/08/87 1417	20 37 44	18	VERY DENSE, DARK GRAY SAND (5Y, 4/1), SILTY WITH A TRACE OF CLAY.	SM	N/A	Hnu= 0 α = 0 ßΓ = 4
115.0								
116.5	07791	12/08/87 1657	1 2 9	12	MEDIUM DENSE, BLUISH-GREEN TYPE OF SAND (NO MUNCELL COLOR CHART CORRELATION), SILTY AND SLIGHTLY CLAYEY.			Hnu= 0 α = 0 ßΓ = 30
119.0								
120.5	07792	12/09/87 1055	7 4 12	18	MEDIUM DENSE, BLUISH-GREEN SAND WITH SOME GRAVEL, VREY CLAYEY.	SC	N/A	Hnu= 0 α = 0 ßΓ = 30
125.0								
126.5	07793	12/09/87 1336	2 2 3	18	LOOSE, OLIVE-GRAY SILTY SAND (5Y, 5/2). SOFT, "BLUE-GRAY" CLAY. (NO MUNCELL COLOR CORRELATION) CLOSEST CORRELATION IS (5Y, 4/1).		<1.0	Hnu= 0 α = 0 ßΓ = 40

BOTTOM OF BORING 120

NOTES:
DRILLING CONTRACTOR: PENNSYLVANIA DRILLING, DRILLER: TIM HARRIS, HELPER: CRAIG COULTER. SAMPLES VIA MUNSELL COL ASTM.

APPENDIX 2

WELL #	DATE MEASURED	TOP OF WELL	TOP OF CASING	REF POINT	WATER LEVEL MEASURED	WATER LEVEL (AMSL)
1645	01/19/91	583.94	584.63	1	3.69	580.25
1645	02/21/91	583.94	584.63	1	3.60	580.34
1645	06/04/91	583.94	584.63	1	5.32	578.62
1645	07/30/91	583.94	584.63	1	8.20	575.74
1645	08/29/91	583.94	584.63	1	7.20	576.74
1645	09/20/91	583.94	584.63	1	6.56	577.38
1645	11/02/91	583.94	584.63	1	8.04	575.90
1645	10/05/91	583.94	584.63	1	16.01	567.93
1645	12/14/91	583.94	584.63	1	4.90	579.04
1646	11/02/91	585.34	585.85	1	23.05	562.29
1646	12/14/91	585.34	585.85	1	17.81	567.53
2010	01/19/91	584.09	584.62	1	59.74	524.35
2010	02/22/91	584.09	584.62	1	59.38	524.71
2010	06/04/91	584.09	584.62	1	59.38	524.71
2010	07/30/91	584.09	584.62	1	61.08	523.01
2010	08/29/91	584.09	584.62	1	61.78	522.31
2010	09/20/91	584.09	584.62	1	62.60	521.49
2010	11/02/91	584.09	584.62	1	63.90	520.19
2010	10/06/91	584.09	584.62	1	63.09	521.00
2010	12/14/91	584.09	584.62	1	64.72	519.37
2013	01/20/91	589.77	590.45	2	66.21	524.24
2013	02/22/91	589.77	590.45	2	66.42	524.03
2013	03/20/91	589.77	590.45	2	66.61	523.84
2013	05/30/91	589.77	590.45	2	66.69	523.76
2013	07/27/91	589.77	590.45	2	69.03	521.42
2013	08/29/91	589.77	590.45	2	70.13	520.32
2013	11/07/91	589.77	590.45	2	72.34	518.11
2013	10/02/91	589.77	590.45	2	71.09	519.36
2013	12/09/91	589.77	590.45	2	72.99	517.46
2019	01/19/91	584.81	585.37	2	60.78	524.59
2019	02/21/91	584.81	585.37	2	60.42	524.95
2019	06/04/91	584.81	585.37	2	60.11	525.26
2019	07/30/91	584.81	585.37	2	61.60	523.77
2021	01/19/91	584.86	585.92	2	61.25	524.67
2021	02/21/91	584.86	585.92	2	60.90	525.02
2021	06/05/91	584.86	585.92	2	60.66	525.26
2021	07/30/91	584.86	585.92	2	62.02	523.90
2021	08/29/91	584.86	585.92	2	62.81	523.11
2021	09/20/91	584.86	585.92	2	63.64	522.28
2021	11/02/91	584.86	585.92	2	64.94	520.98
2021	10/05/91	584.86	585.92	2	64.04	521.88
2021	12/15/91	584.86	585.92	2	65.74	520.18
2027	01/19/91	585.55	585.56	1	61.19	524.36
2027	02/22/91	585.55	585.56	1	60.78	524.77
2027	06/04/91	585.55	585.56	1	60.57	524.98
2027	07/30/91	585.55	585.56	1	62.00	523.55

Reference point 1 is Top Of Well; 2 is Top Of Casing

WELL #	DATE MEASURED	TOP OF WELL	TOP OF CASING	REF POINT	WATER LEVEL MEASURED	**WATER LEVEL (AMSL)**
2027	08/29/91	585.55	585.56	1	62.83	**522.72**
2027	09/19/91	585.55	585.56	1	63.68	**521.87**
2027	11/02/91	585.55	586.09	1	64.94	**520.61**
2027	10/06/91	585.55	586.09	1	64.16	**521.39**
2027	12/14/91	585.55	586.09	1	65.80	**519.75**
2037	01/19/91	590.54	591	1	66.49	**524.05**
2037	02/22/91	590.54	591	1	66.06	**524.48**
2037	06/04/91	590.54	591	1	66.50	**524.04**
2037	08/29/91	590.54	591	1	68.36	**522.18**
2037	09/20/91	590.54	591	1	69.25	**521.29**
2037	11/02/91	590.54	591	1	70.57	**519.97**
2037	10/06/91	590.54	591	1	69.72	**520.82**
2037	12/14/91	590.54	591	1	71.38	**519.16**
2043	01/18/91	579.73	580.06	1	54.71	**525.02**
2043	02/26/91	579.73	580.06	1	54.00	**525.73**
2043	03/27/91	579.73	580.06	1	53.90	**525.83**
2043	06/01/91	579.73	580.06	1	53.42	**526.31**
2043	07/26/91	579.73	580.06	1	54.68	**525.05**
2043	08/23/91	579.73	580.06	1	55.21	**524.52**
2043	09/07/91	579.73	580.06	1	55.54	**524.19**
2043	11/04/91	579.73	580.06	1	57.02	**522.71**
2043	10/07/91	579.73	580.06	1	56.40	**523.33**
2043	12/02/91	579.73	580.06	2	57.81	**522.25**
2051	01/17/91	609.38	609.96	1	86.27	**523.11**
2051	02/26/91	609.38	609.96	1	86.32	**523.06**
2051	03/18/91	609.38	609.96	1	86.07	**523.31**
2051	06/14/91	609.38	609.96	1	87.20	**522.18**
2051	07/25/91	609.38	609.96	1	88.91	**520.47**
2051	08/22/91	609.38	609.96	1	90.00	**519.38**
2051	09/07/91	609.38	609.96	1	90.41	**518.97**
2051	11/05/91	609.38	609.96	1	92.27	**517.11**
2051	10/07/91	609.38	609.96	1	91.59	**517.79**
2051	12/05/91	609.38	609.96	2	93.70	**516.26**
2055	01/20/91	588.22	588.74	1	63.96	**524.26**
2055	02/22/91	588.22	588.74	1	63.84	**524.38**
2055	03/20/91	588.22	588.74	1	63.91	**524.31**
2055	06/05/91	588.22	588.74	1	64.24	**523.98**
2055	07/27/91	588.22	588.74	1	65.84	**522.38**
2055	08/28/91	588.22	588.74	1	66.84	**521.38**
2055	09/12/91	588.22	588.74	1	67.31	**520.91**
2055	11/07/91	588.22	588.74	1	68.98	**519.24**
2055	10/03/91	588.22	588.74	1	67.90	**520.32**
2055	12/09/91	588.22	588.74	1	69.68	**518.54**
2066	01/18/91	579.88	580.38	1	40.91	**538.97**
2066	02/26/91	579.88	580.38	1	40.71	**539.17**
2066	03/27/91	579.88	580.38	1	40.77	**539.11**
2066	06/01/91	579.88	580.38	1	40.71	**539.17**
2066	07/26/91	579.88	580.38	1	40.90	**538.98**

