



Department of Energy
Washington, DC 20585

PROD 7578

December 28, 2016

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Dear Mr. Seely and Mr. Schneider:

Subject: Transmittal of Draft Perfluorinated Compound Groundwater Screening Sampling and Analysis Plan, Fernald Preserve, Ohio.

Reference: Letter, S. Smiley to D. Seely and T. Schneider, Transmittal of Responses to Environmental Protection Agency and Ohio Environmental Protection Agency Comments on the Draft Fourth Five-Year Review Report for the Fernald Preserve and the Final Fourth Five-Year Review Report for the Fernald Preserve, dated August 25, 2016.

This letter transmits the Draft Perfluorinated Compound Groundwater Screening Sampling and Analysis Plan for regulator review to fulfill the first milestone required to address issues identified in the *Final Fourth Five-Year Review Report for the Fernald Preserve* (Reference). As required, the sampling plan is being transmitted by December 31, 2016 and includes a schedule for sampling and reporting.

If you have any questions, please call me at (513) 648-3333. Please send any correspondence to:

U.S. Department of Energy
Office of Legacy Management
10995 Hamilton-Cleves Hwy.
Harrison, OH 45030

Sincerely,

**SUSAN
SMILEY**

Susan Smiley
Fernald Preserve Manager
DOE-LM-20.2

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Page 2

Enclosure

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Project Record File FER030.1(A) (through M. Korte)

PROD 7578

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Perfluorinated Compound
Groundwater Screening
Sampling and Analysis Plan
Fernald Preserve, Ohio

December 2016



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Appendix A PFC Sampling Requirements and Checklist

Abbreviations

AFFF	aqueous film-forming foam
ASCOC	area-specific constituent of concern
BTV	benchmark toxicity value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/s	centimeter per second
CMT	continuous multichannel tubing
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
FTF	Fire Training Facility
GMA	Great Miami Aquifer
HWMU	Hazardous Waste Management Unit
IEMP	Integrated Environmental Monitoring Plan
OSDF	On-site Disposal Facility
OU	Operable Unit
PFC	perfluorinated compounds
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PTFE	polytetrafluoroethylene
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
SSOD	Storm Sewer Outfall Ditch
WAC	waste acceptance criteria

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1.0 Introduction

Perfluorinated compounds (PFCs) are a large group of chemicals of which perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are the two most prevalent in the environment. In May 2016, the U.S. Environmental Protection Agency (EPA) published a health advisory for PFOA and PFOS for drinking water systems. Health advisories are developed by EPA to provide information on contaminants that may cause human health effects and are known to occur in drinking water. EPA's health advisories are nonenforceable and nonregulatory. EPA established the health advisory level at a concentration of 0.07 parts per billion (70 parts per trillion) for the combined concentration when both PFOA and PFOS are present in drinking water.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) *Fourth Five-Year Review Report for the Fernald Preserve* (CERCLA Five-Year Review) (DOE 2016a) identified PFOS and PFOA as emerging contaminants. An emerging contaminant is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or by lack of published health standards. Throughout the United States these chemicals were used in a variety of products such as surfactants and fire-suppressant foams, and the main environmental impacts are the result of manufacturing the chemical or tank and supply-line leaks.

Aqueous film-forming foam (AFFF), which contains PFOS and PFOA, was used for fire training exercises at the former Fire Training Facility (FTF) (Figure 1). The FTF served as a training facility for the Fernald Fire Department and the other local fire departments between 1966 and 1990. The FTF was estimated to have been used an average of 60 days per year. During its operation, the area became contaminated with hazardous materials, low-level radioactive materials, and low levels of polychlorinated biphenyls from the flammable and combustible substances used to start fires. AFFF was typically stored in the original containers on the trucks at the former garage area (Figure 1).

The Fernald, Ohio, Site, including the area of the former FTF and AFFF storage areas (i.e., former garage area), has been extensively remediated; however, data are unavailable to support the contention that PFOS and PFOA, if present, are not a threat to human health and the environment. The CERCLA Five-Year Review required submittal of a limited PFC groundwater screening sampling plan to include a schedule for sampling and reporting by December 31, 2016. This document meets that deliverable requirement specified in the CERCLA Five-Year Review.

To determine if PFCs are present in the groundwater, groundwater samples will be collected from all available channels of five multichannel wells and analyzed for PFCs. Multichannel wells have 3–6 screened intervals and were designed for and installed to monitor the entire thickness of the uranium plume. If any channels are dry at the time of sample collection, samples will not be collected. This plan provides information on the project organization, sampling design, analytical requirements, quality assurance/quality control, and the project schedule for the sampling activities. Key project personnel are identified in Table 1.

2.0 Sampling Design

The following sections present information pertaining to the sampling design for the PFC groundwater screening effort. The history of AFFF usage at Fernald, the remediation history of the site, and the hydrogeological setting and conceptual model of the site are presented below. Table 2 summarizes the history of AFFF usage at the site and remediation of the FTF area, which is detailed in the following sections.

2.1 History of AFFF Use at Fernald

To assist with developing the history of AFFF use at the Fernald site, several members of the former Fernald Fire Department, including the Fire Safety Inspector and Emergency Management Coordinator, were interviewed. Information from these interviews is summarized in this section.

AFFF was developed by the military in 1966 for use as a fire suppressant for aviation safety to extinguish hydrocarbon fires. AFFF quickly forms an aqueous film on the pooled fuel surface that prevents evaporation and reignition of the fuel once it has been extinguished by the foam. AFFF and the delivery apparatus were difficult to obtain outside of the military until the mid 1970s. Prior to the availability of AFFF, protein foams were used for fighting these types of fires. Protein foams are biodegradable, but flow and spread slower than AFFF. Unlike AFFF, the blanket formed by the protein foams has a tendency to break up, which allows the flames to return.

A pool of hydrocarbon-based chemicals burning inside a building was a concern within the chemical-process areas of the plant, especially in Plant 2/3 where tributyl phosphate-kerosene was used in large volumes. Fire-suppression systems were primarily water-supplied sprinkler systems. A limited number of dry powder and carbon dioxide suppression systems were installed in specific areas. No fire-suppression systems at the site ever contained AFFF.

From 1976 to 1990, approximately 100 gallons of 3–6% concentrate AFFF was purchased in 5-gallon plastic buckets for use in the event of a tributyl phosphate-kerosene fire in Plant 2/3. No tributyl phosphate-kerosene fire ever occurred at the site. Of this volume of AFFF purchased, less than 25 gallons was likely used, and that volume was used only in training exercises. This training usage of AFFF was exclusively at the FTF (Figure 1).

During use at the FTF, approximately 5–10 gallons of fuel was poured on the water surface in the pond or skid tank (located in the skid-tank pond) and set on fire. Approximately 1–2 gallons of concentrated AFFF was mixed into a firehose stream using a venturi pump apparatus. The characteristics of the product (i.e., AFFF) are such that very little product was necessary to extinguish the fires.

AFFF use for military exercises, in contrast to the small volumes used at the Fernald site, was much more extensive. For military exercises, 30 gallons of the AFFF concentrate would be mixed with 5000 gallons of water and discharged very quickly on the training fire. The water tank would be filled quickly and mixed with AFFF concentrate several times throughout the military fire training exercises. Depending on the size of the training fire, the entire 200-gallon tank of AFFF concentrate could be expended during an exercise.

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From 1976 until removal of the fire equipment in 2004, approximately twenty 5-gallon plastic buckets of AFFF concentrate were stored on the fire trucks, which were housed in the former garage area (i.e., Heavy Equipment Garage or the Engine House).

Because of the minimal volume of product used on site (i.e., less than 25 gallons), the concentrated area the product was used in (i.e., the former FTF), the transport mechanism of the AFFF concentrate buckets to the location of usage (i.e., on fire trucks), and the durability of the storage containers (i.e., 5 gallon plastic), it is unlikely that significant spills would have occurred.

The AFFF was dispositioned with the fire training equipment, which was donated to local fire departments. Crosby Township Fire Department recently reported that they received 4–6 buckets of the AFFF and had used all the concentrate.

2.2 Remediation of the FTF

The FTF was declared a Hazardous Waste Management Unit (HWMU) under the Resource Conservation and Recovery Act (RCRA) in 1991. Removal Action 28 at the FTF was implemented in July 1994 and concluded in April 1995. The removal action involved removing each structure in the FTF, excavating each area of contamination in the FTF, collecting pre- and post-excavation samples of each area, and backfilling each area. As reported in the Removal Action final report (DOE 1995a), approximately 330 cubic yards of soil containing both radiological and organic contaminants was excavated from the skid-tank pond area (Figure 2). The eastern half of the pond was excavated to 2–3 feet; the western half of the pond was excavated to a depth of 4–5 feet where perched water was encountered. Field screening with a photoionization detector was used to direct the excavation depth. Detailed cross sections or final excavation contours of this excavation are not available.

In the western half of the excavation, field screening indicated that contamination was still present. Because the removal of soil satisfied the objectives of the removal action for surface source control and mitigation of near-term risks to human health and the environment, it was decided that final remediation of the area would be completed under a single integrated CERCLA remedial action. Soil excavated during the removal action was placed in 55-gallon drums and stored in a designated onsite storage facility pending final disposition. Removal Action 28 occurred prior to the establishment of soil final remediation levels (FRLs), which were established in 1996 after the remedial investigation/feasibility study was completed and the Operable Unit (OU) 5 Record of Decision was approved.

A second remedial excavation began in early 2003 in the FTF to remediate soils demonstrating area-specific constituents of concern (ASCOC) concentrations above the FRLs. A list of ASCOC and the FRL for each is provided in Table 3. The Implementation Plan for the Solid Waste Landfill and the FTF (DOE 2003a) addressed the predesign investigation, remedial design, remediation action, and precertification activities for the FTF. On the basis of the predesign sample results, the implementation plan identified the removal of approximately 13,000 cubic yards of impacted material, including approximately 1 cubic yard of uranium-contaminated soil with concentrations above the On-Site Disposal Facility (OSDF) waste acceptance criteria (WAC); 43 cubic yards of technetium-99 above WAC material; 380 cubic yards of

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tetrachloroethane contaminated above WAC material; and 1,210 cubic yards of debris from the FTF. Cross sections of the excavation design from the implementation plan are reproduced herein as Figure 3 through Figure 5. This design grade presented in the implementation plan was based on:

- Remedial investigation (RI) data on the nature of constituents of concern concentration in soil and perched groundwater.
- Data collected during the predesign investigations to delineate the extent of contamination for above-WAC, RCRA, and below-WAC zones.
- Excavation slopes that capture building structures and all constituents of concern contamination above FRLs.
- Stable side slopes adjacent to structures.

Per the implementation plan, the final excavation was to be based on field conditions, radiological survey measurements, and physical sampling results. Figure 6 is a figure developed based on an October 2003 aerial photograph that depicts the final contours following this later excavation. The lowest elevation of the skid-tank pond excavation is approximately 3 feet higher than the planned excavation presented in the implementation plan (i.e., 579 feet above mean sea level versus 576 feet above mean sea level). Of note is the lack of surface features on the surface of the deepest portion of the excavation, which likely indicates that water is present in the excavation; therefore, the final depth of the contours is not likely depicted.

Impacted material that was excavated from the FTF was transported to the OSDF or transported offsite to a permitted disposal facility. Documentation of the certification of the FTF is provided in the *Certification Report for Area 6, Phase I – Part One* (DOE 2003b) and *Certification Report for Area 6, Phase I – Part Two* (DOE 2004). During excavation of the FTF in early 2003, two previously unknown underground storage tanks were discovered, located side by side in the northwestern corner of the FTF. The two underground storage tanks (USTs) contained gasoline. Closure of the USTs was completed in 2004. An aerial photograph for February 2004 indicates that the FTF excavation was completely backfilled.

The certification effort for the FTF area was completed in two parts, Area 6, Phase I, Part One and Area 6, Phase I, Part Two, because of the efforts required to remove metallic debris and utilities discovered during magnetometer scans. The debris and utilities have been removed. Soil removal proceeded until the FRLs for area-specific constituents of concern were met (Table 3).

2.3 Geology

As described earlier, small quantities of AFFF which contain PFCs, were stored in the former garage area. It does not appear that these chemicals were ever used to extinguish a process-related fire in the former production area, but were used for training purposes in the former FTF. Both of these locations are identified in Figure 1. The geology and hydrogeology of the area is documented in the Operable Unit 5 Remedial Investigation (RI) report (DOE 1995b). Brief summaries are provided below.

The former production area was constructed on top of glacial overburden deposits. These deposits are composed mostly of clay-rich till and contain minor outwash silt and sand lenses.

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The glacial overburden rests unconformably upon sand and gravel of the Great Miami Aquifer (GMA). Geologic cross sections through the former production area are presented in the OU 5 RI report (DOE 1995b). Figure 7 is a map that shows the conceptual cross-section line locations.

As shown in Figure 7, two east-west cross sections run through the former FTF cross section M–M' (Figure 8) and cross section N–N' (Figure 9). As shown in the cross sections, with the exception of a very small silt lens in one boring, the former FTF (identified as the “burn pond” in the cross sections) was separated from the underlying sand and gravel of the GMA by approximately 35 feet of clay.

Cross section LL–LL' is oriented east-west and runs through the approximate area where the former garage was located. The cross section indicates that approximately 25 feet of clay separated the former garage area from the underlying sand and gravel of the GMA (Figure 10). The clay is characterized as containing small discontinuous lenses of silt and sand.

2.4 Hydrogeology

As detailed in the Operable Unit 5 Remedial Investigation Report (DOE 1995b), the glacial overburden is heterogeneous and anisotropic. It is saturated from approximately 3 to 5 feet below the ground surface down to the base of the glacial overburden. Unsaturated conditions exist just beneath the base of the glacial overburden. Saturated conditions are again present at the GMA water table. Approximately 3–45 feet of unsaturated sand and gravel exist between the base of the glacial overburden and the water table of the GMA. Because of the unsaturated sediment below the glacial overburden, groundwater within the glacial overburden is perched above the water table of the GMA.

Water moving from the surface down to the GMA must either travel through the glacial overburden or over the glacial overburden to a point where it can enter the GMA. The interpretation of groundwater movement in the glacial overburden is complicated by the heterogeneous nature of the deposit. In general, the water table in the glacial overburden follows surface topography and slopes to the west-southwest towards Paddys Run.

In the OU 5 RI Report, the glacial overburden was divided into four zones based on the minimum representative thickness of gray clay and the presence of sand and gravel lenses (Figure 11). The former Fire Training Area fell within Zone II, and the former Garage Area fell within Zones II and III. Generalized cross sections through each of the glacial overburden zones are provided in Figure 12.

