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DOE-0283-05

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Dear Mr. Saric and Mr. Schneider:

TRANSMITTAL OF THE WASTE STORAGE AREA PHASE II DESIGN REPORT, REVISION A, DRAFT FINAL

The purpose of this letter is to transmit the Waste Storage Area Phase II Design Report for the Aquifer Restoration Wastewater Treatment Project, Operable Unit 5, at the Fernald Closure Project (FCP). This report is being submitted for your agency's review, comment, and approval. Perhaps the key element identified in the Design Report is the recommendation for the installation of one additional groundwater extraction well to be located in the Waste Storage Area.

If you have any questions concerning this report, please contact Dave Lojek at (513) 648-3127.

Sincerely,

for Johnny Reising

William J. Taylor
Director

FCP:Lojek

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WASTE STORAGE AREA
PHASE II DESIGN REPORT

FERNALD CLOSURE PROJECT
FERNALD, OHIO

JUNE 2005

U.S. DEPARTMENT OF ENERGY

52424-RP-0004
REVISION A
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1.0 INTRODUCTION

This report provides an updated characterization of the uranium plume in the Great Miami Aquifer beneath the former Waste Storage Area (WSA) of the Fernald Closure Project (FCP) and a modeled design for the Waste Storage Area Phase II Module. The modeled design presents the location of the extraction well needed for the Phase II Module.

1.1 OBJECTIVE

The objective of the groundwater characterization conducted to support the design of the Waste Storage Area Phase II Module, identified in this design report as the "Phase-II Design", was to assure that the latest uranium plume characterization was used to support the design of the aquifer remediation system. Specifically, the objectives were to:

- Prepare an updated characterization of the vertical and lateral extent of the uranium plume in the Waste Storage Area
- Prepare an updated characterization of the consistent and recent non-uranium groundwater FRL exceedances in the Waste Storage Area
- Determine the number and location of groundwater extraction wells that are required for the Waste Storage Area Phase II Module based on groundwater modeling predictions.

1.2 BACKGROUND

Restoration of the Great Miami Aquifer at the Fernald Closure Project is being accomplished using a series of area-specific groundwater restoration modules and a centralized water treatment facility. The South Plume Module, South Field Module, and Phase I of the Waste Storage Area Module have all been installed and are currently operating. The Waste Storage Area (Phase II) Module is the last module that needs to be designed and installed prior to site closure in 2006.

The Waste Storage Area Module is being designed in two phases to accommodate surface excavation activities. The Phase-I Design was issued in April of 2001 (DOE 2001). Phase-I consists of three extraction wells (EW-26, EW-27, and EW-28) in the Pilot Plant Drainage Ditch area. These wells were installed and began operating in 2002. At the time that Phase I was designed, the waste pits had not yet been remediated, and access beneath and next to the pits could not be obtained for aquifer characterization work. The waste pits have now been remediated, and source material has been removed. Limited access beneath and next to the pits became available in October of 2004.

This design report differs from previous design reports (i.e., South Field Phase II, Waste Storage Area Phase I) in that past design reports only reported on fate and transport modeling for the remediation of the uranium plume. This design report also includes fate and transport modeling for remediation of technetium-99 and manganese in the Waste Storage Area. Technetium-99 was modeled because it's concentration in the groundwater beneath the Waste Storage Area is significantly above it's FRL. Manganese was modeled because it's concentration is also significantly above it's FRL and the footprint of the maximum manganese plume has the potential to be larger than the uranium plume.

Section 2 of this design report presents findings of the groundwater characterization work that was conducted beneath and next to the former waste pits in the Waste Storage Area between October 2004 and April 2005 to facilitate the design of the Waste Storage Area Phase II Aquifer Restoration Module. Section 3 of this design report presents groundwater modeling used to determine the optimum number and location of extraction wells that are needed for the Waste Storage Area Phase II Module. Section 4 provides a summary of findings and recommendations from both the characterization and the groundwater modeling.

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2.0 CHARACTERIZATION RESULTS

The characterization effort conducted to support the Waste Storage Area Phase II Module Design consisted of groundwater sampling at 13 area-specific direct-push sample locations between October 2004 and April 2005 and routine groundwater sampling of the Waste Storage Area monitoring wells as specified in the Integrated Environmental Monitoring Plan (IEMP (DOE 2005). This design report provides an update of plume conditions in the Waste Storage Area beneath and adjacent to the waste pits.

The 13 (thirteen) locations that were sampled using a direct-push sampling tool were 12614b, 12615b, 12617b, 12618b, 12684b, 13320, 13322, 13323, 13324, 13325, 13327, 13328, and 13329. The locations are shown in Figure 2-1. The five locations identified with a "b" suffix were previously sampled during the characterization effort that was conducted for the Waste Storage Area Phase I Design in 2000/2001. The remaining seven direct-push locations were sampled for the first time as part of the Phase II characterization. Direct push sampling was conducted from October 2004 to April 2005. This long time span was not intentional. The original objective was to obtain the water samples in as short a time period as possible, but many sampling delays developed due to wet soil conditions and other access issues related to surface excavation activities.

Direct push sampling was conducted under a variance (52424-PSP-0004-3) to the Project Specific Plan for Direct Push Sampling in Former Soil Excavation Areas (DOE 2004a). Groundwater samples were collected from several different depths in the aquifer at each direct push location beginning at 1 foot below the water table as measured at the time of sampling. Additional groundwater samples were then collected at 10-foot depth intervals beneath the water table in the upper portion of the Great Miami Aquifer. A clay layer is present in the Great Miami Aquifer beneath the Waste Storage Area that divides the Great Miami Aquifer into an upper and lower portion. This clay layer serves as a natural barrier to the downward migration of contamination and was not disturbed by direct push sampling activities.

Five groundwater-monitoring wells are routinely sampled in the Waste Storage Area as part of the Integrated Environmental Monitoring Plan (IEMP) (DOE 2005). These five groundwater-Monitoring Wells are Monitoring Wells 2010, 2648, 2649, 2821, and 3821, (Figure 2-1).

Sampling at both the thirteen direct-push locations and the five IEMP Monitoring Wells focused on those groundwater FRL constituents that have had consistent and recent groundwater FRL exceedances in the Waste Storage Area, as defined in Table 3-3 of the IEMP, Revision 4 (DOE 2005). These constituents

are: uranium, technetium-99, nitrate/nitrite, manganese, molybdenum, nickel, carbon disulfide, and trichloroethene (TCE). TCE sampling was limited to the area around the Clear Well, the only area where TCE exceedances are consistent and recent based on monitoring well results. Tabulated results from each of the thirteen direct push sampling locations can be found in Appendix A of this design report. Table 2-1 contains a summary of the maximum concentration measured at each sampling location, for each FRL constituent measured, regardless of the sampling depth the sample was collected at. For individual sampling depth results at each location, please refer to data presented in Appendix A. Further discussion concerning individual constituent results is provided below.

2.1 URANIUM RESULTS

Uranium is the principal constituent of concern for the FCP groundwater remediation. Prior to the Waste Storage Area Phase II characterization effort, routine IEMP groundwater monitoring documented that uranium FRL exceedances had occurred in several groundwater-monitoring wells in the Waste Storage Area. The groundwater FRL for uranium is 30 μg/L.

Uranium contamination in the aquifer near the former Waste Storage Area Clearwell has been documented in the IEMP for Monitoring Well 2649. In the first half of 2005, Monitoring Well 2649 had a uranium concentration of 87.1 μg/L. Direct push sampling results from the Phase II characterization reveal that uranium concentrations are much higher (up to 2060 μg/L) in the area of the Clearwell than Monitoring Well results had indicated.

Figure 2-2 is an updated uranium plume map for the Waste Storage Area that incorporates Phase II direct-push characterization results, 2005 Monitoring Well results, and the last uranium concentration measured at wells that have been plugged and abandoned in the Waste Storage Area. The highest uranium concentration (2060 μg/L) was measured at Direct Push Location 13328 at a depth of 1 foot below the water table. The > 30 μg/L uranium plume at this location is approximately 20 feet thick. A cross section running from the northwest to the southeast through the highest concentration area of the updated uranium plume is shown in Figure 2-3. A cross-section location line is provided in Figure 2-2. The plume is approximately 20 feet thick at its thickest point (location 13328) and the top of the plume is located at the water table. In the southeast, near location 12618b the thickness is approximately 10 feet.

The uranium plume shown in Figure 2-2 may have been sourced in part from the Plant-1 pad area. As shown in Figure 2-2, an old drainage ditch use to run from the Plant-1 pad area to the Waste Storage Area. It is possible that contamination could have been carried in this ditch to the area around Direct Push Location 13328, where it infiltrated down into the aquifer and contributed to the uranium

plume shown in Figure 2-2. Leakage out of the clear well may have also contributed to the high uranium concentrations in this area of the plume.

High uranium concentrations near the water table beneath a former source area suggests that uranium could be sorbed to soils in the vadose zone above the current water table. The water table in this area has been at a higher elevation in the past. In Figure 2-4, the water level elevations recorded for Monitoring Well 2649 are compared to the water level elevation measured Direct Push Location 13328 when it was sampled in April of 2005 and the water level elevation measured at Direct Push Location 13324 when it was sampled in February of 2005. These two direct push locations had the highest measured uranium concentrations during the Phase II characterization and are close to Monitoring Well 2649. The two highest uranium concentrations (1083 µg/L at location 13324 and 2060 µg/L at location 13328) were measured between a water level elevation of 522.39 feet amsl and 519.90 feet amsl. The water level measured in Monitoring Well 2649 has been higher than 522.39 feet amsl in the past. With the exception of an erratic water level elevation measured in April of 2000 (see Figure 2-4), the water level appears to have been as high as 526.35 feet amsl. This indicates that there is a good possibility that uranium could be sorbed onto aquifer sediments up to an elevation of approximately 526 feet amsl based on water table fluctuations. Had water levels been higher when Direct Push Locations 13328 and 13324 were sampled, measured uranium concentrations might also have been higher. Residual uranium contamination in the vadose zone could hinder future aquifer certification efforts.

2.2 TECHNETIUM-99 RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for technetium-99 in the waste storage area at three groundwater-monitoring wells. The groundwater FRL for technetium-99 is 94 pCi/L.

Figure A-13 of the IEMP, Revision 4, shows that the three wells in the waste storage area that have had consistent and recent groundwater FRL exceedances for technetium-99 are Monitoring Wells 2648, 2649, and 2821. These wells are three of the five-groundwater Monitoring Wells routinely sampled for the IEMP in the Waste Storage Area. The most recent routine groundwater sampling results for these wells, as measured in 2005, are as follows; 849 pCi/L at Well 2649, 304 pCi/L at Well 2821, and 1.14 pCi/L at Well 2648. Technetium-99 concentration versus time plots for these three wells are provided in Figures 2-5 thru 2-7. As shown in Figure 2-5, no technetium-99 groundwater FRL exceedance has been recorded at Monitoring Well 2648 during the last four sampling events, indicating that technetium-99

groundwater FRL exceedances appear to be concentrated in the area around the Clear Well and Pit 2 in Monitoring Wells 2649 and 2821.

Direct push sampling conducted for the Phase II characterization indicates that two of the thirteen locations sampled had groundwater FRL exceedances for technetium-99; locations 13320 and 13322 (Table 2-1). These two locations are also near the Clear Well and Pit 2 (Figure 2-1). Location 13320 is located between Waste Pit 3 and Waste Pit 2, and Location 13322 is located next to the Clear Well. The technetium-99 groundwater FRL exceedance at Location 13320 was measured at a depth of 10 feet and 20 feet below the water table. The exceedance at Location 13322 was measured at a depth of 1 foot and 10 feet below the water table.

The technetium plume that is present in this area is approximately 20 feet thick, with the high concentration of 6280 pCi/L measured at Direct Push Location 13322. All of the technetium-99 groundwater FRL exceedances are located within or very close to the edge of the uranium plume that will be targeted for remediation.

2.3 NITRATE/NITRITE RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for nitrate/nitrite in the waste storage area at several groundwater-monitoring wells. The groundwater FRL for nitrate/nitrite is 11 mg/L. As discussed below, for the Phase II characterization nitrate/nitrite concentrations of 45 mg/L were used to determine an equivalent nitrogen concentration of 10 mg/L.

The groundwater FRL for nitrate/nitrite is based on background measurements made in the Great Miami Aquifer. Nitrate/nitrite is a concern in the aquifer due to the health effects of nitrogen. The MCL for nitrogen is 10 mg/L. A nitrate/nitrite concentration of 45 mg/L is equivalent to a nitrogen concentration of 10 mg/L. For the Waste Storage Area Phase II characterization a nitrate/nitrite concentration of 45 mg/L was used to define a concentration of 10 mg/L nitrogen.

Figure A-12 of the IEMP, Revision 4, shows that five groundwater monitoring wells in the Waste Storage Area have had consistent and recent groundwater FRL exceedances for nitrate/nitrite; wells 2648, 2649, 2821, 3821, and 3009. Monitoring Well 3009 is no longer being routinely sampled as part of the IEMP. The highest reported nitrate/nitrite concentration for well 3009 was 16.6 mg/L on June 22, 1998. Monitoring Well 3009 was last sampled for nitrate/nitrite on April 29, 2003 when the concentration was 1.33 mg/L.

The other four wells with reported consistent and recent groundwater FRL exceedances for nitrate/nitrite in the Waste Storage Area (Monitoring Wells 2648, 2649, 2821, and 3821) are routinely sampled for the IEMP. Only one of these wells has had a nitrate/nitrite concentrations above 45 mg/L; Monitoring Well 2649. Monitoring Well 2649 is located near the Clear Well (Figure 2-1).

Of the thirteen direct push sampling locations sampled for the Phase II characterization, only Location 13320 had a nitrate/nitrite concentration above 45 mg/L. Location 13320 had a nitrate/nitrite concentration of 46.3 mg/L at a depth of 10 feet below the water table (Table 2-1). Direct Push Location 13320 is located between Waste Pit 3 and Waste Pit 2. Monitoring Well 2649 and Direct Push Location 13320 are both located within or very near to the edge of the uranium plume that will be targeted for remediation.

2.4 NICKEL RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for nickel at one monitoring well location in the waste storage area. The groundwater FRL for nickel is 0.10 mg/L.

Figure A-11 of the IEMP, Revision 4, shows that the only location in the Waste Storage Area with a consistent and recent groundwater FRL exceedance for nickel is groundwater Monitoring Well 2649, located near the Clear Well.

Groundwater Monitoring Well 2649 is one of the five wells currently being routinely sampled as part of the IEMP. Figure 2-8 is a nickel concentration versus time plot for Monitoring Well 2649. As shown in the figure, since 1991 only one groundwater FRL exceedance for nickel has been recorded, and this was in 2002.

Of the thirteen direct push sampling locations, sampled for the Phase II characterization, only one had a groundwater FRL exceedance for nickel; Location 13324. Location 13324 is near Monitoring Well 2649. A nickel concentration of 0.118 mg/L was measured at a depth of 1 foot below the water table. Based on these sampling results, nickel contamination in the Waste Storage Area is not considered to be prevalent. The area near the Clear Well, where exceedances have been detected, is within the uranium plume that will be targeted for remediation by the Phase-II extraction wells.

2.5 CARBON DISULFIDE RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for carbon disulfide at three groundwater-monitoring wells in the Waste Storage Area. The groundwater FRL for carbon disulfide is 5.5 µg/L.

Figure A-5 of the IEMP, Revision 4 (DOE 2005) shows that groundwater FRL exceedances for carbon disulfide have occurred at Monitoring Wells 2027, 2649, and 3821. Two of these three wells (Monitoring Wells 2649 and 3821) are being routinely sampled for the IEMP. Monitoring Well 2027 has been plugged and abandoned. At Monitoring Well 2027, a one-time carbon disulfide exceedance (9 mg/L) was measured in November of 1999. The well was sampled again in 2000 and 2001 prior to being plugged and abandoned and no additional groundwater FRL exceedances for carbon disulfide were measured. Based on this data, carbon disulfide does not appear to pose a health threat to the aquifer at this location.

Two groundwater FRL exceedances for carbon disulfide have been measured at Monitoring Well 3821. A carbon disulfide concentration of 14 µg/L was measured on 12/6/1999 and a concentration of 7.79 µg/L was measured on 7/19/2004. One groundwater FRL exceedance for carbon disulfide (7 µg/L) was measured at Monitoring Well 2649 on 11/17/1998. Both Monitoring Wells 3821 and 2649 are within the uranium plume that will be targeted for remediation. No FRL exceedances for carbon disulfide were measured at any of the thirteen direct-push sampling locations sampled for the Phase II characterization.

2.6 TRICHLOROETHENE RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for trichloroethene in two groundwater-monitoring wells in the Waste Storage Area. The groundwater FRL for trichloroethene is 5.0 µg/L.

Figure A-14 of the IEMP, Revision 4 (DOE 2005) shows groundwater FRL exceedances for trichloroethene at Monitoring Wells 2649 and 3009. Monitoring Well 2649 is currently being sampled routinely for the IEMP. The well has had a consistent FRL exceedance for trichloroethene since 1990, when sampling began. The highest trichloroethene concentration measured for Monitoring Well 2649 was 243 µg/L in July of 1991. The most recent sample collected in the first half of 2005 had a trichloroethene concentration of 68.6 µg/L.

Monitoring Well 3009 had an anomalous groundwater FRL exceedance for trichloroethene in December of 1999. The lab result was reported as undetected at 3 µg/L, but the validated result is posted in the SED as 20.7 µg/L with a qualifier of "-" meaning the data is good. All results since then, up to the point that the well was plugged and abandoned in 2003, have been non-detects. The anomalous result posted as 20.7 µg/L in a sample collected in 1999 is considered suspect. Well 3009 is within capture of the Waste Storage Area Phase-I extraction wells.

No FRL exceedances for trichloroethene were measured at any of the thirteen direct-push sampling locations sampled for the Phase II characterization. Based on the data provided above, trichloroethene contamination is present in the area of the Clear Well. This area is within the uranium plume that will be targeted for remediation.

2.7 MOLYBDENUM RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for molybdenum in one groundwater monitoring well in the Waste Storage Area. The groundwater FRL for molybdenum is 0.10 mg/L.

Figure A-10 of the IEMP, Revision 4, indicates that a consistent and recent groundwater FRL exceedance for molybdenum has been recorded at Monitoring Well 2649. Monitoring Well 2649 is one of the five-groundwater Monitoring Wells that are currently being routinely sampled as part of the IEMP. In the first half of 2005 the molybdenum concentration measured at Monitoring Well 2649 was 0.687 mg/L, approximately six times the groundwater FRL. Monitoring Well 2649 is located near the Clear Well.

Two of the thirteen direct-push sampling locations had groundwater FRL exceedances for molybdenum, Location 13322 and Location 13323. Location 13322 is located near the Clear Well, and is near to the uranium plume that will be targeted for remediation. Location 13323 is located next to Waste Pit 6, and is not in the uranium plume being targeted for remediation. The exceedance at Location 13323 (0.765 mg/L) is approximately 7 times the groundwater FRL and was measured at a depth of 40 feet below the water table. The cause of this exceedance is suspect, given that no exceedance was detected at a shallower elevation at this location. If the molybdenum came from a nearby surface source it would have also been detected at shallower elevations and in other nearby locations. This one isolated exceedance at Location 13323 is within capture of the Pilot Plant Drainage Ditch Extraction wells. Monitoring in the area will continue.

2.8 MANGANESE RESULTS

Prior to the start of the Waste Storage Area Phase II characterization, routine IEMP groundwater monitoring had recorded consistent and recent groundwater FRL exceedances for manganese in six groundwater-monitoring wells in the Waste Storage Area. The groundwater FRL for manganese is 0.90 mg/L.

Figure A-8 of the IEMP, Revision 4 (DOE 2005) shows that groundwater FRL exceedances for manganese have occurred at Monitoring Wells 2027, 3027, 3032, 2010, 2648, and 3821. Monitoring Wells 2027, 3027, and 3032 are not routinely sampled for the IEMP. Manganese versus concentration plots for these three wells are provided in Figures 2-9, 2-10 and 2-11, respectively. As shown in Figure 2-9, Monitoring Well 2027 has had one FRL exceedance for manganese since 1993. As shown in Figure 2-10, the manganese concentration at Monitoring Well 3027 has consistently exceeded the groundwater FRL since 1993. As shown in Figure 2-11, one FRL exceedance for manganese was recorded in 1998.

Monitoring Wells 2010, 2648, and 3821 are routinely sampled for the IEMP. Manganese concentration versus time plots for these three wells are provided in Figures 2-12, 2-13 and 2-14, respectively. As shown in Figure 2-12, the manganese concentration in Monitoring Well 2010 has recently increased dramatically. The most recent measurement was above 6 mg/L. The uranium concentration though in Monitoring Well 2010 is below 30 ug/L. As shown in Figure 2-13, manganese concentrations were decreasing at Monitoring Well 2648, but then increased in 2004. Data collected in 2005 indicates that the concentration is decreasing once again. The manganese concentration in Monitoring Well 3821 also appears to be decreasing. As shown in Figure 2-14 the manganese concentration of the last two samples were below the groundwater FRL.

Twelve of the thirteen direct push sampling locations had manganese concentrations that exceeded the groundwater FRL; see Table 2-1. The depth of the exceedances is provided in Appendix A. A map of the maximum manganese plume is provided in Figure 2-15. The data indicates that a consistent and recent manganese plume is present in the Waste Storage Area, and that a portion of the manganese plume is outside of the footprint of the uranium plume. Additional direct-push sampling is needed to help determine if the manganese plume is connected between Monitoring Wells 2010 and 2648.

The presence of the manganese plume in the aquifer beneath the Waste Storage Area could be attributed to wet chemical operations that took place in Plant 8, when that plant was operating. Manganese was used in Plant 8 in a process that recovered UF4. The presence of the manganese plume could also be

associated with biofouling conditions around the monitoring wells. As reported in the 1997 Integrated Site Environmental Report, metallic compounds are often bioaccumulated in a sequential manner around water wells. Iron and zinc concentrate very close to the well screen, while manganese accumulates further out. This possible phenomenon was proposed for some of the manganese FRL exceedances that were being detected at other locations across the site, some being far removed from source areas, such as the eastern property line.

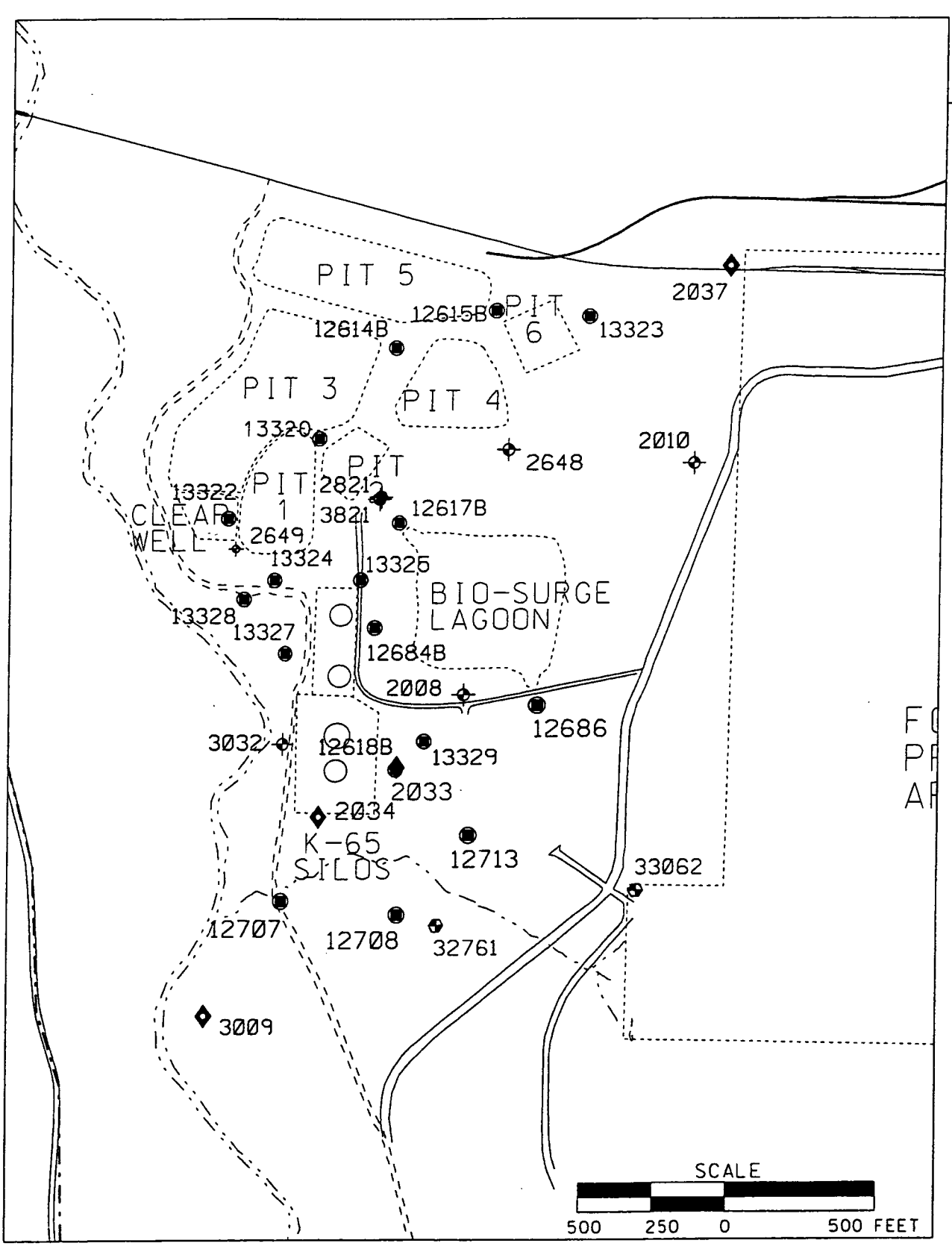
The data presented above indicates that a manganese plume does exist in the Waste Storage Area, and the footprint of the plume is larger than the uranium plume being targeted for remediation. As discussed in Section 3 of this design report, the footprint of the manganese plume is within capture of the Phase I extraction wells, although manganese is generally not movable and is not expected to respond well to P&T operations.