Reference point 1 is Top Of Well; 2 is Top Of Casing

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WELL #	DATE MEASURED	TOP OF WELL	TOP OF CASING	REF POINT	WATER LEVEL MEASURED	WATER LEVEL (AMSL)
2066	08/23/91	579.88	580.38	1	40.18	539.70
2066	09/07/91	579.88	580.38	1	40.90	538.98
2066	11/04/91	579.88	580.38	1	40.96	538.92
2066	10/07/91	579.88	580.38	1	40.96	538.92
2066	12/02/91	579.88	580.38	2	41.26	539.12
2084	01/19/91	585.10	585.49	1	60.58	524.52
2084	02/21/91	585.10	585.49	1	60.22	524.88
2084	06/05/91	585.10	585.49	1	59.95	525.15
2084	07/28/91	585.10	585.49	1	61.13	523.97
2084	08/29/91	585.10	585.49	1	62.02	523.08
2084	11/03/91	585.10	585.49	1	64.10	521.00
2084	10/05/91	585.10	585.49	1	63.09	522.01
2084	12/15/91	585.10	585.49	1	64.94	520.16
2643	01/19/91	583.81	584.27	1	58.95	524.86
2643	02/21/91	583.81	584.27	1	58.62	525.19
2643	06/05/91	583.81	584.27	1	58.26	525.55
2643	07/28/91	583.81	584.27	1	59.41	524.40
2643	08/29/91	583.81	584.27	1	60.30	523.51
2643	11/03/91	583.81	584.27	1	61.99	521.82
2643	10/05/91	583.81	584.27	1	61.40	522.41
2643	12/15/91	583.81	584.27	1	63.20	520.61
2648	01/19/91	583.43	584.03	1	58.59	524.84
2648	02/21/91	583.43	584.03	1	58.25	525.18
2648	06/04/91	583.43	584.03	1	57.94	525.49
2648	07/30/91	583.43	584.03	1	59.45	523.98
2648	08/29/91	583.43	584.03	1	60.25	523.18
2648	09/19/91	583.43	584.03	1	61.09	522.34
2648	11/02/91	583.43	584.03	1	62.31	521.12
2648	10/05/91	583.43	584.03	1	61.49	521.94
2648	12/15/91	583.43	584.03	1	63.24	520.19
2649	01/19/91	577.77	578.25	1	51.85	525.92
2649	02/21/91	577.77	578.25	1	51.52	526.25
2649	06/05/91	577.77	578.25	1	51.43	526.34
2649	07/30/91	577.77	578.25	1	52.89	524.88
2649	11/03/91	577.77	578.25	1	55.39	522.38
2649	10/05/91	577.77	578.25	1	54.64	523.13
2649	12/15/91	577.77	578.25	1	56.15	521.62
3001	01/19/91	585.67	586.01	2	61.01	525.00
3001	02/21/91	585.67	586.01	2	60.63	525.38
3001	06/05/91	585.67	586.01	2	64.80	521.21
3001	07/30/91	585.67	586.01	2	62.05	523.96
3001	08/29/91	585.67	586.01	2	62.65	523.36
3001	09/19/91	585.67	586.01	2	63.41	522.60
3001	11/02/91	585.67	586.01	2	64.66	521.35
3001	10/05/91	585.67	586.01	2	63.84	522.17
3001	12/15/91	585.67	586.01	2	65.55	520.46
3008	01/19/91	576.76	577.76	2	53.11	524.65

Reference point 1 is Top Of Well; 2 is Top Of Casing

WELL #	DATE MEASURED	TOP OF WELL	TOP OF CASING	REF POINT	WATER LEVEL MEASURED	WATER LEVEL (AMSL)
3008	02/22/91	576.76	577.76	2	52.57	525.19
3008	06/05/91	576.76	577.76	2	52.48	525.28
3008	08/29/91	576.76	577.76	2	54.91	522.85
3008	09/19/91	576.76	577.76	2	55.51	522.25
3008	11/02/91	576.76	577.76	2	56.71	521.05
3008	10/05/91	576.76	577.76	2	55.88	521.88
3008	12/14/91	576.76	577.76	2	57.68	520.08
3010	01/19/91	587.84	587.94	2	63.80	524.14
3010	02/22/91	587.84	587.94	2	63.43	524.51
3010	06/04/91	587.84	587.94	2	62.92	525.02
3010	07/30/91	587.84	587.94	2	64.98	522.96
3010	08/29/91	587.84	587.94	2	65.86	522.08
3010	09/20/91	587.84	587.94	2	66.71	521.23
3010	11/02/91	587.84	587.94	2	68.00	519.94
3010	10/06/91	587.84	587.94	2	67.17	520.77
3010	12/14/91	587.84	587.94	2	68.00	519.94
3011	01/16/91	584.15	584.33	1	59.24	524.91
3011	02/19/91	584.15	584.33	1	59.01	525.14
3011	02/28/91	584.15	584.33	1	58.98	525.17
3011	03/18/91	584.15	584.33	1	59.00	525.15
3011	05/30/91	584.15	584.33	1	58.19	525.96
3011	06/15/91	584.15	584.33	1	58.21	525.94
3011	07/25/91	584.15	584.33	1	59.63	524.52
3011	08/01/91	584.15	584.33	1	59.80	524.35
3011	08/21/91	584.15	584.33	1	60.36	523.79
3011	09/06/91	584.15	584.33	1	60.62	523.53
3011	11/06/91	584.15	584.33	1	62.08	522.07
3011	10/07/91	584.15	584.33	1	61.52	522.63
3011	12/02/91	584.15	584.33	2	62.91	521.42
3013	01/20/91	589.71	590.52	2	66.23	524.29
3013	02/22/91	589.71	590.52	2	66.44	524.08
3013	03/20/91	589.71	590.52	2	66.62	523.90
3013	05/30/91	589.71	590.52	2	66.74	523.78
3013	07/27/91	589.71	590.52	2	69.03	521.49
3013	08/29/91	589.71	590.52	2	70.14	520.38
3013	09/09/91	589.71	590.52	2	70.50	520.02
3013	11/07/91	589.71	590.52	2	72.37	518.15
3013	10/02/91	589.71	590.52	2	71.11	519.41
3013	12/09/91	589.71	590.52	2	73.02	517.50
3019	01/19/91	584.96	585.21	2	60.59	524.62
3019	02/21/91	584.96	585.21	2	60.28	524.93
3019	06/04/91	584.96	585.21	2	59.97	525.24
3019	07/30/91	584.96	585.21	2	61.42	523.79
3019	08/29/91	584.96	585.21	2	62.24	522.97
3019	09/20/91	584.96	585.21	2	63.07	522.14
3019	11/02/91	584.96	585.21	2	64.32	520.89
3019	10/06/91	584.96	585.21	2	63.55	521.66
3019	12/14/91	584.96	585.21	2	65.19	520.02