Based on the generalized cross section for Zone II, the former FTF would have been separated from the underlying sand and gravel of the GMA by approximately 10 feet of brown clay and 30 feet of gray clay with horizontal hydraulic conductivities of 3.95×10^{-5} centimeters per second (cm/s) and 1.87×10^{-6} cm/s, respectively. The former garage area would have been separated from the underlying sand and gravel of the GMA by approximately 20 feet of brown clay and sand and 10 feet of gray clay with horizontal hydraulic conductivities of 1.10×10^{-3} cm/s and 1.87×10^{-6} cm/s, respectively. Hydraulic conductivities were determined using core permeability tests, slug tests, and pumping tests.

2.5 Transport Properties of PFOS and PFOA

PFOS and PFOA are hydrophilic and highly soluble in water. Their migration tends to be retarded in the vadose zone, with sorption to surrounding sediments dependent upon the organic content of the soil. The adsorption of solids appears to have limited effects on the transport of PFOS and PFOA once they are in the water (Feng et. al. 2014). Therefore, if PFOA and PFOS reach an aquifer system these contaminants are considered to be mobile.

2.6 Conceptual Model for the Potential Transport of PFCs to the GMA

On the basis of the geology, hydrogeology, and transport properties discussed above, the potential pathway for PFC contaminants to reach the GMA is the same pathway that uranium contamination would have taken to reach the GMA.

Given the thickness of clay-rich glacial till deposits underneath each former potential source area for PFCs, the heterogeneous nature of the glacial till deposits, and the very low hydraulic conductivities of the clay within the glacial till, it is assumed that the most likely pathway for PFCs to reach the GMA would be for the contaminant to migrate across the top of the glacial overburden via surface water to areas where the surface waters come into direct contact with the underlying sand and gravel of the GMA (i.e., glacial overburden is not present). The most likely surface water paths are illustrated in Figure 1 (identified as “General Direction of Historical Flow”). Also illustrated in Figure 1 is the area where the glacial overburden is not present.

Surface water from the former fire training facility would have historically flowed overland via surface water pathways to the west or southwest towards Paddys Run. As shown in Figure 1, Paddys Run has eroded down through the glacial overburden and provides direct access to the GMA. Surface water from the former garage area would have historically flowed off of the former production area via the Storm Sewer Outfall Ditch (SSOD). As shown in Figure 1, the SSOD cuts through the glacial overburden and provides direct access to the GMA.

Potential sources for PFCs have been removed. Both the former FTF and the former garage area were remediated during the CERCLA cleanup of the site. Contaminated soils in both areas were excavated and disposed of either offsite or in the OSDF if they met WAC for the facility. Therefore, it is assumed that any potential PFCs that might have been sorbed to those soils were also removed.

2.7 Selection of Aquifer Sampling Locations

Given that the potential pathway for PFCs to reach the GMA is very likely the same pathway that uranium contamination would have taken to reach the GMA, the sampling network already in place for uranium is appropriate for sampling of PFCs as well.

The nature and extent of the uranium plume is currently being monitored according to the Integrated Environmental Monitoring Plan (IEMP, DOE 2016b). The uranium plume footprint shown in Figure 1 shows the extent of the uranium plume as of December 2015. Figure 13 through Figure 20 are from the *Fernald Preserve 2015 Site Environmental Report* (DOE 2016c) and are reproduced here to illustrate the thickness and aerial extent of the plume.

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The uranium plume is hydraulically captured by a system of 20 extraction wells pumping at a target design pumping rate of 5,075 gallons per minute. To select specific monitoring wells, well construction materials, sampling equipment, and work procedures need to be taken into account in order to obtain a sample that is representative of the PFC concentrations in the aquifer.

Most of the monitoring wells that are being actively sampled under the IEMP are done so using dedicated micropurge bladder pumps that minimize investigation derived waste. The micropurge pump bladders and tubing that are installed in these wells contain Teflon (i.e., polytetrafluoroethylene [PTFE]) that may contribute PFCs to samples and bias results. While it is documented that PTFE does not contribute significant PFCs in the environment to the extent PFCs do, PTFE contact with the groundwater being sampled is not desired as it may result in nonrepresentative sampling results.

Seventeen of the existing monitoring wells in the IEMP have neither PTFE materials in their construction nor PTFE-containing sampling equipment. These are continuous multichannel tubing (CMT) wells constructed of polyethylene tubing with channels that are screened at different depths in the aquifer, across the entire thickness of the total uranium plume. Identified as Type 8 wells in the IEMP (well number begins with an 8), the CMTs are sampled with polyethylene check-ball tubing using a mechanical inertial pump (i.e., Waterra). Polyethylene is an acceptable material for sampling PFCs. An advantage of the CMTs is that they are screened at multiple depths at each location so that a profile of contamination within the groundwater can be determined. Figure 16 through Figure 20 illustrate the sampling depths in relation to the aerial extent of the uranium plume.

Five of the multichannel wells have been selected for sampling of PFCs (Figure 1): one location in the former waste storage area (83338), two locations in the pilot plant drainage ditch area (83124 and 83335), and two locations in the south field (83294 and 83295). These five wells were selected to provide a broad coverage of the area where legacy contamination from former plant production activities is known to occur in the aquifer. The locations were also selected to take into account the mobility of the PFCs in groundwater.

3.0 Sampling and Analytical Requirements

Groundwater samples will be collected from all available channels in the five CMTs listed in Table 4. Samples will be collected using standard purge criteria after the removal of three well volumes from each channel. If any channels are dry at the time of sample collection, samples will not be collected.

Sample collection procedures documented in the *Fernald Preserve Quality Assurance Project Plan* (DOE 2014) will be utilized, along with additional analyte-specific requirements contained within this plan. Analytical data will be validated by a third party.

Quality-control samples will also be collected and consist of one field duplicate and one equipment rinsate to be collected at each CMT location. A field blank will be collected for each day of sampling. A trip blank will be collected at a rate of one per day per sampling crew. One

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rinsate will also be collected by rinsing the water-level probe used for water-level measurement. All quality-control samples will be analyzed for the analytes listed in Table 5.

All samples will be analyzed at Test America, Denver, Colorado using liquid chromatography and tandem mass spectrometry using Modified EPA Method 537 (EPA 2009). The analytes are listed in Table 5. Elevated sample turbidity may result in difficulty meeting the published detection limits. The sample container, holding time, and preservation requirements are listed in Table 6.

The laboratory will supply sample bottles and PFC-free water for field quality-control samples. All materials received from the laboratory will be stored in clean areas that have been cleared of PFC-containing items. All documentation received from the laboratory to document certification of the bottles and water will be reviewed by the field supervisor to ensure that the batch results are less than 20% of the method detection limits listed in Table 5. Documentation will be maintained with the field documentation. Field personnel will document the lot numbers associated with materials used at each location.

Because PFCs are often used in personal items and in many supplies and equipment typically used for environmental sampling and because of the low detection limits required, additional precautions are required when samples are collected for PFC analysis summarized in Appendix A. PFCs have been used to make fluoropolymer coatings and products that are oil and water repellent such as Teflon, StainMaster carpets, Scotchgard, and Gore-Tex. Field personnel should consult Safety Data Sheets for products to determine if PFCs are utilized in the product. If the product contains anything with “fluor” in the name or the acronyms “TPE,” “FEP,” “ETFE” and/or “PFA” the items will not be used. Sampling personnel must adhere to these additional requirements to avoid cross-contamination of the samples. A briefing will be held daily with all field personnel to the requirements listed in Appendix A at the sample location prior to beginning any field activities. Additionally, the checklist contained in Appendix A will be completed prior to beginning field activities at each location.

4.0 Project Schedule

Every attempt will be made to complete items prior to the dates outlined in the project schedule in Table 7. Groundwater sample collection will occur as soon as possible after finalization of this sampling plan. Preliminary data, which is normally available 30 days after receipt of the samples by the laboratory, will be submitted to EPA and Ohio EPA within 2 weeks of receipt of the data. Final results will be presented in the 2017 Site Environmental Report.

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Table 1. Key Project Personnel

Title	Primary	Alternate
Hydrogeologist	Ken Broberg	Hank Becker
Environmental Sampling lead	Dan Foster	Hank Becker
Subcontract laboratory contact	Chuck White	Steve Donovan
Safety and Health representative	Dennis Homola	Larry Oeffner
Environmental Monitoring, Data Management and Reporting lead	Karen Voisard	Chuck White
Environmental Compliance	Mary Sizemore	Scott Osborn
Quality Assurance	Katie Payne	Not applicable

Table 2. Fernald Site AFFF Usage and FTF Remediation Timeline

AFFF Usage	Timeline	Timeline	FTF Usage and Remediation
AFFF developed by military	1966	Began 1966	Fernald and surrounding community fire departments used FTF for training exercises
First purchase of AFFF at Fernald	1975		
Approximately 25 gallons of 3–6% AFFF concentrate used at FTF and 75 gallons stored at former garage area	Began 1976	Ended 1990	
	Ended 1990		
Approximately 75 gallons of 3–6% AFFF concentrate stored at former garage area	Began 1990	1991	FTF declared a HWMU
		1991–1994	Remedial Investigation (DOE 1995b)
		1994–1995	D&D of FTF buildings and excavation of 330 cubic yards of soil, Removal Action 28 (DOE 1995a)
		2002	Remedial Design of FTF (DOE 2002)
	Ended 2003	2003	Excavation of 13,000 cubic yards of soil above FRLs established in OU 5 ROD (DOE 2003a)
AFFF removed site	2004	2004	Completion of FTF soil certification (DOE 2004)

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Table 3. Area-Specific Constituents of Concern for Area 6, Phase I

ASCOC	FRL/(BTV)^a	Type of ASCOC	Where Retained
Total uranium	82 mg/kg	Primary ASCOC	All A6PI certification units
Radium-226	1.7 pCi/g	Primary ASCOC	All A6PI certification units
Radium-228	1.8 pCi/g	Primary ASCOC	All A6PI certification units
Thorium-228	1.7 pCi/g	Primary ASCOC	All A6PI certification units
Thorium-232	1.5 pCi/g	Primary ASCOC	All A6PI certification units
Aroclor-1254	0.13 mg/kg	Secondary ASCOC	All A6PI certification units
Aroclor-1260	0.13 mg/kg	Secondary ASCOC	All A6PI certification units
Arsenic	12 mg/kg	Secondary ASCOC	All A6PI certification units
Beryllium	1.5 mg/kg	Secondary ASCOC	All A6PI certification units
Thorium-230	280 pCi/g	Secondary ASCOC	All A6PI certification units
Benzo(a)anthracene	(1.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
Benzo(a)pyrene	2.0 mg/kg (1.0 mg/kg)	Secondary ASCOC Ecological COC	FTF and FTF buffer certification units only
Benzo(a)fluoranthene	20.0 mg/kg (1.0 mg/kg)	Secondary ASCOC/ Ecological COC	FTF and FTF buffer certification units only
Benzo(g,h,i)perylene	(1.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
Benzo(k)fluoranthene	(1.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
Chrysene	(1.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
Dibenzo(a,b)anthracene	2.0 mg/kg (0.088 mg/kg)	Secondary ASCOC/ Ecological COC	FTF and FTF buffer certification units only
Fluoranthene	(10.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
1,1-Dichloroethene	0.41 mg/kg	Secondary ASCOC	FTF and FTF buffer certification units only
Indeno(1,2,3-cd)pyrene	20.0 mg/kg (1.0 mg/kg)	Secondary ASCOC/ Ecological COC	FTF and FTF buffer certification units only
Phenanthrene	(5.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
Pyrene	(10.0 mg/kg)	Ecological COC	FTF and FTF buffer certification units only
Technetium-99	30.0 pCi/g	Secondary ASCOC	FTF and FTF buffer certification units only
Tetrachloroethene	3.6 mg/kg	Secondary ASCOC	FTF and FTF buffer certification units only
Benzene	8.5 mg/kg	UST-specific COC	FTF, A6PI-UST certification units only
Ethylbenzene	51 mg/kg	UST-specific COC	FTF, A6PI-UST certification units only
Toluene	100,000 mg/kg	UST-specific COC	FTF, A6PI-UST and HWMU certification units only
Xylene	920 mg/kg	UST-specific COC	FTF, A6PI-UST certification units only

Note:

^a FRL = final remediation level; BTV = benchmark toxicity values (in parentheses) apply to ecological constituents of concern, as applicable. An FRL is not listed for constituents of concern (COCs) that are only ecological COCs.

Abbreviations:

mg/kg = milligram per kilogram; pCi/g = picocuries per gram; UST = underground storage tank

Table 4. List of Five Multichannel Well Sample Locations

83124_C1	83294_C1	83295_C1	83338_C1	83335_C1
83124_C2	83294_C2	83295_C2	83338_C2	83335_C2
83124_C3	83294_C3	83295_C3	83338_C3	83335_C3
	83294_C4	83295_C4		
	83294_C5	83295_C5		
	83294_C6	83295_C6		

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Table 5. Required PFC Analyses

Analyte^a	Chemical Abstract Services Registry Number	Reporting Limit (ng/L)	Method Detection Limit (ng/L)
Perfluorobutanoic acid (PFBA)	375-22-4	2.00	0.458
Perfluoropentanoic acid (PFPeA)	2706-90-3	2.00	0.989
Perfluorohexanoic acid (PFHxA)	307-24-4	2.00	0.786
Perfluoroheptanoic acid (PFHpA)	375-85-9	2.00	0.802
Perfluorooctanoic acid (PFOA)	335-67-1	2.00	0.748
Perfluorononanoic acid (PFNA)	375-95-1	2.00	0.654
Perfluorodecanoic acid (PFDA)	335-76-2	2.00	0.440
Perfluoroundecanoic acid (PFUnA)	2058-94-8	2.00	0.748
Perfluorododecanoic acid (PFDoA)	307-55-1	2.00	0.584
Perfluorotridecanoic acid (PFTriA)	72629-94-8	2.00	0.551
Perfluorotetradecanoic acid (PFTeA)	376-06-7	2.00	0.199
Perfluoro- <i>n</i> -hexadecanoic acid (PFHxDA)	67905-19-5	2.00	0.123
Perfluoro- <i>n</i> -octadecanoic acid (PFODA)	16517-11-6	2.00	0.672
Perfluorobutanesulfonic acid (PFBS)	375-73-5	2.00	0.918
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	2.00	0.870
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	2.00	0.713
Perfluorooctanesulfonic acid (PFOS) ^b	1763-23-1	2.00	1.28
Perfluorodecanesulfonic acid (PFDS)	335-77-3	2.00	1.21

Note:

^a Modified EPA Method 537.

