G-000-102.16

260

RCRA PART B PERMIT APPLICATION SECTION E: GROUNDWATER MONITORING APPENDIX E-III REFERENCE DOCUMENTS VOLUME 6 OF 11 SEPTEMBER 22, 1990

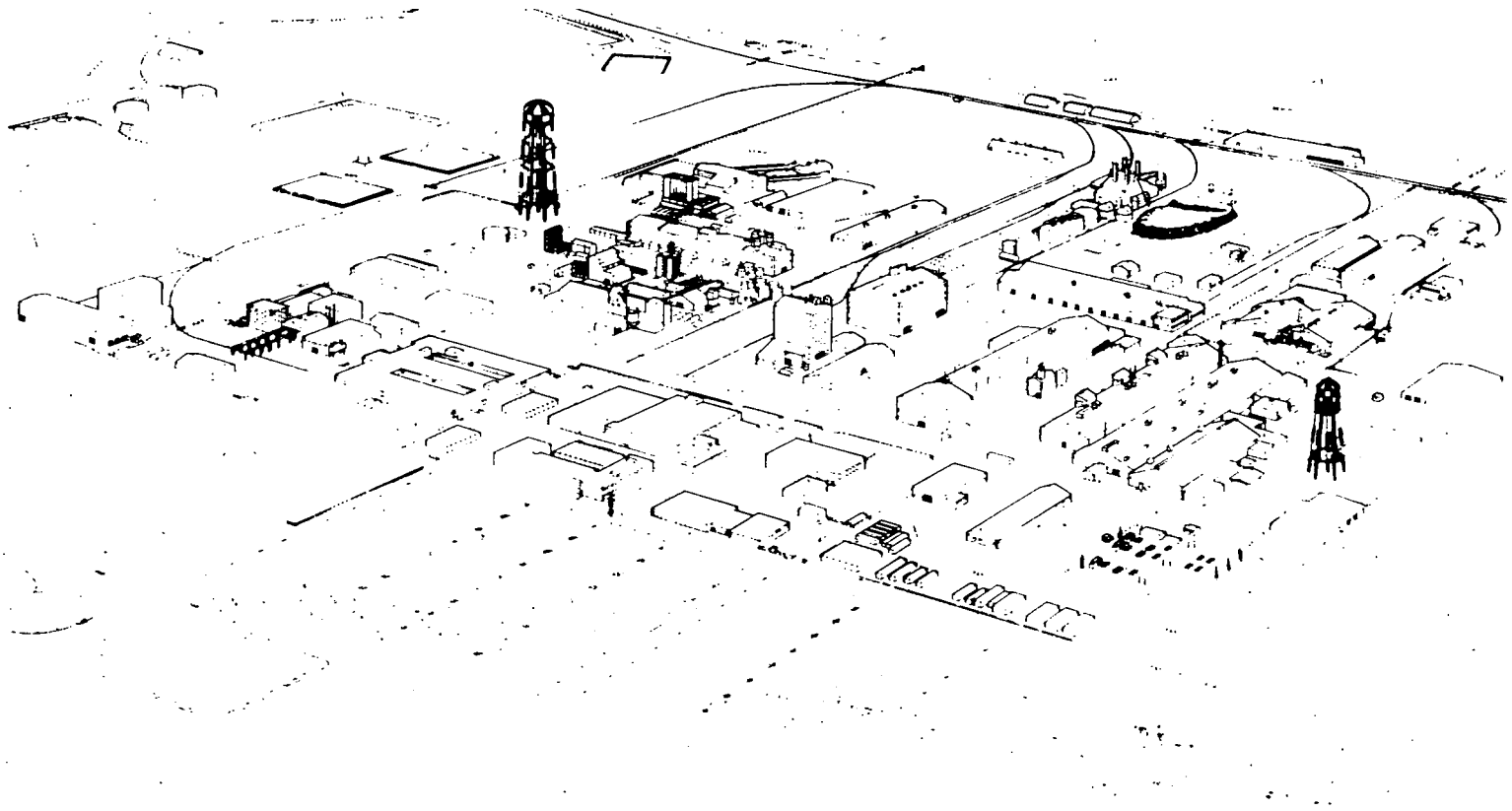
09/22/90

DOE-FMPC/USEPA
175
APPLICATION

[redacted]

260

RCRA PART B PERMIT APPLICATION



SEPTEMBER 22, 1989

SECTION E: GROUNDWATER MONITORING
APPENDIX E-III REFERENCE DOCUMENTS
(Volume 6 of 11)

FEED MATERIALS PRODUCTION CENTER
U.S. DEPARTMENT OF ENERGY
CINCINNATI, OHIO 45239-8705

U.S. EPA IDENTIFICATION NO. 0H6890008976
OHIO EPA PERMIT NO. 05-31-0681

1

APPENDIX

E-III

REFERENCE DOCUMENTS

APPENDIX

E-III

REFERENCE DOCUMENTS

1. Dames & Moore, 1986, Results of Round 1 Groundwater Sampling, Feed Materials Production Center, Fernald, Ohio. Report dated June, 1986.

2. Dames & Moore, 1986, RCRA Groundwater Monitoring Report, Volume 2 - Round 2 Sampling. Report dated November, 1986.

3. Dames & Moore, 1987, RCRA Groundwater Monitoring Report, Volume 3 - Round 3 Sampling. Report dated March, 1987.

4. Dames & Moore, 1987, RCRA Groundwater Monitoring Report, Volume 4 - Round 4 Sampling. Report dated May, 1987.

5. Dames & Moore, 1987, RCRA Groundwater Monitoring Report, Volume 5 - Round 5 Sampling. Report dated November, 1987.

6. ASI, 1988, RCRA Groundwater Monitoring Report, Volume 6 - Round 6 Sampling. Report dated March, 1988.

FIGURES

Description	Page
Figure 1 - Site Location Map	2
Figure 2 - Waste Pit No. 4 Monitoring Wells	3
Figure 3 - Generalized Geologic Cross-Section	5
Figure 4 - Water Table Contours (May 5, 1987)	7
Figure 5 - FMPC Well Locations	10
Figure 6 - Proposed Upgradient Well Cluster	22
Figure 7 - Proposed Downgradient Well Cluster	23
Figure 8 - Site Map - RI/FS Study Area	26
Figure 9 - 100-series Wells - Glacial Till	27
Figure 10 - 100-series Wells - Waste Management Area	28
Figure 11 - 200-series and 300-series Wells - Sand and Gravel	29
Figure 12 - 200 and 300-series Wells - Waste Management Area	30
Figure 13 - Typical Monitoring Well Profile	34
Figure 14 - Location of the Magnetic Survey at the FMPC	42
Figure 15 - Location of the EM31 Survey at the FMPC	43
Figure 16 - Location of the EM34-3 Survey at the FMPC	44
Figure 17 - Location of the GPR Survey at the FMPC	45
Figure 18 - Project Master Schedule	46

TABLES

Description	Page
Table 1 - Round 5 Water Level Elevations	8
Table 2 - Background Means and Variances for Upgradient Wells	12
Table 3 - Statistical Comparison Summary	13
Table 4 - Calculated T^*/T_c Statistics	14,15
Table 5 - Monitoring Well Sampling Order	18
Table 6 - RCRA Groundwater Detection Monitoring Well Parameters	19-21
Table 7 - Placement Rationale for Planned Onsite Well Locations	31

1.0 INTRODUCTION

Waste Pit No. 4 at the Feed Materials Production Center (FMPC) in Fernald, Ohio is subject to regulations of the Resource Conservation and Recovery Act (RCRA). As part of these regulations, certain groundwater monitoring requirements must be provided to the U.S. Environmental Protection Agency (EPA) for review and approval. These requirements are outlined in the Code of Federal Regulations (CFR), specifically 40 CFR 265, Subpart F, and apply to a landfill facility such as Waste Pit No. 4 which is used to manage hazardous waste. A site location map for the FMPC is provided in Figure 1.

1.1 Background

During the period from May, 1980 to April, 1983, an estimated 23,500 pounds of a radioactively contaminated trichloride salt consisting of approximately 55 percent barium chloride were discarded in Waste Pit No. 4 at the FMPC (Reference 1). This material is considered hazardous due to the presence of soluble barium in excess of the maximum allowable concentration, as determined by the Extraction Procedure (EP) toxicity test (EPA Waste Identification No. D005).

As outlined in 40 CFR 265, the groundwater monitoring requirements for a landfill such as Waste Pit No. 4 consist of the development of a groundwater monitoring system, the implementation of a sampling and analysis program, and the evaluation of groundwater monitoring results to determine any necessary response actions. At the FMPC, a groundwater monitoring system has been developed and a sampling and analysis plan has been implemented to meet the requirements of 40 CFR 265.91 and 265.92. The groundwater monitoring system is shown graphically in Figures 2 and 5, and the sampling and analysis plan is contained in Reference 2.

A Groundwater Quality Assessment Program Outline (GQAPO) was prepared in August, 1986 in response to Item A.7 of the RCRA section for the Federal Facility Compliance Agreement (FFCA). This plan was prepared in conformance with 40 CFR 265.93 (a) and was revised in January, 1987 to reflect comments by U.S. EPA on the original submittal (Reference 3). The intent of the GQAPO is to present a groundwater monitoring program for Waste Pit No. 4 which is capable of identifying:

a) whether hazardous waste or hazardous waste constituents have entered the groundwater;

b) the rate and extent of migration of hazardous waste or hazardous waste constituents in the groundwater; and

c) the concentration of hazardous waste or hazardous waste constituents in the groundwater.

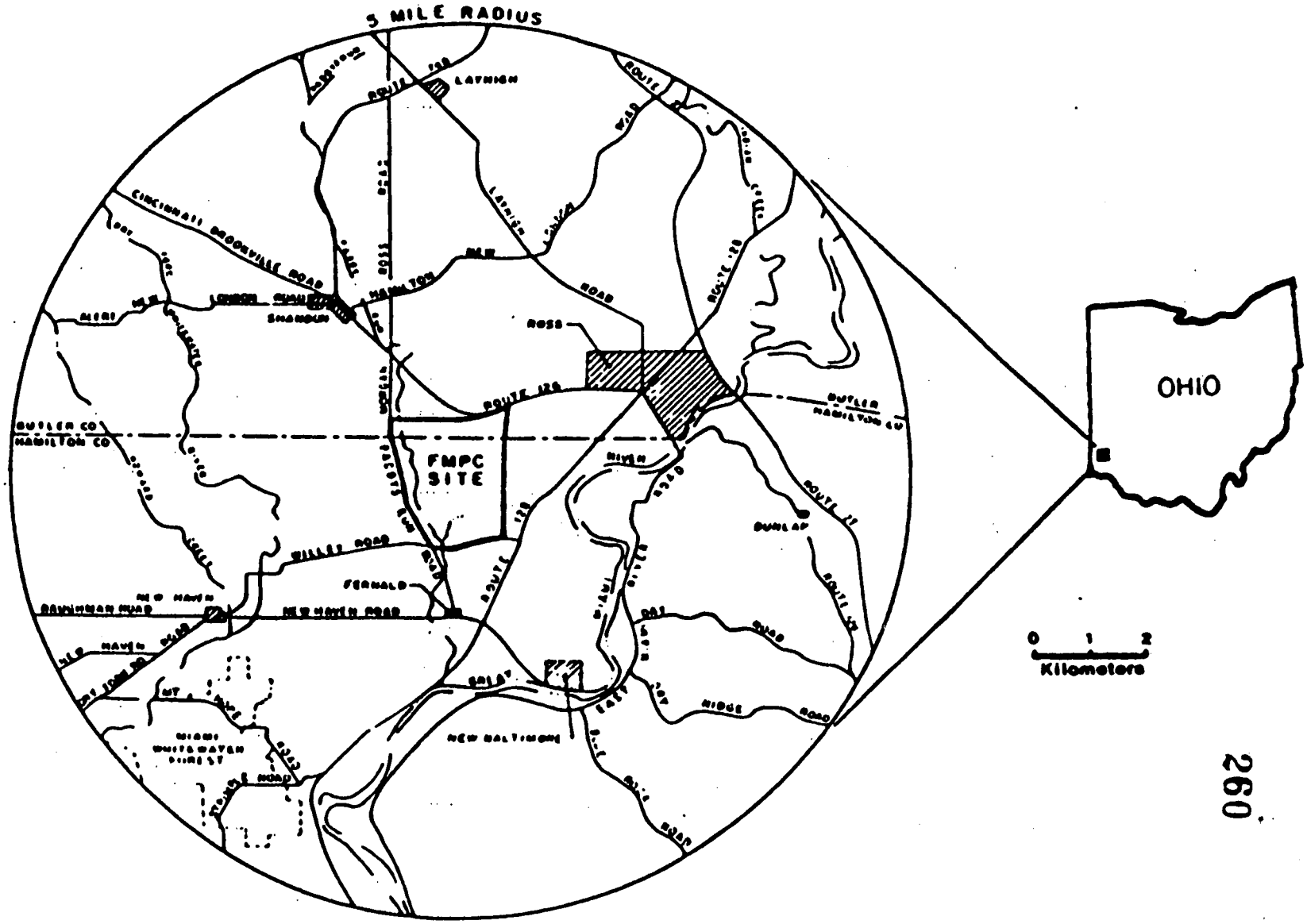


FIGURE 1 SITE LOCATION MAP

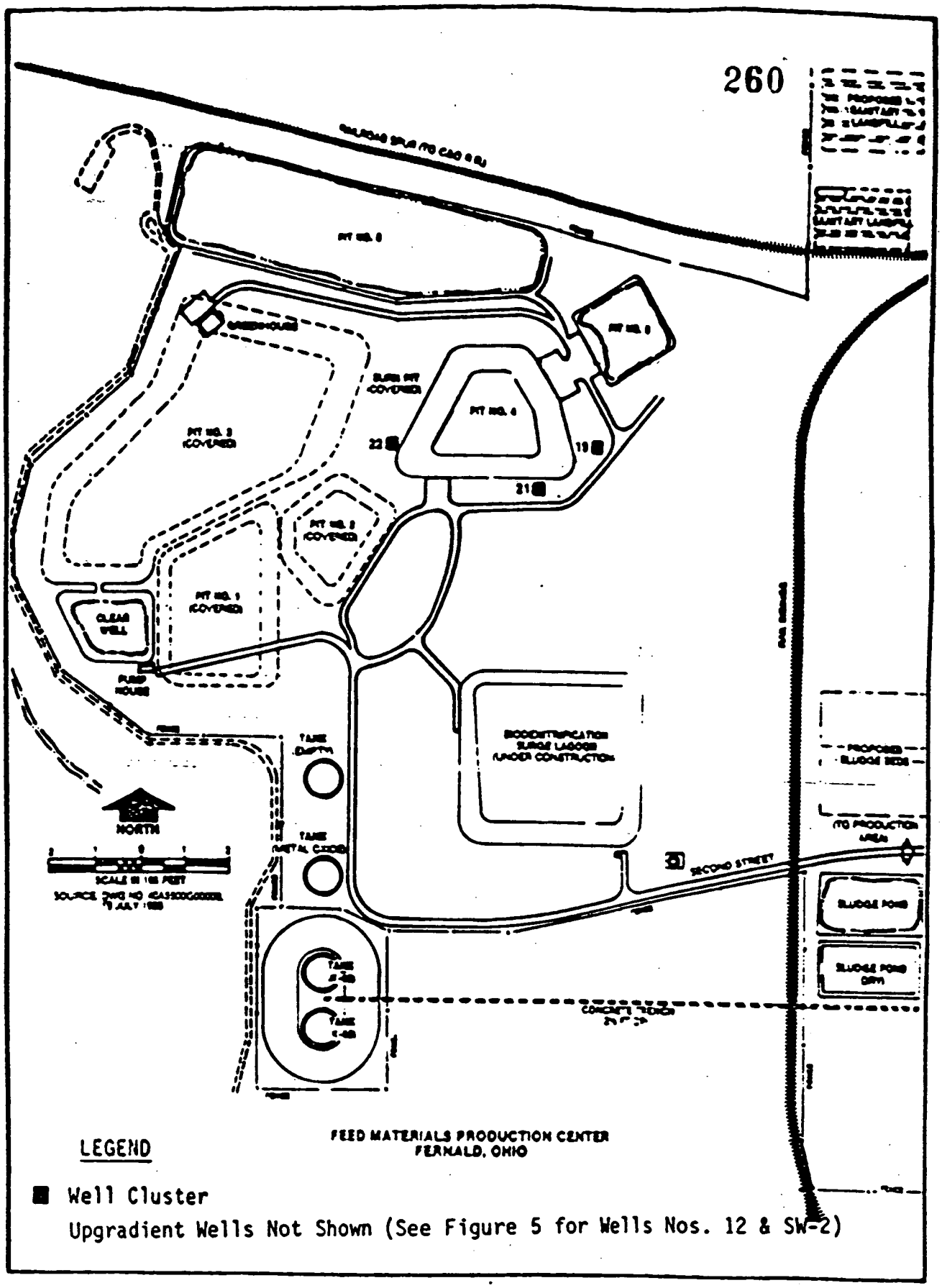


FIGURE 2

WASTE PIT NO. 4 MONITORING WELLS

Since the implementation of the GQAPO has become necessary, a more detailed assessment plan has been developed for review by the appropriate regulatory agencies and is the subject of this report.

260

1.2 Scope

The purpose of this report is to provide the more detailed groundwater quality assessment program plan as identified in the GQAPO. According to 40 CFR 265.93(d)(2), the owner or operator must develop and submit to the U.S. EPA Regional Administrator a specific plan, based on the GQAPO required under paragraph (a) of 40 CFR 265.93, within fifteen (15) days after notification.

Notification indicating that Waste Pit No. 4 may be affecting groundwater quality at the FMPC was provided to U.S. EPA on November 13, 1987. This notification was based on the statistical comparisons required by 40 CFR 265.93(b) which were completed for the designated wells around Waste Pit No. 4. These comparisons indicate that statistically significant changes in various indicator parameters have occurred, thereby requiring regulatory notification and the preparation of this assessment plan.

2.0 FMPC GEOLOGY AND HYDROLOGY

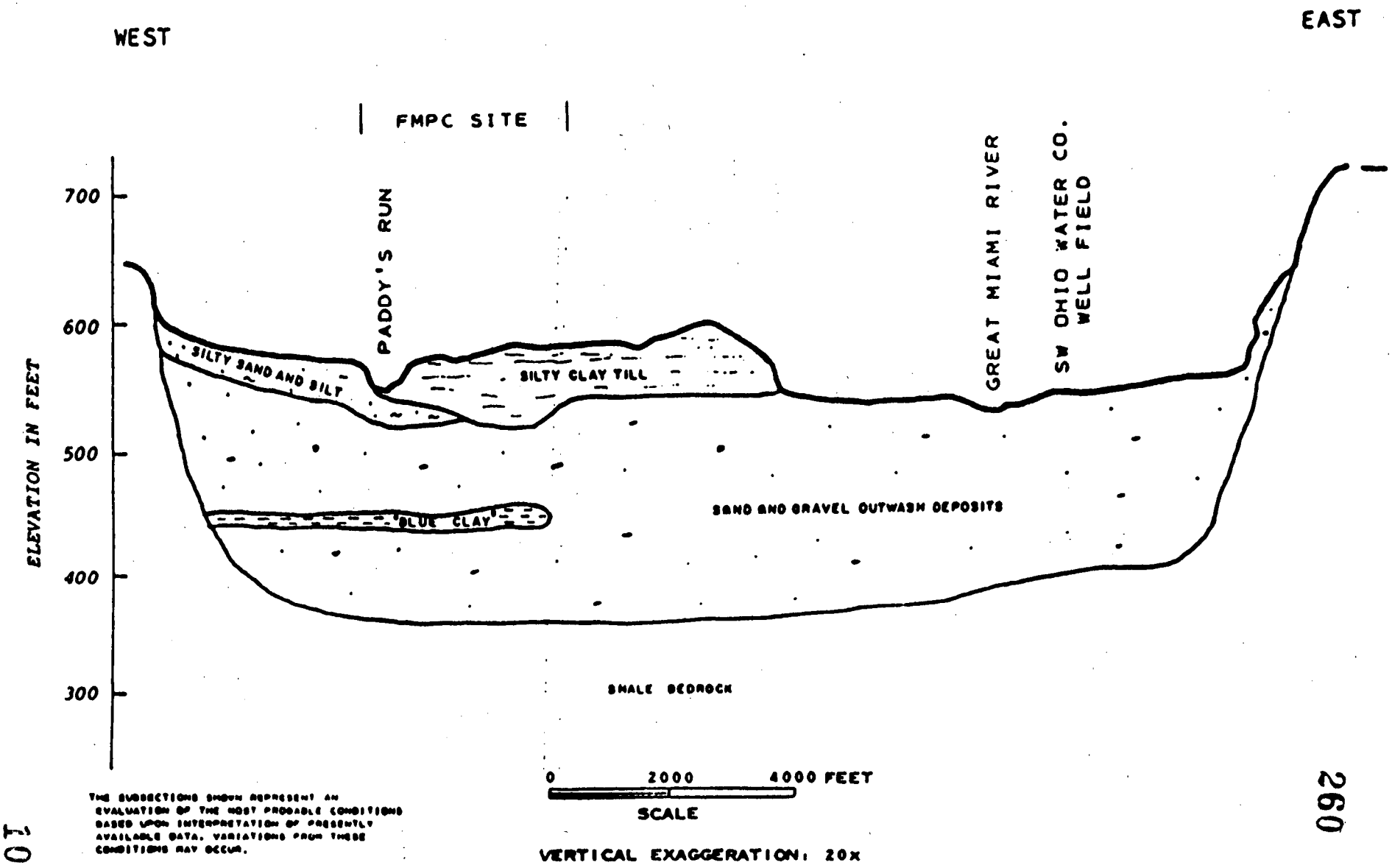
The FMPC is located in a two-mile wide valley filled with glacial desposits. This valley parallels the Great Miami River between the towns of Ross and Hooven, Ohio. A generalized geologic cross-section for the FMPC site area is presented in Figure 3.

Approximately 450 million years ago in late Ordovician time, sediments which would become a predominantly flat-lying shale with thin interbedded limestone were deposited in a shallow sea. This shale, part of the Cincinnatian Series, is the relatively impermeable bedrock which now underlies the FMPC site area.

Sometime prior to, or perhaps contemporaneous with Pleistocene glaciation, a large watercourse (larger than the present-day Great Miami River) cut a channel into this shale bedrock to a level of more than 200 feet below that of the existing Great Miami River. This approximately two-mile wide channel is sometimes referred to as the New Haven Trough and may be an abandoned course of the ancestral Ohio River.

During subsequent Pleistocene glacial advances and retreats across the site area such as the Illinoisan (approximately 300,000 to 400,000 years ago) and the Wisconsinan (approximately 100,000 years ago), the New Haven Trough was filled with about 200 feet of glacial sediments. These sediments were deposited by water flowing from the margins of the glaciers and consisted mainly of well sorted sand and gravel. A blanket of clay-rich, relatively impermeable glacial till from a more recent event was deposited atop the 200 feet of glacial sediments.

Erosion by the Great Miami River and its tributaries has subsequently removed significant portions of the glacial till which contributed to terrace remnants standing topographically higher than the surrounding bottom lands. The FMPC site lies atop one of these terrace remnants.



THE SUBSECTIONS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

FIGURE 3

GENERALIZED GEOLOGIC CROSS SECTION OF NEW HAVEN TROUGH

2.1 Sand and Gravel Aquifer

A sequence of highly permeable sand and gravel outwash deposits, laid down by the meltwaters of receding continental ice sheets, unconformably overlie the shale bedrock in the vicinity of the FMPC. These outwash deposits generally consist of an unconsolidated medium- to coarse-grained, olive brown layer of sand and gravel, ranging in thickness up to 200 feet. The sand and gravel is arranged in irregularly alternating layers of silty sand, medium to coarse sand, and medium to coarse gravel.

In the vicinity of the Waste Pit Storage Area, this layer is separated into two units by a 10 to 20 foot thick layer of greenish-black silty clay. The FMPC production wells are completed below this "blue clay" layer. This blue clay layer underlies about 360 acres of the FMPC and apparently occurs only in the vicinity of the Waste Pit Storage Area and the production wells. This layer was probably deposited in an ice marginal lake or as a backwater deposit of a glacial stream. The top of this blue clay layer lies about 125 feet below the land surface.

The sand and gravel aquifer, separated by the blue clay layer, acts a single, hydrological unit. The blue clay layer is not sufficiently extensive to act as an aquitard and no significant head differences have been detected between wells completed above and below this layer.

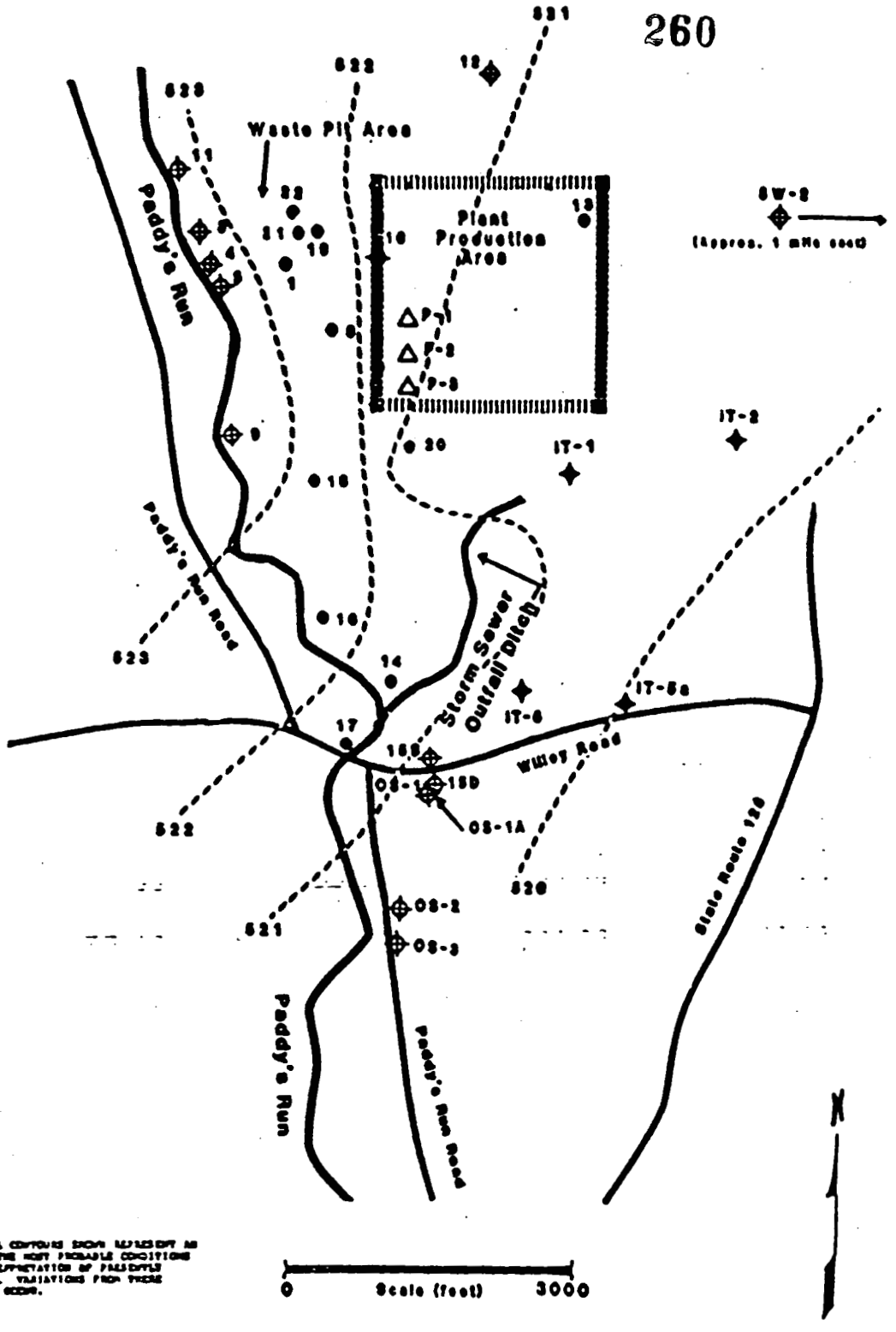
Transmissivities and hydraulic conductivities for the sand and gravel aquifer range from 35,000 gallons per day per foot (gpd/ft) to 300,000 gpd/ft and 270 ft/day to 370 ft/day, respectively. Total porosities of this aquifer have been estimated at 25 percent. Average hydraulic gradients for the area were calculated from water level measurements collected by the U.S. Geological Survey in August, 1982, and range from 0.001 ft/ft to 0.005 ft/ft. Using this data, the rate of groundwater movement, or horizontal groundwater velocity, is calculated to range between 1.1 ft/day and 9.3 ft/day.

A recent water level contour map for the sand and gravel aquifer is shown in Figure 4, with the corresponding water level measurements provided in Table 1. This map indicates a general groundwater movement in the east direction near Waste Pit No. 4. The upper 20 to 30 feet of the sand and gravel deposits are not saturated, with water in this aquifer generally occuring at levels approximately 60 to 90 feet below the land surface. These levels depend on the relative thickness of the glacial till and respective land surface elevation.

2.2 Glacial Till [redacted]

At the land surface of the FMPC, a 20 to 50 foot thick layer of glacial till, composed of a dense, olive-gray silty clay, overlies the sand and gravel outwash deposits. The till varies in texture and composition, both laterally and vertically, and contains lenses of poorly sorted fine to medium grained sand and gravel. The base of the till occurs at the estimated elevation of 540 mean sea level (MSL) and overlies the sand and gravel outwash deposits.

To the south and west of the FMPC, the silty clay till laterally grades into a sequence of silt and silty sand, with some layers of silty clay.



THE WATER LEVEL CONTOURS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

Explanation:

- Single Well Location
- Cluster Well Location
- Production Well Location
- IT Well Location
- WATER TABLE CONTOURS

WATER TABLE CONTOURS
MAY 5, 1987
Figure 4

Round 5 Water Level Elevations

Well #	Depth to Water (ft)	Casing Elev. (MSL)	Grade (MSL)	Water Table Elev. (MSL)
P-1	NA	578.66	576.66	NA
P-2	NA	579.16	577.16	NA
P-3	NA	579.36	577.36	NA
1S	NA	585.55	583.47	NA
1d	63.17	585.31	583.81	522.14
3	NA	560.86	559.30	NA
4	NA	556.85	556.15	NA
5	NA	557.09	555.53	NA
8s	54.33	576.60	574.90	522.27
8d	54.83	576.62	574.82	521.79
9	33.10	557.23	555.31	524.13
10	66.92	588.39	586.56	521.47
11	62.69	585.78	583.64	523.09
12	31.83	639.67	637.48	607.84
13s	70.06	590.37	588.71	520.31
13d	70.08	590.36	588.72	520.28
14s	14.04	535.79	533.76	521.75
14d	14.06	535.99	533.71	521.93
15s	58.85	579.53	577.80	520.68
15d	NA	579.41	577.80	NA
16s	20.15	542.28	540.47	522.13
16d	20.13	542.13	540.50	522.00
17s	14.42	536.19	534.43	521.77
17d	14.54	536.35	534.83	521.81
18s	50.50	573.36	571.31	522.86
18d	NA	573.88	571.56	NA
19s	63.17	585.38	583.26	522.21
19d	63.08	585.25	583.20	522.17
TP-19	7.00	584.96	582.98	577.96
20s	53.81	574.44	573.42	520.63
20d	53.10	574.71	573.31	521.61
TP-20	4.69	574.73	573.21	570.04
21s	63.58	586.02	594.42	522.44
TP-21	4.58	585.61	584.06	581.03
22s	65.29	587.95	587.93	522.66
TP-22	6.83	588.91	587.93	582.08
SW-2	NA	NA	NA	NA
OS-1	NA	581.83	581.35	NA
OS-2	NA	NA	NA	NA
OS-3	NA	NA	NA	NA
OS-1A	NA	581.83	581.83	NA
*IT-1	63.38	579.93	577.93	516.55
*IT-2	75.00	595.58	593.22	520.58
*IT-5A	74.23	594.22	592.17	519.99
*IT-6	55.50	576.02	574.07	520.52

* Not Sampled
NA - Not Available
MSL - Mean Sea Level

The silty clay till is continuous to the north and east of the site, and directly overlies the bedrock in these areas. In the lower reaches of Paddy's Run and the storm sewer outfall ditch, the silty clay till has eroded to expose the underlying sand and gravel. 260

A saturated zone occurs within the silty clay till at levels approximately 4 to 9 feet below the land surface in some areas of the FMPC site. This saturated zone was encountered in three shallow wells (MW-19TP, MW-21TP, and MW-22TP) completed around Waste Pit No. 4, and in another well (MW-20TP) located to the south of the Waste Pit Storage Area. This saturated zone is probably recharged by precipitation and may be present due to vertical variations of composition and texture of the till, or near-surface weathering and desiccation-induced fracturing of the till. The locations for these wells are shown in Figure 5, as part of the cluster well systems 19, 20, 21, and 22.

Aquifer testing of the saturated zone within the glacial till has measured hydraulic conductivities of 0.2 ft/day to 2.5 ft/day, with associated transmissivities of 3.5 gpd/ft to 150 gpd/ft.

3.0 PROBLEM IDENTIFICATION

This section of the groundwater quality assessment program plan describes the four techniques which can be used to identify whether hazardous waste or hazardous waste constituents have entered the groundwater. These techniques include: statistical evaluation of groundwater monitoring data, well re-sampling or sampling of additional wells, review of operational data, and installation of additional wells. Further information regarding the statistical evaluation for these wells is provided in Reference 4.

3.1 Statistical Evaluation

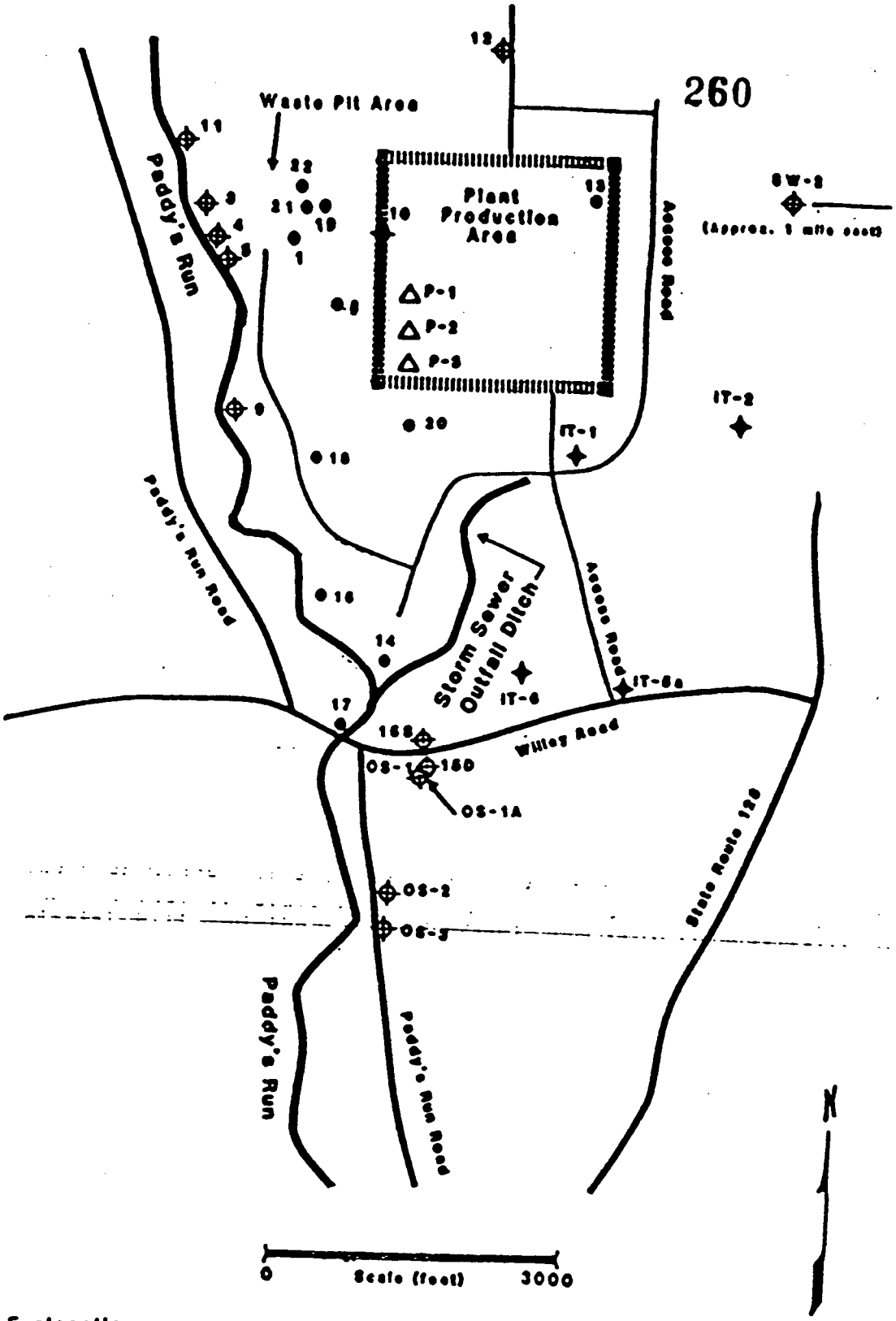
The use of the student's t-test is required for groundwater monitoring data according to 40 CFR 265, Subpart F. For each indicator parameter, the arithmetic mean and variance are calculated for four replicate measurements of each sample collected from the Waste Pit No. 4 monitoring wells and compared to the initial background arithmetic mean. The RCRA groundwater monitoring indicator parameters are Total Organic Carbon (TOC), Total Organic Halogens (TOX), specific conductance (SC), and pH.

The procedure used to compare the background and monitoring values for each well was Cochran's Approximation to the Behrens-Fisher Student's t-test, according to the guidance provided in Appendix IV of 40 CFR Part 264 and the RCRA Technical Enforcement Guidance Document (TEGD, Reference 5).

The test consists of the following steps:

1) Compute the background and monitoring means,

2) Compute the background and monitoring variances,



Explanation:

- Single Well Location
- Cluster Well Location
- Production Well Location
- IT Well Location

WELL LOCATIONS

Figure 15

3) Compute the t-statistic (T*) for each comparison. The t-statistic is derived by dividing the difference in the monitoring and background means by the square root of the difference between the ratio of variance to the number of results for background and monitoring values,

260

4) Calculation of special weightings for background and monitoring data sets. The special weighting is the ratio of the variance to the number of samples, and

5) Calculation of the comparison t-statistic (T_c). The formula for the comparison t-statistic is:

$$T_c = W_b t_b + W_m t_m \;/\; W_b + W_m$$

Where W is the special weighting and t is taken from standard T-Tables at the 0.05 level of significance.

A decision as to whether or not a statistically significant increase (or decrease in the case of pH) has occurred between the two sets of values is made by comparing the T* and T_c values as follows:

1) If T* is larger than T_c, a significant increase has most likely occurred, and

2) In the case of pH, if the absolute value of T* is larger than T_c, a significant change is indicated, with negative values of T* indicating a decrease and positive values indicating an increase.

Two upgradient wells (MW-12 and SW-2) at or near the FMPC were used in the statistical evaluation to represent upgradient water quality in the glacial till and the sand and gravel aquifers, respectively. Means and variances of indicator parameters (i.e., pH, TOC, TOX, and specific conductance) tested on a quarterly basis over the past year for these two wells are provided in Table 2.

Calculated variances for pH, specific conductance, and TOC are within ranges typical for these types of measurements. TOX variances are very large and can be attributed to the two order of magnitude increase in TOX concentrations recorded in the RCRA Round 3 (August, 1986) sampling data (Reference 6).

Results of the statistical comparisons are summarized in Table 3. Table 4 of this report contains a listing of all calculated T* and T_c statistics, as well as monitoring means and variances used in these comparisons. The downgradient glacial till wells are 19TP, 21TP, and 22TP. As shown in Table 3, it is apparent that for the glacial till water bearing zone:

1) TOX did not significantly increase for either the upgradient well or any of the downgradient wells in the RCRA Round 5 sampling, and

16

Table 2
Background Means and Variances for Upgradient Wells

		MW-12 Glacial Till Well	SW-12 Sand and Gravel Well
pH			
	Mean	7.68	7.33
	Var	1.36 E -2	7.53 E -3
S.C.			
	Mean	1001.5	655.9
	Var	5339.7	397.2
TOX			
	Mean	1672.3	1631.7
	Var	1.15 E 7	8.62 E 6
TOC			
	Mean	(<) 1	(<) 1
	Var	0.0	0.0

Table 3
Statistical Comparision Summary

Glacial Till Wells	pH	Specific Cond.	TOC	TOX
		Parameters		
MW-12	Increase	No Change	No Change	No Change
MW-19TP	Decrease	Increase	Increase	No Change
MW-21TP	Decrease	No Change	Increase	No Change
MW-22TP	Decrease	Increase	Increase	No Change

Sand and Gravel Wells	pH	Specific Cond.	TOC	TOX
		Parameters		
SW-2	No Change	No Change	No Change	No Change
MW-19s	No Change	Increase	No Change	No Change
MW-19d	Decrease	Increase	No Change	No Change
MW-21s	No Change	Increase	No Change	No Change
MW-22s	No Change	Increase	No Change	No Change

TABLE 4

CALCULATED T*/Tc STATISTICS

PARAMETER:		WELL NUMBER (1) MW-12	MW-19TP	MW-21TP	MW-22TP
TOX:					
	Mean	10	10	10	37.5
	Variance	0.0	0.0	0	27.67
	T*	-2.19	-2.19	-2.19	-2.15
	Tc	1.73	1.73	1.73	1.73
	Increase	No	No	No	No
TOC:					
	Mean	1	5.5	3	3.75
	Variance	0	0.33	0	0.25
	T*	N/A	15.59	N/A	11.00
	Tc	N/A	2.35	N/A	2.36
	Increase	No	Yes	Yes	Yes
Sp. Cond.:					
	Mean	877	2522.5	970	2020
	Variance	0	34425	3654	19000
	T*	-7.62	16.15	-0.92	14.38
	Tc	1.73	2.33	2.21	2.32
	Increase	No	Yes	No	Yes
pH:					
	Mean	7.81	6.73	7.18	7.01
	Variance	3.3E-05	0.000292	0.000467	0.000158
	T*	4.71	-34.63	-17.79	-24.79
	Tc	2.11	2.20	2.25	2.15
	Change	Incr.	Decr.	Decr.	Decr.

(1) Each well compared to MW-12 background values

TABLE 4 (CONTINUED)

CALCULATED T*/Tc STATISTICS

PARAMETER:		WELL NUMBER (2)				
		MW-19s	MW-19d	MW-21s	MW-22s	SW-2
TOX:						
	Mean	12.25	10	10	10	26.5
	Variance	13.58	0	0	0	1.67
	T*	-2.21	-2.21	-2.21	-2.21	-2.19
	Tc	1.75	1.75	1.75	1.75	1.75
	Increase	No	No	No	No	No
TOC:						
	Mean	1	1	1	1	1
	Variance	0	0	0	0	0
	T*	N/A	N/A	N/A	N/A	N/A
	Tc	N/A	N/A	N/A	N/A	N/A
	Increase	No	No	No	No	No
Sp. Cond.:						
	Mean	1037.5	1090	1105	1062.5	597.25
	Variance	1091.67	0	4300	91.67	6.25
	T*	22.12	87.132	13.54	58.85	-11.41
	Tc	2.3	1.75	2.34	2.04	1.79
	Increase	Yes	Yes	Yes	Yes	No
pH:						
	Mean	7.33	7.05	7.29	7.31	7.38
	Variance	6.7E-05	6.67E-05	0.000467	0.000292	0.0003
	T*	-0.23	-12.91	-1.86	-0.96	2.14
	Tc	2.17	2.17	2.34	2.27	2.28
	Change	None	Decr.	None	None	None

(2) Each well compared to SW-2 background values

2) TOC concentrations significantly increased in all downgradient wells. Also, pH significantly increased in the upgradient well and significantly decreased in all downgradient wells. Specific conductance did not significantly change in the upgradient well, but significantly increased in two of the three downgradient wells.

260

RCRA Round 5 analytical data for the wells completed in the glacial till water bearing zone demonstrate that pH, TOC, and TOX are within typical groundwater ranges for these parameters (Reference 7). Significant changes detected by the statistical comparison may be related to natural fluctuations in groundwater quality. Specific conductance for some of the wells completed in the glacial till are elevated when compared to the upgradient well, but are more consistent with values reported for an offsite well (OS-1A) completed in the glacial till.

For the sand and gravel wells (19s, 19d, 21s, and 22s) Table 3 shows:

1) pH, TOC, TOX, and specific conductance did not significantly change in RCRA Round 5 groundwater sampling for the upgradient well,

2) TOC and TOX did not significantly change in the downgradient wells in the Round 5 sampling, and

3) Specific conductance significantly increased in all downgradient wells and pH significantly decreased in one downgradient well.

The range of values for pH, TOC, and TOX for the downgradient wells appear to be within typical groundwater ranges. Significant changes reported by the statistical comparisons may be related to natural fluctuations in water quality. Specific conductance values reported in the downgradient wells completed in the sand and gravel aquifer are clearly elevated when compared to the upgradient well.

Based on the consistency of the results obtained during the past five rounds of groundwater sampling and analyses, the conclusion presented by the statistical comparisons should be considered accurate, with no confirmatory sampling and analysis required for the indicator parameters. Further monitoring will be performed in conjunction with the proposed groundwater assessment program for the FMPC.

3.2 Additional Sampling

Additional analytical data, beyond that obtained from the past quarterly sampling at the FMPC, may be necessary to confirm the presence of hazardous waste or hazardous waste constituents in the groundwater. Monitoring wells will be resampled in order to confirm data accuracy and repeatability, if warranted.

Further monitoring of the RCRA wells for Waste Pit No. 4 will be conducted as follows. First, the second semi-annual sampling (Round 6)

will be completed by December, 1987 for 41 onsite and offsite wells at the FMPC. The sampling order for these wells is shown in Table 5, with the analytical parameters provided in Table 6. This sampling event will conclude one full year of semi-annual RCRA groundwater monitoring for Waste Pit No. 4 and will provide a sufficient database for further assessment monitoring.

The second form of RCRA groundwater monitoring will be conducted under the current sitewide Remedial Investigation/Feasibility Study (RI/FS) at the FMPC. This effort will include the drilling and installation of numerous groundwater monitoring wells which can be used in further establishing groundwater quality in the vicinity of Waste Pit No. 4. Two well clusters have been installed at locations upgradient and downgradient of Waste Pit No. 4, as specifically requested by Ohio and U.S. EPA. These clusters, shown in Figures 6 and 7, are located northwest of the Waste Pit Storage Area (upgradient) and immediately northeast of Waste Pit No. 4 (downgradient). Also, Well No. 124 (Figure 10) will be used as a RCRA upgradient glacial till monitoring well.

The number and location of additional wells used in assessment monitoring at the FMPC is being addressed under the scope of the RI/FS and is discussed in Section 4.0 of this report. Results of hydrogeologic field program of the RI/FS will be used as a basis for the development of future RCRA groundwater monitoring plans at the FMPC.

3.3 Operational Data

The analytical results of the recently completed Characterization Investigation Study (CIS), which was conducted by the firm of Roy F. Weston, Inc. for the Waste Pit Storage Area, will be evaluated when available. The CIS involved a sampling and analysis program specifically designed to characterize the wastes stored in the various waste storage facilities located at the FMPC.

The CIS information will be used in assessing the potential impacts of these facilities on the local groundwater quality in terms of the presence of hazardous waste or hazardous waste constituents within the Waste Pit Storage Area. For example, if organics and/or metals are found in significant concentrations, groundwater samples from nearby downgradient wells will be analyzed for the Hazardous Substance List (HSL) parameters. In addition, geophysical survey information collected during the CIS will be evaluated as part of the groundwater quality assessment, as indicated in Section 5.0 of this report.

3.4 Additional Well Installation

As previously mentioned in Section 3.2, additional wells have been installed upgradient and downgradient of Waste Pit No. 4. These wells were completed in conjunction with the groundwater sampling program of the sitewide RI/FS, with their specific locations approved by both Ohio and U.S. EPA. A total of 92 groundwater monitoring wells is proposed for installation during the RI/FS.

TABLE 5

Monitoring Well Sampling Order

260

Sampling Order	Well Number	Location
1	12	Off North access road
2	SW-2	Southwest collector
3	P-1	West side production area
4	P-2	West side production area
5	P-3	Water treatment Plant
6	OS-1 deep	Farm house on Willey Road
7	OS-1 dug	Farm house on Willey Road
8	15s	Pasture on Willey Road
9	16d	Guard training area
10	16s	Shooting range
11	17d	Willey Road Bridge
12	17s	Willey Road Bridge
13	18d	South of production area
14	18s	South of production area
15	20d	Southwest of production area
16	20s	Southwest of production area
17	20TP	Southwest of production area
18	14d	Confluence of SSOD with Paddy's Run
19	14s	Confluence of SSOD with Paddy's Run
20	9	Paddy's Run-East bank
21	11	North of production area
22	13d	East of scrap metal site
23	13s	East of scrap metal site
24	8d	South of waste pit storage area
25	8s	South of waste pit storage area
26	10	East end of waste pit area
27	3	East of pit 3 area
28	4	South of pit 3
29	5	South of pit 3
30	1d	North of K-65 tanks
31	1s	North of K-65 tanks
32	19d	East of pit 4
33	19s	East of pit 4
34	19TP	East of pit 4
35	21s	South of pit 4
36	21TP	South of pit 4
37	22s	West of pit 4
38	22TP	West of pit 4
39	OS-1	Exterior tap in yard of farm house off Willey Road
40	OS-2	East side of Paddy's Run Road
41	OS-3	East side of Paddy's Run Road

23

TABLE 6

RCRA GROUNDWATER DETECTION MONITORING PARAMETERS

260

A. For General Water Quality [1]

1. Chloride
2. Iron
3. Manganese
4. Phenols
5. Sodium
6. Sulfate

B. For Indicators of Contamination (Quadruplicate Analysis) [1]

1. pH
2. Specific Conductance
3. Total Organic Carbon (TOC)
4. Total Organ Halogen (TOX)

C. For Drinking Water Suitability [1]

1. Arsenic
2. Barium
3. Cadmium
4. Chromium - Hexavalent
   - Total
5. Fluoride
6. Lead
7. Mercury
8. Nitrate
9. Selenium
10. Silver
11. Gross Alpha
12. Gross Beta
13. Radium

24

14. Endrin
15. Lindane
16. Methoxychlor
17. Toxaphene
18. 2,4-D
19. 2,4,5-TP
20. Coliform Bacteria

D. Site Specific Parameters [2]

1. Nickel
2. Cyanide
3. Copper
4. Zinc
5. Magnesium
6. Calcium
7. Phosphorus
8. Chlorobenzene
9. Chlorodibromomethane
10. Chloroethane
11. 2-chloroethylvinyl
12. Chloroform
13. Dichlorobromomethane
14. Dichlorodifluoromethane
15. Total Dissolved Solids (TDS)
16. Total Potassium
17. Chemical Oxygen Demand (COD)
18. Perchloroethylene (same as No
19. cis 1,2 Dichloroethylene
20. Tributylphosphate
21. Acrolein
22. Acrylonotrille
23. Benzene
24. bis (chloromethyl) Ether
25. Bromoform
26. Bromodichloromethane
27. Bromomethane
28. Carbon tetrachloride
29. Chloromethane
30. 1,2 Dichlorobenzene
31. 1,3 Dichlorobenzene
32. 1,4 Dichlorobenzene

33. 1,1 Dichloroethane
34. 1,2 Dichloroethane
35. 1,1 Dichloroethylene
36. 1,2 Dichloropropane
37. 1,2 Dichloropropylene
38. Ethylbenzene
39. Methylbromide
40. Methylchloride
41. trans-1,2 Dichloroethylene
42. 1,3 Dichloropropene
43. 1,1,2,2 Tetrachloroethane
44. Tetrachloroethylene
45. Toluene
46. 1,1,1 Trichloroethane
47. 1,1,2 Trichloroethane
48. Trichloroethylene
49. Trichlorofluoromethane
50. Vinyl Chloride

E. Radionuclide [2]

1. Potassium 40
2. Total Uranium
3. Radium 226
4. Radium 228
5. Technetium 99
6. Thorium 228
7. Thorium 230
8. Thorium 232
9. Cesium 137
10. Strontium 90
11. Ruthenium 106
12. Neptunium 237
13. Plutonium 238
14. Plutonium 239
15. Plutonium 240

F. Schedule - Quarterly for one (1) year, semiannual thereafter (or as necessary according to regulations).

[1]Required for RCRA and analyzed for each sample.

