3.0 Groundwater Pathway

Results in Brief: 2004 Groundwater Pathway

Groundwater Remedy – At the start of 2004, active restoration of the Great Miami Aquifer continued at the following five groundwater restoration modules:

- South Plume Module, which became operational on August 27, 1993
- South Field Extraction (Phase I) Module, which became operational on July 13, 1998
- South Plume Optimization Module, which became operational on August 9, 1998
- Re-injection Module, which became operational on September 2, 1998
- Waste Storage Area Module, which became operational on May 8, 2002.

The decision was made to convert the advanced wastewater treatment facility (AWWT) into a smaller facility that would remain after site closure in 2006. Construction to convert the facility began in the fall of 2004. Periodic well field operational disruptions occurred during the construction period. Start-up of the converted advanced wastewater treatment facility (CAWWT) is scheduled for spring 2005.

Well-based groundwater re-injection was permanently shut down at the end of September 2004; the remaining two extraction wells in the Waste Storage Area Module were shut down for preventative maintenance, and to support construction of the CAWWT. Based on updated groundwater modeling and the results of the cost/benefit analysis, the decision was made in 2004 to discontinue well-based re-injection. Operations in 2005 will proceed without well-based re-injection. Other operational strategies to enhance the aquifer remedy will be explored (e.g., inducing recharge to the Great Miami Aquifer through the Storm Sewer Outfall Ditch). After Storm Water Outfall Ditch testing is completed, the groundwater remedy design will be modified to incorporate lessons learned.

Since 1993

- 16,686 million gallons (63,157 million liters) of water have been pumped from the Great Miami Aquifer
- 1,936 million gallons (7,328 million liters) of water have been re-injected into the Great Miami Aquifer
- 6,522 net pounds (2,961 kg) of uranium have been removed from the Great Miami Aquifer.

During 2004

- 2,446 million gallons (9,258 million liters) of water were pumped from the Great Miami Aquifer
- 330 million gallons (1,249 million liters) of water were re-injected into the Great Miami Aquifer
- 922 net pounds (419 kg) of total uranium were removed from the Great Miami Aquifer.

Groundwater Monitoring Results – Uranium concentrations within the footprint of the maximum uranium plume continue to decrease in response to pumping.

- Groundwater sampling in the Plant 6 area following the completion of surface excavation activities indicates that no additional groundwater recovery infrastructure needs to be installed in the area prior to site closure in 2006.
- Characterization work began in the waste storage area for the last remaining module design, the Waste Storage Area (Phase II) Design. A decision concerning the need for additional extraction wells in this area is scheduled for 2005. Installation of any additional extraction wells is scheduled for completion prior to site closure in 2006.

On-site Disposal Facility Monitoring – Leak detection monitoring continued in 2004 for Cells 1 through 6 and was initiated for Cells 7 and 8. For those constituents monitored to meet on-site disposal facility requirements, there were no exceedances of groundwater FRLs for either the horizontal till wells or the Great Miami Aquifer wells. Data collected from the cells indicate that the liner systems are performing well within the specifications outlined in the approved cell design.

This chapter provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the Fernald site and summarizes:

- Aquifer restoration progress
- Groundwater monitoring activities and results for 2004.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the accelerated remediation strategy for the Fernald site. The FCP will continue to monitor the groundwater pathway throughout remediation to ensure the protection of this primary exposure pathway.

3.1 Summary of the Nature and Extent of Groundwater Contamination

Groundwater Modeling at the Fernald Site

The Fernald site uses a computer model to make predictions about how the contaminants in the aquifer will look in the future. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with field measurements obtained from groundwater monitoring activities.

If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase cleanup efficiency and reduce the cleanup time and cost, the operational changes are made and monitoring data are collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, modifications are made to the model to improve its predictive capabilities.

The nature and extent of groundwater contamination from operations at the Fernald site have been investigated, and the risk to human health and the environment from those contaminants has been evaluated in the Operable Unit 5 Remedial Investigation Report (DOE 1995d). As documented in that report, the primary groundwater contaminant at the site is uranium.

Groundwater contamination resulted from infiltration of contaminated surface water through the bed of Paddys Run, the Storm Sewer Outfall Ditch, and the Pilot Plant Drainage Ditch. In these areas, the glacial overburden is

eroded, creating a direct pathway between surface water and the sand and gravel of the aquifer. To a lesser degree, groundwater contamination also resulted where past excavations (such as the waste pits) removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

3.2 Selection and Design of the Groundwater Remedy

While a remedial investigation and feasibility study was in progress, and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993, this system was installed south of Willey Road and east of Paddys Run Road to stop the uranium plume in this area from migrating any farther to the south. Figure 3-1 shows the South Plume Module Extraction Wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southern migration of the uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

After the nature and extent of groundwater contamination were defined in the Operable Unit 5 Remedial Investigation Report, various remediation technologies were evaluated in the Feasibility Study Report for Operable Unit 5 (DOE 1995a). Remediation cost, efficiency, and various land-use scenarios were considered during the development of the preferred remedy for restoring the quality of the groundwater in the aquifer. The Operable Unit 5 Feasibility Study Report recommended a concentration-based, pump-and-treat remedy for the groundwater contaminated with uranium, consisting of 28 groundwater extraction wells located on and off property. Computer modeling suggested that the 28 extraction wells pumping at a combined rate of 4,000 gallons per minute (gpm) (15,140 liters per minute [Lpm]) would remediate the aquifer within 27 years.

The recommended groundwater remedy was presented to EPA, OEPA, and stakeholders in the Proposed Plan for Operable Unit 5 as the Preferred Groundwater Remedy (DOE 1995c). Once the Proposed Plan was approved, the Operable Unit 5 Record of Decision was presented to stakeholders and subsequently approved by EPA and OEPA in January 1996. The Operable Unit 5 Record of Decision (DOE 1996) formally defines the selected groundwater remedy and establishes FRLs for all constituents of concern.

Re-injection at the Fernald Site

From 1998 to 2004, re-injection was an enhancement to the groundwater remedy at the Fernald site, supplementing pump-and-treat operations. The term "well-based" refers to the injection of treated water through specially designed re-injection wells. Groundwater pumped from the aquifer is treated to remove contaminants and then re-injected into the aquifer at strategic well locations. Because the treatment process is not 100 percent efficient, a small amount of uranium is re-injected into the aquifer with the treated water. The re-injected groundwater increases the speed at which dissolved contaminants move through the aquifer and are pulled by extraction wells, thereby decreasing the overall remediation time. Based on updated groundwater modeling and the results of a cost/benefit analysis, re-injection was permanently shut down in 2004.

The Operable Unit 5 Record of Decision commits to an ongoing evaluation of innovative remediation technologies so that remedy performance can be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a). Groundwater modeling studies conducted in order to design the enhanced groundwater remedy suggested that, with the early installation of additional extraction wells and the use of re-injection technology, the remedy could potentially be reduced to 10 years. EPA and OEPA approved the enhanced groundwater remedy that relies on pump-and-treat and re-injection technology. As discussed below, the enhanced groundwater remedy is being used to clean up the Great Miami Aquifer. The enhanced groundwater remedy included the use of well-based re-injection up until September 2004.

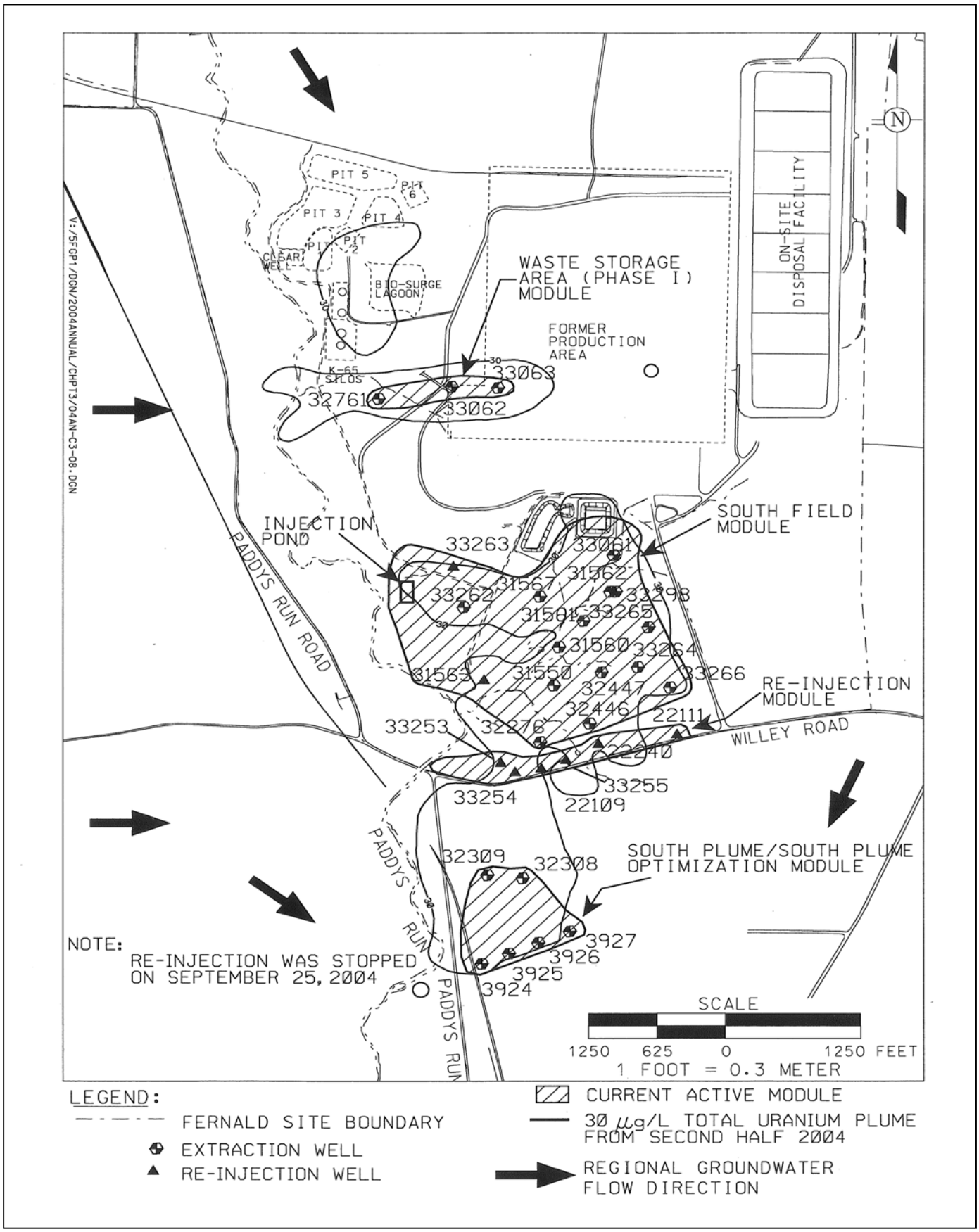

Figure 3-1. Extraction and Re-injection Wells Active in 2004

Evolution of the enhanced groundwater remedy has been documented through a series of approved designs. They are: The Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1), Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas (DOE 2001a), Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module (DOE 2002a), Comprehensive Groundwater Strategy Report (DOE 2003a), and the Groundwater Remedy Evaluation and Field Verification Plan (DOE 2004c).

