Whirlpool CORPORATION

2000 N. M-63 • BENTON HARBOR, MI 49022-2692

December 12, 2014

Mr. Mostafa Mehran
Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, Arkansas 72118

Re: Response to ADEQ Correspondence Dated October 17, 2014
Area 1 Work Plan – September 2014
Whirlpool Corporation
Fort Smith, Arkansas
EPA No. ARD042755389
AFIN No. 66-00048
CAO LIS 13-202

Dear Mr. Mehran:

Whirlpool Corporation is submitting this response to the Arkansas Department of Environmental Quality (ADEQ) letter of October 17, 2014, where ADEQ provides comments on the Area 1 Work Plan – September 2014. In its October 17 letter, ADEQ's comments generally address the voluntary limited soil removal action Whirlpool performed in Area 1. ADEQ asked Whirlpool to consider whether further action may be warranted with respect to remaining soil exhibiting trichloroethylene (TCE) concentrations above the remedial action level (RAL) of 0.129 milligrams per kilograms (mg/kg)]. In particular, ADEQ comments:

- Raised the question of whether the presence of impacted soil in the linear drainage feature will prolong groundwater treatment;
- Requested further information regarding potential complications if Whirlpool were to undertake an expanded soil removal effort;
- Discussed placing large diameter borings closer together to removal additional soil; and
- Suggested consideration of in-situ thermal desorption for treatment of soil.

The attached report from ENVIRON International Corporation (ENVIRON) addresses each of these four topics in detail.

While the Remedial Action Decision Document (RADD) selected an in-situ chemical treatment remedy combined with monitored attenuation to address offsite groundwater impacts, the RADD selected a containment remedy for onsite soils with TCE impacts. In the RADD, ADEQ selected the containment remedy for the Whirlpool property because:

> *A containment based corrective measure would provide protection of human health and the environment since it reduces the exposure to the impacted soils. In addition, containment would reduce and prevent the downward migration of water through the contaminated soils; thus reduces the concentration of trichloroethylene (TCE) transferred from soil to groundwater. This reduction in mobility of TCE bound in soil will assist the groundwater remedy in meeting the RALs. This remedy will be coupled with institutional control to prevent unauthorized excavation of the onsite impacted soils (RADD, Paragraph 9, A).*

In 2014, Whirlpool conducted additional investigation in the vicinity of Area 1. The results of this investigation have not changed the fundamental conclusion that the onsite containment remedy remains protective. While samples collected in and along a trench feature running from the degreaser building in Area 1 more precisely pinpointed the location of TCE at elevated levels in soils in this area, the location of identified impacted soils is consistent with Whirlpool's earlier investigations as outlined in previous reports (see, for example, Figure 3 of the Revised Risk Management Plan, November 30, 2012). Furthermore, this is consistent with the conclusions set forth in the 2013 RADD, which also identified the general vicinity of Area 1 as that area of the Whirlpool property most impacted by TCE and as the potential historic source area for TCE contamination. The presence of this TCE impacted area is a primary reason the RADD selected a containment remedy for onsite TCE impacts.

Moreover, 2014 water level data collected in the vicinity of Area 1 provide evidence of a hydraulic divide just south of Ingersoll Avenue. As a result of this hydraulic divide, TCE in soil and groundwater in the vicinity of Area 1 does not serve as a source of TCE in the offsite northern plume. Because Area 1 is not a source area for the northern plume, further removal of TCE impacted soils in Area 1 will not improve the effectiveness of the ISCO treatment in the offsite northern plume, nor will it result in a more rapid reduction in either the geographic size of the northern plume or the TCE concentrations within that plume.

Nonetheless, as a voluntary measure -- not required by either the RADD or the consent administrative order (CAO) -- Whirlpool worked with ADEQ to remove some of the highly impacted soil in Area 1 through the installation of large diameter borings. The borings were subsequently filled with limestone gravel to increase the native groundwater pH and potentially enhance TCE degradation in this area. After completing the borings, ISCO injections were performed at 40 permanent and 25 temporary locations throughout Area 1 and the linear drainage feature.