[2]Not required for RCRA, but also analyzed for each sample.

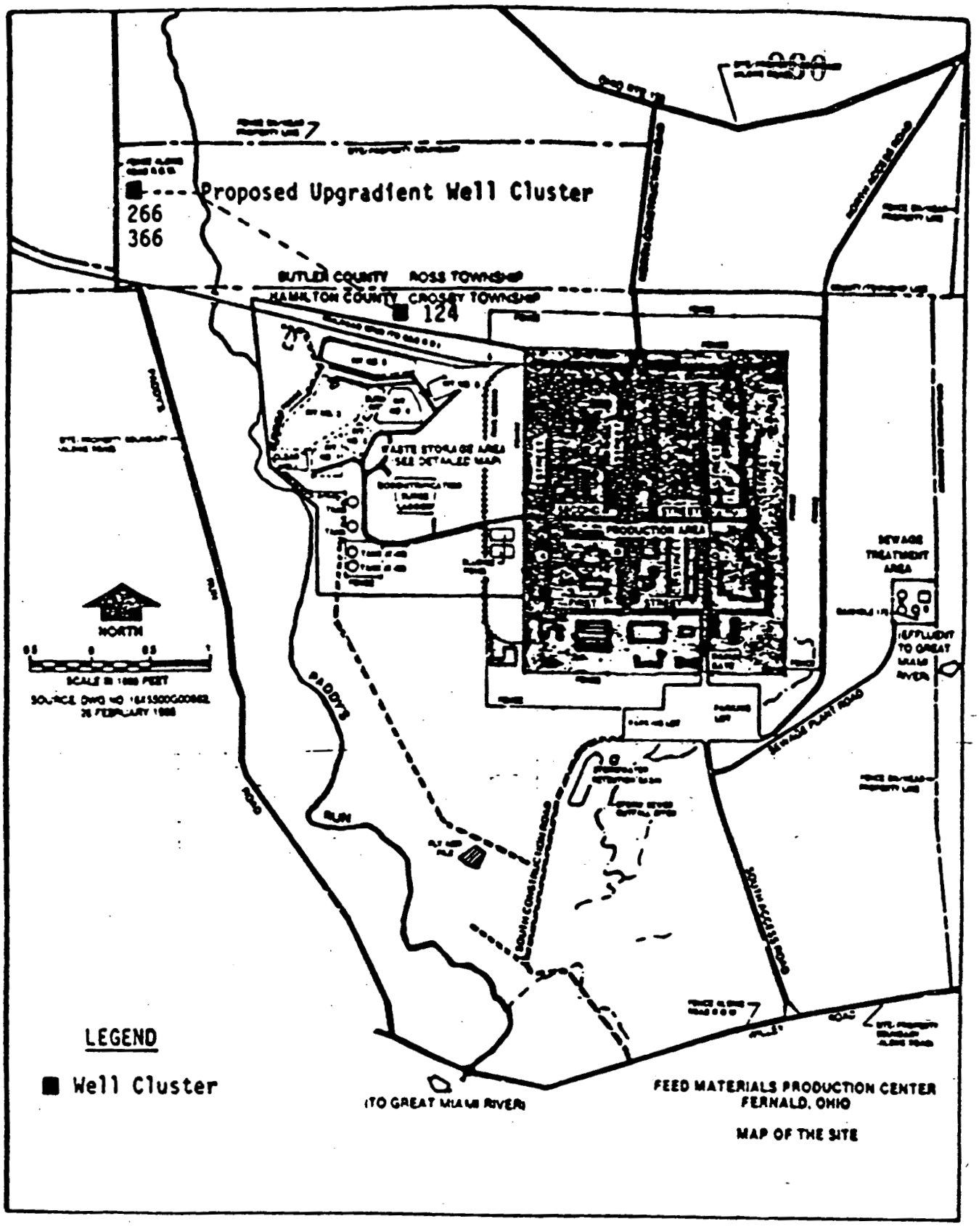


FIGURE 6

PROPOSED UPGRADIENT WELL CLUSTER

27

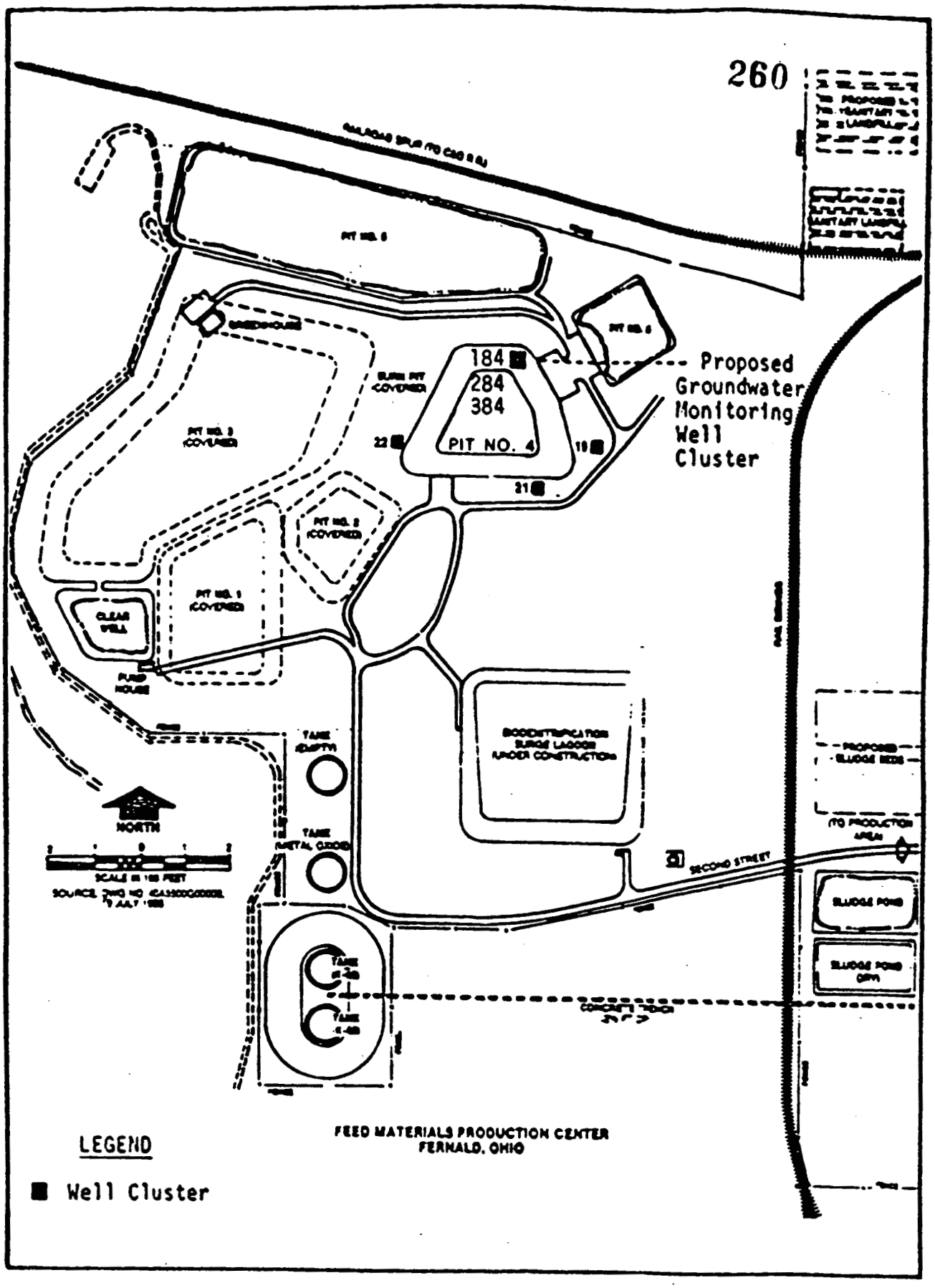


FIGURE 7

PROPOSED DOWNGRADIENT WELL CLUSTER

All boreholes for the wells will be advanced using cable tool drilling methods and will follow the general procedures presented in the Quality Assurance Project Plan (QAPP) of the RI/FS. The use of these wells and resulting groundwater data is the primary objective of the groundwater assessment program at the FMPC, and is discussed in further detail in the following section of this report and the Work Plan for the RI/FS (Reference 8).

260

4.0 ASSESSMENT PROGRAM IMPLEMENTATION

This section of the Groundwater Quality Assessment Program Plan introduces the techniques used to determine the concentration of hazardous waste or hazardous waste constituents in the groundwater and to delineate the rate and extent of migration of these constituents in the groundwater at the FMPC. The groundwater assessment program for Pit 4 at the FMPC will be completed as part of the RI/FS.

4.1 Objectives and Justification

A major objective of the sitewide RI/FS will focus on determining the potential effects of FMPC operations and waste disposal practices on local groundwater. Groundwater assessment sampling will be completed within the scope of the RI/FS program. The overall objective of the RI/FS groundwater sampling program is to satisfy identified data gaps to:

a) Determine if subsurface water-bearing zones below the FMPC have been contaminated,

b) Determine the concentrations and sources of contaminants onsite,

c) Characterize the rate and direction of groundwater flow within each separate hydrologic unit,

d) Determine the effects of groundwater pumping and resulting recharge/discharge relationships on ground water flow and contaminant transport,

e) Define areas of subsurface migration and groundwater discharge for contaminants, and

f) Determine the extent (both vertically and horizontally) of contamination from the FMPC.

The study will focus on identifying sources of groundwater contamination and pathways for contaminant transport, and assessing the risk to potential receptors of the identified contaminants. By properly defining the groundwater system and the sources and pathways of contamination at the FMPC, appropriate remedial actions can be considered and their respective impacts will be assessed with respect to public health and environmental issues.

29

4.2 Program Scope and Well Placement Rationale

As previously mentioned in Section 3.2, a total of 92 monitoring wells will be installed during the RI/FS. Three different water-bearing zones will be intercepted by the proposed monitoring wells. Figures 8 through 12 show the locations of the existing and proposed monitoring wells at or near the FMPC.

Proposed well locations were selected based on data gaps identified from previous groundwater studies and sampling results from existing wells. The existing well locations were used to the maximum extent possible in establishing the monitoring network for this investigation. Well depths at each location were selected to provide necessary information on the respective aquifer of concern.

The number and specific locations of the new wells have been formulated around 17 unresolved technical issues and related data needs. Table 7 has been prepared to relate each new well (as identified by its well number) to the issue or issues that its specific placement will address. Most wells address multiple issues, while each issue is addressed by at least one well. In addition, Table 7 indicates the existing wells at each location to highlight the two- or three-well clusters being formed by the new wells.

4.2.1 Glacial Till Aquifer

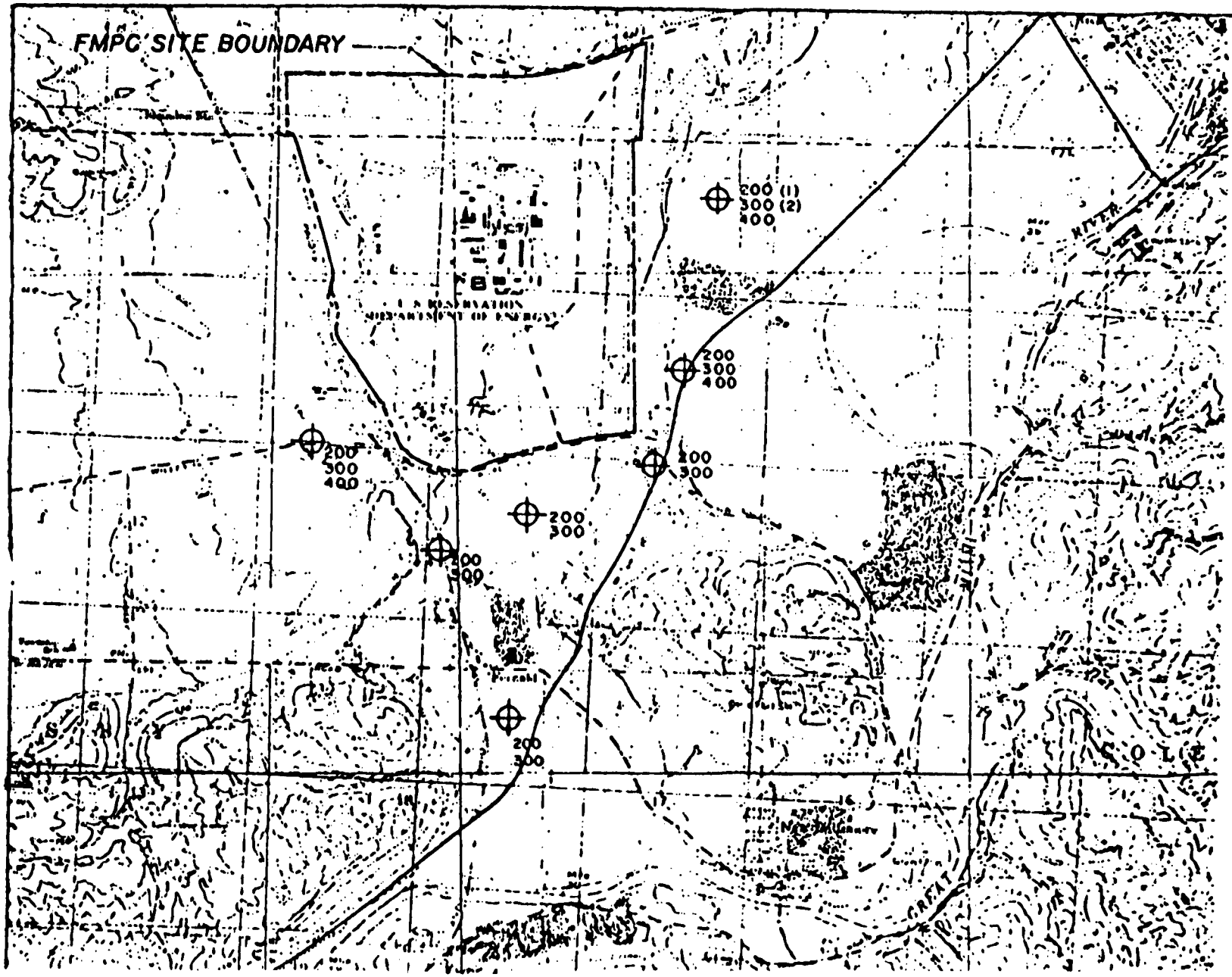
The shallowest wells (100-series) will be completed primarily in the glacial till and will screen either the water table or isolated perched groundwater. Based on stratigraphic logs from existing borings on site, it is estimated that the wells in the glacial till will be up to 35 feet deep. A total of 42 new shallow wells are proposed.

The glacial till is the geologic unit most likely to be contaminated by direct contact with wastes and by surface water infiltrating through waste areas and adjacent contaminated soils. In order to examine the extent of potential impact in the soils overlying the regional aquifer, it will be necessary to place a grouping of shallow wells immediately around the waste storage units and other potentially contaminated areas. This approach is necessary because stratigraphy within the till and near surface soils is variable and subsurface interpretations cannot be extended accurately across large areas. Only local interpretations of the flow system within the glacial till are justifiable.

Most of the 42 shallow wells will be completed in the glacial till; however, the till may be very thin or absent in some proposed locations for shallow wells. Such a condition will not necessarily reduce the value of the shallow well and a 100-series well will be installed in the upper 35 feet of the geologic unit.

4.2.2 Sand and Gravel Aquifer

The sand and gravel outwash deposits which underlie the glacial till are hydrologically less complex than the till. These deposits are also more extensive and represent a regional-scale buried channel aquifer which is



LEGEND

PROPOSED OFF-SITE WELL LOCATION

200
300
400 SERIES WELLS

(1) ALREADY INSTALL
(2) ALREADY PROPOSE

REFERENCES

7.5 MINUTE USGS TOPOGRAPHIC OF HARRISON, OHIO - IND, SHARON GREENHILLS, OHIO, CINCINNATI OHIO, ADDYSTON, OHIO - KY, AND OHIO DATED 1955 (PHOTO-REV 1965) (PHOTO-REV 1965) (PHOTO-REV 1965) (PHOTO-REV 1965) 1962 AND 1964 SCALE 1" = 2000'

SCALE
0 2000 4000

FIGURE 2

SITE MAP - FMPC RI/FS STUDY ARE

WESTINGHOUSE MATERIALS COMPANY OF OHIO
FERNALD, OHIO

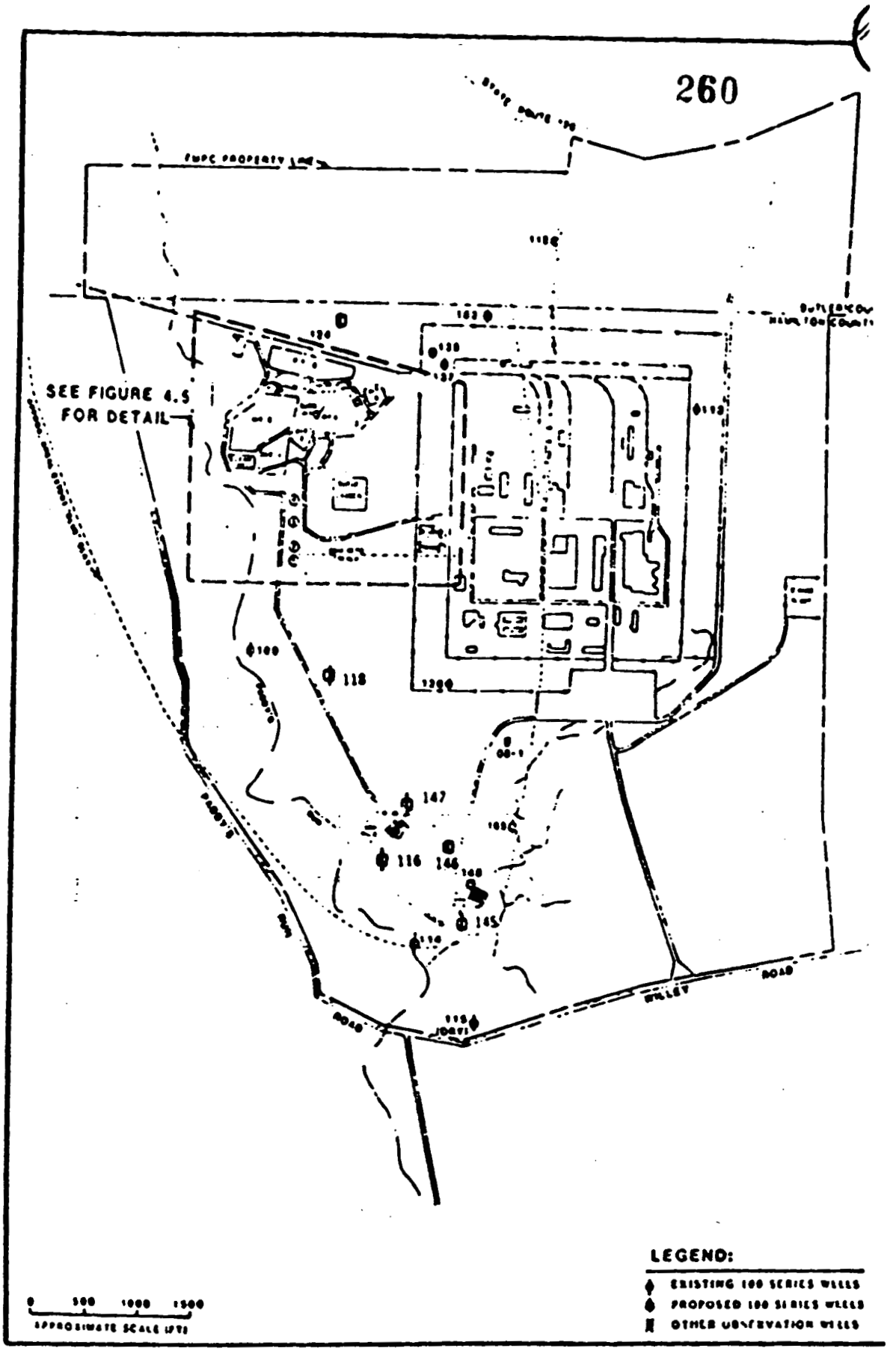


FIGURE 9

32

100 SERIES WELLS- GLACIAL TILL FMPC FACILITY

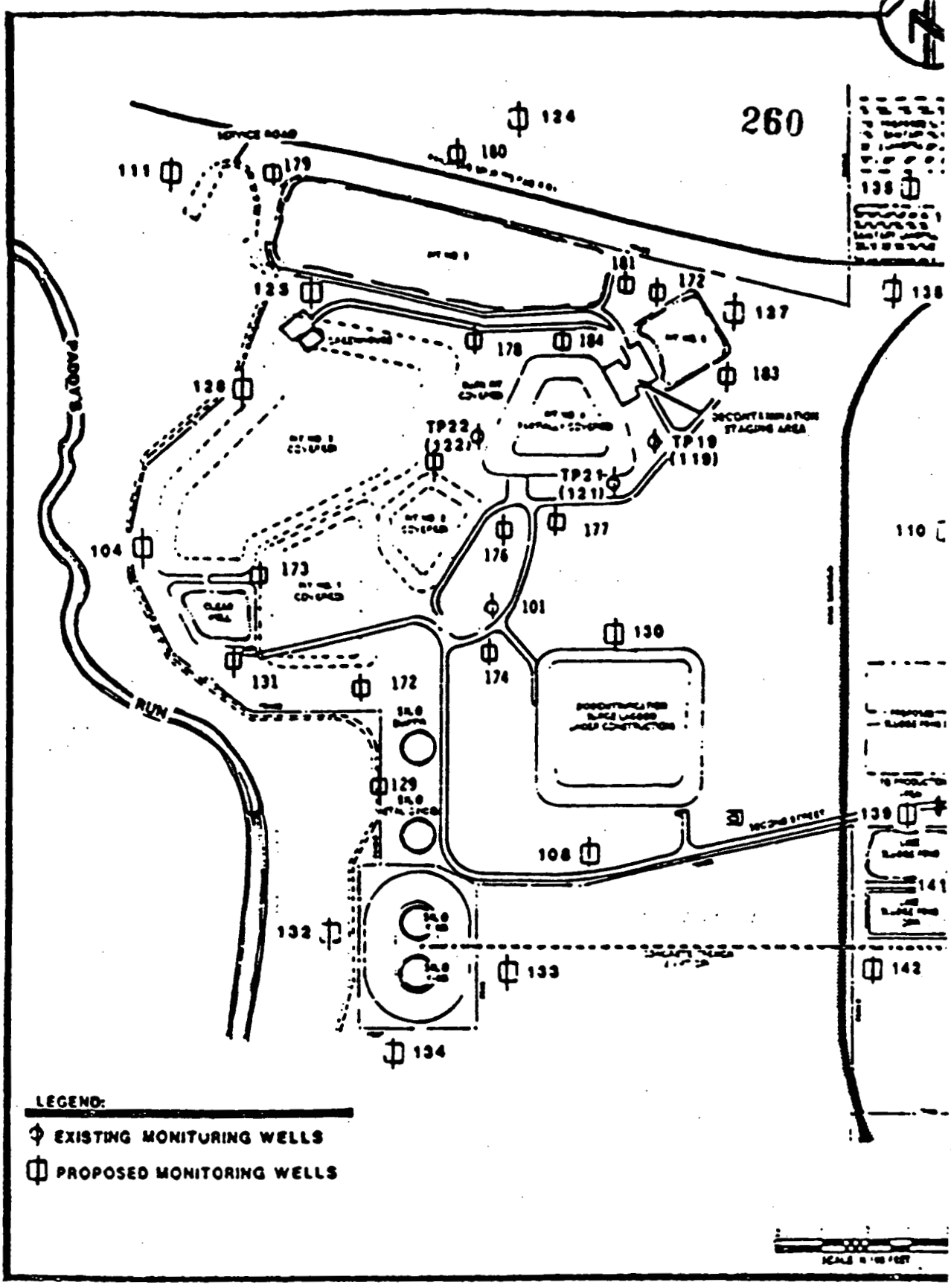


FIGURE 10

100 SERIES WELLS- WASTE MANAGEMENT AREA

33

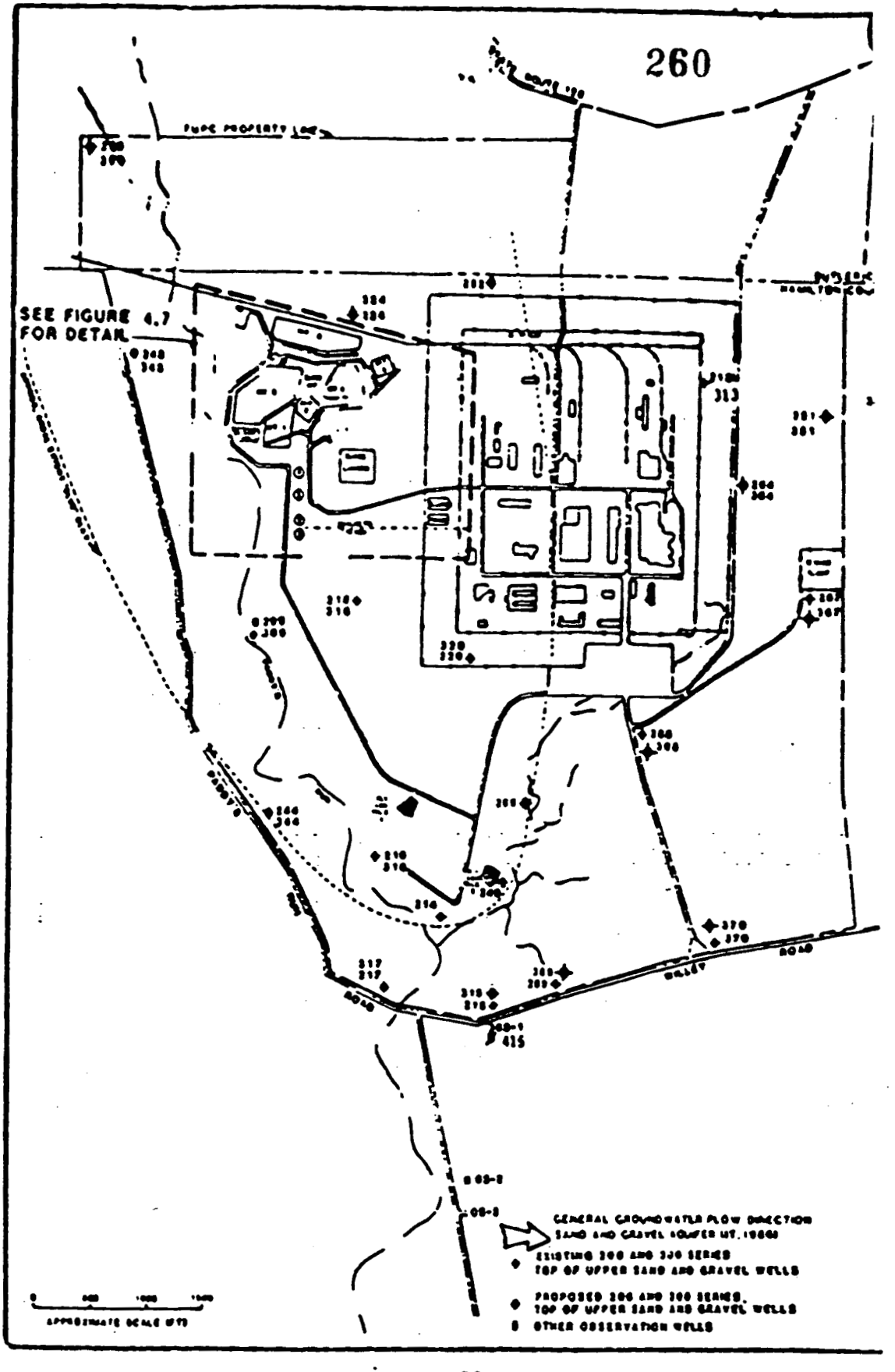


FIGURE 11

200 SERIES AND 300 SERIES WELLS - SAND AND GRAVEL AQUIFER FMPC FACILITY

34

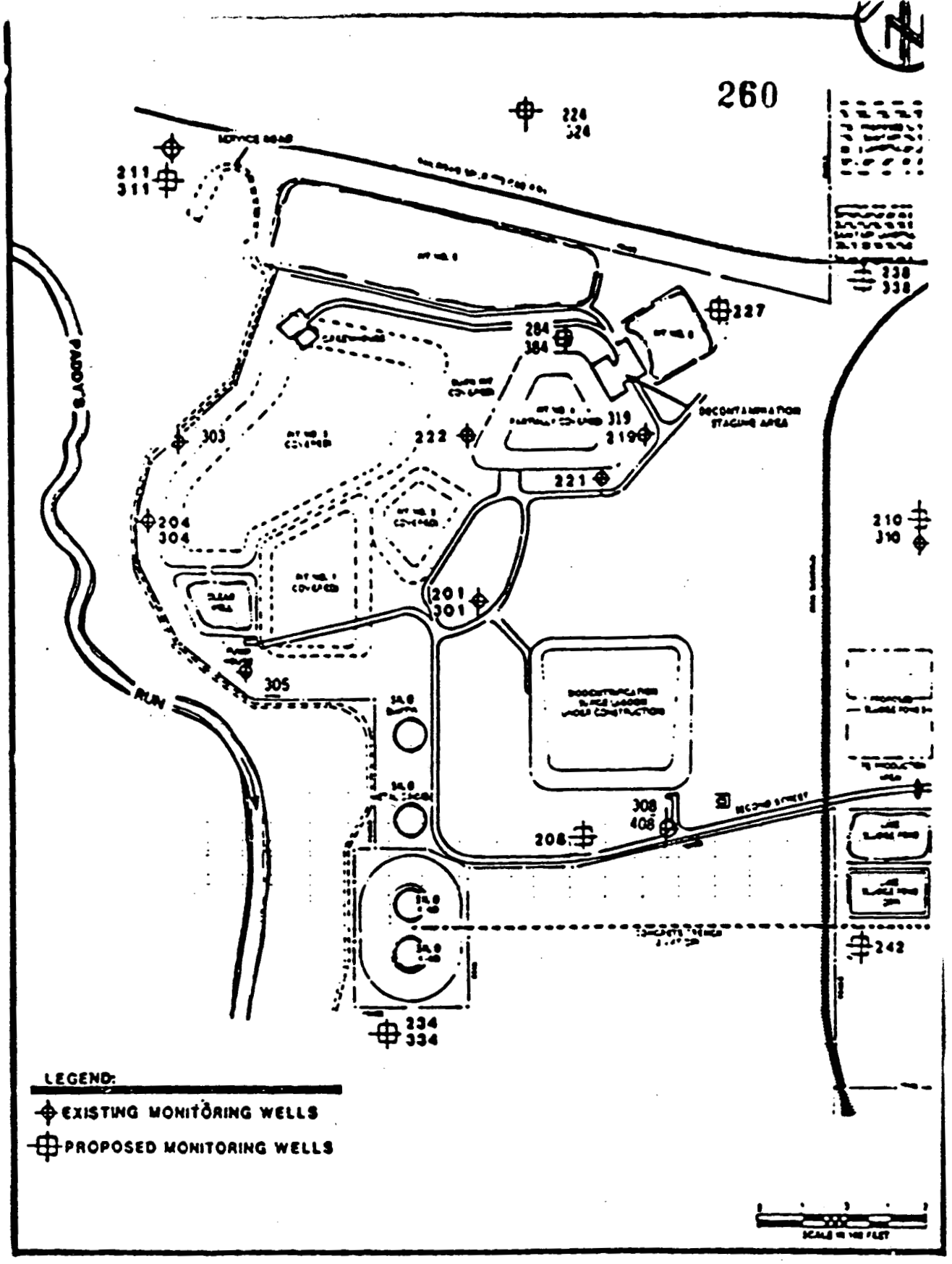


FIGURE 12

200 AND 300 SERIES WELLS- WASTE MANAGEMENT AREA

EXISTING WELLS																									
400 SERIES	300 SERIES	200 SERIES	100 SERIES	MONITOR GROUND WATER IN FILL, DEAD WASTE AREAS	PROVIDE DATA OF WELLS AROUND POTENTIAL SOURCE	EXAMINE FLOW AND QUALITY IN UPPER SAND AND GRAVEL	EXAMINE FLOW AND QUALITY IN LOWER SAND AND GRAVEL	EXAMINE VERTICAL FLOW GRADIENT IN SAND AND GRAVEL	CHARACTERIZE GROUND WATER EAST OF THE PRODUCTION AREA	EXAMINE POTENTIAL FLOW DIVIDE AND EASTWARD FLOW GRADIENT	PROVIDE ADDITIONAL DATA ON DOWNWARD FLOW GRADIENT	EXAMINE REGIONAL FLOW PATTERNS	PROVIDE DATA FOR (UNDERGROUND) CONTROL PROPS	EXAMINE EFFECTS OF PLUME EXPANSION LINE	EXAMINE EFFECTS OF PLUT AND FILES	EXAMINE EFFECTS OF FLOW WITH ORIGINAL DATA	EXAMINE GROUND WATER QUALITY NEAR PUMP'S RUN	EXAMINE FLOW DIRECTION NEAR PUMP'S RUN	EXAMINE PRODUCTION AREA AS POTENTIAL SOURCE	EXAMINE GROUND WATER QUALITY AT FOUR SUMMARY
		301																				
		303																				
	304																					
		308	400	104	108		304	304														
		309		108	109	208		308														
						209		309														
		310									208	208										
	212			110	210	210		310									109	109				
				111			311	311		210							209	209				
112												311	312							210		
113	213												311									
	214	314																				
115	215	315	415																			
	216	316					315	315														
	218	318									315	315					114	114				
119	219			118												315						
	220	320												116			116	116			315	
121	221																					
122	222																					
				124	124	224	324	224														
								324		224	224	224										
				125	125					324	324	324										
				127	127	127																
				128	128																	
				129	129																	
				130	130																	
				131	131																	
				132	132																	
				133	133																	
				134	134	234	334	234														
								334		234	234											
				135	135					334	334											
				137	137																	
				138	138	238	338	238														
								338	238													
				139	139				338													
				141	141														238			
				142	142	242													338			
						243	343	243	242													
											243	243							242			
												343										
						244	344	244								243	243			243		
								344		244	244					343	343					
				145						344	344					244	244			244		
				146												344	344					
				147																		
				148																		
														385								
														386								
														387								
														388								
						249								389								
						251	351	251	251	249	249				209							
								351	351		251											
											351								251	251		
						252						152							351	351		
												252										
						254	354	254	254										252			
									354	254	254								254			
						255				354	354								354			
										255												
						256	356	256							105							
											256	256			206							
												356										
267							357	357	357		357									256		
268							358	358		357	358									256		
269							359	359		358	359		357						357	257		
270							370	370		359	370								358	357		
271							371	371	371	370												
			172	172																359		
			173	173																370		
			174	174																		
			175	175																		
			176	176																		
			177	177																		
			178	178																		
			179	179																		
			180	180																		
			181	181																		
			182	182																		
			183	183																		
			184	184	284	284																
						384																

TABLE 7

PLACEMENT RATIONALE FOR PLANNED ON-SITE MONITOR WELL LOCATIONS

being used for water supply purposes. Results of analysis of previous samples collected from existing wells indicate potential contamination in this aquifer in the area immediately downgradient of the Waste Pit Storage Area. Analysis of samples from offsite wells to the south of the FMPC have also exhibited elevated levels of uranium (Reference 9). The nature and extent (vertical and/or horizontal) of this contamination has not been completely defined using the existing monitoring well network.

Based on a review of existing information, a series of intermediate depth wells (200-series) will be installed to a depth of approximately 70 feet in order to screen the upper portion of the sand and gravel aquifer. Twenty two 200-series wells will be completed in this portion of the aquifer.

The available information on the potential downward transport of contaminants from the upper portion of the sand and gravel aquifer into deeper zones is insufficient at this time. Because this aspect of contaminant transport is critical to an assessment of the current and future effects of the ground water pathway, the proposed well locations for the sand and gravel aquifer were developed to maximize the number of well couplets in the upper and lower zones of the sand and gravel aquifer. Nineteen new 300-series wells will be installed as a result of this program.

Three deep wells (400-series) may be installed onsite below the "blue clay" which underlies the upper sand and gravel aquifer in portions of the site. Data from existing wells completed in this zone have not indicated elevated levels of any radiological or chemical constituents. In addition, the existing data have not indicated that any contaminants reached the lower sand and gravel unit that directly overlies the blue clay. Since the blue clay may impede the downward migration of contaminants to the underlying aquifer and no contamination is known to be present, the penetration of this layer with borings and wells should be avoided if possible.

The investigative approach for the 400-series wells will be to install the 300-series wells as part of this assessment plan to determine the quality of groundwater in the sand and gravel unit overlying the blue clay. If contamination is detected, then deeper wells (400-series) which penetrate the blue clay will be proposed. Some 400-series wells may be proposed if it is necessary for purposes of the computer modeling study.

Three 400-series wells are also proposed for offsite installation. Two wells are proposed to evaluate groundwater quality and hydraulic gradients vertically throughout the aquifer east of the site, where large pumping stresses might induce downward migration of contaminants into the deeper aquifer zones. The third well is in an area outside the influence of the pumping wells and upgradient of the FMPC. A total of sixteen new monitoring wells at seven locations are proposed for installation offsite, with these data points to be included in the RI/FS data collection network. Proposed wells are located southwest, south, southeast, and east of the FMPC (see Figure 8). These monitoring wells will provide information about the quality of water and vertical hydraulic gradients for the sand and gravel aquifer so that an evaluation can be made about the magnitude, rate, and direction of potential contamination in the vicinity of the FMPC.

Additional information is required regarding the quality of groundwater directly beneath the FMPC Production Area. To focus on the Production Area as a distinct source of groundwater contamination and to assess its impact on the water-bearing zones, monitoring wells will be placed in the glacial till and the upper sand and gravel aquifers in both upgradient and downgradient directions. No wells are currently proposed within the active Production Area; however, wells may be proposed after the soils and radiological surveys are completed for the area, as well as detailed evaluation of existing data and modeling to resolve local groundwater patterns.

Current information suggests that groundwater in the till is not directly connected to groundwater in the underlying sand and gravel unit (Reference 9). Water levels in the two units are different, and the top of the sand and gravel unit is not saturated. Until the distribution of constituents in the till is more clearly defined, the approach may be to drill each shallow well in the glacial till before advancing the corresponding deeper holes into the sand and gravel aquifer below. This will avoid the inadvertent spread of contaminants by drilling through potentially high concentrations of compounds. This procedure may be modified based on information obtained in the field during the RI/FS.

4.3 Installation Methods and Materials

As previously discussed, all boreholes for wells installed during the RI/FS will be advanced using cable tool drilling methods and will follow the general procedures presented in the QAPP. A temporary steel casing will be driven as the borehole is advanced to the bottom of the hole. The temporary casing will be nominal eight-inch diameter to allow for construction of the monitoring well. Cuttings will be removed from the borehole using a sand pump or dart valve bailer, whichever proves more effective. During the process of drilling monitoring wells, relatively undisturbed soil samples will be collected with a split-spoon sampler. A typical monitoring well profile is shown in Figure 13. Section 5.12 of the QAPP provides additional information regarding drilling procedures.

Shallow wells (100-series) will be screened (with 2-10 foot sections of screen) in the water table or in localized perched water zones in the till which overlies the upper portion of the sand and gravel aquifer, so that the top of screen is below the base of the till and ten feet of screen below the water table with five feet above. The intermediate wells (200-series) will be screened at the top of the sand and gravel aquifer, so that the top of the screen is below the till base and at least ten feet below the water table. The deep wells (300-series) will be screened (with 10 feet of screen) at the top of the "blue clay" layer. In the event that blue clay is not encountered, the well will be screened at a depth approximately equal to the elevation of the top of the blue clay beneath the Production Area. The 400-series deep wells are to be screened so that the bottom of the screen is ten feet from the top of the bedrock.

The monitoring wells will be constructed in accordance with the well design and installation procedures detailed in Section 5.3 of the QAPP. Four-inch inside diameter (I.D.), screw-fit flush joint 316 stainless steel pipe will be used for well construction. Ten-foot sections of 316

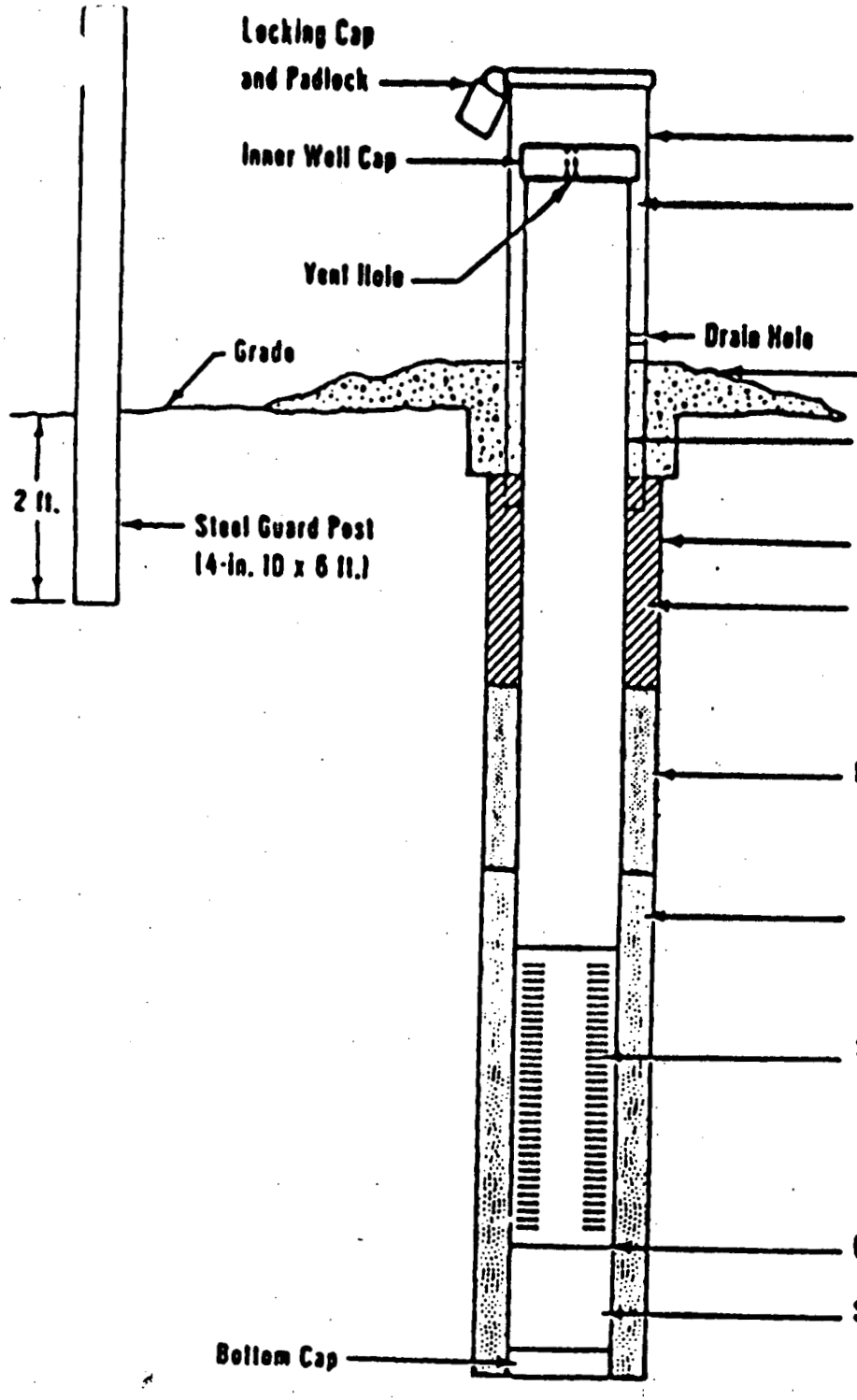


FIGURE 13 TYPICAL MONITORING WELL PROFILE

waste pits; well 108 in the vicinity of the bio-surge lagoon; well 134 in the vicinity of K-65 Silo No. 1; well 141 in the vicinity of the lime sludge ponds; wells 145 and 148 in the fly ash pile areas; well 165 near the Storm Sewer Outfall Ditch; and wells 109, 114, and 116 along Paddy's Run.

260

The diameter and rate of discharge of any potential pumping wells may not be conducive to a long-term pumping test in the relatively permeable and extensive sand and gravel aquifer. The need for a long-term pumping test will be determined only after the preliminary modeling study can be used to predict the level of aquifer response that would be expected.

4.5 Groundwater Sampling

Groundwater samples will be collected from new and selected existing wells. The new wells will include 43 100-series, 23 200-series, 23 300-series, and three 400-series wells. Thirty six additional monitoring wells that exist onsite, along with selected offsite wells, will be included in the sampling network. Also, approximately six 100-series wells, six 200-series sand and gravel aquifer wells, and six 300-series sand and gravel aquifer wells will be selected at upgradient locations and sampled to establish background concentrations.

Sampling during the RI/FS will be performed immediately after all the wells have been installed and on three later occasions during different seasonal conditions. Additional well sampling will not be proposed until the resultant data base is evaluated. Proper groundwater sampling procedures will be used to assure that no contamination or bias is introduced into any samples. A detailed discussion of sampling procedures is provided in Section 6.1 of the RI/FS QAPP.

4.6 Sample Analysis

A total of 143 wells have been identified for groundwater sample collection. During Phase I activities, samples will be collected from each of these wells on two occasions. All samples will be analyzed in the field for pH, temperature, conductivity, and dissolved oxygen.

Since the selection of each new well was specifically justified within the context of the existing monitoring well network, it is necessary to analyze all groundwater samples for a full suite of radiological parameters and a more focused set of general water quality indicators to achieve the overall study objectives. All groundwater samples will be analyzed for a set of radiological parameters that include radionuclides or materials handled at the FMPC. These parameters, which are consistent with those previously tested during RCRA Rounds 1-5, include:

- Total Uranium
- Isotopic Uranium
- Isotopic Plutonium
- Radium-226
- Radium-228
- Neptunium-237
- Total Thorium
- Isotopic Thorium
- Technetium-99
- Cesium-137
- Strontium-90
- Ruthenium-106

140

All samples will also be analyzed for the following parameters that are being used as indicators of drinking water suitability under the ongoing RCRA groundwater monitoring program:

260

- pH
- Specific Conductance
- Chloride
- Iron
- Manganese
- Phenols (Total)
- Sodium
- Sulfate
- Gross Alpha
- Gross Beta
- Total Organic Carbon
- Arsenic
- Barium
- Cadmium
- Chromium (Total and Hexavalent)
- ~~Fluoride~~
- Lead
- Mercury
- Nitrate
- Selenium
- Silver
- Pesticides/PCB's

The analysis of groundwater samples for HSL organics and other toxic metals will be performed on a limited basis. The reason for this reduced scope is twofold:

1) The ongoing RCRA groundwater monitoring is currently testing for organics and metals on a semi-annual basis at 41 onsite and offsite well locations, and

2) The frequency and levels of detection of these species (in comparison with the potential radiological problem) found during the RCRA groundwater monitoring program do not indicate a problem worthy of a comprehensive testing program during the RI/FS for the groundwater underlying the FMPC and adjacent areas.

In order to confirm these conditions are the case, sixteen selected groundwater samples will be analyzed for HSL volatile and semi-volatile organics and HSL organics, including cyanide. Pesticides/PCB's will also be analyzed under this program. The wells to be sampled for HSL analysis have been selected to augment the semi-annual RCRA monitoring program for Waste Pit No. 4. These include three new shallow wells (Nos. 128, 129, 131) near, and what is expected to be downgradient from, the Waste Pit Storage Area; a shallow well (No. 113) immediately to the east of the Production Area; and 200-series wells in the upper sand and gravel aquifer east of the Production Area (No. 264), south of the Production Area along the Storm Sewer Outfall Ditch (No. 265) and wells surrounding the waste pits, sludge ponds, and sanitary landfill to provide information about the presence or absence of HSL compounds in the aquifer in this area (Well Nos. 201, 204, 208, 210, 211, 227, 234, 238, 242, and 252). All well locations are shown in Figures 7 - 11.

41

4.7 Groundwater Modeling

4.7.1 Evaluation of Hydrogeologic Regime

An evaluation of the hydrogeologic regime will be performed based upon a review of project and historic data. This evaluation will provide an understanding of the groundwater flow and chemical species, as well as the distribution observed at the FMPC. The evaluation will also include a water balance for the site to establish recharge to the aquifers, communication between aquifers (direction and rate), and the direction and rate of groundwater flow. An investigation of the observed chemical species concentrations in the soils and groundwater, relative to dispersion analysis and the results of the water balance, will be performed to establish the potential source loadings and to permit evaluations of the mass transport parameters required for subsequent numerical modeling.

The water balance will be performed for the site to evaluate recharge rates through the glacial till and stream channels into the buried channel aquifer. The analysis will consist of evaluating information on site soils and local meteorology to establish rates of evapotranspiration, precipitation, surface water runoff, and infiltration. Infiltration and percolation through the till and stream beds will be evaluated to assess recharge to the underlying aquifers. The significance of existing production wells in the vicinity of the site will also be evaluated during this assessment. Additionally, the potential leakage associated with the site sewer system will be addressed.

The distribution of chemical species in the groundwater will be evaluated to assess the species mass loadings associated with recharge of the aquifer, and to assist in understanding the existing conditions. Existing closed-form solutions for dispersion in uniform flow will be utilized to identify reasonable distribution patterns which are consistent with the observed results from site monitoring wells. By establishing estimates of mass loadings to the aquifer, geochemical parameters for the mass transport analysis can be developed. Irreconcilable differences between observed data and the results of the analysis may suggest areas for further data collection.