TABLE 2-1
MAX CONCENTRATION FOR EACH GEOPROBE LOCATION
Preliminary, has not been QA'd

		U	Tc-99	N	Mn	Mo	Ni	Carb-Dis	TCE
	FRL	30	94	11	0.9	0.1	0.1	0.0055	0.005
	Units	ug/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
12614b	4/19/2005	10.1	55.6	16.3	1.19	0.033	0.033	NS	NS
12615b	12/16/2004	7.9	7.6	0.2	1.47	0.044	0.052	NS	NS
12617b	10/19/2004	54.6	50.5	4.1	1.41	0.025	0.036	ND	ND
12618b	10/26/2004	50.5	6.9	2.8	1.99	0.023	0.066	NS	NS
12684b	10/7/2004	49.8	12.0	2.4	1.84	0.031	0.080	NS	NS
13320	4/21/2005	8.8	193.0	46.3	2.38	0.026	0.039	NS	NS
13322	4/17/2005	133.9	6280.0	11.3	1.35	0.547	0.031	ND	ND
13323	11/10/2004	18.4	ND	0.0	1.09	0.765	0.077	NS	NS
13324	2/23/2005	1083	11.5	2.4	3.28	0.082	0.118	ND	ND
13325	3/9/2005	29.9	9.8	2.3	1.98	0.096	0.028	ND	ND
13327	3/31/2005	447	ND	3.4	1.57	0.036	0.018	ND	ND
13328	4/5/2005	2060	ND	3.2	2.43	0.049	0.052	ND	ND
13329	4/13/2005	34.4	6.8	2.6	0.70	0.028	0.019	2.2	ND

Shading indicates an FRL exceedance

Average	1.74	0.14	0.05
Max	3.28	0.77	0.12
Min	0.70	0.02	0.02



LEGEND:

- FERNALD SITE BOUNDARY
- MONITORING WELL LOCATION
- WELL PLUGGED AND ABANDONED
- GEOPROBE LOCATION

DRAFT

FIGURE 2-1. WSA PHASE II SAMPLING LOCATIONS

STATE PLANAR COORDINATE SYSTEM 1983

31-MAY-2005

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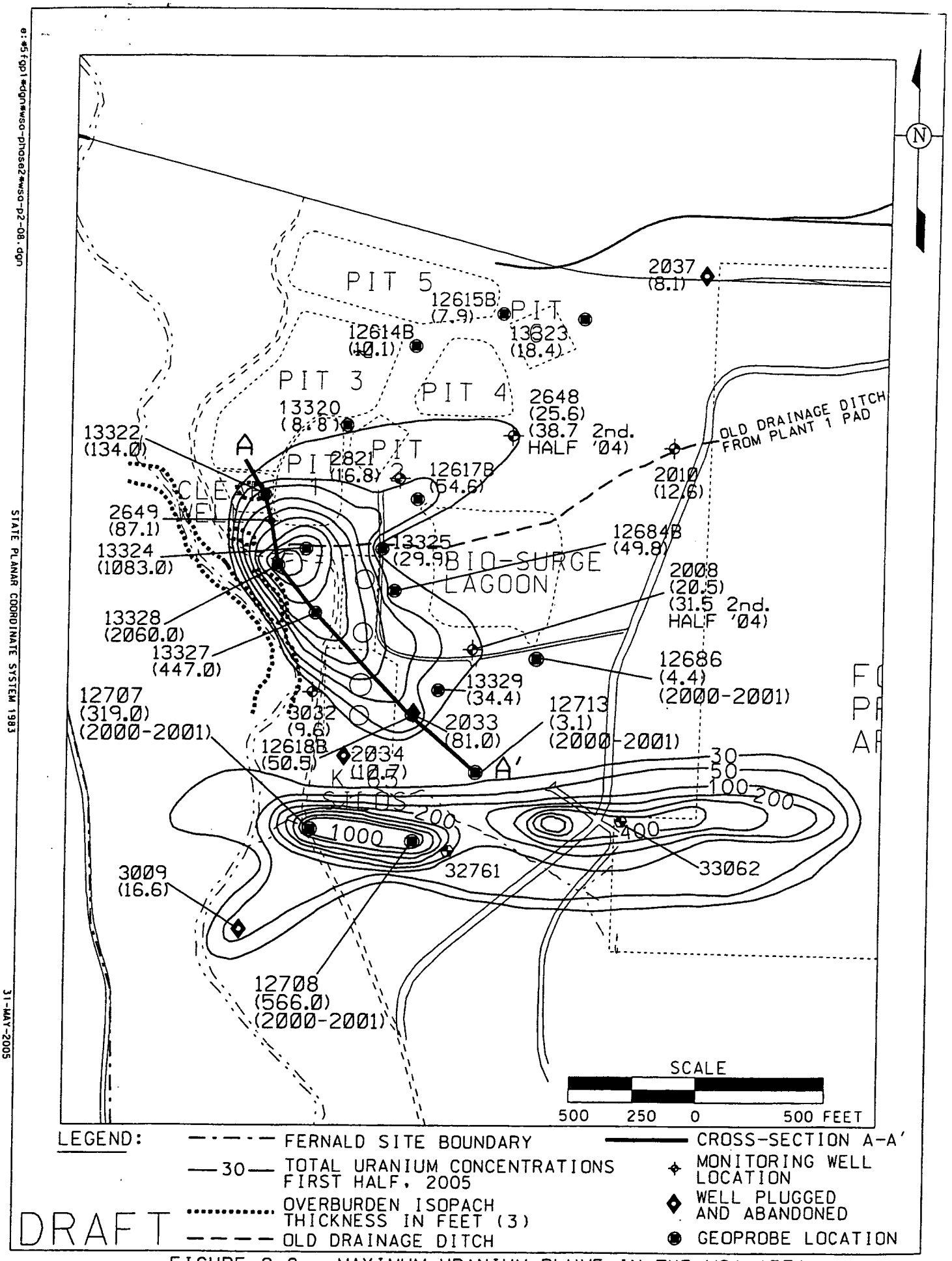

FIGURE 2-2. MAXIMUM URANIUM PLUME IN THE WSA AREA

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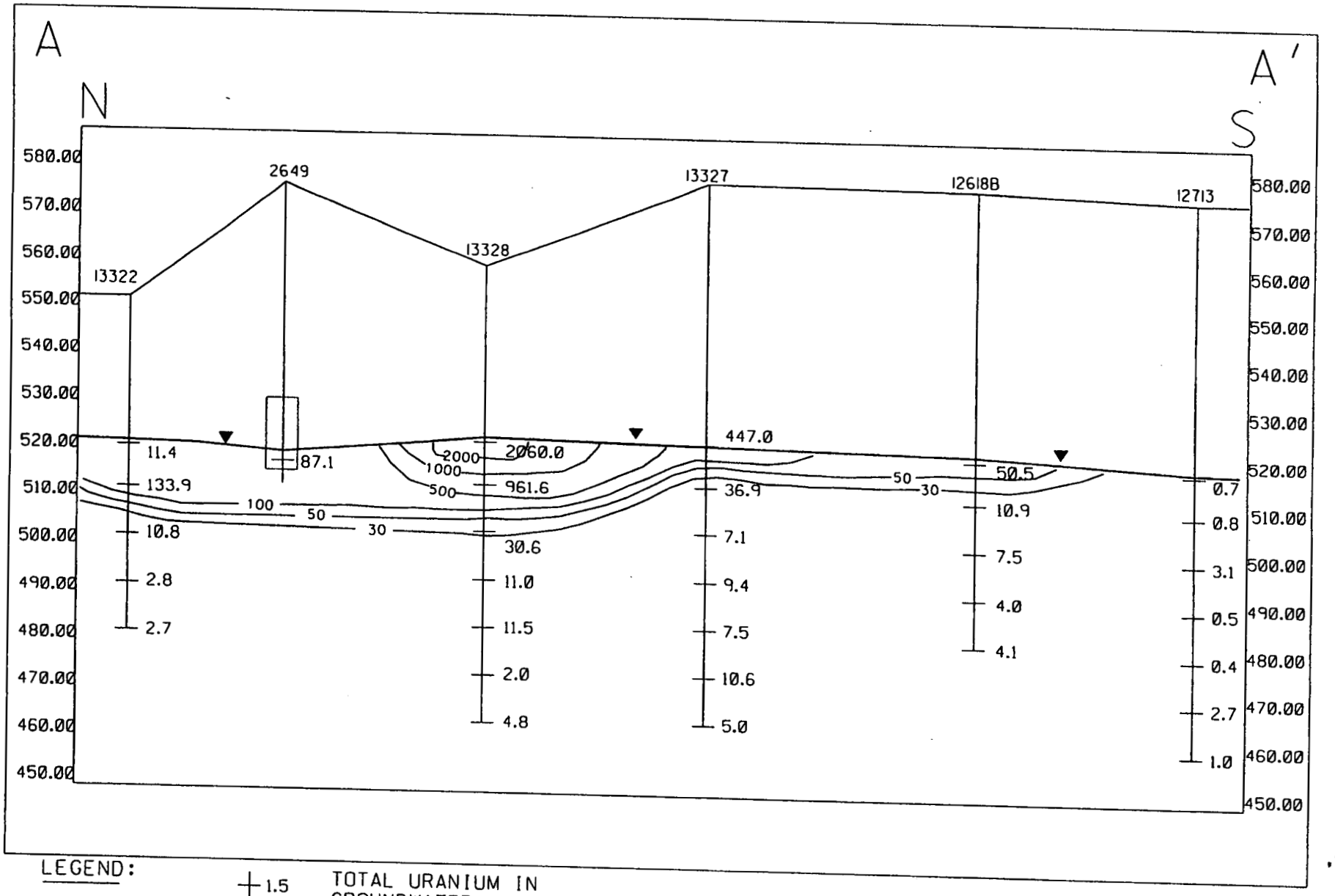
STATE PLANAR COORDINATE SYSTEM 1983

31-MAY-2005



LEGEND:

+1.5	TOTAL URANIUM IN GROUNDWATER $\mu g/L$
12713	SAMPLED 3-13-2000
2649	SAMPLED 1-10-2005

DRAFT

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STATE PLANAR COORDINATE SYSTEM 1983

01-JUN-2005

FIGURE 2-3. WASTE STORAGE AREA, PHASE II CROSS SECTION A - A'

Figure 2-4
A Comparison of Water Level between MW 2649 and Direct Push Locations 13328 and 13324

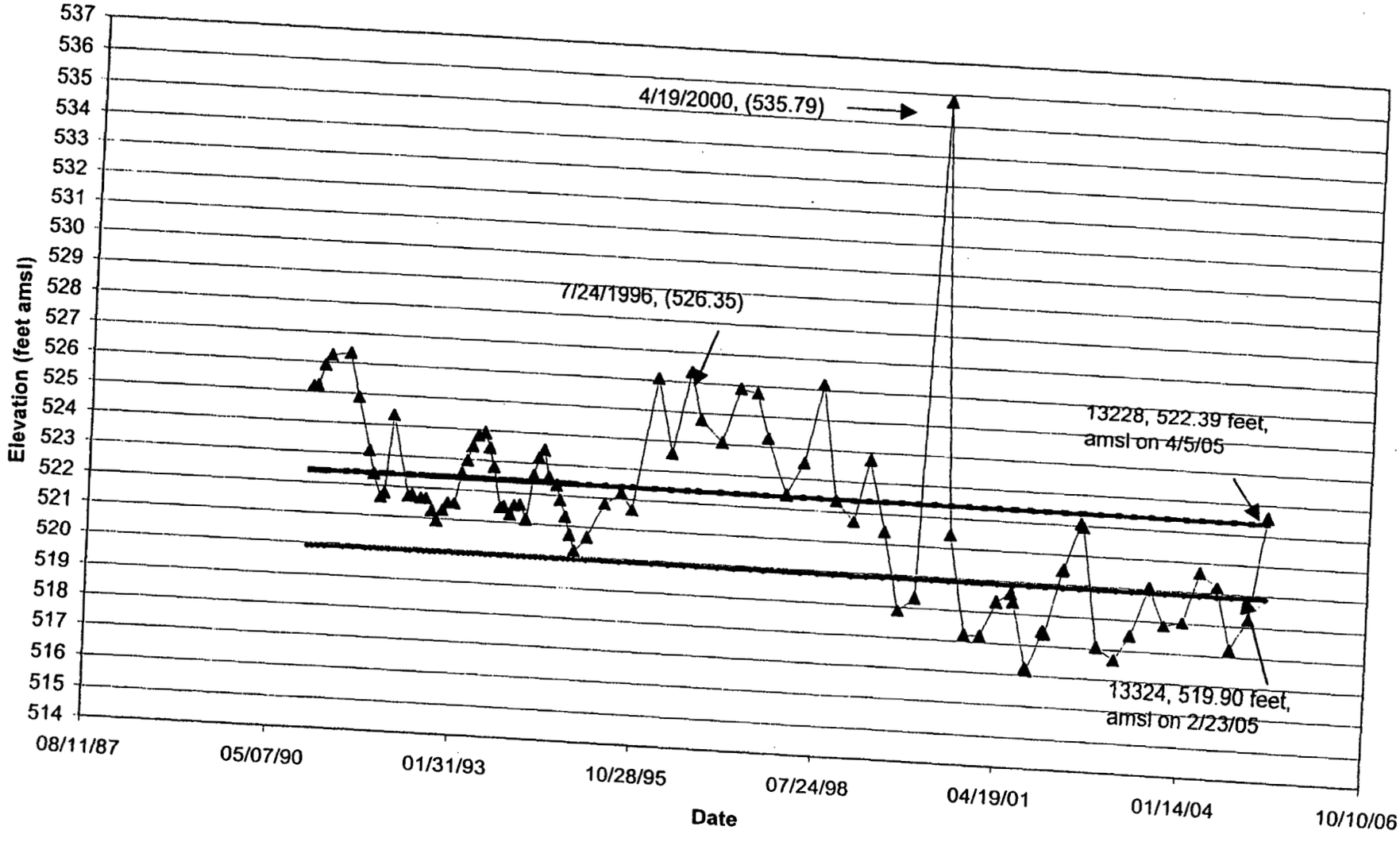


Figure 2-5
Well 2648, Technetium-99 Concentrations
Groundwater FRL = 94 pCi/L

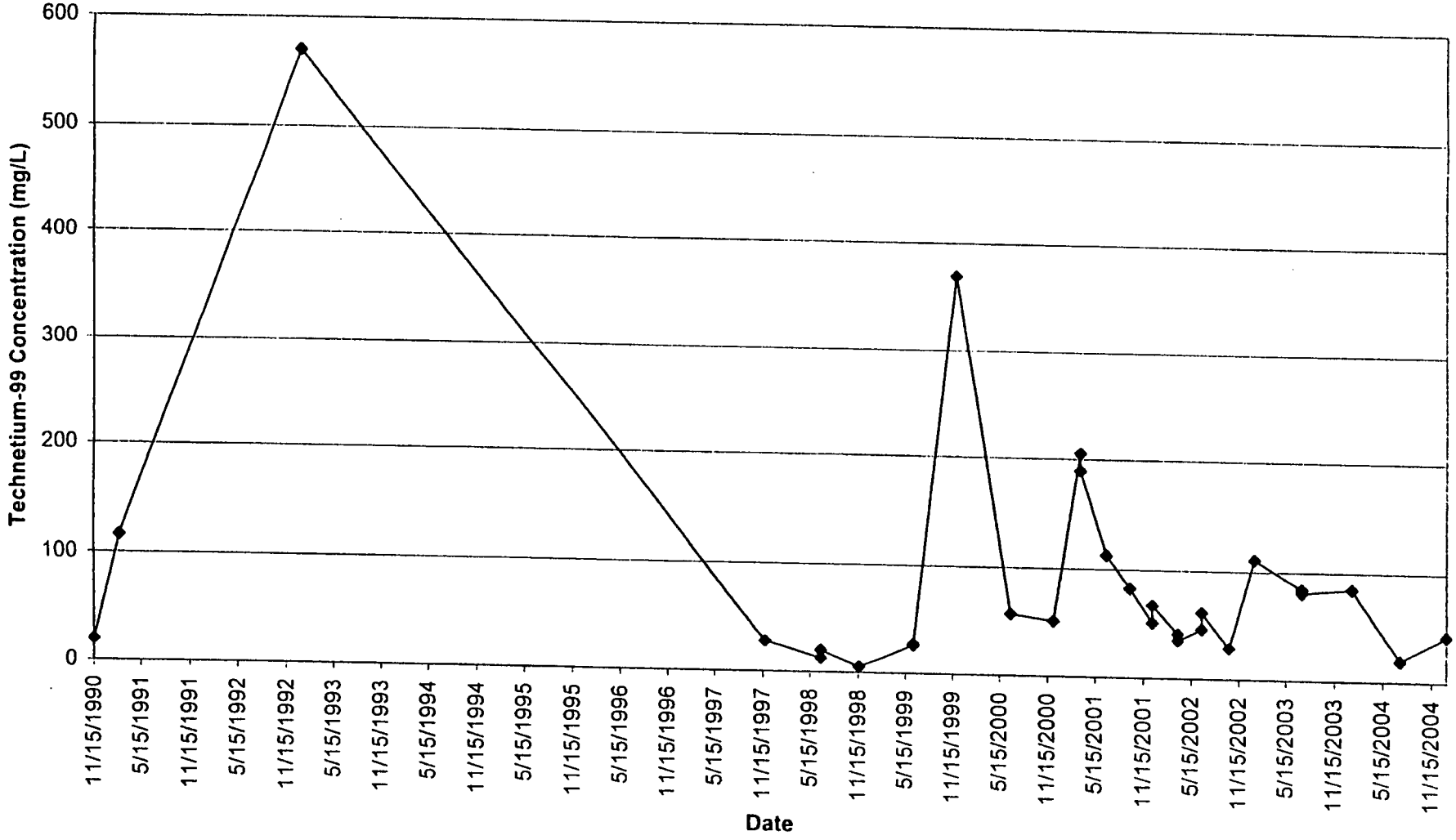


Figure 2-6
Well 2649, Technetium-99 Concentrations
Groundwater FRL = 94 pCi/L

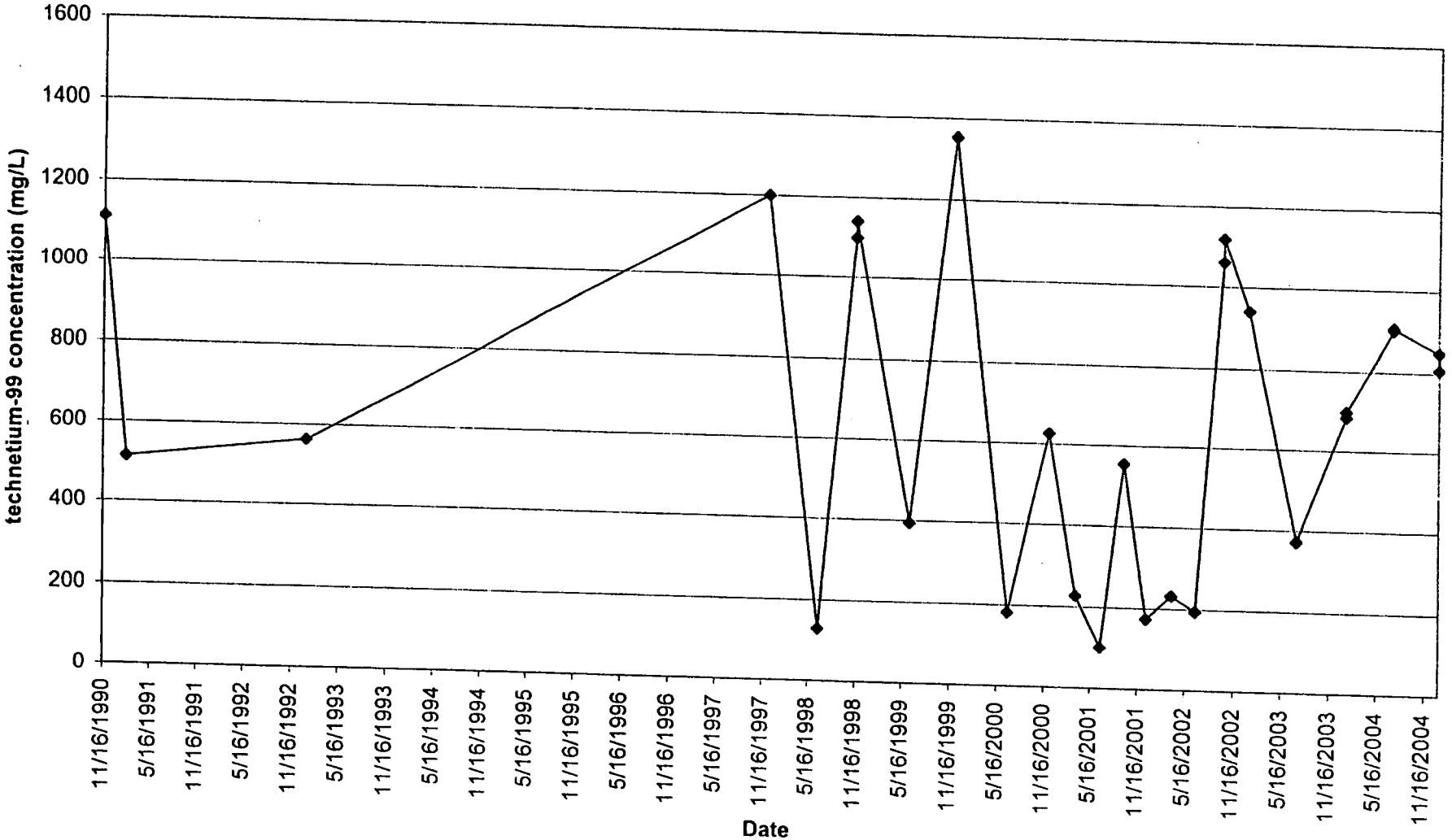


Figure 2-7
Well 2821, Technetium-99 Concentrations
Groundwater FRL = 94 pCi/L

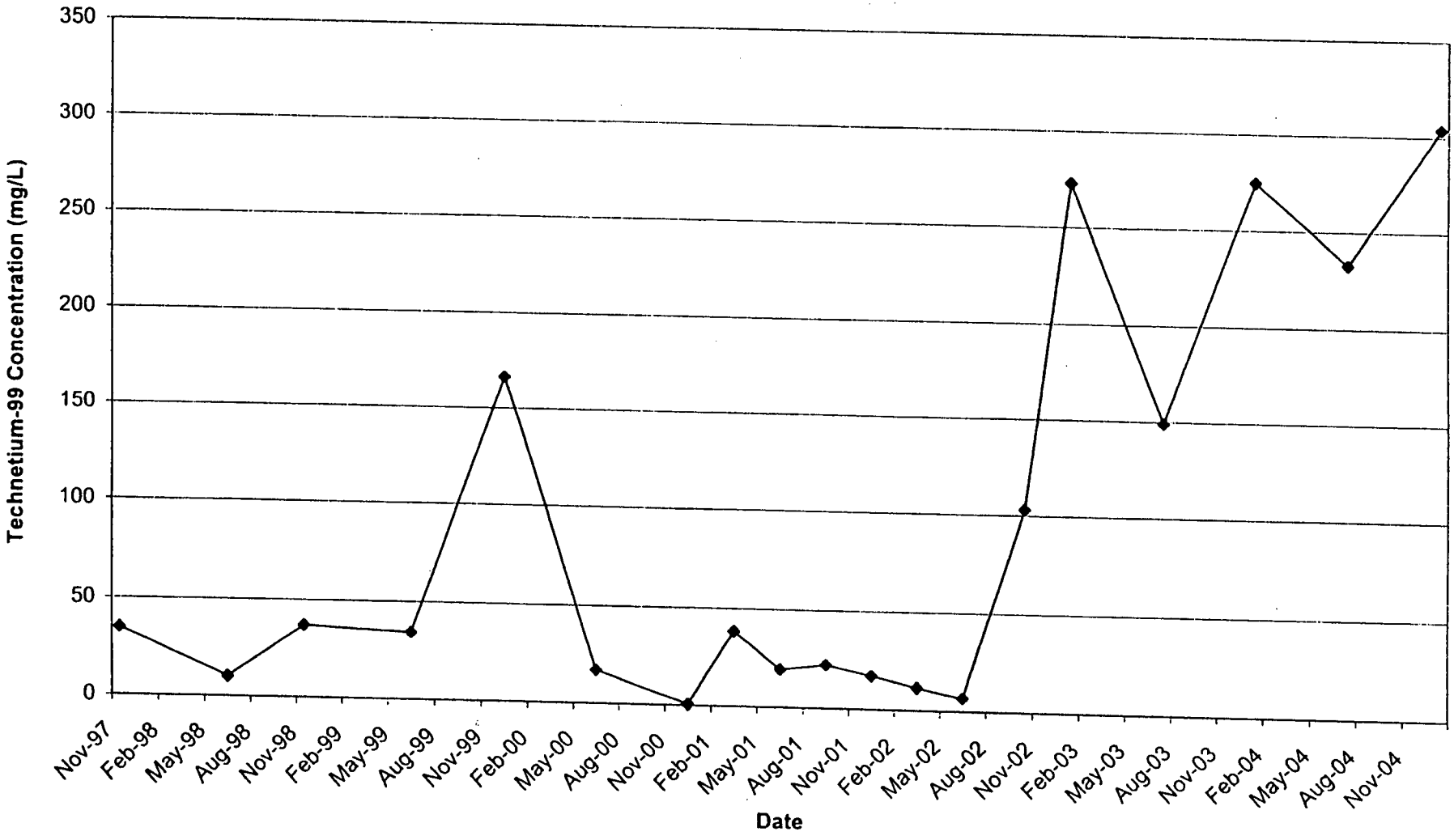


Figure 2-8
Monitoring Well 2649, Nickel Concentrations
Groundwater FRL = 0.10 mg/L

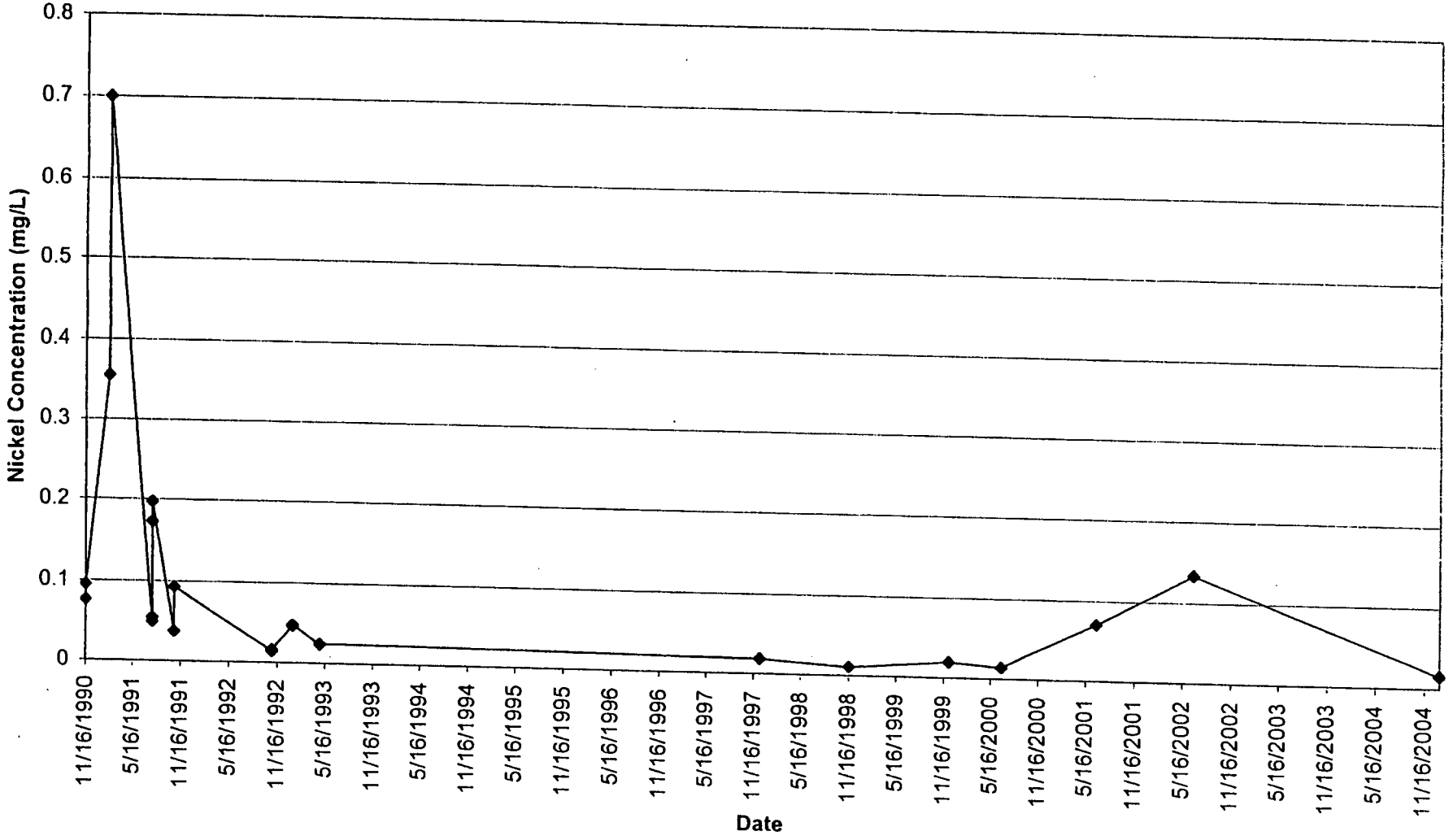


Figure 2-9
Monitoring Well 2027, Manganese Concentrations
Groundwater FRL = 0.90 mg/L

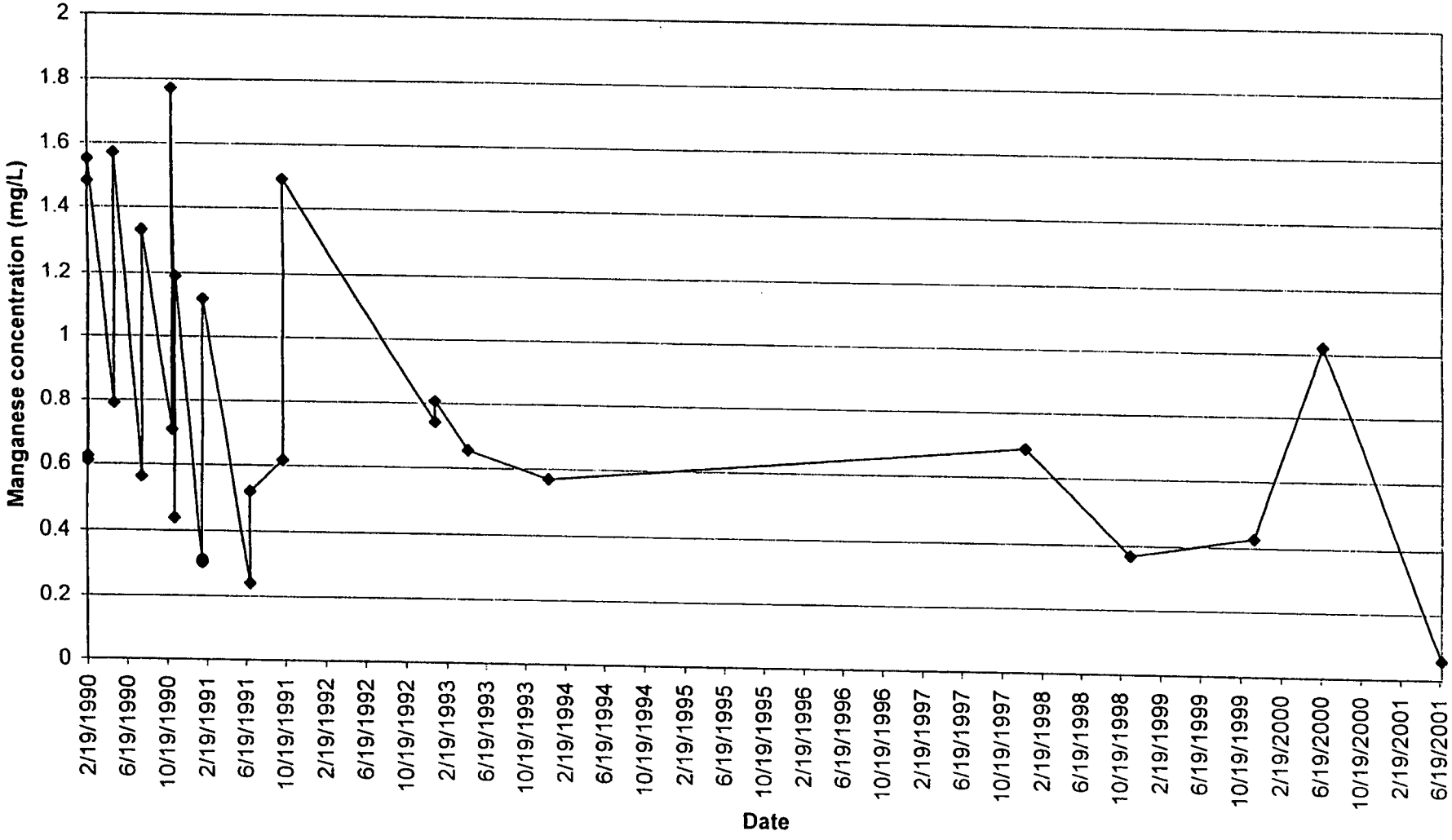


Figure 2-10
Monitoring Well 3027, Manganese Concentrations
Groundwater FRL = 0.90 mg/L