Reference point 1 is Top Of Well; 2 is Top Of Casing

WELL #	DATE MEASURED	TOP OF WELL	TOP OF CASING	REF POINT	WATER LEVEL MEASURED	WATER LEVEL (AMSL)
3024	01/16/91	581.83	582.09	1	57.27	524.56
3024	02/19/91	581.83	582.09	1	57.21	524.62
3024	03/18/91	581.83	582.09	1	56.36	525.47
3024	05/30/91	581.83	582.09	1	56.10	525.73
3024	07/25/91	581.83	582.09	1	57.70	524.13
3024	08/21/91	581.83	582.09	1	58.50	523.33
3024	09/06/91	581.83	582.09	1	58.76	523.07
3024	11/06/91	581.83	582.09	1	60.31	521.52
3024	10/07/91	581.83	582.09	1	59.79	522.04
3024	12/02/91	581.83	582.09	2	61.20	520.89
3037	01/19/91	590.27	590.75	1	66.20	524.07
3037	02/22/91	590.27	590.75	1	65.78	524.49
3037	06/04/91	590.27	590.75	1	65.78	524.49
3037	08/29/91	590.27	590.75	1	68.10	522.17
3037	09/20/91	590.27	590.75	1	68.96	521.31
3037	11/02/91	590.27	590.75	1	70.22	520.05
3037	10/06/91	590.27	590.75	1	69.43	520.84
3037	12/14/91	590.27	590.75	1	71.09	519.18
3043	01/18/91	580.18	580.40	1	55.07	525.11
3043	02/26/91	580.18	580.40	1	54.33	525.85
3043	03/27/91	580.18	580.40	1	54.22	525.96
3043	06/01/91	580.18	580.40	1	53.72	526.46
3043	07/26/91	580.18	580.40	1	55.02	525.16
3043	08/23/91	580.18	580.40	1	55.59	524.59
3043	09/07/91	580.18	580.40	1	55.93	524.25
3043	11/04/91	580.18	580.40	1	57.43	522.75
3043	10/07/91	580.18	580.40	1	56.77	523.41
3043	12/02/91	580.18	580.40	2	58.23	522.17
3055	01/20/91	589.01	589.37	1	64.94	524.07
3055	02/22/91	589.01	589.37	2	64.83	524.54
3055	03/20/91	589.01	589.37	2	64.89	524.48
3055	06/05/91	589.01	589.37	2	65.22	524.15
3055	07/27/91	589.01	589.37	2	66.78	522.59
3055	08/28/91	589.01	589.37	2	67.82	521.55
3055	09/12/91	589.01	589.37	2	68.28	521.09
3055	11/07/91	589.01	589.37	2	70.00	519.37
3055	10/03/91	589.01	589.37	2	68.88	520.49
3055	12/09/91	589.01	589.37	2	70.54	518.83
3066	02/26/91	579.85	580.36	1	54.34	525.51
3066	06/01/91	579.85	580.36	1	53.74	526.11
3066	07/26/91	579.85	580.36	1	54.90	524.95
3066	08/23/91	579.85	580.36	1	55.52	524.33
3066	09/07/91	579.85	580.36	1	55.90	523.95
3066	11/04/91	579.85	580.36	1	57.32	522.53
3084	01/19/91	584.99	585.47	1	60.48	524.51
3084	02/21/91	584.99	585.47	1	60.10	524.89
3084	06/05/91	584.99	585.47	1	59.84	525.15

Reference point 1 is Top Of Well; 2 is Top Of Casing

APPENDIX 3

15.0 GROUNDWATER QUALITY

This section addresses the groundwater quality of the glacial overburden perched zones and the Great Miami Aquifer. The objective of this section is to determine which, if any, chemical constituents detected in groundwater can be related to FMPC activities. This is accomplished primarily by the statistical analysis of FMPC groundwater chemistry data.

The section begins with a review of the hydrogeological features of the FMPC area that are critical to the evaluation of groundwater quality. Background water quality is established and the methodology for the analysis of groundwater quality data is developed. Finally, a detailed discussion of the results of the groundwater quality analysis is presented.

Groundwater quality data collected during RI/FS sampling and discussed in this section are presented in Appendix E. These data were collected during RI/FS sampling from the period March 1988 through August 1989. Also included in Appendix E are groundwater quality data collected from June 1989 through January 1990 as part of the ongoing RCRA compliance program.

Due to the low percentage of detected organic compounds, statistical analysis of organic-compound data was not performed. To supplement RI/FS sampling results for organic compounds, the results of RCRA sampling for organic compounds are also presented. The RCRA data were collected from August 1985 through December 1987 and from June 1989 through January 1990. Also, to supplement limited RI/FS and RCRA data for aluminum, vanadium and zinc, groundwater concentrations of these metals are compared with background data from the Air, Soil, Water, and Health Risk Assessment Report in the vicinity of the FMPC (IT 1986).

15.1 HYDROGEOLOGIC FRAMEWORK FOR GROUNDWATER QUALITY ANALYSIS

The analysis of groundwater quality must begin by understanding the hydrogeology under the FMPC and vicinity. Groundwater flow directions must be known in order to examine the relationship between upgradient water quality, contaminant sources, and downgradient water quality. Regional hydrogeology is discussed in detail in Section 12.0. What follows in this section is a discussion of hydrogeologic features that are critical to the analysis of groundwater quality.

15.1.1 Glacial Overburden

As discussed in Section 12.2, perched groundwater zones are isolated and not interconnected in the vicinity of the FMPC reservation. Thus, by the nature of the perched zones in the glacial overburden, groundwater defined as upgradient under the strictest interpretation may not exist to establish background water quality. Nevertheless, wells that are considered to be representative of typical water quality for perched groundwater have been selected as background wells. These are addressed in Section 15.2.1.1.

15.1.2 Great Miami Aquifer

Three flow systems of the Great Miami Aquifer converge in the vicinity of the FMPC reservation. As shown in Figures 15-1 and 15-2, groundwater in the Dry Fork Section of the New Haven Trough generally flows from west to east. Groundwater in the Shandon Tributary to the New Haven Trough generally flows to the southeast, and groundwater in the Ross Section of the New Haven Trough generally flows to the southwest. Figures 15-1 and 15-2 show that a flow divide is located in the southern portion of the FMPC and separates Dry Fork Section groundwater from Shandon Tributary groundwater. The location of the divide fluctuates, depending on flow conditions; therefore, mixing occurs along the divide.

Groundwater from the Ross Section does not enter the FMPC. A flow divide separating the Ross Section groundwater from Shandon Tributary groundwater is located east of the FMPC, as shown in Figures 15-1 and 15-2. This divide is influenced by pumping of the collector wells located within and near the "big bend" in the Great Miami River.