4.7.2 Planning Level Modeling Study

In 1985, Geotrans, Inc. completed a modeling study of the buried channel aquifer near the FMPC. The results of this study indicated the potential presence of a groundwater divide in a location different from the north-south alignment previously conjectured. Geotrans utilized the results of the study to recommend that additional wells be strategically placed to confirm the new findings, since such findings could have an effect on contaminant pathways and the interpretation of historical data.

The previous work by Geotrans illustrates the value of a numerical model in planning field activities. In particular, the application of even a groundwater flow model, rather than a more complex contaminant transport model, can provide considerable insight into the direction and rate of

groundwater flow in lieu of field data. Examples of the types of information that can be derived from a model include:

1) Identification of aberrant local groundwater flow patterns that may be induced by a combination of stresses, but which would not be otherwise known when planning field efforts,

2) Determination of expected patterns of groundwater flow from waste sources, thereby aiding in any plume monitoring,

3) Assessment of the degree of interaction between aquifers or between streams and aquifers, which would reduce the level of uncertainty in deciding on the need to monitor multiple aquifers in a given area,

4) Approximation of travel times, which when used in combination with long-term monitoring results could provide insight into aquifer flushing times,

5) Estimation of dilution, which is important to the pre-evaluation of public health and environmental risks, and

6) Evaluation of the limits of upgradient dispersion to ensure that planned background wells are indeed outside of any potential contaminant plumes.

The above information can be considered a planning tool to future monitoring programs and a "check" to increase confidence in existing field data and its interpretation.

Preliminary hydrogeologic simulations will be performed. This will aid in the evaluation and interpretation of the data and will allow predictions regarding contaminant migration pathways from potential source areas.

Only models capable of three-dimensional solute transport simulation will be considered for the groundwater assessment program at the FMPC. The reason is that any modeling efforts carried out as part of the data evaluation work will represent a first step in the application of the same model code to subsequent assessment tasks when solute transport becomes critical. The initial effort will be limited to groundwater flow modeling since this alone will provide the necessary input to a groundwater sampling plan at offsite locations.

Two well-verified and widely accepted groundwater model codes, along with numerous analytical problems, have been selected for use in the SWIFT III model code verification. The model codes to be used are:

1) GEOFLOW, a two dimensional (2-D) and quasi-three-dimensional, finite element model capable of solving groundwater flow and solute transport problems developed and verified by IT Corporation,

2) McDonald and Harbaugh, a three-dimensional (3-D) finite difference groundwater flow model developed by the U.S. Geological Survey.

260

Data from the RI/FS study area will be used to construct similar models using these codes so that comparisons of modeling results can be made for the same project setting and flow and solute transport conditions.

The conceptualization of the model will involve the development and quality control "check" of the input data base, as well as the establishment of meaningful boundary conditions and initial conditions.

Data requiring development and review include the geologic setting, initial potentiometric head distribution in each aquifer, fluid transmission and storage properties, and natural or man-made recharge and discharge terms (e.g., pumping). Any newly compiled data will be reviewed and appropriate changes to the input data base will be made.

4.7.3 Hydrogeologic Simulation

The objectives of the computer simulations of groundwater flow and mass transport are to:

1) Determine groundwater flow rates and directions,

2) Further define and quantify recharge,

3) Evaluate the observed water quality data relative to the identified sources in terms of chemical constituent loading rates to areas of the aquifer,

4) Predict current and future contaminant transport patterns for use in the "Risk Assessment", and

5) Provide a framework for predicting and evaluating the effects of proposed remedial alternatives in the Feasibility Study phase of the RI/FS.

To achieve these objectives, the three-dimensional model developed for the planning level modeling study will be updated with the new project data and a contaminant transport code will be incorporated.

For further detailed information regarding the simulation methodology, such as model development, model setup (both horizontal and vertical planes), model input data, model validation, and sensitivity analyses, the RI/FS Work Plan (Reference 8) should be consulted.

4.8 Geophysical Methods

As part of the recently completed CIS, geophysical surveys were conducted on portions of the FMPC to provide information on waste concentrations and shallow stratigraphy. An additional objective was to identify

44

locations potentially dangerous for drilling due to buried steel drums or tanks (Reference 10).

260

Magnetic and electromagnetic terrain conductivity and ground penetrating radar surveys were conducted in the waste storage area, including Pit Nos. 1 through 4, the burn pit, the sanitary landfill, and the south lime sludge pond. An additional ground penetrating radar survey was performed along the slurry line to the K-65 silos. Electromagnetic terrain conductivity surveys were also performed at the slurry line, K-65 and metal oxide silos, upper and lower fly ash piles, the southfield area, and along Paddy's Run and the storm sewer outfall ditch. All geophysical survey locations are shown in Figures 14 through 17.

A substantial volume of buried ferrous metal, possibly including steel drums, was identified from the magnetic surveys in Pit Nos. 1, 2, and 4, the burn pit, and the sanitary landfill. Smaller volumes were identified in Pit No. 3, while little to no evidence of buried ferrous metal was observed at the south lime sludge pond.

Ground penetrating radar (GPR) indicated the presence of other buried solid waste material (e.g., bricks and other construction debris) in Pit Nos. 1 and 4, and the sanitary landfill. Lesser amounts were indicated in the south lime sludge pond and at Pit No. 3. Attenuation of electromagnetic energy resulting from shallow, conductive material was a particular problem in the burn pit and Pit Nos. 2 and 3. As a result, very little information could be derived from the GPR data at these locations.

High apparent conductivity measurements at Pit Nos. 1 through 4 and the burn pit which could not be interpreted as evidence of liquid waste containing high total dissolved solid concentrations. In addition, anomalously high apparent conductivity measurements support the existence of lateral contaminant transport occurring east of Pit No. 2 and south and west of the K-65 and metal oxide silos. Possible groundwater plumes within the fine-grained glacial deposits are present at these two locations; however, cultural interference may have been a contributing factor in the latter case. Elsewhere, no hard conclusions can be formulated regarding the water quality in the glacial materials based on the surface geophysical measurements.

The results of the CIS geophysical surveys, along with waste characterization data obtained during the CIS, will be used in further assessing the effects of FMPC operations on groundwater quality at the FMPC under the current RI/FS program.

5.0 SCHEDULE

The implementation of the Groundwater Quality Assessment Program at the FMPC is currently underway. A major objective of the sitewide RI/FS is to assess the effects of FMPC production and waste operations on the local groundwater quality.

Figure 18 provides a graphical representation of the project master schedule for the RI/FS program at the FMPC. This schedule reflects the various time elements required to complete specific tasks of the RI/FS. The

45

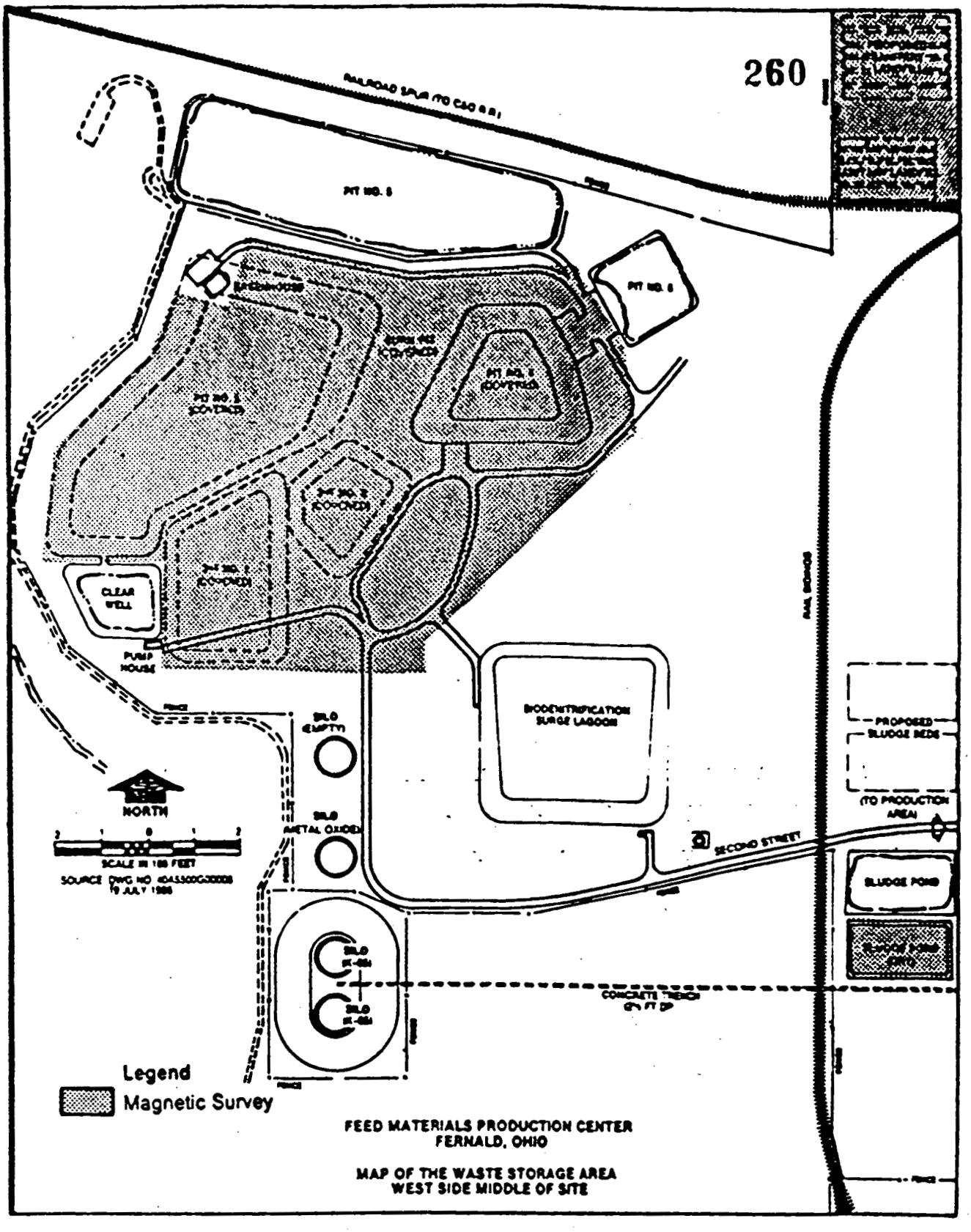


FIGURE 14 LOCATION OF THE MAGNETIC SURVEY AT THE FMPC, FERNALD, OHIO

46

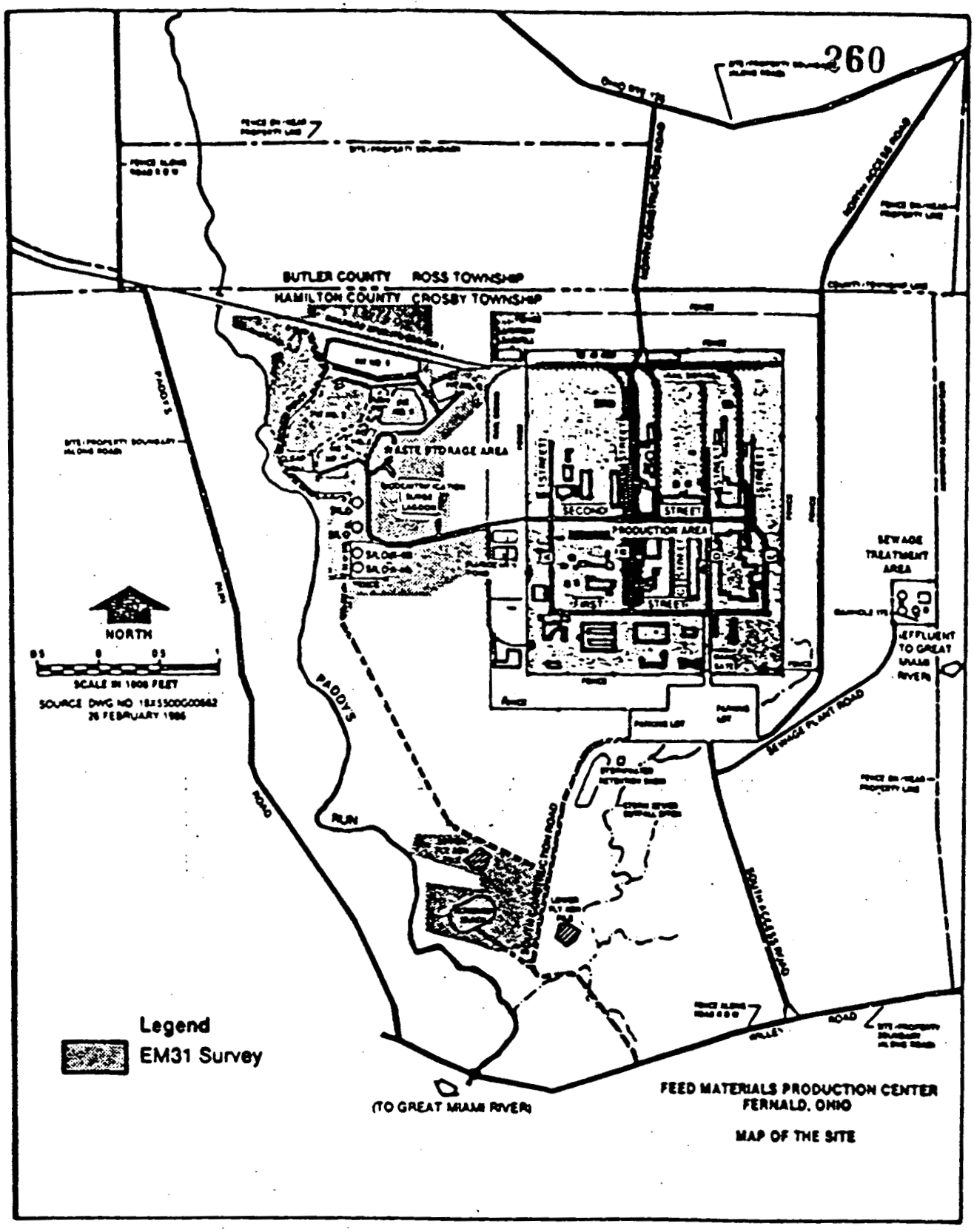


FIGURE 15 LOCATION OF THE EM31 SURVEY AT THE FMPC, FERNALD, OHIO

47

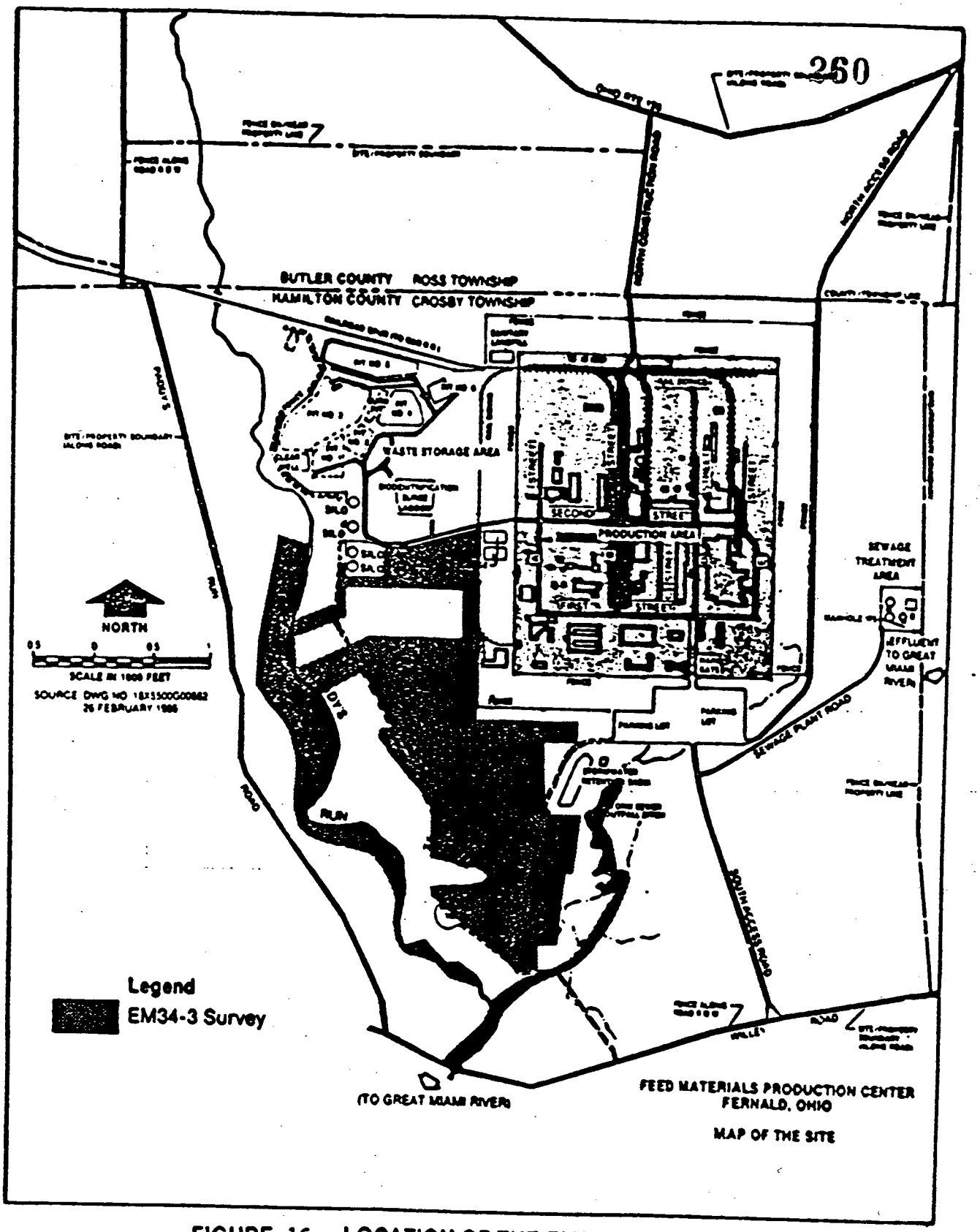


FIGURE 16 LOCATION OF THE EM34-3 SURVEY AT THE FMPC, FERNALD, OHIO

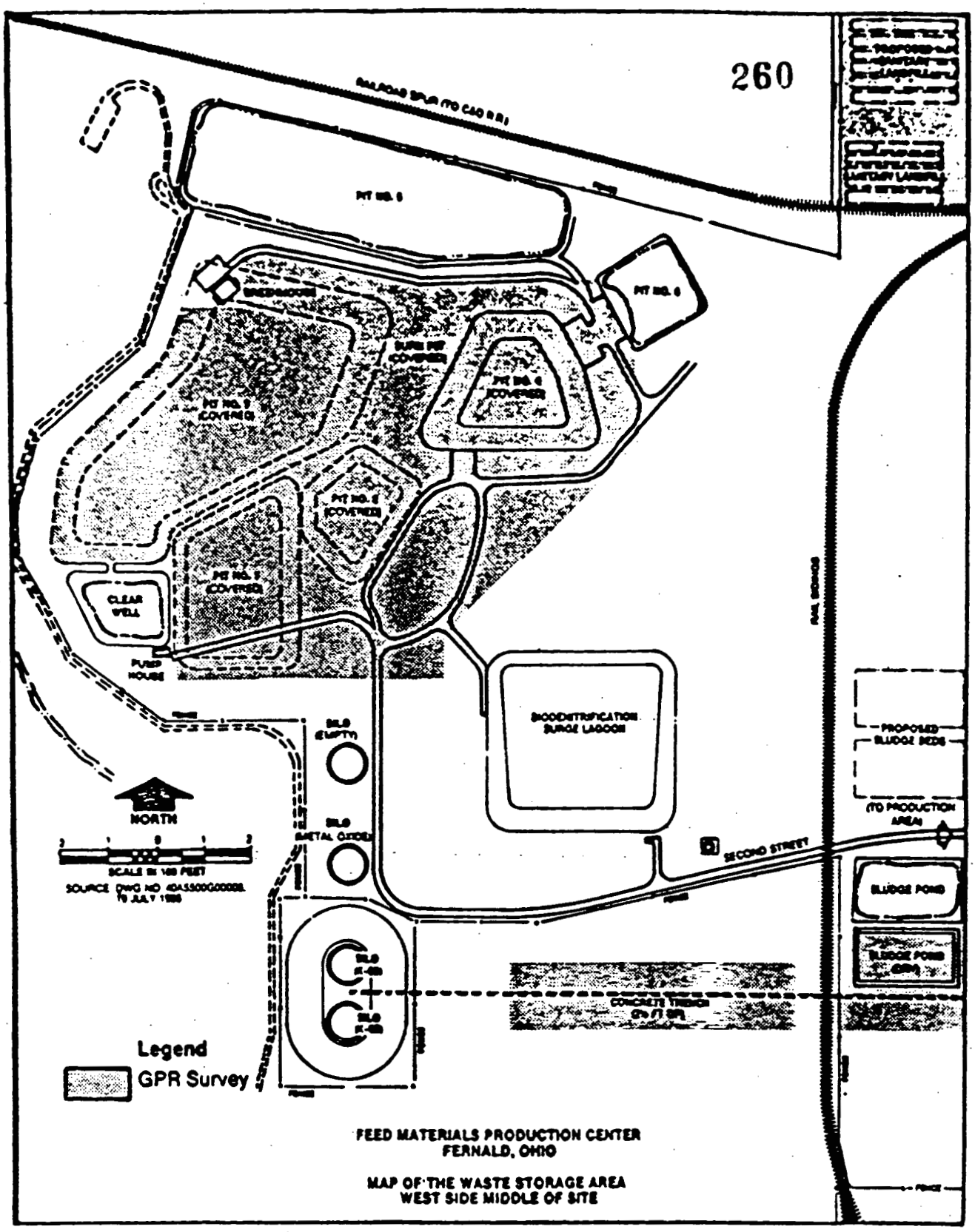
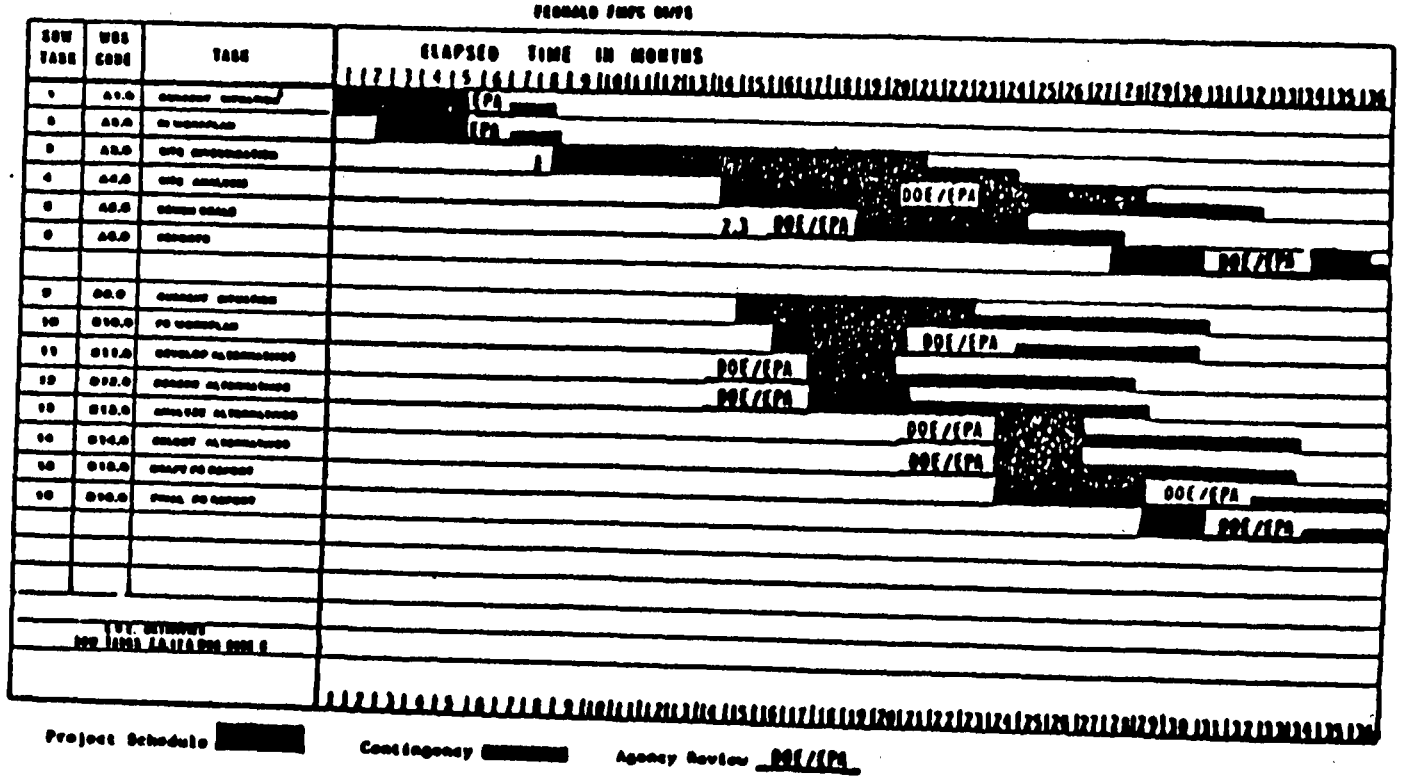


FIGURE 17 LOCATION OF THE GPR SURVEY AT THE FMPC, FERNALD, OHIO

SCHEDULE OF EVENTS



Footnotes:

1. Task A3.0 is contingent on EPA approval of Tasks A1.0 and A2.0.
2. Notification to EPA (30 days) on study need is required.
3. EPA approval required prior to initiation Tasks A5.0, B11.0, B12.0, B13.0, and B15.0

FIGURE 18 PROJECT MASTER SCHEDULE

hydrogeological field program will be conducted as part of the total site investigation task, with data assimilation completed during the site analysis task time frame. Remedial alternatives will be identified and selected as needed during Tasks 11 through 14 of the RI/FS program. These alternatives will address the findings of the groundwater quality assessment conducted during the site investigation.

Detailed information regarding the RI/FS project organization, summary, and breakdown, as well as various schedule and reporting requirements associated with the overall RI/FS program, is provided in Sections 6.1 through 6.5 of the RI/FS Work Plan (Reference 8).

REFERENCES

(1) WMCO, RCRA Part A Permit Application for the FMPC, Revision No. 4, dated September 21, 1987.

(2) WMCO, FMPC Response to Items B - B5 of RCRA Section (FFCA), dated October 16, 1987 (Revised: January 23, 1987).

(3) WMCO, FMPC Response to Items A.1 - A.7 of RCRA Section (FFCA), dated August 17, 1986 (Revised: January 21, 1987).

(4) Dames & Moore, RCRA Groundwater Monitoring Report - 1987, Volume 5 - Round 5, dated November, 1987.

(5) U.S. EPA, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD), OSWER-9950.1, dated 1986.

(6) Dames & Moore, RCRA Groundwater Monitoring Report - 1987, Volume 3 - Round 3, dated March, 1987.

(7) Davis, S. N. and DeWiest, R. J., Hydrogeology, John Wiley & Sons, New York, 1966.

(8) ASI, Work Plan - Remedial Investigation and Feasibility Study, FMPC, Revision 1, dated August, 1987.

(9) Dames & Moore, Groundwater Study - Task C Report, dated July, 1985.

(10) Roy F. Weston, Inc., Characterization Investigation Study, Volume 1: Geophysical Survey, dated September 1987.

CFR	Code of Federal Regulations
CIS	Characterization Investigation Study
DOE	U.S. Department of Energy
EP	Extraction Procedure
EPA	Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
ft/day	Feet per day
ft/ft	Foot per foot
GQAPO	Groundwater Quality Assessment Program Outline
gpd/ft	Gallons per day per foot
GPR	Ground Penetrating Radar
HSL	Hazardous Substances List
MSL	Mean Sea Level
MW	Monitoring Well
OS	Offsite
PCB	Polychlorinated Biphenyl
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study
SC	Specific Conductance
SW-2	Southwestern Ohio Water Company - Collector No. 2
T*	T-statistic
T_c	T-statistic (comparison)
T_m	T-statistic (monitoring)

T_b	T-statistic (background)
TEGD	Technical Enforcement Guidance Document
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TP	Test Pit
U.S. EPA	United States Environmental Protection Agency
W_b	Weighting factor (background)
W_m	Weighting factor (monitoring)
WMCO	Westinghouse Materials Company of Ohio

APPENDIX E-III

FEED MATERIALS PRODUCTION CENTER

GROUNDWATER QUALITY ASSESSMENT PROGRAM OUTLINE

TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 FMPC GEOLOGY AND HYDROLOGY	1
2.1 Sand and Gravel Aquifer	3
2.2 Glacial Till	5
3.0 IDENTIFICATION OF WHETHER HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS HAVE ENTERED THE GROUNDWATER	5
3.1 Statistical Re-evaluation	5
3.2 Well Re-sampling or Sampling of Additional Existing Wells	6
3.3 Review of Operational Procedures	6
3.4 Additional Well Installation	11
4.0 IDENTIFICATION OF RATE & EXTENT OF MIGRATION OF HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS IN THE GROUNDWATER	11
4.1 Sampling and Re-sampling of Wells	11
4.2 Installation of Additional Monitoring Wells	11
4.3 Hydrologic Testing of Aquifer Properties	13
4.4 Computer Modelling of Contaminant Transport	13
4.5 Geophysical Survey Methods	13
5.0 IDENTIFICATION OF THE CONCENTRATION OF HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS	13
REFERENCES	15
ACRONYMS	16

FIGURES

		Page
1	GENERALIZED GEOLOGIC CROSS SECTION OF NEW HAVEN TROUGH	2
2	RCRA ROUND II WATER TABLE CONTOURS	4
3	WELL LOCATIONS	10
4	TYPICAL MONITOR WELL SCHEMATIC	12

APPLICABLE REFERENCES

1. FMPC Remedial Investigation/Feasibility Study; "Task 1 Description of Current Situation"; ASI; January 30, 1987

2. FMPC Remedial Investigation/Feasibility Study; "Work Plan Revision 3"; ASI; March, 1988

3. FMPC Remedial Investigation/Feasibility Study; "FMPC Task 2 Report, Work Plan Requirements, Work Plan Revision 3, Volume 1: Sampling Plan"; ASI; March, 1988

4. FMPC Remedial Investigation/Feasibility Study; "FMPC Task 2 Report, Work Plan Requirements, Work Plan Revision 3, Volume II: Health and Safety Plan; Volume III: Community Relations Plan; Volume IV: Data Management Plan"; ASI; March, 1988

5. FMPC Remedial Investigation/Feasibility Study; "FMPC Task 2 Report, Work Plan Requirements, Work Plan Revision 3, Volume V: Quality Assurance Project Plan"; ASI; March, 1988

6. "Characterization Investigation Study, Volume 1, Geophysical Survey"; Weston; October, 1987

7. "Characterization Investigation Study, Volume 2, Chemical and Radiological Analysis"; Weston; November, 1987

8. "Characterization Investigation Study, Volume 3, Radiological Survey of Surface Soils"; Weston; December, 1987

9. "Characterization Investigation Study, Volume 4, Chemical Analysis Data, Section 1 - 49"; Weston, March, 1988

1.0 INTRODUCTION

Waste Pit #4 at the Feed Materials Production Center in Fernald, Ohio is subject to regulations of the Resource Conservation and Recovery Act (RCRA). Interim status regulations (as described in Task A7 of the Federal Facilities Compliance Agreement FFCA) are addressed by this Response which presents a Groundwater Quality Assessment Program Outline (GQAPO) prepared in conformance with 40CFR 265.93 (a). The intent of this Outline is to present a groundwater monitoring program which is capable of identifying:

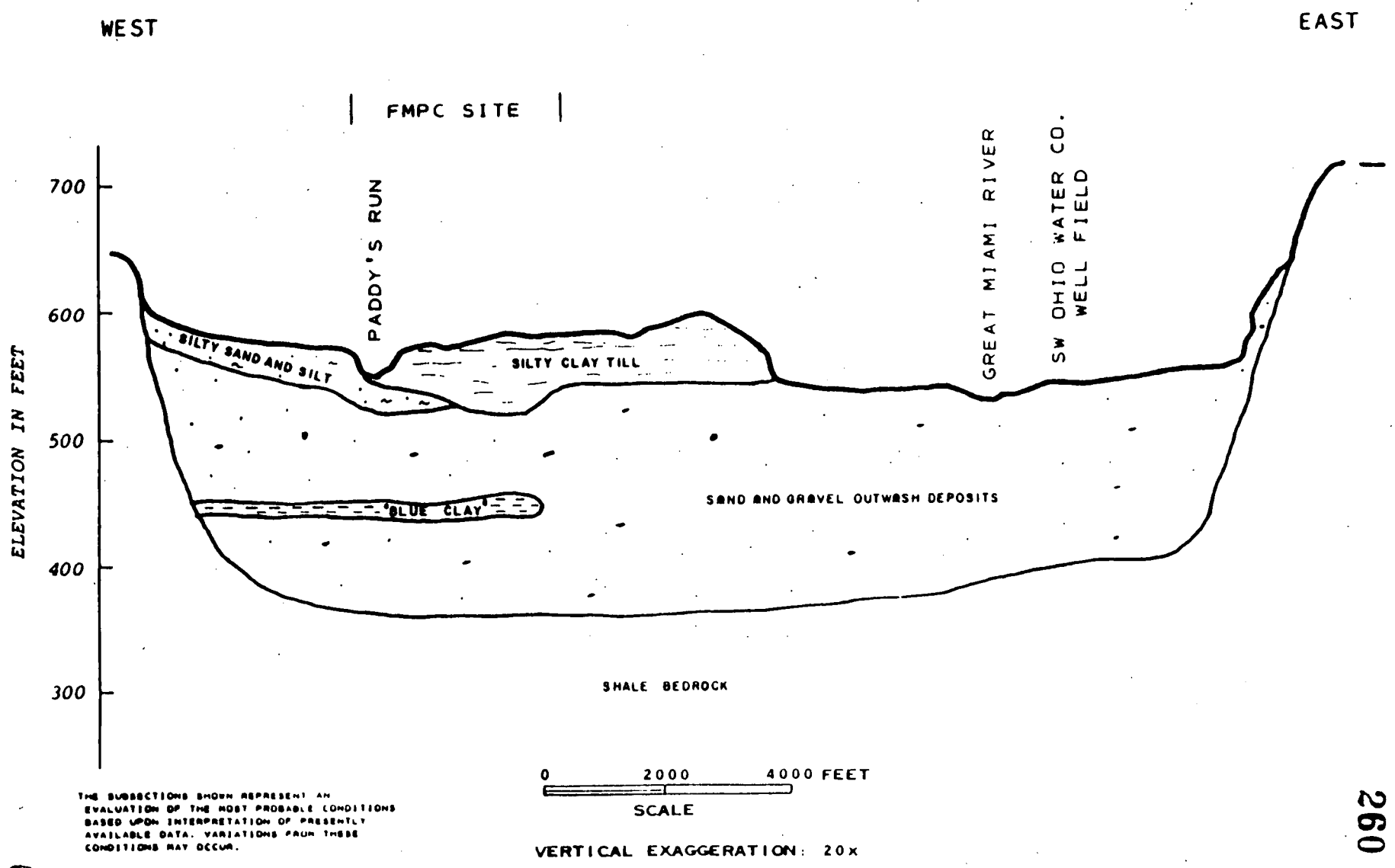
- Whether hazardous waste or hazardous waste constituents have entered the groundwater.
- The rate and extent of migration of hazardous waste or hazardous waste constituents in the groundwater.
- The concentration of hazardous waste or hazardous waste constituents in the groundwater.

In the event that implementation of the GQAPO becomes necessary, a more detailed Work Plan will be developed for review and approval by the appropriate regulatory agencies prior to GQAPO initiation. This Groundwater Quality Assessment Program Outline will be modified as necessary to address groundwater quality in each of the groundwater bearing regimes which underly Pit 4.

2.0 FMPC GEOLOGY AND HYDROLOGY

The FMPC is located in a two-mile wide valley filled with glacial deposits. This valley parallels the Great Miami River between the towns of Ross and Hooven, Ohio. A generalized geologic cross-section for the FMPC site area is presented in Figure 1.

- In Late Ordovician time (approximately 450 million years ago) sediments which would become a predominantly flat-lying shale with thin interbedded limestone were deposited in a shallow sea. This shale (a part of the Cincinnatian Series) is the relatively impermeable bedrock which now underlies the FMPC site area.
- Sometime prior to, or perhaps contemporaneous with, Pleistocene glaciation, a large watercourse (larger than the present-day Great Miami River) cut its channel into this shale bedrock to a level of more than 200 feet below that of the present-day Great Miami River. This approximately two-mile wide channel (informally called the New Haven Trough) may be an abandoned course of the ancestral Ohio River.



THE SUBSECTIONS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

60

260

GENERALIZED GEOLOGIC CROSS SECTION OF NEW HAVEN TROUGH

DAMES & MOORE

FIGURE 1

- During subsequent Pleistocene glacial advances and retreats across the site area (Illinoisan-approximately 300,000 years to 400,000 years ago and Wisconsinan-approximately 100,000 years ago), the New Haven Trough was filled with about 200 feet of glacial sediments. These sediments were deposited by water running from the margins of the glaciers and consisted mainly of well sorted sand and gravel. Deposited on top of these sediments was a blanket of clay-rich, relatively impermeable glacial till from a more recent event.

- Erosion by the Great Miami River and its tributaries then removed significant portions of the glacial till and left terrace remnants which stand topographically higher than surrounding bottom lands. The FMPC site lies on top of one of these terrace remnants.

2.1 SAND AND GRAVEL AQUIFER

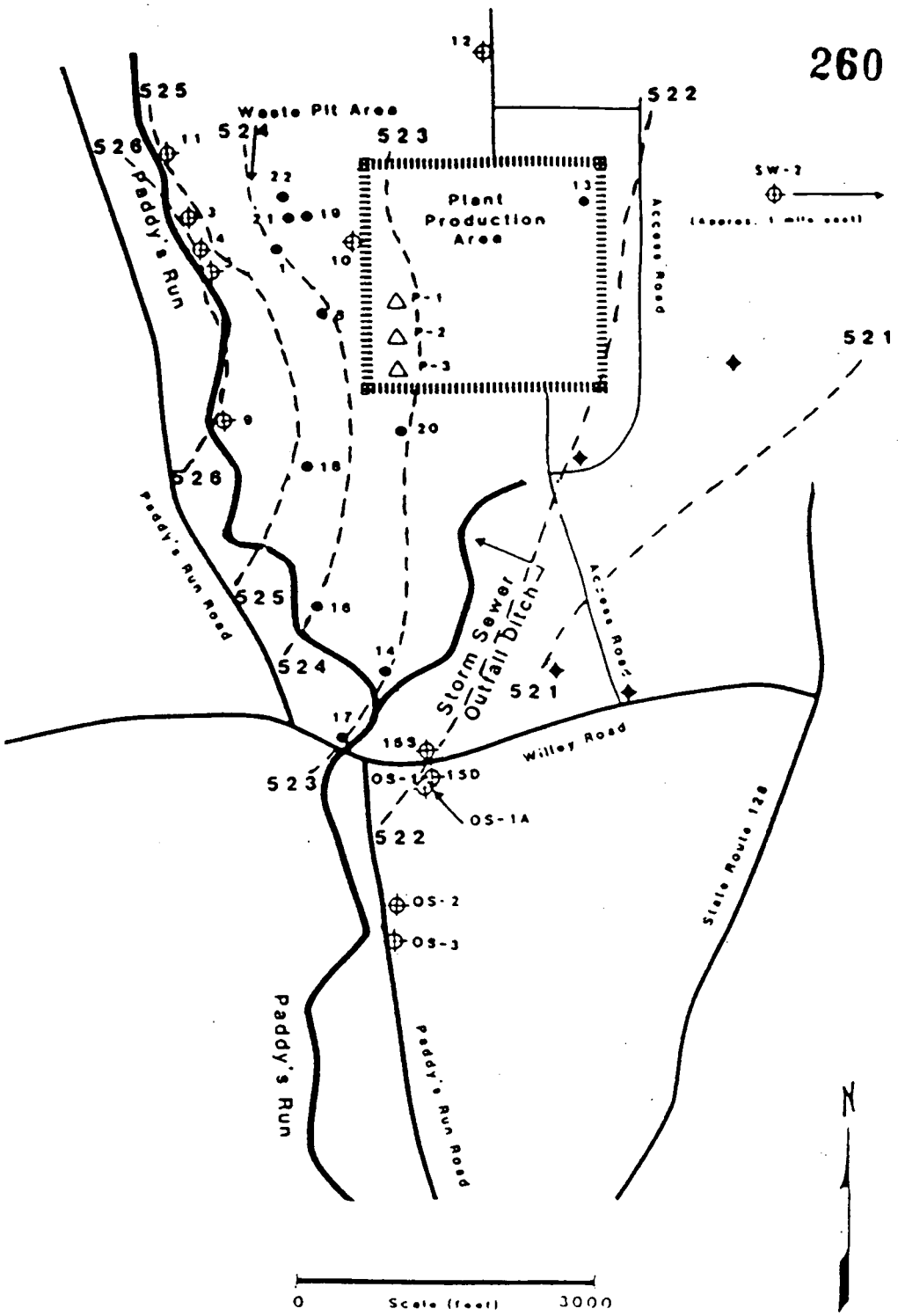
Unconformably overlying the shale bedrock is a sequence of highly permeable sand and gravel glacial outwash deposits laid down by the meltwaters of receding continental ice sheets. These outwash deposits generally consist of an unconsolidated medium to coarse grained, olive brown 200 foot thick layer of sand and gravel. The sand and gravel layer is arranged in irregularly alternating layers of silty sand, medium to coarse sand, and medium to coarse gravel.

In the vicinity of the Waste Pit Storage Area, this layer is separated into two units by a 10 to 20 foot thick layer of greenish-black silty clay. The FMPC production wells are completed below this "blue clay" layer. This blue clay layer underlies about 360 acres of the site and apparently occurs only in the vicinity of the Waste Pit Storage Area and the production wells. It was probably deposited in an ice marginal lake or as a backwater deposit of a glacial stream. The top of this "blue clay" layer lies about 125 feet below the land surface.

Hydrologically, the sand and gravel above and below the "blue clay" layer acts as a single unit. The "blue clay" layer is not sufficiently extensive to act as an aquitard and no significant head differences exist between wells completed above and below this layer.

Transmissivities and hydraulic conductivities for the sand and gravel are reported to range from 35,000 gpd/ft to 300,000 gpd/ft and 270 ft/day to 370 ft/day respectively. Total porosities have been estimated at 25%. Average hydraulic gradients for the area measured by the USGS from water level measurements made in August, 1982 are low and were calculated to range from 0.001 ft/ft to 0.005 ft/ft. Using this data, the rate of groundwater movement (horizontal groundwater velocity) is calculated to range betwen 1.1 ft/day and 9.3 ft/day.

Figure 2 is a Dames & Moore water level contour map for the sand and gravel aquifer. This map shows that groundwater movement is generally to the east in the area around Pit 4. The upper 20 to 30 feet of the sand and gravel deposits are not saturated and water in this aquifer occurs approximately 60 to 90 feet below land surface depending upon surface elevation and thickness of till.



Explanation:

- Single Well Location
- Cluster Well Location
- Production Well Location
- IT WELLS

RCRA ROUND II

WATER TABLE CONTOURS

May 20, 1986

Water Table Contour

THE WATER LEVEL CONTOURS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

DAMES & MOORE

FIGURE 2

2.2 GLACIAL TILL

At the surface of the site and overlying the sand and gravel outwash deposits is a 20 to 50 foot thick layer of glacial till composed of a dense, olive-gray silty clay. The till varies in texture and composition both laterally and vertically and contains lenses of poorly sorted fine to medium grained sand and gravel. The base of the till occurs at about elevation of 540 ft MSL and overlies the sand and gravel outwash deposits.

To the west and south of the site, the silty clay till laterally grades into a sequence of silty sand and silt with some layers of silty clay. The silty caly till continuous to the north and east of the site and directly overlies the bedrock in these areas. In the lower reaches of Paddy's Run and the storm Sewer Outfall Ditch, and silty clay till has been eroded away and the under-lying sand and gravel are exposed.

A saturated zone occurs within the silty clay till approximately 4 to 9 feet below land surface in some areas of the FMPC site. This saturated zone was encountered in three shallow wells around Pit 4 (MW-19TP, MW-21TP and MW-22TP) and is probably recharged by precipitation. It was not detected in test pits near well clusters to the east and south of the Waste Pit Storage Area. This saturated zone may be present because of vertical variations of composition and texture of the till, or near-surface weathering or desiccation induced fracturing of the till.

Aquifer testing of this saturated zone has measured hydraulic conductivities of 0.2 ft/day to 2.5 ft/day with associated transmissivities of 3.5 gpd/ft to 150 gpd/ft.

3.0 IDENTIFICATION OF WHETHER HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS HAVE ENTERED THE GROUNDWATER

This section of the Pit 4 Groundwater Quality Assessment Program Outline describes the four techniques which are used to identify whether hazardous waste or hazardous waste constituents have entered the groundwater. These techniques include: statistical re-evaluation, well re-sampling or sampling of additional wells, review of operational procedures and additional well installation.

3.1 STATISTICAL RE-EVALUATION

The use of the student's t-test is required for groundwater monitoring data under 40 CFR 265 Subpart F. For each indicator parameter, arithmetic mean and variance are calculated, based on four replicate measurements of each sample from the Pit 4 RCRA wells and compared to the initial background arithmetic mean. The student's t-test will be used at the 0.01 level of significance to determine statistically significant increases over initial background.

In accordance with EPA guidelines, Cochran's Approximation to the Behrans-Fisher Student's t-test will be applied to the laboratory analytical results for TOX, TOC, pH, and specific conductance. The background and monitoring means and variances of the data are used to compute two variables, the t-statistic (t*) and the comparison statistic (tc).

Comparison of the t* and tc values, based upon the decision rules in 40 CFR Part 264 (Appendix IV), identifies whether there has been a statistically significant change in the above referenced parameter. Specifically, for each parameter except pH, if t* is greater than tc, then a statistically significant increase in that parameter has occurred. In the case of pH, if the absolute value of t* is greater than tc, a significant change has occurred, with the negative values of t* indicating a decrease and postive values indicating an increase.

The ultimate goal of the statistical re-evaluation is to verify mathematically that hazardous waste or hazardous waste constituents have entered the groundwater. Actual implementation of the (GQAPO) as described in this document is contingent on the identification of hazardous waste or hazardous waste constituents have entered the groundwater. If statistically significant changes are detected in the indicator parameters, the FMPC will immediately resample and determine if this change was due to laboratory error. If a significant change is confirmed, then the FMPC will enter assessment monitoring (see Section 4.0).

3.2 WELL RE-SAMPLING OR SAMPLING OF ADDITIONAL EXISTING WELLS

Additional analytical data beyond that obtained from quarterly sampling at the facility may be necessary to confirm the presence of hazardous waste or hazardous waste constituents materials in the groundwater. Wells will be resampled in order to confirm data accuracy and repeatability of warranted. Currently, quarterly samples are collecter from fourty-one (41) on-site and off-site wells as part of groundwater monitoring efforts at the FMPC. These wells are listed in their respective sampling order in Table 1 and are shown in Figure 3.

Extensive groundwater monitoring programs are underway at the Feed Materials Production Center to support activities relating to waste storage area and site-wide Remedial Investigation/Feasibility Studies (RI/FS) and the Environmental Impact Statement (EIS). Associated with these programs is the drilling and installation of numerous wells specifically designed to monitor groundwater in the vicinity of Pit 4.

The number and location of wells that could be sampled to provide supplementary groundwater quality data related to Pit 4 cannot be specified at this time. However, wells currently are available both upgradient and downgradient of Pit 4 in predominant groundwater flow directions. Groundwater sampling will be conducted with strict adherence to EPA approved procedures (Ref. 1, 2 and 7). Current groundwater analyses consist of the parameters listed in Table 2.