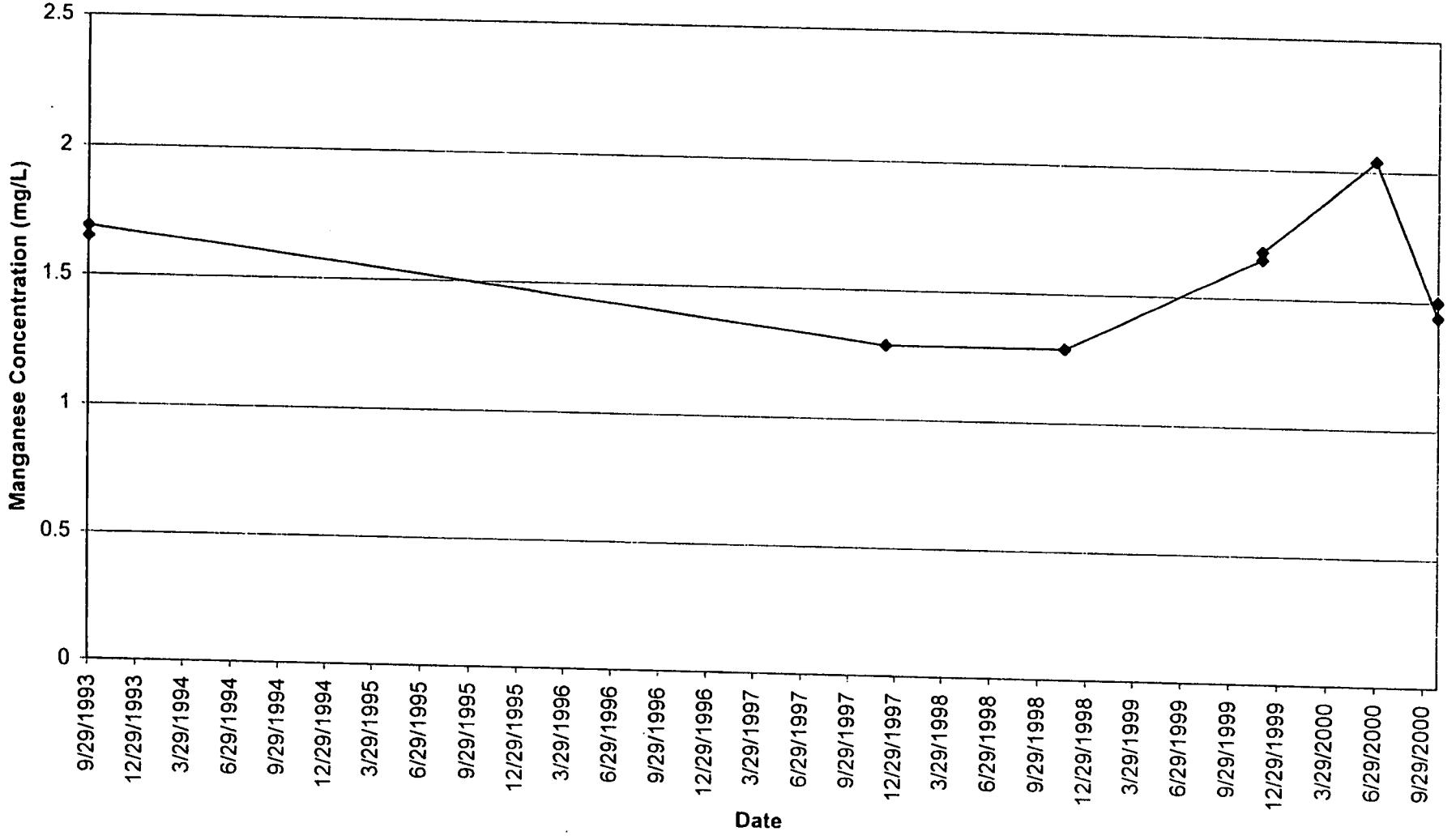


Figure 2-11
Monitoring Well 3032, Manganese Concentrations
Groundwater FRL = 0.90 mg/L

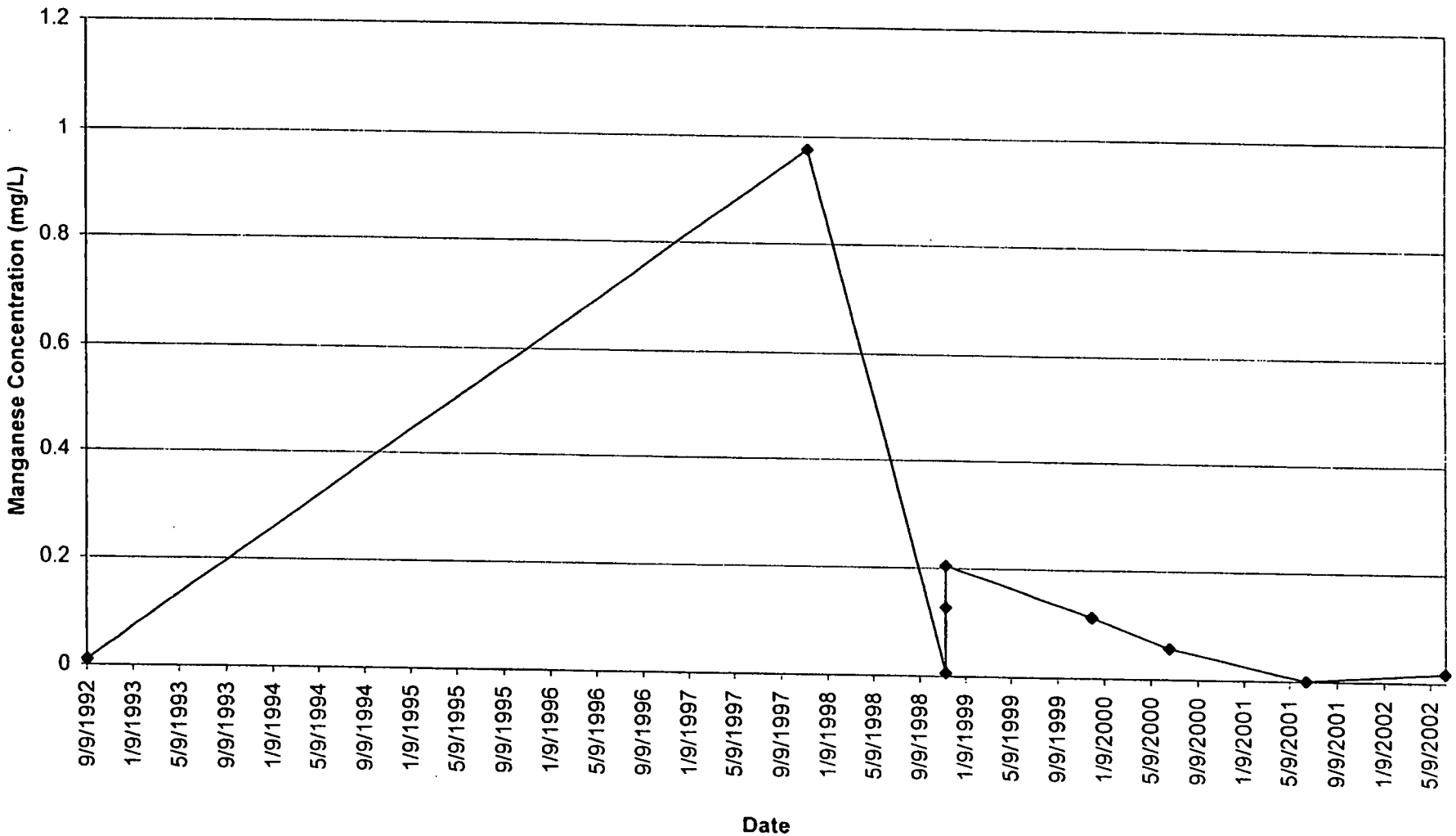


Figure 2-12
Monitoring Well 2010, Manganese Concentrations
Groundwater FRL = 0.90 mg/L

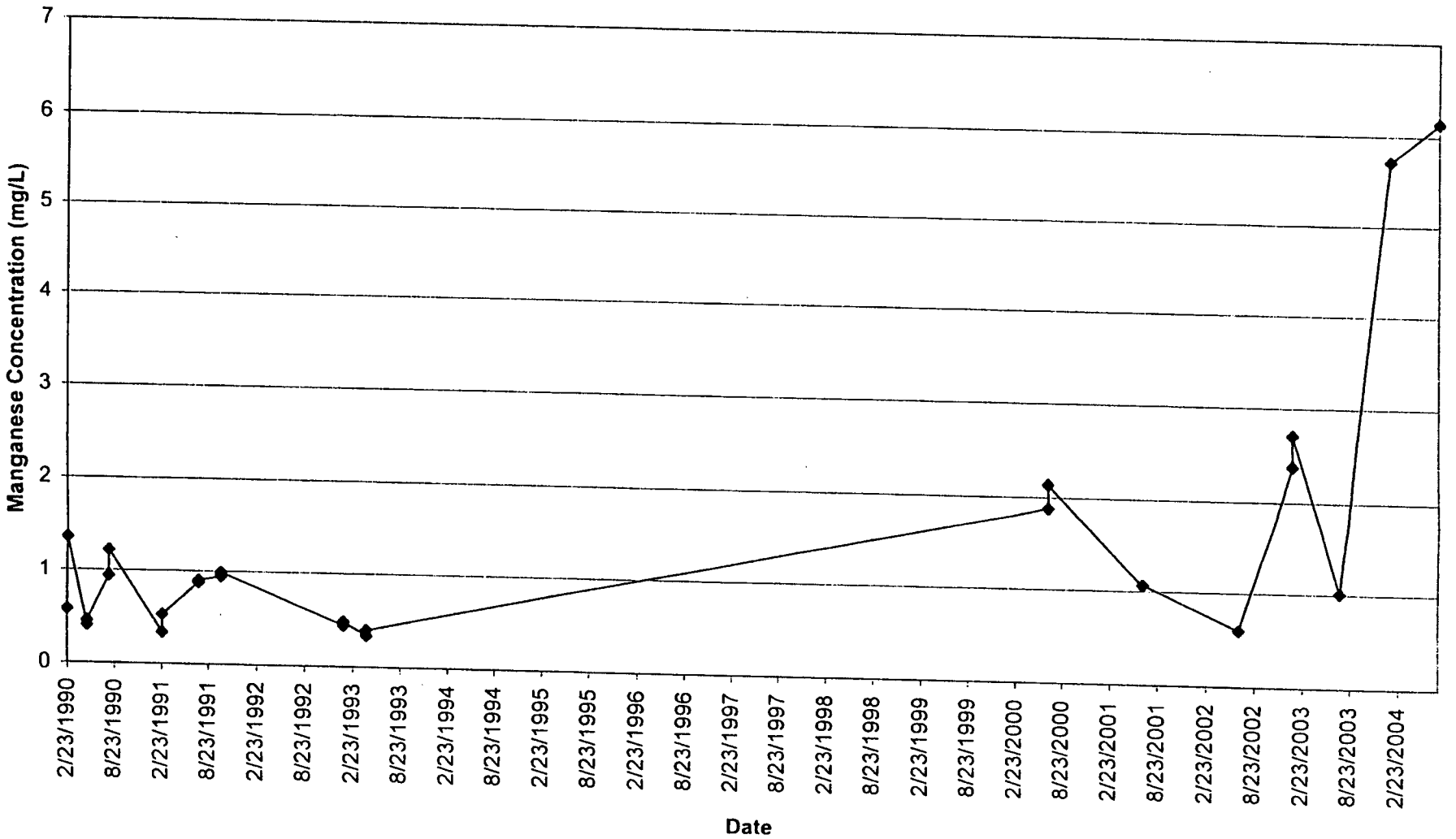


Figure 2-13
Monitoring Well 2648, Manganese Concentrations
Groundwater FRL = 0.90

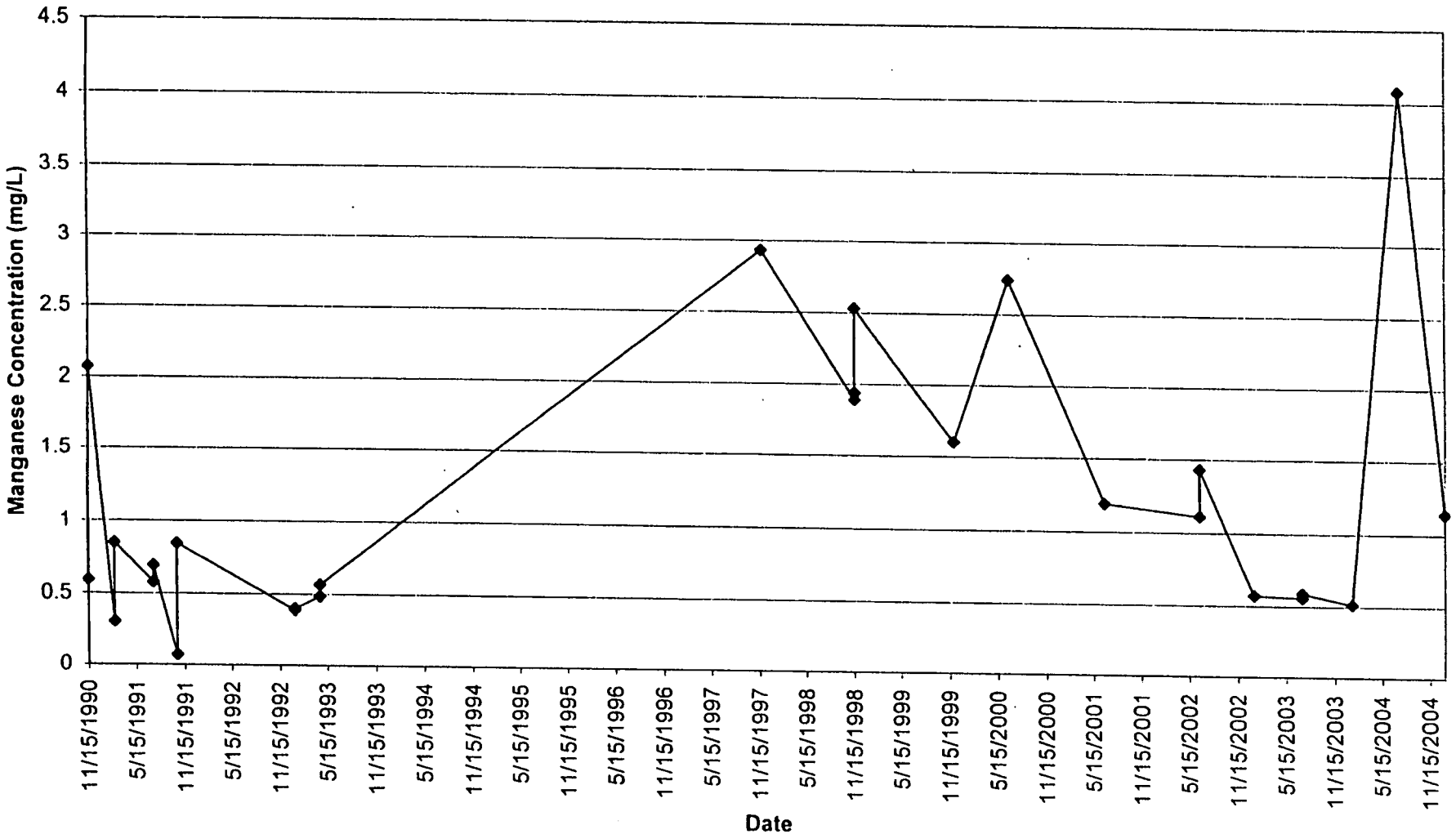
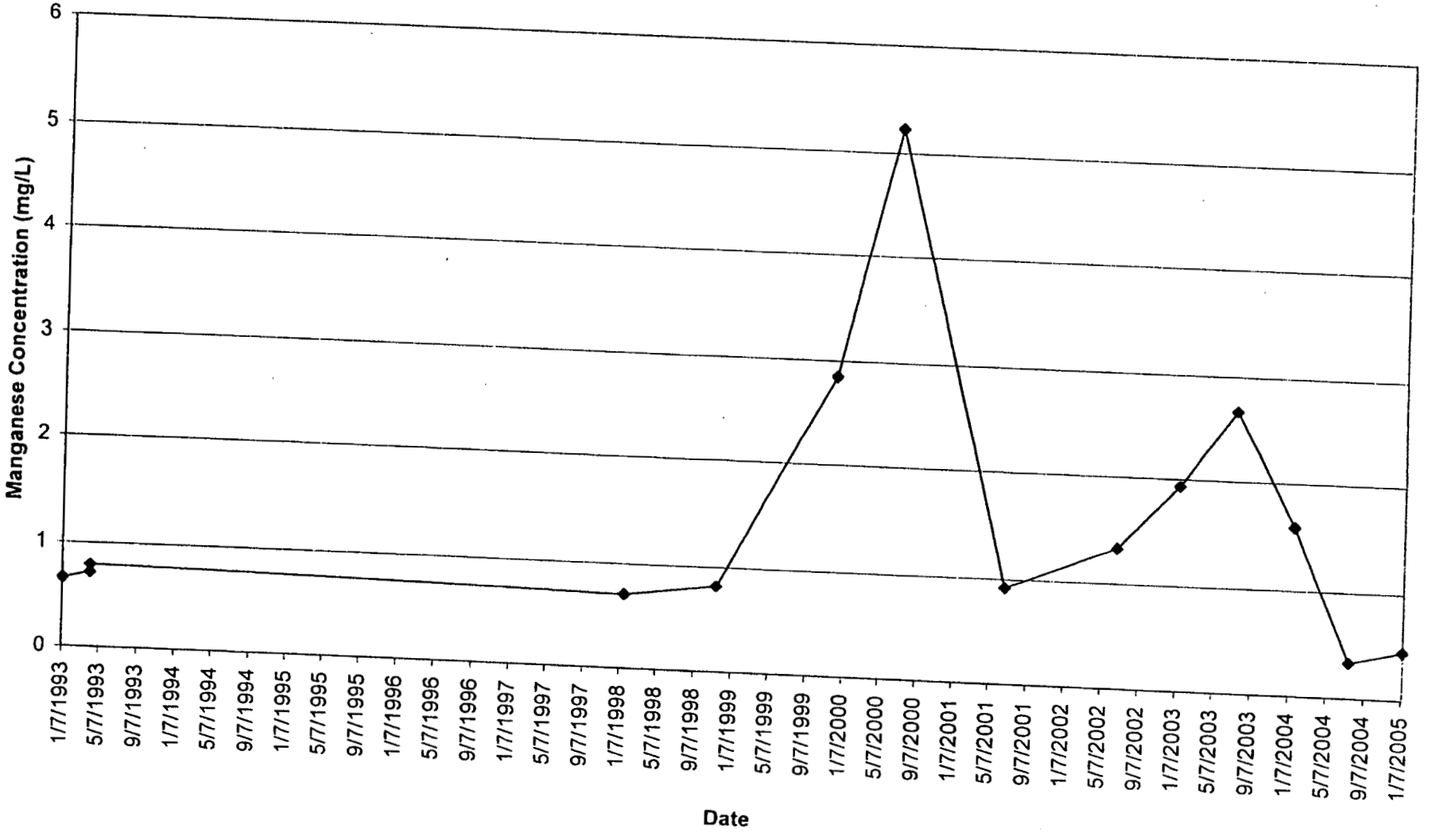


Figure 2-14
Monitoring Well 3821, Manganese Concentrations
Groundwater FRL = 0.90 mg/L



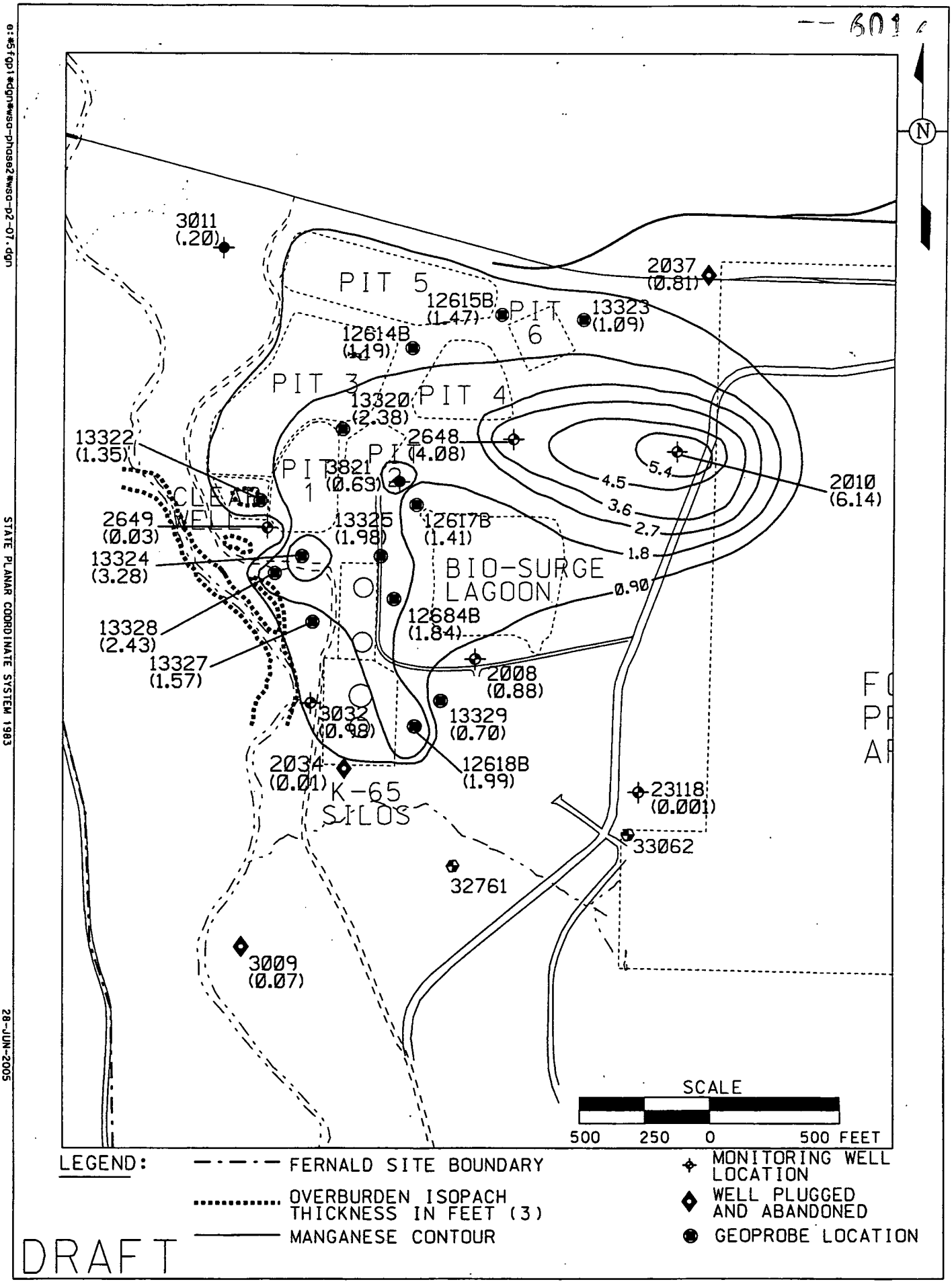


FIGURE 2-15. MAXIMUM MANGANESE PLUME IN THE WSA AREA

STATE PLANAR COORDINATE SYSTEM 1983
28-JUN-2005

3.0 GROUNDWATER MODELING

Groundwater modeling to support the Waste Storage Area Phase II Design was performed using the VAM3D flow and transport modeling code and the fourteen-layer zoom model described in detail in Section 3.0 of Design for Remediation of the Great Miami Aquifer, South Field Phase II Module (DOE, 2002). The fourteen-layer zoom model consists of 72114 finite difference nodes (101 x 51 x 14) with a spacing of 100 feet in both the x and y directions. Figure 3-1 shows the zoom model outline with the larger VAM3D model used prior to the South Field Phase II Design.

Based on characterization results presented in the previous section, modeling began with the assumption that one additional extraction well would be needed to remediate the higher than anticipated uranium concentrations measured near the Clear Well and southeast of the Clear Well.

3.1 FLOW MODELING ASSUMPTIONS

Extractions well pumping rates for this design are shown in Table 3-1. Current pumping rates were used for this design until April 1, 2006 after which time the pumping rates from Approach C in the Groundwater Remedy Evaluation and Field Verification Plan (DOE, 2004b) were used with the pumping of one additional well (WSA-5) in the Waste Storage Area. The pumping rate periods extend from April 1, 2006 until April 1, 2015 when concentrations in the South Plume are predicted to fall below 30 μg/L (the FRL level for total uranium). After April 2015, pumping ceases in the off-property areas and continues in the South Field and Waste Storage Areas until 2023 when all total uranium concentrations are predicted to be below 30 μg/L.

Re-injection was not included in this model design since the induced recharge study in the Storm Sewer Outfall Ditch (SSOD) is not yet complete and because any proposed re-injection in the SSOD will have minimal effect on the operation of extraction wells in the Waste Storage Area.

October 1998 (nominal) constant head boundary conditions were used for all steady-state flow runs in this design. The large VAM3D model was previously calibrated with this set of boundary conditions as described in Great Miami Aquifer VAM3D Flow Model Re-Calibration (DOE, 2000). Boundary conditions for the zoom flow models were obtained from the large VAM3D twelve-layer model (112 x 120 x 12) as described in Section 3.3 of the Design for Remediation of the Great Miami Aquifer, South Field Phase II Module (DOE, 2002). Additional steady state flow runs were made with representative wet (July 1998) and dry (October 1999) boundary conditions to evaluate the effect on clean up times; results follow.

Figures 3-2 through 3-4 show the modeled groundwater elevations in model layer 12 anticipated under each of the three pumping periods shown in Table 3-1. Layer 12 was selected because it is close to the top of the aquifer and contains most of the uranium plume. Figures 3-5 and 3-6 show 10-year, non-retarded, reverse groundwater particle tracks under the 2006 and out-year pumping schedules respectively. Particle tracks are not included for the current pumping period since the anticipated duration is relatively short (less than one year). Figure 3-7 shows forward, non-retarded particle tracks seeded at the 30 μg/L total uranium concentration contour. All particles were seeded at a constant depth of 510 feet above mean sea level (AMSL) and, as shown in the figure, are captured by the existing and proposed extraction wells.

Figures 3-8 and 3-9 show the 10-year non-retarded particle tracks with depth during the 2006 to 2015 pumping period. Figure 3-8 shows a North-South cross section cut from the center of the zoom flow model at an Easting coordinate of 1348250 ('83 State Planar). An additional cut through the Clear Well plume is included at an Easting coordinate of 1346712 to show how the proposed additional extraction well in the Waste Storage Area (WSA-5) impacts the plume in the local area as viewed from East to West. Figure 3-9 shows an East-West cross section cut from the center of the zoom flow model at a Northing coordinate of 478000 ('83 State Planar). An additional cut through the Clear Well plume is included at a Northing of 480917 to show the impact of WSA-5 on the local plume as viewed from South to North. The total uranium concentration contours on these figures are 2D slices from sections of the 3D plume cut at the same locations as the cross sections. The particle tracks depicted show the extent of all tracks in three dimensions as seen looking West in Figure 3-8 and North in Figure 3-9. The particle track Figures 3-5 through 3-9 clearly demonstrate that the total uranium plume as currently defined is completely within the capture zone of the proposed design.