Additional soil excavation, either through additional large diameter borings or through excavation, will not result in the full removal of all TCE impacted soils in the vicinity of Area 1. TCE impacted soils will remain under the manufacturing building, requiring the ultimate implementation of the containment remedy. Importantly, an unsupported excavation would result in an estimated 60% of TCE-impacted soils remaining in place. For a more limited excavation conducted through large diameter borings, substantially more TCE-impacted soils would remain. In addition, further soil excavation efforts raise substantial logistical and technical implementation challenges such as the need to maintain slope integrity, the need to protect the manufacturing building and the electrical substation from potential damage and the need to protect underground utilities. These implementation challenges call into question the cost-effectiveness of further soil excavation efforts when the containment remedy selected by the RADD remains an effective, achievable and protective remedy.

In situ thermal desorption is also not likely to result in the removal of all TCE impacts in Area 1 and thermal desorption presents its own logistical and cost-effectiveness challenges. Thermal desorption is generally less effective at treating soils below the water table, so significant dewatering would be required. Utilities, buildings and other structures can significantly interfere with the effectiveness of thermal desorption. As a result, thermal desorption is not a superior remedy to the containment remedy set forth in the RADD.

ADEQ's basis for selecting the containment remedy remains valid. As the RADD acknowledges much of the onsite area where impacted soils are present is covered by asphalt and concrete which is an effective barrier. The areas where impacted onsite soils are not currently paved will be paved to increase the surface area of the cover (RADD, Paragraph 6, A). The final containment remedy is proposed to be implemented during the third or fourth quarter of 2015 so that monitoring wells and injection wells in Area 1 can be maintained until that time. Further, the deed restriction forming the institutional control for the property has been recorded by Whirlpool as required by the RADD. Given that the containment remedy will be completed in 2015, site conditions do not warrant further voluntary soil excavation or treatment in Area 1.

Finally, the RADD requires an evaluation of remedy effectiveness in December 2015. At that time, Whirlpool is committed to reviewing the overall effectiveness of the ISCO treatment, the continued natural degradation of TCE and the state of the northern plume. Whether any further remedial action should be undertaken should be evaluated on the basis of a full review of all the soil and groundwater data that will be available at that time, as the RADD contemplates. Fundamental changes in remedial approach should not be undertaken without the benefit of this complete review.

Sincerely,

Laurence W. Prange

Laurence W. Prange
Senior Counsel

FINAL



AREA 1 RESPONSE REPORT

Whirlpool Corporation
Ft. Smith, Arkansas
EPA No. ARD042755389
AFIN No. 66-00048
CAO LIS 13-202

Prepared for:
Whirlpool Corporation

Prepared by:
ENVIRON International Corporation
St. Louis, Missouri

Date:
December 2014

Project Number:
34-34399A

ENVIRON

Table of Contents

1 Introduction

ENVIRON International Corporation (ENVIRON), on behalf of Whirlpool Corporation (Whirlpool), has prepared this report to provide technical responses to the Arkansas Department of Environmental Quality (ADEQ) October 17, 2014, letter providing comments on the Area 1 Work Plan – September 2014. In its October 17 letter, ADEQ's comments generally address the voluntary limited soil removal action Whirlpool performed in Area 1. ADEQ asked Whirlpool to consider whether further action may be warranted with respect to remaining soil exhibiting trichloroethylene (TCE) concentrations above the remedial action level (RAL) of 0.129 milligrams per kilograms (mg/kg). In particular, ADEQ comments:

- Raised the question of whether the presence of impacted soil in the linear drainage feature will prolong groundwater treatment;
- Requested further information regarding potential complications if Whirlpool were to undertake an expanded soil removal effort;
- Discussed placing large diameter borings closer together to removal additional soil; and
- Suggested consideration of in-situ thermal desorption (ISTD) for treatment of soil.

This report addresses each of these four topics in detail. The following sections are provided in this report:

- Section 2: Overview of Area 1;
- Section 3: Consideration of Further Excavation in Area 1;
- Section 4: Consideration of In-situ Thermal Desorption;
- Section 5: Consideration of Containment; and
- Section 6: Conclusions.