3.3 REVIEW OF OPERATIONAL PROCEDURES

In the event of a statistically significant increase in water quality indicator criteria, a review of recent Pit 4 operational/disposal procedures will be conducted. This review will help assess if a change in operational or disposal practices at the Pit or the site may have effected local groundwater quality. The review will include correlation of recently disposed waste with affected water quality indicators, examination of inspection reports and manifest or log sheets for unusual occurrences, and an assessment of the physical integrity of the wells reporting the statistically significant

TABLE 1

Monitoring Well Sampling Order

Sampling Order	Well Number	Location
1	12	Off North access road
2	SW-2	Southwest collector
3	P-1	West side production area
4	P-2	West side production area
5	P-3	Water treatment Plant
6	OS-1 deep	Farm house on Willey Road
7	OS-1 dug	Farm house on Willey Road
8	15s	Pasture on Willey Road
9	16d	Guard training area
10	16s	Shooting range
11	17d	Willey Road Bridge
12	17s	Willey Road Bridge
13	18d	South of production area
14	18s	South of production area
15	20d	Southwest of production area
16	20s	Southwest of production area
17	20TP	Southwest of production area
18	14d	Confluence of SSOD with Paddy's Run
19	14s	Confluence of SSOD with Paddy's Run
20	9	Paddy's Run-East bank
21	11	North of production area
22	13d	East of scrap metal site
23	13s	East of scrap metal site
24	8d	South of waste pit storage area
25	8s	South of waste pit storage area
27	3	East of pit 3 area
28	4	South of pit 3
29	5	South of pit 3
30	1d	North of K-65 tanks
31	1s	North of K-65 tanks
32	19d	East of pit 4
33	19s	East of pit 4
34	19TP	East of pit 4
35	21s	South of pit 4
36	21TP	South of pit 4
37	22s	West of pit 4
38	22TP	West of pit 4
39	OS-1	Exterior tap in yard of farm house off Willey Road
40	OS-2	East side of Paddy's Run Road
41	OS-3	East side of Paddy's Run Road

Table 2

RCRA GROUNDWATER
DETECTION MONITORING PARAMETERS

A. For General Water Quality

1. Chloride
2. Iron
3. Manganese
4. Phenols (total)
5. Sodium
6. Sulfate

B. For Indicators of Contamination (Quadruplicate Analysis)

1. pH
2. Specific Conductance
3. Total Organic Carbon (TOC)
4. Total Organic Halogen (TOX)

C. For Drinking Water Suitability

1. Arsenic
2. Barium
3. Cadmium
4. Chromium - Hexavalent
   - Total
5. Fluoride
6. Lead
7. Mercury
8. Nitrate (as N)
9. Selenium
10. Silver
11. Gross alpha
12. Gross beta
13. Radium
14. Endrin
15. Lindane
16. Methoxychlor
17. Toxaphene
18. 2, 4-D
19. 2, 4, 5-TP Silvex
20. Coliform Bacteria

D. Other Metals, Organics, and Site Specific Parameters

1. Nickel
2. Cyanide
3. Copper
4. Zinc
5. Magnesium
6. Calcium
7. Phosphorus
8. Chlorobenzene
9. Chlorodibromomethane
10. Chloroethane
11. 2-chloroethylvinyl Ether
12. Chloroform
13. Dichlorobromomethane
14. Dichlorodifluoromethane
15. Total Dissolved Solids (TDS)
16. Total Potassium
17. Chemical Oxygen Demand (COD)
18. per Chloroethylene
19. cis 1, 2 Dichloroethylene
20. Tributylphosphate

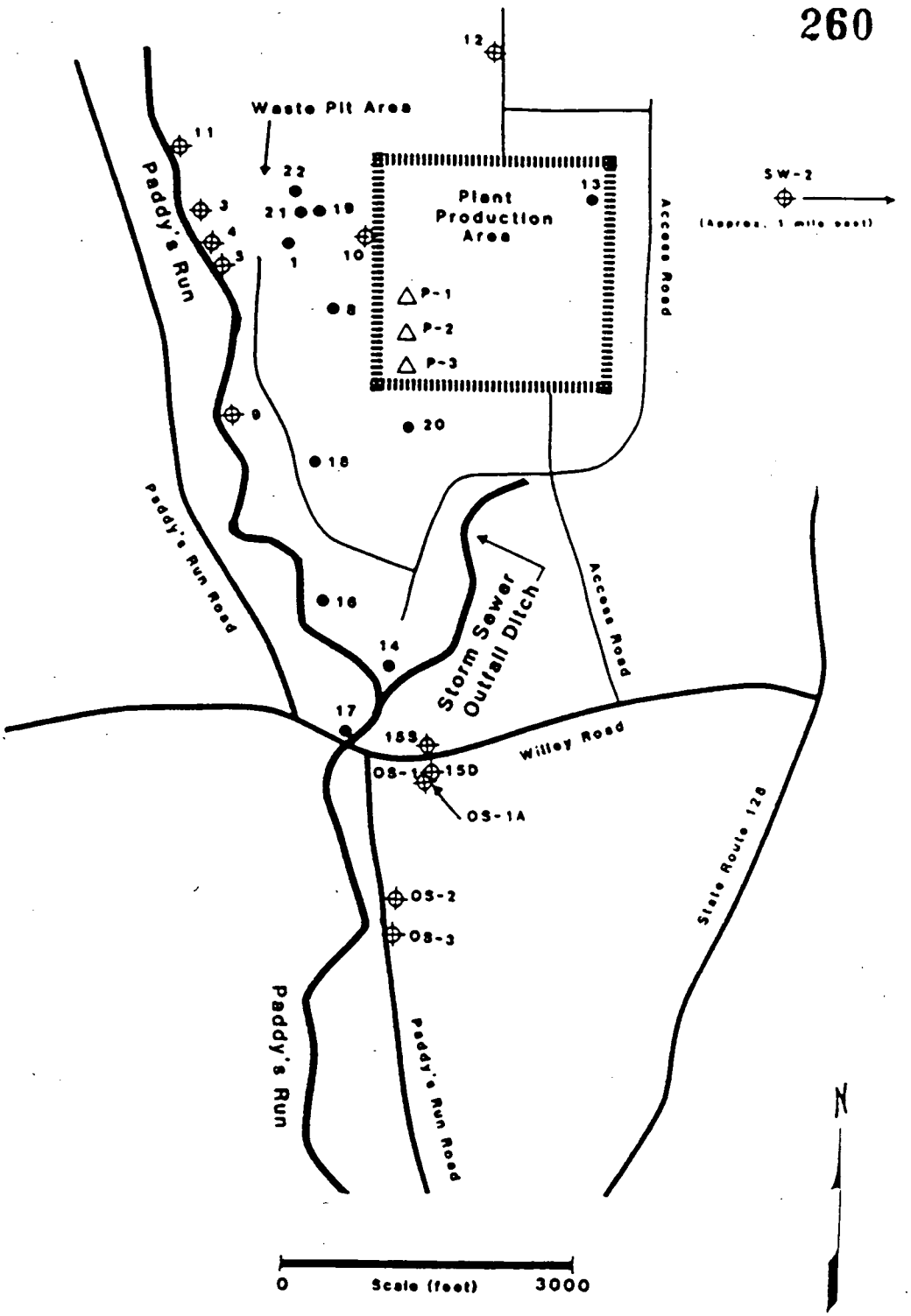
21. Acrolein
22. Acrylonitrile
23. Benzene
24. bis(chloromethyl) Ether
25. Bromoform
26. Bromodichloromethane
27. Bromomethane
28. Carbontetrachloride
29. Chloromethane
30. 1.2 Dichlorobenzene
31. 1,3 Dichlorobenzene
32. 1,4 Dichlorobenzene
33. 1,1 Dichloroethane
34. 1,2 Dichloroethane
35. 1,1 Dichloroethylene
36. 1,2 Dichloropropane
37. 1,2 Dichloropropylene
38. Ethylbenzene
39. Methylbromide
40. Methylchloride
41. trans-1,2 Dichloroethylene
42. 1,3 Dichloropropene
43. 1,1,2,2 Tetrachloroethane
44. Tetrachloroethylene
45. Toulene
46. 1,1,1 Trichloroethane
47. 1,1,2 Trichloroethane
48. Trichloroethylene
49. Trichlorofluoromethane
50. Vinyl Chloride

260

E. Radionuclides

1. Potassium 40
2. Total Uranium
3. Radium 226
4. Radium 228
5. Technetium 99
6. Thorium 228
7. Thorium 230
8. Thorium 232
9. Ces ium 137
10. Strontium 90
11. Ruthenium 106
12. Neptunium 237
13. Plutonium 238
14. Plutonium 239
15. Plutonium 240

F. Schedule - Quarterly for one (1) years, semiannual thereafter (or as necessary according to regulations).



Explanation:

- Single Well Location
- Cluster Well Location
- Production Well Location

WELL LOCATIONS

68

Figure 3

increase. Recent weather conditions also will be evaluated as well as non-FMPC activities in the site area.

3.4 ADDITIONAL WELL INSTALLATION

Wells may be installed on-site and off-site as part of the Groundwater Quality Assessment Program if they are needed to identify whether or not hazardous waste or hazardous waste constituents have entered the groundwater. These wells would be placed so as to assist in the characterization of the source or sources of groundwater pollution. A variety of well drilling techniques are suitable to subsurface conditions. Two of the appropriate methods to be used at the site are cable tool or hollow stem augers (Ref. 2 and 7). All drilling tools, rig and equipment will be thoroughly decontaminated prior to moving to the next well location. Steam cleaning is proposed as the decontamination method to be used for new well installations. In order to minimize the possibility for cross contamination, wells will be installed beginning at locations outside the waste pit storage area and ending at locations inside the waste pit storage area at the FMPC.

A typical well schematic is presented in Figure 4. Well pipe and screen material will be stainless steel with PVC in the unsaturated portion of the aquifer. Well screen slot size will be selected on-site according to the sediment encountered. A seal with a minimum thickness of 2 feet will be installed immediately above the sand pack which surrounds the screen. A sand/bentonite mixture will be used as backfill. To prevent the inflow of surface water along the riser pipe, a secondary seal of grout will be placed at the ground surface. Protective casings with vented locking caps also will be installed for each monitoring well.

4.0 INDENTIFICATION OF RATE AND EXTENT OF MIGRATION OF HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS IN THE GROUNDWATER

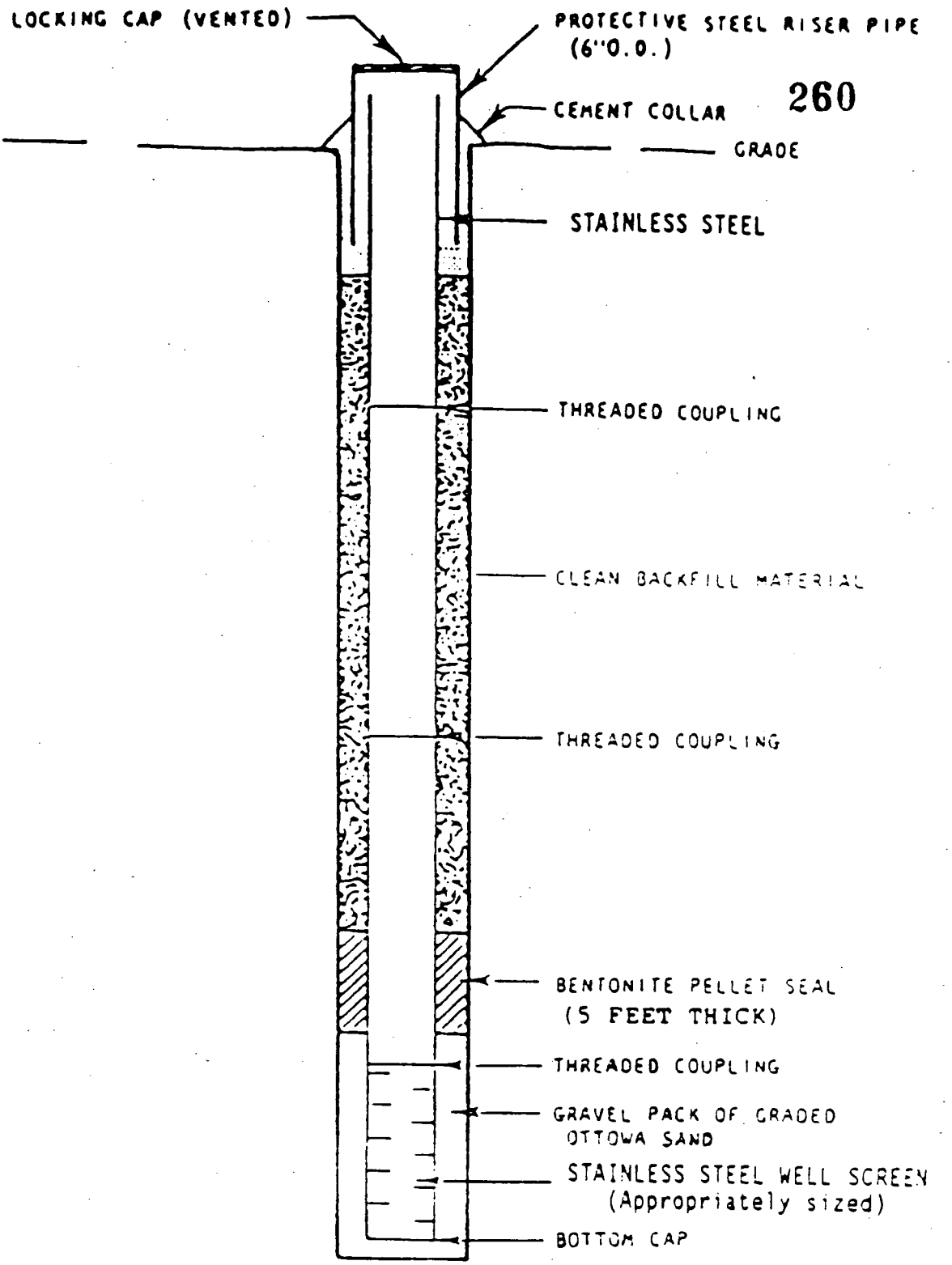
This section of the Groundwater Quality Assessment Program Outline introduces the five techniques which are used to delineate the rate and extent of migration of hazardous wastes or hazardous waste constituents in the groundwater. The techniques that will be discussed are: sampling or resampling of wells, installation of additional monitoring wells, hydrologic testing of aquifer properties, computer modeling of contaminant transport and the use of geophysical surveys.

4.1 SAMPLING OR RESAMPLING OF WELLS

Sampling conducted during the first part of the Groundwater Quality Assessment Program (as outlined in Section 3.0) was focussed in an area close to the predicted point of contaminant entry to groundwater. In order to define the extent of migration of hazardous substances once they have been identified, additional sampling is required. A number of wells are currently in place across the facility and surrounding area. Selected wells may be chosen for sampling in a attempt to delineate the dispersive boundaries of the hazardous substances.

4.2 INSTALLATION OF ADDITIONAL MONITORING WELLS

Many existing wells at the FMPC were placed for reasons other than to specifically monitor PIt #4. Therefore, the installation of additional wells



260

TYPICAL MONITOR WELL SCHEMATIC

70

DAMES & MOORE

FIGURE 1

may be required. These wells would be placed at greater distances from the point of contaminant introduction to the groundwater system in order to delineate plume boundaries. With regards to specific well placement, both U. S. EPA and Ohio EPA will be consulted prior to installation.

4.3 HYDROLOGIC TESTING OF AQUIFER PROPERTIES

In order to estimate the rate of migration of hazardous substances, aquifer properties need to be evaluated. Sieve analyses of selected aquifer sediments collected during well installation yield a plot of grain size distribution. A characterization of the water bearing capacity of these sediments then is possible.

In situ hydraulic conductivity will be measured through the use of slug tests. During these tests, water level recovery is recorded in response to an instantaneous change in the volume of water in the well. In situ measurements of aquifer properties averaged over a large aquifer volume are provided by pump tests. During this field test, water is pumped at a known rate from a well and draw down is measure in one or more observation wells. Analyses of pump test data yields estimates of aquifer transmissivity and storativity. Other tests of aquifer properties may be conducted as needed (Ref 3 & 4).

4.4 COMPUTER MODELING OF CONTAMINANT TRANSPORT

A groundwater species transport model will be used in conjunction with quantitiative contaminant concentrations at selected well locations to aid in the prediction of the extent of hazardous wastes or hazardous waste constituents in the groundwater. The model also will be used to aid in the prediction of the rate and future extent of contamination. The hydraulic aquifer properties discussed in Section 4.3 would be used as necessary in order to calibrate the model to actual site conditions.

The aquifer model will yield a continuous estimate of the plume boundaries and will integrate the scattered contaminant concentration data points derived from the monitoring well sampling program. A two dimensional horizontal (plan view) effluent transport model has been used previously to successfully model the flow system at the site.

4.5 GEOPHYSICAL SURVEY METHODS

Geophysical survey methods may be effective in tracing the location of hazardous wastes or hazardous waste constituents in the groundwater. The use of these methods is contingent on the properties of the detected hazardous substances in the groundwater. A particular method will be selected after the completion of initial stages at the Groundwater Quality Assessment Programs. For example, if barium chloride salts are found to be present in the groundwater, either alone or in conjunction with other hazardous constituents, electrical resistivity methods may effectively define the plume of contamination.

5.0 IDENTIFICATION OF THE CONCENTRATION OF HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS IN GROUNDWATER

Contaminant types and concentrations will be identified during part of the GQAPO described in Sections 3.0 and 4.0. Selected initial samples collected

will be analyzed for priority pollutants and those parameters listed in 40 CFR 264, Appendix IX. Upon completion of these analyses, hazardous waste or hazardous waste constituents which have reached the groundwater will be identified. Samples collected in order to define the extent of contaminant migration will be tested for a series indicator parameters. These parameters will consist of those compounds which were found in detectable concentrations during initial sampling. All samples will be analyzed in accordance with EPA laboratory protocol (Ref. 5 and 6).

REFERENCES

1) Scaff, Marion R., McNabb, James R., Dunlap, Robert L., Fryborgen, John, 1982 Manual of Groundwater Sampling Procedures, U. S. EPA, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma.

2) U. S. Environmental Protection Agency, 1980, Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities, SW-611, Office of Solid Waste.

3) U. S. Department of the Interior, 1981, Groundwater Manual, Water and Power Resources Service. U. S. Government Printing Office.

4) U. S. Department of the Interior, 1977, National Handbook for Recommended Methods for Water Data Acquisition, Chapter 2-Groundwater, Office of Water Data Coordination Geological Survey.

5) U. S. Environmental Protection Agency, Standard Methods for the Examination of Water and Wastewater, 16th. Edition 1985.

6) American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.

7) U. S. Environmental Protection Agency, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD), OSWER-9950.1.

ACRONYMS

CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
FFCA	Federal Facilities Compliance Agreement
FMPC	Feed Materials Production Center
GQAPO	Groundwater Quality Assessment Program Outline
MSL	Mean Sea Level
NPDES	National Pollutant Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
TEGD	Technical Enforcement Guidance Document
TP	Test Pit
USGS	United States Geological Survey

Department of Energy
FMPC Site Office
P.O. Box 398705
Cincinnati, Ohio 45239-8705
(513) 738-6319

260

March 23, 1989
DOE-828-89

Mr. Basil G. Constantelos
Director, Waste Management Division
U.S. Environmental Protection Agency
Region 5ME-14
230 South Dearborn St.
Chicago, IL 60604

Dear Mr. Constantelos:

GROUNDWATER MONITORING AT U.S. DOE FMPC-FERNALD, OHIO

Reference: Letter, W. E. Muno to J. A. Reafsnyder and M. B. Boswell, "Groundwater Monitoring - U.S. DOE FMPC - Fernald OH6 890 008 976," February 3, 1989

This letter provides by attachments: 1) response to U.S. EPA review comments on the FMPC RCRA Groundwater Quality Assessment Program Plan (GQAPP) for Waste Pit No. 4, and RCRA Sampling Rounds 4, 5 and 6 reports, and 2) a revised FMPC RCRA Groundwater Quality Assessment Program Plan. EPA's comments on these documents, detailed in the referenced letter, were received by DOE on February 7, 1989. DOE submitted the original GQAPP to EPA on November 25, 1987.

This revised Assessment Plan also satisfies the requirements of Section 3.7 of the Consent Decree, State of Ohio v. U.S. Department of Energy, et al.

If you have any questions, or require additional information, please contact Mary Stone, of my staff, at 513-738-6655.

Sincerely,

James A. Reafsnyder
Site Manager

DP-84:Craig

Attachment: As stated

APPENDIX E-III

GROUNDWATER QUALITY ASSESSMENT PROGRAM PLAN
FOR WASTE PIT NO. 4
AT THE FEED MATERIALS PRODUCTION CENTER

TABLE OF CONTENTS

Section	Page
1.0 Introduction	page 1
1.1 Background	page 1
1.2 Purpose	page 1
2.0 FMPC Geology and Hydrology	page 3
2.1 Background	page 3
2.2 Glacial Till	page 3
2.3 Sand & Gravel Aquifer	page 5
2.4 Potential Contaminant Pathways	page 5
3.0 History of FMPC RCRA Groundwater Monitoring Systems	page 5
3.1 RCRA Detection Monitoring System	page 5
3.2 Statistical Evaluation of Detection Data	page 6
3.3 Confirmatory Sampling Round	page 6
3.4 RCRA Assessment Monitoring	page 7
3.4.1 RI/FS Monitoring Program, Nov. 1987 to March 1989	page 7
3.4.2 Planned Assessment Program	page 9
4.0 Planned Assessment Program Implementation	page 17
4.1 Objectives/Relationship to CERCLA	page 17
4.2 Rationale For Monitoring Well Locations & Depths	page 18
4.3 Rationale For Selection of Site Specific Parameter	page 29
4.4 RI/FS Well Installation Methods & Materials	page 32
4.5 Sample Collection Methods	page 32
4.6 Analytical Methods	page 32
4.7 Modeling and Additional Hydrologic Studies	page 33
4.8 Procedures For Data Interpretation	page 33
5.0 Schedule	page 33
References	page 132
Abbreviations & Accronyms	page 130
Certification	page 133

FIGURES

Description	Page
Figure 1 - RCRA Detection Wells	page 2
Figure 2 - Geologic Cross-Section	page 4
Figure 3 - Water Table Contours - Till	page 8
Figure 4 - Water Table Contours - Sand & Gravel	page 13
Figure 5 - Uranium Isopeths - 1000 series wells	page 14
Figure 6 - Uranium Isopeths - 2000 series wells	page 15
Figure 7 - Uranium Isopeths - 3000 series wells	page 16
Figure 8 - RI/FS 1000 series wells - FMPC Site	page 20
Figure 9 - RI/FS 1000 series wells - Waste Pit Area	page 21
Figure 10 - RI/FS 2000/3000 series wells - FMPC Site	page 22
Figure 11 - RI/FS 2000/3000 series wells - Waste Pit Area	page 23
Figure 12 - Generalized RI/FS Well Depths and Screen Locations	page 26
Figure 13 - Summary Specification For Well Completion - 1000/2000 Series Wells	page 30
Figure 14 - Summary Specification For Well Completion - 3000/4000 Series Wells	page 31

TABLES

Description	Page
Table 1 - RCRA Detection Parameters	page 7
Table 2 - RCRA Assessment Wells & Parameters	page 19
Table 3 - Summary of CIS Analysis of Pits	page 24
Table 4 - Assessment Well Depths, Casing and Screens	page 27

APPENDICES

Appendix A -	Summary of RI/FS Data Rounds 1 & 2	page 33a
Appendix B -	Assessment Analytical Parameters & Methods	page 46a
Appendix C -	Data from CIS Analysis of Pits	page 63a
Appendix D -	Drilling and Well Installation Methods	page 88a
Appendix E -	Sampling Methods	page 112a

RCRA GROUNDWATER QUALITY ASSESSMENT PROGRAM PLAN FOR FMPC WASTE PIT 4

1.0 Introduction

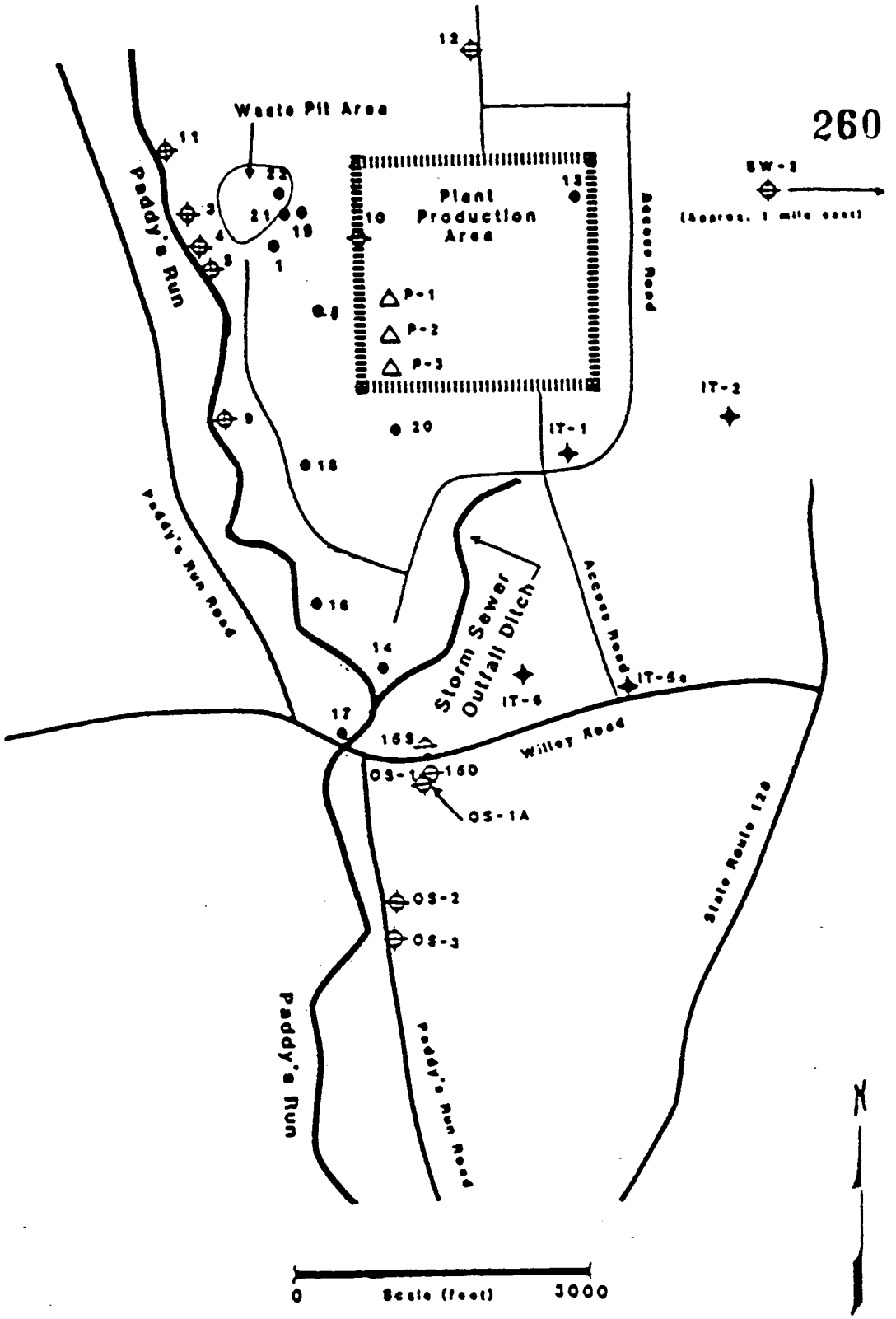
1.1 Background

Waste Pit No. 4 at the Feed Materials Production Center (FMPC) in Fernald, Ohio is subject to the regulations of the Resource Conservation and Recovery Act (RCRA). The RCRA Detection Monitoring Program for FMPC Waste Pit 4 began in August 1985. Samples were collected and analyzed from 41 wells under this detection program from August 1985 to November 1987 (RCRA Rounds 1-5). Required confirmatory sampling was conducted as Round 6 during December 1987. The OEPA and USEPA were notified by the Department of Energy (DOE) on November 13, 1987 that FMPC Waste Pit No. 4 could be affecting groundwater quality in accordance with OAC 3745-65-93 and 40 CFR 265.93. This notification was based on the statistical comparisons required by 40 CFR 265.93 (b), completed for the designated wells around Waste Pit No. 4. These comparisons indicated that statistically significant changes in several indicator parameters had occurred in the vicinity of the landfill. On November 25, 1987 a RCRA Groundwater Quality Assessment Program Plan for Waste Pit No. 4 was submitted to the OEPA and the USEPA. This plan stated that the groundwater assessment program for Waste Pit No. 4 would be completed as part of the ongoing sitewide Remedial Investigation/Feasibility Study (RI/FS) at the FMPC. The RCRA and CERCLA monitoring programs were consolidated because of the similar objectives of the RCRA groundwater assessment program and the RI/FS program.

Waste Pit No. 4 is one of 6 inactive solid and liquid waste disposal units (pits) at the FMPC. All these pits are located together in the FMPC Waste Storage Area northwest of the production area (Figure 1). Waste Pit No. 4 is regulated by RCRA due to disposal of barium salts in this pit from 1980 to 1983. This pit is currently undergoing interim closure under RCRA. All pits, including Waste Pit No. 4, will be remediated under CERCLA, following selection of technical alternatives in the RI/FS process. RCRA technical requirements for closure will be considered as Applicable or Relevant and Appropriate Requirements (ARARS) in the CERCLA remediation process.

1.2 Purpose

The purpose of this report is to provide a revised RCRA Groundwater Quality Assessment Program Plan (GQAPP) for FMPC Waste Pit 4. A GQAPP was submitted to U.S. EPA by DOE in November 1987. EPA's comments on the original plan were received by DOE on February 2, 1989. This submittal is a revision of the GQAPP based on the EPA's comments. This plan also defines the continuation of the Assessment Program, following completion of the RI/FS sampling program. This Plan specifies sampling groundwater for site specific analytical parameters, selected on the basis of Rounds 1 and 2 RI/FS data, and CIS data on the composition of the waste pits. This Plan also specifies sampling 43 RI/FS wells, selected to be upgradient and downgradient of the entire waste pit area, rather than Pit 4. Available analytical data shows that RCRA regulated groundwater constituents are scattered in occurrence, do not delineate a groundwater plume, and cannot be traced specifically to Pit 4 rather than adjacent Pits. No unique "fingerprint" hazardous waste or



Explanation:

- Single Well Location
- Cluster Well Location
- Production Well Location
- IT Well Location

RCRA Detection Well Locations

Figure 1

hazardous waste constituent found in groundwater can be traced specifically to Pit 4 rather than to the whole Waste Storage Area.

2.0 FMPC Geology and Hydrology

2.1 Background

The FMPC is located in a two-mile wide valley filled with glacial deposits. This valley parallels the Great Miami River between the towns of Ross and Hooven, Ohio. A generalized geologic cross-section for the FMPC site area is presented in Figure 2.

Approximately 450 million years ago in late Ordovician time, sediments which would become a predominantly flat-lying shale with thin interbedded limestone were deposited in a shallow sea. This shale, part of the Cincinnatian Series, is the relatively impermeable bedrock which now underlies the FMPC site area.

Sometime prior to, or perhaps contemporaneous with Pleistocene glaciation, a large watercourse (larger than the present-day Great Miami River) cut a channel into this shale bedrock to a level of more than 200 feet below that of the existing Great Miami River. This approximately two-mile wide channel is sometimes referred to as the New Haven Trough and may be an abandoned course of the ancestral Ohio River.

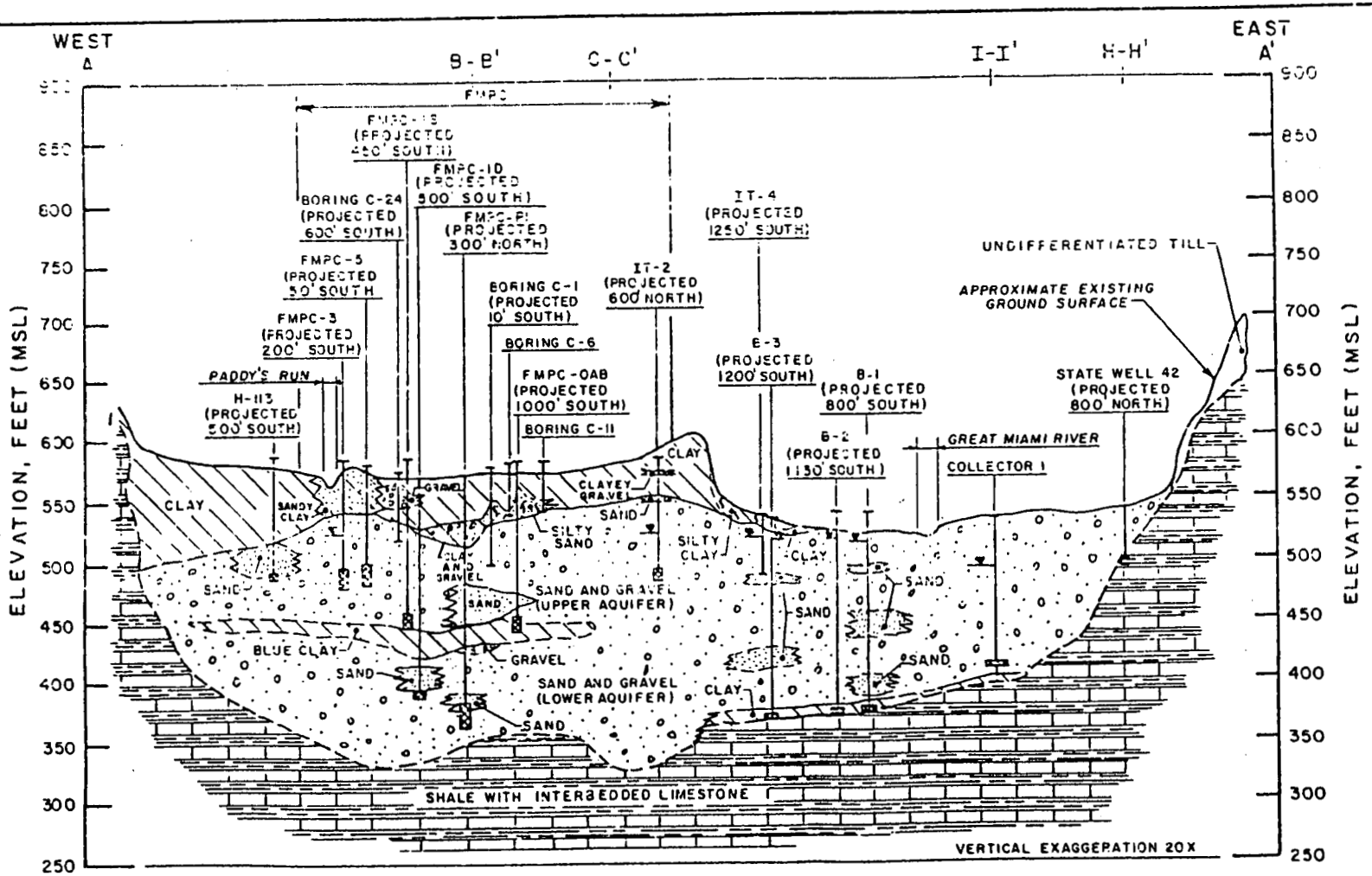
During subsequent Pleistocene glacial advances and retreats across the site area such as the Illinoisan (approximately 300,000 to 400,000 years ago) and the Wisconsin (approximately 10,000 years ago), the New Haven Trough was filled with about 200 feet of glacial sediments. These sediments were deposited by water flowing from the margins of the glaciers and consisted mainly of well sorted sand and gravel. A blanket of clay-rich, relatively impermeable glacial till from a more recent event was deposited atop the 200 feet of glacial sediments.

Erosion by the Great Miami River and its tributaries has subsequently removed significant portions of the glacial till which contributed to terrace remnants standing topographically higher than the surrounding bottom lands. The FMPC site lies atop one of these terrace remnants.

2.2 Glacial Till

At the land surface of the FMPC, a 20 to 50 foot thick layer of glacial till, composed of a dense, olive-gray silty clay, overlies the sand and gravel outwash deposits. The till varies in texture and composition, both laterally and vertically, and contains lenses of poorly sorted fine to medium grained sand and gravel (meltwater channel sands). The base of the till occurs at the estimated elevation of 540 mean sea level (MSL) and overlies the sand and gravel outwash deposits.

To the south and west of the FMPC production area, the silty clay till laterally grades into a sequence of silt and silty sand (Pleistocene lake deposits), with some layers of silty clay. The silty clay till is continuous to the north and east of the site, and directly overlies the bedrock in these areas. In the lower reaches of Paddy's Run and the storm sewer outfall ditch,



LEGEND

OPEN INTERVAL

WATER LEVELS (MEASURED 3/27/86 THRU 4/11/86.)

REFERENCES:

MODIFIED FROM U.S.G.S. PROFESSIONAL PAPER No. 605-A USING AVALIABLE OHIO STATE WATER WELL RECORDS, SOWC WATER WELL DATA, DAMES AND MOORE, DOE, FEED MATERIALS PRODUCTION CENTER GROUND WATER STUDY TASKS A AND C REPORTS AND IT BORING LOGS.

FIGURE ADAPTED FROM FERNALD LITIGATION DRAWING NO 303063-816. PREPARED FOR U.S. DEPARTMENT OF ENERGY BY IT CORPORATION, NOVEMBER, 1985

CROSS SECTION A-A'

(LOOKING NORTH)

VERTICAL SCALE

0 100 200 FEET

HORIZONTAL SCALE

0 2000 4000 FEET

THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED SOIL CONDITIONS AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS OCCURRING AT THESE BORING LOCATIONS ALSO THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS

THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED ON THE SECTIONS WERE GENERALIZED FROM AND INTERPOLATED BETWEEN THE TEST BORINGS INFORMATION ON ACTUAL SUBSURFACE CONDITIONS EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED

84

Figure 2

HYDROGEOLOGIC CROSS SECTION A-A'

PREPARED FOR

FERNALD RI/FS
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS

IT ... Creating a Safer Tomorrow

© 1984 IT CORPORATION
ALL COPYRIGHTS RESERVED

the silty clay till and lake bed silts have been eroded to expose the underlying sand and gravel aquifer.

A saturated zone occurs within the silty clay till at levels approximately 4 to 10 feet below the land surface in some areas of the FMPC site. This saturated zone is probably recharged by precipitation and may be present due to vertical variations of composition and texture of the till, or near-surface weathering and desiccation-induced fracturing of the till.

2.3 Sand and Gravel Aquifer

A sequence of highly permeable sand an gravel outwash deposits, laid down by the meltwaters of receding continental ice sheets, unconformably overlie the shale bedrock in the vicinity of the FMPC. These outwash deposits generally consist of an unconsolidated medium- to coarse- grained, olive brown layer of sand and gravel, ranging in thickness up to 200 feet. The sand and gravel is arranged in irregularly alternating layers of silty sand, medium to coarse sand, and medium to coarse gravel.

In the vicinity of the Waste Storage Area, this layer is separated into two units by a 10 to 20 foot thick layer of greenish-black silty clay. The FMPC production wells are completed below this "blue clay" layer. This blue clay layer underlies about 360 acres of the FMPC and apparently occurs only in the vicinity of the Waste Storage Area and the production wells. This layer was probably deposited in an ice marginal lake or as a backwater deposit of a glacial stream. The top of this blue clay layer lies about 125 feet below the land surface.

The upper 20 to 30 feet of the sand and gravel deposits are not saturated, with water in this aquifer generally occurring at levels approximately 60 to 90 feet below the land surface. These levels depend on the relative thickness of the glacial till and respective land surface elevation.

2.4 Potential Contaminant Pathways

Potential contaminant pathways in the FMPC waste storage area are migration of leachate through the bottom or sides of the pits through the till down to the sand and gravel aquifer. Pleistocene (surface) sediments at the FMPC consist of lake bed silts of moderate permeability, melt water channel sands of moderate permeability and glacial till of very low permeability. The waste storage area is underlain primarily by glacial till. In the waste storage area, glacial till is generally capable of restricting groundwater flow between the surface and the Great Miami Aquifer.

3.0 History of FMPC RCRA Groundwater Monitoring Systems

3.1 RCRA Detection Monitoring System

In August 1985 a program of RCRA groundwater detection monitoring for Pit 4 was initiated at the FMPC. Under this program 4 quarterly rounds of sampling and one semi-annual round of sampling was completed during the period of August 1985 to November 1987 (Rounds 1 through 5). The results of these

Rounds of sampling were provided to EPA. In this detection monitoring program, 41 wells were monitored for 94 analytical parameters. Figure 1 shows the locations of these 41 wells, which are located on the FMPC site and adjacent offsite area. Table 1 lists the 94 analytical parameters included in the detection monitoring program. These parameters included metals, anions, water quality parameters, indicator parameters, organic compounds and radionuclides.

3.2 Statistical Evaluation of Detection Data

In November 1987, DOE notified EPA that Pit 4 could be affecting ground water quality based on statistical evaluation of indicator parameters in wells adjacent to Pit 4 as compared to background wells. This evaluation was performed comparing the mean Total Organic Carbon (TOC), Total Organic Halogen (TOX), specific conductance (SC) and pH of upgradient wells established in monitoring Rounds 1-4 to Round 5 downgradient values using Cochran's Approximation to the Behren's Fisher Student's t-test. The upgradient till well MW-12 (1012) was compared to downgradient till wells MW-19TP (1019), MW-21TP (1021) and MW-22TP (1022). The upgradient sand and gravel well SW-2 (Southwestern Ohio Collector Well) was compared to downgradient wells MW-19s (2019), MW-19d (3019), MW-21s (2021) and MW-22s (2022). Details of this statistical comparison are described in the RCRA Groundwater Monitoring Report, v. 5, Round 5, Nov. 1987.

Results of these statistical comparisons showed that in the till wells:

1) There were no significant increases of TOX in downgradient wells
2) TOC concentrations increased significantly in all downgradient wells.
3) Specific conductance significantly increased in two of the three downgradient wells.
4) pH significantly increased in all downgradient wells.

Results of statistical comparisons in the sand and gravel wells showed:

1) TOX did not significantly increase in the downgradient wells.
2) TOC did not increase significantly in the downgradient wells.
3) Specific conductance increased significantly in all downgradient wells.
4) pH decreased significantly in one downgradient well.

As a result of this statistical analysis, the Ohio and U.S. EPA were notified on November 13, 1987 that FMPC Waste Pit 4 could be affecting groundwater quality in accordance with OAC 375-65-93 and 40 CFR 265.93 (b).

3.3 Confirmatory Sampling Round

The second semi-annual round (Round 6) of RCRA Detection sampling was completed in December 1987. Forty wells were sampled for 94 parameters during this round of sampling. Forty wells were sampled, rather than 41 wells, since one well was dry. The analytical results did not differ significantly from Round 5 results, and confirmed the conclusions made based on Round 5 samples.

Table 1

RCRA Detection Monitoring

ANALYTICAL PARAMETERS

A. For General Water Quality (1)

1. Chloride
2. Iron
3. Manganese
4. Phenols
5. Sodium
6. Sulfate

B. For Indicators of Contamination (Quadruplicate Analysis) (1)

1. pH
2. Specific Conductance
3. Total Organic Carbon (TOC)
4. Total Organ Halogen (TOX)

C. For Drinking Water Suitability (1)

1. Arsenic
2. Barium
3. Cadmium
4. Chromium - Hexavalent
   - Total
5. Fluride
6. Lead
7. Mercury
8. Nitrate
9. Selenium
10. Silver
11. Gross Alpha
12. Gross Beta
13 Radium
14. Endrin
15. Lindane
16. Methoxychlor
17. Toxaphene
18. 2,4-D
19. 2,4,5-TP Silvex
20. Coliform Bacteria

Table 1 (cont'd.)

RCRA Detection Monitoring

ANALYTICAL PARAMETERS (Cont'd.)

D. **Site Specific Parameters**

1. Nickel (1)
2. Cyanide (1)
3. Copper (1)
4. Zinc (1)
5. Magnesium (1)
6. Calcium (1)
7. Phosphorus (1)
8. Chlorobenzene (2)
9. Chlorodibromomethane (2)
10. Chloroethane (2)
11. 2-chloroethylvinyl (2)
12. Chloroform (2)
13. Dichlorobromomethane (2)
14. Dichlorodifluoromethane (2)
15. Total Dissolved Solids (TDS)
16. Total Potassium
17. Chemical Oxygen Demand (COD)
18. cis 1,2 Dichloroethene (2)
19. Tributylphosphate (2)
20. Acrolein (2)
21. Acrylonotrille (2)
22. Benzene (2)
23. bis (Chloromethyl) Ether (2)
24. Bromoform (2)
25. Bromodichloromethane (2
26. Bromoethane (2)
27. Carbon tetrachloride (2)
28. Chloromethane (2)
29. 1,2 Dichlorobenzene (2)
30. 1,3 Dichlorobenzene (2)
31. 1,4 Dichlorobenzene (2)
32. 1,1 Dichloroethane (2)
33. 1,2 Dichloroethane (2)
34. 1,1 Dichloroethylene (2)
35. 1,2 Dichloropropane (2)
36. 1,2 Dichloropropylene (2)
37. Ethylbenzene (2)
38. Methylbromide (2)

RCRA Detection Monitoring
ANALYTICAL PARAMETERS (Cont'd.)

39. Methylchloride (2)
40. trans-1,2 Dichloroethylene (2)
41. 1,3 Dichloropropene (2)
42. 1,1,2,2 Tetrachloroethane (2)
43. Tetrachloroethylene (2)
44. Toulene (2)
45. 1,1,1 Trichloroethane (2)
46. 1,1,2 Trichloroethane (2)
47. Trichloroethylene (2)
48. Trichlorofluoromethane (2)
49. Vinyl Chloride (Chloroethene) (2)

E. Radionuclide (1)

1. Potassium 40
2. Total Uranium
3. Radium 226
4. Radium 228
5. Technetium 99
6. Thorium 228
7. Thorium 230
8. Thorium 232
9. Cesium 137
10. Strontium 90
11. Ruthenium 106
12. Neptunium 237
13. Plutonium 238
14. Plutonium 239
15. Plutonium 240

(1) Analyzed for all samples.

(2) Not required for RCRA, but analyzed for all wells except: MW-1s, MW-3, MW-5, P-1, P-2, P-3, MW-15d, OS-2 and OS-3.

3.4 RCRA Assessment Monitoring

3.4.1 RI/FS Monitoring Program, November 1987 to March 1989

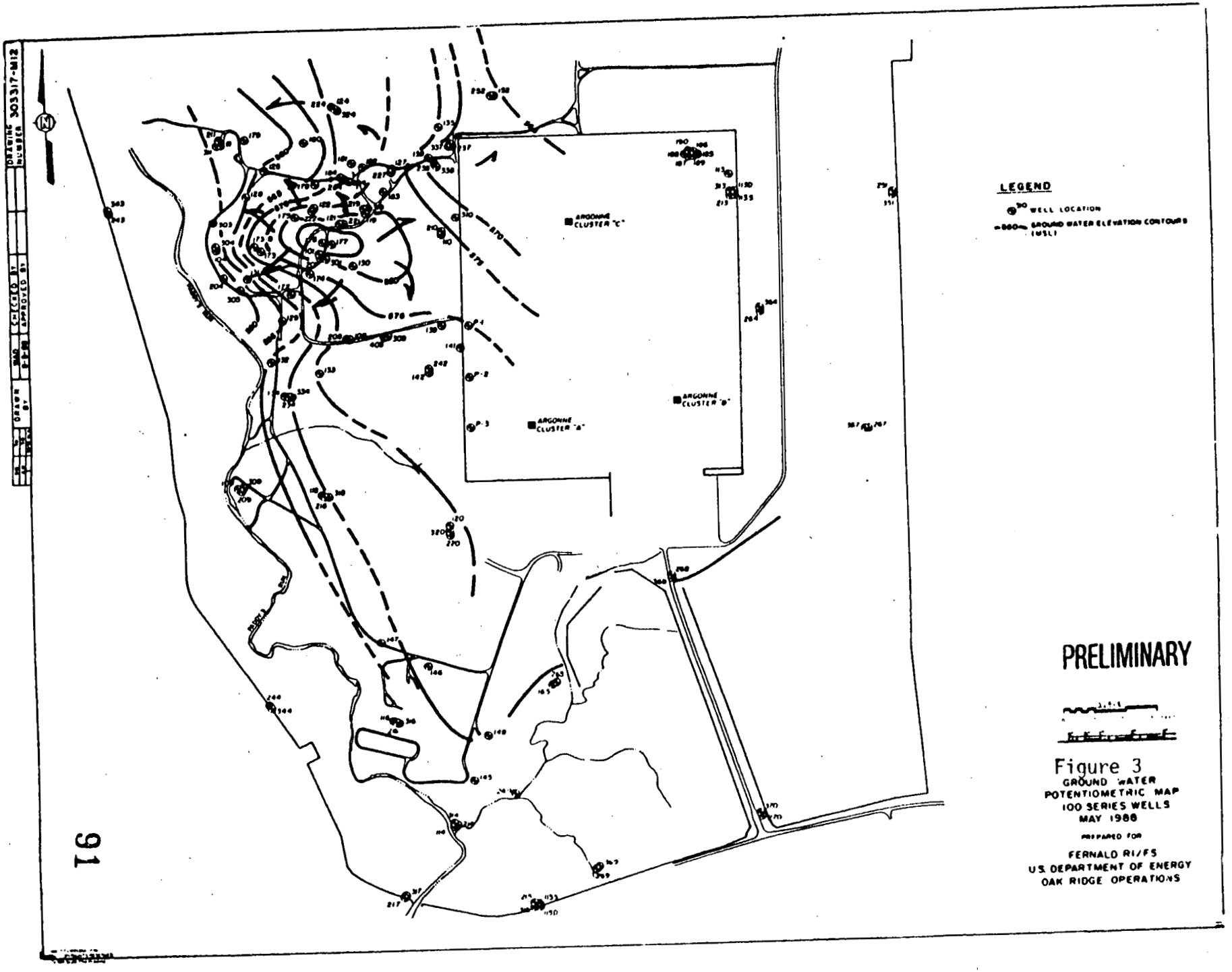
On November 25, 1987 a RCRA Groundwater Quality Assessment Program Plan for Waste Pit 4 was submitted to OEPA and USEPA. This plan stated that the groundwater assessment program for Waste Pit 4 would be completed as part of the ongoing sitewide Remedial Investigation/ Feasibility Study (RI/FS) at the FMPC. The RCRA and CERCLA monitoring programs were consolidated because of the similar objectives of the RCRA groundwater assessment program and the RI/FS.

Pit 4 is one of 6 inactive solid and liquid waste disposal units (pits) at the FMPC. All of these pits are located together in the FMPC Waste Storage Area northwest of the production area. All pits, including Pit 4, will be remediated under CERCLA, following selection of technical alternatives in the RI/FS process. RCRA technical requirements for closure will be considered as Applicable or Relevant and Appropriate Requirements (ARARS) in the CERCLA remediation process.

The first Round of RI/FS groundwater sampling took place in March and April 1988. The second Round of sampling took place in June and July 1988: the third Round occurred in October and November 1988. The fourth Round is currently taking place and will be completed in March 1989. Over 200 parameters were analyzed in groundwater samples, including radionuclides, general water quality indicators, and extended HSL list parameters (HSL volatile and semi-volatile organics, HSL inorganics, HSL pesticides and PCBs, organophosphorus pesticides and dioxins). The extended HSL list parameters were sampled during Round 1. More than 200 on- and off-site wells are being sampled as part of the RI/FS program, according to the RI/FS Workplan, Rev. 3, March 1988 as approved by U.S. EPA. These wells are located in the waste storage area, the production area and the general site area and north, south, east and west of the site,

Preliminary interpretations of Rounds 1 and 2 RI/FS groundwater monitoring data have shown that the piezometric surface in the till aquifer near pit 4 slopes toward the north and northwest and in a limited area to the northeast (see Figure 3). The arrows on Figure 3 show directions of groundwater flow. A groundwater mound is present in the till just south of Waste Pit 4. This mound is hydraulically upgradient of the pit area; any groundwater flow in the till in the pit area would be radial, away from this mound. RI/FS water level data taken over several seasons have confirmed the existence of this mound. This mound is located beneath a topographic low in the waste storage area. Due to the non-continuous nature of the groundwater in the till, there is limited potential for lateral migration of hazardous waste or hazardous waste constituents in the till.

Preliminary interpretation of Rounds 1 and 2 of the RI/FS monitoring data (shown in Appendix A) have shown that the constituents of major concern in the till in the waste storage area are uranium, gross alpha, gross beta, chloride, sulfate and dichloroethane. Of these constituents, only dichloroethane is regulated under RCRA. Barium, the RCRA constituent placed into Pit 4, was not


LEGEND
WELL LOCATION
GROUND WATER ELEVATION CONTOURS (MSL)
ARGONNE CLUSTER "C"
ARGONNE CLUSTER "B"
ARGONNE CLUSTER "A"
PRELIMINARY
Figure 3
GROUND WATER POTENTIOMETRIC MAP
100 SERIES WELLS
MAY 1986
PREPARED FOR
FERNALD RI/FS
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS
DRAWING NUMBER 303317-M12

found in levels above background levels in wells in the waste storage area. A small amount of methylene chloride (18 ppb) was also identified in a till well in the waste storage area. No pesticides, organophosphorus pesticides or PCBs were detected in till wells in the waste storage area.

Data shows (Figure 4) that the water surface in the sand and gravel aquifer below the waste storage area slopes to the east. The arrows on Figure 4 show the direction of groundwater flow. Groundwater velocities in the sand and gravel aquifer in this area have been estimated to be approximately 70 feet per year.