3.2 TRANSPORT MODELING ASSUMPTIONS FOR TOTAL URANIUM

Initial conditions for total uranium for the transport model were developed from total uranium monitoring well and direct push sampling data available as of April 30, 2005. These data were evaluated statistically to determine the proper search radius for Kriging. The horizontal and vertical semi-variograms are shown in Figures 3-10 and 3-11 respectively where the standard traditional estimator [Gamma(h)] is plotted against Lag Distance, h. Kriging performed in support of the Groundwater Remedy Evaluation and Field Verification Plan (DOE, 2004b) used a horizontal search radius of 300 feet with a horizontal to vertical anisotropy ratio of 15 for an effective vertical search radius of 20 feet. An examination of the horizontal ranges of the semi-variogram curves in Figures 3-10 and 3-11 shows these values are appropriate for the December 2004 data set.

Initial conditions for total uranium developed from Kriging are shown in Figures 3-12 through 3-14 for model layers 12, 11, and 10 respectively. The maximum total uranium concentration is 1798 μg/L in model layer 12 near the Clear Well in the Waste Storage Area.

Transport source terms for the Waste Storage Area and Paddys Run were used for the first pumping time period through April 2006. All source terms were assumed to be zero after this time reflecting the soil clean up schedule for the site and the anticipated site closure by March of 2006.

A constant Kd of 3.0 L/Kg was used for total uranium. This value is consistent with the modeling done for the Groundwater Remedy Evaluation and Field Verification Plan (DOE, 2004b) and for the Comprehensive Groundwater Strategy Report (Fluor Fernald, 2003).

3.3 TRANSPORT MODELING RESULTS FOR TOTAL URANIUM

As shown in Figures 3-15 through 3-17, modeled total uranium concentrations in the South Plume are predicted to be below 30 μg/L by the year 2015. This is approximately 2 to 3 years longer than predicted in Approach C of the Groundwater Remedy Evaluation and Field Verification Plan (DOE, June 2004). The additional time is believed to be due to slightly higher initial concentrations in some of the South Plume monitoring wells than had previously been modeled.

Figure 3-18 shows the predicted total uranium concentrations in model layer 12 at year 2022 with three small areas in the Waste Storage Area above 30 μg/L. These areas are all below 30 μg/L by 2023.

The same initial conditions for total uranium were run under dry (October 1999) and wet (July 1998) constant head boundary conditions for the steady state flow model to see how fluctuations in the groundwater elevations might affect clean up times. Under wet boundary conditions with relatively high water levels and increased flushing from surface recharge, the total uranium concentrations are below the 30 μg/L FRL by year 2021 to 2022, an improvement of approximately two years over the nominal boundary condition runs. Under dry boundary conditions with lower water levels and decreased flushing from surface recharge, the total uranium concentrations don't fall below the FRL until years 2030 to 2031, an increase of approximately seven years of the nominal boundary condition runs.

3.4 TRANSPORT MODELING ASSUMPTIONS FOR TECHNETIUM-99

Unlike the methods described above to develop total uranium initial conditions, the semi-variogram/Kriging analysis could not be used for technetium-99 initial conditions because of fewer data points. Instead, initial conditions for technetium-99 were developed from hand drawn contours of direct push sample data taken in the Waste Storage Area. Hand drawn contours of technetium-99 concentrations were digitized then converted by hand into model grid node values for each affected model layer. Initial conditions for technetium-99 in model layers 12, 11, and 10 are shown in Figures 3-19 through 3-21, respectively. The maximum value in the initial condition file is 4563 pCi/L and occurs near the Clear Well in the Waste Storage Area.

No source terms were used for the technetium-99 transport modeling.

Table F.2-5 from the OU5 Feasibility Study indicates a Kd range of 0.02 to 0.2 L/Kg for technetium-99. Technetium-99 moves through the groundwater much faster than uranium as evidenced by the lower Kd range. Therefore, the larger Kd value (0.2 L/Kg) was used in this modeling study since that would be the most conservative value resulting in the longest clean up times under a pump and treat remedy.

3.5 TRANSPORT MODELING RESULTS FOR TECHNETIUM-99

Modeled technetium-99 concentrations in model layers 12, 11, and 10 are shown at 2008 in Figures 3-22 through 3-24 respectively. All concentrations between the FRL of 94 pCi/L and the next contour level of 200 pCi/L are indicated in the figures. The figures also show the technetium-99 plume moving rapidly away from the Clear Well to the southeast toward the pumping wells in the Pilot Plant Drainage Ditch Area. The concentrations represented by the 94 pCi/L contour in these figures are all predicted to be below the FRL by 2009.

3.6 TRANSPORT MODELING ASSUMPTIONS FOR MANGANESE

As with the technetium-99 data, the semi-variogram/Kriging analysis method could not be used to develop initial conditions for manganese because of the relatively fewer data points compared to total uranium data densities. Instead, initial conditions for manganese were developed from hand drawn contours of direct push sample data taken in the Waste Storage Area. Hand drawn contours of manganese concentrations were digitized then converted by hand into model grid node values for each affected model layer. Initial conditions for manganese in model layers 12, 11, and 10 are shown in Figures 3-25 through 3-27, respectively. The maximum value in the initial condition file is 4.6 mg/L and occurs east of the Waste Storage Area near the rail car load out facility.

No source terms were used for the manganese transport modeling.

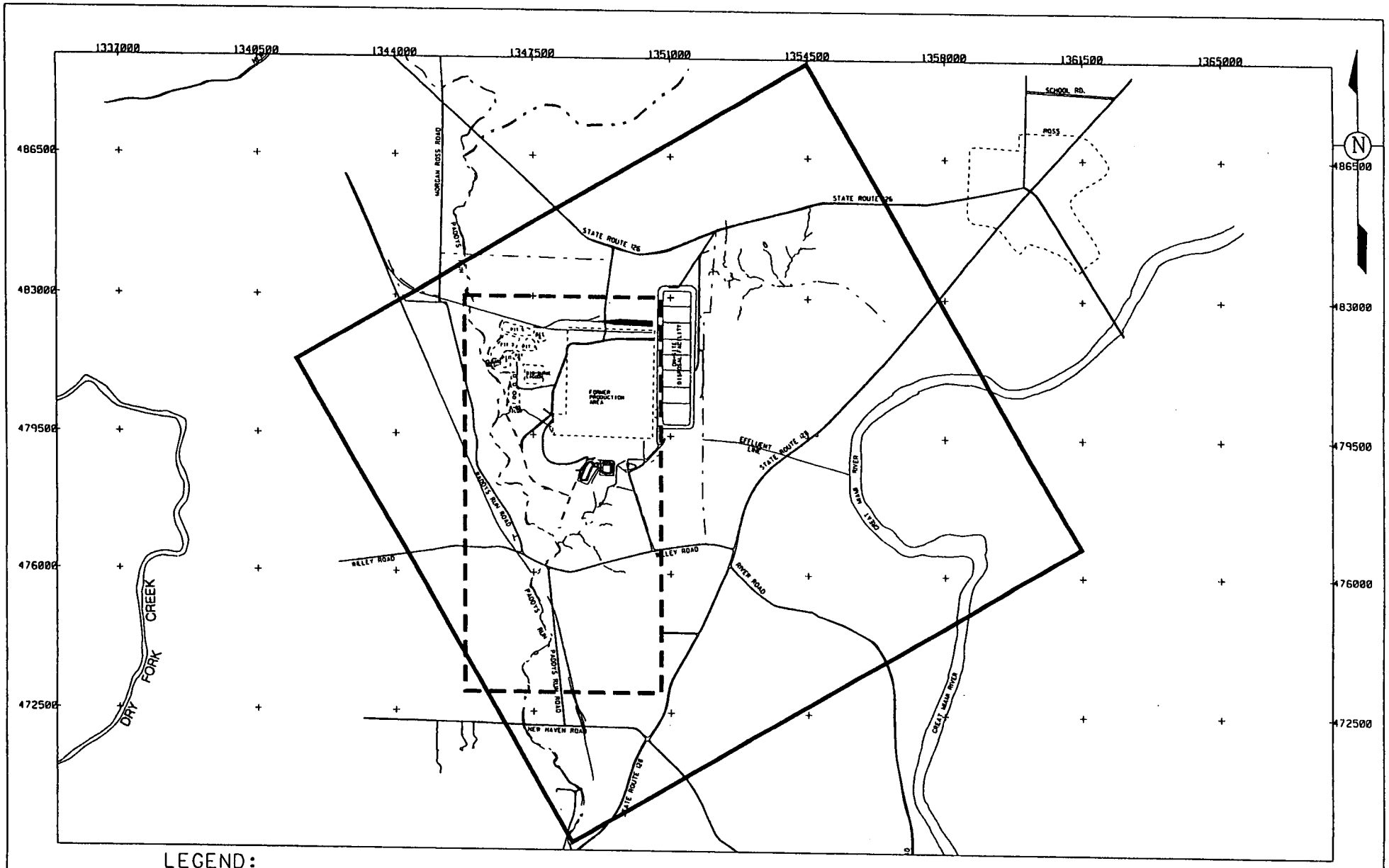
Table F.2-5 from the OU5 Feasibility Study indicates a Kd range of 10 to 30 L/Kg for manganese. Manganese moves through the groundwater much slower than uranium as evidenced by the higher Kd range. The smallest Kd value (10 L/Kg) was used in this modeling study as the most optimistic value since it was anticipated that manganese could not be remediated with a pump and treat remedy.

3.7 TRANSPORT MODELING RESULTS FOR MANGANESE

Modeled manganese concentrations in layers 12, 11, and 10 are shown at 2029 in Figures 3-28 through 3-30, respectively. This is approximately six years after the total uranium concentrations are below the FRL. The figures also show the manganese plume remains almost stationary with concentrations in layer 12 (Figure 3-28) remaining above 2.0 mg/L at 2029 or more than two times the FRL. These modeling results support that manganese is not movable and concentrations are not expected to respond well to P&T operations.

TABLE 3-1
PUMPING RATES FOR WASTE STORAGE AREA PHASE II DESIGN

System/Well ID			Pumping/Re-injection Rates (gpm)		
			5/01/05 to 4/01/06	4/01/06 to 4/1/15	4/01/15 to End
South Plume					
SP-1	RW-1	3924	200	200	0
SP-2	RW-2	3925	200	200	0
SP-3	RW-3	3926	200	200	0
SP-4	RW-4	3927	400	200	0
SP-6	RW-6	32308	200	200	0
SP-7	RW-7	32309	200	200	0
		Sub Total	1400	1200	0
South Field					
SF-31	EW-15a	33262	200	200	300
SF17	EW-17	31567	175	175	175
SF18	EW-18	31550	100	100	100
SF19	EW-19	31560	100	100	100
SF20	EW-20	31561	100	100	400
SF21	EW-21a	33298	200	200	300
SF22	EW-22	32276	300	300	400
SF23	EW-23	32447	300	300	400
SF24	EW-24	32446	300	300	300
SF25	EW-25	33061	100	100	100
SF32	EW-30	33264	300	200	400
SF33	EW-31	33265	200	300	400
SF34	EW-32	33266	200	200	200
		Sub Total	2575	2575	3575
Waste Storage Area					
WSA-1	EW-26	32761	300	300	500
WSA-2	EW-27	33062	400	200	200
WSA-4	EW-28	33063	0	200	200
WSA-5			0	300	300
		Sub Total	700	1000	1200
		Total Pumping	4675	4775	4775



LEGEND:

- FEMP BOUNDARY
- LARGE MODEL BOUNDARY
- ZOOM MODEL BOUNDARY

SCALE

3500 1750 0 3500 FEET

DRAFT

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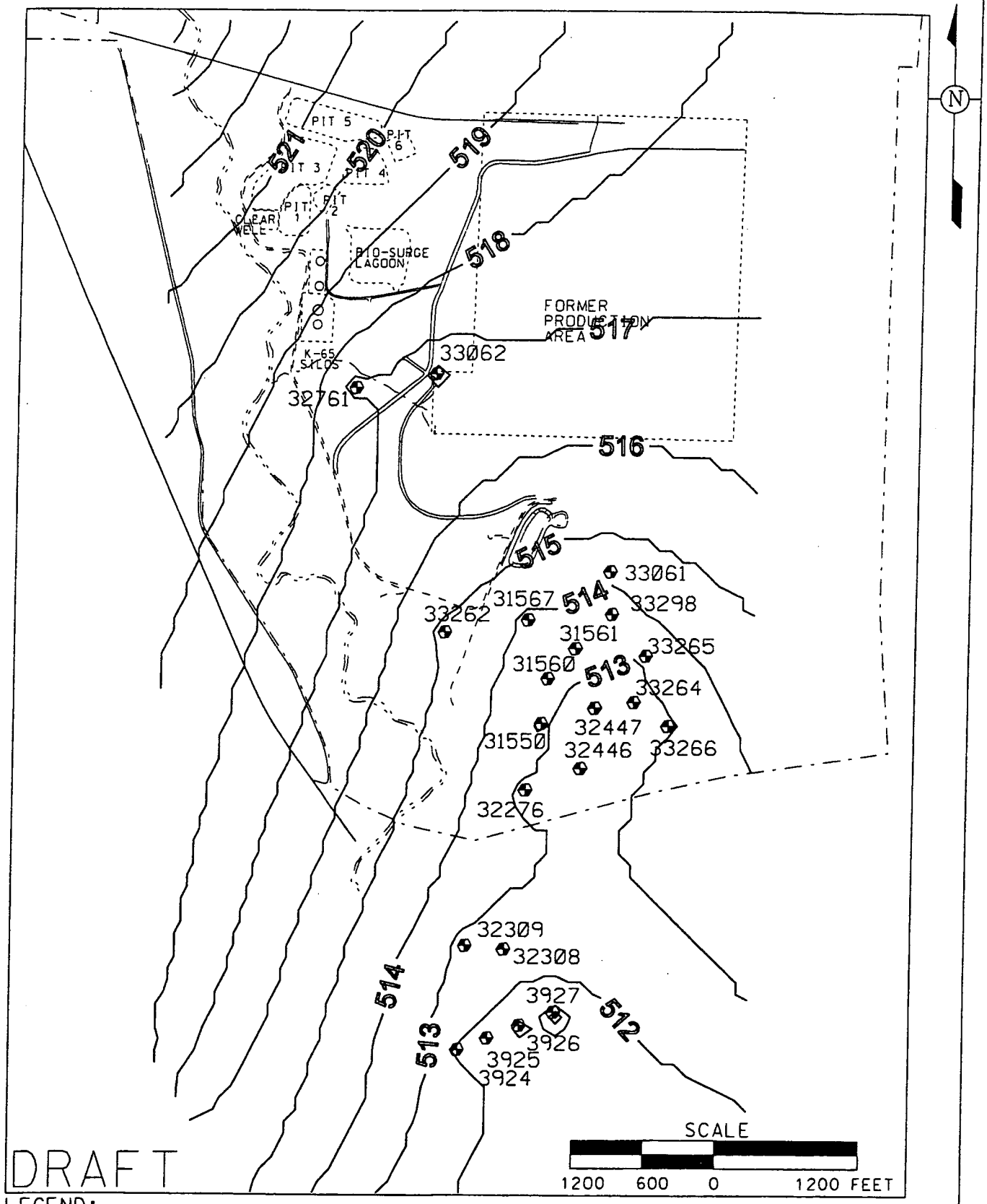
STATE PLANAR COORDINATE SYSTEM 1927

09-JUN-2005

FIGURE 3-1. VAM 3D LARGE MODEL AND ZOOM MODEL BOUNDARIES



LEGEND:

- FERNALD SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL

FIGURE 3-2. PREDICTED GROUNDWATER ELEVATIONS IN MODEL LAYER 12 UNDER CURRENT CONDITIONS

STATE PLANAR COORDINATE SYSTEM 1983

10-JUN-2005

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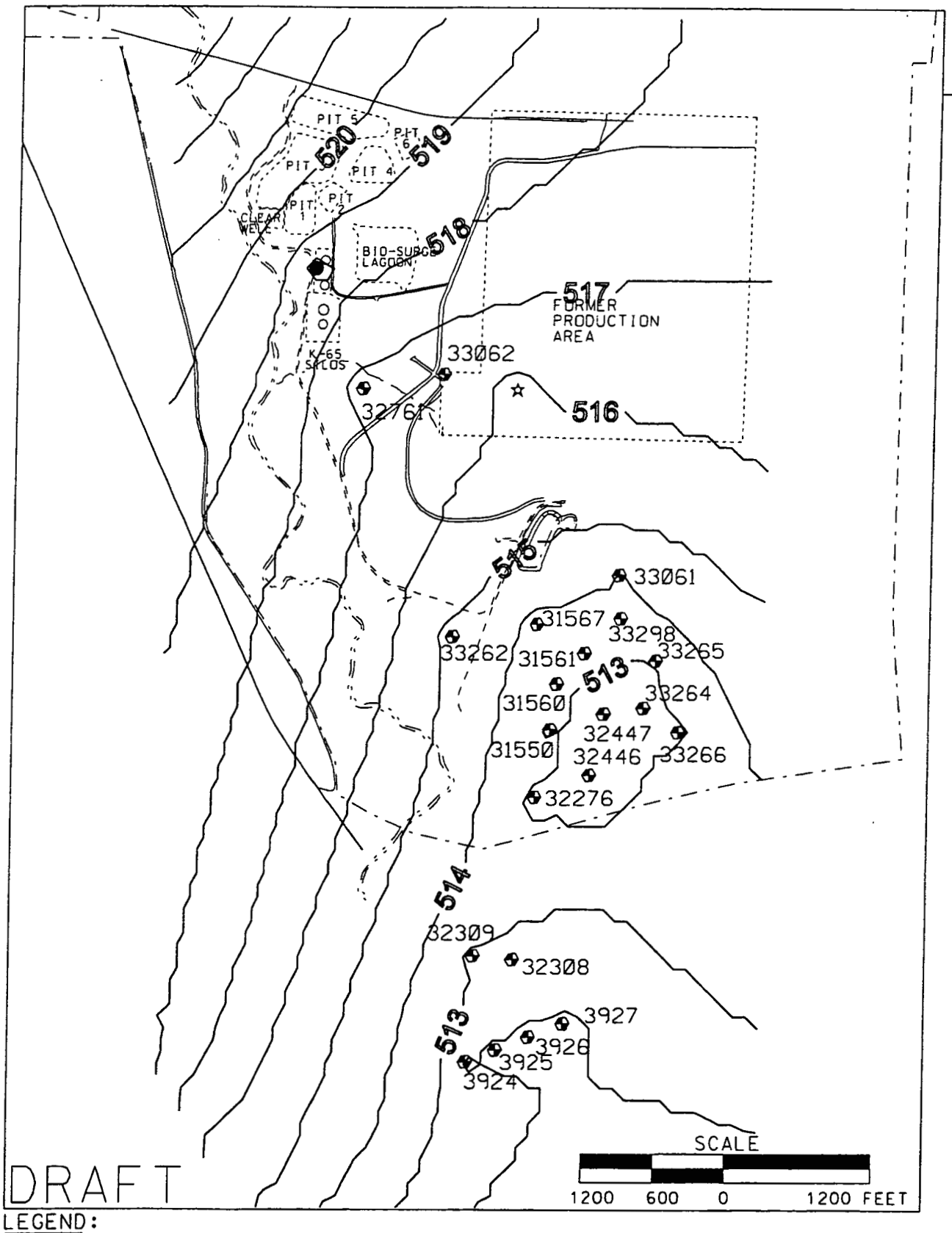

LEGEND:

- FERNALD SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL
- REPLACEMENT LOCATION FOR WELL 33063

FIGURE 3-3. PREDICTED GROUNDWATER ELEVATIONS IN MODEL LAYER 12 UNDER PUMPING CONDITIONS FROM 2006 AND 2015

STATE PLANAR COORDINATE SYSTEM 1983

10-JUN-2005

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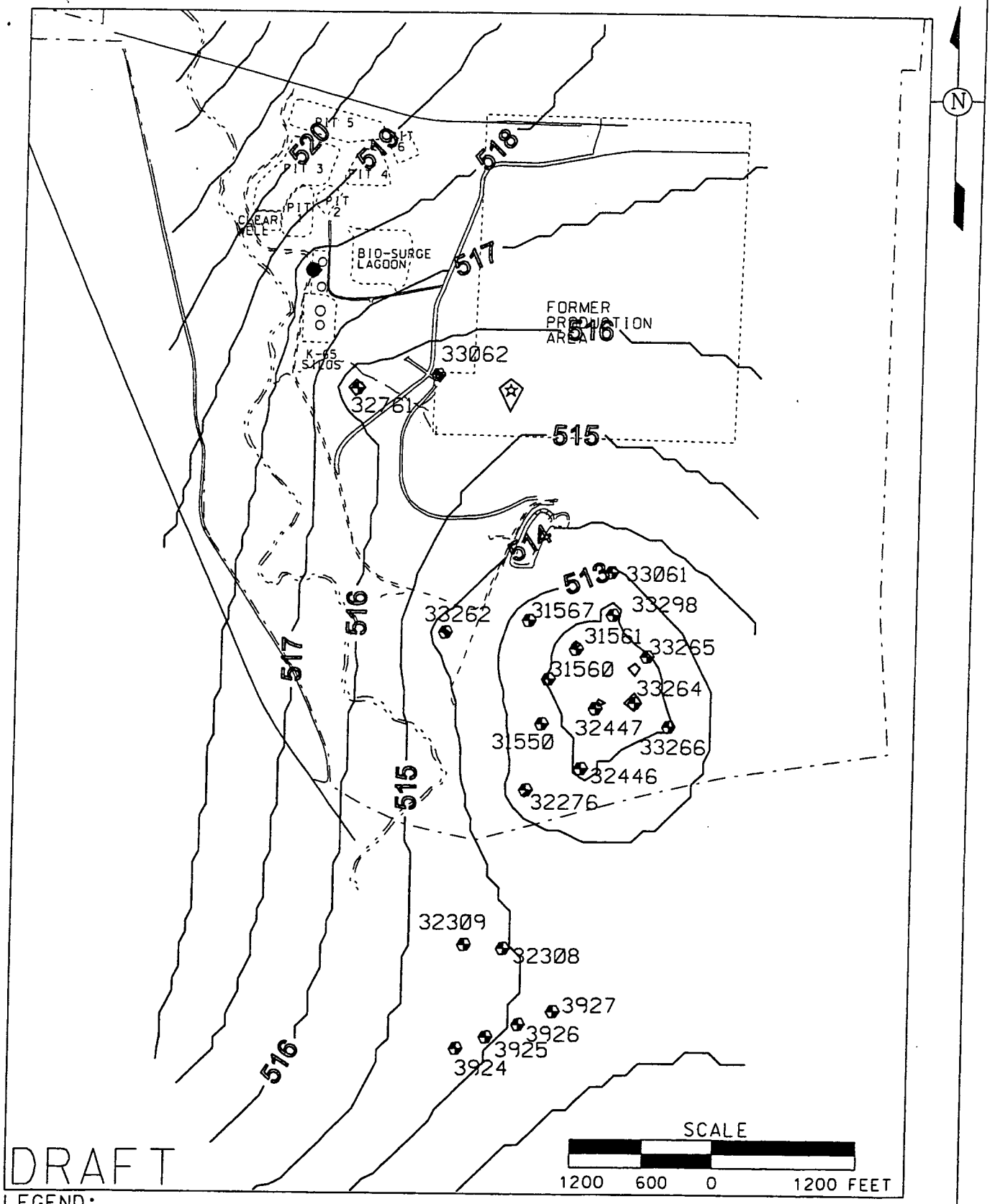

LEGEND:

- FERNALD SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL
- REPLACEMENT LOCATION FOR WELL 33063

FIGURE 3-4. PREDICTED GROUNDWATER ELEVATIONS IN MODEL LAYER 12 UNDER PUMPING CONDITIONS FROM 2015 TO END OF AQUIFER REMEDY

STATE PLANAR COORDINATE SYSTEM 1983

10-JUN-2005

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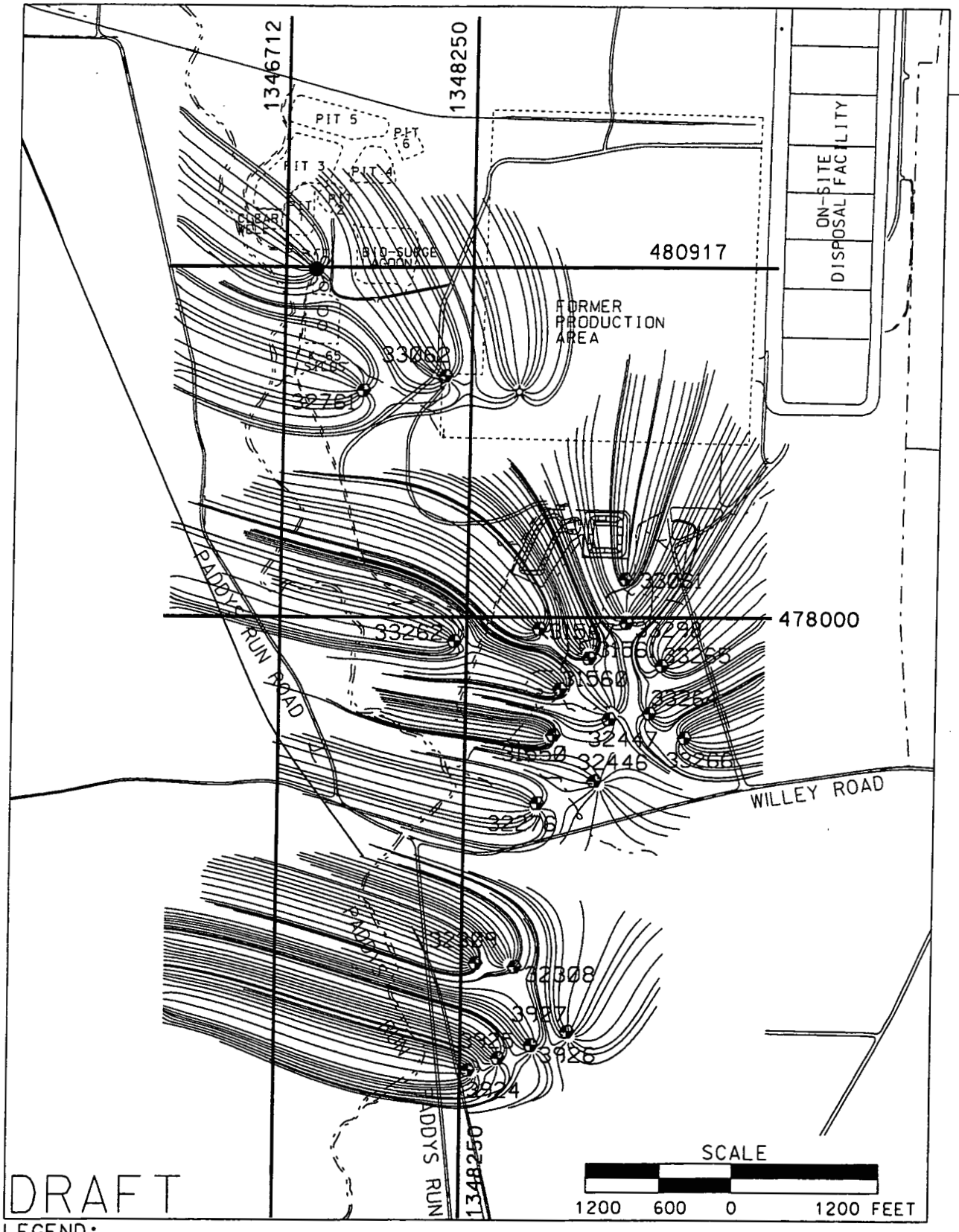

LEGEND:

- FERNALD SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- CROSS SECTION LOCATIONS FOR FIGURES 3.8 AND 3.9
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL
- REPLACEMENT LOCATION FOR WELL 33063

FIGURE 3.5. NON-RETARDED 10-YEAR REVERSE PARTICLE TRACKS UNDER PUMPING CONDITIONS FROM 2006 TO 2015

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STATE PLANAR COORDINATE SYSTEM 1983
21-JUN-2005