2 Overview of Area 1

Recent Data Have Not Fundamentally Changed the Understanding of TCE Impacts in Soil and Groundwater in the Vicinity of Area 1.

Investigations performed since the RADD was finalized in December 2013 have not fundamentally changed the understanding of the nature and extent of TCE impacts in soil and groundwater in Area 1. The primary source of TCE in the Vadose Zone soils and saturated Basal Transmissive Zone soils appears to be the former linear drainage feature that extended from the former degreaser building towards the northwest corner of the building in the vicinity of Area 1. The results of the soil characterization along the former linear drainage feature are set forth in the Area 1 Soil Investigation Summary Report, August 15, 2014. Those results demonstrate:

- The highest TCE concentrations are generally located near the center of the former linear drainage feature extending roughly from DP-29 to the east towards DP-08 to the west.
- TCE concentrations in soils decrease rapidly moving away from the drainage feature centerline in the northern and southern directions.
- TCE concentrations in soils generally decrease with depth. TCE concentrations in the Vadose Zone soils are generally higher than TCE concentrations in the saturated Basal Transmissive Zone soils in Area 1.
- Within the Basal Transmissive Zone, the highest measured TCE concentration occurred at DP-08 and is confined to a relatively limited area of the linear drainage feature.

These results are generally consistent with the identification of the most highly impacted onsite areas in the RADD. The RADD states: “The highest impact of TCE in groundwater onsite has been identified at MW-25 near the northwestern corner of the building. The TCE concentration at MW-25 in 2012 was measured at 56,000 micrograms per liter (µg/L). Additional areas of impact (greater than 10,000 µg/L of TCE) have been identified at ITM-19 with 15,000 µg/L. Together these two points currently constitute the heart of the source area onsite” (RADD, Paragraph 6, B).

Data collected from MW-85 and MW-86 during the second and third phases of in-situ chemical oxidation (ISCO) implementation indicate that the area around MW-25 continues to exhibit the highest TCE groundwater concentrations. IW-141 (in the vicinity of the former soil probe DP-08) and new monitoring wells inside the main manufacturing building (MW-93, MW-94 and MW-95) also exhibit high TCE groundwater concentrations (see attached Preliminary Fourth Quarter TCE Isoconcentration Map).

Based on groundwater data collected over more than 20 years, it appears that TCE concentration trends are stable to decreasing for wells in Area 1. This data, which is shown in Figure 4 in the Third Quarter Groundwater Monitoring Report, supports our existing understanding of Area 1 and does not demonstrate a fundamental change in groundwater conditions that would necessitate a change in remedial approach.

Area 1 is Not an Ongoing Source of TCE in the Northern Plume

The last four quarterly groundwater monitoring reports (Fourth Quarter 2013 and First, Second and Third Quarter 2014 reports) have demonstrated the presence of a groundwater divide just south of Ingersoll Avenue. Water elevation data in these monitoring reports demonstrates that groundwater to the north of this divide is generally moving to the north, while groundwater to the south of this divide is generally moving in a southeasterly direction. Because Area 1 lies to the south of Ingersoll Avenue, the data indicates that groundwater in Area 1 is moving to the southeast -- away from the offsite northern plume. Therefore, as long as the divide continues to exist, it appears that soils and groundwater in Area 1 are no longer a source of TCE in the northern plume.

In addition to the groundwater divide, ISCO treatment has been focused on the neck area in the vicinity of Ingersoll Avenue. This treatment provides a further means to eliminate any potential for groundwater in the vicinity of the hydraulic divide to be a source of continued TCE transport to the north. As a result of the ISCO treatment, recent data indicates that the northern plume has begun to separate from the groundwater contamination remaining on the Whirlpool property in the vicinity of the neck area. (See Fourth Quarter TCE Isoconcentration Map). This is a positive development providing evidence that Area 1 is not a continuing source of the northern plume. Whirlpool expects to continue to monitor this separation over the course of 2015.