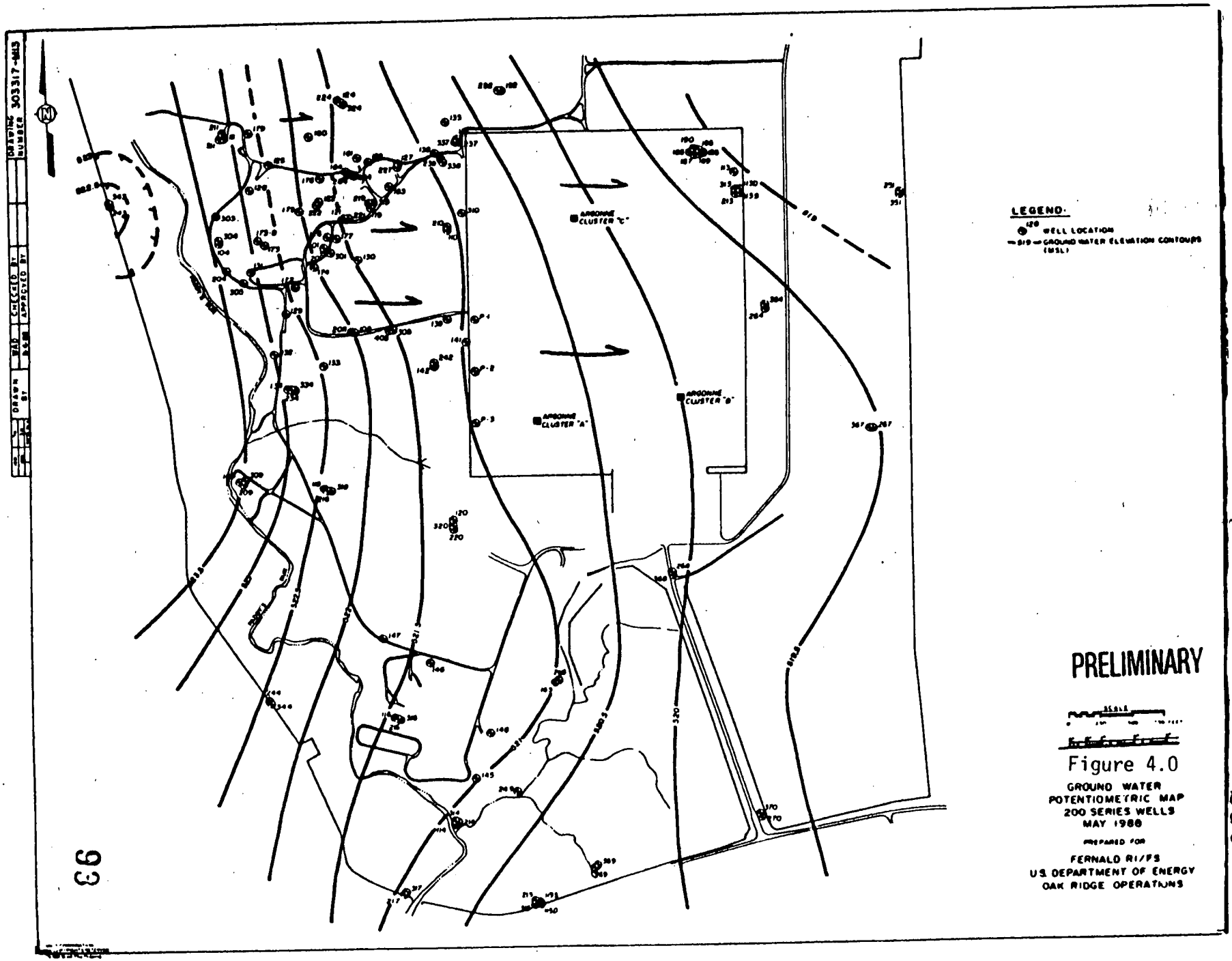
Based on preliminary interpretation of Round 1 and 2 data, the constituents of concern in the sand and gravel aquifer are uranium, gross alpha, gross beta, sulfate, nitrate and total dissolved solids. Small amounts of methylene chloride, toluene and acetone (generally less than 20 ppb) have been found in several scattered wells in the sand and gravel aquifer in the waste storage area (and also in wells outside the waste storage area as well). Again no pesticides, PCBs or dioxins were found in the sand and gravel wells in the pit area.

All data gathered to date indicates that the major constituent of concern, and the best indicator parameter at the FMPC is total uranium. RI/FS monitoring data shows that there are two distinct areas of above background uranium concentrations in groundwater at the FMPC (see Figures 5, 6 and 7). One, already discussed, beneath the site in the waste storage area; the other under the southern portion of the FMPC, extending offsite.

Wells in the south portion of the FMPC reservation, south of the storm sewer outfall ditch and wells off-site to the south of the site show above-background concentrations of uranium, gross alpha and gross beta. Evidence to date shows that the source of these constituents is storm water runoff from the FMPC production area and waste storage area. This surface water infiltrated directly into the aquifer in Paddy's Run and the Storm Sewer Outfall Ditch, where these waterways have eroded through the protective till layer, directly exposing the sand and gravel aquifer in the stream beds. The construction of the Storm Water Retention Basins has eliminated the routine discharge of production area runoff into the Storm Sewer Outfall Ditch.

3.4.2 Planned Assessment Program

Based on the results of the RCRA detection monitoring program, and the RI/FS program data available to date, 43 RI/FS wells adjacent to or downgradient from the waste storage area have been selected for continuation of the RCRA Groundwater Assessment Monitoring Program, following completion of the fourth round of RI/FS sampling. These wells will be sampled until the remediation of Waste Pit 4 is completed under CERCLA. The implementation of this planned program is discussed in section 4.0. The rationale for selection of locations and depths of these monitoring wells, and analytical parameters will be discussed in sections 4.2 and 4.3.


LEGEND:
WELL LOCATION
GROUND WATER ELEVATION CONTOURS (MSL)
ARGONNE CLUSTER "A"
ARGONNE CLUSTER "B"
ARGONNE CLUSTER "C"
PRELIMINARY
SCALE
Figure 4.0
GROUND WATER
POTENTIOMETRIC MAP
200 SERIES WELLS
MAY 1988
PREPARED FOR
FERNALD RI/FS
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS
DRAWING NUMBER 303317-H13
DRAWN BY
CHECKED BY
APPROVED BY

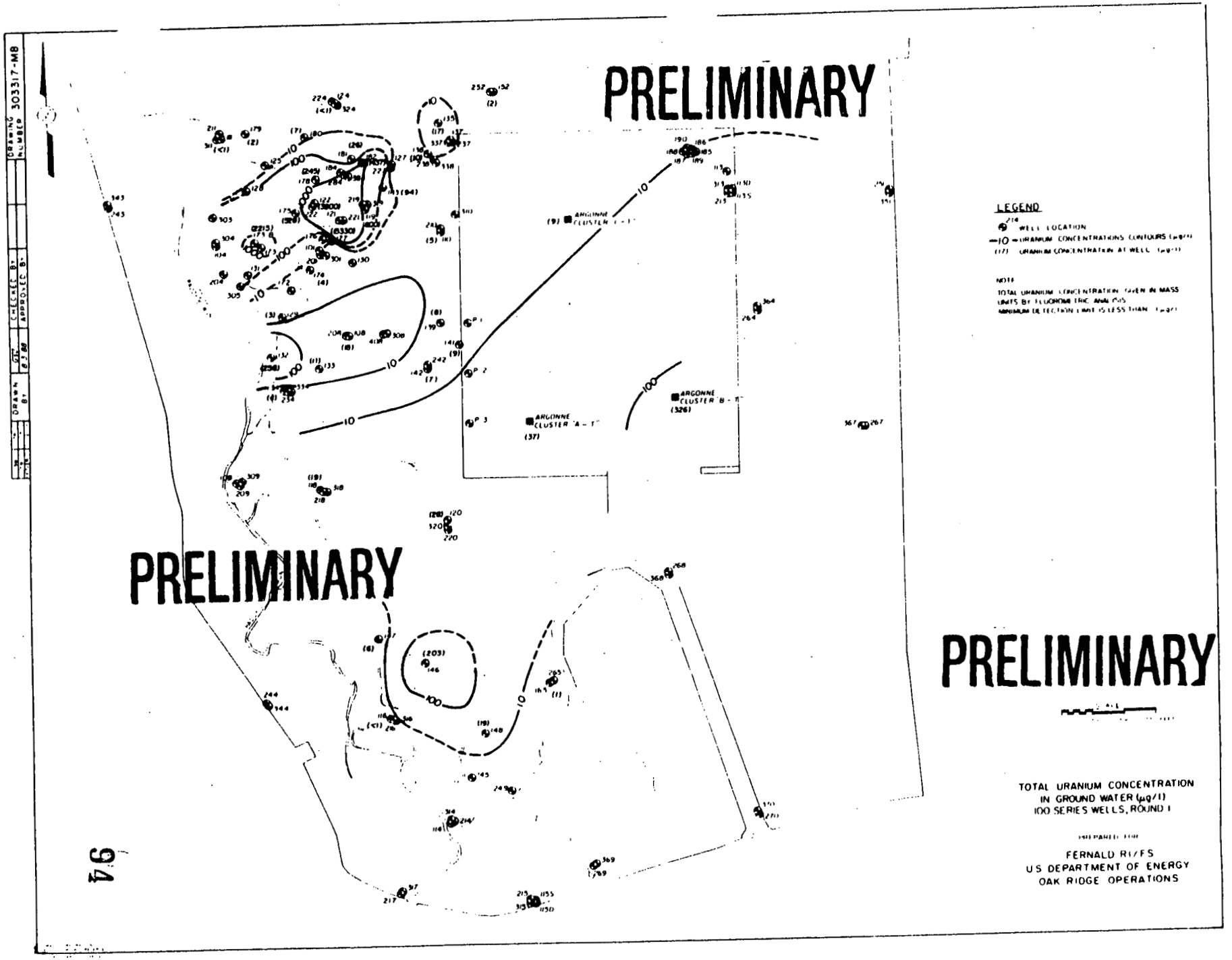

PRELIMINARY
PRELIMINARY
PRELIMINARY
LEGEND
WELL LOCATION
URANIUM CONCENTRATIONS CONTOURS
URANIUM CONCENTRATION AT WELL
NOTE
TOTAL URANIUM CONCENTRATION GIVEN IN MASS UNITS BY FLUOROMETRIC ANALYSIS
MINIMUM DETECTION LIMIT IS LESS THAN
ARGONNE CLUSTER "A-1"
ARGONNE CLUSTER "B-1"
TOTAL URANIUM CONCENTRATION
IN GROUND WATER (µg/l)
100 SERIES WELLS, ROUND I
FERNALD RI/FS
US DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS
DRAWING NUMBER 303317-MB
CHECKED BY
APPROVED BY
DRAWN BY

Figure 5

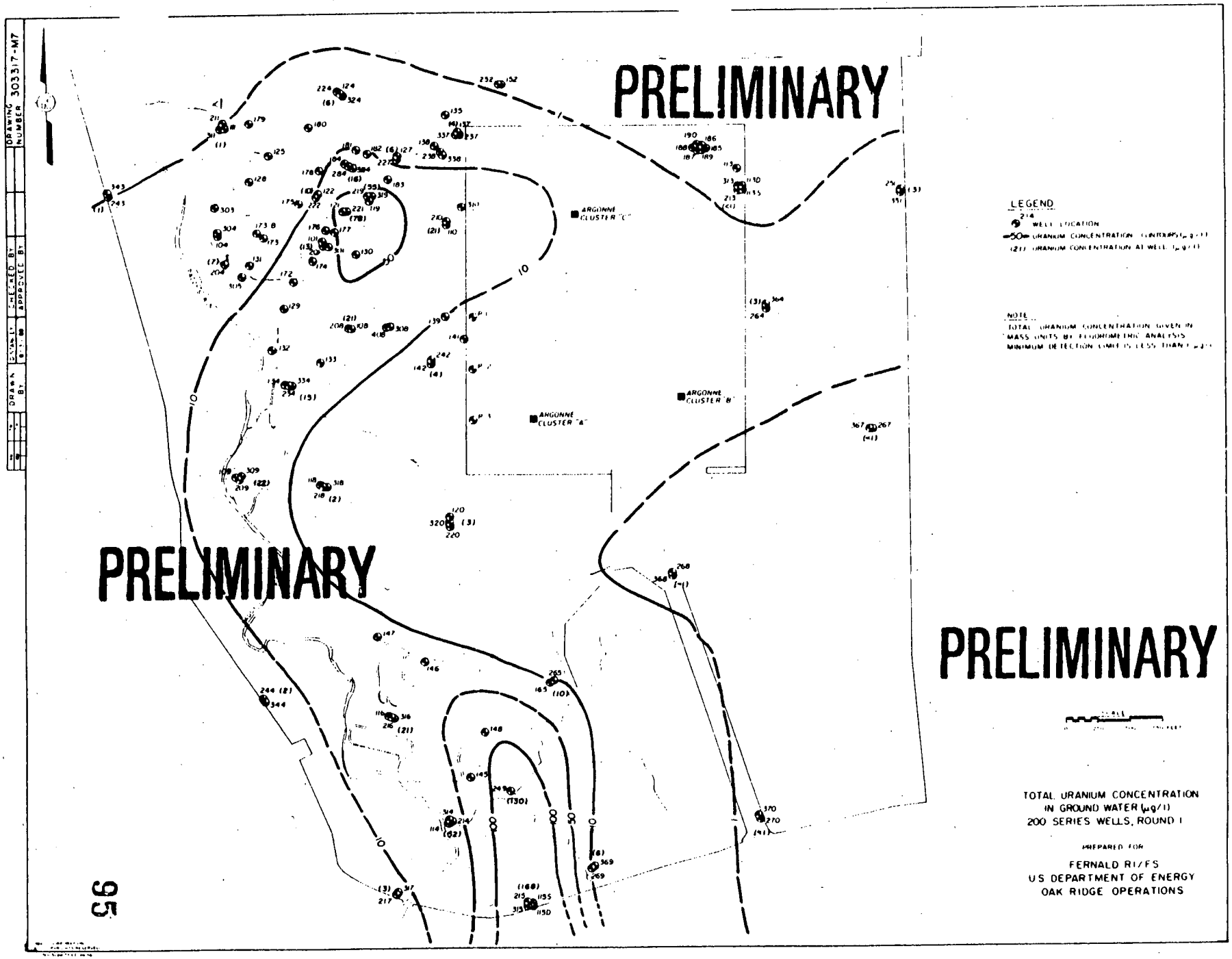

PRELIMINARY
PRELIMINARY
PRELIMINARY
ARGONNE CLUSTER "C"
ARGONNE CLUSTER "A"
ARGONNE CLUSTER "B"
LEGEND
WELL LOCATION
URANIUM CONCENTRATION
URANIUM CONCENTRATION AT WELL
NOTE
TOTAL URANIUM CONCENTRATION GIVEN IN
MASS UNITS BY FLUOROMETRIC ANALYSIS
MINIMUM DETECTION LIMIT IS LESS THAN
TOTAL URANIUM CONCENTRATION
IN GROUND WATER (µg/l)
200 SERIES WELLS, ROUND I
PREPARED FOR
FERNALD RI/FS
US DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS
DRAWING NUMBER 303317-M7
DRAWN BY
EXAMINED BY
CHECKED BY
APPROVED BY

Figure 6

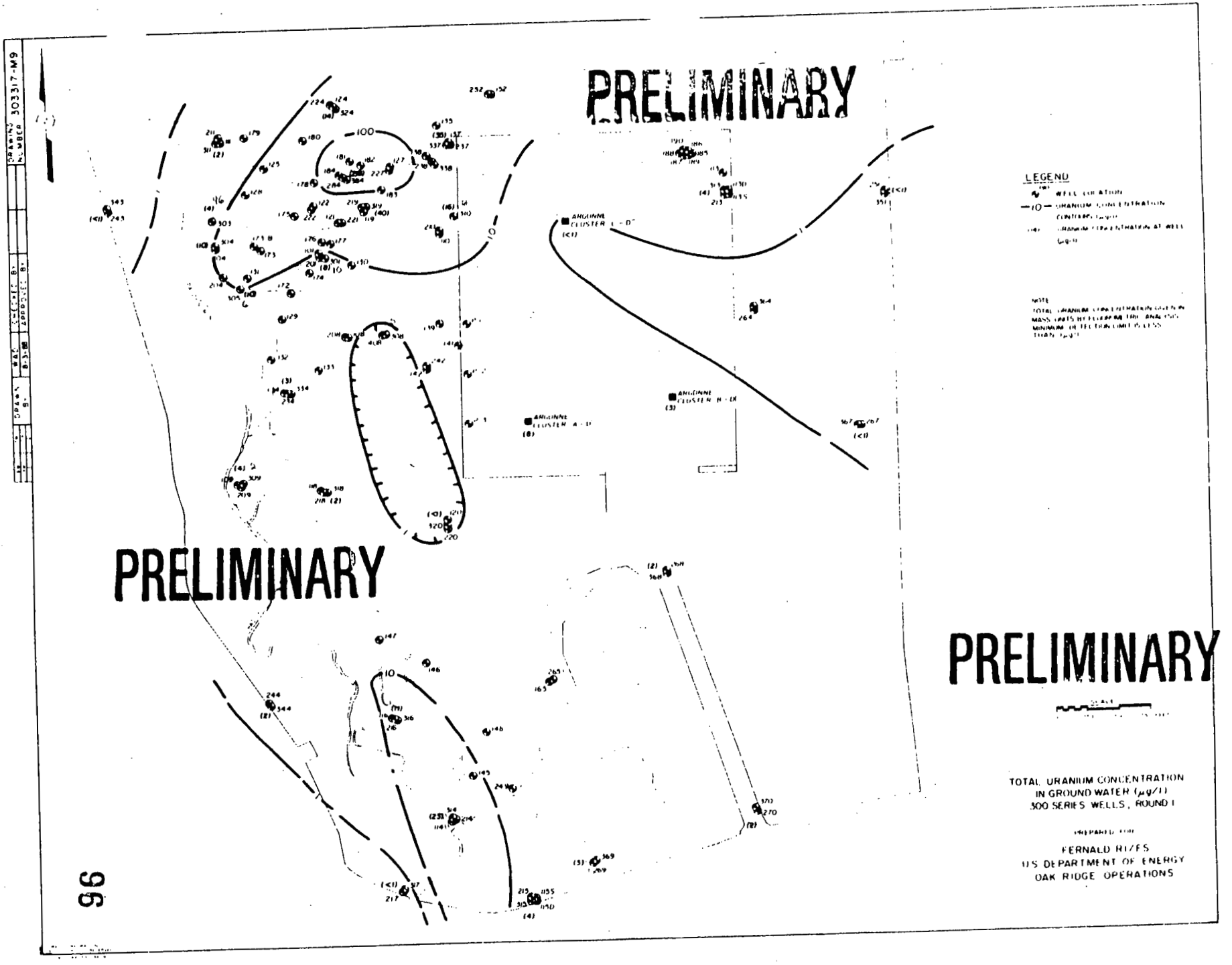

PRELIMINARY
PRELIMINARY
PRELIMINARY
LEGEND
TOTAL URANIUM CONCENTRATION
IN GROUND WATER (µg/l)
300 SERIES WELLS, ROUND I
FERNALD RI/FS
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS

Figure 7

4.0 Planned Assessment Program Implementation

4.1 Objectives/ Relationship to CERCLA

As defined in the Ohio Administrative Code and in 40 CFR, Part 265.93 the objectives of the Groundwater Assessment Program are to determine:

(a) The rate and extent of migration of the hazardous waste or hazardous waste constituents in the groundwater; and

(b) The concentrations of the hazardous waste or hazardous waste constituents in the groundwater.

A sitewide RI/FS is being conducted at the FMPC. A Work Plan for conducting the RI/FS was submitted to OEPA and USEPA in December 1986. Revision 3 of this Work Plan was subsequently approved by USEPA in May 1988. Field activities associated with the RI/FS were initiated in July 1987. A focus of the RI/FS is the completion of a comprehensive hydrogeologic investigation of the potential effects of FMPC operations and waste disposal practices on regional groundwater. The objectives of the hydrogeologic investigation program of the RI/FS are to:

(a) Determine if subsurface water-bearing zones below the FMPC contain above background concentrations of chemical or radiological constituents;

(b) Determine the concentrations and sources of these constituents;

(c) Determine the rate and direction of groundwater flow and constituent movement within each separate hydrogeologic unit;

(d) Determine the effects of groundwater pumping and resulting recharge/discharge relationships on groundwater flow and contaminant transport;

(e) Define areas of subsurface migration and groundwater discharge for identified constituents; and

(f) Determine the nature and extent (both vertically and horizontally) of identified above background constituents.

Pit 4 is currently undergoing Interim RCRA Closure. This Interim Closure will be completed in the spring of 1989. Assessment monitoring will be continued until the Final Remediation of the waste pits under CERCLA. RCRA regulations will be considered as Applicable or Relevant and Appropriate Requirements (ARARS) for the remediation of Pit 4 under CERCLA. A RI/FS Report evaluating remediation alternatives for the waste pits is tentatively scheduled to be delivered to U.S. EPA in the third quarter of 1990. The USEPA is tentatively scheduled to issue a Record of Decision (ROD) selecting the remedial alternatives for the waste storage operable unit in the second quarter of 1991. Within 90 days of the issuance of the ROD by USEPA, plans for Post-Closure monitoring will be submitted to EPA, as specified in the Pit 4 RCRA Closure Plan.

4.2 Rationale for Monitoring Well Locations and Depths

After March 1989, the Assessment program will consist of a quarterly sampling program for 43 wells selected from the RI/FS wells for continuation of the RCRA Assessment program, following completion of the fourth round of RI/FS sampling. Sixteen of the selected wells are 1000 series (till wells) and 27 are sand and gravel wells (2000, 3000 and 4000 series). This program includes two background till wells, outside the waste storage area, and 4 upgradient sand and gravel wells outside the waste storage area. The wells selected for continuation of the Assessment program are listed in Table 2. Figures 8 through 11 show the locations of these wells.

Due to the similar types of materials placed into the 6 waste pits, it is technically impossible to trace constituents to a single pit. Table 3 shows a summary of constituents of all waste pits. This Table demonstrates the similarities of materials found in all pits. No unique indicator constituent to monitor contamination coming from Pit 4 could be identified by examining data from the CIS characterization of the pits.

Since none of the RCRA regulated constituents found in the waste storage area groundwater can be traced specifically to Pit 4, rather than other adjacent waste pits, the RCRA monitoring system wells be placed downgradient from the entire waste storage area. To design a monitoring system specific to Pit 4, sand and gravel wells upgradient to Pit 4 would have to be placed downgradient from Pit 3 in order to isolate constituents coming from Pit 4. This upgradient well would not representative of background conditions. Likewise, since a groundwater mound in the till is located just south of Pit 4, upgradient till wells for Pit 4 would have to be placed on this mound, which is located in the waste storage area, and would not represent background conditions. The proposed RCRA Assessment monitoring system will be located downgradient from the entire waste storage area. Upgradient wells will be located outside of the waste storage area, and will be representative of background conditions. This approach is also justified since all 6 pits will be remediated under CERCLA, and closure options for all pits are being evaluated under a single Feasibility Study document.

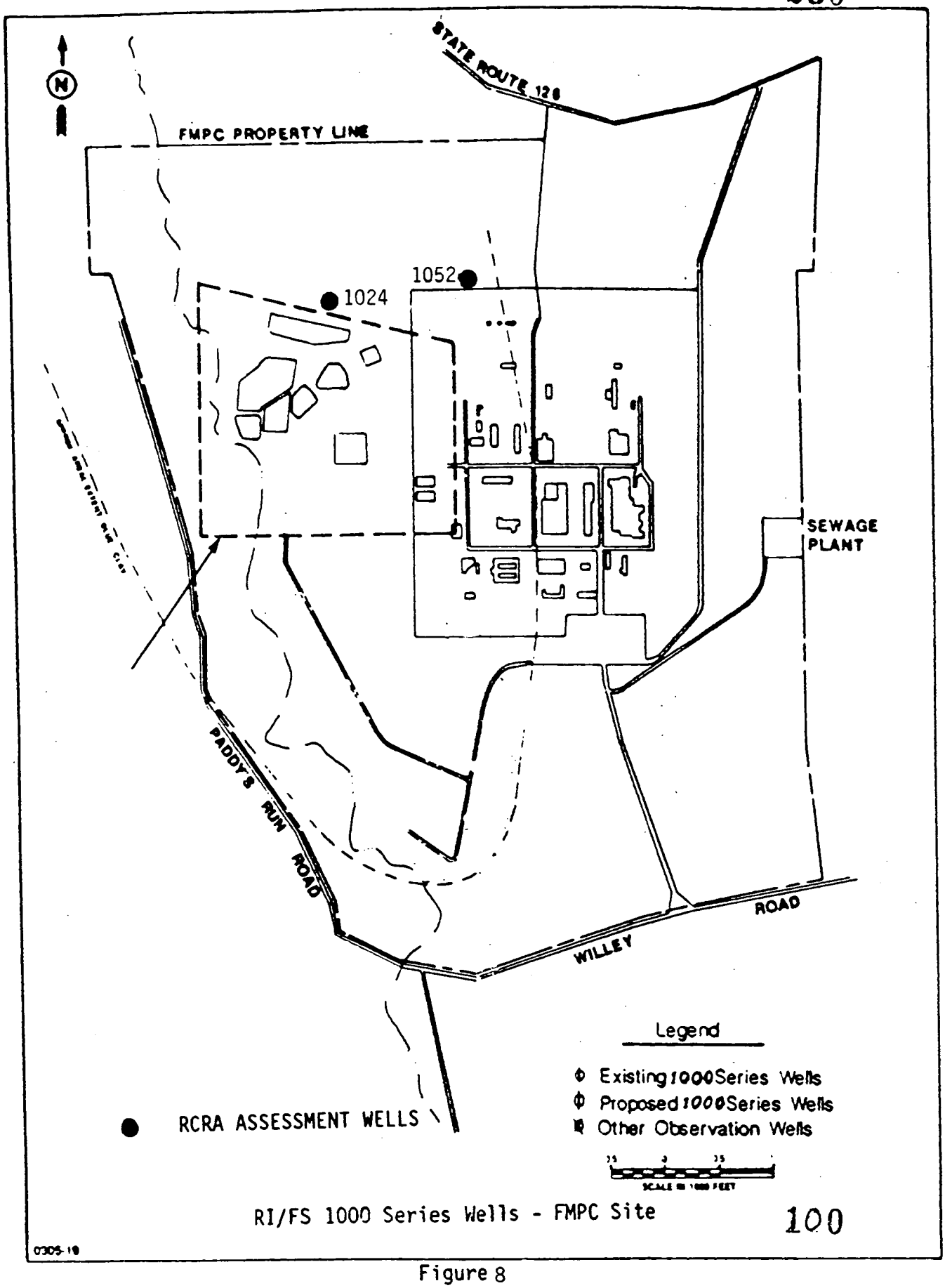
To have the same Pleistocene geology as the pit area, background till wells need to be located either in the pit area, or north of the pit area, or in the production area or east of the production area. Wells in either the production area or waste storage area would not represent background conditions. Wells 1024 and 1052 were selected as the most representative RI/FS background wells for the glacial till. These wells are located 500 feet north and 1400 feet northeast of the pit area, respectively.

The 14 downgradient till wells (1000 series) ring the waste storage area, and are located downgradient from the groundwater mound shown in Figure 3. Wells 1079, 1080, 1027 1081, 1082 and 1038 are located north of the pit area. Wells 1038 1027, 1030, 1083 and 1074 are located east of the waste pits, Wells 1031, 1072, 1074 and 1030 are located south of the pit area. Wells 1011, 1079, 1028, 1040, 1025 and 1031 are located west of the waste storage area. Most of these wells are located within 20 feet of the edge of the waste pits.

TABLE 2

Selected RI/FS Wells and Site Specific
Parameters for the RCRA Assessment Program

PARAMETERS	UPGRADIENT TILL WELLS
Cobalt	1024
Beryllium	1052
Zinc	
Vanadium	**DOWNGRADIENT TILL WELLS**
Nickel	
Copper	1027
Magnesium	1080
Calcium	1079
Aluminum	1004
Barium	1074
Chromium	1031
Lead	1028
Silver	1072
Iron	1030
Fluoride	1038
Nitrate	1081
Chloride	1083
Sulfate	1082
pH	1025
Conductivity	
TOC	**UPGRADIENT SAND & GRAVEL**
TOX	
Tetrachloroethene	2066/3066
Methylene chloride	2043/3043
Dichloroethane	
Acetone	**DOWNGRADIENT SAND & GRAVEL**
Trichloroethene	
Toluene	3001/4001
Total Uranium	2084/3084
Uranium-234	2021
Uranium-235	2019/3019
Uranium-238	2027
Thorium-228	2010/3010/4010
Thorium-230	2013/3013/4013
Technetium-99	2051/3051
	2055/3055
	3008/4008
	3024
	2084/3084
	2037/3037



RI/FS 1000 Series Wells - FMPC Site

Figure 8

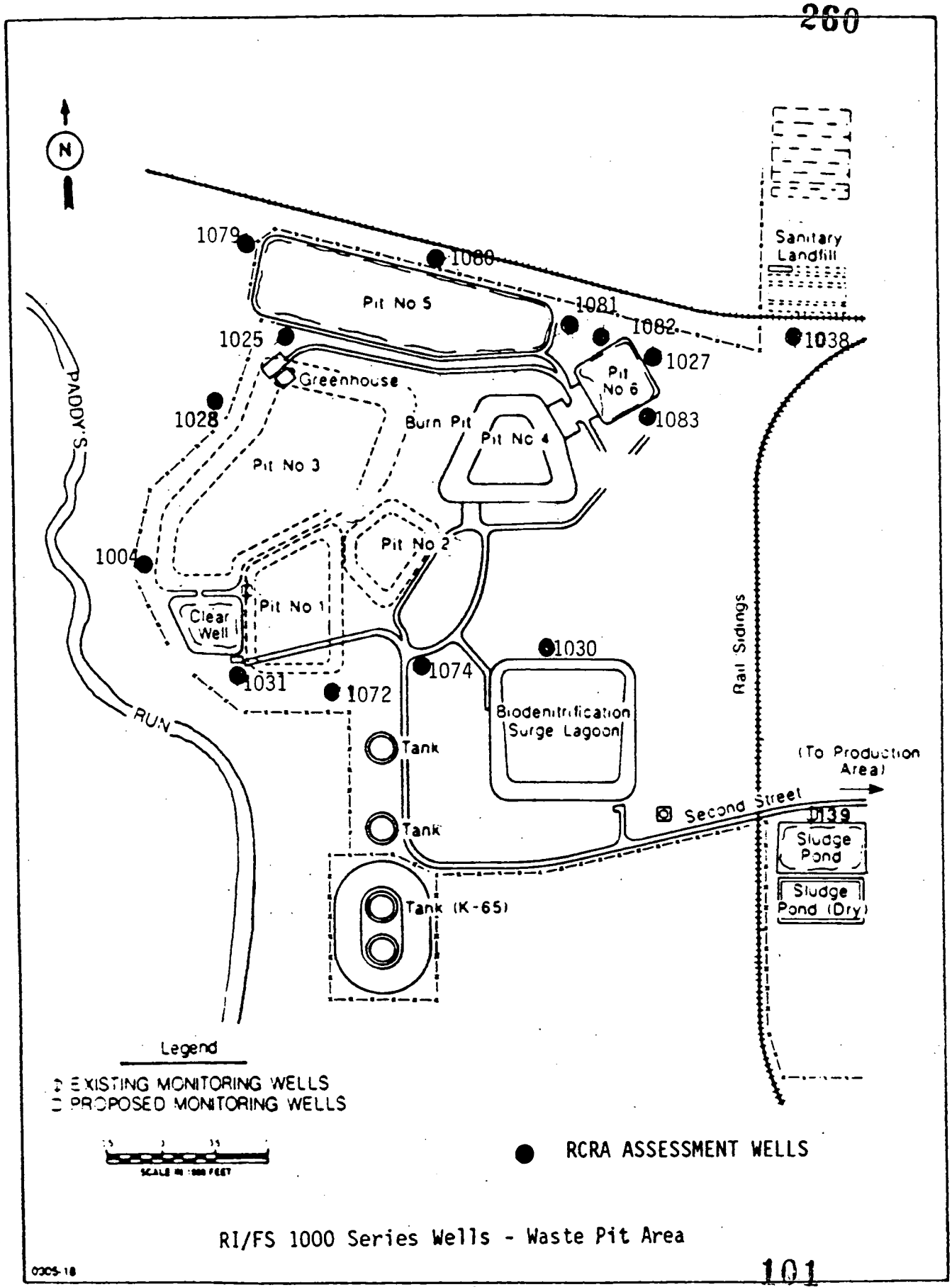

N
1079
1080
Pit No 5
1081
1082
1025
1027
1038
Sanitary Landfill
Greenhouse
Pit No 6
1028
Burn Pit
Pit No 4
1083
Pit No 3
PADDY'S
Pit No 2
1004
Pit No 1
Clear Well
1030
1074
1031
1072
Rail Sidings
Biodenitrification Surge Lagoon
RUN
Tank
(To Production Area)
Second Street
1039
Tank
Sludge Pond
Sludge Pond (Dry)
Tank (K-65)
Legend
EXISTING MONITORING WELLS
PROPOSED MONITORING WELLS
RCRA ASSESSMENT WELLS
RI/FS 1000 Series Wells - Waste Pit Area

Figure 9

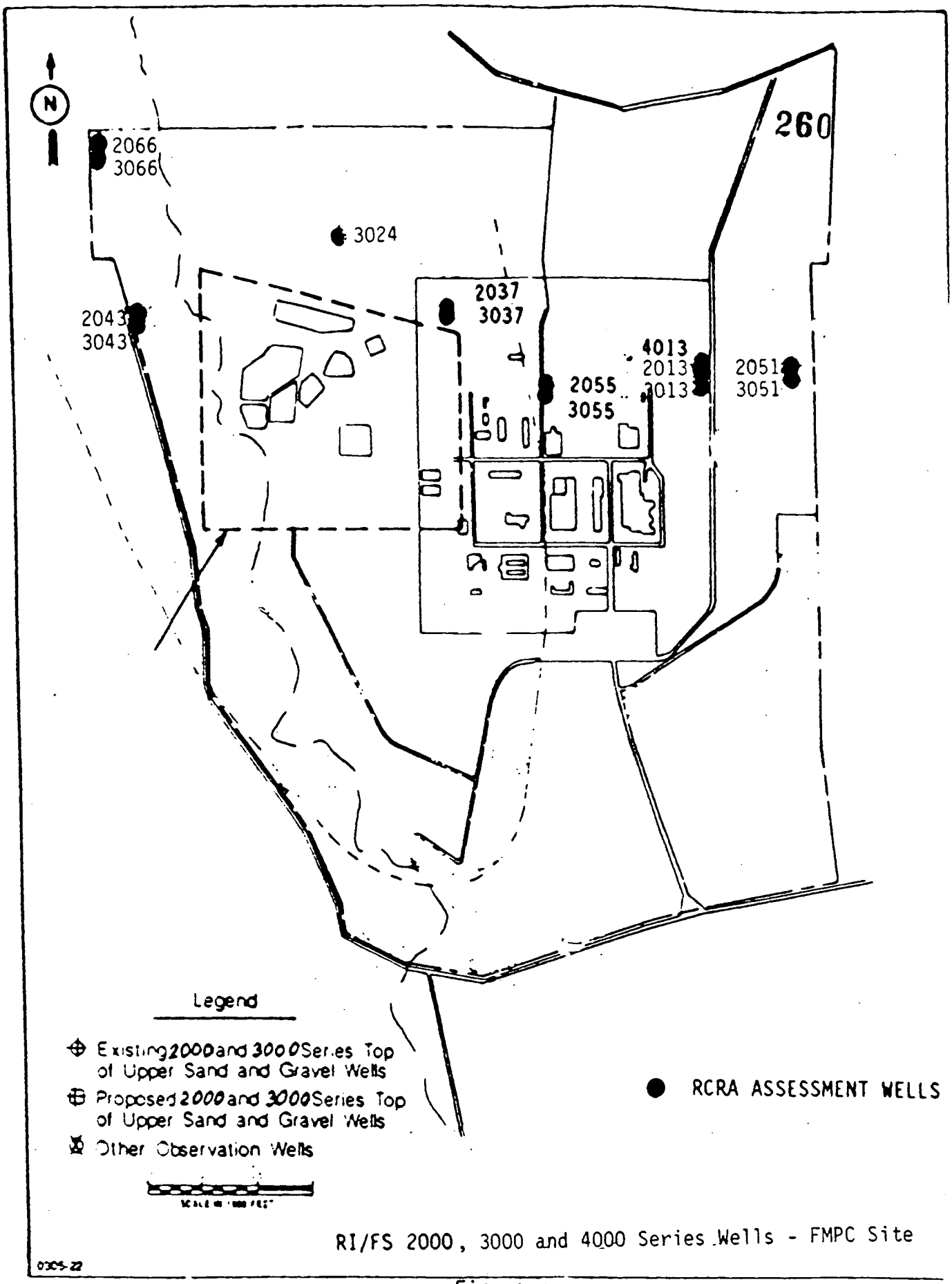
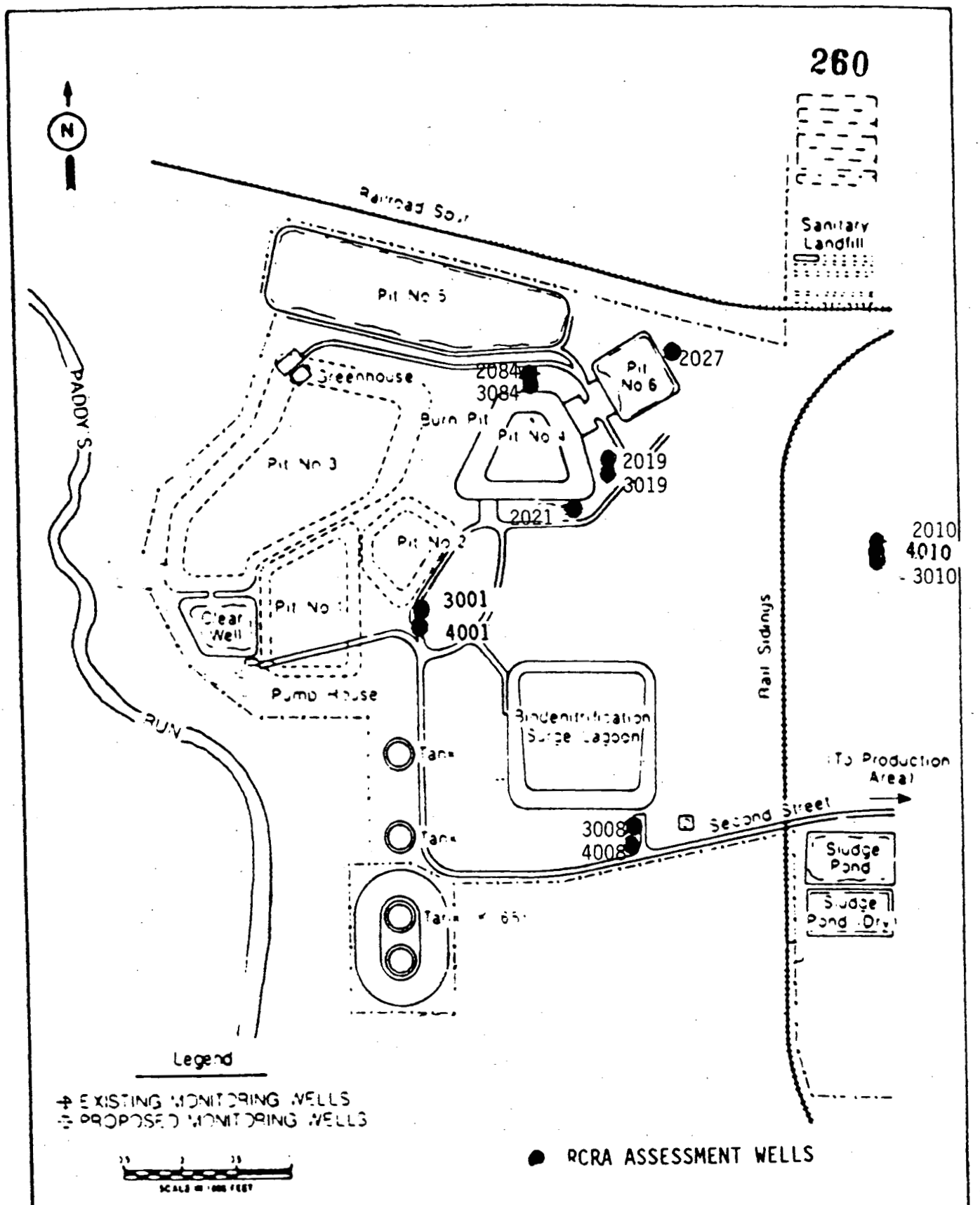

N
260
2066
3066
3024
2037
3037
2043
3043
4013
2013
3013
2051
3051
2055
3055
Legend
Existing 2000 and 3000 Series Top of Upper Sand and Gravel Wells
Proposed 2000 and 3000 Series Top of Upper Sand and Gravel Wells
Other Observation Wells
RCRA ASSESSMENT WELLS
RI/FS 2000, 3000 and 4000 Series Wells - FMPC Site

Figure 10



RI/FS 2000/3000/4000 Series Wells - Waste Pit Area

Figure 11

SUMMARY OF CONTENTS OF WASTE PITS

	METALS											ORGANICS				RADIONUCLIDES					
	Al	Ca	Fe	Mg	F	Ba	As	Hg	Pb	V	Ag	PCBs	VOCs	S-Vs	Pest.	U-234	U-235	U-238	Th-230	Tc-99	Ra-226
Pit 1	x	x	x	x								x	x	x		x	x	x	x	x	x
Pit 2	x	x	x	x								x	x	x	x	x	x	x	x	x	x
Pit 3	x	x	x	x	x	x	x		x	x		x				x	x	x	x	x	x
Pit 4	x	x	x	x	x	x						x	x	x	x	x	x	x	x	x	x
Pit 5	x	x	x	x			x	x		x		x				x	x	x	x	x	x
Pit 6	x	x		x				x	x		x	x	x			x	x	x		x	
Burn Pit	x	x	x	x					x		x	x	x	x		x	x	x	x	x	
Clearwell	x	x	x	x			x	x				x				x	x	x	x	x	x

PCBs are Arochlors
VOCs are chloroform, vinyl chloride, tetrachloroethylene, tetrachloroethane
S-Vs are chrysene, phenanthrene, fluoranthene, pyrenes
Pest. are DDT, malathion, ethyl parathion and methyl parathion

Data source is: Weston CIS Study, v. 2, 1987

TABLE 3

The upgradient sand and gravel wells are wells 2066/3066 and 2043/3043, located respectively 2300 feet northwest and 1500 feet west of the waste storage area. These wells are all hydraulically upgradient from the waste storage area.

The 23 downgradient sand and gravel wells are all located under the east edge or east or northeast of the waste storage area. Well 2084/3084 is in the east portion of the waste storage area. Wells 3001/4001, 2021, 2019/3019, and 2027 are located immediately adjacent to the waste storage area, usually within 20 feet of the pits. Wells 2037/3037 are located approximately 500 and 700 feet east and slightly north of the pit area respectively. Well 3024 is located approximately 600 feet north of the waste storage area. Well 3008/4008 is located approximately 800 feet southeast of the waste storage area, and well 2010/3010/4010 is located about 800 feet east (downgradient) of the waste storage area. Well 2055/3055 is located approximately 1600 feet east of the waste storage area. Wells 2013/3013/4013 and 2064/3064 are located approximately 3000 feet east of the waste storage area.

Figure 12 shows a cross section of the generalized monitoring well depths and screen locations. The 1000 series wells (till) monitor the till aquifer, which is just below the surface ranging from 30 to 40 feet in depth. These wells are screened at the interval where perched water is encountered in the till, which can be quite variable, generally anywhere from 17 to 35 feet below the surface. The screened interval of these wells is 2 feet. The till wells are appropriate to study migration of constituents from the waste pits into the till horizon, and study any vertical migration through the till down into the sand and gravel aquifer. Table 4 lists monitoring well depths, casing materials and screened elevations of FMPC wells selected for the RCRA Assessment program.

The 2000 series wells (upper sand and gravel) are screened at the top the water table in the sand and gravel aquifer, using 15 feet of screen installed so that five feet of the screen is above the water table and ten feet below. This will allow for a seasonal variation in the elevation of the top of the water table, allowing a minimum of 10 feet of water contacting the well screen. These wells are screened at depths below the surface generally ranging from 62 to 103 feet, depending on ground surface elevations. The 2000 series wells are appropriate for monitoring light organics or other pollutants as they first reach the water table.

The 3000 series wells (lower part of the upper sand and gravel) are screened just above the clay layer referred to as the blue clay. In the event that the blue clay was not encountered, the well was screened just above the depth at which the blue clay is generally encountered under the production area. The screened interval of the 3000 series wells is 10 feet. The depth of the screened interval generally varies between 117 and 146 feet below the surface, depending on the surface elevation. The 3000 series wells are appropriate for monitoring for heavy metals such as uranium. Rounds 1 and 2 RI/FS monitoring data confirm that uranium concentrations are higher in the 3000 series sand and gravel wells than in the 2000 series wells near the pit area.

The 4000 series wells (lower sand and gravel) are generally screened so that the bottom of the screen is 10 feet from the bedrock floor of the buried

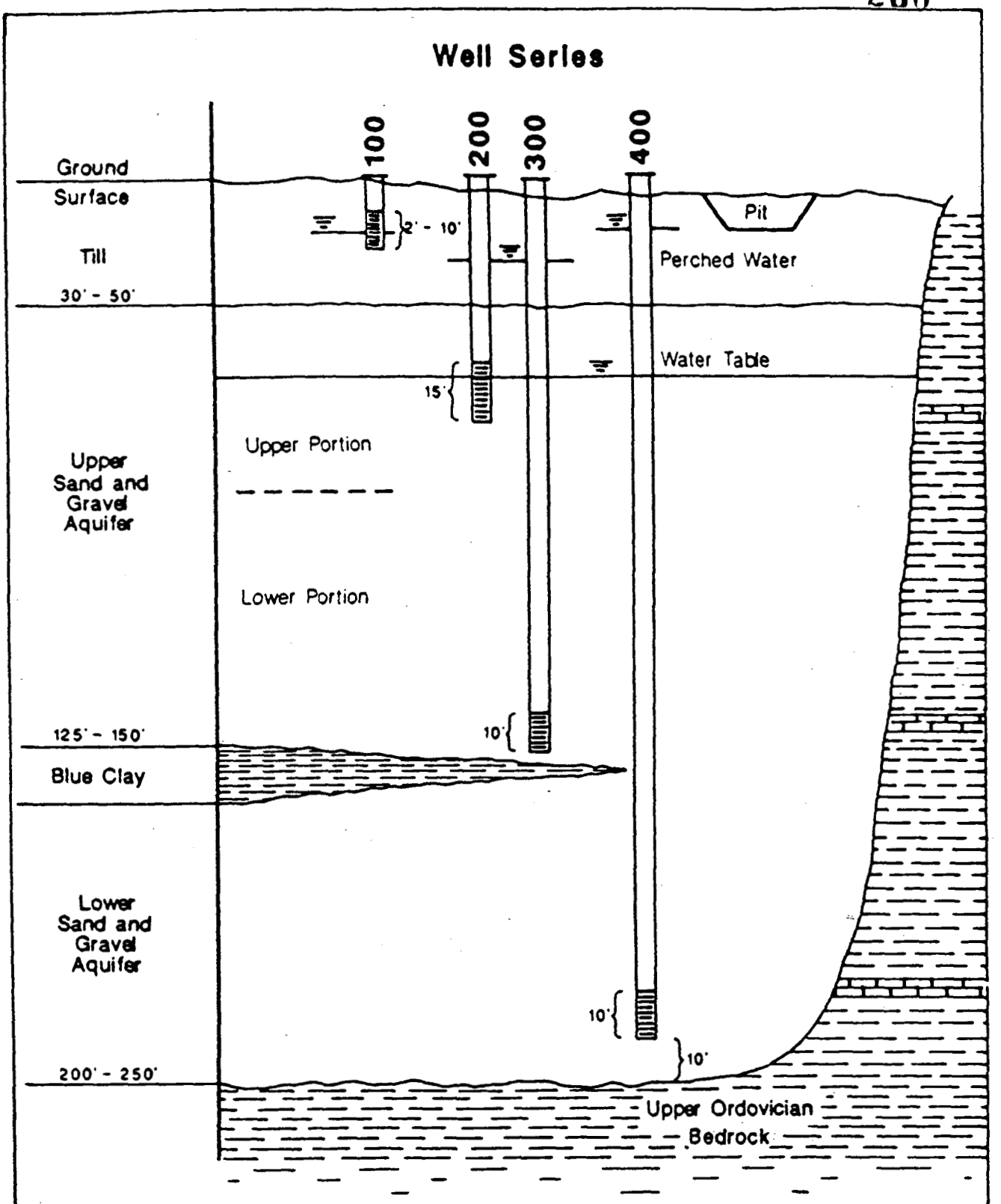


Figure 12 RI/FS General Monitoring Well Depths and Screen Locations

TABLE 4

RCRA PROGRAM ASSESSMENT WELLS
DEPTHS, CASING AND SCREENS

Well Number	Depth (ft)	Casing	Dia. (in)	Screen Elev.(MSL)	Length (ft.)
1052	28.9	STS	4	554-556	2
1024	27	STS	4	553-551	2
1027	31	STS	4	554-552	2
1080	30.9	STS	4	553-551	2
1079	31	STS	4	554-552	2
1028	29	STS	4	560-558	2
1004	31	STS	4	550-548	2
1031	26	STS	4	552-550	2
1072	31	STS	4	547-545	2
1074	23.5	STS	4	557-555	2
1030	30	STS	4	548-546	2
1038	28.5	STS	4	556-554	2
1081	33	STS	4	559-557	2
1083	21.5	STS	4	563-561	2
1082	23	STS	4	562-560	2
1025	21	STS	4	562-560	2
				Bottom Elevation	
Pit 1				560	
Pit 2				570	
Pit 3				548	
Pit 4				560	
Pit 5				558	
Pit 6				560	
2066	62.4	STS	4	531-516	15
2043	66.8	STS	4	527-512	15
2084	76	STS	4	522-507	15
2019	74	PVC	4	514-509	5
2027	76	STS	4	522-507	15
2021	74	PVC	4	515-510	5
2037	82.5	STS	4	521-506	15
2010	75.5	STS	4	522-507	15
2055	Not Comp.	STS	4		15
2013	78	PVC	4	516-511	5
2051	102.4	STS	4	520-505	15

Table 4 (cont.)