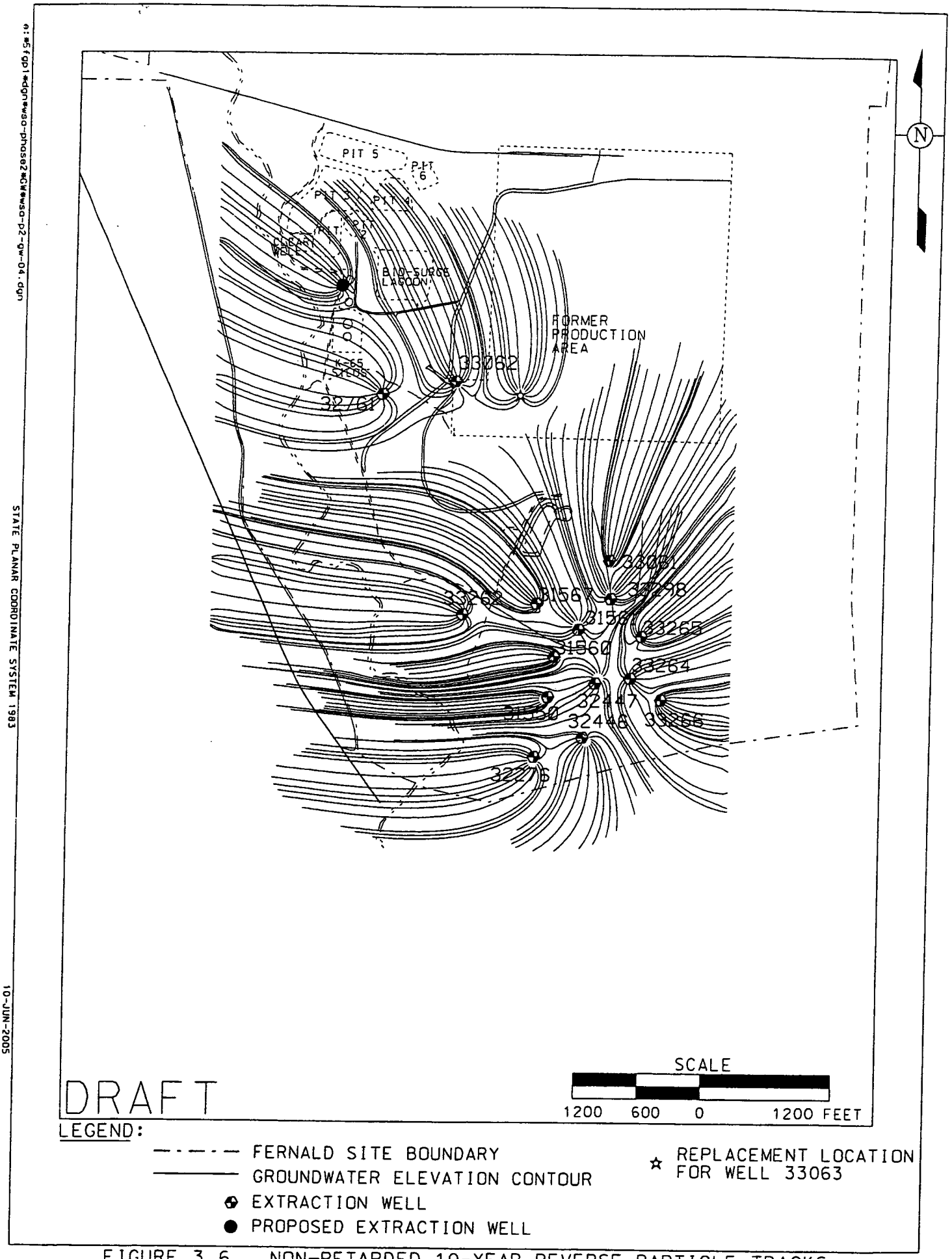
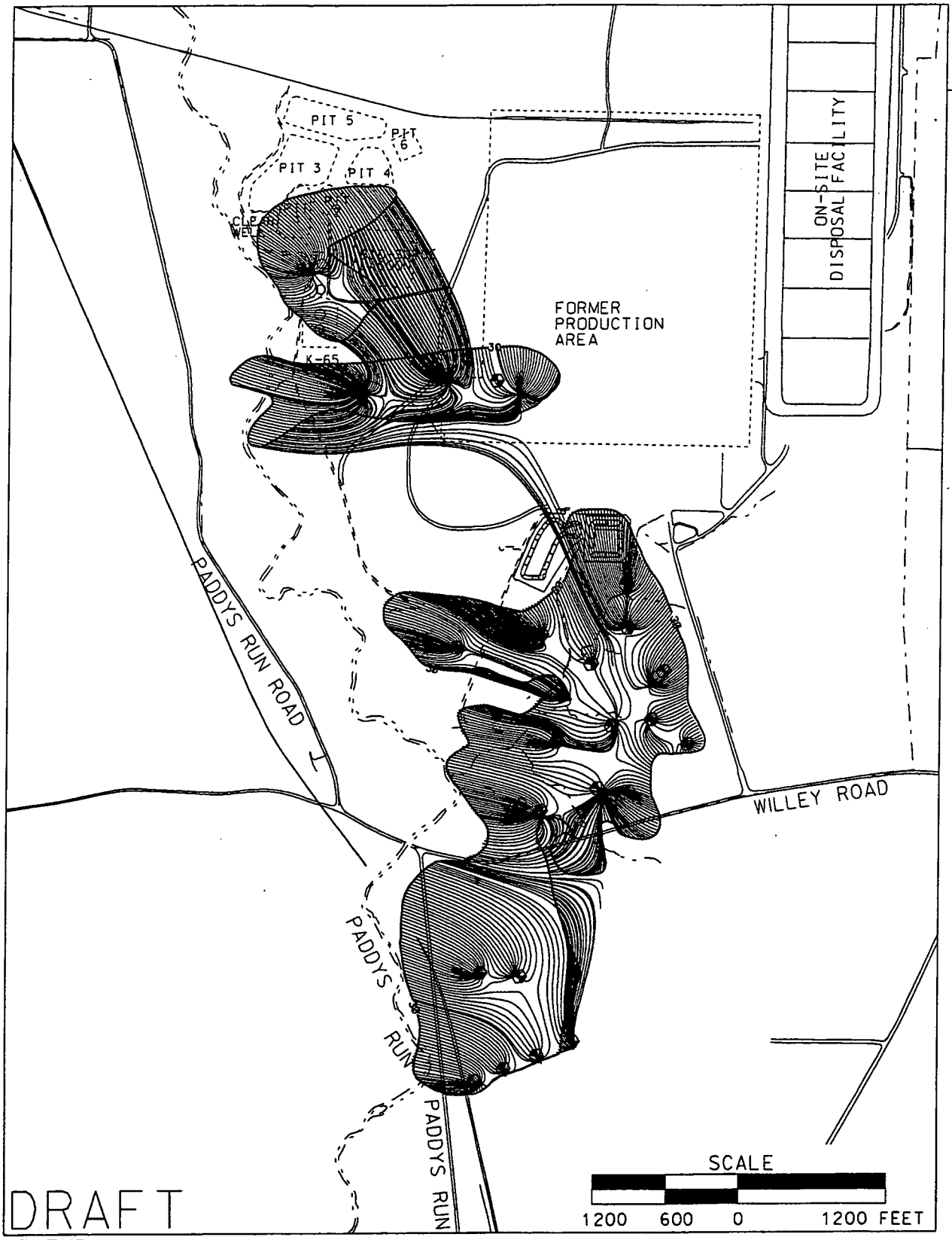


FIGURE 3.6. NON-RETARDED 10-YEAR REVERSE PARTICLE TRACKS UNDER PUMPING CONDITIONS FROM 2015 TO END OF AQUIFER REMEDY



LEGEND:

- —·—·— FERNALD SITE BOUNDARY
- ——— PARTICLE TRACK
- —30— TOTAL URANIUM PLUME CONTOUR
- ⊕ EXTRACTION WELL LOCATION

FIGURE 3-7. NON-RETARDED FORWARD PARTICLE TRACKS UNDER PUMPING CONDITIONS FROM 2006 TO 2015 SEEDED AT TOTAL URANIUM 30 $\mu g/L$ BOUNDARY

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STATE PLANAR COORDINATE SYSTEM 1983
21-JUN-2005

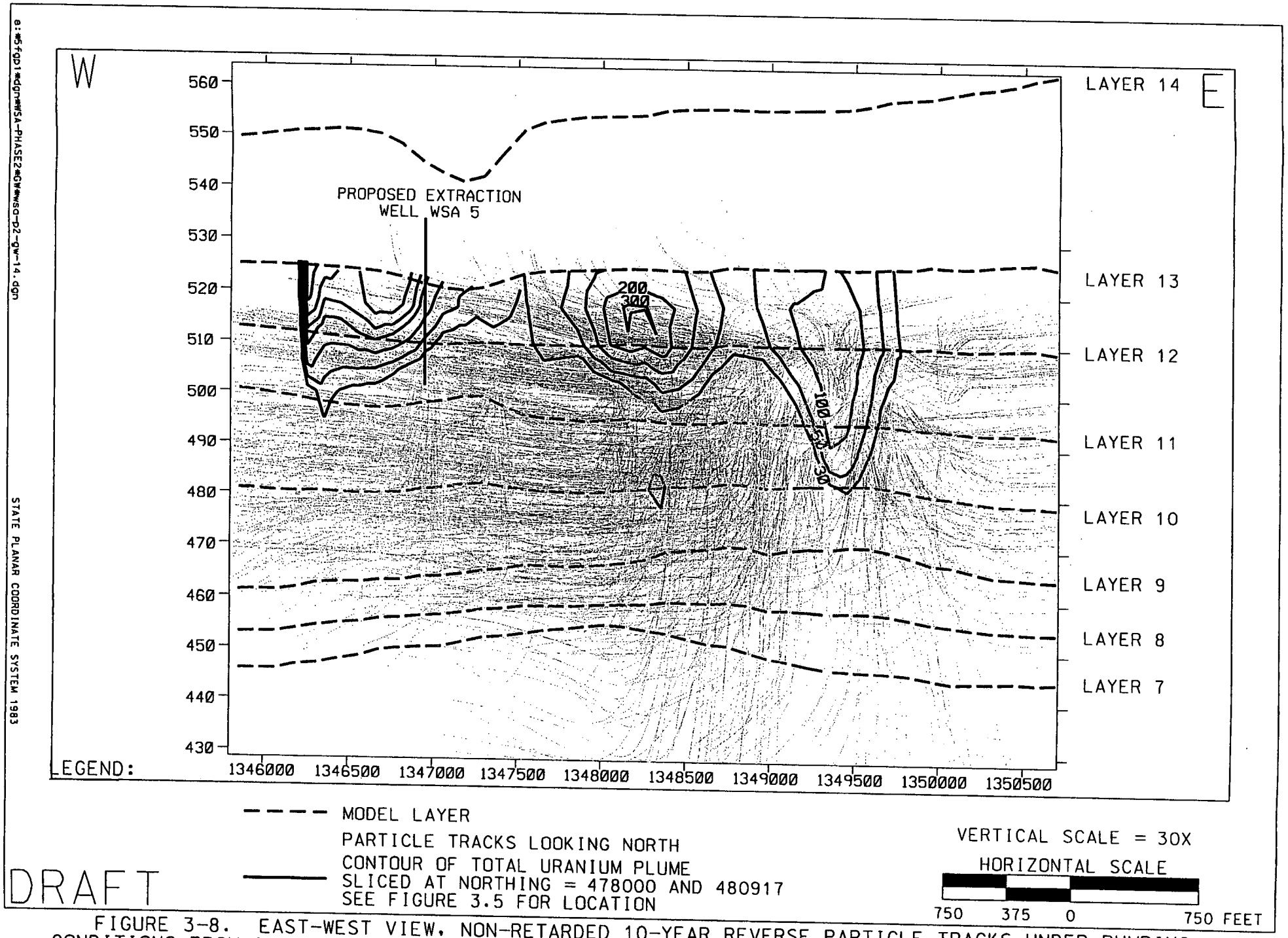
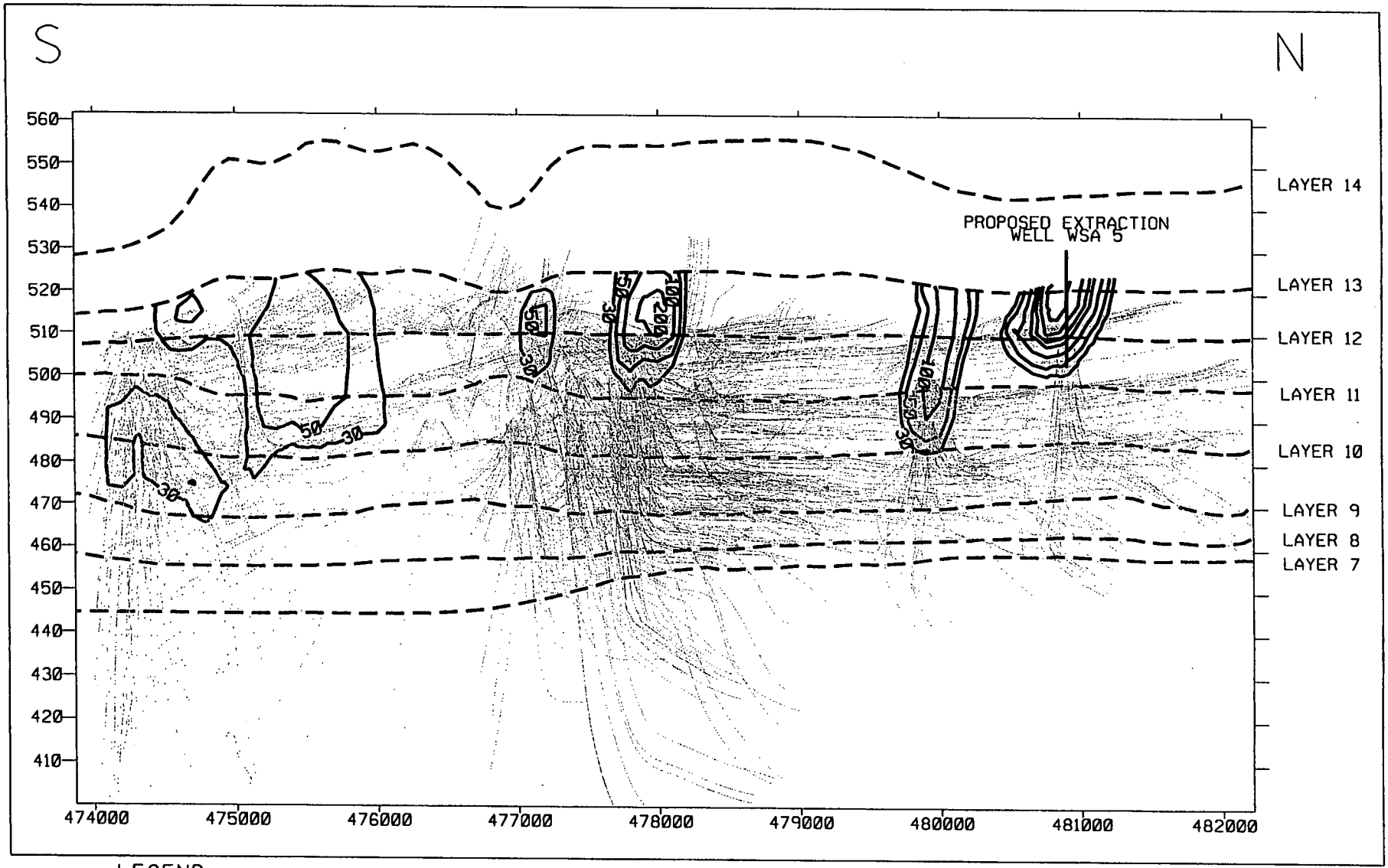


FIGURE 3-8. EAST-WEST VIEW, NON-RETARDED 10-YEAR REVERSE PARTICLE TRACKS UNDER PUMPING CONDITIONS FROM 2006 TO 2015 WITH TOTAL URANIUM PLUME SLICED AT NORTHINGS OF 478000 AND 480917.



LEGEND:

- MODEL LAYER
- PARTICLE TRACKS LOOKING WEST
- CONTOUR OF TOTAL URANIUM PLUME SLICED AT EASTING = 1348250 AND 1346712 SEE FIGURE 3.5 FOR LOCATION

VERTICAL SCALE = 30X

HORIZONTAL SCALE

1050 525 0 1050 FEET

DRAFT

STATE PLANAR COORDINATE SYSTEM 1983

e:\5fgp1\dgn\WSA-PHASE2\GW\wsa-p2-gw-16.dgn

FIGURE 3-9. NORTH-SOUTH VIEW, NON-RETARDED 10-YEAR REVERSE PARTICLE TRACKS UNDER PUMPING CONDITIONS FROM 2006 TO 2015 WITH TOTAL URANIUM PLUME SLICED AT EASTINGS OF 1348250 AND 1346712

Figure 3.10 Horizontal Variograms for December 2004 Total Uranium Groundwater Data

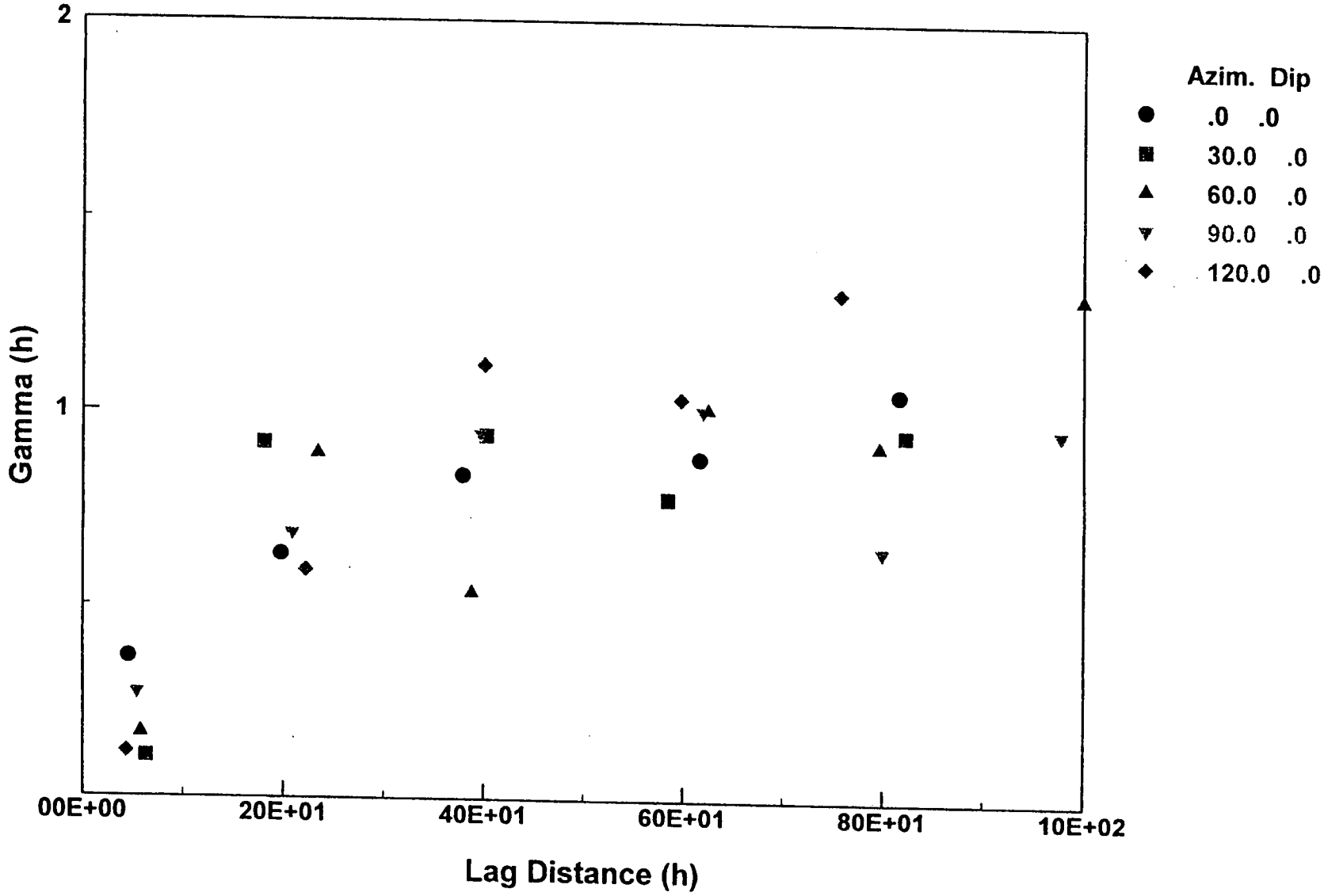
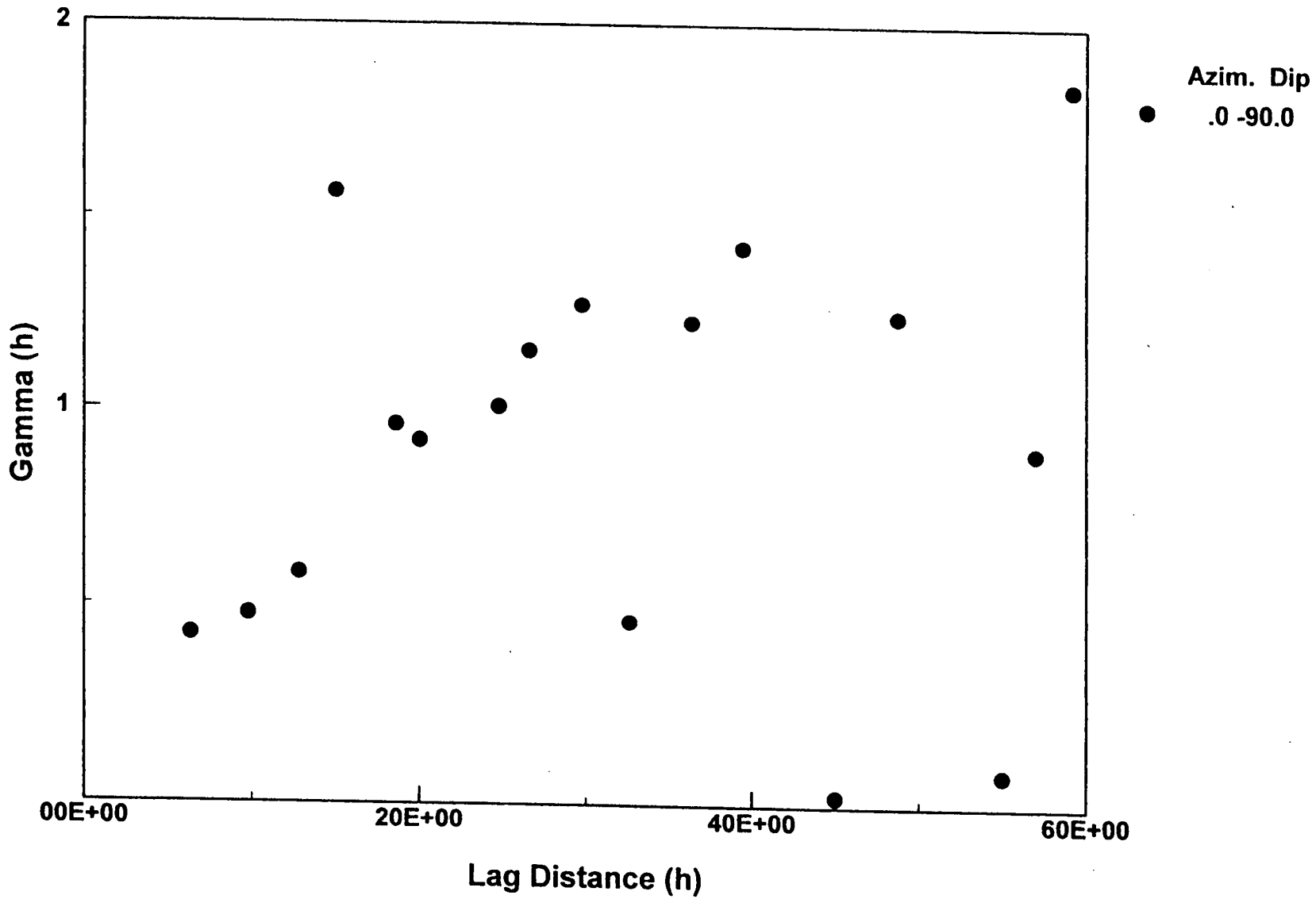


Figure 3.11 Vertical Variogram for December 2004 Total Uranium Groundwater Data



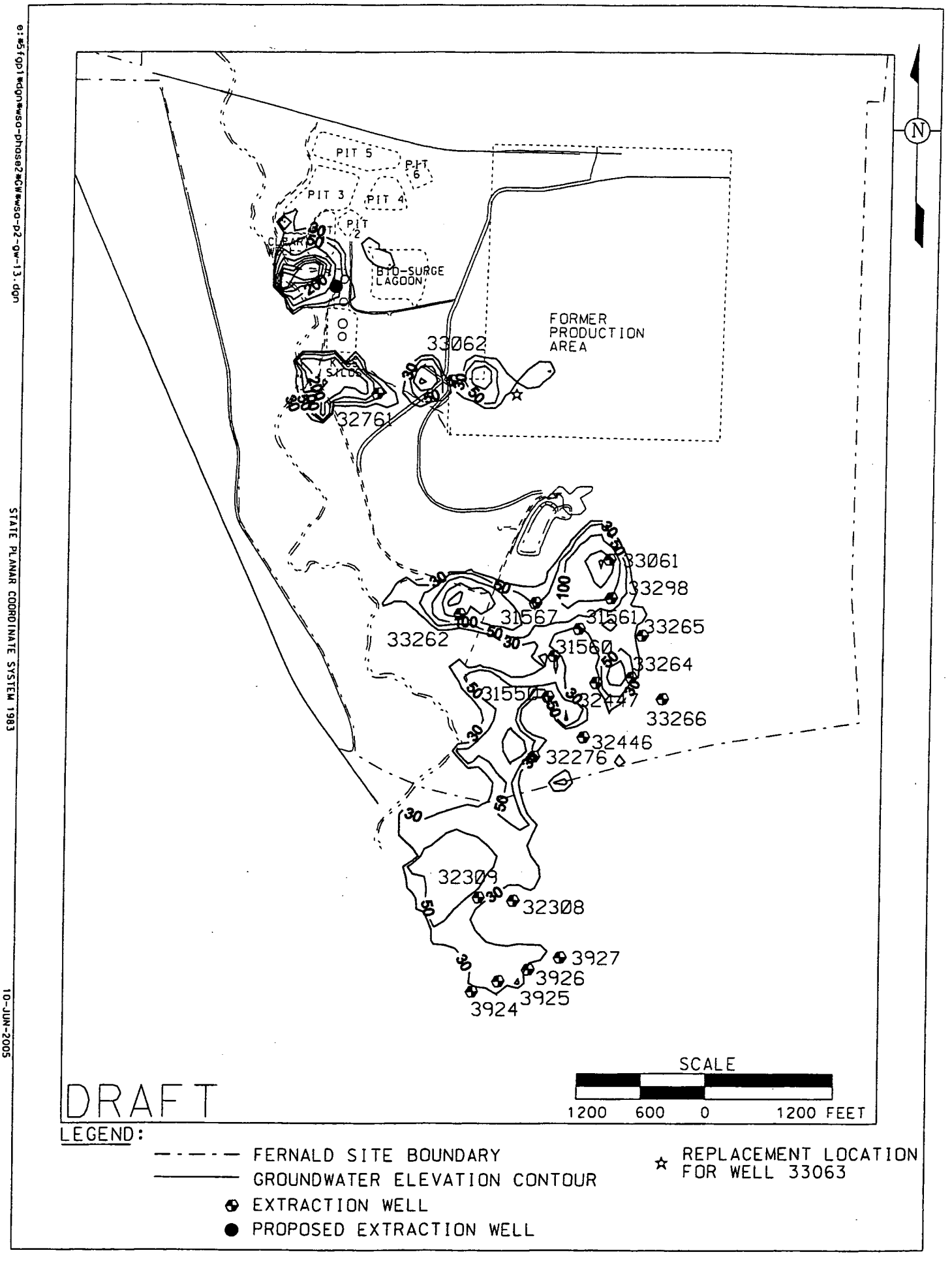
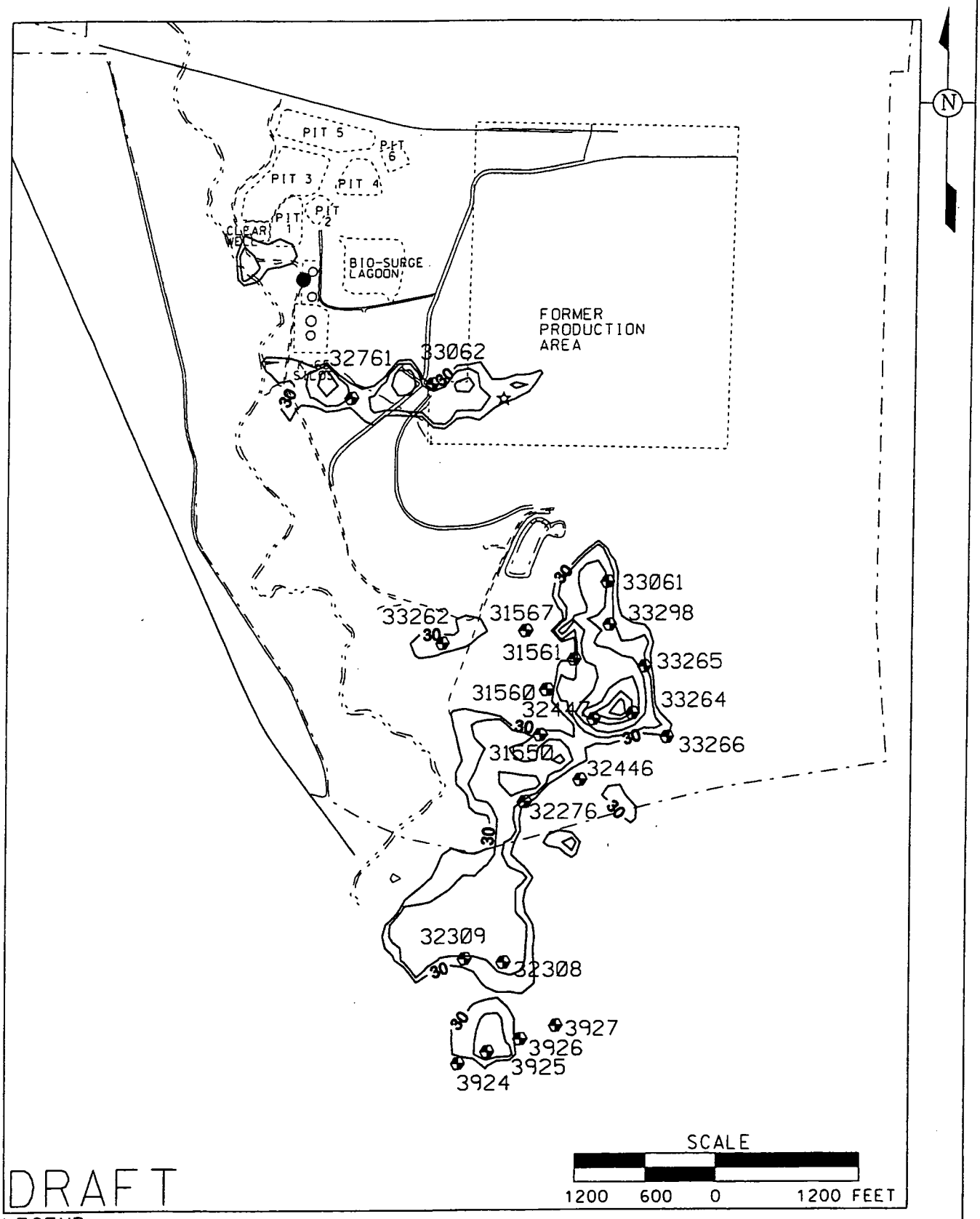