The enhanced groundwater remedy commenced in 1998 with the start-up of the South Field (Phase I), South Plume Optimization, and Re-injection Demonstration Modules. It focuses primarily on the removal of uranium, but has also been designed to limit the further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the site's boundary. Start-up of the enhanced groundwater remedy included a year-long re-injection demonstration that was initiated in September 1998. Through the years, additional extraction and re-injection wells have been added to these initial restoration modules.

In 2001, the EPA and OEPA approved the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas. Approval of this design initiated the installation of the next planned aquifer restoration module. The design specified three extraction wells in the waste storage area to address contamination in the Pilot Plant Drainage Ditch plume (Phase I), and two extraction wells to address the remaining contamination after the waste pit excavation is completed (Phase II). One of the three Phase I waste storage area wells was installed in 2000 to support an aquifer pumping test to help determine the restoration well field design. The remaining two Phase I wells were installed in the summer of 2001 after the design was approved by EPA and OEPA. All three wells became operational on May 8, 2002. One was abandoned in 2004 in order to facilitate surface excavation work. A replacement well is scheduled for installation in 2005.

The Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas also provided data indicating that the uranium plume in the Plant 6 area was no longer present. It was believed that the uranium plume had dissipated to concentrations below the FRL as a result of the shut-down of plant operations in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action #1 in the early 1990s. Because a uranium plume with concentrations above the groundwater FRL was no longer present in the Plant 6 area at the time of the design, a restoration module for the area was determined to be unnecessary. Groundwater monitoring continued in the Plant 6 area with one well in the area having sporadic total uranium FRL exceedances.

In 2002, the EPA and OEPA approved the next planned groundwater restoration design document, the Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module. The Phase II design presents an updated interpretation of the uranium plume in the South Field area along with recommendations on how to proceed with remediation in the area, based on the updated plume interpretation. Installation of Phase II components was initiated in 2002. The overall system (Phases I and II) is referred to as the South Field Module.

In 2003, groundwater remediation approaches were evaluated to determine the most cost-effective groundwater remedy infrastructure, including the wastewater treatment facility, to remain after site closure. An evaluation of alternatives was put into the Comprehensive Groundwater Strategy Report. In October 2003, initial discussions were held with the regulators and the public concerning the various alternatives identified in the report. These discussions culminated in an identified path forward to work collaboratively with the Fernald Citizens Advisory Board, EPA, and OEPA to determine the most appropriate course of action for the ongoing aquifer restoration and water treatment activities at the Fernald site.

In 2004, a decision regarding the future aquifer restoration and wastewater treatment approach was made following regulatory and public input. In May, EPA and OEPA approved the decision to reduce the size of the AWWT; in June, they approved the decision to discontinue the use of well-based re-injection. Reducing the size of the AWWT provides the opportunity to dismantle and dispose of approximately 90 percent of the existing facility in the on-site disposal facility in time to meet the 2006 closure schedule, and results in a protective, more cost-effective, long-term water treatment facility to complete aquifer restoration. Well-based re-injection was discontinued based upon groundwater modeling cleanup predictions presented in the Comprehensive Groundwater Strategy Report and the Groundwater Remedy Evaluation and Field Verification Plan. The updated modeling indicated that the aquifer restoration time frame would likely be extended beyond dates previously predicted in part due to refined modeling input. The updated modeling also indicated that continued use of the groundwater re-injection wells would shorten the aquifer remedy by approximately three years. Therefore, the benefit of continuing re-injection did not justify the cost. Well-based re-injection was discontinued in September 2004 to support construction of the converted advanced wastewater treatment facility (CAWWT). The decision was made to not resume well-based re-injection once the CAWWT was operational in 2005. All re-injection wells are remaining in place as potential points for the groundwater remedy performance monitoring. Operations will proceed without well-based re-injection, and other operational strategies to enhance the aquifer remedy will be explored (e.g., inducing infiltration to the Great Miami Aquifer through the Storm Sewer Outfall Ditch). Testing to determine the feasibility of inducing infiltration to the Great Miami Aquifer through the Storm Sewer Outfall Ditch is scheduled for 2005. The controlling document for the testing is the Groundwater Remedy Evaluation and Field Verification Plan. The remedy design will be modified in 2005 to incorporate lessons learned from the testing.

During 2004, active remediation of the Great Miami Aquifer continued at the South Plume/South Plume Optimization, South Field, Waste Storage Area, and Re-injection Modules until September. As indicated above, well-based re-injection activities were discontinued in September. Additionally, the extraction wells in the waste storage area were shut down in September for preventative maintenance, and from October through December to support conversion of the AWWT to the CAWWT. Figure 3-1 shows the extraction and re-injection well locations that were active in 2004. The operational information associated with these modules is presented in the following subsections. Figure 3-2 identifies current and future extraction well locations. At the end of 2004, the only remaining planned enhanced groundwater remedy module component, pending design and installation, was the Phase II component of the Waste Storage Area Module. Characterization work began in the waste storage area for Waste Storage Area Module (Phase II) Design, and a decision concerning the need for additional extraction wells in this area is scheduled to be made in 2005. If additional extraction wells are needed, they will be installed and operational prior to site closure in 2006.

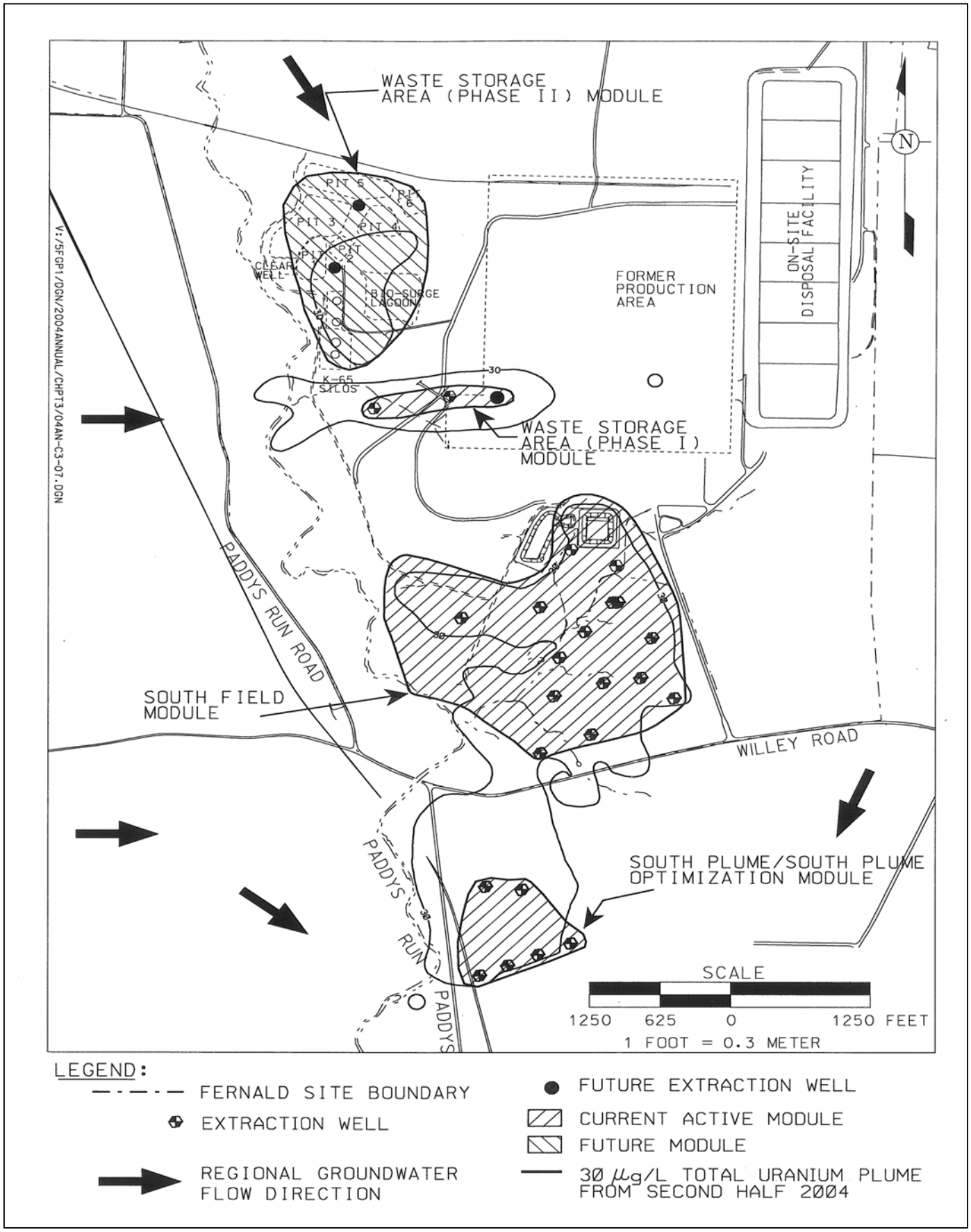

Figure 3-2. Current and Future Extraction and Re-injection Wells for the Enchanced Groundwater Remedy

3.3 Groundwater Monitoring Highlights for 2004

For this annual site report, groundwater monitoring results are discussed in terms of restoration and compliance monitoring.

The key elements of the Fernald site groundwater monitoring program design are described below. Note that with the implementation of the IEMP, Revision 3 (DOE 2003c), the groundwater monitoring approach was streamlined to focus on areas where exceedances (total uranium and non-uranium) were occurring while continuing to meet compliance requirements.