^b Perfluorooctanesulfonic acid is also known as perfluorooctane sulfonate.

Abbreviation:

ng/L = nanograms per liter

Table 6. Sample Containers, Holding Times, and Preservation

Analytes	Container	Preservation	Holding Time
PFCs	250-milliliter wide-mouth HDPE with HDPE-lined screw caps ^a	Cool to 4 °C	14 days

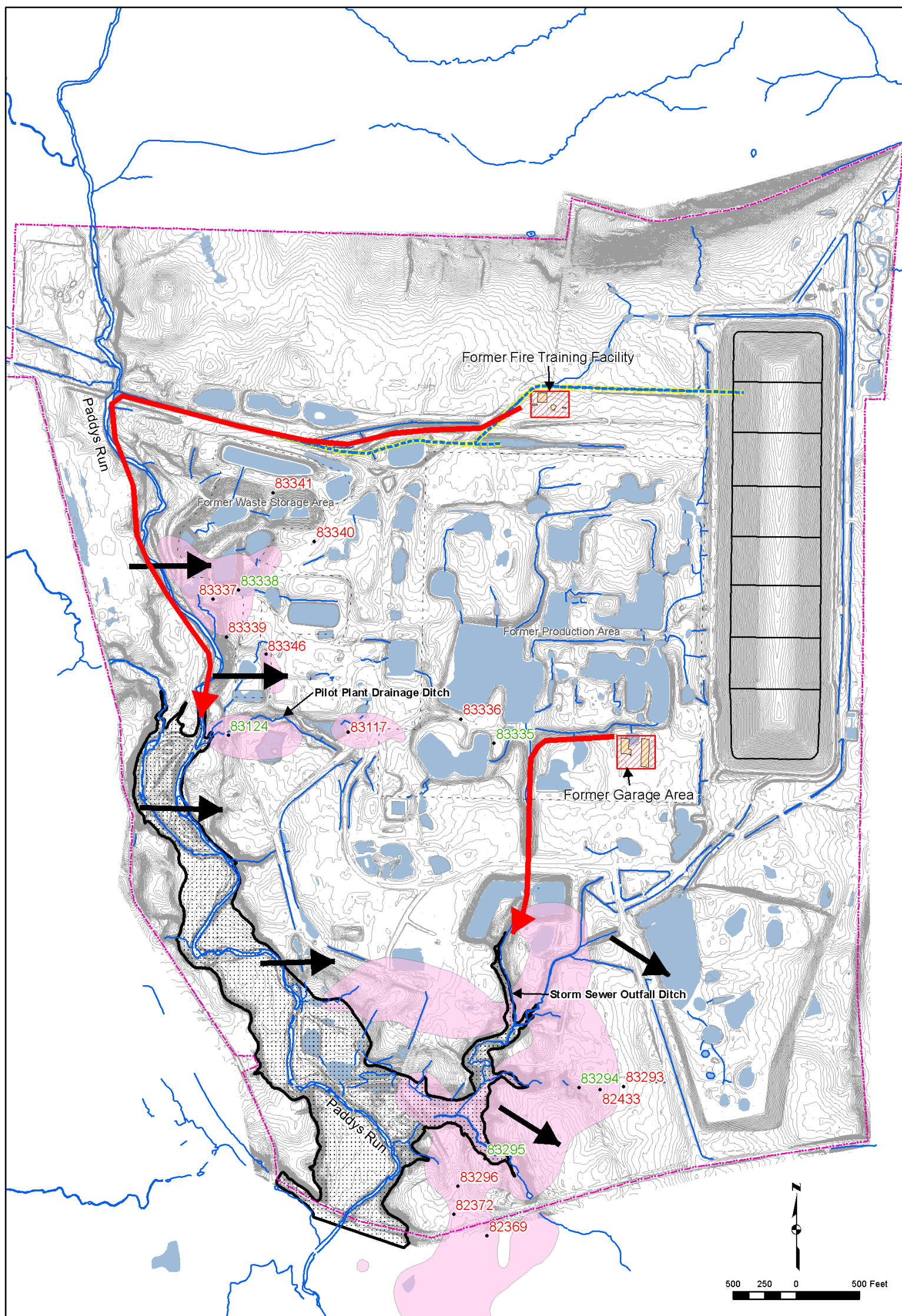
Note:









^a Double volume is required for matrix spike/matrix duplicates.

Table 7. Project Schedule

Item	Completion Date
Receive EPA and Ohio EPA Comments	January 31, 2017
Finalize Sampling Plan	February 28, 2017
Groundwater Sample Collection	March 31, 2017–April 14, 2017
Preliminary Data Letter Report	May 1, 2017
Comprehensive PFC Investigation Plan	March 31, 2018
2017 Site Environmental Report	June 1, 2018

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- | | | | |
|---|-----------------------------------|---|---|
|  | Potential Source Area | • | Recommended Continuous Multichannel Tubing Wells To Be Sampled |
|  | Historical Surface Water Drainage | • | Other Continuous Multichannel Tubing Wells |
|  | Current Surface Water Drainage |  | General Direction of Historical Surface Water Flow |
|  | Current Wetland |  | General Direction of Historical Groundwater Flow |
|  | Glacial Till Zero Thickness |  | Total Uranium Plume Second Half 2015 |

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Figure 1. Sampling Locations with Respect to Former Fire Training Facility and Former Garage Area

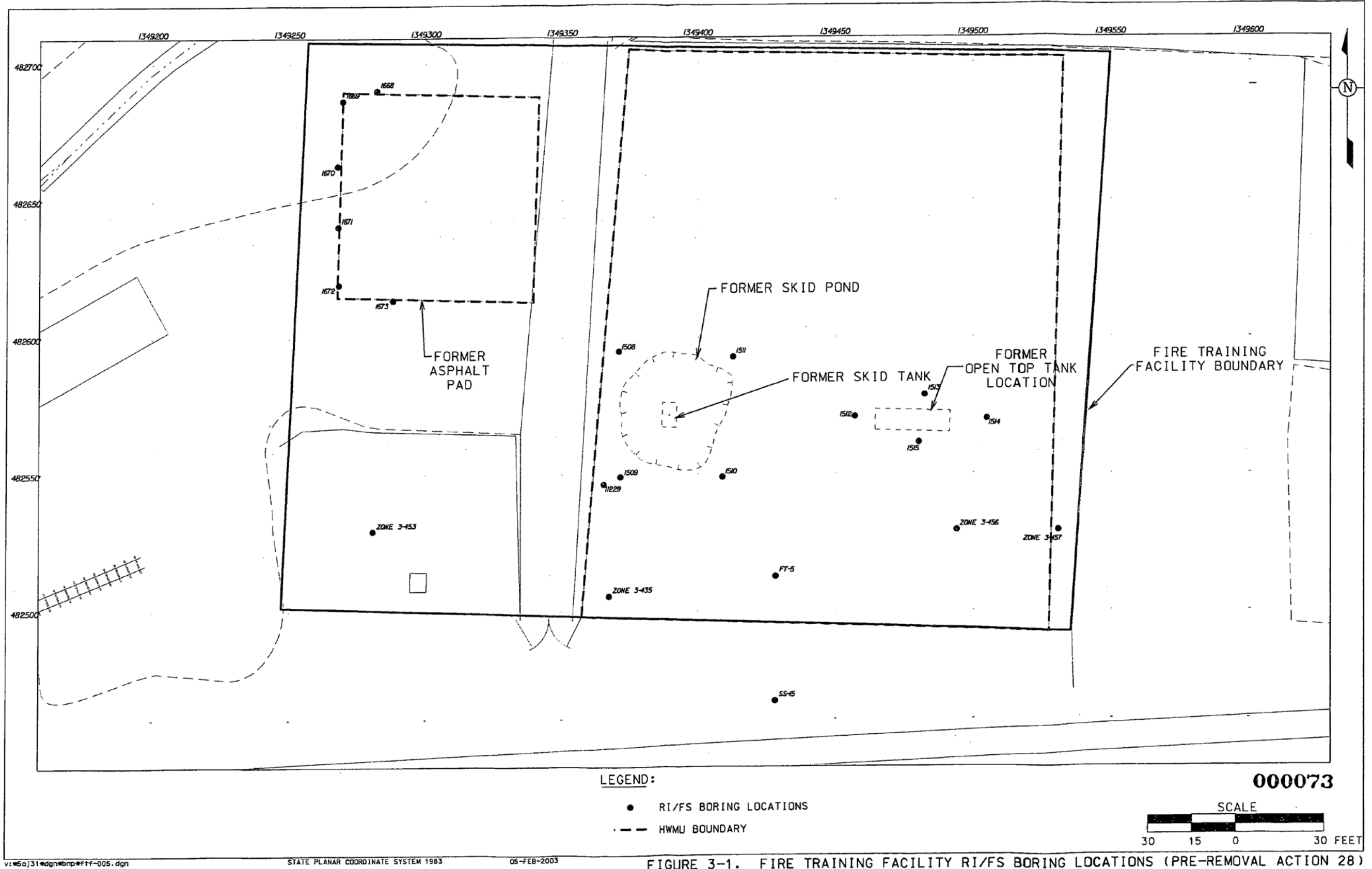


Figure 2. Fire Training Facility Remedial Investigation/Feasibility Study Boring Locations (Pre-Removal Action 28) (DOE 2003a)

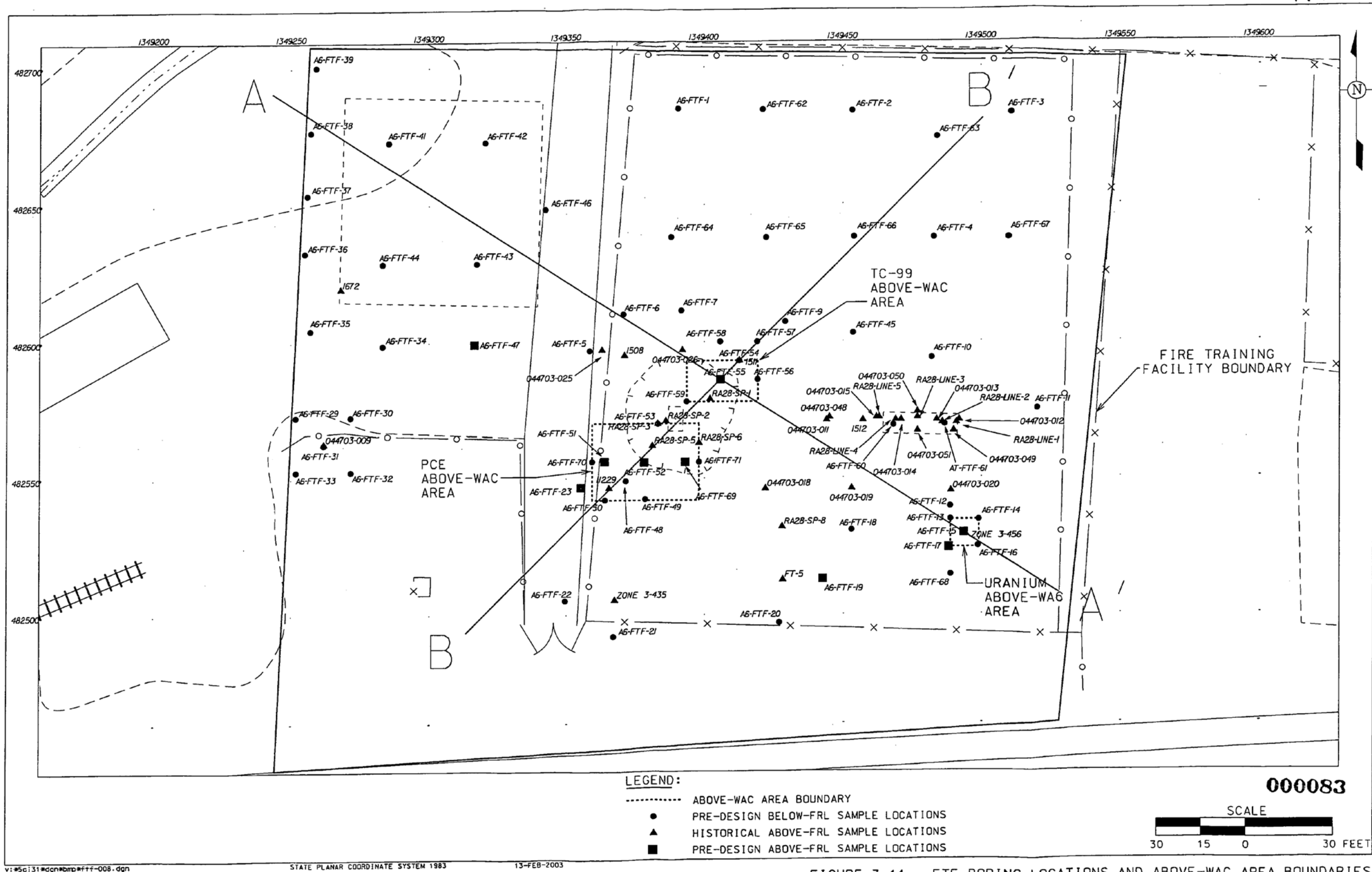


FIGURE 3-11. FTF BORING LOCATIONS AND ABOVE-WAC AREA BOUNDARIES

Figure 3. Location of Cross Section A-A' and B-B' (DOE 2003a)