The two groundwater flow divides that separate these three flow systems were delineated using the FMPC RI/FS groundwater flow model and the particle tracking program, STLINE. A sensitivity analysis using a range of groundwater flow conditions showed that the location of the flow divides could fluctuate for average precipitation conditions up to 750 feet on either side of the divides shown in Figures 15-1 and 15-2.

Due to the hydrogeological configuration in the vicinity of the FMPC, wells are grouped prior to the analysis of water quality based on where they are located with respect to the groundwater flow divides shown in Figures 15-1 and 15-2.

15.2 BACKGROUND CONDITIONS

This section describes background groundwater quality and the rationale for grouping background wells based on groundwater flow.

15.2.1 Background Well Selection

Background wells were selected to establish upgradient groundwater quality that is not influenced by operations at the FMPC. Wells designated as background were sampled from the second quarter

3065 [redacted]

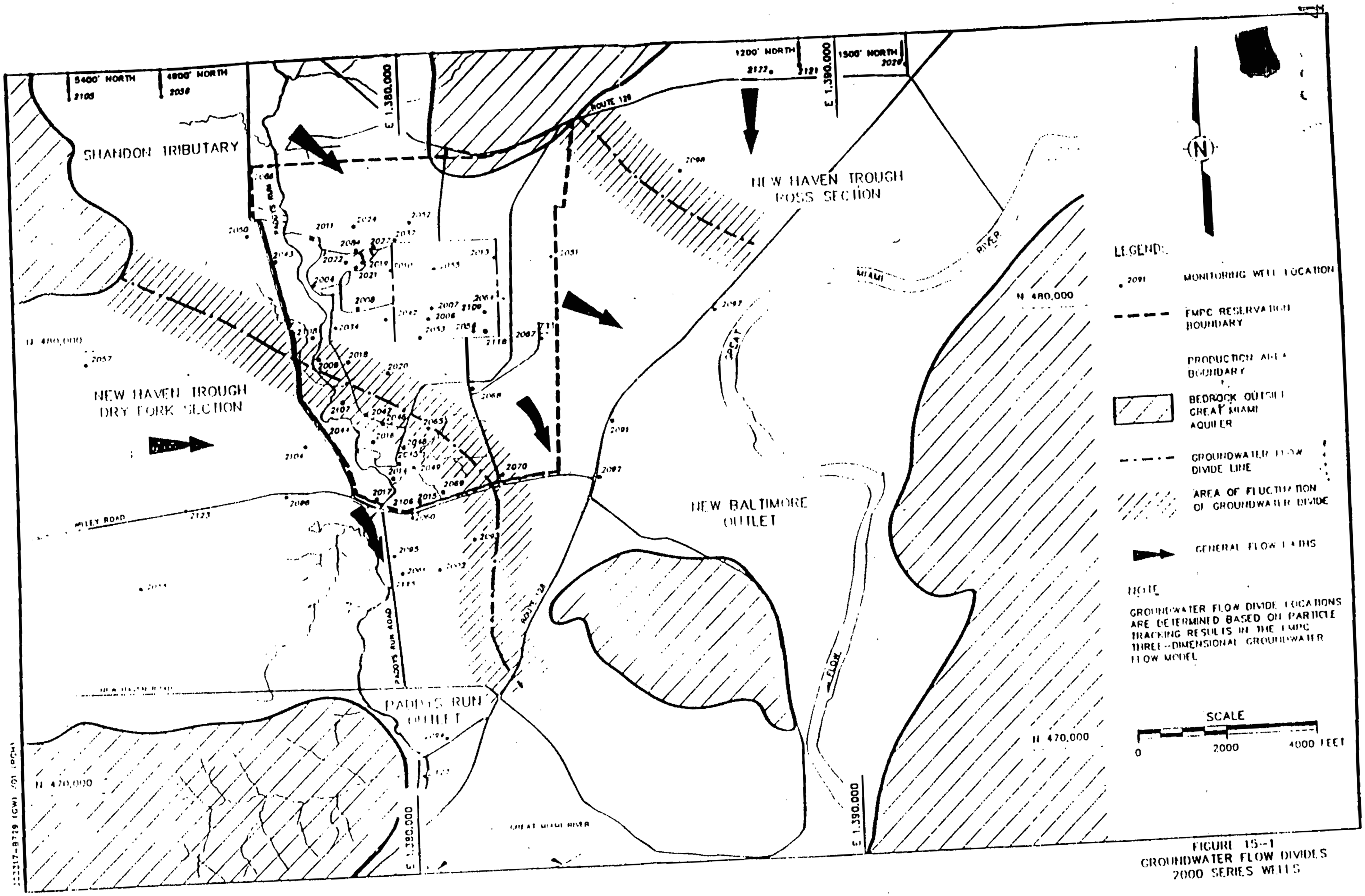

FIGURE 15-1
GROUNDWATER FLOW DIVIDES
2000 SERIES WELLS

3065

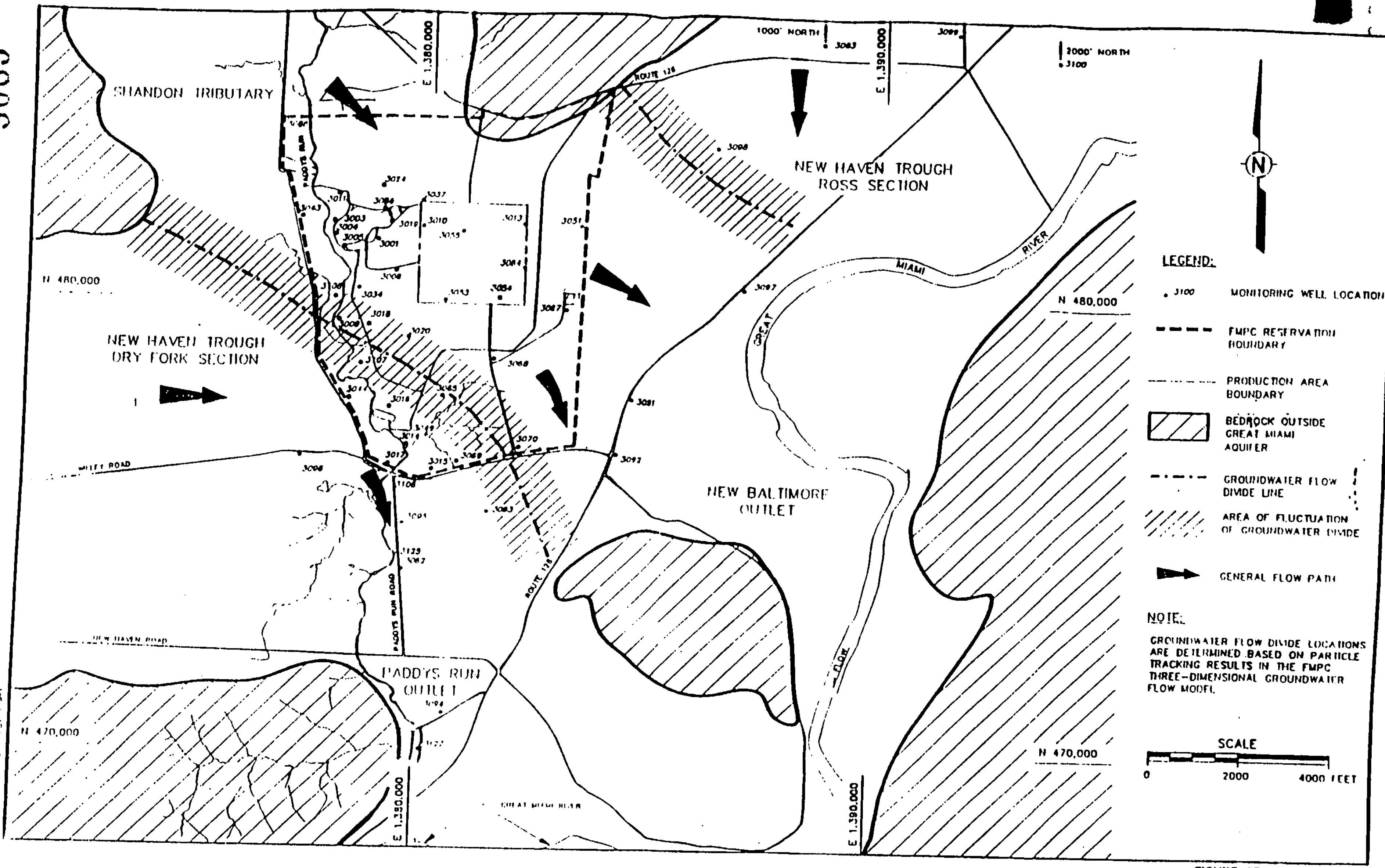

FIGURE 15-2
GROUNDWATER FLOW DIVIDES
3000 SERIES WELLS

1988 through the first quarter 1989 as part of the RI and some were sampled from June 1989 through January 1990 as part of the ongoing RCRA compliance program. Thus, the average value reported in this section are based on at least four quarterly samples from each well.

15.2.1.1 Glacial Overburden

Wells 1024, 1059, 1060, and 1065 are designated as background wells for glacial overburden groundwater because they are located in areas that are not likely to have been impacted by FMPC activities (refer to Figure 6-2 for locations). Due to the isolated nature of perched groundwater zones in the glacial overburden (Section 12.2), these wells are not truly upgradient wells. However it is assumed that the groundwater chemistry data from these wells is representative of typical groundwater quality in glacial overburden not affected by FMPC releases.

15.2.1.2 Great Miami Aquifer

As discussed in Section 15.2.2, the chemistry of groundwater from each flow system in the Great Miami Aquifer is distinctly different from that of the other flow systems. Because of the heterogeneity of upgradient groundwater chemistry, it is not possible to derive a single representative background water chemistry for the Great Miami Aquifer groundwater. Thus, the background wells are divided into Ross, Dry Fork, and Shandon background groups before the analysis of groundwater quality proceeds.

Wells 2026, 2121, 2122, 3063, 3099, and 3100 are designated as background wells for groundwater from the Ross Section of the Great Miami Aquifer. These wells, which are referred to as Ross background wells, are located upgradient of the FMPC and are shown in Figures 15-1 and 15-2. All of these wells are private wells and may be used for drinking water supply.

Wells 2036, 2057, and 2123 are designated as background wells for groundwater from the Dry Fork Section of the Great Miami Aquifer. These wells, which are referred to as Dry Fork background wells, are located upgradient of the FMPC and are shown in Figure 15-1. These wells are also private wells, and probably are used for drinking water supply. Note that Wells 2096, 3096, 4096, and 2104 also appear to be upgradient of the FMPC. Well 4096 is located adjacent to Wells 2096 and 3096. However, as discussed in Section 12.5.2, a seasonal groundwater mound develops beneath Paddys Run during periods of high precipitation. While the mound persists, groundwater may flow toward the west, and potentially carry contaminated water toward Wells 2096, 3096, 4096, and 2104. The mounding is a transient effect; but, because the magnitude of the impact is not fully understood, these wells are not designated as background.