- **Sampling** – Sample locations, frequency, and constituents were selected to address operational assessment, restoration assessment, and compliance requirements. Selected wells are monitored for up to 50 groundwater FRL constituents. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction. Figure 3-3 shows a typical groundwater monitoring well at the site and Figure 3-4 identifies the relative placement depths of groundwater monitoring wells at the site. As part of the comprehensive groundwater monitoring program specified in the IEMP, approximately 150 wells were monitored for water quality in 2004. Figures 3-5 and 3-6 identify the locations of the current water quality monitoring wells. In addition to water quality monitoring, approximately 170 wells were monitored quarterly for groundwater elevations. Figure 3-7 depicts the routine water level (groundwater elevation) monitoring wells, including extraction wells, as specified in the IEMP.

- **Data Evaluation** – The integrated data evaluation process involves review and analysis of the data collected from wells to determine capture and restoration of the uranium plume; capture and restoration of non-uranium FRL constituents; water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules; and the impact of ongoing groundwater restoration on the Paddys Run Road Site plume (a separate contaminant plume south of the Fernald site along Paddys Run Road resulting from independent industrial activities in the area).

- **Reporting** – All data are reported through the IEMP program Mid-Year Data Summary Report and the annual Site Environmental Report.

3.3.1 Restoration Monitoring

In general, restoration monitoring tracks the progress of the groundwater remedy and water quality conditions. All operational modules were evaluated during the year to determine the progress of aquifer remediation. Concentration maps are developed from analytical data and compared with groundwater elevation maps depicting the location of capture zones.

More detailed information can be found in Appendix A of this report. Subsections that follow identify the specific attachment of Appendix A where the detailed information can be found.