RCRA PROGRAM ASSESSMENT WELLS
DEPTHS, CASING AND SCREENS

Well Number	Depth (ft)	Casing	Dia. (in)	Screen Elev.(MSL)	Length (ft.)
3066	137.4	STS	4	451-441	10
3043	120	STS	4	470-460	10
3084	102.4	STS	4	491-481	10
3019	124	PVC	4	465-460	5
3024	110	STS	4	480-470	10
3037	135.5	STS	4	463-453	10
3001	130	ST	8	510-490	20
3008	116	ST	4	464-459	5
3010	130	GVST	6	480-460	20
3055	120.8	STS	4	476-466	10
3013	117	PVC	4	482-472	10
3051	145.9	STS	4	471-461	10
4001	180	ST	4	410-405	5
4008	180	ST	4	400-395	5
4010	Not Comp.	STS	4		10
4013	Not Comp.	STS	4		10

STS Stainless Steel
PVC Polyvinyl Chloride
ST Steel
GVST Galvanized Steel

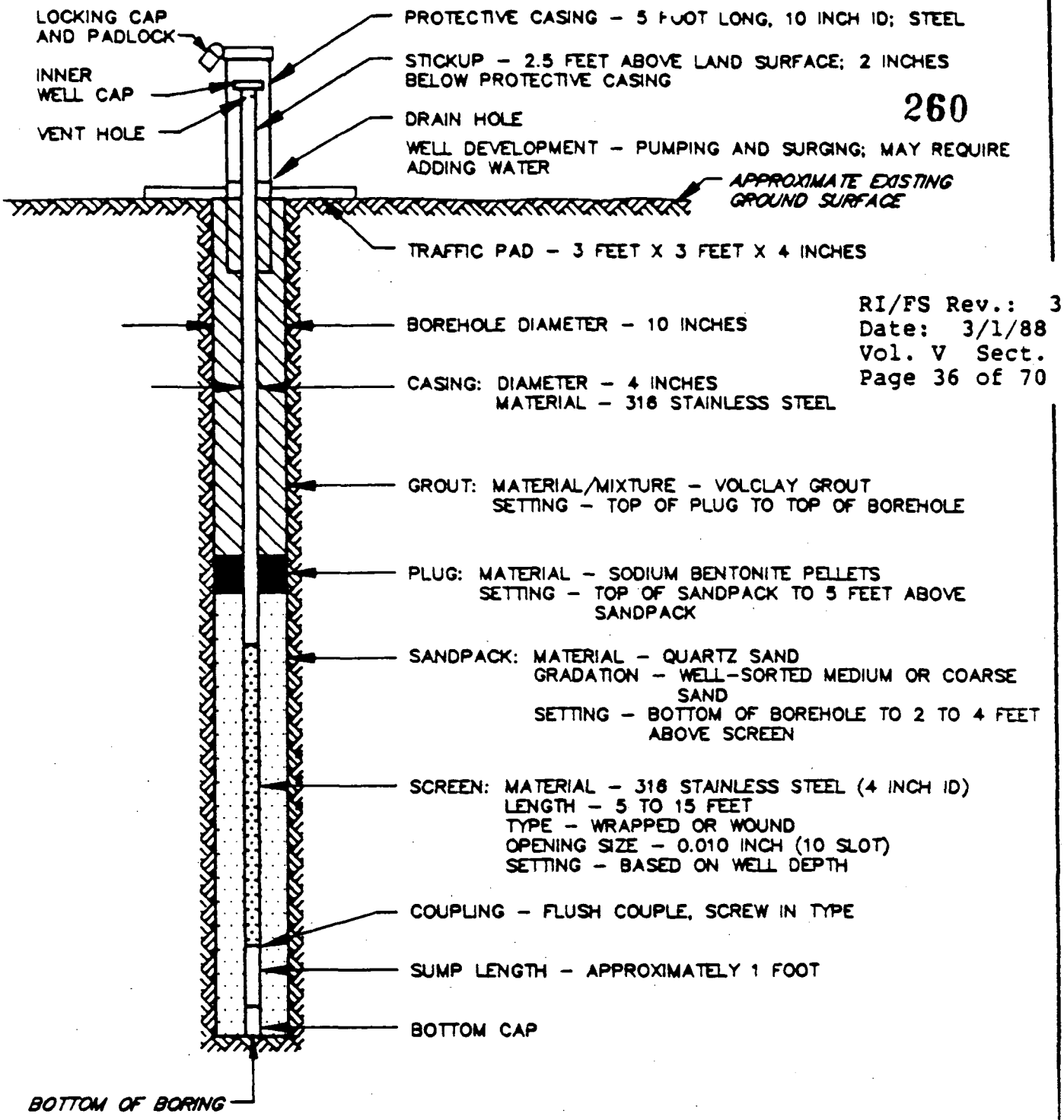
valley aquifer. The screened interval of the 4000 series wells is also generally 10 feet. The depth of the screened interval generally ranges from 160 to 200 feet depending on surface elevation and depth of the bedrock surface. The 4000 series wells will confirm if the blue clay layer is acting as an aquitard. Results to date show no contaminants in these wells. The purpose of these 4000 series wells is to confirm the absence of contaminants below the blue clay. Therefore, there are currently no 4000 series wells upgradient of the pit area. An extensive study of the aquifer will not be made at the 4000 level unless analytical results in these wells or groundwater modelling results suggest that contamination has reached the 4000 series wells.

4.3 Rationale for Selection of Site Specific Parameters

Assessment Program wells will be sampled quarterly beginning in May 1989 for selected site specific parameters. The wells will not be monitored for all Appendix IX constituents. Full Appendix IX monitoring is not technically justified, since the waste pits have previously been characterized in the CIS study and the groundwater in the waste storage area by the RI/FS. The pits were analyzed for Appendix IX constituents in the CIS study, and groundwater in the waste storage area has been analyzed in the RI/FS program for the extended HSL list parameters, as described in section 3.4. Site specific parameters were selected after reviewing the results of the CIS study, and previous RCRA and RI/FS groundwater monitoring data (see Appendices B and C). These parameters are: uranium (total and isotopic), thorium-230, technetium-99, aluminum, calcium, iron, magnesium, fluoride, barium, chromium, copper, lead, nickel, vanadium, zinc, beryllium, cobalt, silver, tetrachloroethene, methylene chloride, dichloroethane, acetone, trichloroethene and toluene. These parameters are also listed in Table 2. These parameters were either found in significant amounts in Waste Pit 4, or above detection limits in groundwater in the waste storage area, or both. HSL semi-volatile compounds, PCBs, pesticides and dioxins are not included in the list of site specific parameters, since they were not detected in waste storage area groundwater in the RI/FS monitoring program.

4.3 RI/FS Well Installation Methods and Materials

At this time, no additional well installation is planned for the Assessment Program; existing monitoring wells will be used. All monitoring wells previously installed as part of the RI/FS program were drilled using cable tool equipment using a casing-advance drilling methods. The casing advance method maintained an open borehole without the use of drilling muds and provided a barrier against the downward migration of contaminants from shallower aquifers. The backs of the drill rigs, tools, casing and well screens for each well were cleaned and decontaminated before moving to a new drilling location or well completion. Once the borehole reached the desired depth, the well was constructed according to the schematic drawings shown in Figures 13 and 14. The well casing and screens are 4 inch diameter 316 stainless steel. The screened area was backfilled with a sand pack, the casing above the screen was grouted. The monitoring wells were developed by pumping and flushing. A protective steel cover with a locked, hinged cover embedded in a cement grout cap was provided for each well riser. See Appendix D for details of RI/FS well installation and materials.



260

RI/FS Rev.: 3
Date: 3/1/88
Vol. V Sect.
Page 36 of 70

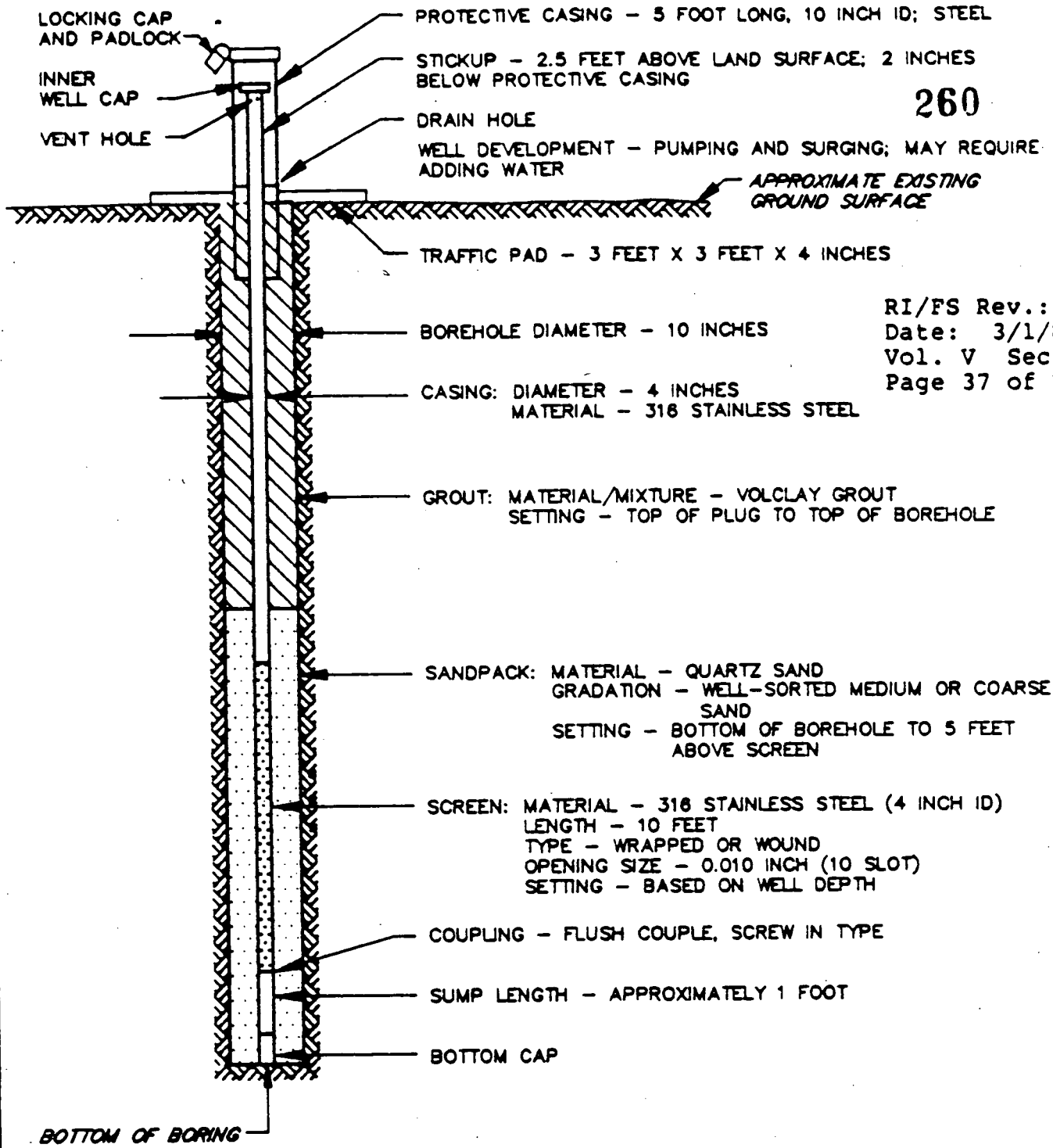
DRAWN BY: R. Wadle 1-18-88
CHECKED BY: TCE 3/28/88
APPROVED BY: TCE 3/28/88
DRAWING NUMBER: 303317-A16

FIGURE 13

SUMMARY OF SPECIFICATIONS FOR WELL COMPLETION
100- AND 200- SERIES WELLS

110

"Do Not Scale This Drawing"



"NOT TO SCALE"

FIGURE 14

SUMMARY OF SPECIFICATIONS FOR WELL COMPLETION
300– AND 400– SERIES WELLS

DRAWN BY R. Webb 1-18-88
CHECKED BY TCC 3/25/88
APPROVED BY TCC 3/29/88
DRAWING NUMBER 303317-A17

"Do Not Scale This Drawing"

4.4 Sample Collection Methods

These sampling methods were used in collection of groundwater samples for the RI/FS program, and will continue to be used in the Assessment Program. Three well volumes are evacuated from each well before sampling. Only stainless steel or teflon pumps and bailers are used to evacuate the wells and collect water samples. After the well is evacuated, the water samples are collected in order of stability and volatility. Samples for VOCs, pH, specific conductivity, temperature and dissolved oxygen are collected first. All samples are analyzed in the field for pH, temperature, conductivity and dissolved oxygen. Samples are collected using positive displacement gas displacement pumps or bailers. Plastic sheeting is spread to cover the ground near the well head as samples are taken. All pumps and sampling equipment is cleaned between sampling different wells using non-phosphate detergents, tap water rinses, dilute acid, alcohol and distilled water rinses as appropriate for various analytical parameters. After samples are collected, they are sealed, chain-of-custody papers, field collection reports, sample collection logs and lab analyses request forms are filled out, and samples are placed in a cooler at 4 °C. Sample collection methods are detailed in Appendix E.

4.5 Analytical Methods

These analytical methods were used in analysis of groundwater samples for the RI/FS program, and will continue to be used in the Assessment Program. When samples are received in the analytical laboratory, the bottles received are checked against chain of custody papers and sample holding times. The laboratory provides each sample with a unique sample number and logs the sample into the laboratory. Samples are placed in appropriate storage conditions after a radiological screening to evaluate radiological hazard associated with the sample. Samples are then analyzed by the laboratory following the procedures and QA/QC objectives listed in Appendix B. The chemical and radiological parameters analyzed in the assessment program are listed in Table 2.

4.6 Modeling and Additional Hydrologic Studies

A three dimensional flow and solute transport model, Swift III is being developed as part of the RI/FS program. The flow model has been verified against known analytical and numerical models, and has also been calibrated using field water level data. Sensitivity analyses of the flow model have also been conducted. The solute transport portion of the model is still undergoing development. Geochemical modeling will also be performed to aid in understanding of any potential chemical reactions in groundwater. As part of the geochemical modeling program, sorption determinations will be made experimentally, leaching tests performed and soil mineralogy studied. This groundwater model will be used primarily in the Risk Assessment for the Remedial Investigation and evaluation of remedial alternatives in the Feasibility Study. If need arises, however, this model can be used in evaluating groundwater and constituent flow for the RCRA monitoring program.

As part of the RI/FS, slug testing has been performed on till wells 1008, 1012, 1016, 1018, 1025, 1031, 1034, 1035, 1041, 1046, 1048, 1065 and 1079 to

aid in estimating hydrologic properties of the till unit (1000 series). Wells 1079 and 1031 are included in the RCRA assessment monitoring program. Falling head field permeability tests were used for slug testing. In this procedure, a known volume of water is added to the well and a number of depth-time measurements are taken, until the water level returns to equilibrium conditions (or enough measurements to define a straight line on semi-log plot of head vs. time). FMPC fire hydrant water was used for this purpose. The only solid materials allowed to contact the well water were stainless steel and teflon. The first water level measurement was made 10 to 15 seconds after the slug was added. Slug tests are generally a reliable field method of determining permeability or transmissivity near the screened zone of the well in units of low hydraulic conductivity (10-4 to 10-7 cm/sec), such as the 1000 series wells. The hydraulic conductivity of well 1079 was 1.8x10-5 cm/sec (19 ft/yr). The hydraulic conductivity of well 1031 is not included, since the screened interval of this well was only partially saturated, and would not represent the saturated hydraulic conductivity of the till in the vicinity of this well.

4.7 Procedures for Data Interpretation

Existing RI/FS data for Assessment Program wells and site specific parameters will be analyzed, as well future data collected in the continuing Assessment Program. Background (upgradient) levels (means) will be established for all site specific parameters, and data from downgradient data will be compared to these upgradient levels. Data will be compiled in tabular format, and mapped and plotted as appropriate. If this approach provides no clear determination of the rate of migration or extent of release, statistical comparisons of upgradient concentrations and downgradient concentrations will be made using appropriate statistical techniques.

5.0 Schedule

Beginning in May 1989 these wells will be sampled quarterly for the site specific parameters listed in Table 2. This sampling will be conducted in May, August, November, and February of each year. This schedule of sampling will continue until Final Remediation of the pits, anticipated to begin in 1992 or early 1993. After the ROD for remediation of the pits is issued by EPA (tentatively scheduled in the second quarter of 1991), a post-closure groundwater monitoring plan will be developed within 90 days.

APPENDIX A

Round 1

WELLS UPGRADIENT TO PIT 4
SHALLOW (TILL) GROUNDWATER
(All results in ppm except as noted)

Name	WELL 1024	WELL 1012	WELL 1011
Arsenic	< 0.2	< 0.03	< 0.03
Barium	0.091	0.11	0.15
Cadmium	< 0.005	< 0.005	< 0.005
Chloride	1.4	100	14
Chromium	< 0.02	< 0.01	< 0.01
Fluoride	0.83	2.1	1.9
Iron	0.667	0.12	16.4
Lead	< 0.05	< 0.03	< 0.03
Manganese	0.08	0.005	1.7
Mercury	< 0.0002	< 0.001	< 0.001
Nitrates	< 0.1	< 5	< 5
Phenol	< 0.01	< 0.01	0.01
Selenium	< 0.2	< 0.001	< 0.06
Silver	< 0.01	< 0.005	< 0.005
Sodium	19.73	212	5.3
Specific conductivity (mmhos/cm)	480	1400	980
pH	7.1	7.83	6.84
VOCs (ppb)	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA
Dioxin (ppt)	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3
Total Uranium (ppb)	< 1	< 1	< 1
Sulfate	50	< 2	80

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 2

WELLS UPGRADIENT TO PIT 4
SHALLOW (TILL) GROUNDWATER
(All results in ppm except as noted)

Name	WELL 1024	WELL 1012	WELL 1011
Arsenic	< 0.01	< 0.01	< 0.2
Barium	< 0.2	< 0.5	0.135
Cadmium	< 0.005	< 0.005	< 0.002
Chloride	18	135	4
Chromium	0.12	< 0.01	< 0.02
Fluoride	1.3	1.3	0.4
Iron	4.9	< 0.1	1.299
Lead	< 0.2	< 0.005	< 0.05
Manganese	0.22	< 0.01	1.225
Mercury	0.0004	< 0.0002	< 0.0002
Nitrates	< 0.1	0.06	< 0.1
Phenol	< 0.05	< 0.002	< 0.01
Selenium	< 0.005	< 0.005	< 0.2
Silver	< 0.01	< 0.01	< 0.01
Sodium	12	340	5.16
Specific conductivity (mmhos/cm)	700	1300	1000
pH	7.21	7.5	6.81
VOCs (ppb)	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA
Dioxin (ppt)	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1
Radium 228 (pCi/l)	< 3	< 3	3.1
Total Uranium (ppb)	2	< 1	< 1
Sulfate	130	< 1	41
TOX	NA	NA	NA

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 1

WELLS DOWNGRADIENT OF PIT 4
SHALLOW (TILL) GROUNDWATER
(All results in ppm except as noted)

Name	WELL 1078	WELL 1076	WELL 1077	WELL 1084	WELL 1022	WELL 1021	WELL 1019	WELL 1027	WELL 1083
Arsenic	0.0073	0.0021	< 0.2		< 0.2	< 0.002	< 0.002	< 0.2	< 0.0019
Barium	0.14	0.0594	0.092		0.025	0.127	0.1	0.051	0.0738
Cadmium	< 0.0007	< 0.0007	0.0059		< 0.005	< 0.002	< 0.002	< 0.005	< 0.0007
Chloride	237	9.1	10.7		12.2	136	305	8.8	31.4
Chromium	< 0.0017	< 0.0017	< 0.02		< 0.02	< 0.02	< 0.02	< 0.02	< 0.0017
Fluoride	1.95	0.22	1.1		0.9	1.6	0.6	1.2	0.41
Iron	0.0854	0.0297	0.25		< 0.005	< 0.005	0.746	0.3	0.0773
Lead	< 0.0105	< 0.0021	< 0.05		< 0.05	< 0.002	< 0.002	< 0.05	< 0.0021
Manganese	0.106	0.147	0.048		0.315	0.791	1.046	0.081	0.0627
Mercury	< 0.00029	< 0.00029	< 0.0002		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nitrates	1.67	< 0.08	0.1		0.1	0.1	< 0.1	0.3	0.3
Phenol	< 0.06	< 0.05	0.02		0.01	< 0.01	< 0.01	0.02	< 0.01
Selenium	< 0.0018	< 0.0018	< 0.2		< 0.2	0.0021	< 0.002	< 0.2	< 0.0018
Silver	< 0.0043	< 0.0043	0.2		0.174	< 0.0005	< 0.0005	< 0.02	0.0043
Sodium	27.0	20.8	11.3		8.5	8.88	118.3	9.02	17.1
Specific conductivity (mmhos/cm)	1980	1080	625		1800	590	1990	725	850
pH	6.78	7.28	7		6.9	7.57	6.7	6.3	7
VOCs (ppb)	ND	ND	NA		NA	ND	43 ppb	NA	ND
Semi-Volatiles (ppb)	10 Unk.	1 Unk.	NA		NA	3 Unk.	5 Unk	NA	7 Unk.
Pesticides/PCBs (ppb)	ND	ND	NA		NA	ND	NA	NA	NA
Organo-Phos. Pesticides(ppb)	ND	ND	NA		NA	ND	ND	NA	ND
Dioxin (ppt)	NA	ND	NA		NA	ND	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	0.8		< 1	< 1	NA	< 1	1.5
Radium 228 (pCi/l)	< 3	< 3	< 3		< 3	< 3	NA	< 3	< 3
Total Uranium (ppb)	245	16	30	Dry	3800	15330	600	1	94
Sulfate	157	132	57		1180	305	575	60	185

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 2

WELLS DOWNGRADIENT OF PIT 4
SHALLOW (TILL) GROUNDWATER
(All results in ppm except as noted)

Name	WELL 1078	WELL 1076	WELL 1077	WELL 1084	WELL 1022	WELL 1021	WELL 1019	WELL 1027	WELL 1083
Arsenic	0.34	< 0.002	< 0.002	< 0.002	< 0.2	< 0.2	0.44	< 0.01	< 0.002
Barium	0.143	0.058	0.090	0.113	0.04	0.2	0.17	< 0.2	0.082
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.005	< 0.002
Chloride	270	2.5	3	4	67.5	15.5	1750	9.6	32.5
Chromium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.01	< 0.02
Fluoride	0.78	1.1	0.86	1.6	0.98	1.75	0.25	1.7	0.55
Iron	0.017	< 0.005	0.018	< 0.005	0.027	0.651	0.924	2.1	< 0.005
Lead	< 0.05	< 0.002	< 0.002	< 0.002	< 0.05	< 0.05	< 0.05	< 0.005	< 0.002
Manganese	0.284	0.354	0.265	0.023	2.1	2.1	1.6	0.07	0.079
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0003	< 0.0002
Nitrates	13	0.22	0.27	0.17	0.19	0.17	0.13	0.13	1.6
Phenol	0.02	0.02	0.02	0.01	< 0.01	< 0.01	0.02	< 0.05	0.02
Selenium	< 0.2	< 0.002	< 0.002	< 0.002	< 0.2	< 0.2	< 0.2	< 0.005	< 0.002
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	24.43	25.5	13.1	42	22.7	10.3	360	12	22
Specific conductivity (mmhos/cm)	1800	1100	820	1130	2650	720	4680	750	970
pH	7.3	7.3	7.3	7.4	6.9	7.3	6.6	7.3	7.2
VOCs (ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dioxin (ppt)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3	< 3	< 3	< 5	< 3	< 3	< 3
Total Uranium (ppb)	53	33	86	590	3500	10000	207	< 1	71
Sulfate	140	< 2	130	498	1120	184	266	140	139
TOX	NA	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.24	NA	< 0.05

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 1

WELLS UPGRADIENT TO PIT 4
SAND AND GRAVEL AQUIFER
(All results in ppm except as noted)

Name	WELL 2066	WELL 2043	WELL 2011	WELL 3066	WELL 3043	WELL 3011
Arsenic	< 0.2	< 0.2	< 0.002	< 0.2	< 0.2	< 0.2
Barium	0.758	0.195	0.014	0.509	0.214	0.097
Cadmium	< 0.005	< 0.002	< 0.002	< 0.005	< 0.002	< 0.005
Chloride	96	51.1	18.4	826	2.75	20.2
Chromium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Fluoride	0.94	0.58	< 0.17	0.23	0.46	0.38
Iron	1.6	NA	< 0.005	19.3	NA	0.6
Lead	< 0.05	< 0.05	< 0.002	< 0.05	< 0.05	< 0.05
Manganese	0.068	0.168	0.04	0.11	0.06	0.148
Mercury	0.001	< 0.0002	0.0003	0.0008	< 0.0002	0.0011
Nitrates	< 0.1	< 0.1	0.1	< 0.1	0.12	< 0.1
Phenol	0.01	0.02	0.03	< 0.01	0.05	0.01
Selenium	< 0.2	< 0.2	< 0.002	< 0.2	< 0.2	< 0.2
Silver	< 0.01	< 0.01	< 0.005	< 0.01	< 0.01	< 0.01
Sodium	46.6	35.3	9.76	276	13.8	13.9
Specific conductivity (mmhos/cm)	600	910	600	2050	500	NA
pH	7.6	7.25	7.3	7.12	7.4	7.4
VOCs (ppb)	NA	NA	50 ppb	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	6 Unk	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	ND	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	ND	NA	NA	NA
Dioxin (ppt)	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	< 1	1.4	< 1	< 1	1.7	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3	< 3	< 3	< 3
Total Uranium (ppb)	< 1	1	1	< 1	< 1	2
Sulfate	< 2	40	< 2	29	8	109

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 2

WELLS UPGRADIENT TO PIT 4
SAND AND GRAVEL AQUIFER
(All Results in ppm except as noted)

	WELL 2066	WELL 2043	WELL 2011	WELL 3066	WELL 3043	WELL 3011
None						
Arsenic	0.03	< 0.01	< 0.2	0.1	0.01	< 0.2
Barium	0.8	0.02	0.132	0.5	0.3	0.157
Cadmium	< 0.005	< 0.005	< 0.002	< 0.005	< 0.005	< 0.002
Chloride	68	66	9.6	680	11.5	14.5
Chromium	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.02
Fluoride	0.9	0.58	0.25	< 0.1	0.34	0.25
Iron	1.7	1.1	2.16	18	4	1.44
Lead	< 0.005	< 0.005	< 0.05	< 0.005	< 0.005	< 0.05
Manganese	0.06	0.15	0.17	0.12	0.05	0.134
Mercury	< 0.0002	< 0.0003	< 0.0002	< 0.0002	< 0.0003	< 0.0002
Nitrates	< 2.5	< 0.1	< 0.1	< 2.5	< 0.1	< 0.1
Phenol	< 0.01	0.03	< 0.01	< 0.01	0.02	< 0.01
Selenium	< 0.005	< 0.005	< 0.2	< 0.005	< 0.005	< 0.2
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	48	40	9.53	320	16	9.94
Specific conductivity (mmhos/cm)	680	830	500	2320	500	520
pH	6.5	7.12	7.17	7	7.62	7.35
VOCs (ppb)	NA	NA	NA	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA	NA	NA	NA
Dioxin (ppt)	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1	1.9	8.5	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3	< 3	< 3	< 3
Total Uranium (ppb)	< 1	1	< 1	< 1	< 1	< 1
Sulfate	< 1.5	13	80	< 7.5	12	73
TOX	NA	NA	NA	NA	NA	NA

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 1

WELLS DOWNGRADIENT OF PIT 4
SAND AND GRAVEL AQUIFER
(all results in ppm except as noted)

Name	WELL 2084	WELL 2022	WELL 2021	WELL 2019	WELL 2027	WELL 2010	WELL 2013	WELL 2051	WELL 2064
Arsenic	< 0.2	0.0042	0.0047	< 0.002	< 0.0019	< 0.005	< 0.2	< 0.2	< 0.002
Barium	0.08	0.0521	0.067	0.056	0.105	0.0873	0.06	0.073	0.092
Cadmium	< 0.005	< 0.0007	< 0.0007	< 0.002	< 0.0007	< 0.005	< 0.005	< 0.005	< 0.002
Chloride	200	57.9	42.4	38.4	79.9	< 27	62.6	5.8	26.2
Chromium	< 0.02	< 0.0017	< 0.0017	< 0.02	< 0.0017	< 0.01	< 0.02	< 0.02	< 0.02
Fluoride	0.21	0.66	0.35	0.41	0.3	0.2	0.31	0.27	0.3
Iron	2.3	0.0255	0.0254	0.1	8.06	0.265	2.58	1.721	2.372
Lead	< 0.05	0.0034	< 0.0021	0.0024	< 0.0021	< 0.005	< 0.05	< 0.05	0.0138
Manganese	0.53	0.0063	0.0114	0.005	0.461	0.329	0.2	0.278	0.492
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nitrates	0.1	0.1	9.2	17	< 0.1	< 0.02	< 0.1	< 0.1	< 0.1
Phenol	0.01	0.01	0.01	< 0.01	< 0.01	< 0.011	0.02	< 0.01	< 0.01
Selenium	< 0.2	< 0.0018	< 0.0018	< 0.002	< 0.0018	< 0.005	< 0.2	< 0.2	< 0.002
Silver	< 0.01	< 0.0043	< 0.0043	< 0.0005	< 0.0043	< 0.01	< 0.01	< 0.01	< 0.005
Sodium	66.5	29.2	46.8	24.64	30.6	14.6	12.2	10.36	17.36
Specific conductivity (mmhos/cm)	1600	810	1100	850	1450	690	780	700	975
pH	6.8	7	7.15	6.8	6.7	7.21	7.3	7.2	7.1
VOCs (ppb)	NA	ND	ND	35 ppb	ND	ND	NA	NA	ND
Semi-Volatiles (ppb)	NA	14 Unk.	6 Unk.	2 TIC	4 Unk.	ND	NA	NA	1 Unk.
Pesticides/PCBs (ppb)	NA	NA	NA	NA	NA	ND	NA	NA	ND
Organo-Phos. Pesticides(ppb)	NA	ND	ND	ND	ND	ND	NA	NA	NA
Dioxin (ppt)	NA	ND	ND	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1	< 1	1.6	< 1	< 1	1.4	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Total Uranium (ppb)	16	10	78	9	6	21	< 1	3	3
Sulfate	428	123	111	14	645	160	85	120	40

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 2

WELLS DOWNGRADIENT OF PIT 4
SAND AND GRAVEL AQUIFER
(All Results in ppm except as noted)

Name	WELL 2084	WELL 2022	WELL 2021	WELL 2019	WELL 2027	WELL 2010	WELL 2013	WELL 2051	WELL 2064
Arsenic	< 0.002	< 0.2	< 0.2	0.4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	0.07	0.06	0.07	0.053	< 0.2	< 0.2	< 0.2	< 0.5	< 0.5
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chloride	185	95	47	48	120	31	25	39	29
Chromium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	0.21	0.69	0.34	0.37	1.8	0.1	0.1	0.26	0.3
Iron	4.2	0.017	0.008	< 0.005	6.1	4.7	2.6	4.5	2.8
Lead	0.02	< 0.05	< 0.05	< 0.05	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Manganese	0.5	0.003	0.003	0.04	0.49	0.35	< 0.19	0.33	0.23
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0003	< 0.0002	< 0.0002	0.0004	< 0.0002
Nitrates	16	< 0.15	0.28	23.4	0.11	< 2.5	< 5	0.12	0.11
Phenol	< 0.01	< 0.1	< 0.1	0.02	< 0.1	< 0.01	< 0.01	< 0.002	< 0.002
Selenium	< 0.002	< 0.2	< 0.2	< 0.2	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	58.7	32.2	47.8	23.3	34	15	12	14	19
Specific conductivity (mmhos/cm)	1950	1100	1180	800	1175	1050	650	950	640
pH	7	7.3	7.3	7.3	7.2	6.93	7.27	7.04	7.2
VOCs (ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dioxin (ppt)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	1.1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	< 1
Radium 228 (pCi/l)	3.7	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Total Uranium (ppb)	19	6	1	< 1	6	2	< 1	1	2
Sulfate	339	80	52	58	300	310	100	311	140
TOX	< 0.05	< 0.05	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	NA

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 1

WELLS DOWNGRADIENT OF PIT 4
SAND AND GRAVEL AQUIFER
(all results in ppm except as noted)

Name	WELL 3084	WELL 3019	WELL 3010	WELL 3055	WELL 3013	WELL 3051	WELL 3064
Arsenic	< 0.2	< 0.2	< 0.2	< 0.002	< 0.2	< 0.2	< 0.2
Barium	< 0.05	< 0.05	< 0.05	< 0.067	0.08	0.158	0.078
Cadmium	< 0.005	< 0.005	< 0.005	< 0.002	< 0.005	< 0.005	< 0.005
Chloride	153	170	74.2	51.5	70.3	53.6	18
Chromium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Fluoride	0.29	0.21	0.24	0.53	0.26	0.35	0.21
Iron	0.6	0.23	0.26	1.87	6.58	0.583	0.977
Lead	< 0.05	< 0.05	< 0.05	0.002	< 0.05	< 0.05	< 0.05
Manganese	2.4	2.54	3.84	0.078	0.37	0.161	0.214
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nitrates	< 0.1	8.4	22.8	0.1	< 0.1	0.17	< 0.1
Phenol	0.02	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01
Selenium	< 0.2	< 0.2	< 0.2	< 0.002	< 0.2	< 0.2	< 0.2
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	68	38.5	96.8	56.8	42.2	26.59	13.9
Specific conductivity (mmhos/cm)	1650	1200	2810	1170	1120	810	590
pH	6.6	6.6	6.74	6.8	7.1	7.2	7.3
VOCs (ppb)	NA	NA	NA	NA	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA	NA	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA	NA	NA	NA	NA
Dioxin (ppt)	NA	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1	1.1	1.5	< 1	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Total Uranium (ppb)	218	40	16	< 1	4	< 1	< 1
Sulfate	530	650	800	159	322	103	70

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

Round 2

WELLS DOWNGRADIENT OF PIT 4
SAND AND GRAVEL AQUIFER
(All Results in ppm Except Where Noted)

Name	WELL 3084	WELL 3019	WELL 3010	WELL 3055	WELL 3013	WELL 3051	WELL 3064
Arsenic	< 0.002	< 0.2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	0.03	0.027	< 0.2	< 0.2	< 0.2	< 0.5	< 0.5
Cadmium	< 0.002	< 0.002	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chloride	207	70	68	58	62	79	35
Chromium	0.04	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	0.16	0.14	< 0.1	< 0.1	< 0.1	0.24	0.19
Iron	0.3	0.037	0.5	5.5	7.1	3.7	2.5
Lead	0.038	< 0.05	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Manganese	2.8	2.9	3.9	< 0.23	0.37	< 0.13	0.02
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nitrates	< 2.5	10.1	< 5	< 2.5	< 2.5	0.1	0.22
Phenol	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.002	< 0.002
Selenium	< 0.002	< 0.2	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	66.1	42.3	110	53	46	33	15
Specific conductivity (mmhos/cm)	1600	1040	1450	1100	1080	800	575
pH	6.9	6.9	6.89	7	7.2	7.25	7.3
VOCs (ppb)	NA	NA	NA	NA	NA	NA	NA
Semi-Volatiles (ppb)	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ppb)	NA	NA	NA	NA	NA	NA	NA
Organo-Phos. Pesticides(ppb)	NA	NA	NA	NA	NA	NA	NA
Dioxin (ppt)	NA	NA	NA	NA	NA	NA	NA
Radium 226 (pCi/l)	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Radium 228 (pCi/l)	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Total Uranium (ppb)	25	23	17	< 1	4	< 1	< 1
Sulfate	335	390	730	340	280	130	107
TOX	0.05	< 0.05	< 0.05	NA	< 0.05	NA	NA

< = AT OR BELOW DETECTION LIMIT
ND = Not Detected
NA = Not Analyzed

PRELIMINARY HSL RESULTS

RI/FS GROUND WATER SAMPLING PROGRAM

1000-Series Wells Waste Pit Area	VOCs	BNA's (Semivolatiles)	Pesticides/PCB's	Organo-Phosphorus Pesticides	Dioxin
1019	18 ppb MC 25 ppb DCA 1 UNK	ND 5 UNK		ND	
1083	ND	ND 7 UNK		ND	
1029	ND	ND	ND		
1010	ND 1 TIC (50 ppb)	ND, 3 UNK (14-64 ppb)		ND	
1075	ND	ND, 4 UNK (10-700 ppb) 2 TIC (30-80 ppb)	ND	ND	
1021	ND	ND, 3 UNK (20-30 ppb)	ND	ND	ND
1076	ND	ND, 1 UNK (10 ppb)	ND	ND	ND
1078	ND	ND, 10 UNK (10-30 ppb)	ND	ND	
1073	76 ppb DCA	ND, 4 UNK (10-100 ppb)	ND	ND	
1074	ND	ND, 1 UNK (50 ppb)	ND	ND	
1025	ND	ND, 5 UNK (5-70 ppb)	ND		
Fly Ash Area					
1016	ND	ND	ND		

LEGEND

ND = NOT DETECTED UNK - UNKNOWN COMPOUND TIC = TENTATIVELY IDENTIFIED COMPOUND

PRELIMINARY HSL RESULTS

RI/FS GROUND WATER SAMPLING PROGRAM

2000-Series Wells Waste Pit Area	VOCs	BNA's (Semivolatiles)	Pesticides/PCB's	Organo-Phosphorus Pesticides	Dioxin
2019	22 ppb MC 13 ppb Acetone	ND, 2 TIC (8-16 ppb)		ND	
2042	9 ppb MC	ND, 1 TIC, 1 UNK (8-37 ppb)		ND	
2008	ND	ND	ND	ND	
2010	ND	ND	ND	ND	
2021	ND	ND, 6 UNK (10-48 ppb)		ND	ND
2027	ND	ND, 4 UNK (8-50 ppb)		ND	
2022	ND	ND, 14 UNK (10-146 ppb)		ND	ND
2001	10 ppb Toluene	ND	ND	ND	
2034	ND	ND, 1 UNK (10 ppb)	ND	ND	
2037	ND	ND	ND	ND	ND
2004	ND	ND	ND	ND	

LEGEND

ND = NOT DETECTED UNK - UNKNOWN COMPOUND TIC = TENTATIVELY IDENTIFIED COMPOUND

PRELIMINARY HSL RESULTS

RI/FS GROUND WATER SAMPLING PROGRAM

2000-Series Wells Outside Production Area and Waste Pits	VOCs	BNA's (Semivolatiles)	Pesticides/PCB's	Organo-Phosphorus Pesticides	Dioxin
2064	ND	ND, 1 UNK (14 ppb)	ND		
2011	37 ppb Acetone 8 ppb Carbon Disulfide 5 ppb Toluene 1 TIC	ND, 6 UNK (6–84 ppb)	ND	ND	
2065	ND	20 ppb Diethylphthalate			
2015	6 ppb TCA	ND			
2020	ND	ND	ND		
2016	ND	ND, 1 UNK (18 ppb)	ND		
2014	ND	ND, 2 UNK (15–32 ppb)	ND		
2052	1 TIC (11 ppm)	ND	ND	ND	ND

LEGEND

ND = NOT DETECTED

UNK – UNKNOWN COMPOUND

TIC = TENTATIVELY IDENTIFIED COMPOUND

APPENDIX B

GENERAL CHEMISTRY AND METALS
METHOD REFERENCES AND QUALITY CONTROL OBJECTIVES
FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS (%)	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Alkalinity	pH meter	Daily(b) (water)	±10	-	90	1000 ug/l(g)(water)	310.1	1
		Daily (solids)	±10	-	90	500 mg/kg(h)(solids)	3.2.3	
Aluminum	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	100 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	20 mg/kg (solids)	200.7	12
Ammonia	Distillation with UV/VIS Spectrophotometer	Daily (water)	±10	±20	90	50 ug/l (water)	350.2	1
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	33-2,350.2	11,1
	Specific Ion Meter/ Microprocessor	Daily (water)	±10	±20	90	50 ug/l (water)	350.2	1
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	33-2,350.2	11,1
Antimony	Atomic Absorption Spectrophotometer	Daily (water)	±10	±20	90	10 ug/l (water)	204.1,204.2	1
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	7040,7041	3
Arsenic	Atomic Absorption Spectrophotometer	Daily (water)	±10	±20	90	10 ug/l (water)	206.2	1
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	7060	3

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Barium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 20 mg/kg (solids)	200.7 200.7	12 12
Beryllium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	5 ug/l (water) 1 mg/kg (solids)	200.7 200.7	12 [illegible]
Boron	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	10 ug/l (water) 2 mg/kg (solids)	200.7 200.7	12 12
Cadmium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	5 ug/l (water) 1 mg/kg (solids)	200.7 200.7	12 12
Calcium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 20 mg/kg (solids)	200.7 200.7	12 12

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS (%)	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Cation Exchange Capacity	Atomic Absorption Spectrophotometer	Daily (solids)	±10	±20	90	1 mg/kg (solids)	3.2.17	
Chloride	Buret/Indicator	Daily (water)	±10	±20	90	500 ug/l (water)	325.3	1
		Daily (solids)	±10	±20	90	5 mg/kg (solids)	10-2,325.3	11,1
Chromium (Total)	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	10 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	200.7	12
Chromium VI	UV/VIS Spectrophotometer	Daily (water)	±10	±20	90	10 ug/l (water)	7196	3
		Daily (solids)	±10	±20	90	1 mg/kg (solids)	7196	3
Cobalt	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	10 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	200.7	12
Copper	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	10 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	200.7	12
Cyanide (Total)	Distillation with UV/VIS Spectrophotometer	Daily (water)	±10	±20	90	20 ug/l (water)	335.2	
		Daily (solids)	±10	±20	90	0.50 mg/kg (solids)	9010	
Dissolved Solids (Total)	Filtration/ Analytical Balance	3 months (water)	±10	-	90	1000 ug/l (water)	160.1	1

See footnotes at end table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Fluoride	pH meter with Specific Ion Electrode	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 1 mg/kg (solids)	340.2 10-2,340.2	1 11,1
Iron	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 20 mg/kg (solids)	200.7 200.7	12 12
Iron (Leachable)	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (solids)	±10	±20	90	1 mg/kg (solids)	200.7(e)	5,12
Lead	Atomic Absorption Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	5 ug/l (water) 1 mg/kg (solids)	239.1,239.2 7420,7421	1 3
Lithium	Atomic Absorption Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 2 mg/kg (solids)	303A 303A	6 6
Magnesium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 20 mg/kg (solids)	200.7 200.7	12 12

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Manganese	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	10 ug/l (water) 2 mg/kg (solids)	200.7 200.7	12 12
Manganese (Leachable)	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (solids)	±10	±20	90	1 mg/kg (solids)	200.7(e)	5,12
Mercury	Atomic Absorption Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	0.2 ug/l (water) 0.10 mg/kg (solids)	245.1 7471	1 3
Molybdenum	Atomic Absorption Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	10 ug/l (water) 2 mg/kg (solids)	246.1,246.2 246.1,246.2	1 1
Nickel	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	30 ug/l (water) 6 mg/kg (solids)	200.7 200.7	12 12
Nitrate	UV/VIS Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 1 mg/kg (solids)	352.1 10-2,352.1	1 11,1

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Organic Carbon (Total) (TOC)	Total Organic Carbon Analyzer	Daily (water) Daily (solids)	±25 ±25	±20 ±20	90 90	1000 ug/l (water) 1 mg/kg (solids)	415.1 (f)	1 8
Organic Halogens (Total) (TOX)	Total Organic Halide Analyzer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	10 ug/l (water) 0.1 mg/kg (solids)	9020 9020	3 3
Organic Nitrogen (Total)	Distillation with UV/VIS Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	1.0 mg/l (water) 2 mg/kg (solids)	351.3 351.3	1 1
	Specific Ion Meter/ Microprocessor	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	1.0 mg/l (water) 2 mg/kg (solids)	351.3 351.3	1 1
pH	pH meter	Daily (water) Daily (solids)	±10 ±10	- -	90 90	0.05 pH unit (water) 0.05 pH unit (solids)	150.1 3.2.2	1 2
Phosphorus	UV/VIS Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	10 ug/l (water) 100 ug/kg (solids)	365.2 (f)	1 9
Potassium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 20 mg/kg (solids)	200.7 200.7	12 12
Selenium	Atomic Absorption Spectrophotometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	5 ug/l (water) 1 mg/kg (solids)	270.2 7740	1 3
Silicon	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water) Daily (solids)	±10 ±10	±20 ±20	90 90	100 ug/l (water) 20 mg/kg (solids)	200.7 200.7	12 12

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS (%)	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Silver	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	10 ug/l (water)	200.7	.
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	200.7	.
Sodium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	100 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	20 mg/kg (solids)	200.7	12
Specific Conductance	Conductivity Meter	Daily (water)	±10	-	90	1 umho/cm (water)	120.1	1
		Daily (solids)	±10	-	90	1 umho/cm (solids)	10-2,120.1	11,1
Strontium	Atomic Absorption Spectrophotometer	Daily (water)	±10	±20	90	10 ug/l (water)	303A	6
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	303A	6
Sulfate	UV/VIS Spectrophotometer	Daily (water)	±10	±20	90	2000 ug/l (water)	375.4	1
		Daily (solids)	±10	±20	90	10 mg/kg (solids)	3.2.6	2
Sulfide	Buret/Indicator	Daily (water)	±10	±20	90	500 ug/l (water)	376.1	1
		Daily (solids)	±10	±20	90	10 mg/kg (solids)	9030	3
Thallium	Atomic Absorption Spectrophotometer	Daily (water)	±10	±20	90	10 ug/l (water)	279.1,279.2	1
		Daily (solids)	±10	±20	90	2.0 mg/kg (solids)	7840,7841	

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION RPD %(a)	TYPICAL ACCURACY % OF RECOVERY	EXPECTED COMPLETENESS	EXPECTED METHOD DETECTION LIMIT(i)	METHOD NO.	REFERENCE
Tin	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	50 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	10 mg/kg (solids)	200.7	12
Vanadium	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	50 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	10 mg/kg (solids)	200.7	[illegible]
Zinc	Inductively Coupled Argon Plasma Emission Spectrometer	Daily (water)	±10	±20	90	10 ug/l (water)	200.7	12
		Daily (solids)	±10	±20	90	2 mg/kg (solids)	200.7	12

(a)RPD = relative percent difference.

(b)Each day samples are analyzed.

(c)The indicated relative percent difference is representative of the corresponding U.S Environmental Protection Agency (U.S. EPA) Contract Laboratory Program (CLP) Hazardous Substance List (HSL) compounds as a group.

(d)The indicated percent recovery range represents the minimum and maximum acceptable value for the indicated U.S. EPA CLP HSL compounds as a group. However, individual percent recovery ranges have been established for each matrix spike compound. Consult "Chemical Analytical Services for Multi-Media Multi-Concentration Organics, GC/MS Techniques," WA-87-K236, U.S. EPA, Washington, D.C., 1987 for more detailed quality assurance/quality control criteria.

(e)A method number is not assigned to the iron and manganese leaching procedures cited from the corresponding reference.
(f)A method number is not assigned to the indicated analytical procedures cited from the corresponding reference.
(g)ug/l equals micrograms per liter or parts per billion (ppb)
(h)mg/kg equals milligrams per kilogram or parts per million (ppm).
(i)Method detection limits may vary with sample matrix.

REFERENCES:

(1) U.S. Environmental Protection Agency (EPA), March 1983, "Methods for Chemical Analysis of Water and Wastes," Publication EPA-600/4-79-020.

(2) U.S. Environmental Protection Agency (EPA), March 1978, "Field and Laboratory Methods Applicable to Overburdens and Mine Soils," EPA-600/2-78-054.

(3) U.S. Environmental Protection Agency (EPA), November 1986, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, revised 3rd edition.

(4) U.S. Environmental Protection Agency (EPA), 1984, "Proposed Sampling and Analytical Methodologies for Addition to Test Methods for Evaluating Solid Waste Physical/Chemical Methods," PB85-103026.

(5) Filipek, L. H., et al., 1981, "Factors Affecting the Partitioning of Cu, Zn, and Pb in Boulder Coatings and Stream Sediments in the Vicinity of a Polymetallic Sulfide Deposit," Chemical Geology, No. 33, pp. 45-64.

(6) APHA-AWWA-WPCF, 1985, Standard Methods for the Examination of Water and Waste Water, 16th Edition.

(7) Federal Register, October 26, 1984, "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," Appendix A, 40 CFR 136, published in Volume 49, No. 209.

(8) Oceanographics International Corporation, no date, Operating Procedure Manual for 524B Total Carbon System, College Station, Texas.

(9) Walsh, L. M. and J. D. Blaton, 1973, "Soil Testing and Plant Analysis," Soil Science Society of America, Madison, Wisconsin.

(10) U.S. Department of the Interior, 1967, "Methods for Analyzing and Testing Coal and Coke," Bulletin 638, U.S. Bureau of Mines, Washington, D.C.

(11) American Society of Agronomists, 1982, "Methods of Soil Analysis," Part II, "Chemical and Microbial Properties," A. L. Page, Editor, 9, Madison, Wisconsin

(12) U.S. Environmental Protection Agency (EPA), 1987, "Chemical Analytical Services for Multi-Media Multi-Concentration Metals and Inorganics," WA-87-K026, Washington, D.C.