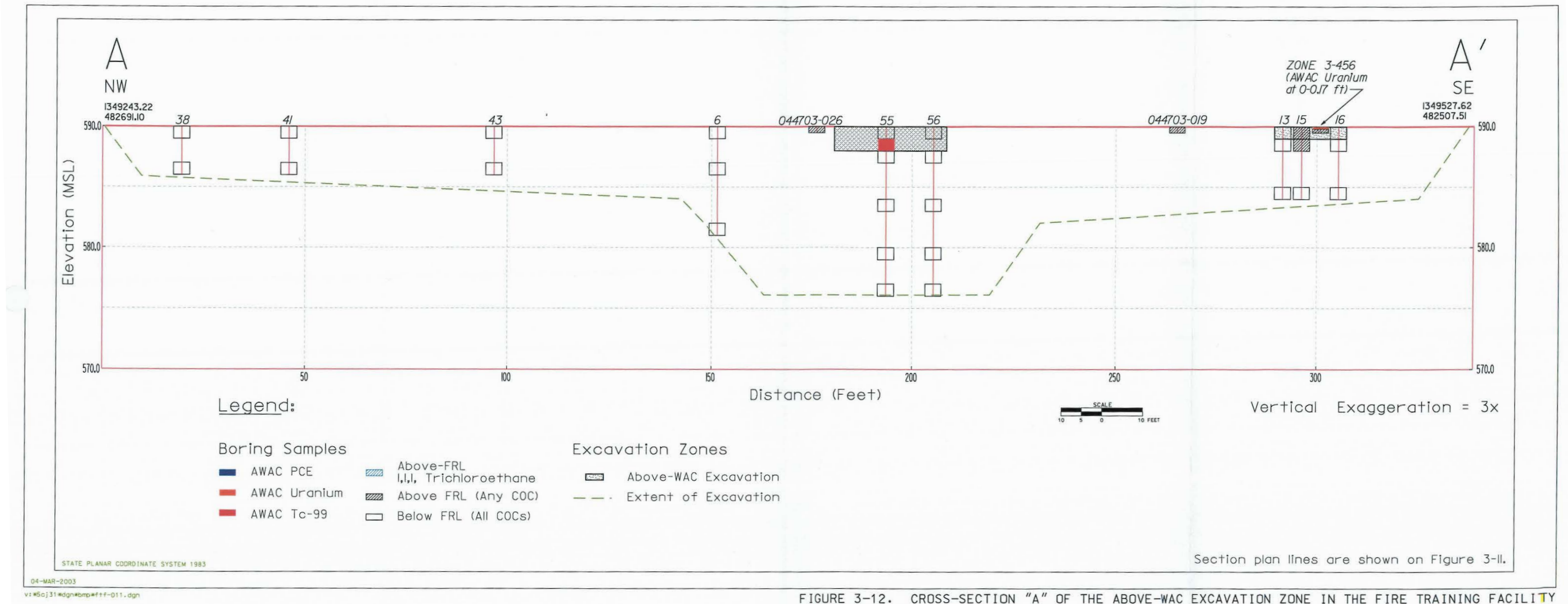


FIGURE 3-12. CROSS-SECTION "A" OF THE ABOVE-WAC EXCAVATION ZONE IN THE FIRE TRAINING FACILITY

Figure 4. Cross Section A-A' with Extent of Planned Excavation (DOE 2003a)

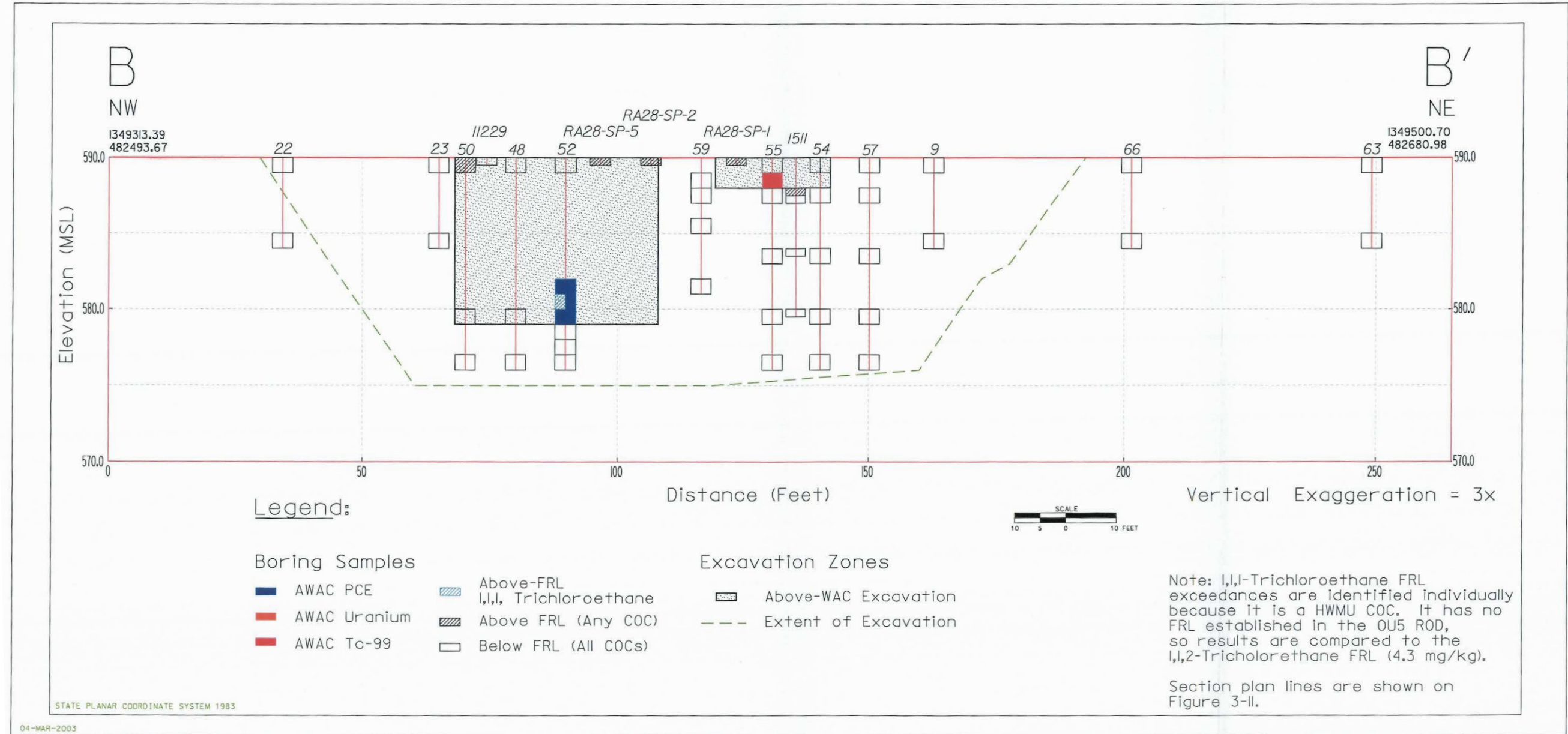


FIGURE 3-13. CROSS-SECTION "B" OF THE ABOVE-WAC EXCAVATION ZONE IN THE FIVE TRAINING PLOTS

Figure 5. Cross Section B-B' and Extent of Planned Excavation (DOE 2003a)

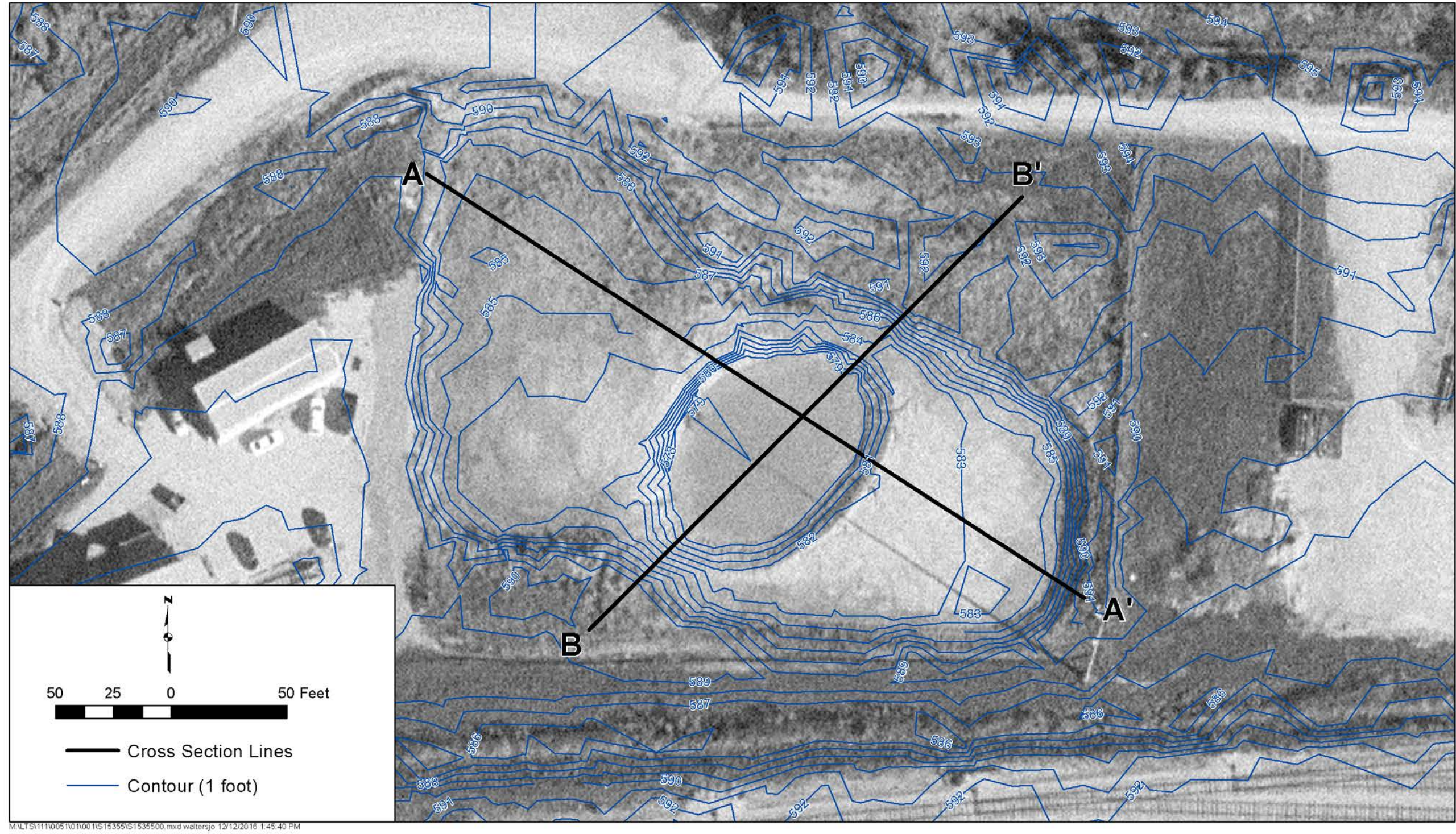


Figure 6. October 2003 Excavation Contours

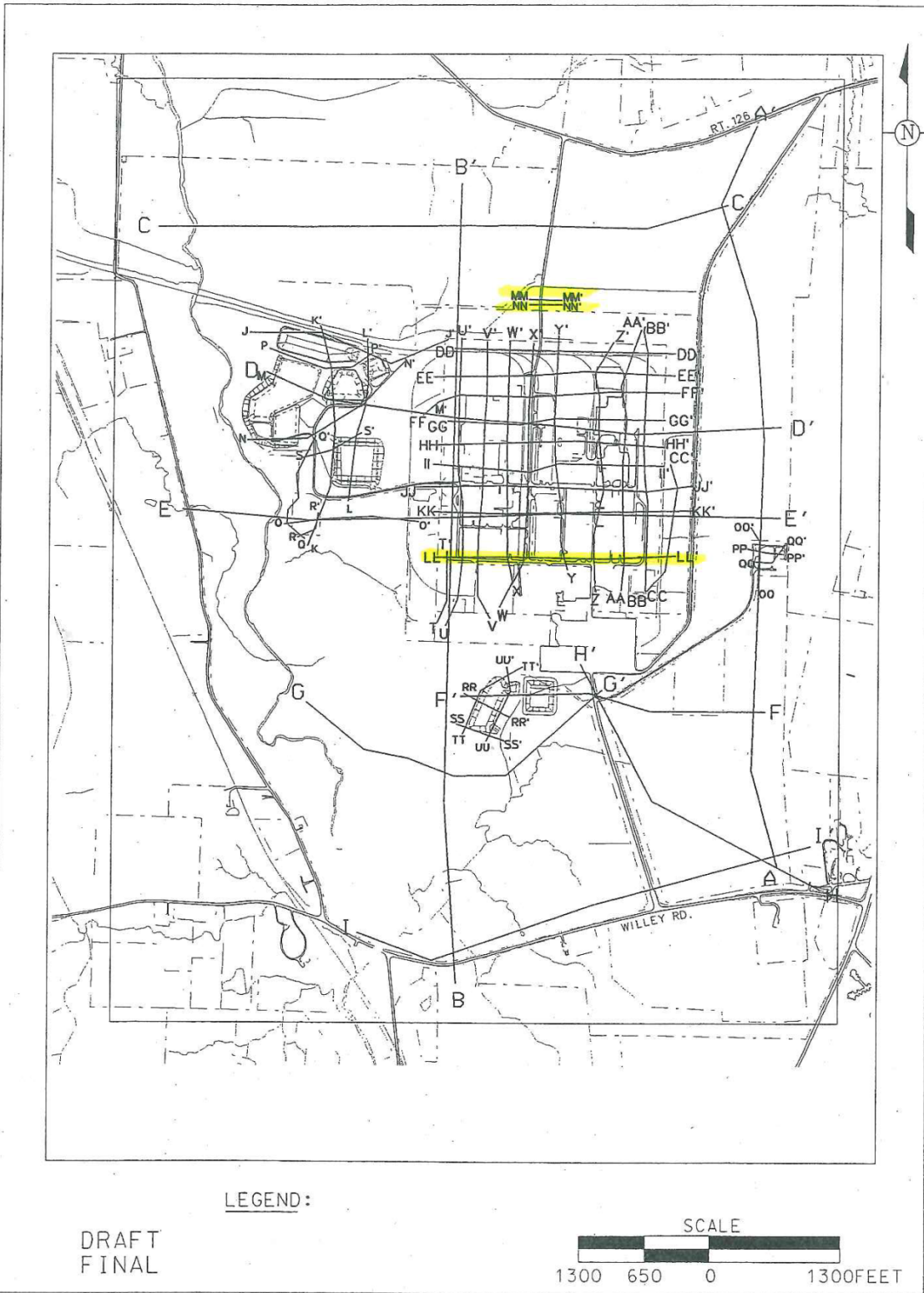


FIGURE 3-27. CONCEPTUAL CROSS-SECTION LINE LOCATIONS

Figure 7. Conceptual Cross-Section Line Locations, from OU 5 Remedial Investigation (DOE 1995b)