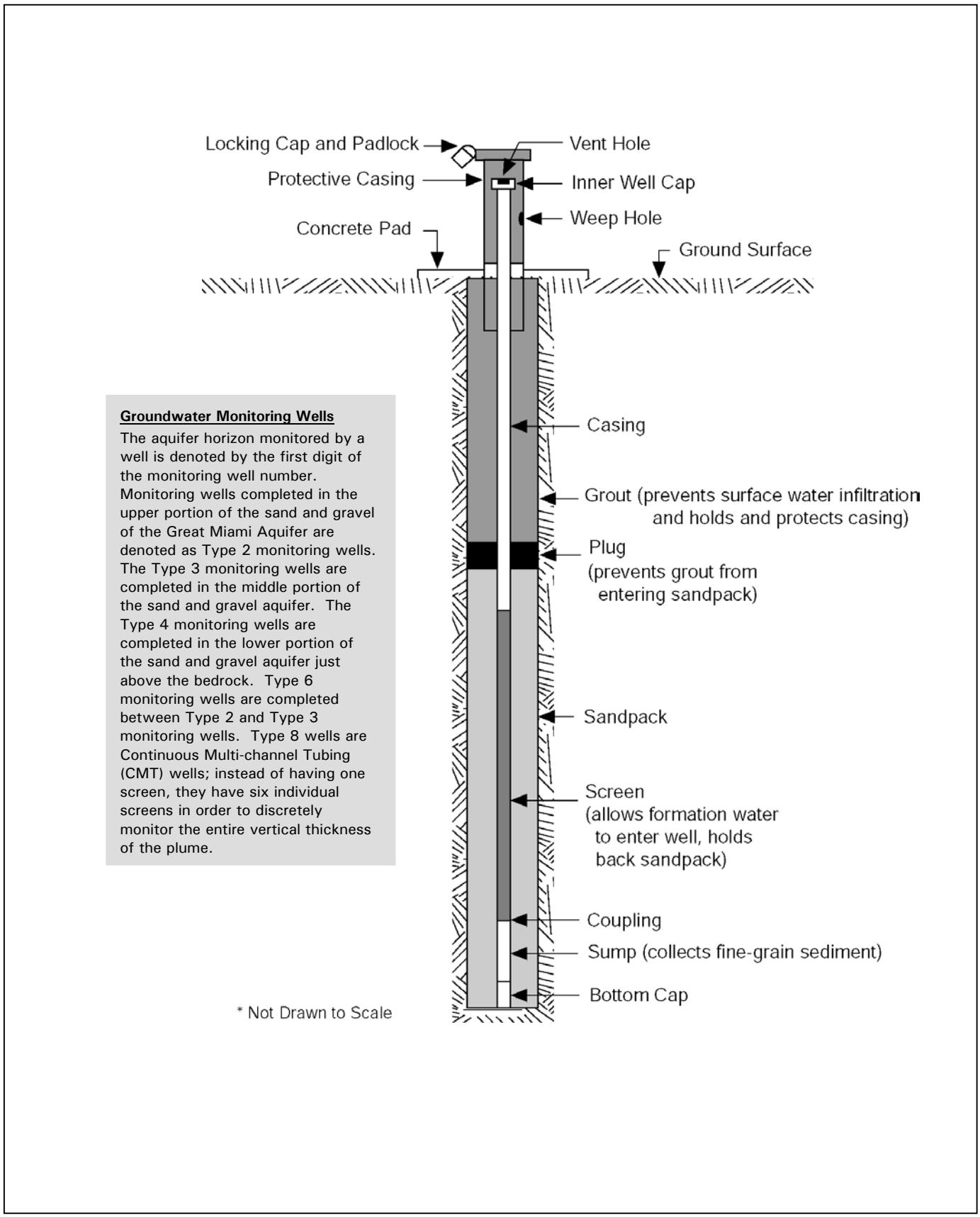

Figure 3-3. Diagram of a Typical Groundwater Monitoring Well

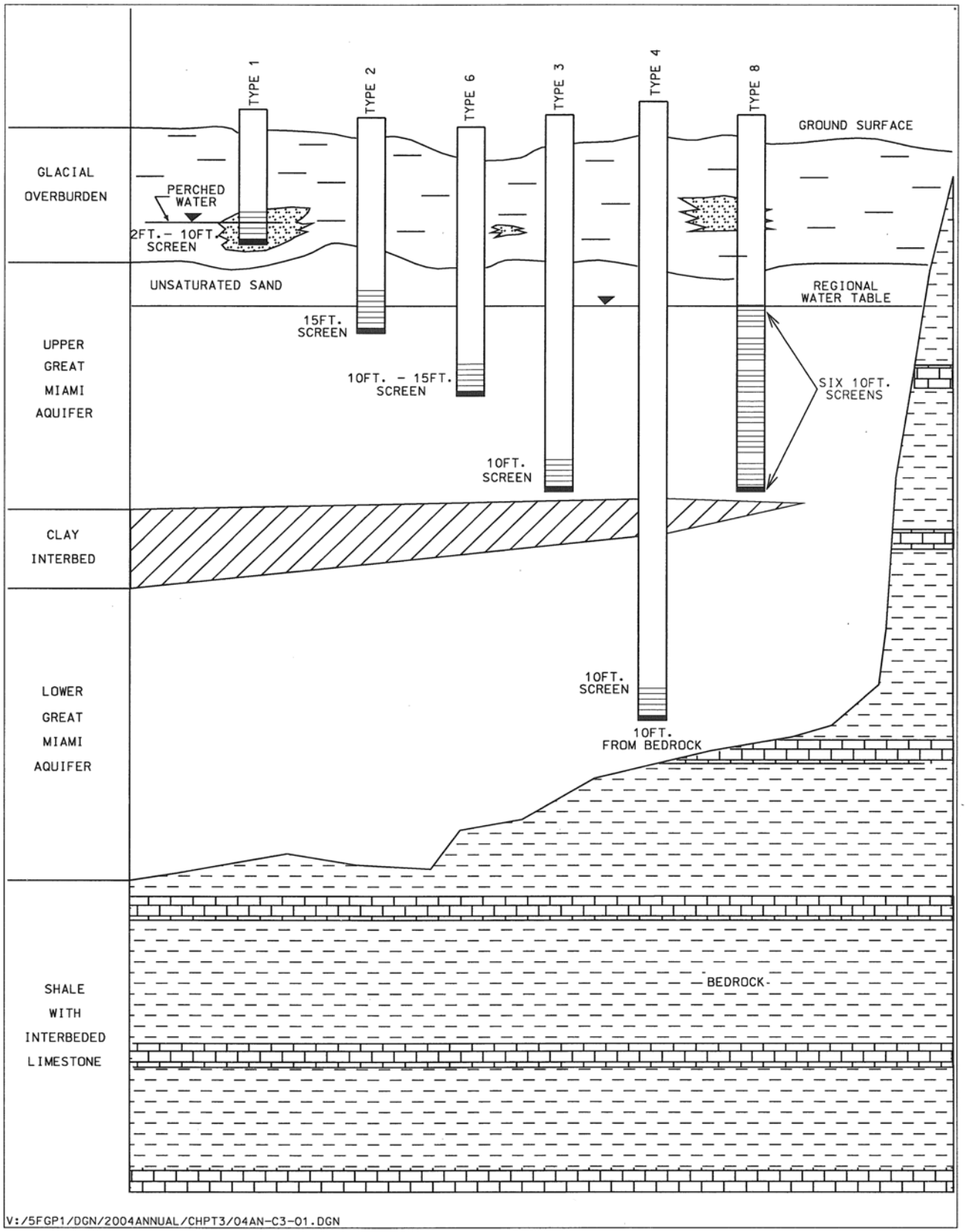

Figure 3-4. Monitoring Well Relative Depths and Screen Locations

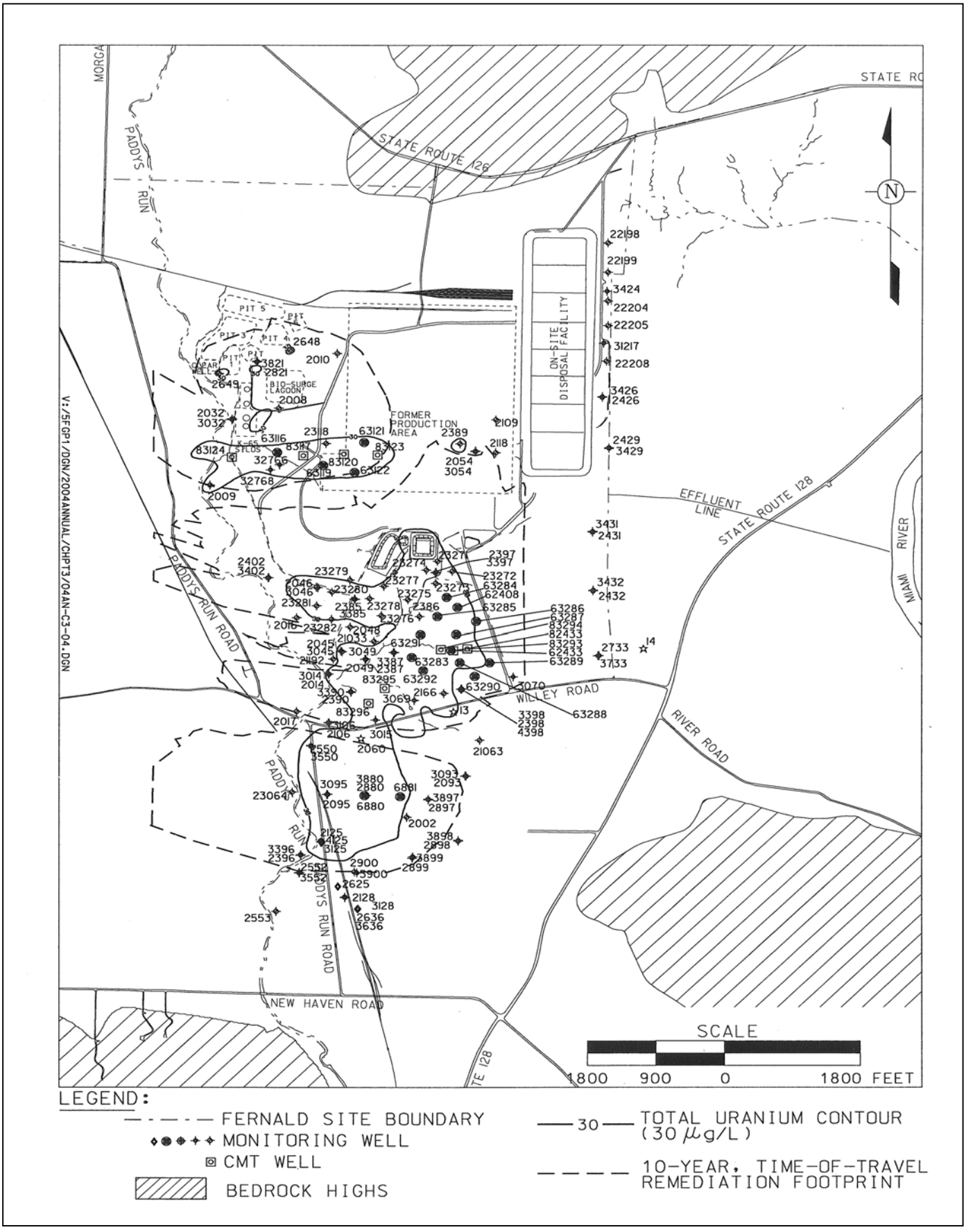

Figure 3-5. Locations for Semiannual Total Uranium Monitoring

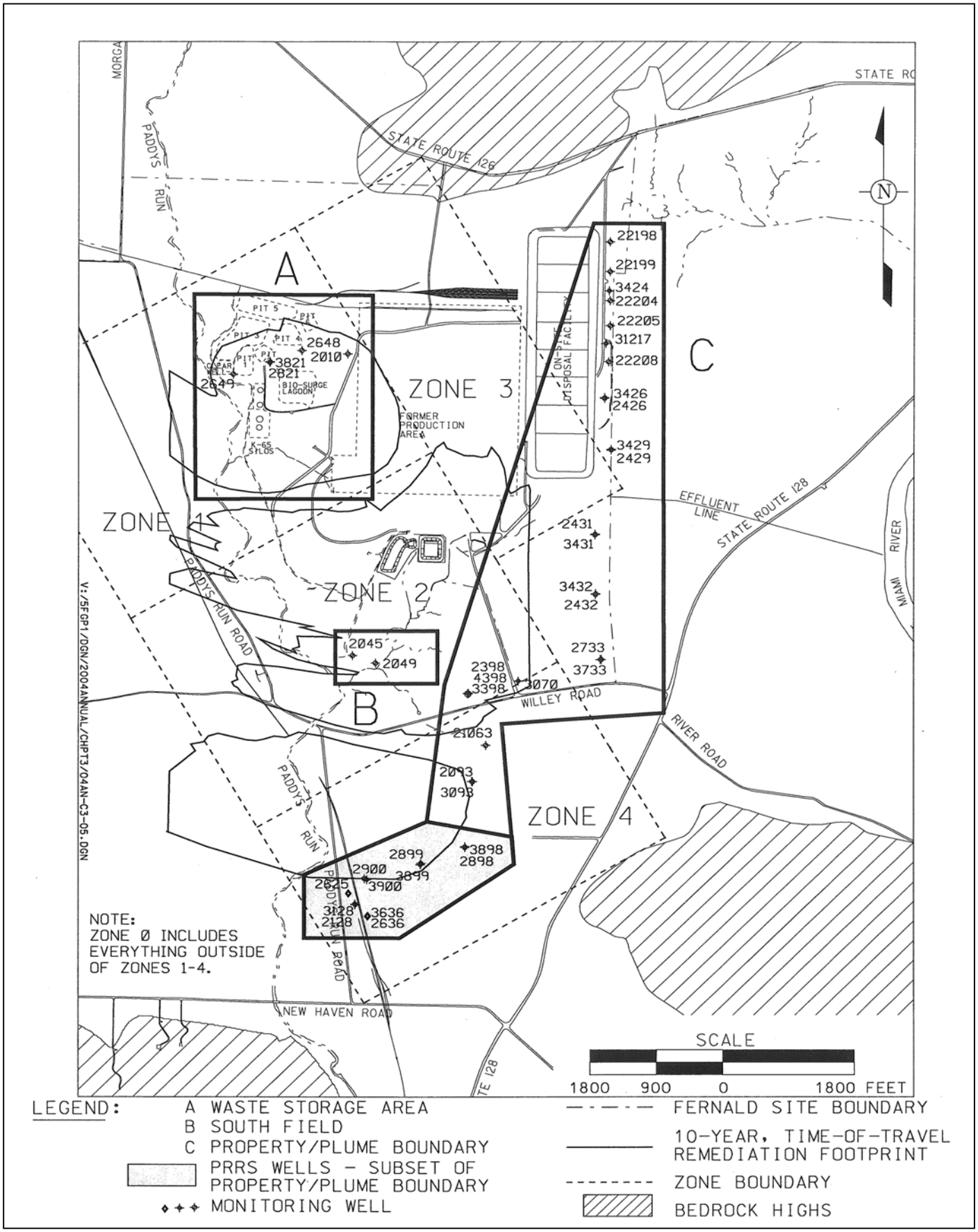

Figure 3-6. Locations for Semiannual Non-uranium Monitoring

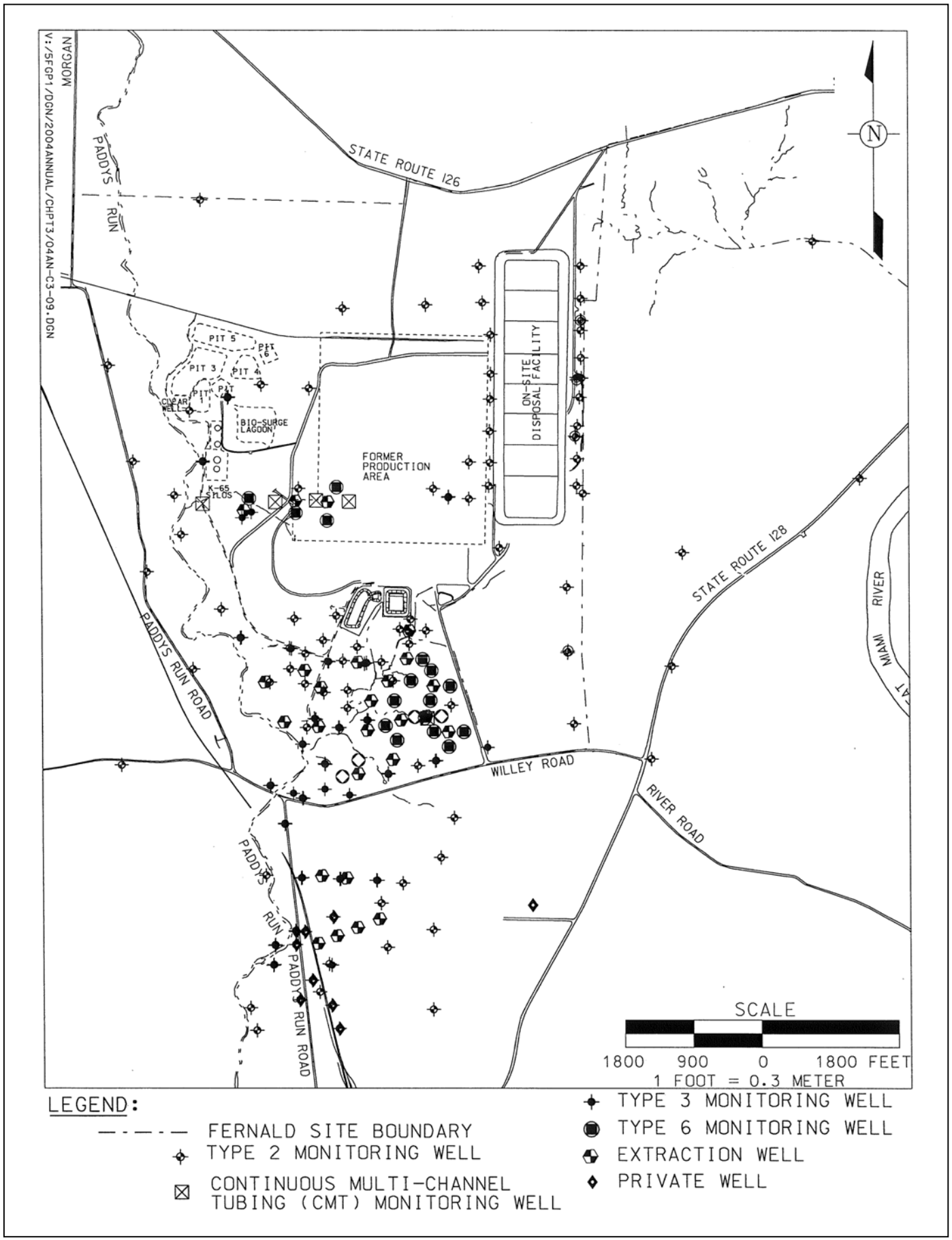

Figure 3-7. IEMP Groundwater Elevation Monitoring Wells

3.3.1.1 Operational Summary

Figure 3-1 shows the extraction and re-injection well locations associated with the restoration modules operating in 2004. With the exception of the waste storage area, all wells currently planned for the enhanced groundwater remedy have been installed. Table 3-1 summarizes the pounds of uranium removed, amount of groundwater pumped, pounds of uranium re-injected, and amount of treated groundwater re-injected by the active restoration modules during 2004. For reporting purposes, operational data for the re-injection wells located in the South Field as well as the Injection Pond (which is also located in the South Field) are tabulated with the Re-injection Module operational data in Table 3-1. Several operational disruptions were necessary during the period from October through December 2004 to facilitate construction of the CAWWT. Additional details are provided in the individual module operational summaries provided in Sections 3.3.1.2 through 3.3.1.5. Figure 3-8 identifies the yearly and cumulative pounds of uranium removed from the Great Miami Aquifer from 1993 through 2004.