FIGURE 3-12. TOTAL URANIUM INITIAL CONDITIONS IN MODEL LAYER 12



LEGEND:

- FERNALD SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL
- REPLACEMENT LOCATION FOR WELL 33063

FIGURE 3-13. TOTAL URANIUM INITIAL CONDITIONS IN MODEL LAYER 11

g:\5fgp1\dgn\wso-phase2\cw\wso-p2-cw-10.dgn
STATE PLANAR COORDINATE SYSTEM 1983
10-JUN-2005

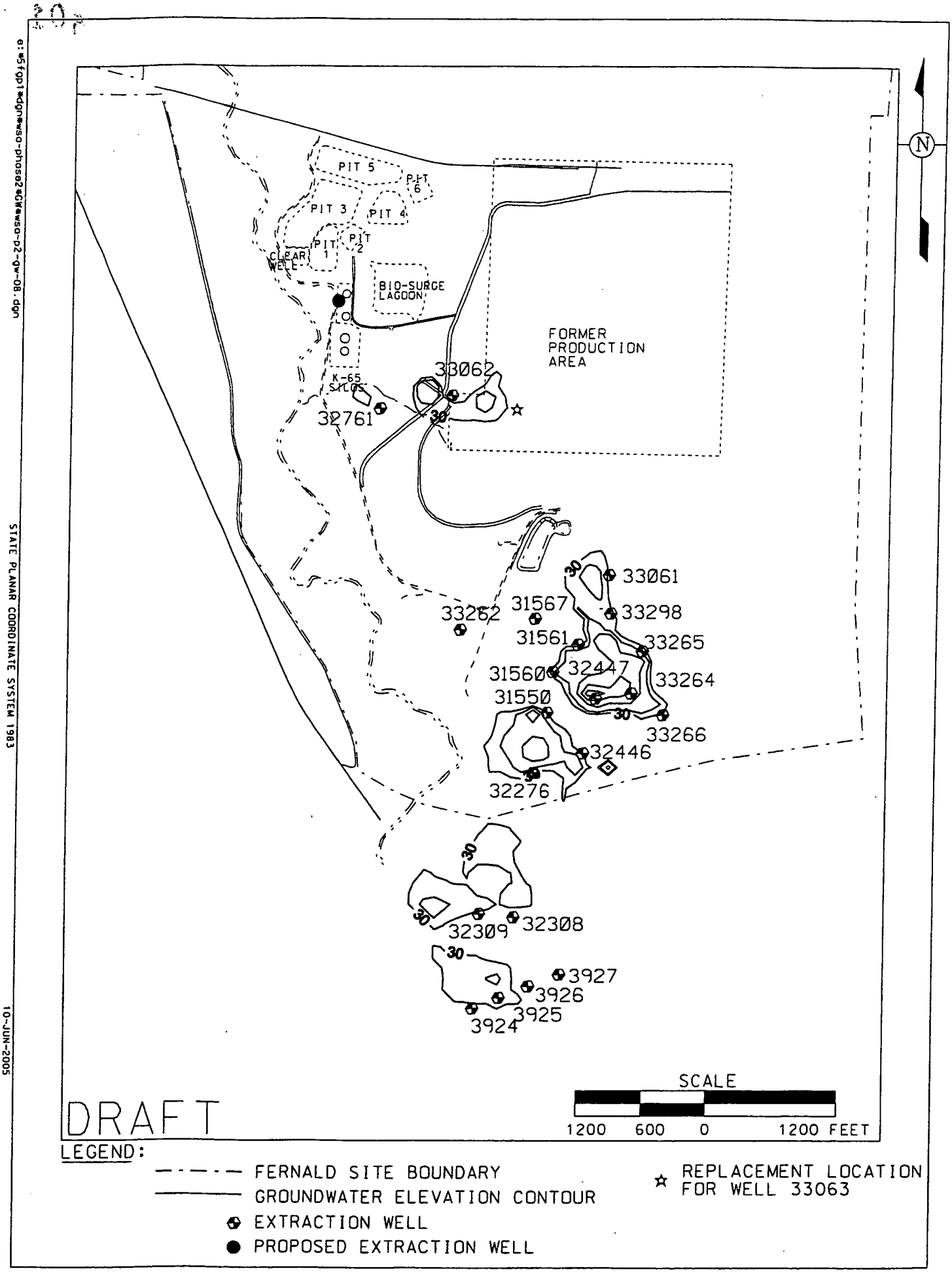
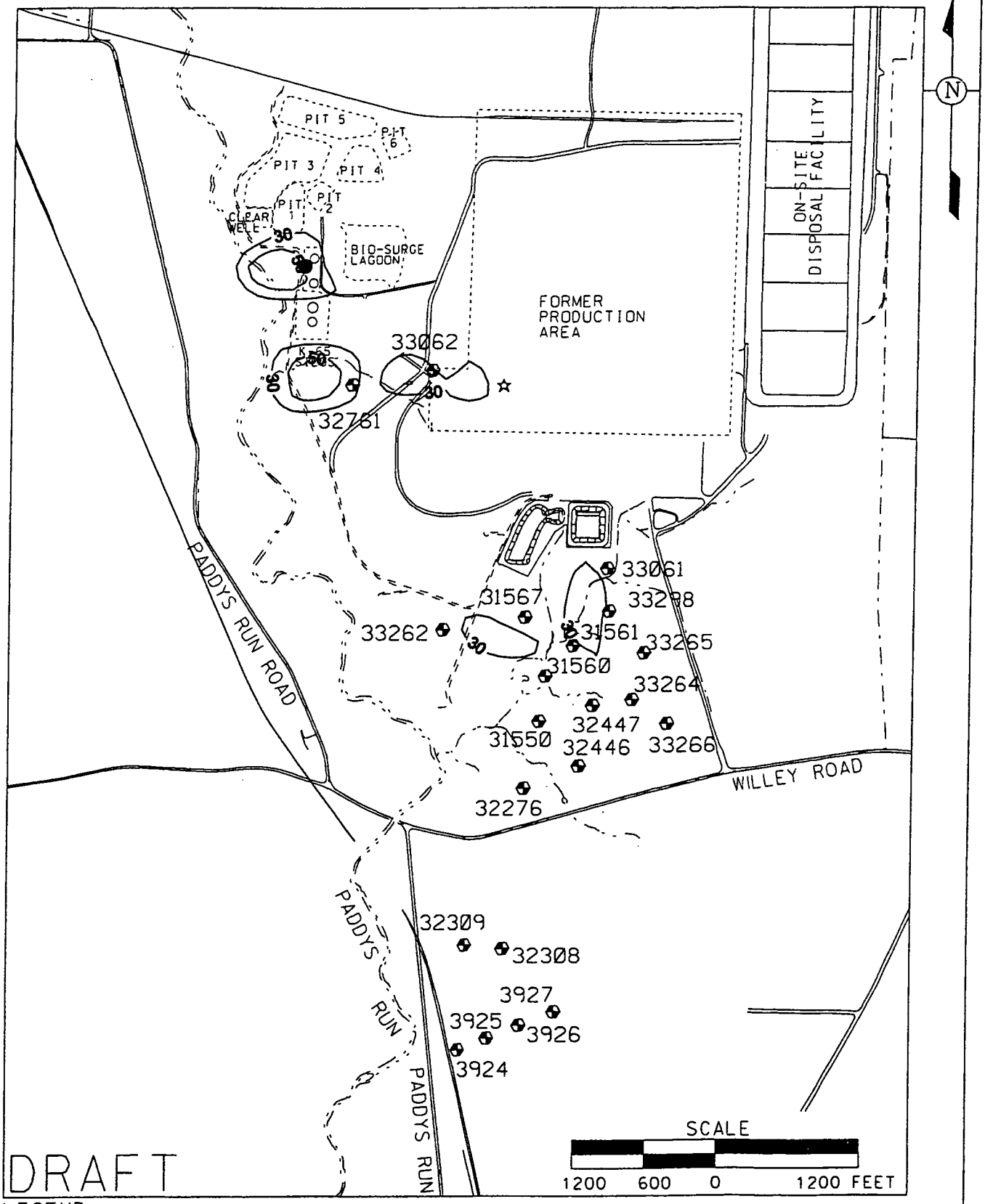


FIGURE 3-14. TOTAL URANIUM INITIAL CONDITIONS IN MODEL LAYER 10



LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL
- ☆ REPLACEMENT LOCATION FOR WELL 33063

FIGURE 3-15. PREDICTED TOTAL URANIUM CONCENTRATIONS IN MODEL LAYER 12 AT 2015

STATE PLANAR COORDINATE SYSTEM 1983
10-JUN-2005

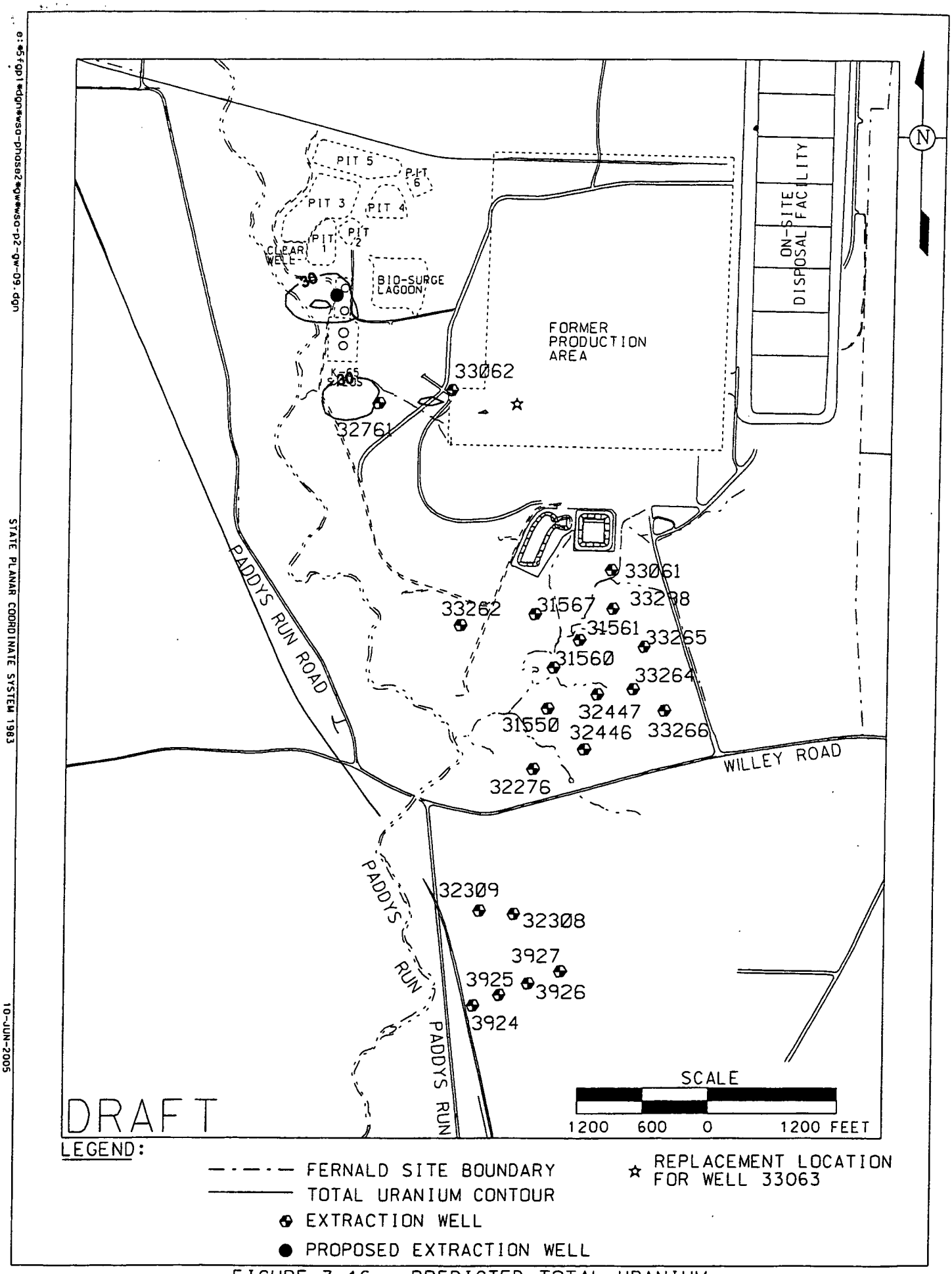
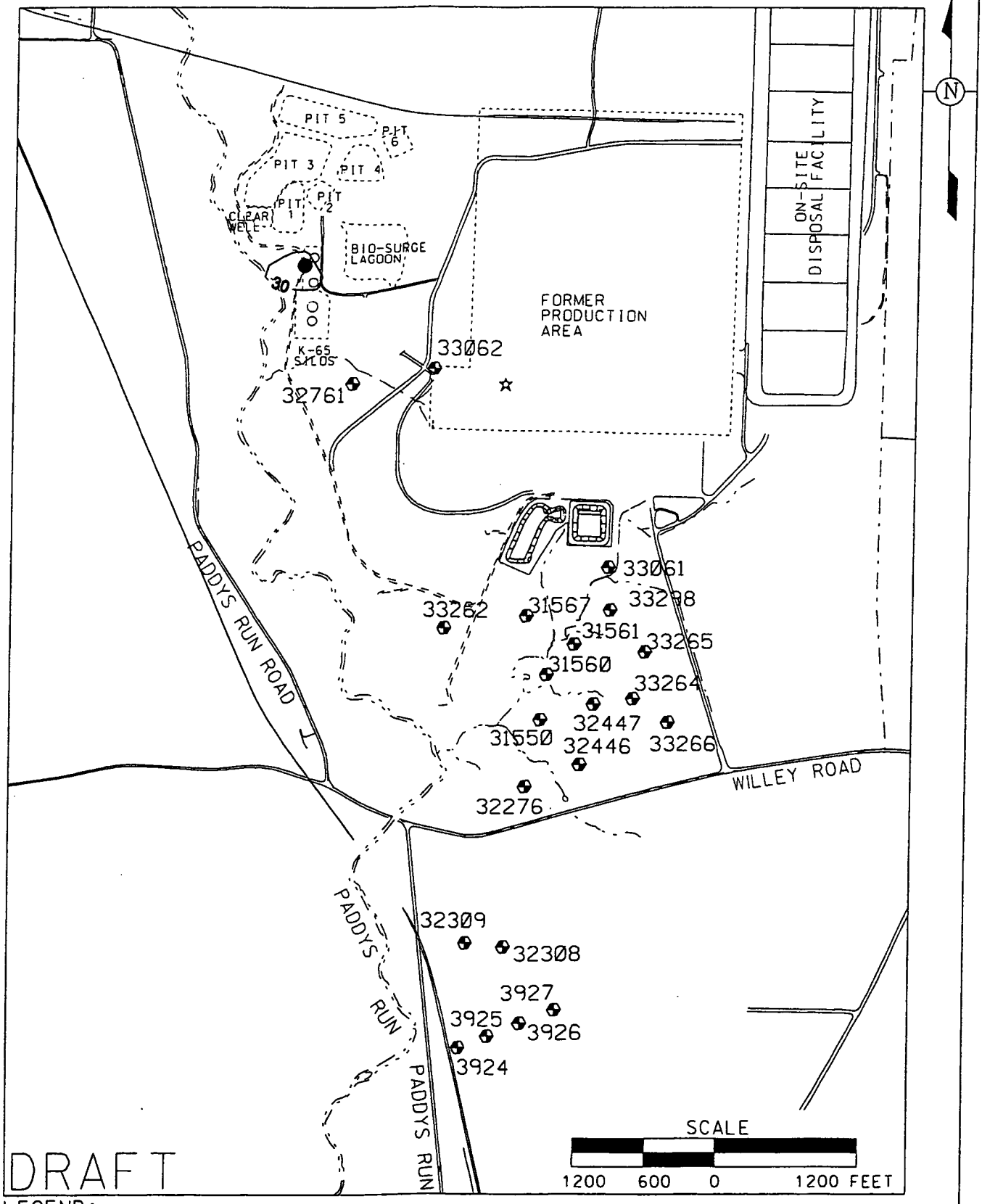


FIGURE 3-16. PREDICTED TOTAL URANIUM CONCENTRATIONS IN MODEL LAYER 11 AT 2015



LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL
- ☆ REPLACEMENT LOCATION FOR WELL 33063

FIGURE 3-17. PREDICTED TOTAL URANIUM CONCENTRATIONS IN MODEL LAYER 10 AT 2015

e:\5fgp1\dgn\wsg-phase2\qw\wsg-p2-qw-07.dgn
STATE PLANAR COORDINATE SYSTEM 1983
10-JUN-2005

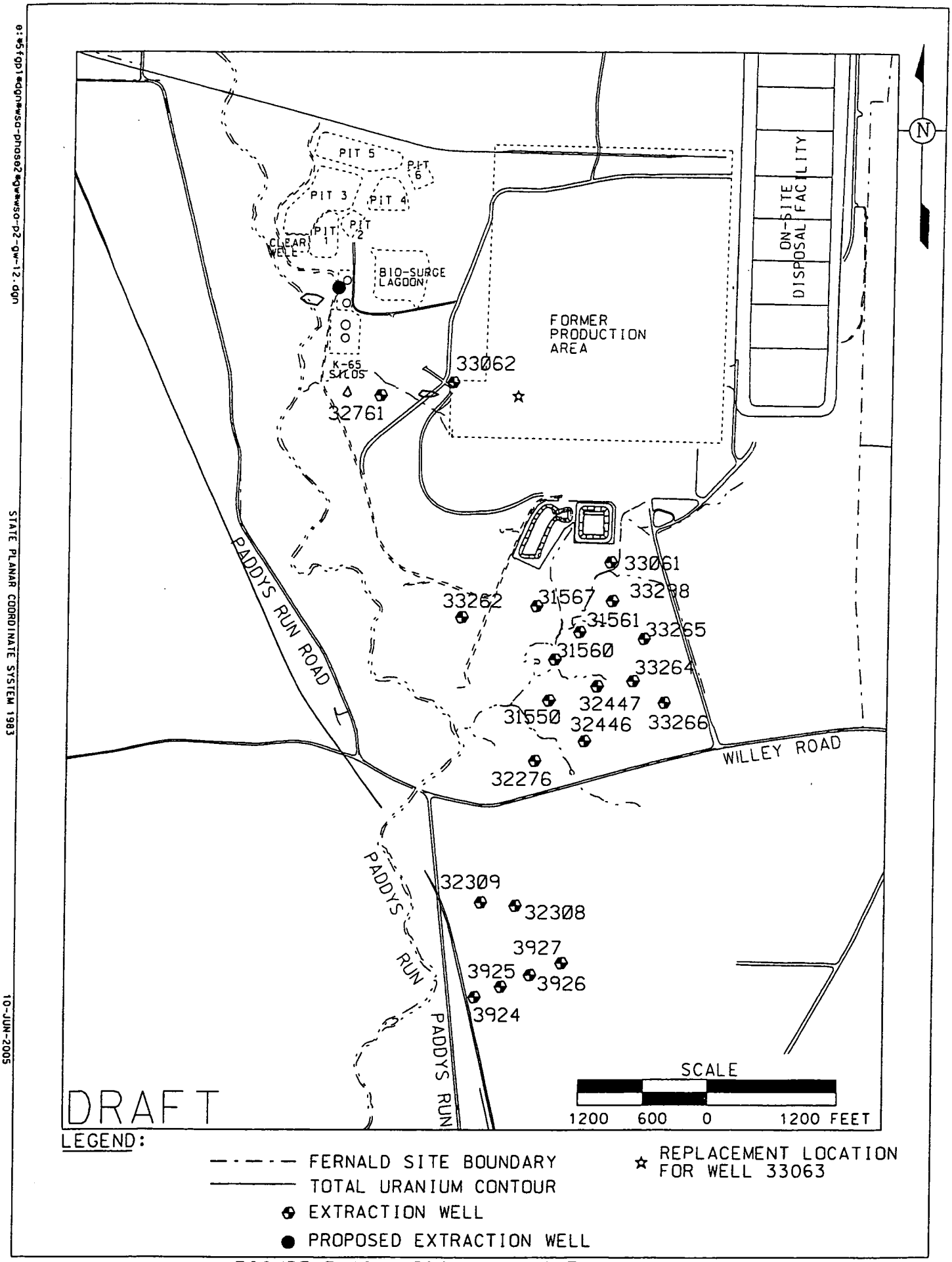


FIGURE 3-18. PREDICTED TOTAL URANIUM CONCENTRATIONS IN MODEL LAYER 12 AT 2022

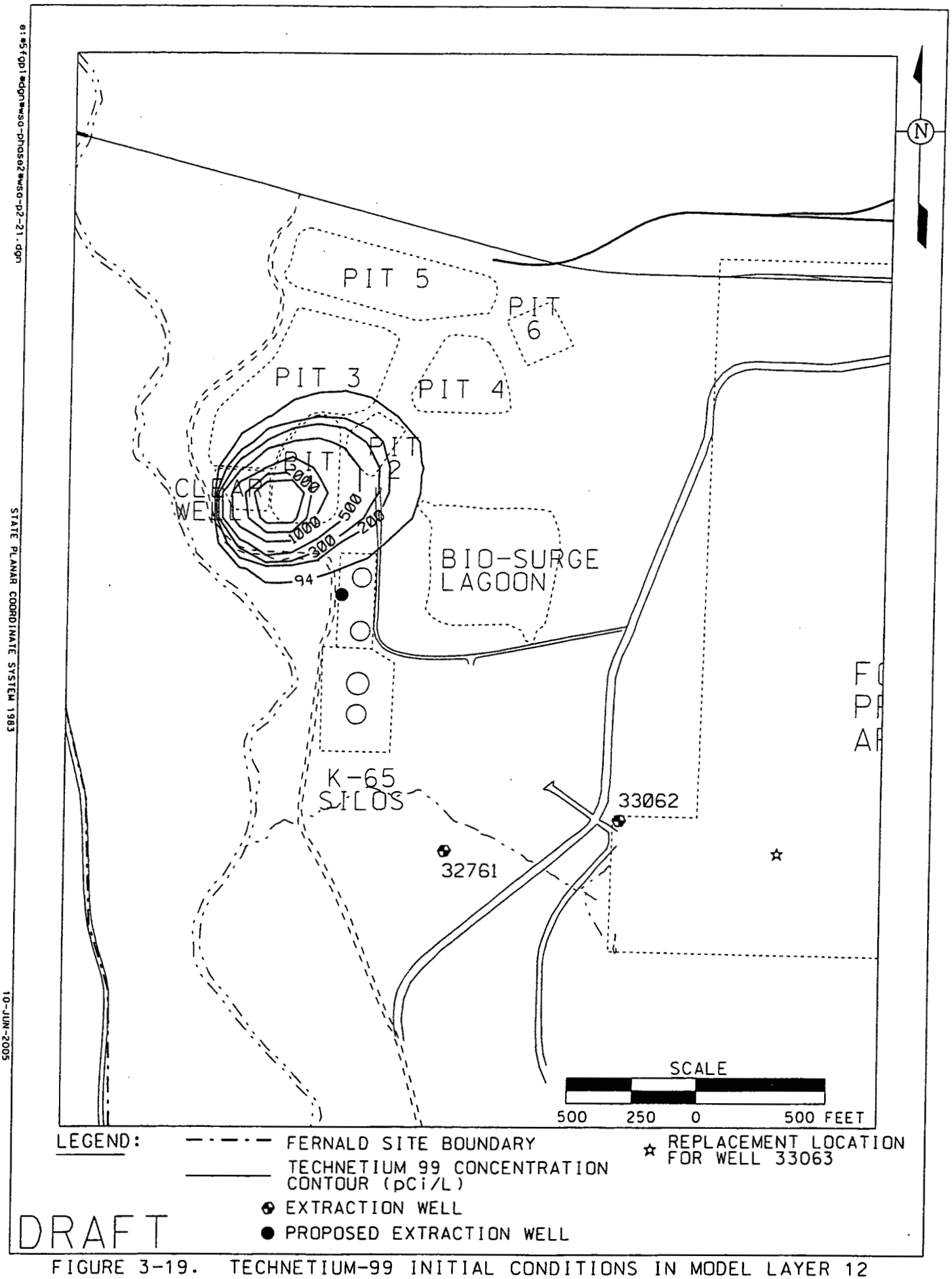


FIGURE 3-19. TECHNETIUM-99 INITIAL CONDITIONS IN MODEL LAYER 12

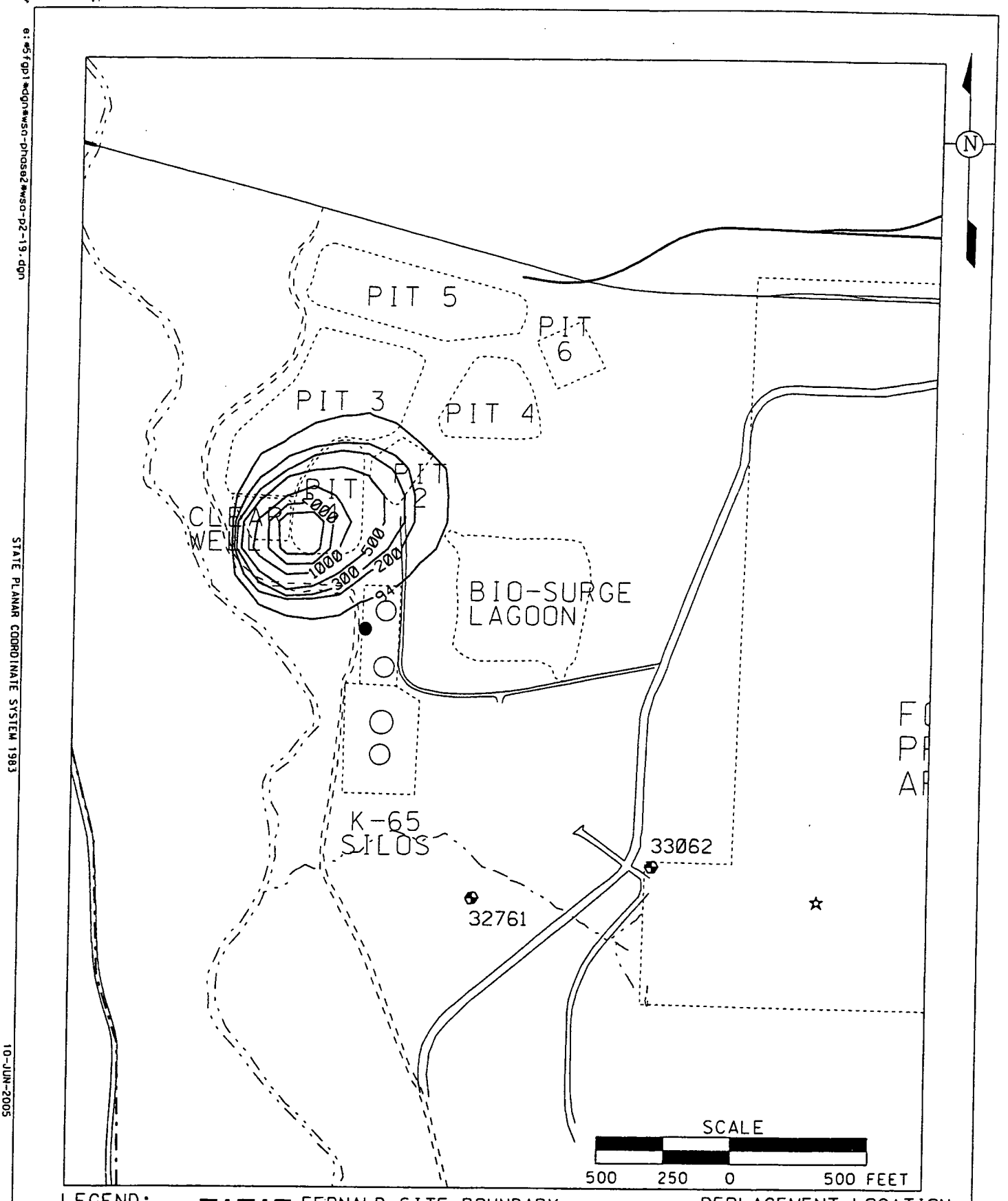


FIGURE 3-20. TECHNETIUM-99 INITIAL CONDITIONS IN MODEL LAYER 11

e:\5fgp1\dgn\wso-phase2\wso-p2-19.dgn
STATE PLANAR COORDINATE SYSTEM 1983
10-JUN-2005