Wells 2050, 2056, 2066, and 2105 are designated as background wells for groundwater from the Shandon Tributary of the Great Miami Aquifer. These wells, which are referred to as Shandon background wells, are located upgradient of the FMPC and are shown in Figure 15-1. Well 2066 is a monitoring well installed during the RI/FS program. The other wells are private wells, and all but 2050 may be used for drinking water supply. Well 2050 is a water supply well for a light industry. Well 3066 is not included in the Shandon background well group. The groundwater chemistry of samples from this well is anomalous compared with that of samples from other Shandon background wells. A portion of the groundwater sampled at Well 3066 may flow through bedrock and acquire the anomalous chemical characteristics. Alternatively, the chemistry may be influenced by the greater percentage of clay minerals in the Shandon Tributary, relative to the rest of the aquifer.

15.2.2 Background Groundwater Quality

Groundwater from glacial overburden and the Great Miami Aquifer is classified as fresh water since total dissolved solids (TDS) generally range from 500 to 700 milligrams per liter (mg/L). In general, calcium is the dominant cationic constituent, and bicarbonate is the dominant anionic constituent. Generally, background groundwater is saturated with respect to calcium carbonate.

15.2.2.1 Glacial Overburden

Table 15-1 lists radionuclide, metal, and general chemical concentrations observed in groundwater samples from glacial overburden background wells. The concentration range of most constituents is greater compared with groundwater from the Great Miami Aquifer. This is most likely due to the diverse mineralogy of glacial overburden materials and the interreaction between these materials and groundwater. Calcium, followed by magnesium, sodium, potassium, and iron, are the dominant metals found in glacial overburden groundwater. Trace concentrations of several other metals are also observed. Bicarbonate, followed by sulfate and chloride, are dominant anionic constituents. Nitrate and ammonia concentrations are low in glacial overburden groundwater. The pH of glacial overburden groundwater is neutral; the average pH is 7.2. The average TDS concentration is 665 mg/L.

Some radionuclides are shown to be naturally present at detectable, but low activity concentrations. In particular, radium, thorium, and uranium were observed at detectable levels.

15.2.2.2 Great Miami Aquifer

Ross and Dry Fork Section groundwater chemistries are similar; however, Shandon Tributary groundwater chemistry is quite different from that of the other parts of the aquifer. The

TABLE 15-1

GROUNDWATER QUALITY, GLACIAL OVERBURDEN BACKGROUND WELLS

GLACIAL OVERBURDEN BACKGROUND			
Parameter	Average[a]	Standard Deviation[a]	Range[a]
Radionuclides (pCi/L) * AEA Source, Special Nuclear, and by-product materials are regulated under RCRA.			
Cs-137	20 U	-	20 U - 20 U
Np-237	1 U	-	1 U - 1 U
Pu-238	1 U	-	1 U - 1 U
Pu-239/240	1 U	-	1 U - 1 U
Ra-226	1 U	-	1 U - 1 U
Ra-228	3.2	0.7	3 U - 5.2
Ru-106	150 U	-	150 U - 150 U
Sr-90	5 U	-	5 U - 5 U
Tc-99	30 U	-	30 U - 30 U
Th-228	1.1	0.2	1 U - 1.6
Th-230	1.1	0.3	1 U - 2
Th-232	1 U	-	1 U - 1 U
Th-Total[b]	13 U	-	13 U - 13 U
U-234	1.1	0.3	1 U - 1.9
U-235/236	1 U	-	1 U - 1 U
U-238	1.0	0.1	1 U - 1.5
U-Total[b]	1.6	1.2	1 U - 5.3
Metals (mg/L)			
Al	0.12	0.00	0.1206 - 0.123
As	0.002	0.00	0.002 U - 0.003
Ba	0.069	0.022	0.05 U - 0.112
Cd	0.003	0.002	0.002 U - 0.007
Ca	96.38	17.41	74.4 - 130
Cr	0.023	0.005	0.02 U - 0.0345
Cu	0.016	0.010	0.01 U - 0.044
Fe	0.689	1.345	0.005 - 4.9
Pb	0.003	0.001	0.002 U - 0.006
Mg	34.28	9.39	20.4 - 47.8
Mn	0.044	0.038	0.003 - 0.1
Hg[b]	0.22	0.06	0.2 U - 0.4
Mo	0.02 U	-	0.02 U - 0.02 U
Ni	0.02	0.00	0.02 U - 0.026
K	8.90	9.07	0.891 - 31.5
Se	0.002 U	-	0.002 U - 0.002 U

See footnotes at end of table.