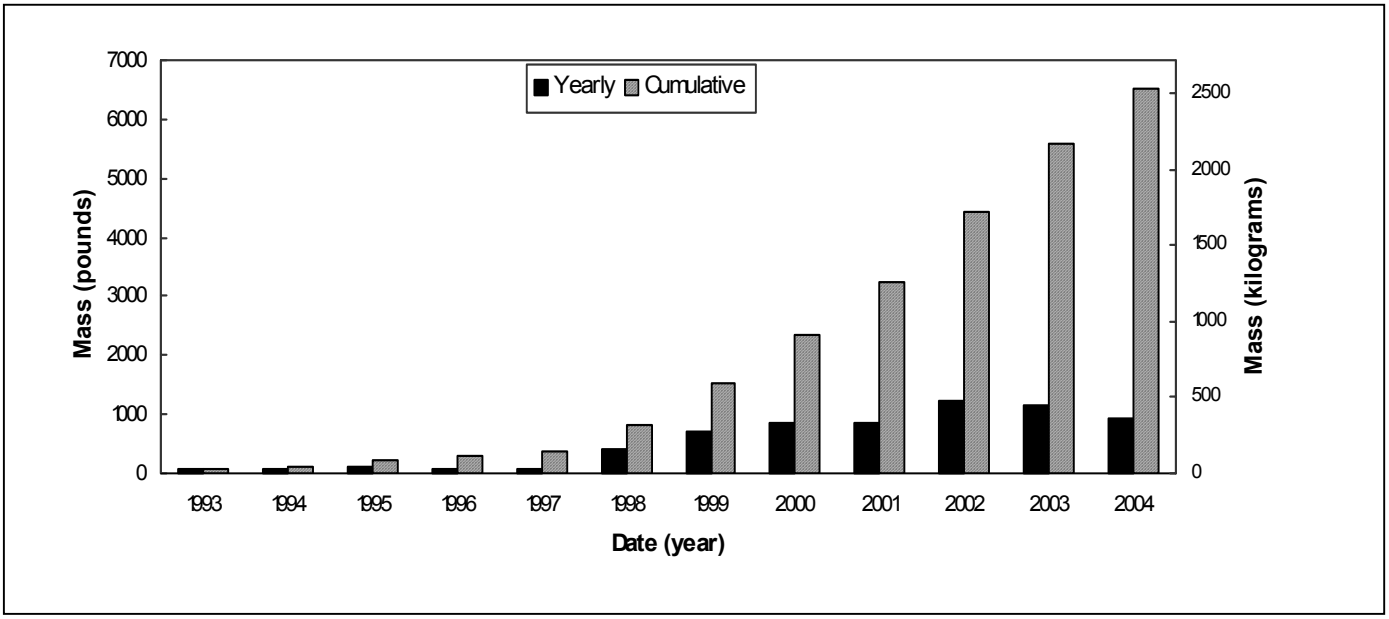

Figure 3-8. Net Pounds of Uranium Removed from the Great Miami Aquifer, 1993-2004

Since 1993:

- 16,686 million gallons (63,157 million liters) of water have been pumped from the Great Miami Aquifer
- 1,936 million gallons (7,328 million liters) of treated water have been re-injected into the Great Miami Aquifer
- 6,522 net pounds (2,961 kg) of total uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment A.1, of this report provides detailed operational information on each extraction and re-injection well, such as pumping and re-injection rates, uranium removal indices, and total uranium concentration graphs. Following is an overview of the individual modules.

TABLE 3-1
GROUNDWATER RESTORATION MODULE STATUS FOR 2004

Module	Restoration Wells	Target Pumping Rate gpm	Target Pumping Rate Lpm	Gallons Pumped/ (Gallons Re-injected) M gal	Gallons Pumped/ (Gallons Re-injected) M liters	Uranium Removed/ (Re-injected) lbs	Uranium Removed/ (Re-injected) kg
South Plume/ South Plume Optimization Module	3924 3925 3926 3927 32308 32309	1,900	7,191.50	750	2,838.75	159	72.19
South Field Module	31550 31560 31561 31562[a] 31563[b] 31564[c] 31565[d] 31566[e] 31567 32276 32446 32447 33061 33298 33262 33264 33265 33266	3,365[j]	12,736.53	1,341	5,075.69	599	271.95
Waste Storage Area Module	32761 33062 33063	1,100[k]	4,163.5	355	1,343.68	176	79.90
Re-injection Module and South Field Re-injection Wells and Pond	22107[f] 22108[g] 22109 22240 33253 33254 33255 33263[h] 31563[h] Injection Pond[i]	(1,425)[l]	(5,393.63)	(330)	(1,249.05)	(11.74)	(5.33)
Aquifer Restoration System Totals							
Pumped		6,365	24,091.53	2,446	9,258.11	934	424.04
(Re-injected)		(1,425)	(5,393.63)	(330)	(1,249.05)	(11.74)	(5.33)
Net		4,940	18,697.9	2,116	8,009.06	922	418.59

[a]Extraction Well 31562 began operating in July 1998. It was removed from service in March 2003 and was replaced by Extraction Well 33298 which became operational on July 29, 2003.

[b]Extraction Well 31563 began operating in July 1998. It was removed from service in December 2002.

[c]Extraction Well 31564 began operating in July 1998. It was removed from service in December 2001.

[d]Extraction Well 31565 began operating in July 1998. It was removed from service in May 2001.

[e]Extraction Well 31566 began operating in July 1998. It was removed from service in August 1998.

[f]Re-injection Well 22107 began operating in August 1998. It was replaced by Re-injection Well 33253 in November 2002.

[g]Re-injection Well 22108 began operating in August 1998. It was replaced by Re-injection Well 33254 in November 2002.

[h]Re-injection Wells 33263 and 31563 are located in the South Field.

[i]Injection Pond is located in the South Field.

[j]Target pumping rate from January 1, 2004 through September 24, 2004. Target pumping rate from September 25, 2004 through December 31, 2004 was 2,675 gallons (10,125 liters).

[k]In July 2004, Extraction Well 33063 was shut down so that it could be plugged and abandoned to facilitate surface excavation activities. From September through the remainder of the year, the two remaining extraction wells were shut down for preventive maintenance and to facilitate CAWWT construction.

[l]Well-based re-injection was permanently shut down in September 2004.

3.3.1.2 South Plume/South Plume Optimization Module Operational Summary

The four extraction wells of the South Plume Module (Extraction Wells 3924, 3925, 3926, and 3927) began operating in August 1993. The two extraction wells of the South Plume Optimization Module (Extraction Wells 32308 and 32309) began operating in August 1998. Figure 3-9 illustrates the uranium plume capture observed for the South Plume/South Plume Optimization Module in the fourth quarter of 2004. During 2004, 750 million gallons (2,839 million liters) of groundwater and 159 pounds (72 kg) of uranium were removed from the Great Miami Aquifer by the South Plume/South Plume Optimization Module. Pumping in the South Plume Module was disrupted in October and December 2004 to facilitate CAWWT construction. Based on analysis of the data in 2004, the module continues to meet its primary objectives as demonstrated by the following:

- Southward movement of the uranium plume beyond the southern most extraction wells has not been detected.
- Active remediation of the central portion of the off-property uranium plume continues to reduce plume concentration. Nearly the entire off-property uranium plume concentration is now below 100 µg/L. At the start of pumping in 1993, areas in the off-property uranium plume had concentrations over 300 µg/L.
- Paddys Run Road Site plume, located south of the extraction wells, is not being adversely affected by the pumping.

3.3.1.3 South Field Module Operational Summary

The South Field Module was constructed in two phases. Phase I began operating in July 1998 and Phase II began operating in July 2003. The 10 original extraction wells installed under Phase I were 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276. Five of the original 10 wells have been shutdown (31564, 31565, 31566, 31563, and 31562). Extraction Wells 31564 and 31565 were shut down in December 2001 and May 2001, respectively, to accommodate soil remedial activities. Extraction Well 31566 was shut down in August 1998, and was replaced by Extraction Well 33262, which was installed as part of South Field (Phase II) Module. Extraction Well 31563 was shut down in December 2002 and converted to a re-injection well that began operating in 2003. Extraction Well 31562 was shut down in March 2003 and replaced by Extraction Well 33298.

Three new extraction wells (Extraction Wells 32446, 32447, and 33061) were added to the South Field Module between 1998 and 2002. These three new extraction wells were installed in the eastern, downgradient portion of the South Field plume, at locations where total uranium concentrations were considerably above the associated FRL. Two of the three new wells (Extraction Wells 32446 and 32447) were installed in late 1999 and began pumping in February 2000. The third (Extraction Well 33061) was installed in 2001 and became operational in 2002.