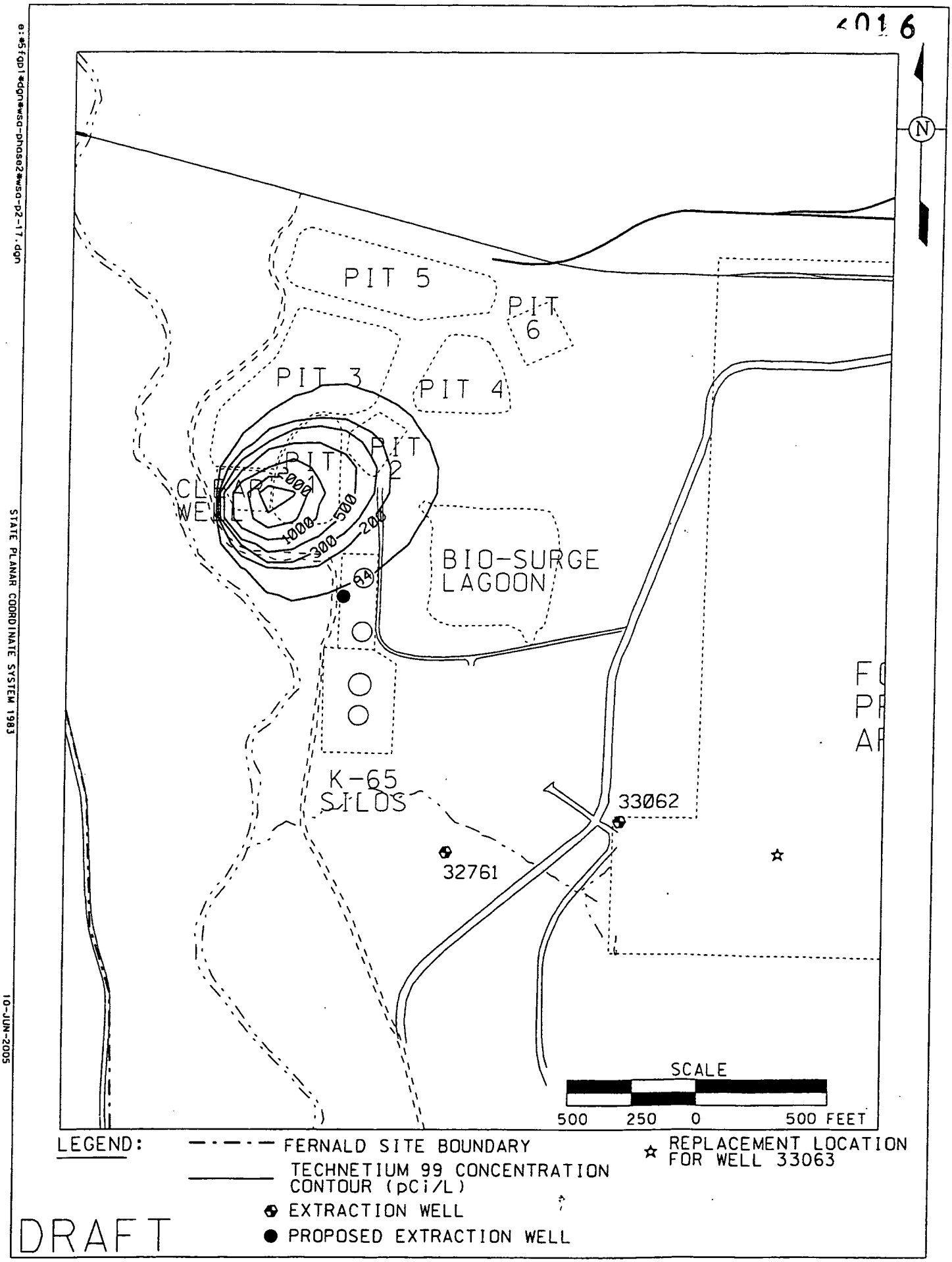


FIGURE 3-21. TECHNETIUM-99 INITIAL CONDITIONS IN MODEL LAYER 10

STATE PLANAR COORDINATE SYSTEM 1983

10-JUN-2005

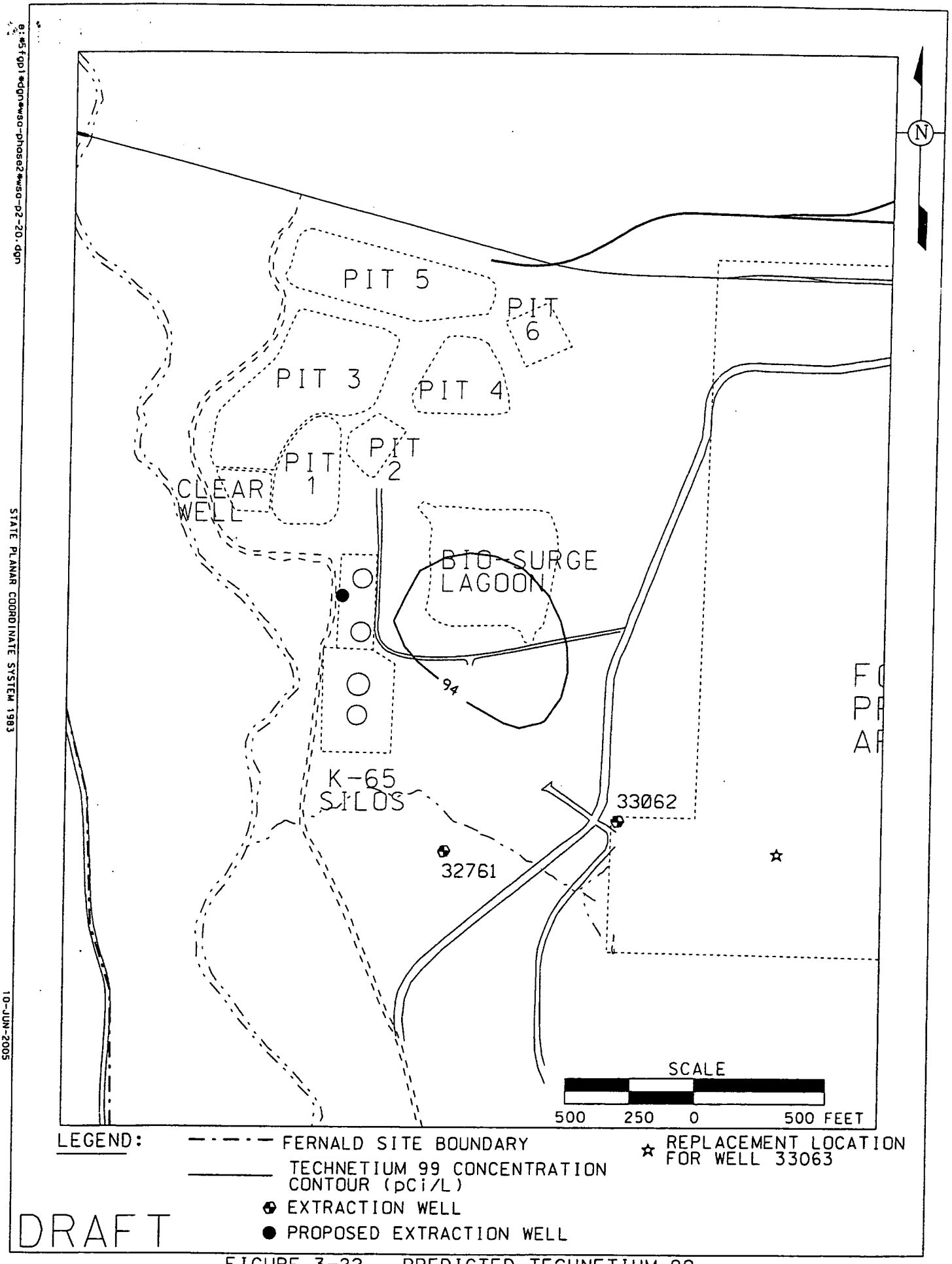


FIGURE 3-22. PREDICTED TECHNETIUM-99 CONCENTRATIONS IN MODEL LAYER 12 AT 2008

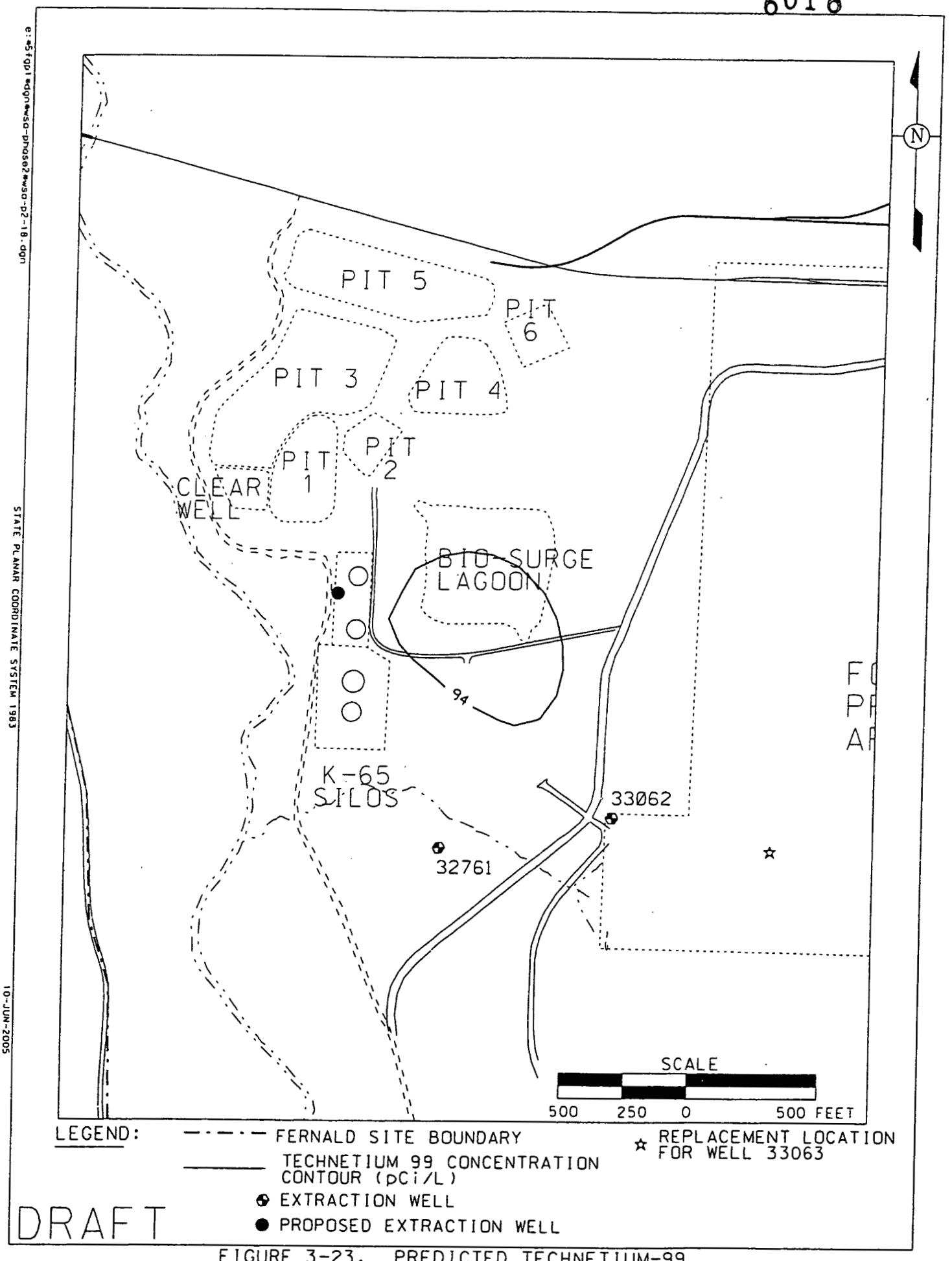


FIGURE 3-23. PREDICTED TECHNETIUM-99 CONCENTRATIONS IN MODEL LAYER 11 AT 2008

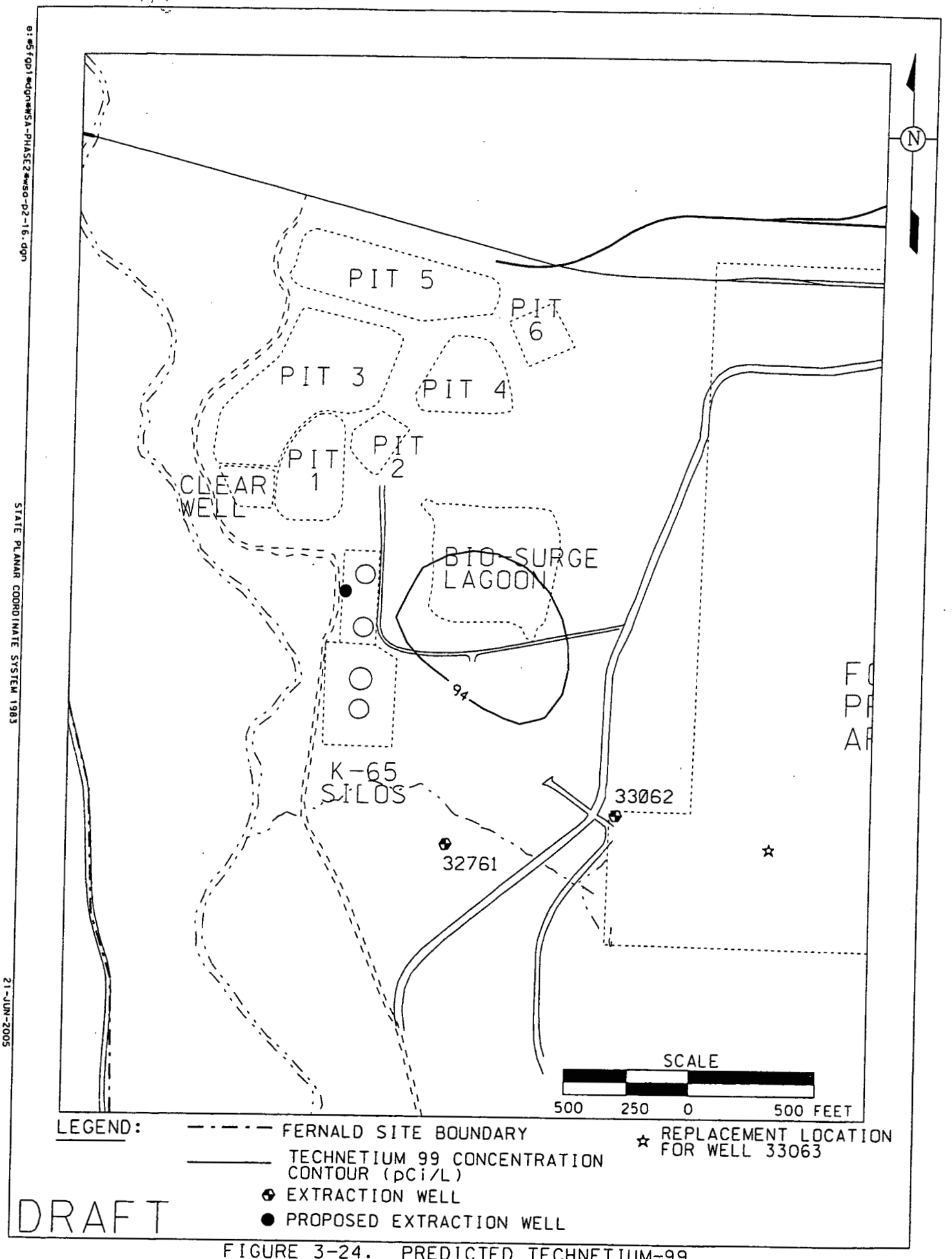


FIGURE 3-24. PREDICTED TECHNETIUM-99 CONCENTRATIONS IN MODEL LAYER 10 AT 2008

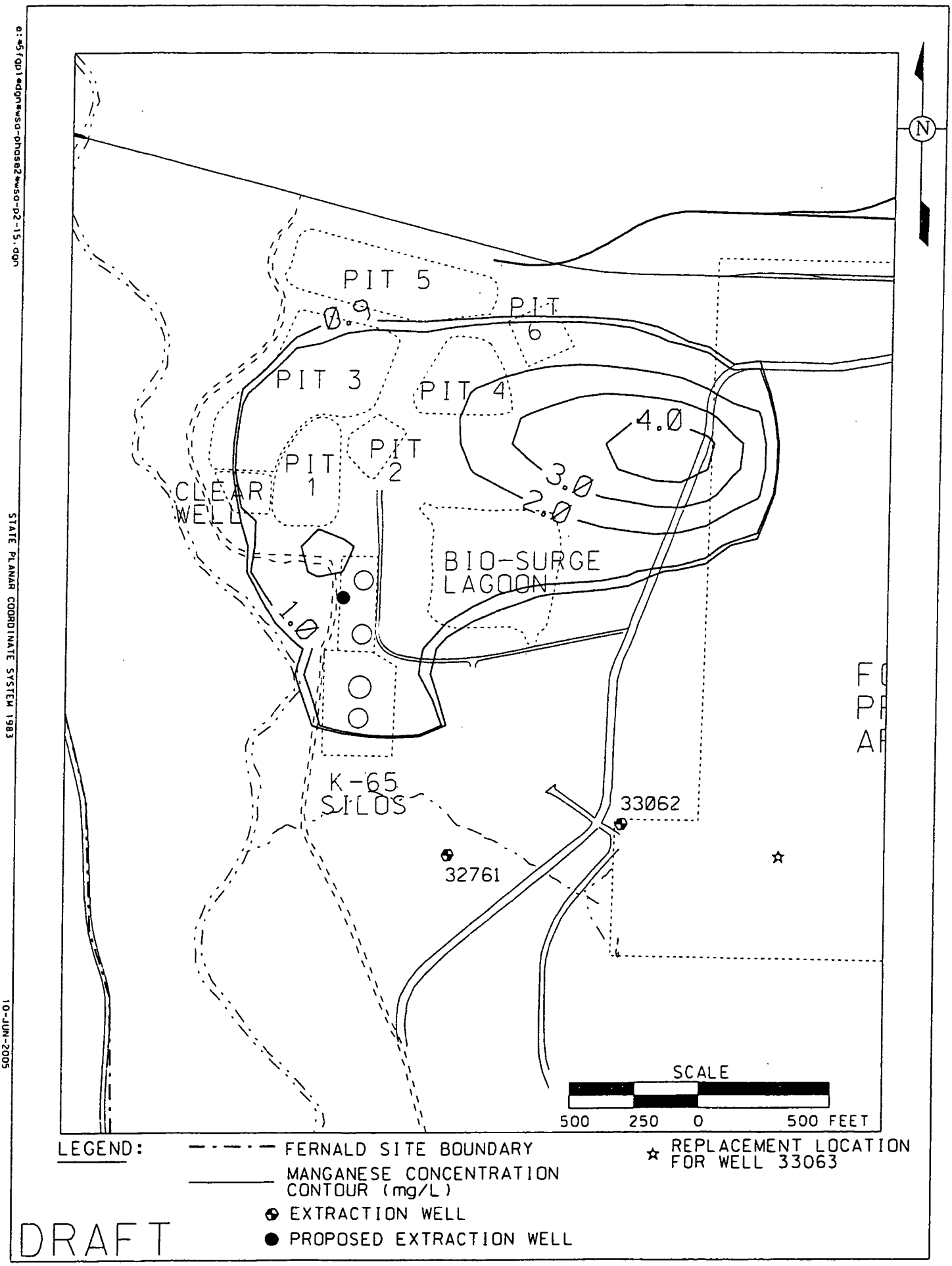


FIGURE 3-25. MANGANESE INITIAL CONDITIONS IN MODEL LAYER 12

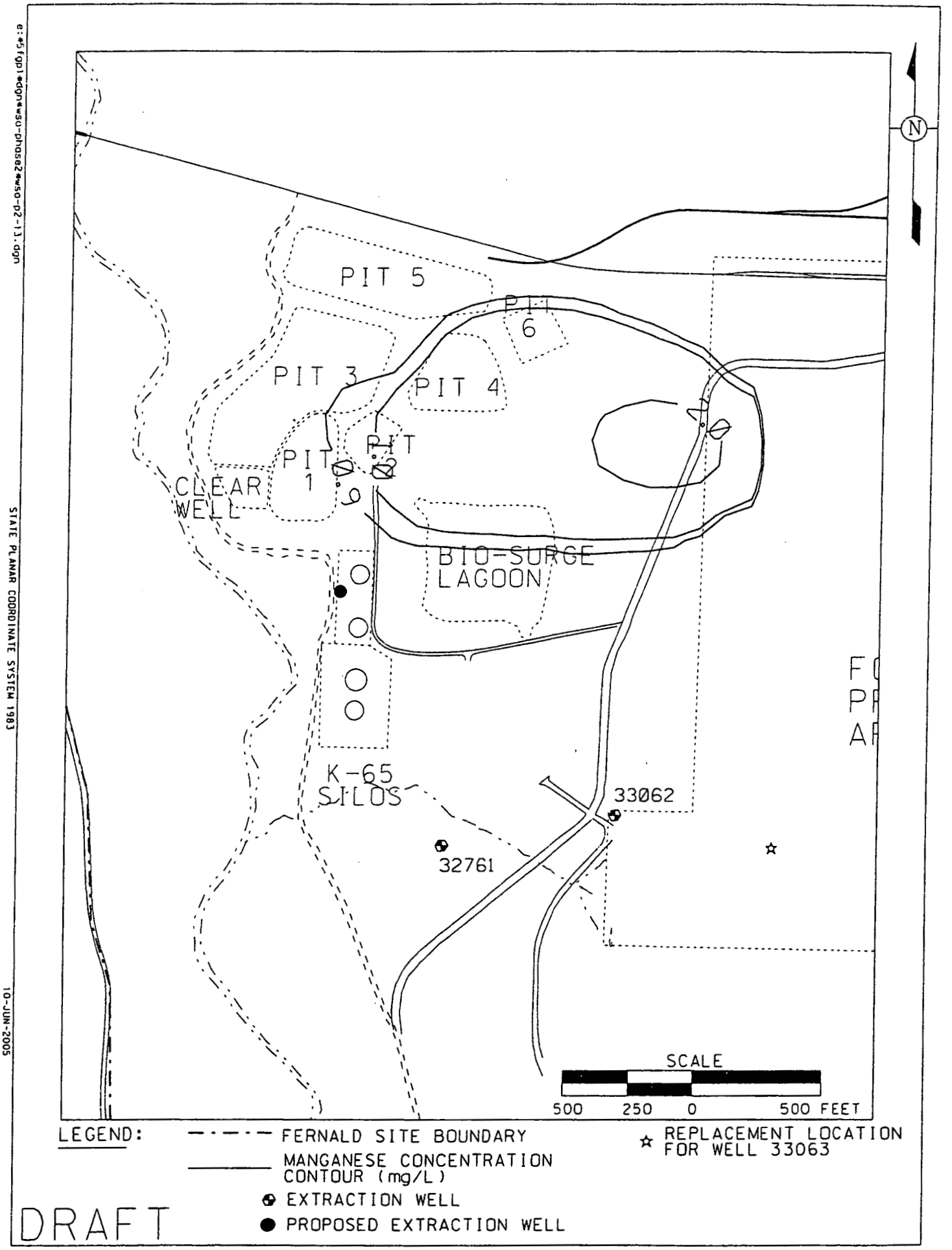


FIGURE 3-26. MANGANESE INITIAL CONDITIONS IN MODEL LAYER 11

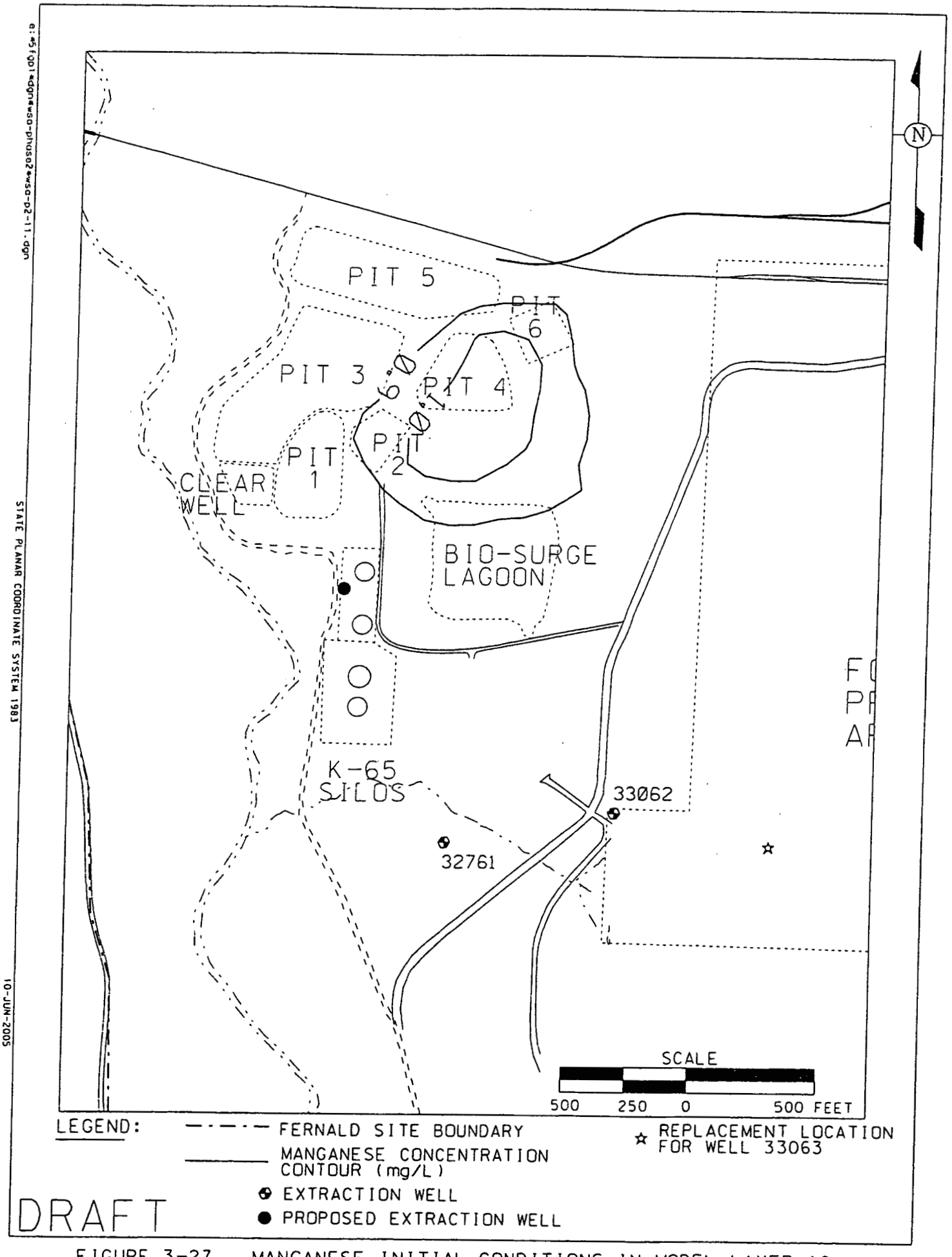


FIGURE 3-27. MANGANESE INITIAL CONDITIONS IN MODEL LAYER 10

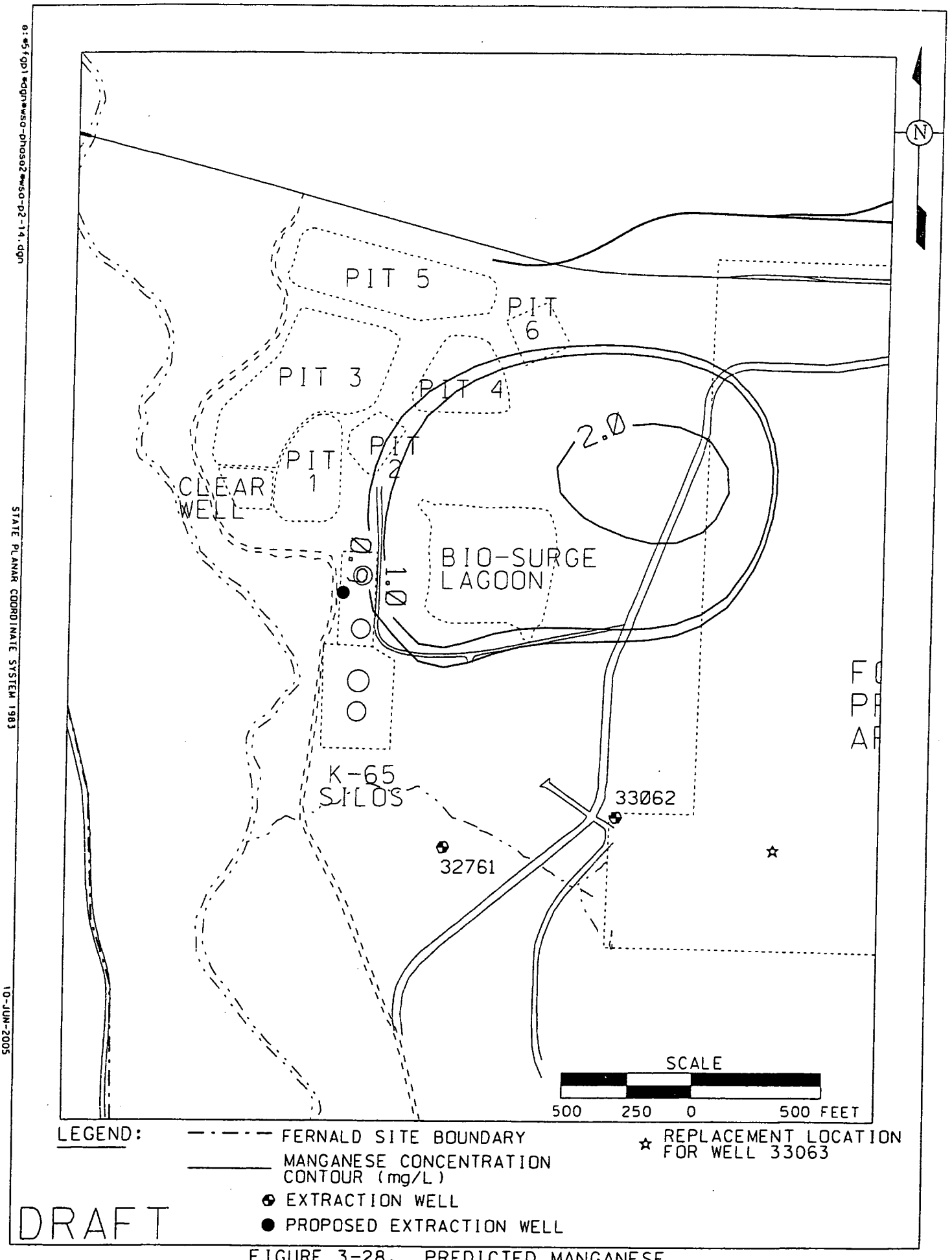


FIGURE 3-28. PREDICTED MANGANESE CONCENTRATIONS IN MODEL LAYER 12 AT 2029

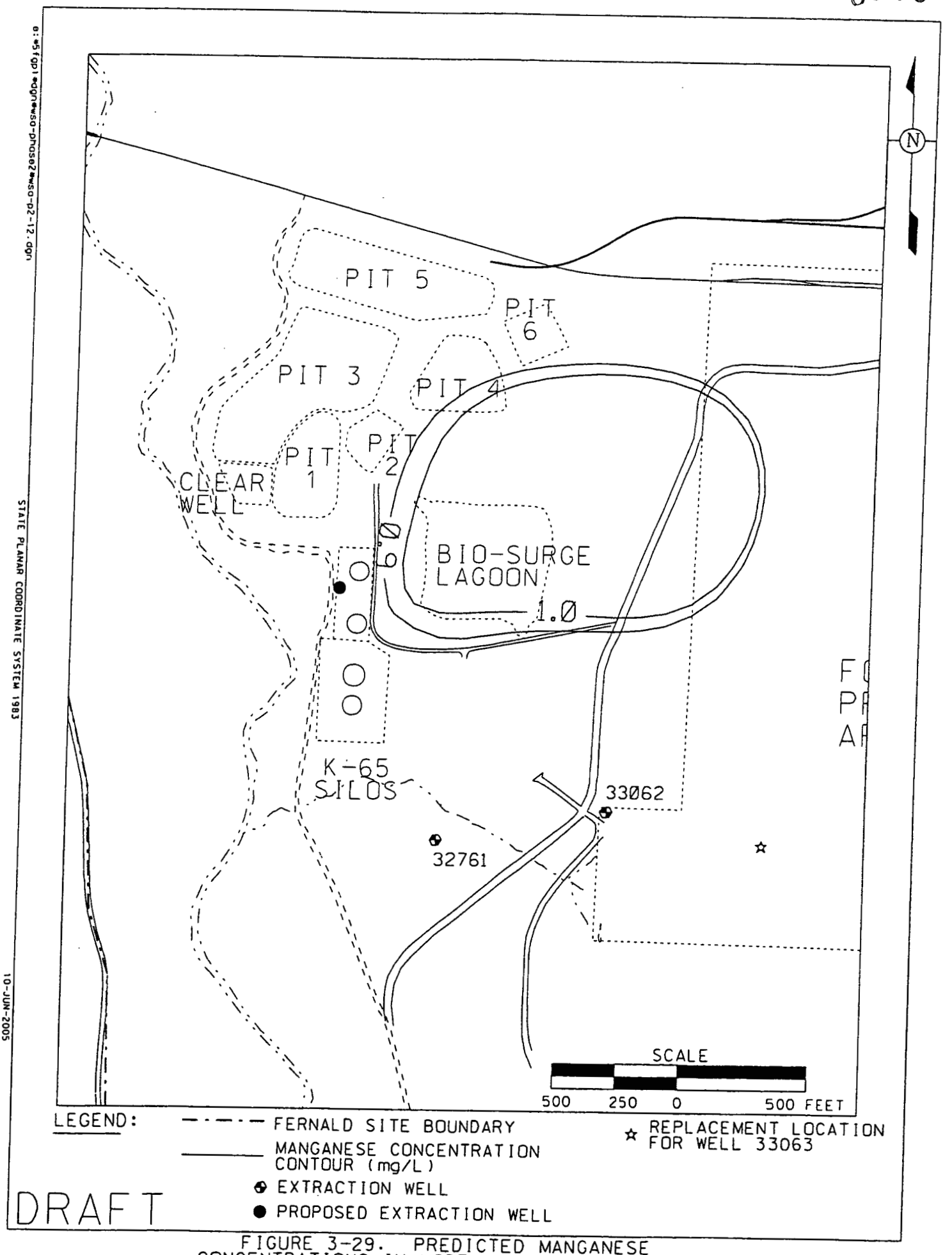


FIGURE 3-29. PREDICTED MANGANESE CONCENTRATIONS IN MODEL LAYER 11 AT 2029

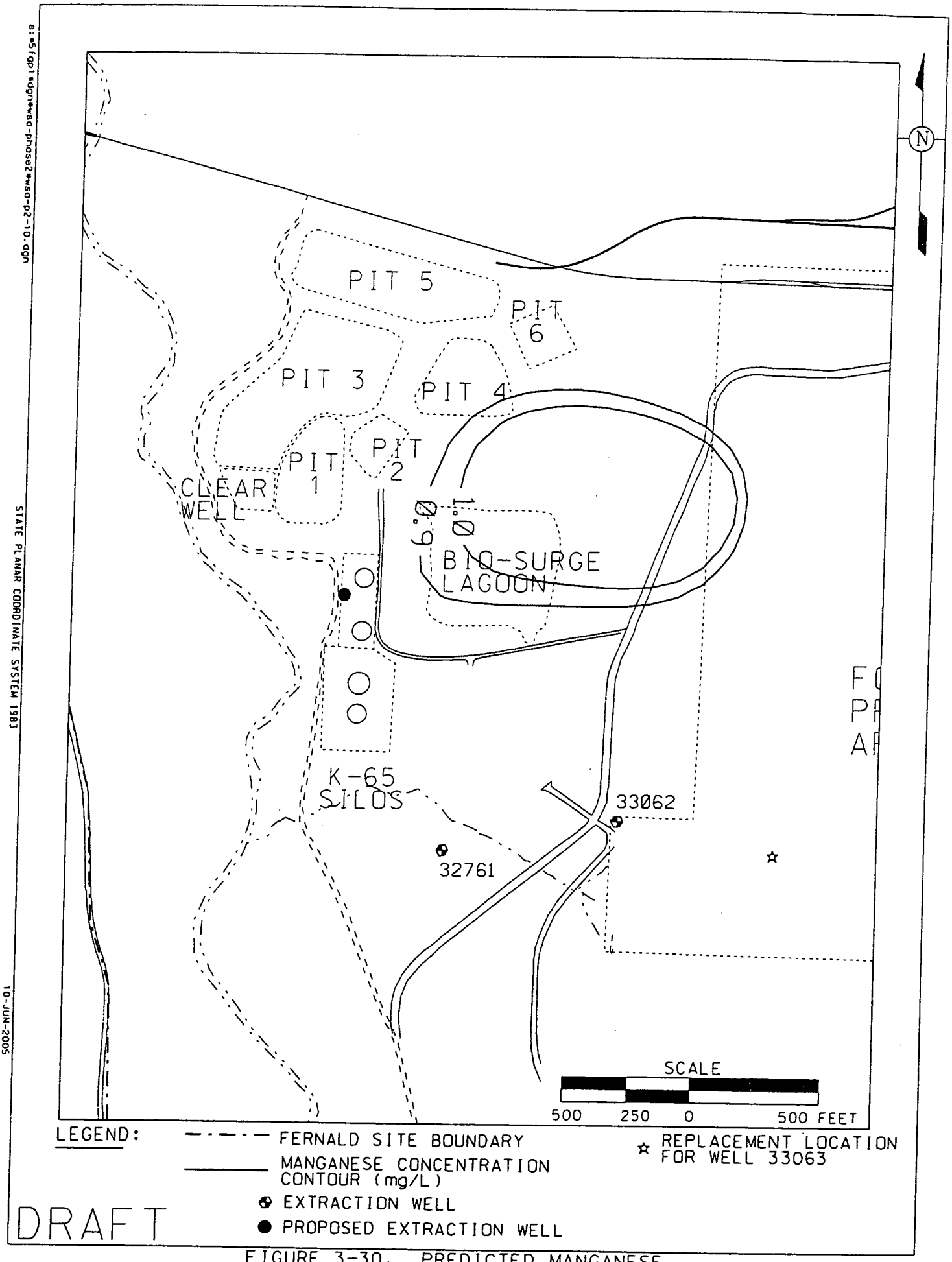


FIGURE 3-30. PREDICTED MANGANESE CONCENTRATIONS IN MODEL LAYER 10 AT 2029

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CHARACTERIZATION CONCLUSIONS

4.1.1 Uranium

- Direct push sampling results indicate that uranium concentrations in the area of the Clear Well are much higher than previous monitoring well results had indicated.
- The highest groundwater uranium concentration (2060 µg/L) was measured one foot below the water table at Direct Push Location 13328 which is located southeast of the Clear Well.
- The uranium plume is approximately 20 feet thick at its thickest point.
- The uranium plume in the Waste Storage Area was likely sourced from the Plant-1 Pad Area via runoff through an old drainage ditch and also from leakage out of the Clearwell.
- It is likely that uranium may be sorbed onto aquifer sediments above the present elevation of the water table.
- Residual uranium contamination in the vadose zone of the aquifer could hinder future aquifer cleanup/certification efforts.

4.1.2 Technetium-99

- Groundwater FRL exceedances for technetium-99 are located in the area around the Clear Well and between Waste Pit 3 and Waste Pit 2.
- The technetium-99 plume in the Waste Storage Area is approximately 20 feet thick with a high concentration of 6280 pCi/L.
- All of the technetium-99 groundwater FRL exceedances are located within or very close to the uranium plume that is being targeted for remediation.

4.1.3 Nitrate/Nitrite

- A nitrate/nitrite concentration of 45 mg/L was used for the Phase II characterization to define an exceedance of 10 mg/L nitrogen.
- Nitrate/nitrite contamination above 45 µg/L is limited to the area around the Clear Well.
- Nitrate/nitrite contamination is within the uranium plume that is being targeted for remediation by the Phase II module.

4.1.4 Nickel

- Groundwater FRL exceedances for nickel occur in the area of the Clear Well.
- The Clear Well area is within the uranium plume that is being targeted for remediation by the Phase II module.

4.1.5 Carbon Disulfide

- Only two monitoring wells were determined to have consistent and recent groundwater FRL exceedances for carbon disulfide.
- Both monitoring wells with consistent and recent groundwater FRL exceedances for carbon disulfide are located within the uranium plume that is being targeted for remediation by the Phase II module.

4.1.6 Trichloroethene

- Groundwater FRL exceedances for trichloroethene are present in the area of the Clear Well and have been present in the past in the area of Monitoring Well 3009.
- Monitoring Well 3009 is within capture of the Waste Storage Area Phase I Module extraction wells.
- The Clear Well is within the uranium plume that is being targeted for remediation by the Phase II module.

4.1.7 Molybdenum

- Groundwater FRL exceedances for molybdenum are present in the area of the Clear Well and Waste Pit 6.
- The Clear Well is within the uranium plume that is being targeted for remediation by the Phase II module.
- The Waste Pit 6 area is within capture of the Waste Storage Area Phase I Module.

4.1.8 Manganese

- Twelve of the thirteen direct push sampling locations had groundwater FRL exceedances for manganese.
- A manganese plume is present in the Waste Storage Area.
- The footprint of the manganese plume is larger than the footprint of the uranium plume that is being targeted for remediation by the Phase II module.
- The manganese plume in the Waste Storage Area could be attributed to wet chemical operations that took place in Plant 8.
- The manganese plume in the Waste Storage Area could be attributed to biofouling conditions around groundwater monitoring wells.
- The manganese plume is within capture of the Waste Storage Area Phase I Module.

4.2 GROUNDWATER MODELING CONCLUSIONS

4.2.1 Total Uranium Modeling

- Particle track modeling demonstrates that the footprint of the total uranium plume is within capture of the Waste Storage Area Remediation System (Phase I and Phase II).

- Modeled total uranium concentrations in the South Plume are predicted to be below 30 μg/L by the year 2015. This is approximately 2 to 3 years longer than predicted in Approach C of the Groundwater Remedy Evaluation and Field Verification Plan (DOE, June 2004).

- Modeled total uranium concentrations in model layer 12 are below 30 μg/L by year 2023, assuming nominal water level boundary conditions. Under wet boundary conditions modeled total uranium concentrations in model layer 12 are below 30 μg/L by year 2021. Under dry boundary conditions modeled total uranium concentrations in model layer 12 are below 30 μg/L by year 2031.

4.2.2 Technetium-99 Modeling

- Modeling indicates that the Technetium-99 plume moves rapidly away from the Clear Well area to the southeast toward pumping wells in the Pilot Plant Drainage Ditch Area.

- Modeling predicts that the Technetium-99 concentration will be below the groundwater FRL of 94 pCi/L by 2009.

4.2.3 Manganese Modeling

- Modeling predicts the manganese plume in the Waste Storage Area will not be effectively remediated with a pump and treat remedy.

- Modeling indicates that the manganese plume remains almost stationary with concentrations remaining above the groundwater FRL for manganese at year 2029.

4.3 RECOMMENDATIONS

- Install one new extraction well just southwest of Silo 4.

- Operate Waste Storage Area extraction wells at pumping rates listed in Table 3-1.

- Continue to monitor for manganese in the Waste Storage Area. Conduct additional direct-push sampling between Monitoring Well 2648 and Monitoring Well 2010 to determine if the manganese plume actually extends as far east as depicted in Figure 2-15, or if high concentrations measured at Monitoring Well 2010 may be due to biofouling conditions around the well.

REFERENCES

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U.S. Dept. of Energy, 2002, "Design for Remediation of the Great Miami Aquifer, South Field Phase II Module, Revision A", Final, Fernald Closure Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 2004a, "Project Specific Plan for Direct-Push Groundwater Sampling in Former Soil Excavation Areas, Revision 1", Final, Fernald Closure Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, June 2004b, "Groundwater Remedy Evaluation and Field Verification Plan, Rev. 0", Fernald Closure Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 2005, "Integrated Environmental Monitoring Plan, Revision 4", Final, Fernald Closure Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

APPENDIX A

DIRECT PUSH SAMPLE RESULTS

GEOPROBE 12614b

Easting '83: 1347113.67
Northing '83: 481844.749
Reference Elevation: 549.981 feet amsl
Depth to Water Table: 30 feet bgs (519.981 feet amsl)
Work Completed: 4/19/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCi/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)