[redacted]

TABLE 15-1
(continued)

GLACIAL OVERBURDEN BACKGROUND

Parameter	Average[a]	Standard Deviation[a]	Range[a]		
Metals (Continued)					
Ag	0.015	0.013	0.01 U	-	0.05[illegible]
Na	21.33	16.80	5.71	-	56.3
V	0.02	0.00	0.018	-	0.01[illegible]
Zn	0.04	0.01	0.0317	-	0.04[illegible]
General Chemistry (mg/L)					
Ammonia as N	0.18	0.17	0.1 U	-	0.58
Chloride	12.19	12.20	1.4	-	35.7
Conductance[c]	640.3	157.6	470	-	975
Fluoride	0.62	0.34	0.22	-	1.3
Nitrate as N	0.15	0.07	0.1 U	-	0.3
Total phosphorus	0.07	0.04	0.05 U	-	0.18
Sulfate	71.15	49.52	3.24	-	175
Total organic halide	0.05	0.01	0.05 U	-	0.067
Alkalinity as HCO3	416.3	49.7	334	-	501.1
pH	7.2	-	7	-	7.4
Total dissolved solids[d]	563.40	76.35	441.35	-	986.89

[a]Outliers and inconsistent MDLs are excluded. Nondetects are set equal to the MDLs and included in the calculation of averages and standard deviations (Section 15.3.2.2).

U = below the MDL shown.

[b]In ug/L.

[c]In umhos/cm.

[d]TDS is calculated based on following assumptions:

> The mass contributed by radionuclides is negligible.
> Phosphorus is present as phosphate.

[redacted]

background groundwater chemistry of each section of the Great Miami Aquifer is discussed separately below.

Ross Section

Table 15-2 lists radionuclide, metal, and general chemical concentrations observed in groundwater samples from Ross background wells. Since both 2000 and 3000 Series wells are present in the Ross background area, Ross background water quality data are separated in Table 15-2 into Ross background from 2000 Series wells and Ross background from 2000 and 3000 Series wells. Calcium, followed by magnesium, sodium, and potassium, are the dominant metals found in Ross groundwater. Trace concentrations of many other metals were also detected. Bicarbonate, followed by sulfate, chloride, and nitrate, are the dominant anionic constituents. The pH of Ross groundwater is neutral; the average pH is 7.1. The average TDS concentration is 544 mg/L.

Low activity concentrations of radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-230), and thorium-230 were detected in Ross background groundwater. Low concentrations of total uranium were also detected. These radionuclides are naturally occurring, but their presence may also be due to contaminant sources upgradient of the Ross area. For unknown reasons, the average arsenic concentration, 0.106 mg/L, calculated for Ross groundwater is high relative to the average arsenic concentrations of other background groundwater. Background concentrations for aluminum, vanadium, and zinc for the Ross section groundwater could not be established because of the absence of data.

Dry Fork Section

Table 15-3 lists the average and range of radionuclide, metal, and general chemical concentrations observed in groundwater samples from Dry Fork background wells. Calcium, followed by magnesium, sodium, and potassium, are the dominant metals found in Dry Fork groundwater. Trace concentrations of several other metals were also observed. Bicarbonate, followed by sulfate, chloride, and nitrate, are dominant anionic constituents. The pH of Dry Fork groundwater is neutral; the average pH is 7.2. Dry Fork background groundwater generally contains less dissolved solids than other background groundwaters; the average TDS concentration is 500 mg/L.

Other than a one-time, low-level detection of Th-230 at Well 2123, no radionuclides were detected in groundwater samples from Dry Fork background wells. Data from the IT (1986) report were used to establish background concentrations of aluminum, vanadium, and zinc in Dry Fork groundwater.

TABLE 15-2

GROUNDWATER QUALITY, GREAT MIAMI AQUIFER
ROSS BACKGROUND WELLS

	GREAT MIAMI AQUIFER ROSS BACKGROUND (2000 AND 3000 SERIES WELLS)		
Parameter	Average[a]	Standard Deviation[a]	Range[a]
Radionuclides (pCi/L) *			
Cs-137	20 U	-	20 U - 20 U
Np-237	1 U	-	1 U - 1 U
Pu-238	1 U	-	1 U - 1 U
Pu-239/240	1 U	-	1 U - 1 U
Ra-226	1.0	0.0	1 U - 1.1
Ra-228	3.1	0.4	3 U - 4.5
Ru-106	150 U	-	150 U - 150 U
Sr-90	5 U	-	5 U - 5 U
Tc-99	30 U	-	30 U - 30 U
Th-228	1.0	0.0	1 U - 1.2
Th-230	1.0	0.2	1 U - 1.7
Th-232	1 U	-	1 U - 1 U
Th-Total[b]	13 U	-	13 U - 13 U
U-234	1 U	-	1 U - 1 U
U-235/236	1 U	-	1 U - 1 U
U-238	1 U	-	1 U - 1 U
U-Total[b]	1.0	0.2	1 U - 2.0
Metals (mg/L)			
Al[c]	--	--	-- --
As	0.106	0.189	0.002 U - 0.55
Ba	0.051	0.010	0.035 - 0.073
Cd	0.005	0.001	0.005 U - 0.01
Ca	92.48	8.51	70.2 - 110
Cr	0.021	0.003	0.02 U - 0.03
Cu	0.047	0.052	0.01 U - 0.176
Fe	0.028	0.039	0.005 U - 0.145
Pb	0.002	0.001	0.002 U - 0.004
Mg	26.00	5.43	17 - 33
Mn	0.004	0.004	0.001 U - 0.016
Hg[b]	0.21	0.04	0.2 U - 0.4

* AEA Source, Special Nuclear, and by-product materials are not regulated under RCRA.

See footnotes at end of table.