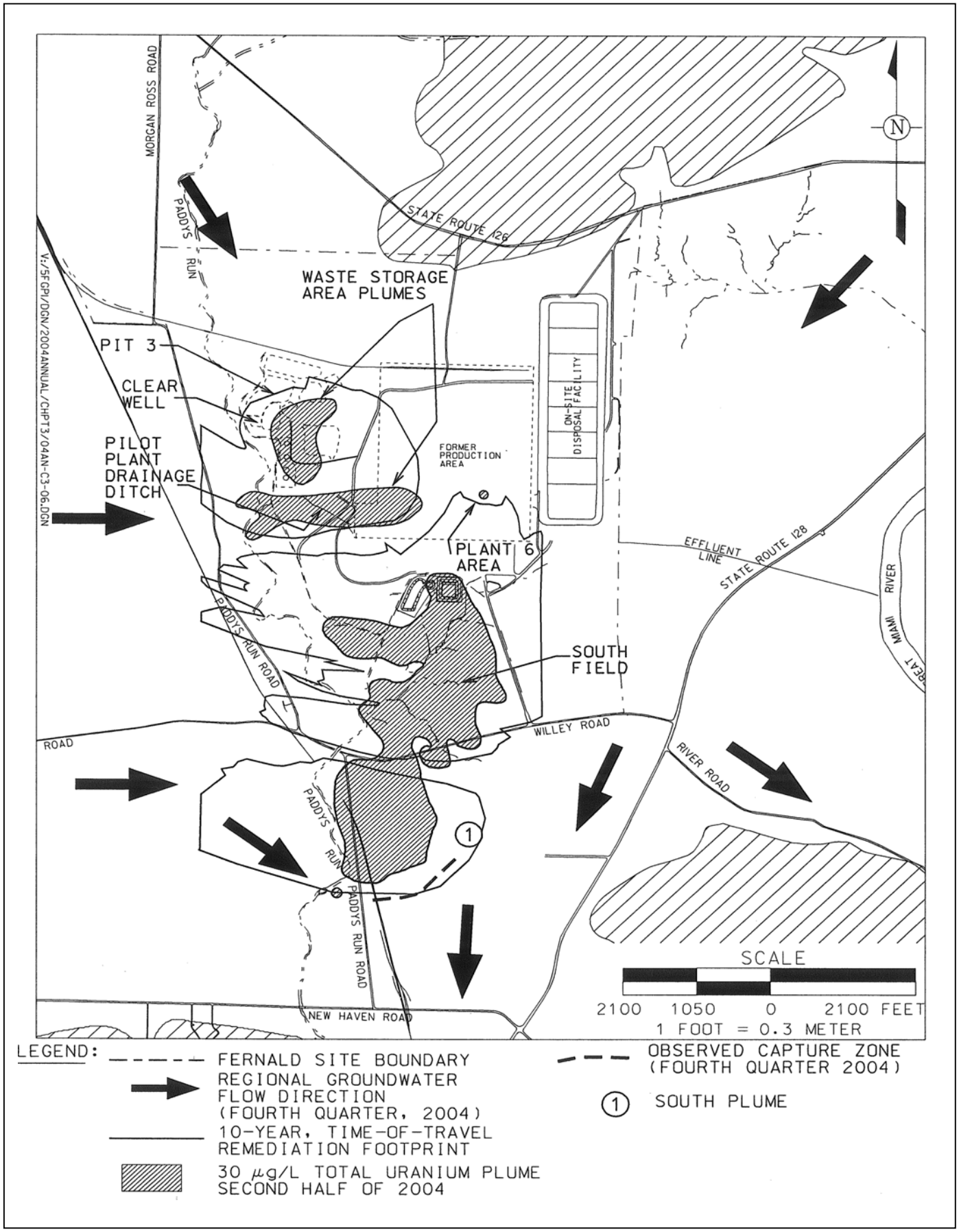

Figure 3-9. Total Uranium Plume in the Aquifer with Concentrations Greater than 30 µg/L at the End of 2004

Phase II components of the South Field Module are described in the Design for Remediation of the Great Miami Aquifer, South Field (Phase II) Module, which was issued in May of 2002. The design provides an updated characterization of the uranium plume in the Great Miami Aquifer beneath the southern portion of the Fernald site and a modeled design for the South Field Module located in that area. All Phase II design components became operational in 2003. The components include:

- Four additional extraction wells, one in the Southern Waste Unit area (Extraction Well 33262), and three along the eastern edge of the on-property portion of the southern uranium plume (Extraction Wells 33264, 33265, and 33266).
- One additional re-injection well in the Southern Waste Units area (Re-injection Well 33263).
- A converted extraction well (Extraction Well 31563), which was converted into a re-injection well.
- An injection pond, which is located in the western portion of the Southern Waste Units excavations.

During 2004, 1,341 million gallons (5,076 million liters) of groundwater and 599 pounds (272 kg) of uranium were removed from the Great Miami Aquifer by the South Field Module. Wells in the South Field Module were shut down at various times from October through December to facilitate CAWWT construction.

3.3.1.4 Re-injection Module Operational Summary

The use of re-injection at the Fernald site began with a demonstration test that was conducted from September 2, 1998 to September 2, 1999. The demonstration indicated that re-injection was a viable technology for the aquifer remedy. Based on the success of the demonstration, it was decided to incorporate re-injection technology into the aquifer remedy. The Re-injection Demonstration Test Report detailing the demonstration was issued to EPA and OEPA on May 30, 2000.

The original Re-injection Module consisted of five re-injection wells (Re-injection Wells 22107, 22108, 22109, 22111, and 22240). Residual plugging of the re-injection wells became a concern in the last half of 2000. During 2001, the re-injection wells were subjected to the new treatment method and this new process was economically viable in three of the five original wells (Re-injection Wells 22109, 22111, and 22240). It was determined that it was more cost effective to replace the other two wells (Re-injection Wells 22107 and 22109) rather than attempt another treatment.

Re-injection Well 22107 was replaced by Re-injection Well 33253. Re-injection Well 22108 was replaced by Re-injection Well 33254. These two new replacement wells began operating in November 2002. In addition to the two new replacement wells, a sixth re-injection well (Re-injection Well 33255) was added to the module. This new re-injection well is located half way between Re-injection Wells 22109 and 22240, and began operating on May 22, 2003. During 2004, 330 million gallons (1,249 million liters) of groundwater and 11.74 pounds (5.33 kg) of uranium were re-injected into the Great Miami Aquifer by the Re-injection Module wells and re-injection wells, and the Injection Pond in the South Field Module. Re-injection Module wells operated less frequently in 2004 than in previous years.

During the first quarter of 2004, the wells were often turned off in order to meet discharge limits at the Parshall Flume and, as previously stated, well-based re-injection was permanently shut down in September of 2004. Groundwater modeling presented in the Comprehensive Groundwater Strategy Report predicts that continued use of large-scale re-injection using current re-injection wells would shorten the aquifer remedy by only three years. These results indicate limited benefit to maintaining the infrastructure for large-scale, well-based re-injection. Re-injection wells will not be plugged and abandoned so they can serve as future aquifer monitoring locations.

3.3.1.5 Waste Storage Area (Phase I) Operational Summary

The Waste Storage Area Module became operational on May 8, 2002, nearly 17 months ahead of the start date of October 1, 2003 established in the Operable Unit 5 Remedial Action Work Plan. The module consisted of three extraction wells: 32761, 33062, and 33063. These three wells were installed to remediate a uranium plume in the Pilot Plant Drainage Ditch area, according to the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas. In July 2004, Extraction Well 33063 was plugged and abandoned to make way for surface excavation activities. Additionally, monitoring wells that hindered surface excavation activities (Monitoring Wells 83120, 83123, 63121, and 63122) were plugged and abandoned in 2004. The remaining two extraction wells in the Waste Storage Area Module were shut down at the end of September for preventative maintenance and from October through December to facilitate construction of the CAWWT. Upon completion of the CAWWT in 2005, the extraction wells will become operational once again. A replacement for Extraction Well 33063 is planned for 2005. Other monitoring wells will also be replaced in 2005 as necessary. During 2004, 355 million gallons (1,344 million liters) and 176 pounds (80 kg) of uranium were removed from the Great Miami Aquifer by the Waste Storage Area Module.

3.3.1.6 Monitoring Results for Total Uranium

The 10-year, time-of-travel remediation footprint is an updated model prediction. It illustrates how far a particle of water will travel in response to pumping over a 10-year time period using current pumping locations and target pumping rates for 2003. It replaces the 10-year, uranium-based restoration footprint that was prepared several years ago based on previous model predictions using previous pumping locations and rates that are no longer relevant.

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant and has impacted the largest area of the aquifer. Figure 3-9 shows general groundwater flow directions observed during the fourth quarter of 2004 and the interpretation of the uranium plume in the aquifer updated through the second half of 2004. The shaded areas represent the interpreted size of the maximum uranium plume that is above the 30-µg/L groundwater FRL for total uranium. As of December 31, 2004, approximately 196 acres (79 hectares) of the Great Miami Aquifer were contaminated above the 30-µg/L groundwater FRL for total uranium, identified as an increase of 17 acres from the 179-acre area identified in 2003. The increase was due to additional characterization work in the Waste Storage Area (Phase II) Module Design. Capture zones observed during the fourth quarter of 2004 for the active restoration modules are also identified on Figure 3-9. These capture zones indicate that the South Plume is being captured by the existing system and that farther movement of uranium to the south of the extraction wells is being prevented. Figure 3-9 also depicts the 10-year, time-of-travel remediation footprint that was predicted using 2003 target pumping rates and no well-based re-injection.

Geoprobe® (Direct-Push Sampling)

The Geoprobe®, a hydraulically powered, direct-push sampling tool, is used at the Fernald site to obtain groundwater samples at specific intervals without installing a permanent monitoring well. Direct-push means that the tool employs the weight of the vehicle it is mounted on and percussive force to push into the ground without drilling (or cutting) to displace soil in the tool's path. The Fernald site uses this technique to collect data on the progress of aquifer restoration and to determine the optimal location and depth of additional monitoring and extraction wells that may be installed in the future.

Waste Storage Area – In 2004, the footprint of the maximum uranium plume in the waste storage area was revised to incorporate new data collected from existing monitoring wells and from five direct-push sampling locations, sampled as part of the Waste Storage Area Module (Phase II) Design. The new outline of the 30-ug/L uranium plume is shown in Figure 3-9. Phase II of the Waste Storage Area Module is currently being designed to address the plume in the Waste Storage Area that is not already being addressed by the Waste Storage Area (Phase I) Module. Additional direct-push sampling for the Waste Storage Area (Phase II) Design will be completed in 2005. A final design for the Waste Storage Area (Phase II) Module will be issued in 2005.

Plant 6 Area – During 2004, surface excavation work in the Plant 6 area was completed. As a follow-up to the excavation work, direct-push groundwater sampling was conducted in the Plant 6 area to determine if any groundwater FRL exceedances for uranium or technetium-99 were present in the Great Miami Aquifer that might require the installation of an extraction well prior to site closure in 2006. Each direct-push sampling location was sampled at different depths below the water table in order to obtain a depth/concentration profile. The direct-push data indicate that no additional extraction wells are needed. However, groundwater monitoring results in the second half of 2004 indicated that an FRL exceedance for uranium was detected at Monitoring Well 2389. Monitoring Well 2389 has had a history of sporadic uranium FRL exceedances. It appears that a thin layer of uranium contamination is present in the upper foot of the aquifer at this location. There is not enough contamination to require the installation of a groundwater extraction well, but continued groundwater monitoring in the area is warranted.