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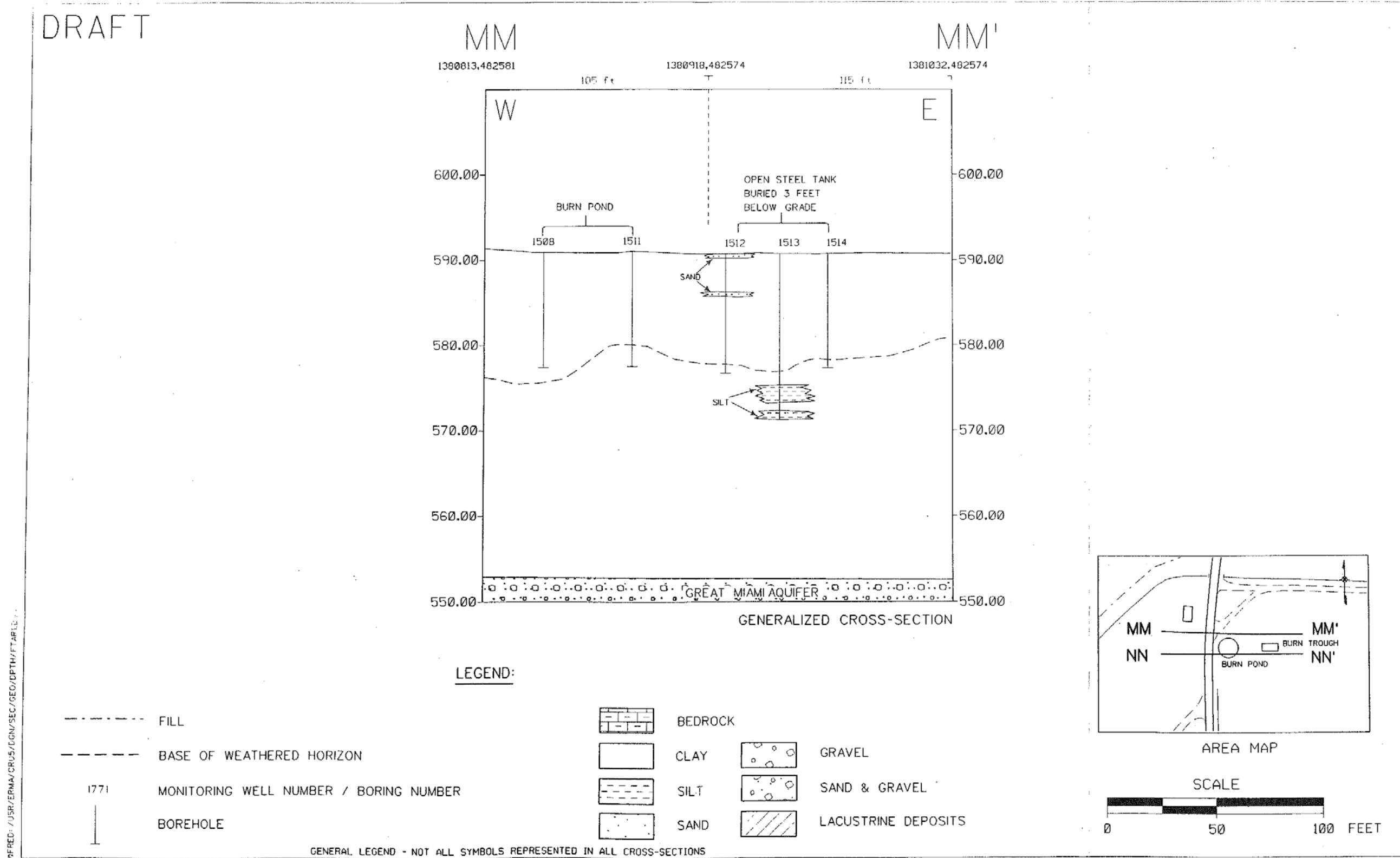
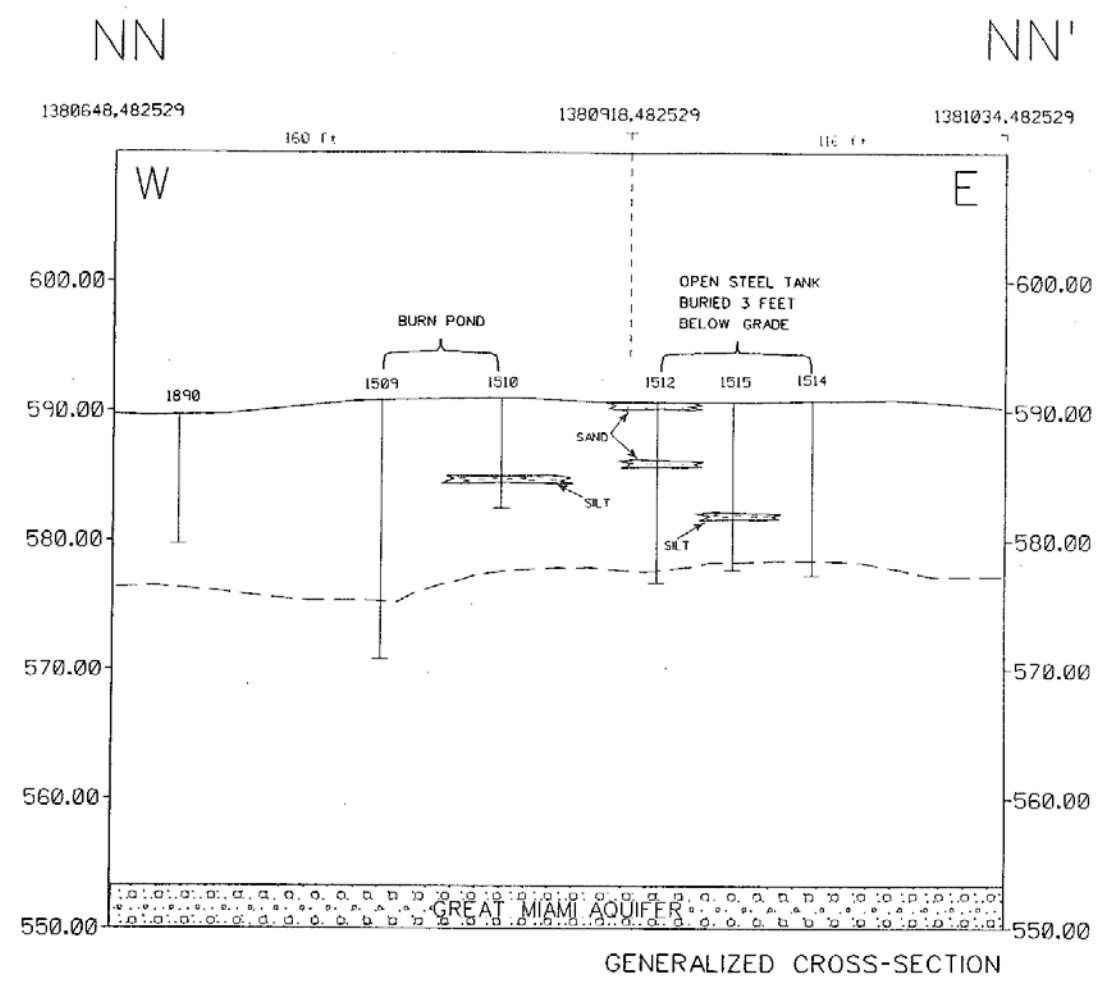


FIGURE Q-30.
FIRE TRAINING CROSS-SECTION MM-MM'

Figure 8. Fire Training Facility Cross Section MM-MM' (DOE 1995b)

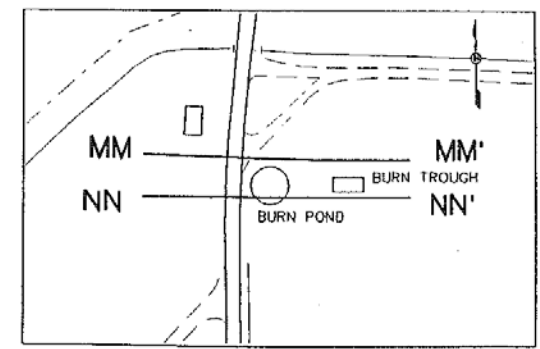
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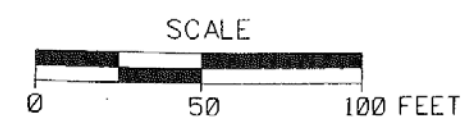
LEGEND:

- FILL
- BASE OF WEATHERED HORIZON
- 1771 MONITORING WELL NUMBER / BORING NUMBER
- | BOREHOLE
- [Bedrock symbol] BEDROCK
- [Clay symbol] CLAY
- [Silt symbol] SILT
- [Sand symbol] SAND
- [Gravel symbol] GRAVEL
- [Sand & Gravel symbol] SAND & GRAVEL
- [Lacustrine Deposits symbol] LACUSTRINE DEPOSITS

GENERAL LEGEND - NOT ALL SYMBOLS REPRESENTED IN ALL CROSS-SECTIONS



AREA MAP



SCALE

Figure 9. Production Area Cross Section NN-NN' (DOE 1995b)

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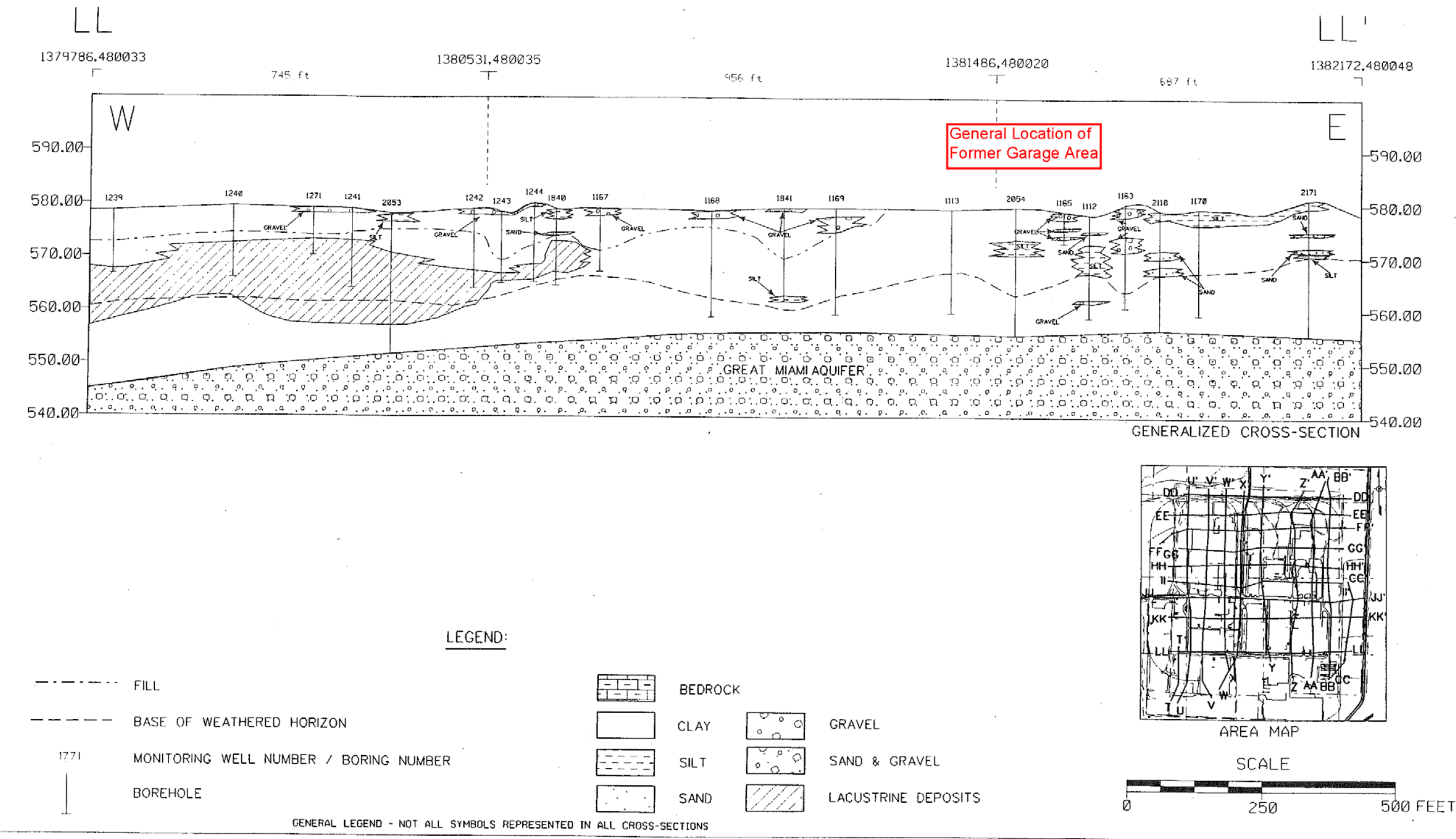


FIGURE Q-29.
PRODUCTION CROSS-SECTION LL-LL'

Figure 10. Production Cross Section LL-LL', from OU 5 Remedial Investigation (DOE 1995b)

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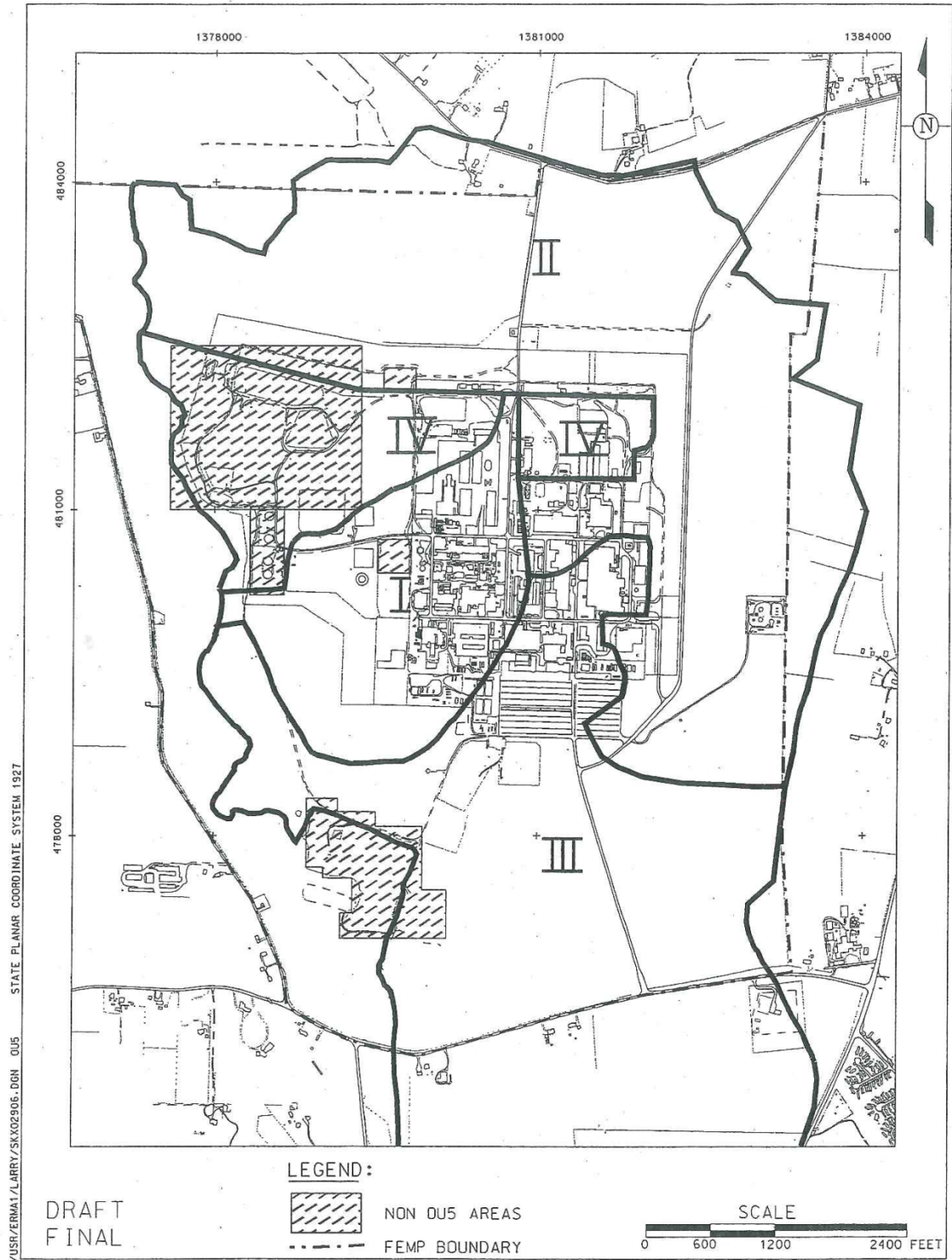