TABLE 15-2
(continued)

GREAT MIAMI AQUIFER ROSS BACKGROUND
(2000 AND 3000 SERIES WELLS)

Parameter	Average[a]	Standard Deviation[a]	Range[a]		
Metals (Continued)					
Mo	0.02	0.02	0.02 U	-	0.092
Ni	0.02	0.00	0.02 U	-	0.024
K	2.62	0.03	2.07	-	3.28
Se	0.002 U	-	0.002 U	-	0.002
Ag	0.011	0.005	0.01 U	-	0.033
Na	15.25	3.96	9.41	-	26.7
V[c]	--	--	--		--
Zn[c]	--	--	--		--
General Chemistry (mg/L)					
Ammonia as N	0.11	0.03	0.1 U	-	0.2
Chloride	29.14	12.20	7	-	49.5
Conductance[d]	585.8	109.1	400	-	800
Fluoride	0.25	0.06	0.18	-	0.365
Nitrate as N	4.11	3.78	0.28	-	12.4
Total Phosphorus	0.05	0.00	0.05 U	-	0.065
Sulfate	47.05	18.15	3.08	-	72
Total Organic Halides	0.05 U	-	0.05 U	-	0.05 U
Alkalinity as HCO3	312.6	34.3	236.8	-	363.55
pH	7.1	-	6.64	-	7.7
Total Dissolved Solids[e]	544.25	45.30	347.44	-	714.95

[redacted]

See footnotes at end of table.

TABLE 15-2
(continued)

GREAT MIAMI AQUIFER ROSS BACKGROUND
(2000 SERIES WELLS)

* AEA Source, Special Nuclear, and by-product materials are not regulated under RCRA.

Parameter	Average[a]	Standard Deviation[a]	Range[a]
Radionuclides (pCi/L)			
Cs-137	20 U	-	20 U - 20 U
Np-237	1 U	-	1 U - 1 U
Pu-238	1 U	-	1 U - 1 U
Pu-239/240	1 U	-	1 U - 1 U
Ra-226	1.0	0.0	1 U - 1.1
Ra-228	3.1	0.4	3 U - 4.5
Ru-106	150 U	-	150 U - 150 U
Sr-90	5 U	-	5 U - 5 U
Tc-99	30 U	-	30 U - 30 U
Th-228	1 U	-	1 U - 1 U
Th-230	1.1	0.2	1 U - 1.7
Th-232	1 U	-	1 U - 1 U
Th-Total[b]	13 U	-	13 U - 13 U
U-234	1 U	-	1 U - 1 U
U-235/236	1 U	-	1 U - 1 U
U-238	1 U	-	1 U - 1 U
U-Total[b]	1.1	0.3	1 U - 2.0
Metals (mg/L)			
Al[c]	-	-	-
As	0.143	0.232	0.002 U - 0.55
Ba	0.047	0.012	0.035 - 0.073
Cd	0.005 U	-	0.005 U - 0.005
Ca	87.04	7.88	70.2 - 95.2
Cr	0.02	-	0.02 U - 0.02
Cu	0.050	0.063	0.01 U - 0.176
Fe	0.011	0.015	0.005 U - 0.05
Pb	0.002 U	-	0.002 U - 0.002
Mg	22.95	5.92	17 - 33
Mn	0.002	0.001	0.001 U - 0.003
Hg[b]	0.2 U	-	0.2 U - 0.2 U
Mo	0.02	0.01	0.02 U - 0.04
Ni	0.02 U	-	0.02 U - 0.02 U
K	2.67	0.32	2.07 - 3.01
Se	0.002 U	-	0.002 U - 0.002

See footnotes at end of table.

TABLE 15-2
(continued)

GREAT MIAMI AQUIFER ROSS BACKGROUND
(2000 SERIES WELLS)

Parameter	Average[a]	Standard Deviation[a]	Range[a]		
Metals (Continued)					
Ag	0.012	0.007	0.01 U	-	0.03
Na	16.20	5.79	9.41	-	26.9
V	--	--	--	-	--
Zn	--	--	--	-	--
General Chemistry (mg/L)					
Ammonia as N	0.11	0.03	0.1 U	-	0.2
Chloride	24.06	13.02	7	-	45.15
Conductance[d]	564.17	116.95	400	-	800
Fluoride	0.26	0.06	0.2	-	0.35
Nitrate as N	4.35	3.46	0.4	-	8.4
Total Phosphorus	0.05	0.00	0.05 U	-	0.05[illegible]
Sulfate	37.36	17.13	3.08	-	58
Total Organic Halide	0.05 U	-	0.05 U	-	0.05
Alkalinity as HCO3	294.7	37.2	236.8	-	343.2
pH	7.1	-	7	-	7.7
Total Dissolved Solids[e]	505.18	47.03	348.00	-	643.45

[a]Outliers and inconsistent MDLs are excluded. Nondetects are set equal to the MDLs and included in the calculation of averages and standard deviations (Section 15.3.2.2).

U = below the MDL shown.

[b]In ug/L.

[c]Ross background wells have not been analyzed for aluminum, vanadium, and zinc.

[d]In umhos/cm.

[e]TDS is calculated based on following assumptions:

- The mass contributed by radionuclides is negligible.
- Phosphorus is present as phosphate.

TABLE 15-3

GROUNDWATER QUALITY, GREAT MIAMI AQUIFER, DRY FORK BACKGROUND WELLS

GREAT MIAMI AQUIFER DRY FORK BACKGROUND

Parameter	Average[a]	Standard Deviation[a]	Range[a]
Radionuclides (pCi/L)	* AEA Source, Special Nuclear, and by-product materials are not regulated under RCRA.		
Cs-137	20 U	-	20 U - 20 U
Np-237	1 U	-	1 U - 1 U
Pu-238	1 U	-	1 U - 1 U
Pu-239/240	1 U	-	1 U - 1 U
Ra-226	1 U	-	1 U - 1 U
Ra-228	3 U	-	3 U - 3 U
Ru-106	159 U	-	159 U - 159 U
Sr-90	5 U	-	5 U - 5 U
Tc-99	30 U	-	30 U - 30 U
Th-228	1 U	-	1 U - 1 U
Th-230	1.1	0.3	1 U - 2.1
Th-232	1 U	-	1 U - 1 U
Th-Total[b]	13 U	-	13 U - 13 U
U-234	1 U	-	1 U - 1 U
U-235/236	1 U	-	1 U - 1 U
U-238	1 U	-	1 U - 1 U
U-Total[b]	1 U	-	1 U - 1 U
Metals (mg/L)			
Al	0.1 U	-	0.1 U - 0.1 U
As	0.002	0.001	0.002 U - 0.004
Ba	0.038	0.004	0.034 - 0.045
Cd	0.005 U	-	0.005 U - 0.005 U
Ca	89.10	5.43	81.7 - 99.4
Cr	0.021	0.003	0.02 U - 0.03
Cu	0.016	0.008	0.01 U - 0.033
Fe	0.015	0.009	0.005 U - 0.03
Pb	0.002	0.001	0.002 U - 0.004
Mg	23.20	1.71	20.7 - 26.2
Mn	0.201	0.237	0.001 U - 0.48
Hg[b]	0.2 U	-	0.2 U - 0.2 U
Mo	0.02 U	-	0.02 U - 0.02 U
Ni	0.02 U	-	0.02 U - 0.02 U
[illegible]	1.28	0.24	1 U - 1.7

See footnotes at end of table.