South Field and South Plume Areas – Data collected in 2004 indicate that uranium concentrations continue to decrease in the South Field and South Plume areas in response to remediation activities. The outline of the maximum uranium plume updated through 2004 is provided in Figure 3-9. In the second half of 2004, a uranium FRL exceedance was detected south of the main body of the plume. Data collected in 2004 also provide evidence for concentration rebound occurring in the South Field. In 2004, uranium concentrations increased in Monitoring Well 2045 with a correlating rise in water level. The rise in water level is attributed to seasonal water table fluctuations due to recharge, and to shutting down a nearby extraction well. The source of the uranium is attributed to uranium partitioned to aquifer sediment in the vadose zone. Concentration rebounds after pumping stops are common for pump-and-treat remediation operations. Concentration rebounds are expected to occur at other monitoring locations when extraction wells are shut down, and will be factored into future operational decisions.

Appendix A, Attachment A.2, provides individual monitoring well total uranium results and detailed uranium plume maps for 2004. Appendix A, Attachment A.3, provides quarterly groundwater elevation maps and capture zone interpretations, along with graphical displays of groundwater elevation data.

3.3.1.7 Monitoring Results for Non-uranium Constituents

Although the enhanced groundwater remedy is primarily targeting remediation of the uranium plume, other FRL constituents contained within the uranium plume are also being monitored. Figure 3-10 identifies the locations of the wells that had non-uranium FRL exceedances, and Table 3-2 summarizes the results of monitoring for non-uranium FRL exceedances. Table 3-2 shows the number of wells exceeding the FRL in 2004; the number of wells exceeding the FRL outside the 10-year, time-of-travel remediation footprint; the groundwater FRL; and the range of 2004 data inside or outside the 10-year, time-of-travel remediation footprint.

TABLE 3-2
NON-URANIUM CONSTITUENTS WITH RESULTS ABOVE FINAL REMEDIATION LEVELS DURING 2004

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the 10-Year, Time-of-Travel Remediation Footprint	Groundwater FRL	Range of 2004 Data Inside the 10-Year, Time-of-Travel Remediation Footprint[a]	Range of 2004 Data Outside the 10-Year, Time-of-Travel Remediation Footprint[a]
General Chemistry			**(mg/L)**	**(mg/L)**	**(mg/L)**
Nitrate/Nitrite	2	0	11[b]	16.6 to 102	NA
Inorganics					
Antimony	1	1	0.0060	NA	0.00741
Arsenic	1	1	0.050	NA	0.051
Manganese	6	3	0.90	1.59 to 6.14	1.34 to 1.44
Molybdenum	1	0	0.10	0.436 to 0.539	NA
Zinc	1	1	0.021	NA	0.155
Volatile Organics			**(µg/L)**	**(µg/L)**	**(µg/L)**
Carbon disulfide	1	0	5.5	7.79	NA
Trichloroethene	1	0	5.0	54.7 to 56.5	NA
Radionuclides			**(pCi/L)**	**(pCi/L)**	**(pCi/L)**
Technetium-99	2	0	94	233 to 906	NA

[a]NA = not applicable
[b]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4; however, the sampling results are for nitrate/nitrite.

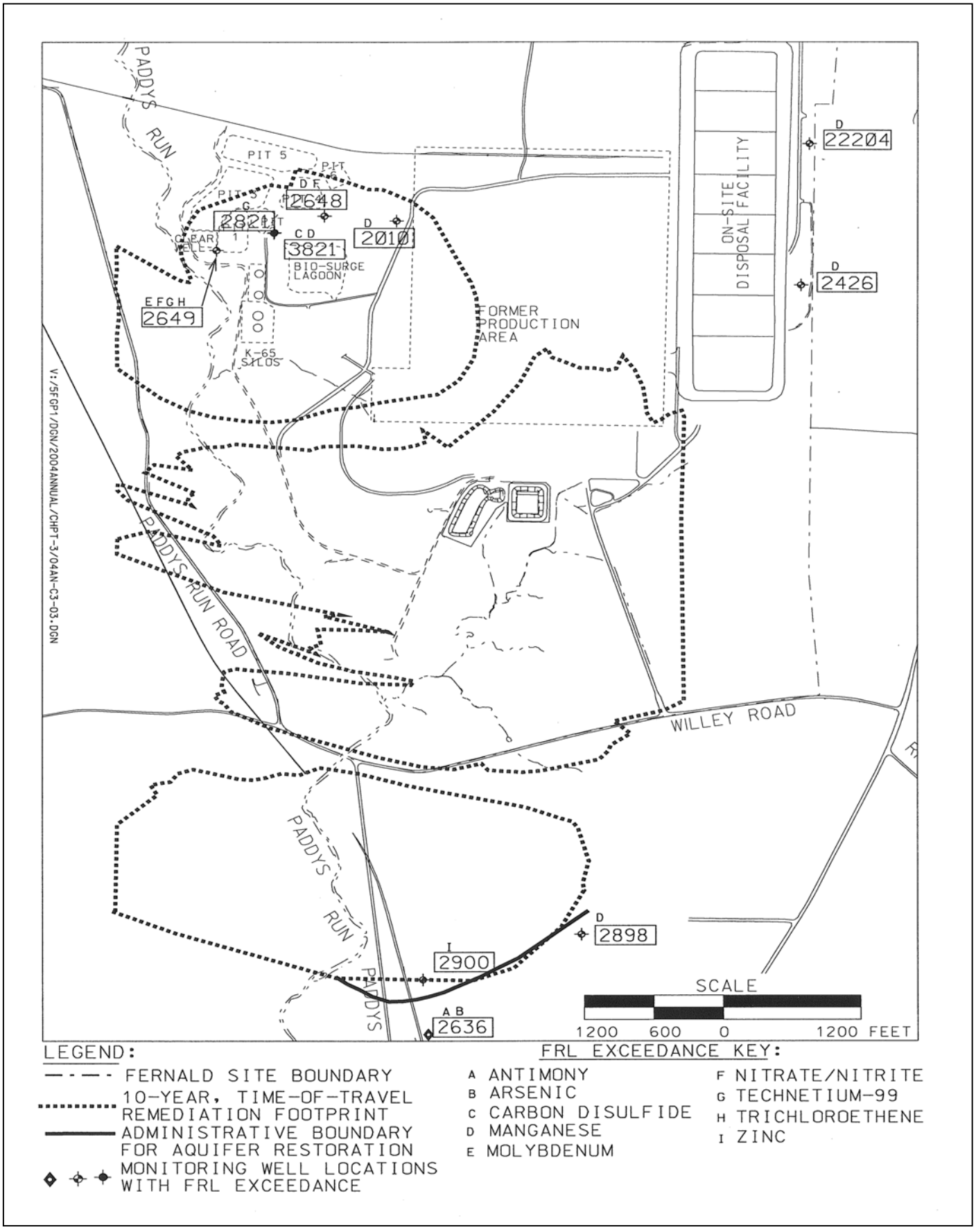

Figure 3-10. Non-uranium Constituents with 2004 Results Above Final Remediation Levels

During 2004, non-uranium FRL exceedances were observed at 10 monitoring well locations as shown in Figure 3-10. A total of nine non-uranium FRL constituents exceeded FRLs in 2004. The waste storage area exceedances will be further evaluated in the design of the Waste Storage Area (Phase II) Module. The exceedance locations along the eastern Fernald site boundary and in the South Plume area are outside the 10-year, time-of-travel remediation footprint. No plumes for the above-FRL constituents at the locations outside the 10-year, time-of-travel remediation footprint were identified in the extensive groundwater characterization efforts evaluated as part of the Remedial Investigation Report for Operable Unit 5.

The constituents with FRL exceedances at the well locations outside the 10-year, time-of-travel remediation footprint were further evaluated to determine whether they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment A.4. Two of the exceedances in 2004 were classified as persistent: arsenic at Monitoring Well 2636, and manganese at Monitoring Well 2426. In past years, exceedances identified as persistent became non-persistent in later years. Appendix A, Attachment A.4, provides detailed information on non-uranium FRL exceedances and the persistence of these exceedances.

Note that Monitoring Well 2636 is located south of the administrative boundary in the Paddys Run Road Site contaminant plume area. The administrative boundary is located between the Fernald site uranium plume and the Paddys Run Road Site contaminant plumes. The Paddys Run Road Site consists of documented releases of inorganic compounds (including arsenic), volatile organic compounds, and semi-volatile organic compounds. FCP groundwater monitoring is occurring south of the administrative boundary to assess the impact of pumping the South Plume Extraction Wells on the Paddys Run Road Site plumes.

3.3.2 Other Monitoring Commitments

Two other groundwater monitoring activities are included in the IEMP: private well monitoring and property boundary monitoring.

As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium and, where necessary, non-uranium constituents of concern. The discussion that follows provides additional details on the two compliance monitoring activities.

The three private wells (Monitoring Wells 2060 [12], 13, and 14) located along Willey Road are monitored under the IEMP to assist in the evaluation of the uranium plume migration (for well locations, refer to Figure 2-2 in Chapter 2). It was at one of these private wells that off-property groundwater contamination was initially detected in 1981. Monitoring stopped at the other private wells in 1997 because a DOE-sponsored public water supply became available to Fernald site neighbors who were affected by off-property groundwater contamination.

The availability of the public water supply resulted in the discontinued monitoring of many private wells in the affected off-property areas where groundwater is being remediated. Data from the three private wells sampled under the IEMP were incorporated into the uranium plume map shown in Figure 3-9.

During 2004, Property/Plume Boundary Monitoring was comprised of 35 monitoring wells located downgradient of the Fernald site, along the eastern and southern portions of the property boundary. Twenty-four Type 2 and 3 wells were monitored along the eastern Fernald site boundary and slightly downgradient of the South Plume to determine if any contaminant excursions were occurring. Eleven Type 2 and 3 wells were monitored in the Paddys Run Road Site area to document the influence, or lack thereof, that pumping in the South Plume was having on the Paddys Run Road Site Plume. Data from the property/plume boundary wells were integrated with other groundwater data for 2004 and were incorporated into the uranium plume maps shown Figure 3-9 and in Attachment A.2. Non-uranium data from these wells were included above in the section on monitoring results for non-uranium constituents.

Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process (subject to OEPA approval), without issuance of a new Director's Order. As determined by OEPA, the IEMP will remain in effect throughout the remedial actions.