CONTRACT LABORATORY PROGRAM (CLP)
HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND
METHOD REFERENCES AND QUALITY CONTROL OBJECTIVES
FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	MATRIX SPIKE PRECISION RPD%(a) Water	MATRIX SPIKE PRECISION RPD%(a) Solids	MATRIX SPIKE ACCURACY % OF RECOVERY Water	MATRIX SPIKE ACCURACY % OF RECOVERY Solids	SURROGATE SPIKE ACCURACY % OF RECOVERY Water	SURROGATE SPIKE ACCURACY % OF RECOVERY Solids	EXPECTED COMPLETENESS %	EXPECTED METHOD DETECTION LIMIT(b) Water ug/l(c)	EXPECTED METHOD DETECTION LIMIT(b) Solids ug/kg(d)	METHOD NO.	REFERENCE
Volatiles:	Gas Chromatograph/ Mass Spectrometers	Daily							90			Exhibit D	1
Chloroethane			-	-	-	-	-	-		10	10		
Bromoethane			-	-	-	-	-	-		10	10		
Vinyl Chloride			-	-	-	-	-	-		10	10		
Chloroethane			-	-	-	-	-	-		10	10		
Methylene Chloride			-	-	-	-	-	-		5	5		
Acetone			-	-	-	-	-	-		10	10		
Carbon Disulfide			-	-	-	-	-	-		5	5		
1,1-Dichloroethene			14	22	61-145	59-172	-	-		5	5		
1,1-Dichloroethane			-	-	-	-	-	-		5	5		
trans-1,2-Dichloroethene			-	-	-	-	-	-		5	5		
Chloroform			-	-	-	-	-	-		5	5		
1,2-Dichloroethane			-	-	-	-	-	-		5	5		
2-Butanone			-	-	-	-	-	-		10	10		
1,1,1-Trichloroethane			-	-	-	-	-	-		5	5		
Carbon Tetrachloride			-	-	-	-	-	-		5	5		
Vinyl Acetate			-	-	-	-	-	-		10	10		
Bromodichloroethane			-	-	-	-	-	-		5	5		
1,1,2,2-Tetrachloroethane			-	-	-	-	-	-		5	5		
1,2-Dichloropropane			-	-	-	-	-	-		5	5		
trans-1,3-Dichloropropene			-	-	-	-	-	-		5	5		
Trichloroethene			14	24	71-120	62-137	-	-		5	5		
Dibromochloroethane			-	-	-	-	-	-		5	5		
1,1,2-Trichloroethane			-	-	-	-	-	-		5	5		
Benzene			11	21	76-127	66-142	-	-		5	5		
cis-1,3-Dichloropropene			-	-	-	-	-	-		5	5		

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	MATRIX SPIKE PRECISION RPD%(a) Water	MATRIX SPIKE PRECISION RPD%(a) Solids	MATRIX SPIKE ACCURACY % OF RECOVERY Water	MATRIX SPIKE ACCURACY % OF RECOVERY Solids	SURROGATE SPIKE ACCURACY % OF RECOVERY Water	SURROGATE SPIKE ACCURACY % OF RECOVERY Solids	EXPECTED COMPLETENESS %	EXPECTED METHOD DETECTION LIMIT(b) Water ug/l(c)	EXPECTED METHOD DETECTION LIMIT(b) Solids ug/kg(d)	METHOD NO.	REFERENCE
Volatiles (Continued):													
2-Chloroethyl Vinyl Ether			-	-	-	-	-	-		10	10		
Bromoform			-	-	-	-	-	-		5	5		
2-Hexane			-	-	-	-	-	-		10	10		
4-Methyl-2-pentanone			-	-	-	-	-	-		10	10		
Tetrachloroethene			-	-	-	-	-	-		5	5		
Toluene			13	21	76-125	59-139	-	-		5	5		
Chlorobenzene			13	21	75-130	60-133	-	-		5	5		
Ethylbenzene			-	-	-	-	-	-		5	5		
Styrene			-	-	-	-	-	-		5	5		
Total Xylenes			-	-	-	-	-	-		5	5		
SURROGATE COMPOUNDS:													
Toluene-d_8			-	-	-	-	88-110	81-117		-	-		
4-Bromofluorobenzene			-	-	-	-	86-115	74-121		-	-		
1,2-Dichloroethane-d_4			-	-	-	-	76-114	70-121		-	-		
Acid/Base-Neutral Extractables:	Gas Chromatograph/ Mass Spectrometers	Daily							90			Exhibit D	1
Phenol			42	35	12-89	26-90	-	-		10	330		
Bis(2-Chloroethyl)ether			-	-	-	-	-	-		10	330		
2-Chlorophenol			40	50	27-123	25-102	-	-		10	330		
1,3-Dichlorobenzene			-	-	-	-	-	-		10	330		
1,4-Dichlorobenzene			28	27	36-97	28-104	-	-		10	330		
Benzyl Alcohol			-	-	-	-	-	-		10	330		
1,2-Dichlorobenzene			-	-	-	-	-	-		10	330		
2-Methylphenol			-	-	-	-	-	-		10	330		
Bis(2-chloroisopropyl)ether			-	-	-	-	-	-		10	330		
4-Methylphenol			-	-	-	-	-	-		10	330		
N-Nitroso-di-n propylamine			38	38	41-116	41-126	-	-		10	330		
Hexachloroethane			-	-	-	-	-	-		10	330		
Nitrobenzene			-	-	-	-	-	-		10	330		
Isophorone			-	-	-	-	-	-		10	330		

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	MATRIX SPIKE PRECISION RPD%(a) Water	MATRIX SPIKE PRECISION RPD%(a) Solids	MATRIX SPIKE ACCURACY % OF RECOVERY Water	MATRIX SPIKE ACCURACY % OF RECOVERY Solids	SURROGATE SPIKE ACCURACY % OF RECOVERY Water	SURROGATE SPIKE ACCURACY % OF RECOVERY Solids	EXPECTED COMPLETENESS %	EXPECTED METHOD DETECTION LIMIT(b) Water ug/l(c)	EXPECTED METHOD DETECTION LIMIT(b) Solids ug/kg(d)	METHOD NO.	REFERENCE
Acid/Base-Neutral Extractables: (Continued)													
2-Nitrophenol			-	-	-	-	-	-		10	330		
2,4-Dimethylphenol			-	-	-	-	-	-		10	330		
Benzoic Acid			-	-	-	-	-	-		50	1600		
Bis(2-chloroethoxy)methane			-	-	-	-	-	-		10	330		
2,4-Dichlorophenol			-	-	-	-	-	-		10	330		
1,2,4-Trichlorobenzene			28	23	39-98	38-107	-	-		10	330		
Naphthalene			-	-	-	-	-	-		10	330		
4-Chloroaniline			-	-	-	-	-	-		10	330		
Hexachlorobutadiene			-	-	-	-	-	-		10	330		
4-Chloro-3-methylphenol			42	33	23-97	26-103	-	-		10	330		
2-Methylnaphthalene			-	-	-	-	-	-		10	330		
Hexachlorocyclopentadiene			-	-	-	-	-	-		10	330		
2,4,6-Trichlorophenol			-	-	-	-	-	-		50	1600		
2,4,5-Trichlorophenol			-	-	-	-	-	-		10	330		
2-Chloronaphthalene			-	-	-	-	-	-		50	1600		
2-Nitroaniline			-	-	-	-	-	-		10	330		
Dimethylphthalate			-	-	-	-	-	-		10	330		
Acenaphthylene			31	19	46-118	31-137	-	-		50	1600		
3-Nitroaniline			-	-	-	-	-	-		10	330		
Acenaphthene			-	-	-	-	-	-		50	1600		
2,4-Dinitrophenol			-	-	-	-	-	-		50	1600		
4-Nitrophenol			50	50	10-80	11-114	-	-		10	330		
Dibenzofuran			-	-	-	-	-	-		10	330		
2,4-Dinitrotoluene			38	47	24-96	28-89	-	-		10	330		
2,6-Dinitrotoluene			-	-	-	-	-	-		10	330		
Diethylphthalate			-	-	-	-	-	-		10	330		
4-Chlorophenyl Phenyl Ether			-	-	-	-	-	-		10	330		
Fluorene			-	-	-	-	-	-		50	1600		
4-Nitroaniline			-	-	-	-	-	-		50	1600		
4,6-Dinitro-2-methylphenol			-	-	-	-	-	-		10	330		
N-Nitrosodiphenylamine			-	-	-	-	-	-		10	330		
4-Bromophenyl Phenyl Ether			-	-	-	-	-	-		10	330		
Hexachlorobenzene			-	-	-	-	-	-		50	1600		
Pentachlorophenol			50	47	9-103	17-109	-	-		10	330		
Phenanthrene			-	-	-	-	-	-					

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	MATRIX SPIKE PRECISION RPD%(a) Water	MATRIX SPIKE PRECISION RPD%(a) Solids	MATRIX SPIKE ACCURACY % OF RECOVERY Water	MATRIX SPIKE ACCURACY % OF RECOVERY Solids	SURROGATE SPIKE ACCURACY % OF RECOVERY Water	SURROGATE SPIKE ACCURACY % OF RECOVERY Solids	EXPECTED COMPLETENESS %	EXPECTED METHOD DETECTION LIMIT(b) Water ug/l(c)	EXPECTED METHOD DETECTION LIMIT(b) Solids ug/kg(d)	METHOD NO.	REFERENCE
Acid/Base-Neutral Extractables: (Continued)													
Anthracene			-	-	-	-	-	-		10	330		
Di-n-butylphthalate			40	47	11-117	29-135	-	-		10*	330		
Fluoranthene			-	-	-	-	-	-		10	330		
Pyrene			31	36	26-127	35-142	-	-		10	330		
Butyl Benzyl Phthalate			-	-	-	-	-	-		10	330		
3,3'-Dichlorobenzidine			-	-	-	-	-	-		20	660		
Benzo(a)anthracene			-	-	-	-	-	-		10	330		
Bis(2-ethylhexyl)phthalate			-	-	-	-	-	-		10	330		
Chrysene			-	-	-	-	-	-		10	330		
Di-n-octylphthalate			-	-	-	-	-	-		10	330		
Benzo(b)fluoranthene			-	-	-	-	-	-		10	330		
Benzo(k)fluoranthene			-	-	-	-	-	-		10	330		
Benzo(a)pyrene			-	-	-	-	-	-		10	330		
Indeno(1,2,3-cd)pyrene			-	-	-	-	-	-		10	330		
Dibenzo(a,h)anthracene			-	-	-	-	-	-		10	330		
Benzo(g,h,i)perylene			-	-	-	-	-	-		10	330		
SURROGATE COMPOUNDS:													
Nitrobenzene-d_5			-	-	-	-	35-114	23-120		-	-		
2-Fluorobiphenyl			-	-	-	-	43-116	30-115		-	-		
p-Terphenyl-d_{14}			-	-	-	-	33-141	18-137		-	-		
Phenol-d_5			-	-	-	-	10-94	24-113		-	-		
2-Fluorophenol			-	-	-	-	21-100	25-121		-	-		
2,4,6-Tribromophenol			-	-	-	-	10-123	19-122		-	-		
Pesticides/Polychlorinated Biphenyls	Gas Chromatograph	Daily							90			Exhibit D	1
alpha-BHC			-	-	-	-	-	-		0.05	8.0		
beta-BHC			-	-	-	-	-	-		0.05	8.0		
delta-BHC			-	-	-	-	-	-		0.05	8.0		
gamma-BHC			15	50	56-123	46-127	-	-		0.05	8.0		
Heptachlor			20	31	40-131	35-130	-	-		0.05	8.0		
Aldrin			22	43	40-120	34-132	-	-		0.05	8.0		

See footnotes at end of table.

141

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	MATRIX SPIKE PRECISION RPD%(a) Water	MATRIX SPIKE PRECISION RPD%(a) Solids	MATRIX SPIKE ACCURACY % OF RECOVERY Water	MATRIX SPIKE ACCURACY % OF RECOVERY Solids	SURROGATE SPIKE ACCURACY % OF RECOVERY Water	SURROGATE SPIKE ACCURACY % OF RECOVERY Solids	EXPECTED COMPLETENESS %	EXPECTED METHOD DETECTION LIMIT(b) Water ug/l(c)	EXPECTED METHOD DETECTION LIMIT(b) Solids ug/kg(d)	METHOD NO.	REFERENCE
Pesticides/Polychlorinated Biphenyls: (Continued)													
Heptachlor Epoxide			-	-	-	-	-	-		0.05	8.0		
Endosulfan I			-	-	-	-	-	-		0.05	8.0		
Dieldrin			18	38	52-126	31-134	-	-		0.10	16.0		
4,4'-DDE			-	-	-	-	-	-		0.10	16.0		
Endrin			21	45	56-121	42-139	-	-		0.10	16.0		
Endosulfan II			-	-	-	-	-	-		0.10	16.0		
4,4'-DDD			-	-	-	-	-	-		0.10	16.0		
Endosulfan Sulfate			-	-	-	-	-	-		0.10	16.0		
4,4'-DDT			27	50	38-127	23-134	-	-		0.10	16.0		
Endrin Ketone			-	-	-	-	-	-		0.10	16.0		
Methoxychlor			-	-	-	-	-	-		0.5	80.0		
Chlordane			-	-	-	-	-	-		0.5	80.0		
Toxaphene			-	-	-	-	-	-		1.0	160.0		
Aroclor 1016			-	-	-	-	-	-		0.5	80.0		
Aroclor 1221			-	-	-	-	-	-		0.5	80.0		
Aroclor 1232			-	-	-	-	-	-		0.5	80.0		
Aroclor 1242			-	-	-	-	-	-		0.5	80.0		
Aroclor 1248			-	-	-	-	-	-		0.5	80.0		
Aroclor 1254			-	-	-	-	-	-		1.0	160.0		
Aroclor 1260			-	-	-	-	-	-		1.0	160.0		
SURROGATE COMPOUND:													
Dibutylchlorendate			-	-	-	-	24-154(e)	20-150(e)		-	-		

(a)RPD equals relative percent difference.

(b)The indicated detection limits are appropriate to low level water and solids samples. Medium water Contract Detection Limits (CRDL) for Volatile, Acid/Base-Neutral Extractable, and Pesticide HSL compounds are 100 times the individual low water CRDL. Medium solids CRDLs for Volatile, Acid/Base-Neutral Extractable, and Pesticide HSL compounds are 100, 60, and 15 times individual low solid CRDL, respectively.

(c)ug/l equals micrograms per liter or parts per billion (ppb).

(d)ug/kg equals micrograms per kilogram or parts per billion (ppb).

(e)The indicated surrogate spike percent recovery limits are for advisory purposes only. These limits are not used to determine whether a sample should be reanalyzed.

REFERENCES

(1)U.S. Environmental Protection Agency (EPA), 1987, "Chemical Analytical Services for Multi-Media, Multi-Concentration Organics, GC/MS Techniques," WA-87-K236, Washington, D.C.

LABORATORY RADIOLOGICAL TESTING
QUALITY CONTROL PERFORMANCE SUMMARY
FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION % RSD(a)	TYPICAL ACCURACY % Bias(b)	COMPLETENESS (%)	EXPECTED METHOD DETECTION LIMIT(e)	METHOD NO.	REFERENCE
Gross Alpha	Tennelec Low Background Alpha/Beta Counting System	Daily (c)	±20	±30	90	1.0 pCi/l(f,h) (water)	RSL-308	1
	or							
	Ludlum Scaler Scintillation Counters Models 1000, 2000, and 2200	Daily	±20	±30	90			
Gross Beta	Tennelec Low Background Alpha/Beta Counting System	Daily	±20	±30	90	4.0 pCi/l(h) (water)	RSL-308	1
Radium-226	Alpha Spectrometer	Daily	±20	±30	90	1.0 pCi/l (water) 300 pCi/kg(g) (solids)	RSL-309 RSL-201, RSL-309	2,3,4,5 2,3,4,5
	and/or							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data System Only)	NA	NA(d)	NA	NA			
Radium-228	Tennelec Low Background Alpha/Beta Counting System	Daily	±20	±30	90	3.0 pCi/l (water) 500 pCi/kg (solids)	RSL-309 RSL-201, RSL-309	2,3,4,5 2,4,3,5
Strontium-90	Tennelec Low Background Alpha/Beta Counting System	Daily	±20	±30	90	5 pCi/l (water) 500 pCi/kg (solids)	RSL-305 RSL-201, RSL-305	6,7,8 6,7,8
Technetium-99	Packard Liquid Scintillation Spectrometer	Daily	±20	±30	90	30 pCi/l (water) 900 pCi/kg (solids)	RSL-310 RSL-201, RSL-310	9 9
Thorium, Isotopic	Alpha Spectrometer	Daily	±20	±30	90	1.0 pCi/l (water) 600 pCi/kg (solids)	RSL-304 RSL-201, RSL-304	2,3,4,5 2,3,4,5
	and							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data System Only)	NA	NA	NA	NA			

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION % RSD(a)	TYPICAL ACCURACY % Bias(b)	COMPLETENESS (%)	EXPECTED METHOD DETECTION LIMIT(e)	METHOD NO.	REFERENCE
Uranium, Isotopic	Alpha Spectrometer	Daily	±20	±30	90	1.0 pCi/l (water) 600 pCi/kg (solids)	RSL-304 RSL-201, RSL-304	2,3,4,5 2,3,4,5
Uranium, Total						1 ug/l (total)		
	and							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data Systems Only)	NA	NA	NA	NA			
Plutonium, Isotopic	Alpha Spectrometer	Daily	±20	±30	90	1.0 pCi/l (water) 600 pCi/kg (solids)	RSL-304 RSL-201, RSL-304	2,3,4,5 2,3,4,5
	and							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data Systems Only)	NA	NA	NA	NA			
Neptunium-237	Alpha Spectrometer	Daily	±20	±30	90	1.0 pCi/l (water) 600 pCi/kg (solids)	RSL-304 RSL-201, RSL-304	2,3,4,5 2,3,4,5
	and							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data Systems Only)	NA	NA	NA	NA			
Cesium-137 Gamma Spec	Intrinsic Germanium Detectors	Daily	±20	±30	90	20 pCi/l (water) 200 pCi/kg (solids)	RSL-201, RSL-112 RSL-201, RSL-112	1 1
	and							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data System Only)	NA	NA	NA	NA			

See footnotes at end of table.

PARAMETER	INSTRUMENT	FREQUENCY OF CALIBRATION CHECKS	TYPICAL PRECISION % RSD(a)	TYPICAL ACCURACY % Bias(b)	COMPLETENESS (%)	EXPECTED METHOD DETECTION LIMIT(e)	METHOD NO.	REFERENCE
Ruthenium-106	Intrinsic Germanium Detectors	Daily	±20	±30	90	150 pCi/l (water) 1 nCi/kg (solids)	RSL-201, RSL-112 RSL-201, RSL-112	1 1
	and							
	Nuclear Data Computer Based Gamma Spectrometer Model ND9900 (Data System Only)	NA	NA	NA	NA			

(a)Precision is expressed as the percent relative standard deviation of the corresponding method.

(b)Accuracy is expressed as the percent bias of the analyzed versus actual spike concentration for the indicated method.

(c)Each day samples are analyzed.

(d)The indicated instrumentation is a system used for data acquisition and reduction. Therefore, analytical definitions of method precision and accuracy are not applicable.

(e)The indicated method detection limits (MDLs) represent the 95 percent confidence limit for false detection and false rejection discrimination.

(f)pCi/l = picocuries per liter.

(g)pCi/kg = picocuries per kilogram.

(h)For sample with solids <500 ppm.

REFERENCES

(1)Krieger, H. L. and E. L. Whittaker, August 1980, "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, U.S. Environmental Protection Agency (U.S. EPA).

(2)Kraus, K. A. and G. E. Moore, 1955, "The Separation of Pa (V) and Fe (III) with HCl Mixtures," Journal of American Chemical Society 77, p. 1383.

(3)Wish, Leon, March 1959, "Quantitative Radiochemical Analysis by Ion Exchange," Analytical Chemistry 31, pp. 326-329.

(4)Campbell, E. E. and W. D. Rowe, October 10-11, 1963, "Determination of Plutonium in Urine by Ion Exchange," Proceedings of the Ninth Annual Conference on Bioassay and Analytical Chemistry, San Diego, Cal.

(5)Hemley, L. C., May 1978, Radiochemical Procedures of the Industrial Safety and Applied Health Physics Division, Oak Ridge National Laboratory, ORNL/TM-6372.

(6)Rowe, D. N., N. E. Ballou, and L. E. Gendenin, June 1945, CN-2815, pp. 23-26.

(7)Swift, E. H., 1940, A System of Chemical Analysis, Prentice-Hall, New York, p. 376.

(8)Willard, H. H. and E. W. Goodspeed, 1936, "Separation of Strontium, Barium, and Lead from Calcium and Other Metals," Ind. Eng. Chem., Anal. Ed., 8, p. 414.

(9)Anders, Edward, November 1960, The Radiochemistry of Technetium, National Academy of Sciences - National Research Council.

APPENDIX C

Pit One

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	1702.92	20223.31	MG/KG	6
ARSENIC, TOTAL	14.46	15.20	MG/KG	2
BARIUM, EP LEACHATE	1018.00	3743.00	UG/L	4
BARIUM, TOTAL	116.48	395.37	MG/KG	6
BERYLLIUM, TOTAL	2.03	2.20	MG/KG	2
CADMIUM, TOTAL	1.46	4.96	MG/KG	3
CALCIUM, TOTAL	4755.83	192497.97	MG/KG	6
CHROMIUM, TOTAL	6.35	46.33	MG/KG	5
COBALT, TOTAL	27.85	27.85	MG/KG	1
COPPER, TOTAL	19.05	160.79	MG/KG	6
IRON, TOTAL	1832.56	19687.98	MG/KG	6
LEAD, EP LEACHATE	660.00	660.00	UG/L	1
LEAD, TOTAL	4.98	89.92	MG/KG	6
MAGNESIUM, TOTAL	7613.78	36957.20	MG/KG	6
MANGANESE, TOTAL	144.81	2914.70	MG/KG	6
MERCURY, TOTAL	.26	.36	MG/KG	2
NICKEL, TOTAL	9.22	64.53	MG/KG	5
POTASSIUM, TOTAL	165.48	2564.10	MG/KG	6
SILVER, TOTAL	2.25	33.09	MG/KG	3
SODIUM, TOTAL	386.12	3638.58	MG/KG	5
VANADIUM, TOTAL	13.74	66.74	MG/KG	5
ZINC, TOTAL	6.09	57.91	MG/KG	4

Pit One

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
4,4-DDT	1600.00	1600.00	UG/KG	1
AROCLOR-1248	3500.00	3500.00	UG/KG	1
AROCLOR-1254	720.00	10000.00	UG/KG	4
AROCLOR-1260	7000.00	7000.00	UG/KG	1
CHLOROFORM	210.00	210.00	UG/KG	1
CHRYSENE	510.00	510.00	UG/KG	1
PHENANTHRENE	770.00	2300.00	UG/KG	2

Pit One

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	.20	1.10	PCI/G	5
NP-237	.10	.30	PCI/G	5
PU-238	.10	.10	PCI/G	5
PU-239/240	.10	.10	PCI/G	5
RA-226	12.00	60.20	PCI/G	5
RU-106	2.00	4.00	PCI/G	5
SR-90	.30	.60	PCI/G	5
TC-99	1.00	15.00	PCI/G	5
TH-228	1.80	18.00	PCI/G	5
TH-230	122.00	1980.00	PCI/G	5
TH-232	1.80	17.00	PCI/G	5
U-234	244.00	1180.00	PCI/G	5
U-235	16.00	151.00	PCI/G	5
U-238	360.00	6980.00	PCI/G	5

Pit Two

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	7242.30	22421.77	MG/KG	5
ARSENIC, TOTAL	2.75	10.06	MG/KG	4
BARIUM, EP LEACHATE	4221.00	9458.00	UG/L	3
BARIUM, TOTAL	62.37	208.49	MG/KG	5
BERYLLIUM, TOTAL	1.87	8.92	MG/KG	3
CADMIUM, TOTAL	3.04	9.59	MG/KG	5
CALCIUM, TOTAL	34414.38	80154.23	MG/KG	5
CHROMIUM, TOTAL	16.17	91.26	MG/KG	5
COBALT, TOTAL	13.63	450.56	MG/KG	4
COPPER, TOTAL	26.18	329.06	MG/KG	5
IRON, TOTAL	13265.46	24037.73	MG/KG	5
LEAD, TOTAL	20.70	190.29	MG/KG	5
MAGNESIUM, TOTAL	8884.98	26676.81	MG/KG	5
MANGANESE, TOTAL	495.43	916.57	MG/KG	5
MERCURY, EP LEACHATE	.27	.27	UG/L	1
MERCURY, TOTAL	.22	.70	MG/KG	4
NICKEL, TOTAL	28.75	608.90	MG/KG	5
POTASSIUM, TOTAL	667.42	4318.50	MG/KG	5
SELENIUM, TOTAL	1.59	10.19	MG/KG	3
SILVER, TOTAL	5.90	23.16	MG/KG	3
SODIUM, TOTAL	410.72	2303.20	MG/KG	5
VANADIUM, TOTAL	26.95	105.94	MG/KG	5
ZINC, TOTAL	53.58	3247.15	MG/KG	5

Pit Two

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
2-METHYLNAPHTHALENE	7000.00	7000.00	UG/KG	1
4,4-DDT	580.00	1400.00	UG/KG	2
4-CHLOROPHENYL-PHENYLETHER	62000.00	62000.00	UG/KG	1
ACENAPHTHENE	43000.00	43000.00	UG/KG	1
ANTHRACENE	120000.00	120000.00	UG/KG	1
AROCLOR-1248	321.00	321.00	UG/KG	1
AROCLOR-1254	323.00	323.00	UG/KG	1
AROCLOR-1260	740.00	1800.00	UG/KG	2
BENZO(A)ANTHRACENE	860.00	180000.00	UG/KG	3
BENZO(A)PYRENE	700.00	140000.00	UG/KG	3
BENZO(B)FLUORANTHENE	760.00	110000.00	UG/KG	2
BENZO(G,H,I)PERYLENE	42000.00	42000.00	UG/KG	1
BENZO(K)FLUORANTHENE	600.00	120000.00	UG/KG	3
CHRYSENE	920.00	180000.00	UG/KG	2
DIBENZOFURAN	36000.00	36000.00	UG/KG	1
FLUORANTHENE	590.00	460000.00	UG/KG	3
FLUORENE	62000.00	62000.00	UG/KG	1
INDENO(1,2,3-CD)PYRENE	46000.00	46000.00	UG/KG	1
NAPHTHALENE	16000.00	16000.00	UG/KG	1
PHENANTHRENE	1700.00	370000.00	UG/KG	2
PYRENE	1600.00	310000.00	UG/KG	2
VINYL CHLORIDE	670.00	670.00	UG/KG	1

Pit Two

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	.20	3.60	PCI/G	5
NP-237	.10	.40	PCI/G	5
PU-238	.10	.10	PCI/G	5
PU-239/240	.05	.60	PCI/G	5
RA-226	12.20	412.00	PCI/G	5
RU-106	2.00	35.00	PCI/G	5
SR-90	.30	1.00	PCI/G	5
TC-99	1.00	618.00	PCI/G	5
TH-228	.30	73.00	PCI/G	5
TH-230	1.20	3980.00	PCI/G	5
TH-232	.10	88.00	PCI/G	5
U-234	39.00	18200.00	PCI/G	5
U-235	1.00	8780.00	PCI/G	5
U-238	53.00	17900.00	PCI/G	5

Pit Three

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	8219.61	64100.08	MG/KG	7
ARSENIC, EP LEACHATE	514.00	3116.00	UG/L	4
ARSENIC, TOTAL	15.41	3049.06	MG/KG	7
BARIUM, TOTAL	251.19	14354.90	MG/KG	7
BERYLLIUM, TOTAL	2.76	24.01	MG/KG	6
CADMIUM, TOTAL	1.91	12.65	MG/KG	7
CALCIUM, TOTAL	53183.03	178241.20	MG/KG	7
CHROMIUM, TOTAL	16.38	151.84	MG/KG	7
COPPER, TOTAL	79.50	2332.66	MG/KG	7
IRON, TOTAL	10730.37	26919.20	MG/KG	7
LEAD, TOTAL	25.57	613.21	MG/KG	7
MAGNESIUM, TOTAL	21492.80	51570.00	MG/KG	7
MANGANESE, TOTAL	407.29	10570.89	MG/KG	7
MERCURY, EP LEACHATE	.25	7.23	UG/L	2
MERCURY, TOTAL	.45	4.01	MG/KG	4
NICKEL, TOTAL	22.34	503.97	MG/KG	7
POTASSIUM, TOTAL	810.24	2894.00	MG/KG	7
SELENIUM, EP LEACHATE	257.00	257.00	UG/L	1
SELENIUM, TOTAL	1.29	89.80	MG/KG	4
SILVER, TOTAL	3.54	8.11	MG/KG	4
SODIUM, TOTAL	1191.68	7640.00	MG/KG	7
SULFIDE	1.95	1.95	MG/KG	1
THALLIUM, TOTAL	5.89	12.21	MG/KG	2
VANADIUM, TOTAL	50.06	9695.51	MG/KG	7
ZINC, TOTAL	37.87	311.19	MG/KG	7

Pit Three Organic Data Summary

Borehole Number	Sample Id	Batch Number	Parameter	Concentration	Unit Of Measure	Qualifier
03-02	FMP-PS-03-089	8704-145-0060	AROCLOR-1254	82.00	UG/KG	J
			BIS(2-ETHYLHEXYL)PHTHALATE	660.00	UG/KG	*
			DI-N-BUTYL PHTHALATE	84.00	UG/KG	J*
			ACETONE	91.00	UG/KG	J*
03-03	FMP-PS-03-008	8704-121-0010	AROCLOR-1254	140.00	UG/KG	J
			PENTACHLOROPHENOL(2)	1300.00	UG/KG	J
			BIS(2-ETHYLHEXYL)PHTHALATE	250.00	UG/KG	J*
			ACETONE	150.00	UG/KG	J*
			N-NITROSODIPHENYLAMINE(1)	130.00	UG/KG	J
03-04	FMP-PS-03-028	8704-121-0080	BIS(2-ETHYLHEXYL)PHTHALATE	480.00	UG/KG	J*
			AROCLOR-1254	550.00	UG/KG	J
			PENTACHLOROPHENOL(2)	630.00	UG/KG	J
			ACETONE	130.00	UG/KG	J*
03-05	FMP-PS-03-051	8704-145-0010	ACETONE	98.00	UG/KG	J*
			DI-N-BUTYL PHTHALATE	84.00	UG/KG	J*
			BIS(2-ETHYLHEXYL)PHTHALATE	280.00	UG/KG	J*
			AROCLOR-1254	100.00	UG/KG	J
03-06	FMP-PS-03-072	8704-145-0020	ACETONE	210.00	UG/KG	J*
			AROCLOR-1254	74.00	UG/KG	J
			DI-N-BUTYL PHTHALATE	84.00	UG/KG	J*
			BIS(2-ETHYLHEXYL)PHTHALATE	110.00	UG/KG	J*
03-07	FMP-PS-03-109	8704-180-0010	ACETONE	390.00	UG/KG	J*
			BENZO(B)FLUORANTHENE	110.00	UG/KG	J
			BENZO(A)ANTHRACENE	60.00	UG/KG	J
			CHRYSENE	75.00	UG/KG	J
			2-BUTANONE	3600.00	UG/KG	*
			METHYLENE CHLORIDE	420.00	UG/KG	*
			PYRENE	190.00	UG/KG	J
			BIS(2-ETHYLHEXYL)PHTHALATE	1100.00	UG/KG	*
			PHENANTHRENE	120.00	UG/KG	J
			FLUORANTHENE	230.00	UG/KG	J

J = Concentration is below quantification level; * = Common laboratory contaminant

Pit Three Organic Data Summary

Borehole Number	Sample Id	Batch Number	Parameter	Concentration	Unit Of Measure	Qualifier
03-07	FMP-PS-03-109	8704-180-0010	AROCLOR-1254	140.00	UG/KG	J

J = Concentration is below quantification level; * = Common laboratory contaminant

Tue Nov 24

Pit Three

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	.20	6.00	PCI/G	7
NP-237	.10	2.10	PCI/G	7
PU-238	.05	1.00	PCI/G	7
PU-239/240	.05	14.00	PCI/G	7
RA-226	3.10	369.00	PCI/G	7
RU-106	2.00	35.00	PCI/G	7
SR-90	.50	26.00	PCI/G	7
TC-99	1.00	1110.00	PCI/G	7
TH-228	1.00	82.00	PCI/G	7
TH-230	15.00	21900.00	PCI/G	7
TH-232	1.00	121.00	PCI/G	7
U-234	27.00	475.00	PCI/G	7
U-235	2.50	21.00	PCI/G	7
U-238	134.00	1380.00	PCI/G	7

Pit Four

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	3645.60	10325.99	MG/KG	5
ARSENIC, EP LEACHATE	582.00	582.00	UG/L	1
ARSENIC, TOTAL	4.63	4.63	MG/KG	1
BARIUM, EP LEACHATE	1023.00	81470.00	UG/L	3
BARIUM, TOTAL	444.03	6668.76	MG/KG	5
BERYLLIUM, TOTAL	13.30	13.30	MG/KG	1
CADMIUM, EP LEACHATE	141.00	141.00	UG/L	1
CADMIUM, TOTAL	1.92	28.72	MG/KG	3
CALCIUM, TOTAL	14252.84	61252.80	MG/KG	5
CHROMIUM, TOTAL	7.92	93.63	MG/KG	5
COBALT, TOTAL	84.06	84.06	MG/KG	1
COPPER, TOTAL	20.35	187.73	MG/KG	5
FLUORIDE	47812.36	124576.13	MG/KG	4
IRON, TOTAL	3045.60	16127.52	MG/KG	5
LEAD, EP LEACHATE	753.00	753.00	UG/L	1
LEAD, TOTAL	13.71	62.51	MG/KG	5
MAGNESIUM, TOTAL	11423.80	24251.31	MG/KG	5
MANGANESE, TOTAL	1383.43	3596.38	MG/KG	5
MERCURY, EP LEACHATE	1.06	1.06	UG/L	1
MERCURY, TOTAL	.18	.63	MG/KG	3
NICKEL, TOTAL	20.67	49.73	MG/KG	3
PHENOL	.43	.83	MG/KG	3
POTASSIUM, TOTAL	303.10	1920.00	MG/KG	4
SILVER, EP LEACHATE	2767.00	2767.00	UG/L	1
SILVER, TOTAL	2.59	443.65	MG/KG	4
SODIUM, TOTAL	254.90	1237.55	MG/KG	5
SULFIDE	.50	.50	MG/KG	1
VANADIUM, TOTAL	13.85	235.36	MG/KG	4
ZINC, TOTAL	13.92	84.06	MG/KG	5

Pit Four

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
ANTHRACENE	510.00	510.00	UG/KG	1
AROCLOR-1242	99.00	1034.00	UG/KG	2
AROCLOR-1248	460.00	854.00	UG/KG	2
AROCLOR-1254	1008.00	1008.00	UG/KG	1
BENZO(A)ANTHRACENE	750.00	750.00	UG/KG	1
BENZO(A)PYRENE	550.00	550.00	UG/KG	1
BENZO(B)FLUORANTHENE	510.00	510.00	UG/KG	1
BENZO(K)FLUORANTHENE	560.00	560.00	UG/KG	1
CHLOROFORM	430.00	1300.00	UG/KG	2
CHRYSENE	760.00	760.00	UG/KG	2
ETHYL PARATHION	82.00	860.00	UG/KG	3
FLUORANTHENE	1000.00	2200.00	UG/KG	3
MALATHION	670.00	670.00	UG/KG	1
METHYL PARATHION	370.00	2100.00	UG/KG	3
PHENANTHRENE	1000.00	2100.00	UG/KG	3
PYRENE	670.00	1400.00	UG/KG	3
TETRACHLOROETHENE	530.00	30000.00	UG/KG	2
TRICHLOROETHENE	300.00	300.00	UG/KG	1

Pit Four

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	.20	.50	PCI/G	4
NP-237	.10	.40	PCI/G	4
PU-238	.10	.50	PCI/G	4
PU-239/240	.10	.40	PCI/G	4
RA-226	5.00	20.00	PCI/G	4
RU-106	2.00	4.00	PCI/G	4
SR-90	.40	1.00	PCI/G	4
TC-99	6.80	225.00	PCI/G	4
TH-228	.30	24.00	PCI/G	4
TH-230	2.20	566.00	PCI/G	4
TH-232	.30	21.00	PCI/G	4
U-234	149.00	2320.00	PCI/G	4
U-235	35.00	426.00	PCI/G	4
U-238	509.00	15800.00	PCI/G	4

Pit Five

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	6373.77	15400.00	MG/KG	6
ANTIMONY, TOTAL	28.00	28.00	MG/KG	1
ARSENIC, EP LEACHATE	516.00	516.00	UG/L	1
ARSENIC, TOTAL	139.00	2800.00	MG/KG	6
BARIUM, EP LEACHATE	2260.00	3171.00	UG/L	2
BARIUM, TOTAL	15800.00	36938.95	MG/KG	7
BERYLLIUM, TOTAL	2.85	18.00	MG/KG	5
BERYLLIUM,TOTAL	8.80	8.80	MG/KG	1
CADMIUM, TOTAL	17.00	17.00	MG/KG	1
CADMIUM,TOTAL	4.40	4.40	MG/KG	1
CALCIUM, TOTAL	116000.00	206144.40	MG/KG	6
CHROMIUM, TOTAL	25.66	223.29	MG/KG	6
COBALT, TOTAL	16.00	43.99	MG/KG	3
COPPER, TOTAL	672.21	3370.00	MG/KG	6
IRON, TOTAL	10979.43	17900.00	MG/KG	6
LEAD, TOTAL	59.50	236.00	MG/KG	6
MAGNESIUM, TOTAL	25201.76	63200.00	MG/KG	6
MANGANESE, TOTAL	346.29	4740.00	MG/KG	6
MERCURY, EP LEACHATE	1.90	6.20	UG/L	3
MERCURY, TOTAL	.39	1.80	MG/KG	6
NICKEL, TOTAL	52.55	202.00	MG/KG	3
POTASSIUM, TOTAL	611.10	1490.00	MG/KG	6
SELENIUM, TOTAL	2.80	7.47	MG/KG	3
SILVER, TOTAL	8.18	9.40	MG/KG	2
SODIUM, TOTAL	1425.90	9980.00	MG/KG	6
THALIUM, TOTAL	2.80	2.80	MG/KG	1
VANADIUM, TOTAL	791.98	5380.00	MG/KG	6
ZINC, TOTAL	116.92	212.00	MG/KG	6

Pit Five

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
AROCLOR-1254	750.00	750.00	UG/KG	1

Pit Five

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	2.00	76.00	PCI/G	6
NP-237	.30	23.00	PCI/G	6
PU-238	.10	4.40	PCI/G	6
PU-239/240	.10	13.00	PCI/G	6
RA-226	235.00	999.00	PCI/G	6
RU-106	13.00	35.00	PCI/G	6
SR-90	.80	23.00	PCI/G	6
TC-99	423.00	2990.00	PCI/G	6
TH-228	41.00	191.00	PCI/G	6
TH-230	3080.00	20200.00	PCI/G	6
TH-232	21.00	90.00	PCI/G	6
U-234	310.00	1250.00	PCI/G	6
U-235	14.00	79.00	PCI/G	6
U-238	387.00	1230.00	PCI/G	6

Pit Six

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	4730.37	4730.37	MG/KG	1
ARSENIC, TOTAL	7.61	7.61	MG/KG	1
BARIUM, EP LEACHATE	1092.00	1092.00	UG/L	1
BARIUM, TOTAL	95.22	95.22	MG/KG	1
BERYLLIUM, TOTAL	2.00	5.73	MG/KG	2
CADMIUM, EP LEACHATE	251.00	251.00	UG/L	1
CADMIUM, TOTAL	.60	5.73	MG/KG	2
CALCIUM, TOTAL	22189.54	22189.54	MG/KG	1
CHROMIUM, TOTAL	4.80	29.74	MG/KG	4
COBALT, TOTAL	26.09	26.09	MG/KG	1
COPPER, TOTAL	13.00	222.02	MG/KG	4
IRON, TOTAL	2749.88	2749.88	MG/KG	1
LEAD, EP LEACHATE	1894.00	1894.00	UG/L	1
LEAD, TOTAL	5.00	59.62	MG/KG	4
MAGNESIUM, TOTAL	32101.13	32101.13	MG/KG	1
MANGANESE, TOTAL	34.96	34.96	MG/KG	1
MERCURY, TOTAL	.03	.07	MG/KG	3
NICKEL, TOTAL	7.70	51.39	MG/KG	4
POTASSIUM, TOTAL	913.15	913.15	MG/KG	1
SILVER, EP LEACHATE	2068.00	2068.00	UG/L	1
SILVER, TOTAL	158.10	158.10	MG/KG	1
SODIUM, TOTAL	600.07	600.07	MG/KG	1
VANADIUM, TOTAL	100.18	100.18	MG/KG	1
ZINC, TOTAL	4.80	51.00	MG/KG	4

Pit Six

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
1,1,2,2-TETRACHLOROETHANE	29000.00	29000.00	UG/KG	1

Pit Six

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	4.00	31.00	PCI/G	4
NP-237	.90	4.50	PCI/G	4
PU-238	.40	1.40	PCI/G	4
PU-239/240	4.00	15.00	PCI/G	4
RA-226	16.00	30.00	PCI/G	4
RU-106	35.00	35.00	PCI/G	4
SR-90	.50	4.00	PCI/G	4
TC-99	84.00	164.00	PCI/G	4
TH-228	.20	2.00	PCI/G	4
TH-230	14.00	41.00	PCI/G	4
TH-232	.20	1.20	PCI/G	4
U-234	2000.00	5330.00	PCI/G	4
U-235	350.00	1750.00	PCI/G	4
U-238	12500.00	18700.00	PCI/G	4

Burn Pit

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	2911.89	11935.61	MG/KG	7
ARSENIC, TOTAL	4.38	20.91	MG/KG	4
BARIUM, EP LEACHATE	1252.00	4291.00	UG/L	7
BARIUM, TOTAL	56.23	7097.22	MG/KG	6
BERYLLIUM, TOTAL	1.45	16.38	MG/KG	2
CADMIUM, TOTAL	1.33	34.84	MG/KG	4
CALCIUM, TOTAL	10114.49	116321.92	MG/KG	7
CHROMIUM, TOTAL	7.87	87.52	MG/KG	7
COBALT, TOTAL	22.22	104.11	MG/KG	2
COPPER, TOTAL	12.25	166.54	MG/KG	7
IRON, TOTAL	3746.90	17444.92	MG/KG	7
LEAD, TOTAL	6.68	52.58	MG/KG	7
MAGNESIUM, TOTAL	3859.06	57078.97	MG/KG	7
MANGANESE, TOTAL	119.19	1717.27	MG/KG	7
MERCURY, EP LEACHATE	.21	.32	UG/L	3
MERCURY, TOTAL	.14	.24	MG/KG	3
NICKEL, TOTAL	8.91	59.73	MG/KG	5
POTASSIUM, TOTAL	485.94	1451.80	MG/KG	7
SELENIUM, TOTAL	1.91	1.91	MG/KG	1
SILVER, TOTAL	6.84	506.05	MG/KG	2
SODIUM, TOTAL	355.52	1265.14	MG/KG	5
VANADIUM, TOTAL	14.09	289.53	MG/KG	7
ZINC, TOTAL	14.53	74.66	MG/KG	7

Burn Pit

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
2-METHYLNAPHTHALENE	50.00	50.00	UG/KG	1
AROCLOR-1016	290.00	290.00	UG/KG	1
AROCLOR-1242	290.00	290.00	UG/KG	1
AROCLOR-1248	200.00	200.00	UG/KG	1
AROCLOR-1254	1957.00	2700.00	UG/KG	2
BENZO(A)ANTHRACENE	61.00	64.00	UG/KG	2
BENZO(B)FLUORANTHENE	69.00	170.00	UG/KG	4
BENZO(G,H,I)PERYLENE	85.00	85.00	UG/KG	1
CHRYSENE	73.00	77.00	UG/KG	2
ETHYLBENZENE	270.00	270.00	UG/KG	1
FLUORANTHENE	74.00	220.00	UG/KG	4
PENTACHLOROPHENOL(2)	1200.00	2600.00	UG/KG	2
PHENANTHRENE	100.00	190.00	UG/KG	3
PHENOL	650.00	650.00	UG/KG	1
PYRENE	79.00	140.00	UG/KG	3
TETRACHLOROETHENE	260.00	260.00	UG/KG	1
TOTAL XYLENES	890.00	890.00	UG/KG	1

Burn Pit

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	.20	.60	PCI/G	6
NP-237	.10	.70	PCI/G	6
PU-238	.10	.50	PCI/G	6
PU-239/240	.10	.40	PCI/G	6
RA-226	2.00	3.90	PCI/G	6
RU-106	2.00	2.00	PCI/G	6
SR-90	.50	.90	PCI/G	6
TC-99	.40	64.00	PCI/G	6
TH-228	.10	9.60	PCI/G	6
TH-230	.10	26.00	PCI/G	6
TH-232	.10	7.70	PCI/G	6
U-234	9.90	415.00	PCI/G	6
U-235	.50	27.00	PCI/G	6
U-238	22.00	454.00	PCI/G	6

Clear Well

Inorganic

Compound	Minimun Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
ALUMINUM, TOTAL	12939.30	23770.50	MG/KG	4
ARSENIC, TOTAL	8.41	18.46	MG/KG	4
BARIUM, EP LEACHATE	1222.00	2613.00	UG/L	3
BARIUM, TOTAL	733.35	6913.40	MG/KG	4
BERYLLIUM, TOTAL	9.10	9.10	MG/KG	1
CADMIUM, TOTAL	5.11	7.15	MG/KG	2
CALCIUM, TOTAL	129304.89	183078.02	MG/KG	4
CHROMIUM, TOTAL	41.17	76.05	MG/KG	4
COBALT, TOTAL	18.34	18.34	MG/KG	1
COPPER, TOTAL	194.61	1119.30	MG/KG	4
CYANIDE, TOTAL	9.18	9.18	MG/KG	1
IRON, TOTAL	19618.07	21066.50	MG/KG	4
LEAD, TOTAL	32.26	83.00	MG/KG	4
MAGNESIUM, TOTAL	16784.64	44629.00	MG/KG	4
MANGANESE, TOTAL	761.15	1660.41	MG/KG	4
MERCURY, EP LEACHATE	.32	1.25	UG/L	4
MERCURY, TOTAL	.42	4.38	MG/KG	4
NICKEL, TOTAL	46.62	66.95	MG/KG	2
POTASSIUM, TOTAL	1690.00	3653.28	MG/KG	4
SELENIUM, TOTAL	3.72	3.72	MG/KG	1
SILVER, TOTAL	3.30	3.30	MG/KG	1
SODIUM, TOTAL	1293.44	3501.06	MG/KG	4
VANADIUM, TOTAL	99.70	2596.10	MG/KG	4
ZINC, TOTAL	81.81	194.35	MG/KG	4

Clear Well

Organic

Compound	Minimun Concentration	Maximum Concentration	Unit Of Measure	No. Of Measurements
AROCLOR-1248	308.00	308.00	UG/KG	1
AROCLOR-1254	737.00	737.00	UG/KG	1

Tue Nov 24

Clear Well

Radiochemistry

Compound	Minimum Activity Concentration	Maximum Activity Concentration	Unit Of Measure	No. Of Measurements
CS-137	18.00	450.00	PCI/G	4
NP-237	.40	2.70	PCI/G	4
PU-238	.10	.10	PCI/G	4
PU-239/240	.10	.10	PCI/G	4
RA-226	21.60	458.00	PCI/G	4
RU-106	3.00	24.00	PCI/G	4
SR-90	1.30	26.00	PCI/G	4
TC-99	.40	278.00	PCI/G	4
TH-228	.20	41.00	PCI/G	4
TH-230	.30	5600.00	PCI/G	4
TH-232	.10	39.00	PCI/G	4
U-234	242.00	376.00	PCI/G	4
U-235	24.00	49.00	PCI/G	4
U-238	548.00	670.00	PCI/G	4

APPENDIX D

D.1 DRILLING PROCEDURES

Soil borings are made to determine the nature, arrangement, thickness and extent of the soil strata. The depth of borings, frequency, and the type of testing and sampling required are dependent upon the purpose of the subsurface investigation.

Borehole advancement for monitoring wells will be performed using cable tool drilling techniques. The use of mud rotary or continuous flight hollow stem augers is prohibited for monitoring wells. A soil auger drilling rig will be used to collect undisturbed soil samples in clay layers that may be found in the till. With the cable tool techniques, the hammer is used to dislodge the soils and mix them with potable water for recovery and removal from the hole. Cable tool borehole drilling will be performed in accordance with Section 2.2.5, Percussion Drilling Borehole Advancement, IT Manual of Practice, Subsurface Investigations.

Comments from the IT Manual of Practice, Subsurface Investigations pertinent to the cable tool drilling technique follow:

- When advancing the boring using cable tool drilling techniques, a temporary steel casing will be drilled, driven, or pushed as the borehole is advanced. The temporary casing will be nominal ten-inch diameter to allow for construction of the monitoring well. Cuttings will be removed from the borehole using a sand pump or dart valve bailer.

- During the process of drilling monitoring wells, disturbed soil samples will be collected. Disturbed samples will be collected with a split-barrel or split-spoon sampler in accordance with ASTM D1586.

- Relatively undisturbed soil samples will be collected with thin-walled tubes or Shelby tubes in accordance with ASTM D1587. These samples will be collected with a soil auger drill rig. The soil auger drill rig will only be used for borings to collect samples for geochemical and geotechnical purposes. Undisturbed samples are not being collected from borings for monitoring wells because the heavy blows from cable tool (percussion) drilling will result in significant densification of cohesionless soils and remolding of cohesive soils, which will adversely affect sampling and testing operations.

- Drilling operations shall be performed in such a manner to minimize the introduction of contaminants into the subsurface soil and ground water. Accordingly, only clear, potable water will be used as a drilling fluid and only as a last resort. Water samples will be collected from the on-site source and each water tank hose and analyzed for the full list of organic, inorganic, and radiological parameters. If possible, all drilling operations will be performed dry without the use of water.

- The source(s) of any water to be used in drilling, grouting, and well and/or piezometer installation must be approved prior to field operations. Water used in aid of drilling will be analyzed and results reviewed prior to introduction into the borehole.

- Field Activity Daily Logs (Figure D-1) will be completed daily to indicate drilling and sampling activities such as footage drilled, materials used, etc. Boring logs (Figure D-2) will be generated to document subsurface conditions.

- The abandonment of borings and wells will be approved by the project director prior to any casing removal or sealing/backfilling. Once approved, these borings and/or wells shall be sealed by grouting from the bottom of the boring or well to ground surface. This shall be done by placing a grout pipe to the bottom of the boring or well and pumping grout through this until undiluted grout flows from the boring or well at ground surface. The grout shall consist of Volclay grout mixed properly with the recommended activator. After the grout has set (about 72 hours), the contractor shall check the abandoned site for grout settlement.

FIELD ACTIVITY DAILY LOG

PROJECT NAME	PROJECT NO.
FIELD ACTIVITY SUBJECT:	
DESCRIPTION ON DAILY ACTIVITIES AND EVENTS:	
VISITORS ON SITE:	CHANGES FROM PLANS AND SPECIFICATIONS, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.
WEATHER CONDITIONS:	IMPORTANT TELEPHONE CALLS:
PERSONNEL ON SITE:	
SUPERVISOR:	DATE:

FIGURE D-1

Any depression in the grout shall then be filled with additional grout. Methods other than those set forth herein may be implemented as dictated by appropriate state and/or local agencies.

- The use of dug sumps is not allowed. The use of drums or a plastic-lined, above-ground holding structure is required for cuttings and water removed from the borehole.

- No dyes, tracers, or other substances shall be used or otherwise introduced into borings, wells, piezometers, grout, backfill, ground water, or surface water unless specifically required by the contract.

- Drilling equipment that enters a boring will be cleaned using a high-pressure, hot-water sprayer between borings to prevent cross-contamination.

- Each operating drill rig shall have a geologist assigned to it who will be responsible for logging the samples, preparing the boring logs (Figure D-2) and well sketches, and installing the well. No geologist will be responsible for more than one operating rig per project site or installation involving soil sampling, rock coring, or monitoring well installation functions.

- Soils will be sampled continuously to the base of the till, then at five-foot intervals or at every lithologic change thereafter. These samples are to be obtained with a driven split-spoon or pushed thin-wall Shelby tube sampler or both in each boring. A sufficient number of continuous cores will be completed to adequately characterize the geology of the site.

The contractor shall be responsible for securing any and all boring or well drilling permits required by state or local authorities and for complying with any and all state or local regulations with regard to the submission of well logs, samples, etc.

The contractor shall also be responsible for complying with any and all regulations (to include placement) for drilling safety and underground utility detection.

260

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER:	PROJECT NAME	
BORING NUMBER:	COORDINATES:	DATE
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST:	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS:		PAGE OF

DEPTH	SAMPLE TYPE & NO.	BLOWS ON SAMPLER PER	RECOVERY	DESCRIPTION	USCS SYMBOL	MEASURED CONSISTENCY (TSF)	REMARKS

NOTES

FIGURE D-2

D.2 MONITORING WELL/PIEZOMETER DESIGN AND INSTALLATION 260

To provide proper quality control of monitoring well design and installation, the following standard operating procedures have been set forth, along with the applicable forms, to successfully complete a field drilling investigation that obtains hydrogeological and future water quality information.

All field measurements and comments will be recorded on the appropriate forms (Figures D-3 through D-7). Per data reporting format and protocols, all lines on the forms will be completed. The letter designation "NA" for not applicable or "NK" for not known will be used in all blank spaces. Also acceptable is a neat and precisely drawn arrow through applicable spaces from an "NA" or "NK." If some steps or procedures were not performed as described, the reason must be stated as completely as possible on the appropriate form or submitted as an attachment thereto.