TABLE 15-3
(continued)

GREAT MIAMI AQUIFER DRY FORK BACKGROUND

Parameter	Average[a]	Standard Deviation[a]	Range[a]		
Metals (Continued)					
Se	0.002 U	-	0.002 U	-	0.0
Ag	0.012	0.008	0.01 U	-	0.0
Na	3.23	0.59	1.96	-	3.9
V	0.01 U	-	0.01 U	-	0.01
Zn	0.17	-	0.17	-	0.17
General Chemistry (mg/L)					
Ammonia as N	0.11	0.03	0.1 U	-	0.2
Chloride	9.20	4.09	3	-	13
Conductance[c]	535.0	108.2	370	-	750
Fluoride	0.25	0.08	0.1	-	0.38
Nitrate as N	4.64	4.87	0.1 U	-	11.4
Total Phosphorus	0.08	0.05	0.05 U	-	0.19
Sulfate	29.59	6.80	21	-	39.9
Total Organic Halide	0.05 U	-	0.05 U	-	0.05
Alkalinity	322.1	24.0	285.2	-	344.3
pH	7.2	-	7.0	-	7.6
Total Dissolved Solids[d]	499.56	33.71	415.85	-	581.23

[a] Outliers and inconsistent MDLs are excluded. Nondetects are set equal to the MDLs and included in the calculation of averages and standard deviations (Section 15.3.2.2).

U = below the MDL shown

[b] In ug/L.

[c] In umhos/cm.

[d] TDS is calculated based on following assumptions:

The mass contributed by radionuclides is negligible.
Phosphorus is present as phosphate.

While Dry Fork background chemistry is very similar to Ross background chemistry, concentrations of sodium, chloride, sulfate, and TDS appear to be slightly higher in Ross groundwater. This may be due to greater urbanization of the Ross Section of the aquifer relative to the Dry Fork Section.

Shandon Tributary

Table 15-4 lists the average and range of radionuclide, metal, and general chemistry concentrations observed in groundwater samples from Shandon background wells. Calcium is the dominant metal in Shandon groundwater, followed by sodium, magnesium, iron, and potassium. Trace concentrations of other metals were also observed. Bicarbonate, followed by chloride, ammonia, and sulfate, are dominant anionic constituents. The pH of Shandon groundwater is neutral; the average pH is 6.9. The average TDS concentration is 598 mg/L.

Ra-226 and total uranium were the only radionuclides detected in groundwater samples from Shandon background wells. The detections were low and inconsistent. Detections of Ra-226 were 1.8 and 2 pCi/L from Wells 2050 and 2056, respectively, during second quarter 1988 sampling. Detections of total uranium occurred in Wells 2056 and 2066 with concentrations of 1.85 and 3 ug/L, respectively. Data from the IT (1986) report were used to establish background concentrations of aluminum, and zinc in Shandon groundwater.

Calcium and bicarbonate are the dominant dissolved constituents of all background groundwaters. The second most abundant ionic constituents in the Shandon groundwater are sodium and chloride; for Ross and Dry Fork groundwater, they are magnesium and sulfate. The barium concentration of Shandon groundwater is approximately an order of magnitude greater than that of other background groundwaters. It is believed that low sulfate concentrations most likely prevent the precipitation of barite, $BaSO_4$, from controlling barium concentrations in Shandon groundwater.

Differences in the geology and the chemical redox state of groundwater in the Shandon Tributary, compared with other areas of the aquifer, most likely contribute to the observed groundwater chemistry differences. The Shandon Tributary portion of the aquifer is mantled by thick deposits of undissected glacial overburden (Section 11.5); therefore, surface water infiltration may be slow. Shandon Tributary groundwater may have lower dissolved oxygen levels; i.e., is chemically reduced, relative to groundwater from other areas. Nitrogen is present in Shandon Tributary groundwater predominantly in the reduced form as ammonia (NH_3), whereas nitrogen is present in an oxidized form as nitrate (NO_3) in groundwater from other areas of the aquifer (Tables 15-2 and 15-3). Reduced iron (Fe^{+2}) concentrations also appear to be higher in Shandon groundwater relative to other background groundwaters.

TABLE 15-4

GROUNDWATER QUALITY, GREAT MIAMI AQUIFER SHANDON BACKGROUND WELLS

GREAT MIAMI AQUIFER SHANDON BACKGROUND

Parameter	Average[a]	Standard Deviation[a]	Range[a]
Radionuclides (pCi/L)	* AEA Source, Special Nuclear, and by-product materials are not regulated under RCRA.		
Cs-137	20 U	-	20 U - 20 U
Np-237	1 U	-	1 U - 1 U
Pu-238	1 U	-	1 U - 1 U
Pu-239/2401	1 U	-	1 U - 1 U
Ra-226	1.1	0.3	1 U - 2
Ra-228	3 U	-	3 U - 3 U
Ru-106	150 U	-	150 U - 150 U
Sr-90	5 U	-	5 U - 5 U
Tc-99	30 U	-	30 U - 30 U
Th-228	1.1	0.2	1 U - 1.99
Th-230	1 U	-	1 U - 1 U
Th-232	1 U	-	1 U - 1 U
Th-Total[b]	13 U	-	13 U - 13 U
U-234	1 U	-	1 U - 1 U
U-235/236	1 U	-	1 U - 1 U
U-238	1 U	-	1 U - 1 U
U-Total[b]	1.2 U	0.5	1 U - 3
Metals (mg/L)			
Al	0.11	0.02	0.1 U - 0.143
As	0.021	0.012	0.004 - 0.042
Ba	0.638	0.104	0.48 - 0.8
Cd	0.005	0.000	0.005 U - 0.006
Ca	74.55	13.69	30.4 - 89
Cr	0.021	0.000	0.02 U - 0.03
Cu	0.01 U	-	0.01 U - 0.01 U
Fe	2.272	0.664	1.6 - 3.55
Pb	0.001	0.005	0.002 U - 0.015
Mg	26.06	3.54	15.8 - 31.3
Mn	0.047	0.035	0.014 - 0.113
Hg[b]	0.26	0.20	0.2 U - 1
Mo	0.02	0.00	0.02 U - 0.03
'i	0.02 U	-	0.02 U - 0.02 U

See footnotes at end of table.

[redacted] [redacted]

3065

TABLE 15-4
(continued)

GREAT MIAMI AQUIFER SHANDON BACKGROUND

Parameter	Average[a]	Standard Deviation[a]	Range[a]
Metals (Continued)			
K	1.49	0.28	1.13 - 2
Se	0.002 U	-	0.002 U - 0.002
Ag	0.010	0.001	0.01 U - 0.014
Na	41.09	6.83	28.1 - 48
V	0.014	0.004	0.01 U - 0.016
Zn	0.03	0.02	0.01 - 0.052
General Chemistry (mg/L)			
Ammonia as N	3.15	1.14	0.3 - 4.22
Chloride	61.01	11.80	39.5 - 78.9
Conductance[c]	624.2	86.11	450 - 850
Fluoride	0.85	0.22	0.4 - 1.25
Nitrate as N	0.1	-	0.1 U - 0.1
Total Phosphorus	0.10	0.03	0.05 U - 0.18
Sulfate	3.66	3.25	2 U - 13.4
Total Organic Halide	0.05 U	-	0.05 U - 0.05 U
Alkalinity	387.0	13.8	369.2 - 416.6
pH	6.9	-	6 - 7.6
Total Dissolved Solids[d]	603.79	24.28	489.87 - 691.77

[a]Outliers and inconsistent MDLs are excluded. Nondetects are set equal to the MDLs and included in the calculation of averages and standard deviations (Section 15.3.2.2).

U = below the MDL shown.

[b]In ug/L.

[c]In umhos/cm.

[d]TDS is calculated based on following assumptions:

The mass contributed by radionuclides is negligible.
Phosphorus is present as phosphate.

[redacted]

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