FIGURE 3-44. ZONATION OF GLACIAL OVERBURDEN BASED ON THICKNESS OF GRAY CLAY

Figure 11. Zonation of Glacial Overburden Based on Thickness of Gray Clay, from OU 5 Remedial Investigation (DOE 1995b)

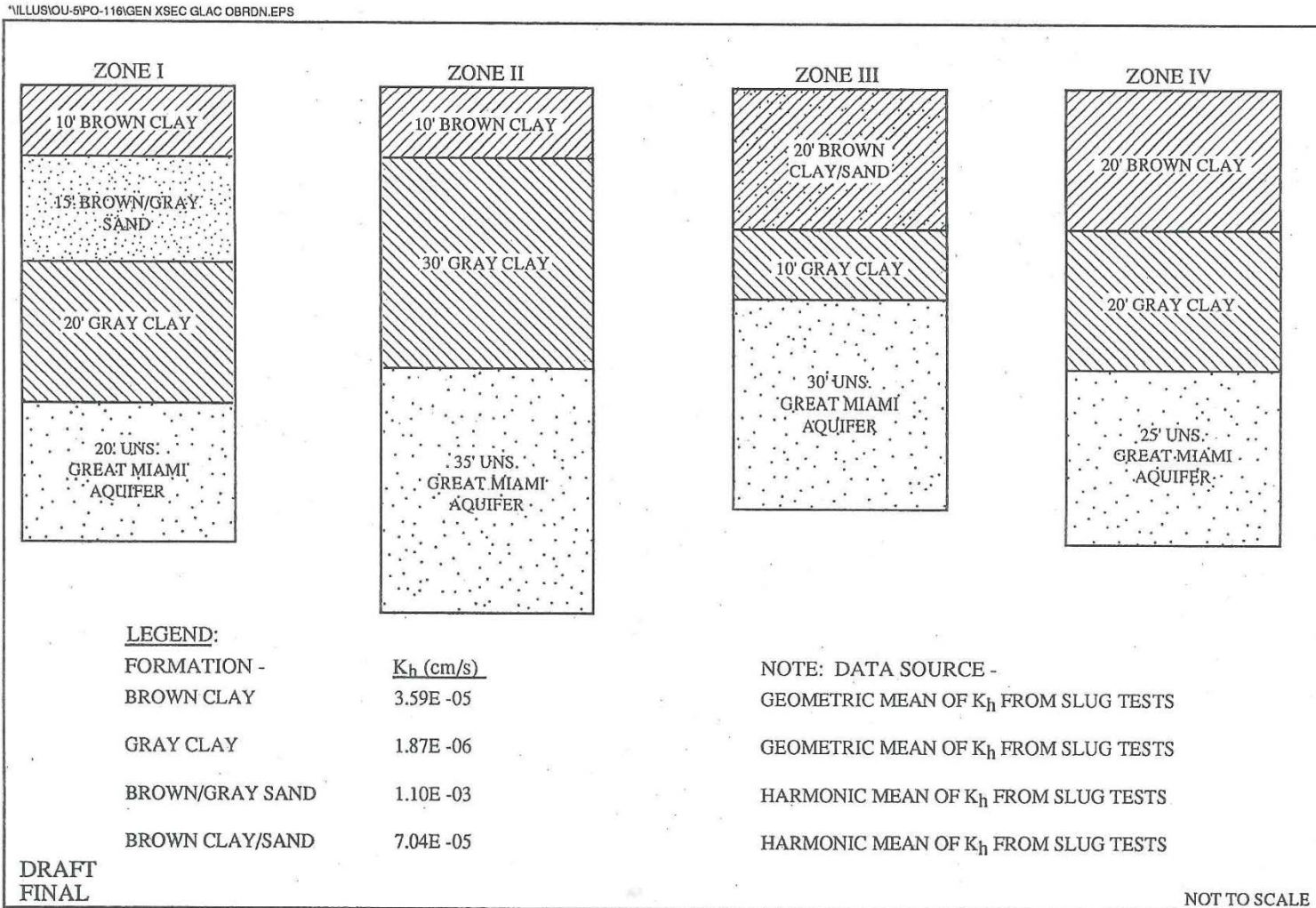


FIGURE 3-45. GENERALIZED CROSS SECTIONS THROUGH GLACIAL OVERBURDEN ZONES

Figure 12. Generalized Cross-Sections Through Glacial Overburden Zone (DOE 1995b)

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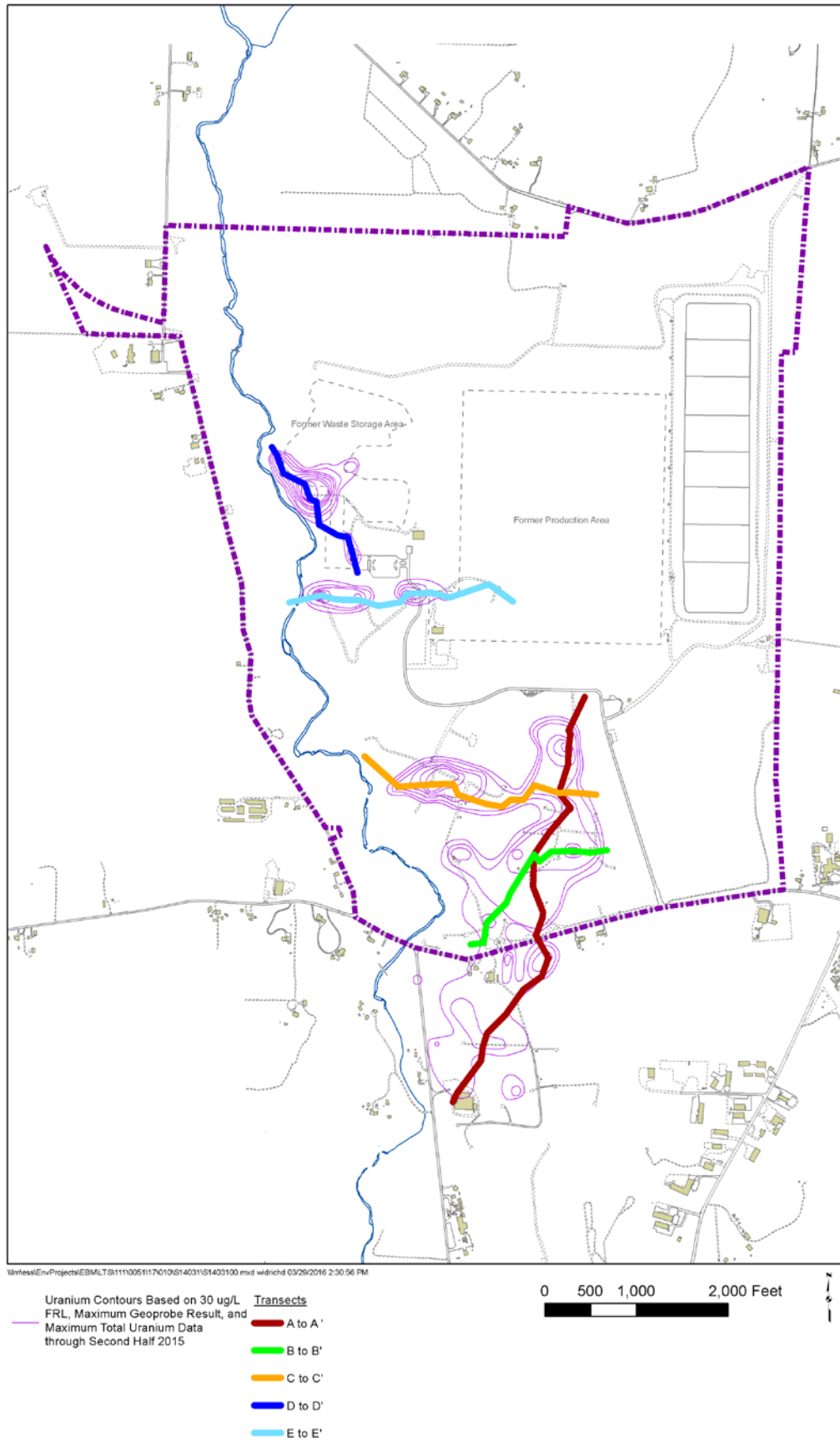


Figure 13. Cross-Section Location Map (DOE 2016c)

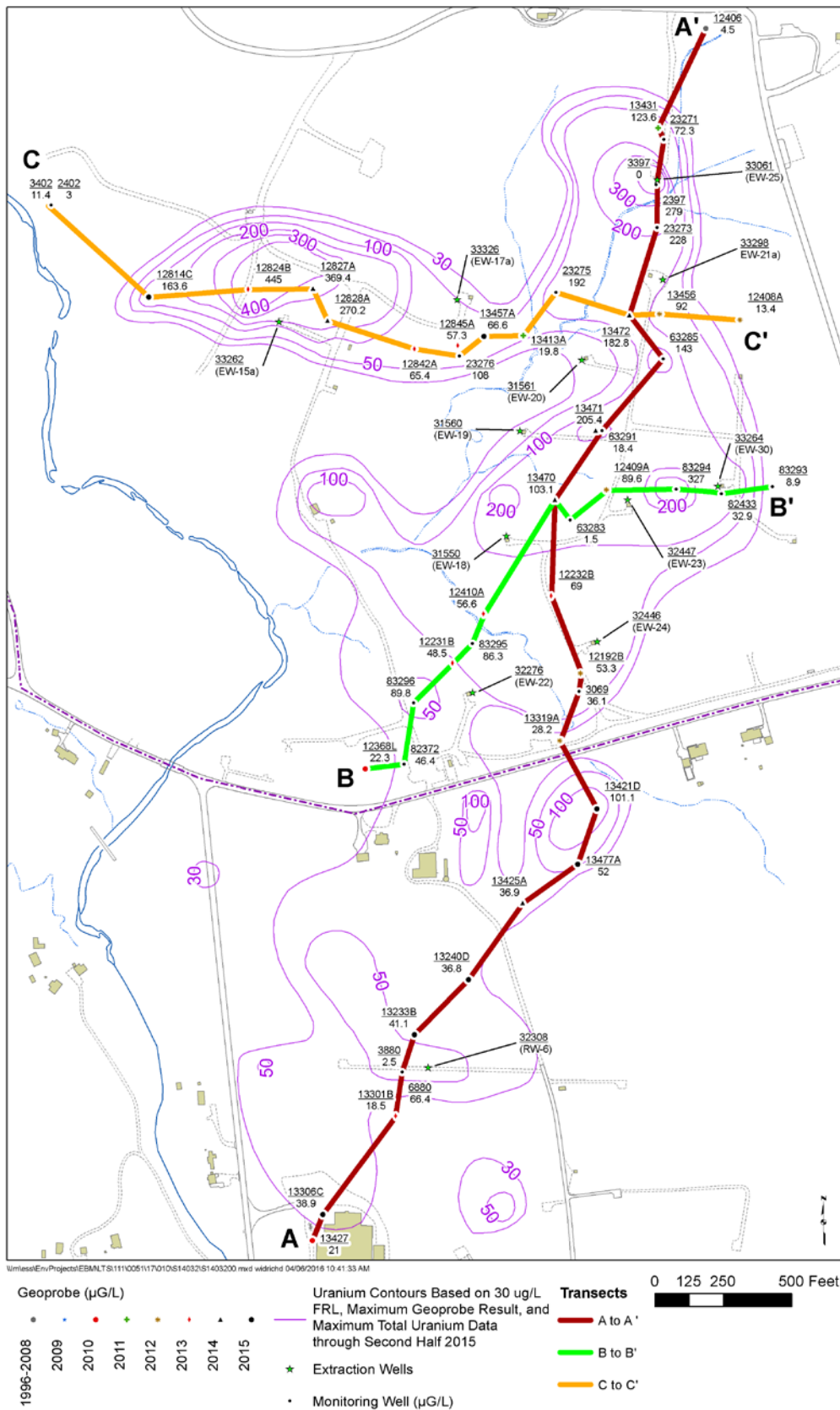


Figure 14. South Cross-Section Location Map (DOE 2016c)