All monitoring wells/piezometers will use the following design and materials:

- Well casing will be four-inch inside diameter, 316 stainless steel with flush-thread joints for monitoring wells.
- Five, ten, and fifteen foot sections of commercial 0.01-inch-slot stainless steel screens will be used (minimum three square inches open area per foot of screen).
- Screen gravel pack material will be a well-sorted medium or coarse quartz sand. A representative sample will be retained for documentation.
- Sodium bentonite pellets and Volclay grout will be used in the backfill for 1000- and 2000-series wells. Only Volclay grout will be used in 3000- and 4000-series wells. Samples of all grouts will be retained for documentation.
- Wells (1000 and 2000 series) will be backfilled with a sand pack to a height of two to four feet above the screen, then a five foot bentonite pellet plug will be placed on top of the sand pack and, finally, grout to the surface. The 3000- and 4000-series wells will be

FERNALD RI/FS

260

PIEZOMETER INSTALLATION SHEET

PROJECT NAME _____ FIELD ENG./GEO. _____ DATE _____
PROJECT NO. _____ CHECKED BY _____ DATE _____
BORING NO. _____
PIEZOMETER NO. _____ DATE OF INSTALLATION _____

BOREHOLE DRILLING

DRILLING METHOD _____	TYPE OF BIT _____
DRILLING FLUID (S) USED:	CASING SIZE (S) USED:
FLUID _____ FROM _____ TO _____	SIZE _____ FROM _____ TO _____
FLUID _____ FROM _____ TO _____	SIZE _____ FROM _____ TO _____

PIEZOMETER DESCRIPTION

TYPE _____	RISER PIPE MATERIAL _____
DIAMETER OF PERFORATED SECTION _____	RISER PIPE DIAMETERS:
PERFORATION TYPE:	O.D. _____ I.D. _____
SLOTS ☐ HOLES ☐ SCREEN ☐	LENGTH OF PIPE SECTIONS _____
AVERAGE SIZE OF PERFORATIONS _____	JOINING METHOD _____
TOTAL PERFORATED AREA _____	

PROTECTION SYSTEM

RISER PROTECTIVE PIPE LENGTH _____	OTHER PROTECTION _____
PROTECTIVE PIPE O.D. _____	

ITEM	DISTANCE ABOVE/BELOW GROUND SURFACE ( )		ELEVATION ( )	
TOP OF RISER PIPE				
GROUND SURFACE	0.0			
BOTTOM OF PROTECTIVE PIPE				
BOREHOLE FILL MATERIALS:				
GROUT/SLURRY	TOP	BOTTOM	TOP	BOTTOM
BENTONITE	TOP	BOTTOM	TOP	BOTTOM
SAND	TOP	BOTTOM	TOP	BOTTOM
GRAVEL	TOP	BOTTOM	TOP	BOTTOM
PERFORATED SECTION	TOP	BOTTOM	TOP	BOTTOM
PIEZOMETER TIP				
BOTTOM OF BOREHOLE				
GWL AFTER INSTALLATION				

WAS THE PIEZOMETER FLUSHED AFTER INSTALLATION? YES ☐ NO ☐
WAS A SENSITIVITY TEST PERFORMED ON THE PIEZOMETER? YES ☐ NO ☐
REMARKS _____

FIGURE D-3

DATE						
TIME						
PAGE ___ OF ___						
PAGE						

FERNALD
RI/FS

260

PIEZOMETER SENSITIVITY TEST

PROJET NAME_____TESTED BY_____DATE_____
PROJECT NO._____

BORING NO. _____
PIEZOMETER NO. _____
TEST TRIAL NO. _____
GWL BELOW TOP OF PIPE PRIOR TO TEST _____(M-scope, 0.01 foot accurac
TIME READING TAKEN _____

THE PIEZOMETER WAS FILLED WITH WATER. THE FOLLOWING DATA SHOW THE DROP OF WATER FROM THE TOP OF THE PIPE AS TIME ELAPSED.

ELAPSED TIME (MINUTES)	DROP OF WATER (FEET)

BASED ON THE ABOVE DATA, IT IS CONCLUDED THAT THE PIEZOMETER IS:

_____FUNCTIONING PROPERLY
_____NOT FUNCTIONING PROPERLY

FIGURE D-4

FERNALD RI/FS

PIEZOMETER DATA SHEET

PAGE ___ OF ___

PAGE

PROJECT NAME _____ PROJECT NO. _____

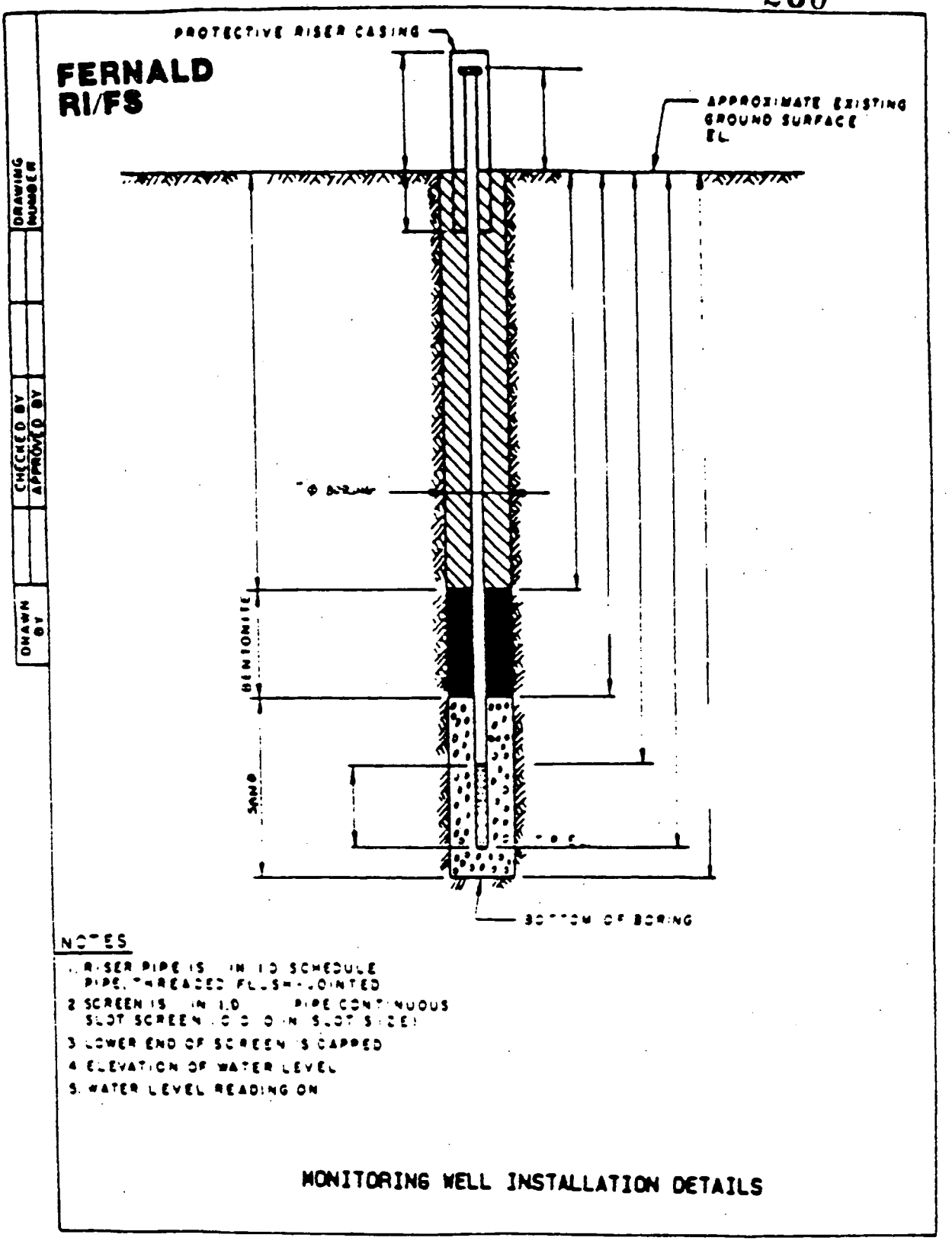
(1) DEPTH TO THE WATER LEVEL FROM THE TOP OF PIPE
(2) ELEVATIONS SHOWN ARE TOP OF PIEZOMETER PIPE

DATE & RECORDER	PIEZOMETER READINGS - FEET (1)										
	# EL (2)	# EL	# EL	# EL	# EL	# EL	# EL	# EL	# EL	# EL	# EL

ELEVATION OF WATER LEVEL - FEET

FIGURE D-5

260



182

FIGURE D-6

PAGE ___ OF ___

PAGE

PMPC 81/78
MONITORING WELL COMPLETION CHECKLIST
PROJECT 602

WELL NUMBER

ITEM											COMMENTS.
1. A steel protective casing with steel lid and hasp welded to casing has been installed with a lock.											
2. The protective casing has been painted satisfactorily.											
3. The well identification no. has been welded into the top of the protective casing.											
4. The well I.D. number has been painted with enamel type paint on the inside of the lid of the protective casing.											
5. The grout seal has been installed in the annulus between the well riser and the outer protective casing to a height of about 6" above ground surface.											
6. A weep hole has been drilled through the protective casing at the proper location.											
7. A 3 feet by 3 feet by 4 inch concrete pad has been installed around the protective casing.											
8. The disturbed area around the well has been regraded as per project specifications.											
9. The well riser is finished with a vented stainless steel cap.											
10. A measuring point notch is filed on the top of the well riser for vertical control.											
11. 3" diameter steel posts, located 4' radially around the well, placed 2' below the ground and having 4' minimally above the ground are concreted in place.											

Y = YES
N = NO

DATE: _____

FIGURE D-7

backfilled with a sandpack to a height of five feet above the screen and then grouted to the surface. The grout will consist of a slurry of American Colloid Company Volclay grout. A sample of the backfill material will be collected for analysis to identify the presence of contaminants of interest.

- Annular space grout seals will be composed of a Volclay grout mixed with potable water and activator as per manufacturer's instructions.

- All grout material will be placed using pumps and tremie line methods.

- A five-foot length (minimum thickness 1/4 inch) of ten-inch inside diameter black iron pipe will be used as a protective casing. Each protective casing will be fitted with a hinged cap, hasp, and lock. A drain hole will be drilled in the oversleeve one foot above the land surface.

- A mixture of approximately 1:2 cement:sand and approved water will be placed between the well riser and the outer protective casing to a height just below the drain hole mentioned above. This design will allow water which enters the annulus to drain.

- The top of the inside casing will be finished with a vented stainless steel cap or an airtight cap and a vent hole not more than six inches from the top of the casing.

- All wells and piezometers will be identified with a number welded into the lid of the protective casing. All protective casings will be painted high-visibility orange.

- A measuring point notch will be filed on the inner casing of each well and will be identified on the notes and well sketches.

- All disturbed drilling areas will be regraded and restored to near original conditions upon completion.

A one-quart or one-liter representative sample of each type of proposed granular backfill shall be submitted by the contractor for approval prior to use. Each sample shall be described in terms of lithology, grain size distribution, and source (both company from whom purchased and pit or quarry of origin). This

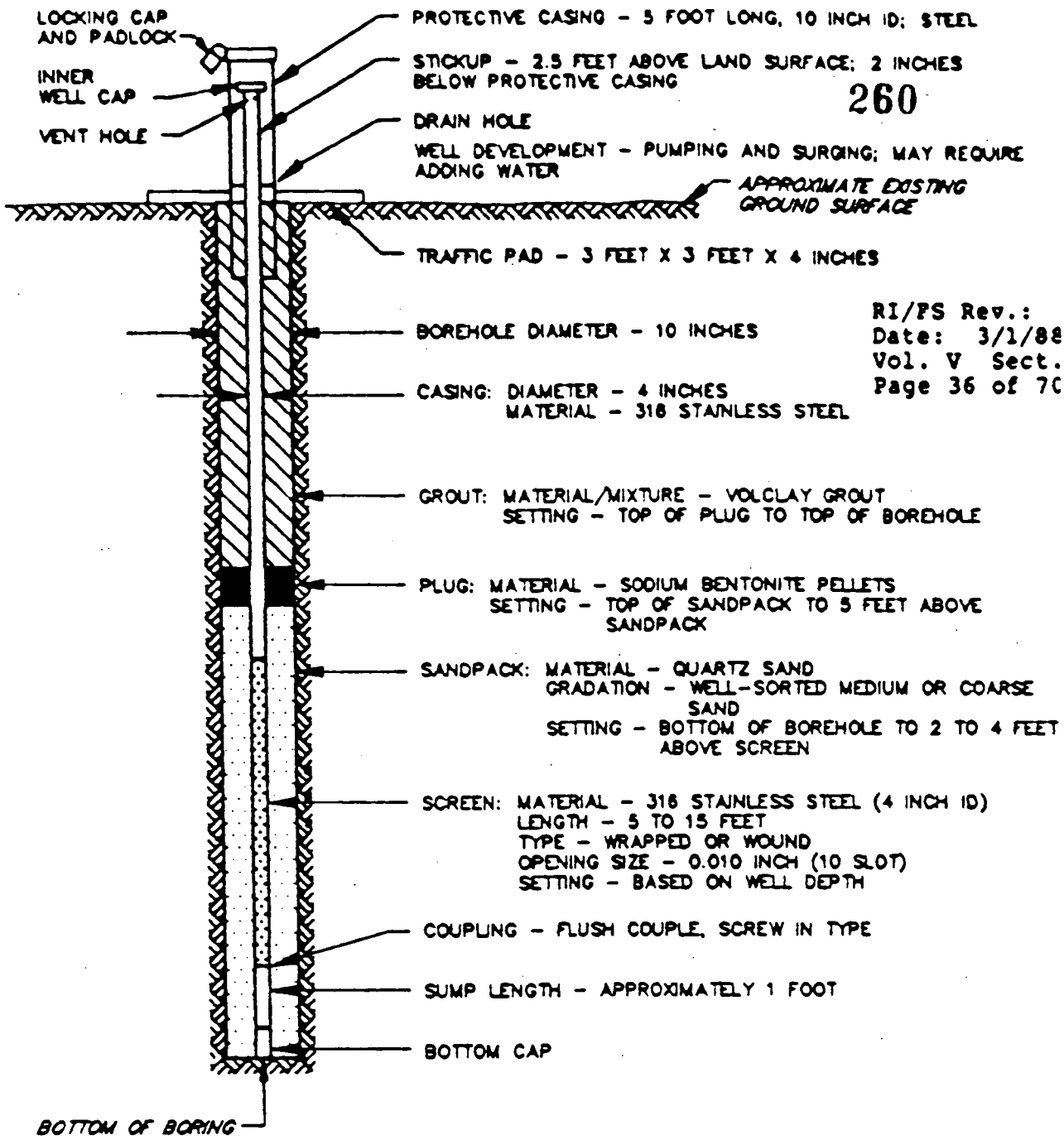
material shall be clean, inert, and siliceous. Typically, graded sand meeting the requirements of ASTM C-33 for fine aggregate (concrete sand) is sufficient.

A sketch of any well installation (see Figures D-8 and D-9) including piezometers, shall be recorded and shall show (by depth from surface grade) the bottom of the boring, screen location, granular backfill, seals, grout, cave-in, centralizers, if used, and height of riser above ground surface. The actual composition of the grout, seals, and granular backfill shall also be recorded. Also indicated shall be the screen, slot size (in inches), and slot configuration. Any use of polyvinylchloride (PVC) solvents, glues, or cleaners is prohibited.

Well sketches shall also include details of the protective casing.

Protective casing shall be installed around all monitoring wells. Exceptions will be on a case-by-case basis, as determined. Minimum elements in the protection design include:

- A five-foot minimum length of black 10-inch-diameter iron pipe or galvanized pipe extending approximately 2.5 feet above the ground surface and set in Volclay grout and concrete apron.
- A locking cover and lock shall be provided and secured to the top of each protective casing.
- The location identification shall be labeled on the well protector in two places using two methods: (1) painted on the inside of the cover with enamel type paint; and (2) welded into the top of the locking cover. Location identification shall conform with format and shall be designated by the site manager.
- The cover must keep precipitation out of the protective casing and shall be secured to that casing with a padlock.
- All padlocks at a given site shall be able to be opened by the same key.
- Protective casings are to be painted high-visibility orange.

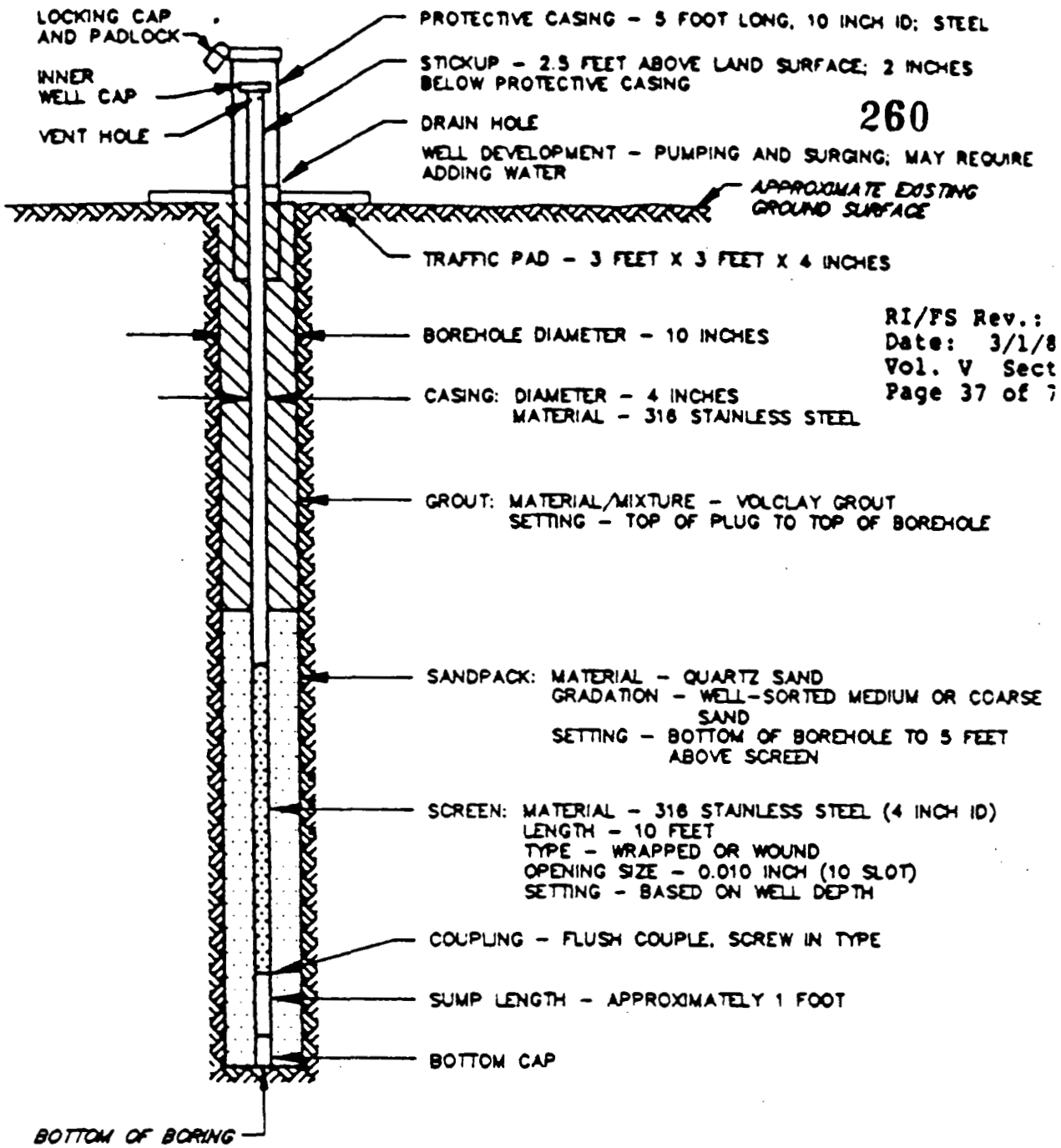


RI/FS Rev.:
Date: 3/1/88
Vol. V Sect.
Page 36 of 70

DRAWN BY R. Wattle 1-18-88
CHECKED BY
APPROVED BY
DRAWING NUMBER 303317-A16

FIGURE D-8

SUMMARY OF SPECIFICATIONS FOR WELL COMPLETION
100- AND 200- SERIES WELLS



DRAWN BY | R. Wilkin 1-18-88 | CHECKED BY | APPROVED BY | 3/25/88 | 3/25/88 | DRAWING NUMBER 303317-A17

FIGURE D-9

SUMMARY OF SPECIFICATIONS FOR WELL COMPLETION
300- AND 400- SERIES WELLS

- Three-inch diameter steel posts, each radially located four feet around each well, placed two feet below ground surface, concreted in place (optional), and having four feet minimum above ground surface.

Once the boring has been advanced to the desired depth, the well/piezometer will be constructed by the following procedure:

- Place the desired length of screen and casing inside the temporary casing.
- Place the sand pack in the annular space between the screen/casing and temporary casing.
- Withdraw the temporary casing slowly while placing sand pack material.
- After placing the sand pack to a level of at least two feet but not more than four feet above the screen, a five-foot-thick bentonite pellet layer (only for 100- and 200-series wells) is placed on top of the sand pack as the temporary casing continues to be withdrawn slowly. Periodic measurements will be made to check the uniform placement of the sand pack.
- The remaining annular space will be filled to the surface using Volclay grout.
- The temporary casing will be removed gradually as the backfill materials are placed in such a manner that the bottom of the temporary casing is kept below the top of the backfill material.
- The protective casing will be installed and concreted in place.
- A three-foot by three-foot by four-inch concrete apron will be installed around the protective casing.

D.3 MONITORING WELL DEVELOPMENT

The following procedure is presented for the proper development of monitoring wells and piezometers for ground water sampling purposes.

All field measurements and comments will be recorded on the appropriate data reporting form (Figure D-10). All lines on the form will be completed. The letter designation "NA" for not

FERNALD RI/FS
PROJECT NO. 602
TASK 3.2

MONITORING WELL DEVELOPMENT

PAGE ___ OF ___

WELL NUMBER _____

DATE(S) OF WELL INSTALLATION _____

WELL DEVELOPMENT START DATE/TIME _____ COMPLETION DATE/TIME _____ 260

		BEFORE DEVELOPMENT	AFTER DEVELOPMENT
STATIC WATER LEVEL			
DEPTH OF OPEN HOLE			
CHANGES IN PHYSICAL CHARACTER OF WATER REMOVED	TURBIDITY		
	COLOR		
	PARTICULATES		
	ODOR		

TOTAL CALCULATED VOLUME OF WATER TO BE REMOVED (IN GALLONS) _____

TOTAL VOLUME OF WATER ACTUALLY REMOVED DURING DEVELOPMENT (GALLONS) _____

TYPE AND SIZE OF PUMP _____ TYPE AND SIZE OF BAILER _____

PHYSICAL CHARACTER OF REMOVED SEDIMENTS (LITHOLOGY AND GRAIN SIZE)

DESCRIPTION OF SURGE TECHNIQUES (IF USED)

METER CALIBRATION

pH TEMP	pH STD.	pH STD.	SPECIFIC CONDUCT.	uMHOS/CM	uMHOS/CM	TURBIDITY NTU	TURBIDITY NTU

METER MODEL/ SERIAL NO.	pH METER	SPECIFIC CONDUCTANCE METER	TURBIDITY METER	DISSOLVED OXYGEN METER

FIELD ENGINEER/GEOLOGIST _____ DATE _____

DRILLER/HELPER _____

CHECKED/VERIFIED BY _____ DATE _____

MWDEV (2/88)

FIGURE D-10

DATE AND TIME SAMPLE COLLECTED	GALLONS OF WATER PURGED FROM WELL	TEMP.	SPECIFIC CONDUCTANCE	pH	DO	TURBIDITY	REMARKS 260

REMARKS/OBSERVATIONS

FIGURE D-10

(CONTINUED)

applicable or "NK" for not known will be used in all blank spaces. Also acceptable is a neat and precisely drawn arrow through applicable spaces from an "NA" or "NK." If some steps or procedures are not performed as described, the reason must be stated as completely as possible on the appropriate form or submitted as an attachment.

Monitoring well development will be performed as soon as possible after well installation, but no sooner than 48 hours after grouting is completed.

Well development equipment may include, but is not limited to, bailers, surge blocks, pumps, and hoses. Equipment and materials used for well development will be properly decontaminated the same way as drilling equipment, before and between each use. Decontamination will normally be high-pressure hot-water washing (steam cleaning) of equipment used to develop the well. However, if, during well development, the equipment becomes visibly contaminated, decontamination will be a high-pressure/hot-water wash, methanol wash followed by two separate deionized water rinses. In the case of visible inorganic contaminants (visibly contaminated with soil/sediment) decontamination will be high-pressure/ hot-water wash, dilute-hydrochloric-acid wash followed by two separate deionized water rinses. The internal mechanisms of pumps will be flushed using either dilute solutions of methanol and deionized water or dilute hydrochloric acid and deionized water when contaminants are visible. Development shall be continued with a sump and/or bottom discharge bailer, possibly supplemented with a surge block, until the well water is clear and sediment within the well is removed to the fullest extent practical. The natural hydraulic conductivity of the formation should have been restored and foreign sediment removed to provide turbid-free ground water samples. If the well continues to yield turbid ground water samples, the "Decision Chart for Turbid Ground-Water Samples" procedure described in the TEGD will be followed in an attempt to

achieve turbidity-free water. The recommended acceptance/ rejection value of five nephelometric turbidity units (NTU) is based on the need to minimize biochemical activity and possible interferences with ground water sample quality. As a minimum:

- For those wells where the boring was made without the use of drilling fluid water, remove five times the standing water volume in the well (well screen and casing plus saturated annulus). Should recharge be so slow that five volumes could not be removed in one day or the water remains discolored or contains greater than one percent particulates after this five volume removal, the hydrogeology task leader will direct an alternate procedure based on the judgment of the field geologist.

- For those wells where the boring was made or enlarged with the use of drilling fluid (water), remove five times the measured amount of total fluids lost while drilling plus five times the standing water volume as above. The same procedure also applies here as above for cases of slow recharge, discolored, or particulate-laden water.

- No water will be added to the well to assist development without prior approval. No dispersing agents, acids, or disinfectants will be used.

- During development, an effort will be made to remove the standing water from points near the bottom of the well screen as well as from the top of the water column.

- If problems are encountered during development, the task leader will be promptly notified by telephone.

- The volume of water collected for analysis will depend on the analytical needs of the project.

The following data will be recorded on the Monitoring Well Development form (Figure D-16) as part of development:

- Well designation (location ID);

- Date(s) of well installation;

- Date(s) and time of well development;

- Static water level before and after development;

FERNALD RI/FS
PROJECT NO. 602
TASK 3.2

MONITORING WELL DEVELOPMENT

PAGE ___ OF ___

WELL NUMBER _____

260

DATE(S) OF WELL INSTALLATION _____

WELL DEVELOPMENT START DATE/TIME _____ COMPLETION DATE/TIME _____

		BEFORE DEVELOPMENT	AFTER DEVELOPMENT
STATIC WATER LEVEL			
DEPTH OF OPEN HOLE			
CHANGES IN PHYSICAL CHARACTER OF WATER REMOVED	TURBIDITY		
	COLOR		
	PARTICULATES		
	ODOR		

TOTAL CALCULATED VOLUME OF WATER TO BE REMOVED (IN GALLONS) _____

TOTAL VOLUME OF WATER ACTUALLY REMOVED DURING DEVELOPMENT (GALLONS) _____

TYPE AND SIZE OF PUMP _____ TYPE AND SIZE OF BAILER _____

PHYSICAL CHARACTER OF REMOVED SEDIMENTS (LITHOLOGY AND GRAIN SIZE)

DESCRIPTION OF SURGE TECHNIQUES (IF USED)

METER CALIBRATION

pH TEMP	pH STD.	pH STD.	SPECIFIC CONDUCT.	uMHOS/CM	uMHOS/CM	TURBIDITY	
						NTU	NTU

METER MODEL/ SERIAL NO.	pH METER	SPECIFIC CONDUCTANCE METER	TURBIDITY METER	DISSOLVED OXYGEN METER

FIELD ENGINEER/GEOLOGIST _____ DATE _____

DRILLER/HELPER _____

CHECKED/VERIFIED BY _____ DATE _____

MWDEV (2/88)

193

FIGURE D-16

DATE AND TIME SAMPLE COLLECTED	GALLONS OF WATER PURGED FROM WELL	TEMP.	SPECIFIC CONDUCTANCE	pH	DO	TURBIDITY	REMARKS 260

REMARKS/OBSERVATIONS

FIGURE D-16

(CONTINUED)

- Quantity of water removed and time of removal;
- Depth of open hole inside the well before and after development;
- Physical character of the removed water, to include changes during development of turbidity, color, and odor;
- Physical character of removed sediments, to include lithology and grain size;
- Type and size/capacity of pump and/or bailer used;
- Description of surge techniques, if used; and
- Field characteristics of water removed including pH, specific conductance, temperature, and dissolved oxygen.

APPENDIX E

E.1 GROUND WATER SAMPLING TECHNIQUES

The primary consideration in ground water sampling is to obtain a representative sample of the ground water body. To safeguard against collecting nonrepresentative stagnant water from a well or piezometer, the following guidelines and techniques should be observed during sample withdrawal:

- As a general rule, all monitoring wells will be pumped or bailed prior to collecting a sample. Evacuation of at least three well volumes of water is recommended for a representative sample.

- For wells that can be pumped or bailed dry, the well will be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and if time allows, evacuation of more than one volume of water is recommended.

- As soon as the well recovers, samples will be collected in accordance with the stability and volatility of the parameters to be tested and the Water Quality Field Collection Report (Figure E-1) will be completed. For instance, samples for HSL volatile organic compounds, pH, specific conductance, and temperature will be collected first. Parameters which are not sensitive to pH or volatilization should be drawn last.

- For wells that cannot be pumped or bailed dry, at least three well volumes of water will be removed before collecting samples.

- Care will be taken to avoid excessive pumping of a monitoring well. Excessive pumping can lead to an increase or decrease in the concentrations of a contaminant at the sampling point of interest.

- A stainless steel submersible pump will be used to purge the monitoring wells prior to sample collection. A water-level measurement will be initially taken to determine the depth to ground water in the casing. The submersible pump will be lowered to a depth of five to ten feet below the water level, always above the well screen. The well will be initially purged from this depth so that fresh water from the screened interval will move upward through the casing and completely flush the well. The pumping rate will be less than 20 gallons per minute (gpm) and will continue until field pH, temperature, and specific conductance readings have stabilized.

- The purge pump and lines will be decontaminated between wells using procedures as specified below.

- If drawdown is significant, the submersible pump will be lowered during purging to keep the pump five to ten feet below the water level in the casing and the pumping rate will

DATE						
TIME						
PAGE ___ OF ___						
PAGE						

FERNALD RI/FS

260

WATER QUALITY FIELD COLLECTION REPORT

PROJECT NAME _____
PROJECT NUMBER _____
DATE COLLECTED _____
TIME COLLECTED _____
COLLECTED BY _____
DATE RECEIVED BY LAB _____
RECEIVED BY _____

SAMPLE DESCRIPTION

SAMPLE NUMBER _____
SAMPLE TYPE:
CHEM. _____ BACT. _____
FIXED _____ D.O. _____
(METALS) ORGANIC _____
NUTRIENTS _____

SAMPLING INFORMATION

AIR TEMPERATURE _____
WATER TEMPERATURE _____
DEPTH OF SAMPLE _____
pH _____ μ _____ μMHOS/CM
D.O. _____ MG/L

LOCATION SKETCH

METER CALIBRATION

pH TEMP.	pH STD.	pH STD.	D.O. TEMP.	D.O. @ 0	D.O. @ STD
OK ✓			OK ✓		

REDOX:
SAMPLE _____ mv @ _____ °C ZOBEL _____ mv @ _____ °C

EXACT LOCATION _____

WEATHER CONDITIONS _____

SOURCES OF POLLUTION _____

ADDITIONAL REMARKS _____

FIGURE E-1

be reduced.

- Once the well has been purged and allowed to recharge and stabilize, samples will be collected using a positive gas displacement stainless steel and/or Teflon bladder pump or Teflon bailer.

- During sampling, the pump will be operated continuously and the flow rate reduced to one liter/minute for the collection of volatile organic compound samples.

- When the pump and lines are removed from a well, they will be placed on plastic sheeting to avoid contact with the ground.

- Prior to reuse, the pump and lines will be drained and the outside surfaces will be decontaminated with a water wash and deionized water rinse. The internal surfaces will be decontaminated by pumping deionized water through the pump system. Purging of the next monitoring well will further reduce the possibility of cross contamination. Should the equipment become visibly contaminated, it will be disassembled and cleaned by the following procedures:

  - In the case of inorganic contaminants, the equipment will first be washed with a nonphosphate detergent and then rinsed with dilute (0.1 N) hydrochloric acid followed by two separate deionized water rinses.

  - In the case of organic contaminants, the equipment will first be washed with a nonphosphate detergent and then rinsed with tap water, methanol, and two separate deionized water rinses.

  - As described above, the equipment shall be thoroughly rinsed with two deionized water rinses to remove traces of hydrochloric acid, detergent, and methanol (acetone may be substituted for methanol if volatile organic compounds are not being determined).

  - Sampling equipment will not be placed directly on the ground or on other contaminated surfaces prior to insertion into the well, but will be placed on a clean plastic sheet adjacent to or around the well.

  - One sample of the final deionized water rinse will be collected in sample bottles containing the appropriate preservatives. Rinsate samples will be analyzed at a frequency of one per every set of twenty samples or fraction thereof to check for cross contamination between monitoring wells.

  - Decontamination of the submersible sampling pump(s) and other sampling equipment will be performed at a designated central staging area at the FMPC. If this is not possible due to extenuating circumstances, the sampling equipment may be decontaminated in the field.

- Existing wells with limited access will be sampled from the pump discharge.

- Field measurements will be performed on unpreserved samples immediately after sample collection. Samples collected for field measurements will be kept separate from samples preserved for shipment to the laboratory.

- A sufficient amount of sample will be collected to perform all the required analyses. The sample bottles containing the appropriate preservatives will be filled to the bottle neck with the sample, without overflowing. Sample container lids will be tight and secure.

- Samples collected will be stored in the field in a cooler and maintained at approximately 4 degrees Celsius using blue ice or other approved, sealed cooling materials.

- Samples will be properly labeled and chain-of-custody records, water quality field collection report (Figure E-1), sample collection log, and laboratory request for analysis forms will be properly filled out.

E.1.1 PARAMETER-SPECIFIC SAMPLING PROCEDURES

Water sample collection for volatile organic compounds, acid and base-neutral extractable compounds, dissolved metals, and general chemistry parameters should be performed in accordance with the following procedures:

- Volatile Organic Compounds

  - Two screw-cap vials with Teflon-lined silicone rubber septa (U.S. EPA-approved vials) will be filled to overflowing and sealed without any entrapped air bubbles. These vials will be 40 milliliters or larger.

  - Each vial will be visually checked for air bubbles and placed in a cooler.

  - A field/trip blank per each sample set will accompany the samples back to the laboratory. The field/trip blank will consist of organic-free deionized water used in the field to decontaminate the sampling equipment. The field/trip blank will monitor for ambient contamination levels in the cooler during transport. Field/trip blanks will be analyzed at a frequency of one per every set of twenty samples or fraction thereof.

  - Rinsate samples will be collected from sample collection tools following each well sampling to

monitor for potential cross contamination of samples between wells or laboratory cleaned sampling equipment will be used for each well. Rinsate samples will be analyzed at a frequency of one per every set of twenty samples or fraction thereof.

- A sample collection log, a chain-of-custody record, a laboratory request for analysis form, and a sample label will be completed in the field. All these forms, except for the sample collection log, will accompany the samples to the laboratory.

- The cooler will be packed with artificial icing material to maintain the samples at 4 degrees Celsius during shipment, sealed, and transported to the laboratory.

. Acid and Base-Neutral Extractable Compounds and Pesticides/PCBs

- Appropriate glass sample bottles complete with teflon-lined caps will be filled to capacity and sealed.

- The sample bottles will be placed in a cooler with sufficient packing to prevent breakage during shipment.

- A field/trip blank per each sample set will accompany the samples back to the laboratory. The field/trip blank will consist of organic-free deionized water used in the field to decontaminate the sampling equipment. Field/trip blanks will be analyzed at a frequency of one per every set of twenty samples or fraction thereof.

- Rinsate samples will be collected following each well sampling to monitor for potential cross contamination of samples between wells or laboratory cleaned sampling equipment will be used in each well. Rinsate samples will be analyzed at a frequency of one per every set of twenty samples or fraction thereof.

- A sample collection log, a chain-of-custody record, a laboratory request for analysis form, and a sample label will be filled out in the field. All of these forms, except for the sample collection log will accompany the samples to the laboratory.

- The cooler will be packed with artificial icing material to maintain the samples at 4 degrees Celsius during shipment, sealed, and transported to the laboratory.

- Dissolved Metals

  - When it is desired to determine concentrations of dissolved metals in a water system, the sample should be filtered in the field, as soon as possible after collection, through a 0.45-micron filter using a Millipore filtration apparatus or equivalent equipped with a hand or electrical vacuum pump.

  - The filtering apparatus or equivalent should be cleaned or rinsed thoroughly with deionized water before filtering each sample.

  - It is recommended that the first 100 to 150 milliliters of filtrate from each sample be discarded to rinse the filter and filtration apparatus of any contaminating substances.

  - The filtered sample is immediately transferred to a 500-milliliter plastic bottle containing one milliliter of concentrated nitric acid preservative per 100 milliliters of sample.

  - The sample pH will be checked with pH paper or a pH meter to check that the pH is less than two. The bottle will be sealed with a plastic cap fitted with a polyethylene liner.

  - A sample collection log, a chain-of-custody record, a laboratory request for analysis form, and a sample label will be completed in the field. All of these forms, except for the sample collection log, will accompany the sample to the laboratory.

- General Chemistry Parameters

  - Sample bottles will be either polyethylene or glass and will contain the appropriate chemical preservatives. Sample bottle closures will be plastic with polyethylene liners.

  - Sample bottles will be filled to capacity and sealed.

  - A field/trip blank per each sample set will accompany the samples back to the laboratory. The field/trip blank will consist of organic-free deionized water used in the field to decontaminate the sampling equipment. Field/trip blanks will be analyzed at a frequency of one per every set of twenty samples or fraction thereof.

  - Rinsate samples will be collected following each well sampling to monitor for potential cross contamination

of samples between wells or laboratory cleaned sampling equipment will be used for each well. Rinsate samples will be analyzed at a frequency of one per every set of twenty samples or fraction thereof.

- The sample bottles will be placed in a cooler with sufficient packing to prevent breakage during shipment.

- Collected samples will be stored in the field in an ice chest filled with blue ice and maintained at approximately 4 degrees Celsius.

- Samples will be properly labeled and sample collection logs, chain-of-custody records, and laboratory request for analysis form will be properly completed.

• Radionuclide Parameters

- In general, samples for radionuclide analyses can be collected in the same manner as samples for other chemical analyses.

- Flush sample lines and sampling equipment with sample medium to minimize radionuclide adsorption effects.

- Sample containers made of Teflon, polyethylene, or polyvinyl chloride (PVC) will be used to minimize radionuclide losses by adsorption. (Glass and metal containers tend to adsorb radionuclides.)

- Floating debris and bottom sediments will be avoided when sampling surface waters. Avoid suspended sediments when sampling ground water.

- The pump or Teflon bailer will be decontaminated in accordance with the procedures in Appendix D, Ground Water Sampling Techniques, to minimize contamination of subsequent samples.

- Water samples will be filtered in the field through an 0.45-micron membrane filter as soon as possible after sample collection when dissolved radionuclides are to be determined. Containers without preservative will be used to initially collect samples prior to filtration. Transfer samples to containers with preservative after filtration has been performed. When samples are collected for analysis of total radionuclide concentrations, containers with preservative will be used to collect the sample and filtration will not be required.

- Sample container lids will be tightly secured.

- Samples will be properly labeled and chain-of-custody records, sample collection logs, and laboratory request for analysis forms will be properly completed.

E.1.2 WATER LEVEL MEASUREMENTS

The following procedures should be followed for collecting water level data from wells:

- Obtain permission from owner to measure water level in well if required off site.
- In the case of domestic wells, ask the owner not to use water for short time so pump does not activate and affect water level. Make sure water level is stable.
- Remove well cap if an access hole is not available. (Be sure not to take water-level measurements in the riser pipe from the pump discharge line.)
- Lower M-scope probe until water is reached (this will be indicated by a buzzer, meter needle deflection, or light); raise probe above the water level and slightly shake; then lower again and recheck. Be careful not to get tangled with electrical wiring from pump, if present.
- Note depth to water to 0.01 foot from the measuring point, i.e., top of casing, top of sanitary seal.
- Enter water level and measuring point in log with date and time or on Figure E-2, Piezometer Data Sheet.
- Replace cover on well.

E.2 FIELD ANALYTICAL PROCEDURES FOR GROUND WATER SAMPLES

Immediately following sample collection, temperature, pH, specific conductance, and dissolved oxygen will be measured in the field and documented on the Water Quality Field Collection Report (Figure E-1). The following field procedures pertain to these tests. All determinations will be performed on unpreserved samples. In adverse weather conditions, field determinations may be performed indoors in an area maintained at 20 to 25 degrees Celsius. Ground water field measurements may also be taken in

FERNALD RI/FS

PIEZOMETER DATA SHEET

PAGE ____ OF ____

PAGE

PROJECT NAME _____ PROJECT NO. _____

(1) DEPTH TO THE WATER LEVEL FROM THE TOP OF PIPE
(2) ELEVATIONS SHOWN ARE TOP OF PIEZOMETER PIPE

DATE / RECORDER	PIEZOMETER READINGS - FEET (1)										
	# EL (2)	# EL	# EL	# EL	# EL	# EL	# EL	# EL	# EL	# EL	# EL

ELEVATION OF WATER LEVEL - FEET

FIGURE E-2

206

situ (downhole) to avoid changes which might occur if the sample is removed from the well.

E.2.1 TEMPERATURE

Scope and Application

The temperature of surface and ground water is important for numerous applications. It is required to normalize data from other analytical determinations such as pH, specific conductance, alkalinity, dissolved oxygen etc.

Summary of Method

Temperature readings are obtained by partially immersing the thermometer in a sample and allowing it to equilibrate for about two minutes. A minimum of two consecutive readings are obtained on each sample.

Apparatus

A metal-cased, direct-reading thermocouple with a normal range of zero to 50 degrees Celsius measured in two-degree intervals is used.

Measurement Practices

- Temperature readings should be taken immediately after sample collection on unpreserved samples.
- Readings should be taken until two identical values are obtained.
- The average readings for each sample will be documented immediately on field measurement or collection forms.

Reference

1. American Public Health Association, et al., 1985, Standard Methods for the Examination of Water and Wastewater, 16th Edition, Method 212, pp. 126-127.

E.2.2 pH

Scope and Application

pH is defined as the negative logarithm of hydrogen-ion activity in a sample and is a measure of effective hydrogen-ion concentration. The pH values are very useful for assessing the acidic or basic nature of a body of water and also for elucidating complex chemical reactions occurring in water.

Summary of Method

The pH of water is normally determined by immersing a combination electrode (glass and reference electrode) in the solution and measuring the potential difference with a pH meter.

Apparatus

- Standard pH meter (battery operated) with an expanded scale capable of measuring pH to the nearest 0.01 unit.
- Combination electrode.
- Three standard buffer solutions
  - pH 4.0;
  - pH 7.0; and
  - pH 10.0.
- A metal-cased direct-reading thermocouple with a normal range of zero to 50 degrees Celsius measured in two-degree intervals.

Calibration

- Expose filling hole by lowering rubber sleeve.
- Make sure that the electrode is filled with potassium chloride (KCl) solution.
- Rinse electrodes with distilled water.
- Set pH meter to proper ambient water temperature. Temperature correction of readings is automatic.

- Calibrate pH meter with at least two appropriate buffers before starting pH measurement and also after every fifth sample. Follow manufacturer's instructions for calibration.

Sample Measurement

- Rinse electrodes with distilled water.
- Transfer sample into a 100-milliliter beaker.
- Insert electrode into the sample solution and let it equilibrate for a few minutes. Stir the sample during measurement.
- Read the pH values on the pH meter to the nearest 0.1 unit.

Measurement Practices

- Measure temperature and set meter to the correct temperature setting.
- Rinse electrodes with distilled water between each measurement.
- Make sure that the line cord is properly attached to the instrument.
- Expose filling hole on the electrode by lowering rubber sleeve.
- Electrode tip needs to be immersed only one inch to obtain accurate readings.
- Never move or touch connecting cables during pH measurement.

References

1. American Public Health Association, et al., 1985, Standard Methods for the Examination of Water and Wastewater, 16th Edition, Method 423, pp. 429-437.

2. American Society for Testing and Materials (ASTM), 1985, Water, Standard D1293-84, pp. 253-264.

3. Instruction Manual for Orion's 407A Specific Ion Meter.

E.2.3 SPECIFIC CONDUCTANCE

Scope of Application

The ability of a solution to carry an electric current under specific conditions is reflected by specific conductance values. These values also indicate the concentration of dissolved solids in the natural water. Since specific conductance of a sample can change with time, this determination will be carried out in the field. The field measurement can also aid in assessing whether the sample is representative of the site.

Summary of Method

A conductivity cell is immersed in a sample of water and the conductance in micromhos per centimeter (umhos/cm) is measured directly from the meter. The readings are corrected for temperature and are recalculated for 25 degrees Celsius.

Apparatus

- Conductivity cell or probe;
- Conductivity meter; and
- Thermometer.

Calibration

- Switch on the instrument and let it warm up for a few minutes.
- Calibrate according to the manufacturer's instructions.

Sample Measurement

- Insert the probe completely into the sample.
- Switch the meter to the appropriate scale and record the readings in (umhos/cm).
- Measure the temperature of the sample with a thermometer.
- Record all readings on the field measurement form.

- Correct the specific conductances values for temperature using appropriate temperature correction factors.

Measurement Practice

- Replace battery when the read line adjustment cannot be accomplished.
- Rinse probe with distilled water between each measurement.

References

1. American Public Health Association, et al., 1985, Standard Methods for the Examination of Water and Wastewater, 16th Edition, Method 205, pp. 76-80.

2. Instruction Manual for YSI Model 33 S-C-T Meter, Yellow Springs Instrument Company.

E.2.4 DISSOLVED OXYGEN

Scope and Application

Adequate dissolved oxygen is necessary to maintain the life of aquatic organisms. The dissolved oxygen concentration may also have an effect on the redox potential of surface and ground water and the chemical behavior of aqueous constituents. Physical, chemical, and biochemical activities in water may affect the dissolved oxygen levels.

Summary of Method

Dissolved oxygen is normally measured in the field by immersing a membrane electrode into the water. Oxygen gas molecules diffuse through a membrane into a measuring cell at a rate proportional to the concentration of molecular oxygen in the water. Inside the sensor, the oxygen reacts with an electrolyte and is reduced spontaneously or by an applied voltage, depending on the instrument. The current that is generated is directly proportional to the concentration of molecular oxygen in the water outside the sensor. The instrument reading is converted to the concentration

of molecular oxygen present by calculation or proper calibration of the instrument.

Apparatus

- Oxygen-sensitive membrane electrode (polarographic or galvanic); this includes two solid metal electrodes separated from the test solution by a selective membrane (commonly polyethylene or fluorocarbon).
- Samples with known dissolved oxygen concentration for calibration or reading against water-saturated air;
- Distilled water for calibration and instrument cleaning; and
- A metal-cased, direct-reading thermocouple with a normal range of zero to 50 degrees Celsius measured in two-degree intervals.

Calibration

Follow the manufacturer's calibration instructions. Generally, calibration is performed against water-saturated air or water with a known dissolved oxygen concentration when measuring fresh water containing possible interfering substances.

Measurement Practices

- Temperature measurements should be taken at the time of dissolved oxygen reading.
- Insert probe into the sample.
- Allow sufficient sample flow across membrane surface to overcome any erratic responses of instrument.
- Read current from meter (correct for temperature if the equipment is so equipped).
- Record all readings on field measurement form (Water Quality Field Collection Report, Figure E-1).
- Convert current generated to concentration and correct for temperature (if the equipment does not compensate for temperature).

ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
CIS	Characterization Investigation Study
DOE	U.S. Department of Energy
EP	Extraction Procedure
EPA	Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
ft/day	Feet per day
ft/ft	Foot per foot
GQAPO	Groundwater Quality Assessment Program Outline
gpd/ft	Gallons per day per foot
GPR	Ground Penetrating Radar
HSL	Hazardous Substances List
MSL	Mean Sea Level
MW	Monitoring Well
OS	Offsite
PCB	Polychlorinated Biphenyl
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study
SC	Specific Conductance
SW-2	Southwestern Ohio Water Company - Collector No. 2
T*	T-statistic
T_c	T-statistic (comparison)

T_m	T-statistic (monitoring)
T_b	T-statistic (background)
TEGD	Technical Enforcement Guidance Document
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TP	Test Pit
U.S. EPA	United States Environmental Protection Agency
W_b	Weighting factor (background)
W_m	Weighting factor (monitoring)
WMCO	Westinghouse Materials Company of Ohio

- Frequently change and calibrate membrane electrode to eliminate interference from gases other than oxygen.

- Rinse probe with distilled water between each measurement.

- Store the probe in a water-saturated air environment.

References

1. American Public Health Association, et al., 1985, Standard Methods for the Examination of Water and Wastewater, 16th Edition, Method 421F, pp. 422-426.

REFERENCES

(1) WMCO, RCRA Part A Permit Application for the FMPC, Revision No. 4, dated September 21, 1987.

(2) WMCO, FMPC Response to Items B - B5 of RCRA Section (FFCA), dated October 16, 1987 (Revised: January 23, 1987).

(3) WMCO, FMPC Response to Items A.1 of RCRA Section (FFCA), dated August 17, 1986 (Revised: January 21, 1987).

(4) Dames & Moore, RCRA Groundwater Monitoring Report - 1987, Volume 5 - Round 5, dated November, 1987.

(5) U.S. EPA, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD), OSWER-9950.1, dated 1986.

(6) Dames & Moore, RCRA Groundwater Monitoring Report - 1987, Volume 3 - Round 3, dated March, 1987.

(7) Davis, S. N. and DeWiest, R. J., Hydrogeology, John Wiley & Sons, New York, 1966.

(8) ASI, Work Plan - Remedial Investigation and Feasibility Study, FMPC, Revision 3, dated March 1988.

(9) Dames & Moore, Groundwater Study - Task C Report, dated July, 1985.

(10) Roy F. Weston, Inc., Characterization Investigation Study, Volume 1: Geophysical Survey, dated September 1987.

(11) WMCO, Groundwater Quality Assessment Program Plan For Waste Pit No. 4, dated November 1987.

(12) ASI, Quality Assurance Project Plan - Remedial Investigation and Feasibility Study, FMPC, Revision 3, dated March 1, 1988.