1	518.981	31	1	10.1	ND	1.95	1.15	0.0135	0.0249
2	509.981	40	10	ND	10.6	2.90	1.19	0.0333	0.033
3	499.981	50	20	1.2	48.0	16.20	0.567	0.0116	0.0149
4	499.981	50	20-D	1.8	55.6	16.30	0.514	0.0104	0.0118
5	489.981	60	30	5.2	ND	0.186	0.297	0.0106	0.0073
6	479.981	70	40	3.0	ND	0.521	0.807	0.0083	0.008

-6016

GEOPROBE 12615b

Easting '83: 1347533.358
Northing '83: 482037.863
Reference Elevation: 578.221 feet amsl
Depth to Water Table: 62 feet bgs (516.221 feet amsl)
Work Completed: 12/16/04

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCi/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)
1	515.221	63.0	1	7.9	ND	0.163	0.704	0.0346	0.0161
2	506.221	72	10	6.9	7.6	0.0259	0.669	0.0127	0.0105
3	496.221	82	20	1.5	ND	0.00688	0.692	0.0274	0.0208
4	496.221	82	20-D	1.2	ND	0.00761	1.130	0.0424	0.0446
5	486.221	92	30	6.4	ND	0.00834	1.470	0.0441	0.0515
6	476.221	102	40	3.7					

GEOPROBE 12617b

Easting '83: 1347225
Northing '83: 481285
Reference Elevation: 581.9 feet amsl
Depth to Water Table: 61.5 feet bgs (520.4 feet amsl)
Work Completed: 10/19/04

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	519.4	62.5	1	36.7	20.01	2.26	0.989	0.0109	0.0151	ND	ND
2	510.4	71.5	10	54.6	50.45	4.08	0.455	0.0082	0.0068	ND	ND
3	500.4	81.5	20	11.1	8.98	2.23	1.41	0.0287	0.0452	ND	ND
4	500.4	81.5	20-D	11.5	13.24	1.68	1.23	0.0191	0.0359	ND	ND
5	490.4	91.5	30	2.3	ND	0.174	1.6	0.0238	0.0109	ND	ND
6	480.4	101.5	40	2.2	ND	ND	0.308	0.0179	0.0075	ND	ND
7	470.4	111.5	50	2.6	ND	0.00739	0.539	0.0202	0.0179	ND	ND
8	460.4	121.5	60	6.5	ND	0.0201	1.01	0.025	0.0227	ND	ND

-6016

GEOPROBE 12618b

Easting '83: 1347182.375
Northing '83: 480412.526
Reference Elevation: 576.409 feet amsl
Depth to Water Table: 59 feet bgs (520.409 feet amsl)
Work Completed: 10/26/04

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)
1	516.409	60	1	50.5	6.90	0.678	1.99	0.0087	0.0435
2	507.409	69	10	10.9	ND	2.79	0.253	0.0174	0.0044
3	497.409	79	20	7.3	ND	1.26	0.758	0.0231	0.0435
4	497.409	79	20-D	7.5	ND	0.546	0.632	0.0213	0.0369
5	487.409	89	30	4.0	ND	2.74	0.914	0.0192	0.0658
6	477.409	99	40	4.1	ND	1.46	0.473	0.0205	0.0273

GEOPROBE 12684b

Easting '83: 1347142.83
Northing '83: 480922.99
Reference Elevation: 576.85 feet amsl
Depth to Water Table: 59 feet bgs (517.85 feet amsl)
Work Completed: 10/07/04

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)
1	516.85	60	1	49.8	11.98	2.43	0.259	0.0159	0.01
2	507.85	69	10	17.7	ND	0.337	1.84	0.0309	0.0799
3	497.85	79	20	5.0	ND	2.2	0.488	0.0184	0.0115
4	497.85	79	20-D	4.8	ND	1.7	0.445	0.0149	0.0095
5	487.85	89	30	ND	ND	2.26	0.421	0.0109	0.0102
6	477.85	99	40	ND	ND	0.095	0.53	0.0123	0.0106

9 of 16

GEOPROBE 13320

Easting '83: 1346841.02
Northing '83: 481553.842
Reference Elevation: 562.528 feet amsl
Depth to Water Table: 42 feet bgs (520.528 feet amsl)
Work Completed: 4/20/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)
1	519.528	43	1	ND	10.4	2.27	2.38	0.026	0.0391
2	510.528	54	10	8.8	122	46.3	0.916	0.0111	0.0199
3	500.528	64	20	5.1	157	4.67	0.92	0.0094	0.0191
4	500.528	64	20-D	5.2	193	4.41	0.583	0.0059	0.0117
5	490.528	74	30	2.6	41.1	1.48	0.984	0.0122	0.0242
6	480.528	84	40	6.2	15.6	3.7	0.219	0.0119	0.0118

GEOPROBE 13322

Easting '83: 1346680.027
Northing '83: 481348.78
Reference Elevation: 555.072 feet amsl
Depth to Water Table: 34 feet bgs (521.072 feet amsl)
Work Completed: 4/17/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCi/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	520.072	35	1	11.4	6280	0.489	1.35	0.547	0.0306	ND	ND
2	511.072	44	10	133.9	258	11.3	0.519	0.062	0.0098	ND	ND
3	501.072	54	20	10.5	21.7	1.61	0.487	0.035	0.0093	ND	ND
4	501.072	54	20-D	10.8	20.6	1.62	0.314	0.0209	0.0079	ND	ND
5	491.072	64	30	2.8	9.22	0.4	0.287	0.0264	0.0048	ND	ND
6	481.072	74	40	2.7	15.2	0.00931	0.276	0.0198	0.0134	ND	ND

6016

GEOPROBE 13323

Easting '83: 1347859.564
Northing '83: 481998.983
Reference Elevation: 582.814 feet amsl
Depth to Water Table: 67 feet bgs (515.814 feet amsl)
Work Completed: 11/10/04

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCi/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)
1	514.814	68.0	1	ND	ND	ND	0.827	0.0186	0.0312
2	505.814	77	10	12.5	ND	0.0137	0.642	0.0101	0.013
3	495.814	87	20	14.6	ND	0.0039	0.587	0.0235	0.0246
4	495.814	87	20-D	12.8	ND	ND	0.957	0.025	0.0373
5	485.814	97	30	18.4	ND	ND	1.09	0.0321	0.0396
6	475.814	107	40	1.5	ND	0.00509	0.642	0.765	0.0772
7	465.814	117	50	ns	NS	NS	NS	NS	NS
8	455.814	127	60	ND	ND	0.0137	0.700	0.0975	0.0629

GEOPROBE 13324

Easting '83: 1346794
Northing '83: 481088.3
Reference Elevation: 566.90 feet amsl
Depth to Water Table: 47 feet bgs (519.90 feet amsl)
Work Completed: 02/23/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	518.9	48	1	1083.0	11.52	0.075	3.280	0.082	0.1180	ND	ND
2	509.9	57	10	559.9	5.13	1.470	1.100	0.047	0.0329	ND	ND
3	499.9	67	20	28.6	2.94	1.770	0.416	0.021	0.0217	ND	ND
4	499.9	67	20-D	30.5	4.83	1.380	0.428	0.021	0.0229	ND	ND
5	489.9	77	30	7.2	4.50	2.370	0.155	0.006	0.0034	ND	ND
6	479.9	87	40	4.9	1.26	2.280	1.070	0.020	0.0591	ND	ND
7	469.9	97	50	1.8	0.69	0.021	1.360	0.027	0.0560	ND	ND
8	464.9	102	55	2.8	ND	0.019	0.557	0.026	0.0131	ND	ND

0016

GEOPROBE 13325

Easting '83: 1347094
Northing '83: 481088
Reference Elevation: 576.65 feet amsl
Depth to Water Table: 57 feet bgs (519.65 feet amsl)
Work Completed: 03/09/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	518.65	58	1	29.9	9.466	1.510	0.435	0.0155	0.0085	ND	ND
2	508.65	68	10	6.0	ND	1.020	1.980	0.0956	0.0275	ND	ND
3	498.65	78	20	5.9	ND	2.280	0.434	0.0106	0.0101	ND	ND
4	498.65	78	20-D	6.0	ND	2.310	0.432	0.0110	0.0104	ND	ND
5	488.65	88	30	1.5	ND	2.060	0.512	0.0111	0.0083	ND	ND
6	478.65	98	40	ND	ND	0.262	0.400	0.0109	0.0130	ND	ND
7	468.65	108	50	ND	9.8	0.011	0.521	0.0088	0.0097	ND	ND
8	463.65	113	55	3.3	ND	0.009	0.931	0.0081	0.0162	ND	ND

GEOPROBE 13327

Easting '83: 1346808.854
Northing '83: 480802.604
Reference Elevation: 575.422 feet amsl
Depth to Water Table: 54 feet bgs (521.422 feet amsl)
Work Completed: 03/31/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	520.422	55	1	447.0	ND	1.900	1.270	0.0363	0.0158	ND	ND
2	511.422	64	10	36.9	ND	1.890	0.728	0.0353	0.0126	ND	ND
3	501.422	74	20	7.1	ND	3.420	0.170	0.0092	0.0037	ND	ND
4	501.422	74	20-D	7.0	ND	3.270	0.183	0.0100	0.0042	ND	ND
5	491.422	84	30	9.4	ND	1.550	0.398	0.0098	0.0038	ND	ND
6	481.422	94	40	7.5	ND	0.646	0.883	0.0165	0.0181	ND	ND
7	471.422	104	50	10.6	ND	0.243	1.570	0.0264	0.0375	ND	ND
8	466.422	109	55	5.0	ND	0.586	1.310	0.0208	0.0271	ND	ND

6016

GEOPROBE 13328

Easting '83: 1346653.464
Northing '83: 481066.304
Reference Elevation: 557.388 feet amsl
Depth to Water Table: 35 feet bgs (522.388 feet amsl)
Work Completed: 04/05/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	521.388	36	1	2060.0	ND	0.290	0.582	0.0172	0.0096	ND	0.001
2	512.388	45	10	961.6	ND	0.379	2.430	0.0437	0.0517	ND	ND
3	502.388	55	20	30.6	ND	3.160	0.255	0.0348	0.0068	ND	ND
4	502.388	55	20-D	23.8	ND	2.690	0.773	0.0487	0.0248	ND	ND
5	492.388	65	30	11.0	ND	1.340	0.557	0.0130	0.0429	ND	ND
6	482.388	75	40	11.5	ND	1.530	0.187	0.0118	0.0071	ND	ND
7	472.388	85	50	2.0	ND	1.490	0.180	0.0105	0.0075	ND	ND
8	467.388	90	55	4.8	ND	0.029	0.510	0.0064	0.0064	ND	ND

GEOPROBE 13329

Easting '83: 1347306.474
Northing '83: 480540.773
Reference Elevation: 579.173 feet amsl
Depth to Water Table: 58 feet bgs (521.173 feet amsl)
Work Completed: 04/13/05

Sample Point	Elevation (ft amsl)	Depth (ft, bgs)	Depth (bwt)	Uranium (µg/L)	Tech-99 (pCI/L)	Nitrate/Nitrite (mgL)	Manganese (mgL)	Molybdenum (mgL)	Nickel (mgL)	Carbon Disulfide (mgL)	TCE (mgL)
1	520.173	59	1	34.4	0.153	2.62	0.678	0.0279	0.0124	ND	ND
2	511.173	68	10	22.7	2.01	1.77	0.236	0.0108	0.0052	ND	ND
3	501.173	78	20	10.3	6.23	1.62	0.417	0.0096	0.0044	ND	ND
4	501.173	78	20-D	10.6	3.78	1.63	0.398	0.0084	0.0047	ND	ND
5	491.173	88	30	ND	2.38	ND	ND	ND	ND	ND	ND
6	481.173	98	40	ND	4.67	0.00327	0.461	0.0145	0.0119	ND	ND
7	471.173	108	50	ND	5.33	1.94	0.41	0.0094	0.0137	2.2	ND
8	466.173	113	55	ND	6.84	1.41	0.696	0.0034	0.0186	ND	ND

6016