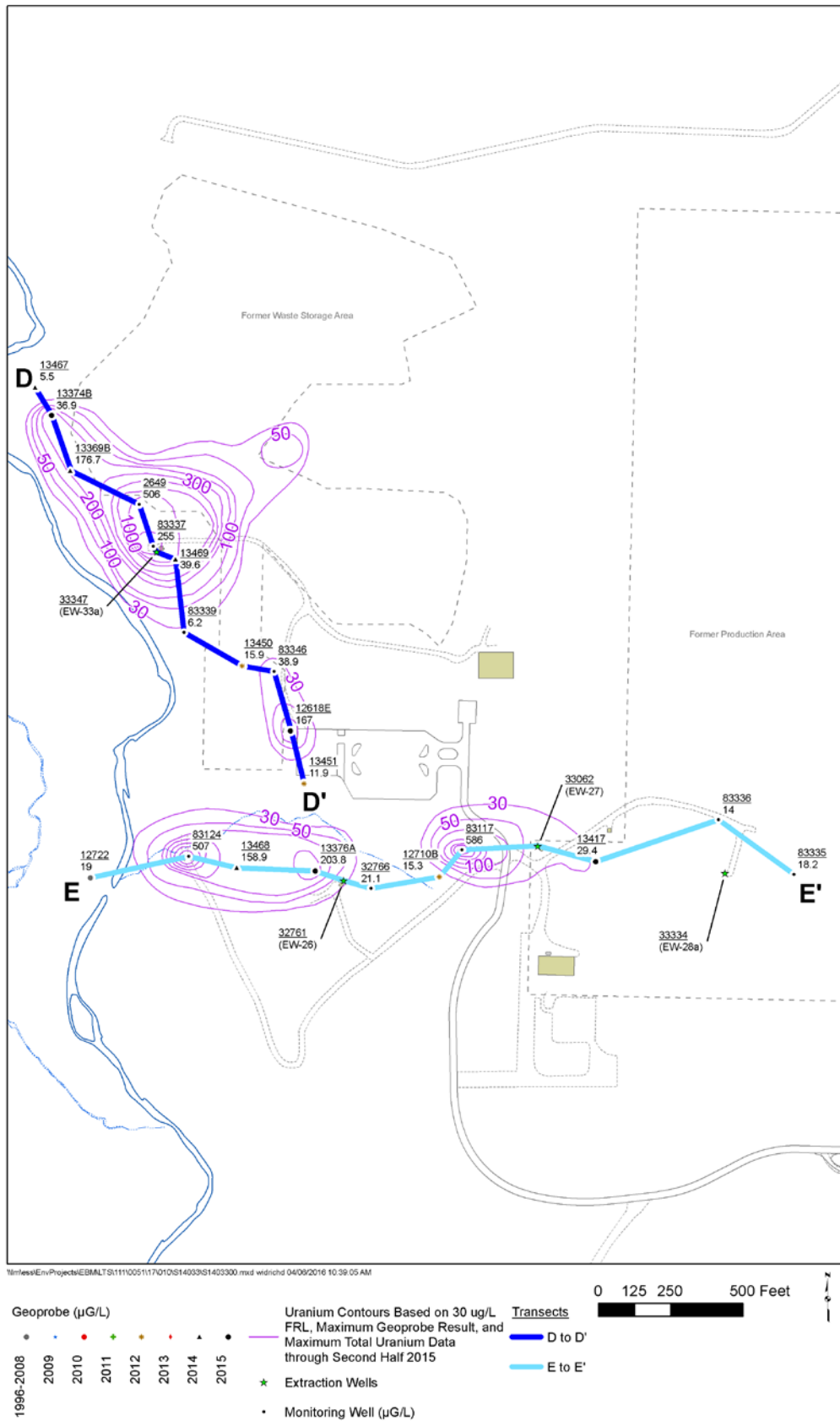


Figure 15. North Cross-Section Location Map (DOE 2016c)

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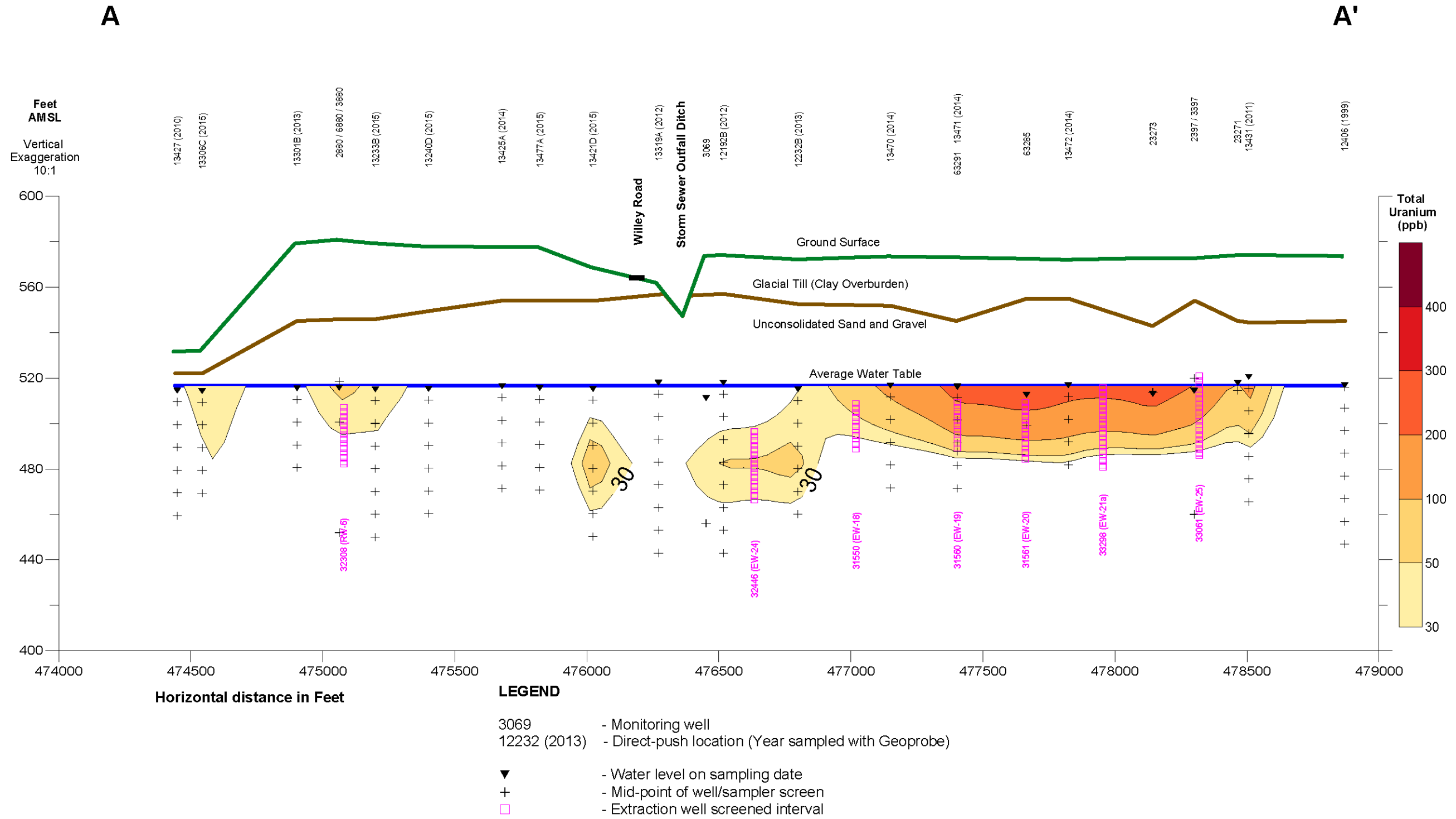


Figure 16. Cross Section A-A' (DOE 2016c)

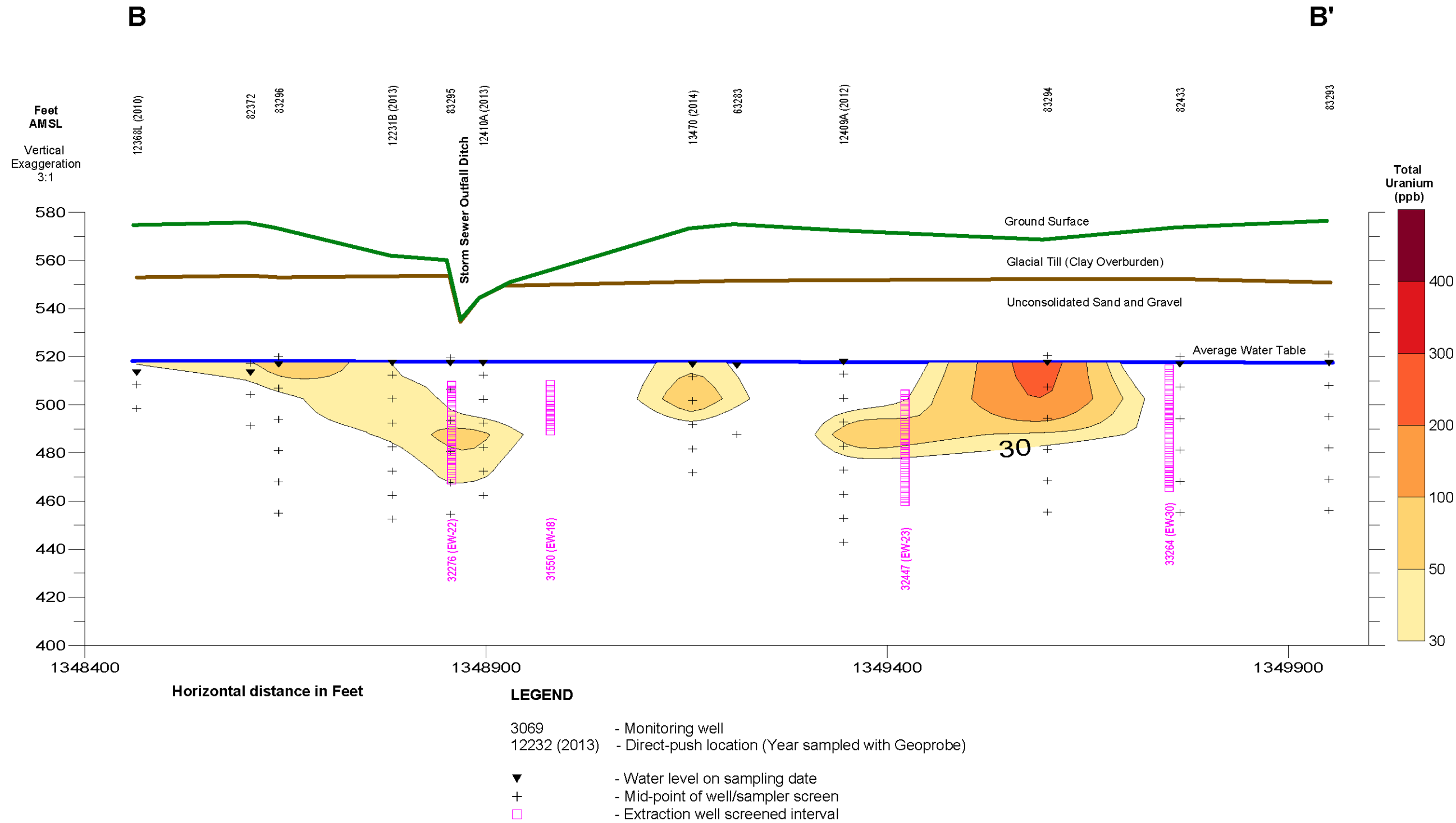


Figure 17. Cross Section B-B' (DOE 2016c)

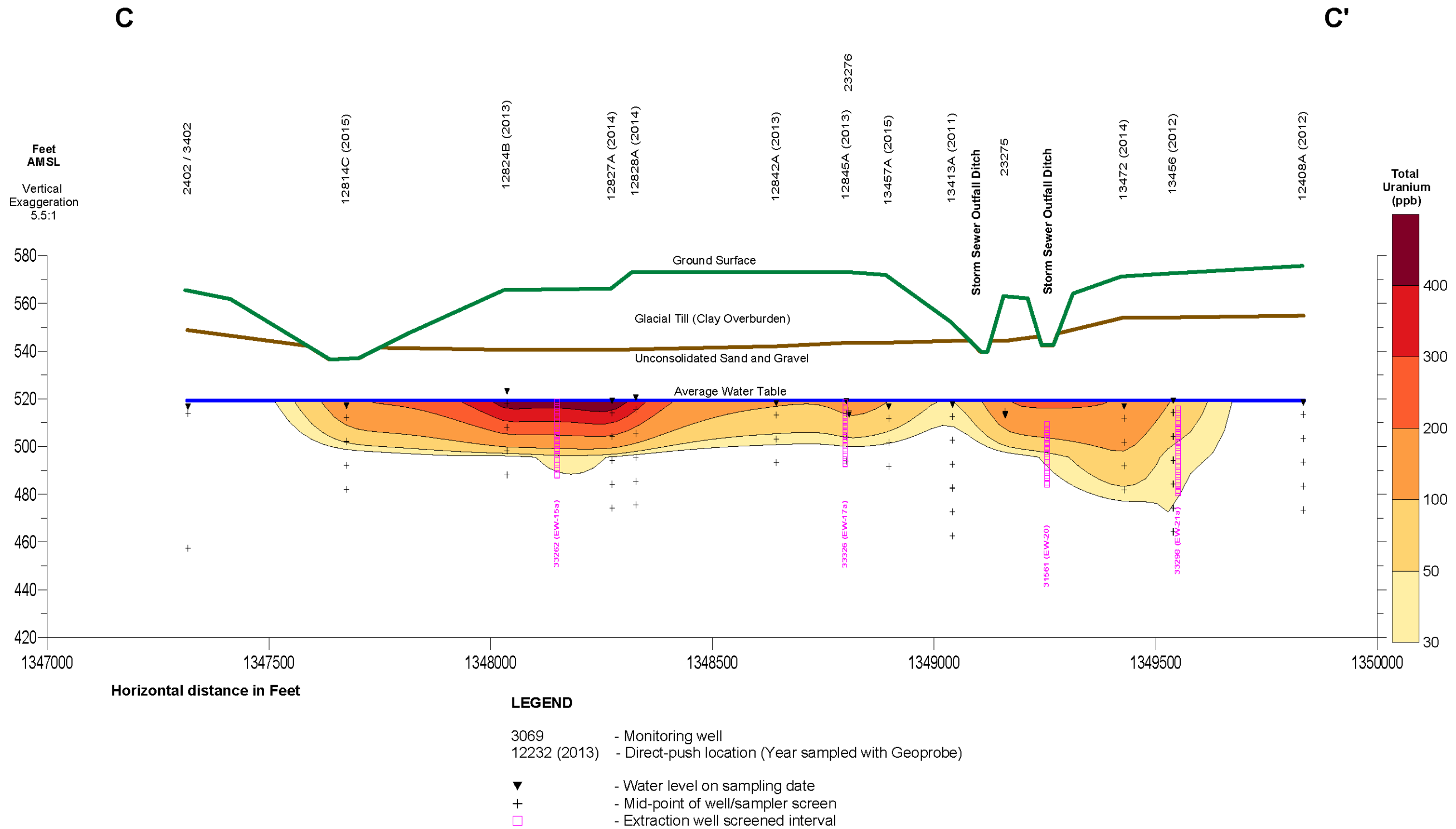


Figure 18. Cross Section C-C' (DOE 2016c)