3.4 On-site Disposal Facility Monitoring

Groundwater monitoring for the cells of the on-site disposal facility is conducted in the glacial till (perched water) and in the Great Miami Aquifer. Groundwater monitoring in support of the on-site disposal facility continued in 2004. This monitoring program is designed to accomplish the following:

- Establish a baseline of groundwater conditions in both the perched groundwater and the Great Miami Aquifer beneath each cell of the on-site disposal facility. The baseline data will be used to evaluate future changes in perched groundwater and Great Miami Aquifer groundwater quality to help determine if the changes are due to on-site disposal facility operations.

- Continue routine groundwater sampling following waste placement and cell capping as part of the comprehensive leak detection monitoring program for the on-site disposal facility. This information will be used to help verify the ongoing performance and integrity of the on-site disposal facility.

Table 3-3 summarizes the groundwater, leachate collection system, and leak detection system monitoring information associated with the on-site disposal facility. Table 3-3 provides information for Cells 1 through 8 along with sample information and range of total uranium concentrations. In 2004, monitoring continued for Cells 1 through 6 and was initiated for Cells 7 and 8. During 2004, no constituents sampled to meet on-site disposal facility monitoring requirements exceeded groundwater FRL exceedances; however, one non-uranium constituent (manganese), which is sampled to meet IEMP requirements, exceeded its FRL at Monitoring Well 22204, as identified in Section 3.3.1.7.

The final anticipated on-site disposal facility dimensions are: capacity of 2.9 million cubic yards (yd^3); maximum height of approximately 65 feet (ft); and an estimated area coverage of 80 acres of the northeastern area of the Fernald site. At the end of 2004, approximately 1.85 million in-place yd^3 of waste were placed in the OSDF, of which in 2004 approximately 513,000 in-place yd^3 of waste (including some excavated material, debris, etc.) were placed in Cells 4, 5, 6, 7, and 8 of the OSDF. Cells 1 through 3 were 100 percent full and capped. Cell 4 was also filled to its capacity in 2004 and the final cover system construction was in progress as of the end of the year. Cell 5 reached approximately 55 percent of its capacity. Cell 6 reached approximately 44 percent of its capacity.

TABLE 3-3
ON-SITE DISPOSAL FACILITY GROUNDWATER, LEACHATE, AND LEAK DETECTION SYSTEM MONITORING SUMMARY

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a] (μg/L)
Cell 1	12338C	Leachate Collection System	February 17, 1998	33	ND – 142.186
(December 1997)	12338D	Leak Detection System	February 18, 1998	28	1.5 – 23.2
	12338	Glacial Till	October 30, 1997	53	ND – 19
	22201	Great Miami Aquifer	March 31, 1997	56	ND – 8.33
	22198	Great Miami Aquifer	March 31, 1997	80	0.513 – 12.7
Cell 2	12339C	Leachate Collection System	November 23, 1998	27	4.51 – 71.6
(November 1998)	12339D	Leak Detection System	December 14, 1998	30	8.69 – 22.3[b]
	12339	Glacial Till	June 29, 1998	50	ND – 8.07
	22200	Great Miami Aquifer	June 30, 1997	46	ND – 1.11
	22199	Great Miami Aquifer	June 25, 1997	51	ND– 12.1
Cell 3	12340C	Leachate Collection System	October 13, 1999	22	9.27 – 83.7
(October 1999)	12340D	Leak Detection System	August 26, 2002	9	15.1 – 27.7[b]
	12340	Glacial Till	July 28, 1998	48	ND – 29.3
	22203	Great Miami Aquifer	August 24, 1998	45	ND – 7.92
	22204	Great Miami Aquifer	August 24, 1998	48	ND – 5.99
Cell 4	12341C	Leachate Collection System	November 4, 2002	8	4.41 – 165
(November 2002)	12341D	Leak Detection System	November 4, 2002	9	5.45 – 16.4
	12341	Glacial Till	February 26, 2002	21	4.89 – 7.91
	22206	Great Miami Aquifer	November 6, 2001	28	ND – 5.78
	22205	Great Miami Aquifer	November 5, 2001	36	0.446 – 19.7
Cell 5	12342C	Leachate Collection System	November 4, 2002	11	3.39 – 128
(November 2002)	12342D	Leak Detection System	November 4, 2002	7	2.93 – 15.7
	12342	Glacial Till	February 26, 2002	21	8.51 – 21.1
	22207	Great Miami Aquifer	November 6, 2001	29	ND – 4.48
	22208	Great Miami Aquifer	November 5, 2001	34	ND – 2.1
Cell 6	12343C	Leachate Collection System	October 27, 2003	7	7.95 – 141
(November 2003)	12343D	Leak Detection System	October 27, 2003	5	3.1 – 18
	12343	Glacial Till	March 14, 2003	17	ND – 10.9
	22209	Great Miami Aquifer	December 16, 2002	26	ND – 2.38
	22210	Great Miami Aquifer	December 16, 2002	23	ND – 1.02
Cell 7	12344C	Leachate Collection System	September 2, 2004	3	4.65 – 68.4
(September 2004)	12344D	Leak Detection System	September 2, 2004	1	12.2 – 12.2
	12344	Glacial Till	February 24, 2004	9	0.674 – 3.65
	22212	Great Miami Aquifer	January 21, 2004	12	ND – 3.41
	22211	Great Miami Aquifer	January 21, 2004	13	ND – 0.751
Cell 8	12345C	Leachate Collection System	October 18, 2004	1	1.51 – 1.51
(December 2004)	12345D	Lead Detection System	October 18, 2004	2	0.888 – 9.38
	12345	Glacial Till	May 19, 2004	5	3.48 – 5.54
	22213	Great Miami Aquifer	March 31, 2004	10	ND – 0.374
	22214	Great Miami Aquifer	March 31, 2004	10	ND – 1.3

[a]ND = not detectable
[b]Some data not considered representative of true leak detection system uranium concentrations in Cell 2 (December 14, 1998 through May 23, 2000 data set) due to malfunction in the Cell 2 leachate pipeline and the resultant mixing of individual flows. Additionally, it is suspected that some November 2004 samples (i.e., 12339C and 12339D, 12340C and 12340D) were switched. If data from these events were included above, the maximum total uranium concentrations would be 71 μg/L for 12339D and 72.4 μg/L for 12340D.

Cell 7, constructed in 2004, reached approximately 9 percent of its capacity. Cell 8, also constructed in 2004, reached approximately 2 percent of its capacity.

Figure 3-11 identifies the on-site disposal facility footprint and monitoring well locations for Cells 1 through 8. For additional information on the groundwater leak detection and leachate sampling results for the on-site disposal facility, refer to Appendix A, Attachment A.5.

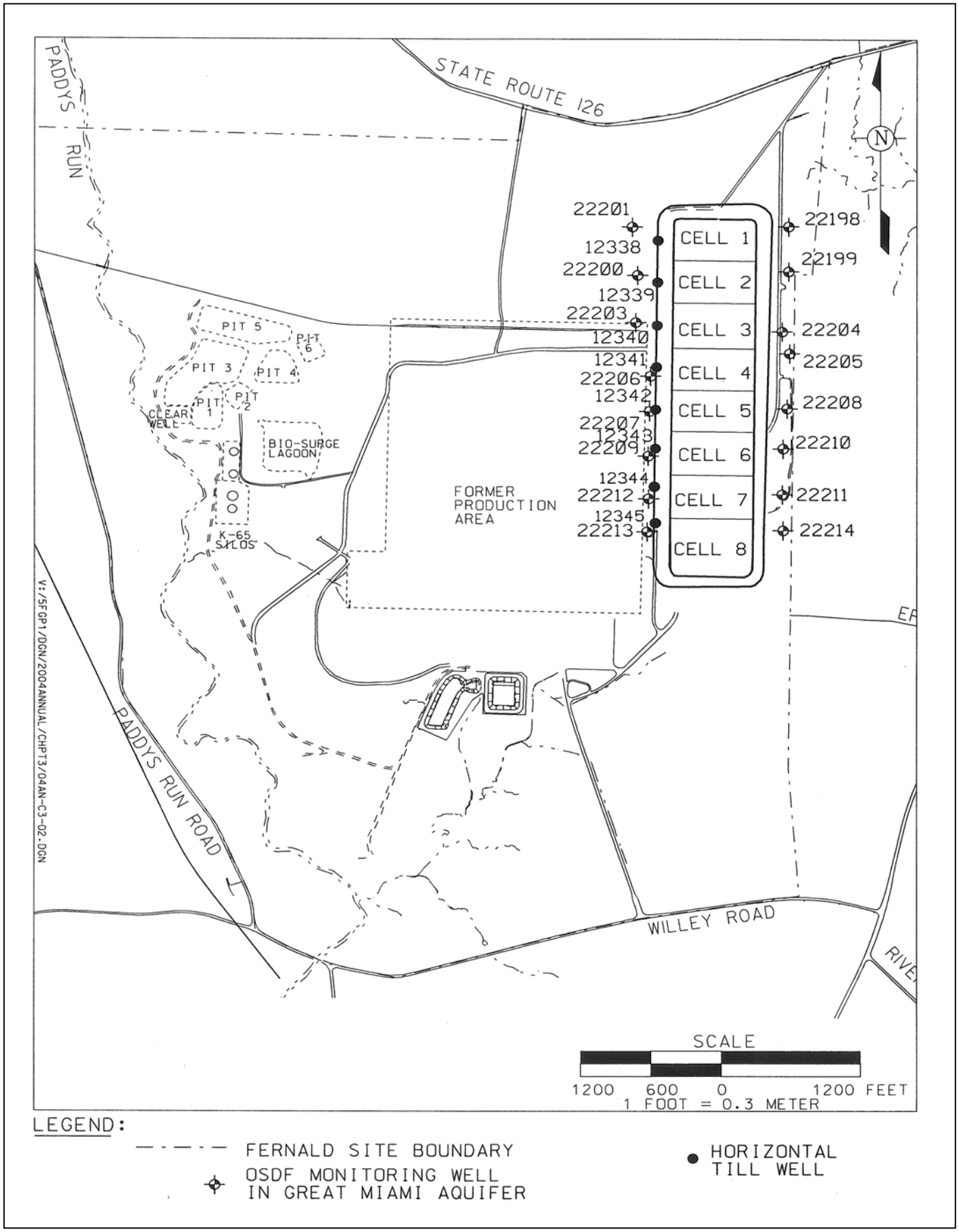

Figure 3-11. On-site Disposal Facility Footprint and Monitoring Well Locations