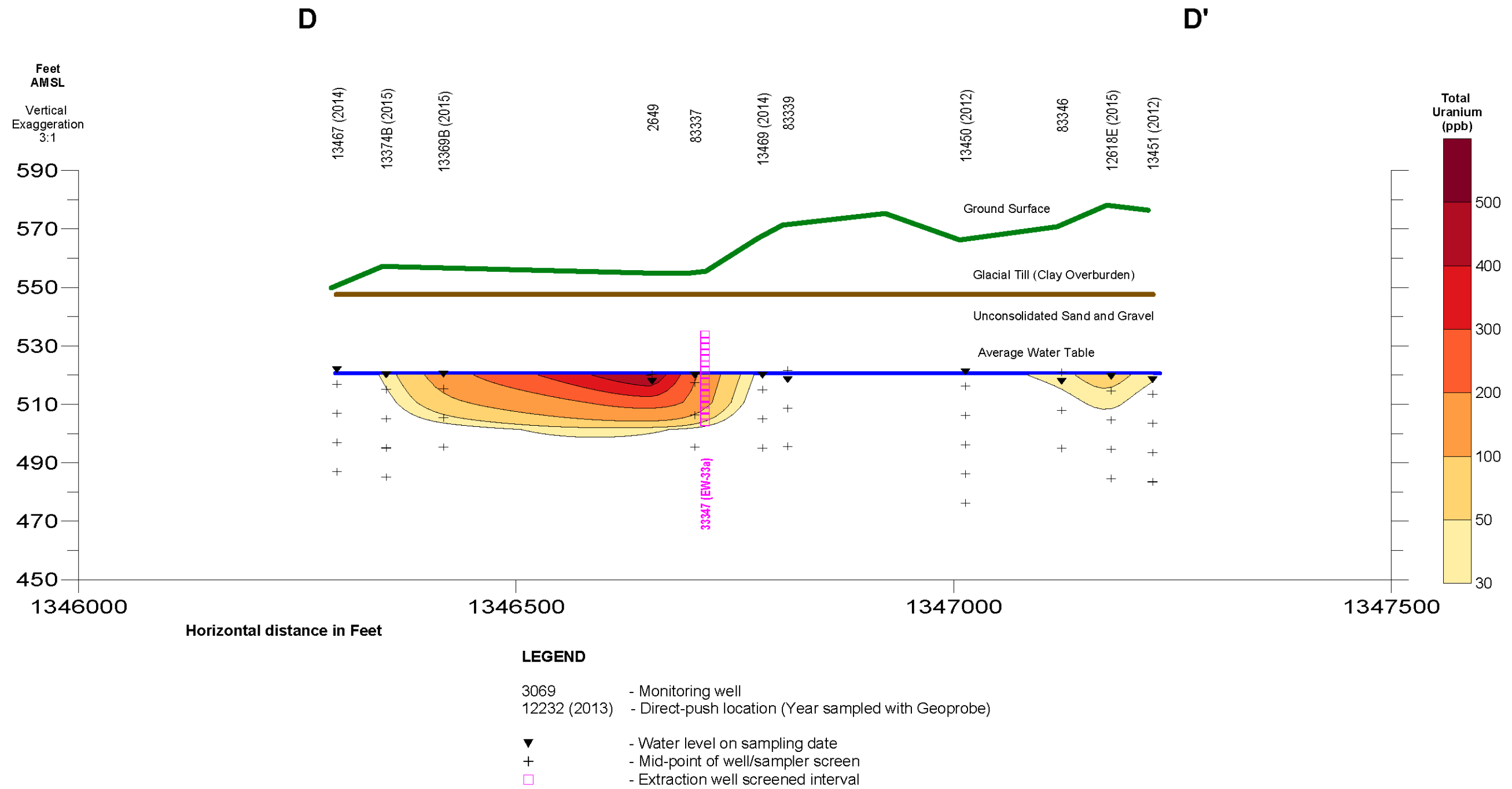
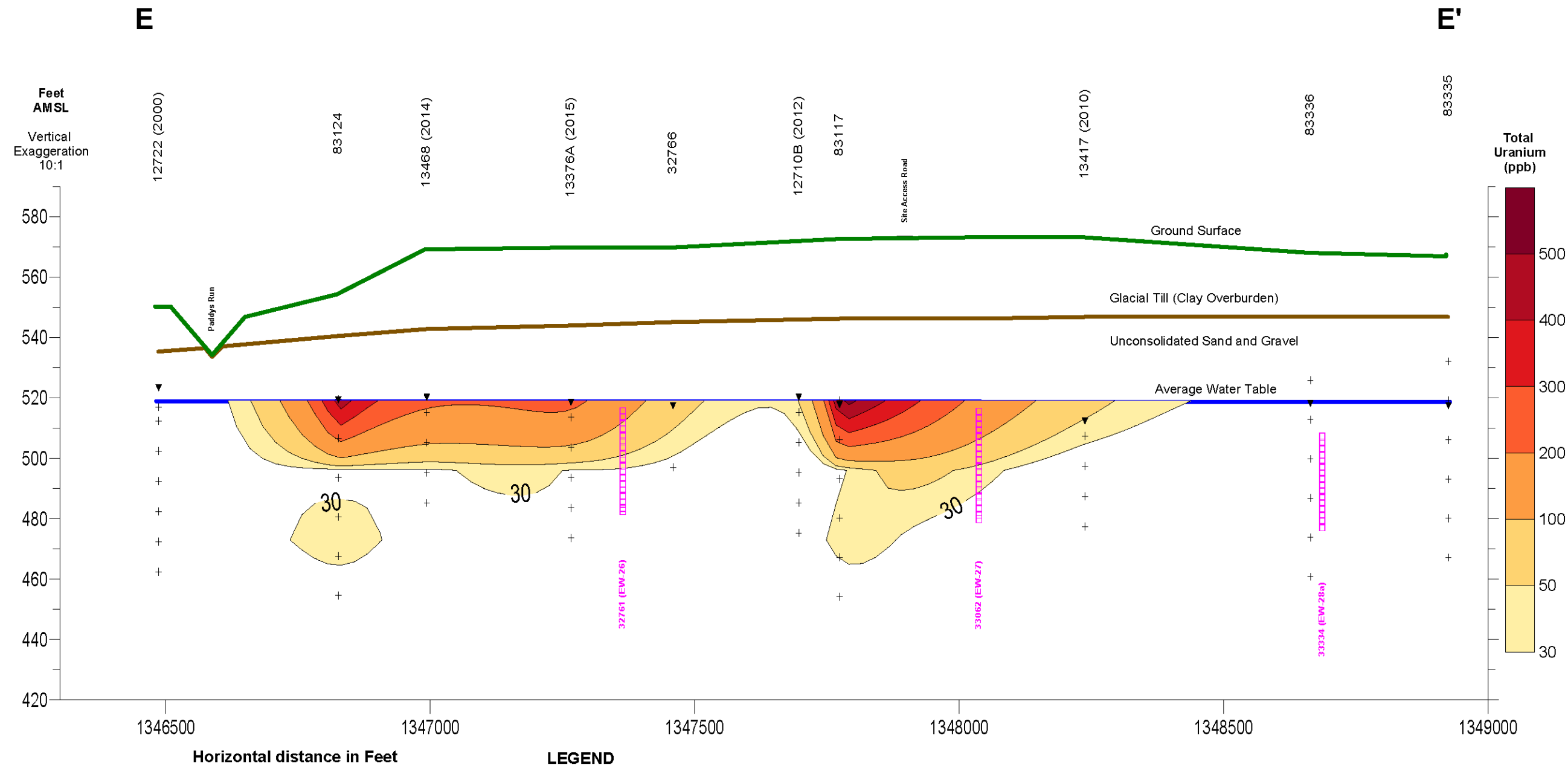


Figure 19. Cross Section D-D' (DOE 2016c)



LEGEND

3069 - Monitoring well
 12232 (2013) - Direct-push location (Year sampled with Geoprobe)

▼ - Water level on sampling date
 + - Mid-point of well/sampler screen
 □ - Extraction well screened interval

Figure 20. Cross Section E-E' (DOE 2016c)

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Appendix A

PFC Sampling Requirements and Checklist

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PFC Sampling Requirements

Field Equipment

- Use new equipment to the maximum extent possible.
- Do not use Teflon-containing materials (e.g., Teflon tubing, bailers, tape, plumbing paste, or other Teflon materials).
- Do not use low-density polyethylene (LDPE) materials for items that come into contact with the sample. High-density polyethylene (HDPE) and silicon materials are acceptable.
- Any documentation will be completed on loose-leaf paper outside the exclusion zone.
- Aluminum clipboards are acceptable.
- Plastic clipboards, binders, or spiral hard-cover notebooks are not acceptable.
- Post-It Notes and other items with adhesive are not allowed within the exclusion zone.
- Documentation of the sampling event will be completed by the Sampling lead OUTSIDE the exclusion zone.
- The Sampling lead will not handle any samples. Samples will only be handled by the samplers.
- Do not use markers. Use ball-point pens or pencils for documenting field activities in the field log and on field forms as well as for labeling sample containers and preparing the Chain of Custody.
- Do not use “blue ice.” This includes for storage of food as well as samples. Use regular ice contained in plastic (polyethylene) bags (double-bagged).
- Do not use or come into contact with Styrofoam or plastic wrappers.
- No electronics allowed inside the exclusion zone.

Field Clothing and Personal Protective Equipment

- Do not wear synthetic water-resistant, waterproof, or stain-treated clothing during the field program. Field clothing to be worn onsite should be restricted to natural fibers (preferably cotton). Field clothing should be laundered by avoiding the use of fabric softener. Preferably, field gear should be of cotton construction and well laundered (a minimum of 6 times from time of purchase). New cotton clothing may contain PFC-related treatments; do not wear new clothing while sampling or sample handling.
- Do not wear clothing or boots containing Gore-Tex.
- All safety footwear will consist of steel-toed boots made with polyurethane and/or polyvinyl chloride (PVC) and leather.
- Do not wear Tyvek clothing.
- Disposable nitrile gloves must be worn at all times. A NEW pair of nitrile gloves shall be donned:
 - Prior to decontamination of reusable sampling equipment.
 - Prior to contact with sample bottles or water containers.
 - Prior to lowering anything into a well (e.g., HDPE tubing, bailer, etc.).
 - After completion of monitor well purging and prior to sample collection.
 - Prior to handling of any quality-control field samples.
 - Prior to handling quality-assurance/quality-control samples including field blanks and equipment blanks.
 - After the handling of any nondedicated sampling equipment, contact with nondecontaminated surfaces, or when judged necessary by field personnel.

Sample Containers

- Different laboratories may supply sample collection containers of varying sizes dependent on the type of samples being collected. All samples should be collected in polypropylene or HDPE bottles fitted with an unlined (no Teflon), polypropylene HDPE screw cap. Glass containers should be avoided.

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- Container labels will be completed using ball-point pens (**NO MARKERS**) after the caps have been placed back on each bottle.

PFC Sampling Requirements (continued)

Wet Weather

- Sampling will not be conducted in wet weather.

Equipment Decontamination

- Field sampling equipment that is utilized at each sample location (e.g., water-level probes) will require cleaning between uses. Alconox and Liquinox soap are acceptable.
- Water used for the decontamination of sampling equipment will be laboratory certified “PFC-free” water.

Personnel Hygiene

- Do not use cosmetics, moisturizers, hand cream, or other related products, because they may contain PFCs.
- Many manufactured sunblock and insect repellents contain PFCs and should not be brought or used by sampling personnel. Sunblock and insect repellents that are used should consist of 100% natural ingredients.
- Use an air dryer, not paper towels, to dry hands.
- Do not use or come into contact with Styrofoam or plastic wrappers.

Food Considerations

- No food or drink shall be brought to the sampling site, with the exception of bottled water, which will only be allowed to be brought and consumed within the staging area. Sampling personnel will avoid bringing food in coated food container boxes (e.g., pizza boxes, fast-food boxes), Styrofoam, or plastic wrappers.

Visitors

- Visitors to the site are asked to remain outside of the exclusion zone during sampling activities.

Perfluorinated Compounds Pre-Sampling Checklist

Date:	Sample Location:
Sampling Lead:	<input type="checkbox"/> Daily PFC Sampling Briefing Completed
Controls Inside Exclusion Zone <input type="checkbox"/> Set up exclusion zone with staging area downwind of sample location. <input type="checkbox"/> Limit materials and equipment inside exclusion zone. <input type="checkbox"/> Complete sample collection and containerization inside exclusion zone. <input type="checkbox"/> Complete sampling documentation in staging area. <input type="checkbox"/> Use new, dedicated HDPE tubing (properly stored). <input type="checkbox"/> Complete decontamination of water-level probe with Alconox and laboratory-supplied water; allow to air dry. <input type="checkbox"/> Do not use paper towels. <input type="checkbox"/> Limit materials and items in exclusion zone (no aluminum foil). <input type="checkbox"/> No food or drink. <input type="checkbox"/> No artificial ice packs. <input type="checkbox"/> Wear disposable nitrile gloves at all times. <input type="checkbox"/> Use only ball-point pens, not Sharpies or markers. <input type="checkbox"/> No adhesives (e.g., Post-It notes and sample labels). <input type="checkbox"/> Use laboratory-supplied containers. <input type="checkbox"/> Use laboratory-supplied water for field QC samples. <input type="checkbox"/> Package samples in the field for shipment.	Personal Item Controls <input type="checkbox"/> Field personnel have not used cosmetics, moisturizers, hand creams, or other related products. <input type="checkbox"/> Field personnel have not applied unauthorized sunscreen or insect repellent. <input type="checkbox"/> Cotton clothing, washed minimum of 6 times since purchase. <input type="checkbox"/> Clothing washed without fabric softener. <input type="checkbox"/> Clothing NOT treated with Scotchgard. <input type="checkbox"/> No Tyvek, Gore-Tex, or waterproof gear, clothing, boots, or portable shelters. <input type="checkbox"/> No electronics.
Don New Pair of Nitrile Gloves <input type="checkbox"/> Prior to contact with sample bottles <input type="checkbox"/> Prior to contact with water containers <input type="checkbox"/> Prior to lowering anything into a well <input type="checkbox"/> After completion of well purging and prior to sample collection <input type="checkbox"/> Prior to handling any quality-control field samples <input type="checkbox"/> Prior to handling any field samples <input type="checkbox"/> After the handling of any nondedicated sampling equipment <input type="checkbox"/> Prior to contact with nondecontaminated surfaces <input type="checkbox"/> When judged necessary by other field personnel	
Comments	

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