Based upon the evaluation of the groundwater flow direction and the presence of a hydraulic divide and the recent data demonstrating plume separation in the neck area following ISCO treatment, Area 1 is not contributing to the groundwater impact present to the north of the hydraulic divide. Further soil removal or thermal desorption in Area 1 would not, therefore, result in more rapid reduction of either the size of the northern plume or the TCE concentrations within that plume.

3 Consideration of Further Soil Excavation in Area 1

ENVIRON previously provided a preliminary analysis of possible expanded removal efforts in an initial response to comments dated October 7, 2014. This analysis further addresses ADEQ's request that Whirlpool consider additional soil removal in the vicinity of Area 1.

Because soil containing TCE is present immediately adjacent to and underneath the main site building and is also present in the immediate vicinity of the electric substation, there are practical limits to excavation. Any substantial soil removal effort to attempt to achieve soil RALs would encounter several complications and would have to be designed to address:

- The potential for excavation slope failures, soil settlement and/or foundation failure with the former manufacturing building and electrical substation;
- Possible complications regarding underground utilities present in Area 1;
- The potential that substantial dewatering efforts may be required to excavate deeper soils; and
- Complications resulting from the potential need to remove relatively less impacted Vadose Zone soil in order to reach more highly impacted deeper soils.

A full geotechnical investigation would be required to obtain necessary engineering data to address these issues. Without an extensive geotechnical investigation, it is difficult to generate firm estimates of slope stability, excavation depth, dewatering methodologies, and other issues that would impact the extent to which removal may be feasible. However, based on existing data, we set forth below a preliminary excavation analysis followed by a discussion of complications associated with underground utilities and dewatering efforts.

3.1 Excavation

In our prior correspondence, ENVIRON conservatively estimated an appropriate excavation slope for an unsupported excavation of one horizontal to one vertical (1H:1V) to preclude excavation slope failure or foundation failures for the manufacturing building and electrical substation. That estimate may have been too optimistic based upon the Occupational Safety and Health Administration (OSHA) requirements for unsupported excavations. OSHA requirements for an unsupported excavation for the types of soil encountered at the site require excavation slopes of 1.5H:1V (Type A soil over Type C soil, Figure V:2-13 Slope Configurations: Excavations in Layered Soils). Appendix A provides the OSHA excavation slope restrictions and descriptions of Type A and C soil. The attached cross section drawings depict the limits of an unsupported excavation in Area 1 with a 1.5H:1V slope from the foundation of the former manufacturing building and from the fence for the electrical substation to preclude undermining the foundation of the former manufacturing building and the electrical substation.

Importantly, the 1.5H:1V OSHA excavation slope configuration may also be overly optimistic since the loading caused by the former manufacturing building is not considered in this simple model of excavation limits. Therefore, if an unsupported excavation is completed near the building or the substation to a depth 30 feet, then at a minimum the total depth for the excavation can only be achieved approximately 45 feet away from the building or electrical substation. As the cross-section drawings make clear, this 1.5H:1V slope would therefore result in only a limited removal of TCE impacted soil within Area 1. TCE impacted soil would still remain in the sloped areas and under the manufacturing building. Considerable quantities of affected soil would remain if an unsupported excavation is performed.

Further, underground utilities would either need to be removed or excavation would be required to be limited in the vicinity of such utilities to protect both the utilities and, more importantly, workers performing the excavation.

The total volume of Area 1 is approximately 28,900 cubic yards (yd^3) based upon dimensions of 325 feet by 80 feet by 30 feet deep. Assuming a 1.5H:1V excavation slope can be safely achieved, and underground utilities remain in place (complications with underground utilities are discussed below), then more than 16,000 yd^3 of affected soil would remain in Area 1 after performing an unsupported excavation. The volume of remaining impacted soil is based upon 1.5H:1V excavation slopes at the following locations (see attached cross-section figures depicting slopes for an unsupported excavation):

- Approximately 8,125 yd^3 (bank[1]) of impacted soil would remain along the building wall during an unsupported excavation based upon a wedge of impacted soil remaining along the building wall with dimensions of 325 feet by 30 feet deep by 45 feet lateral by 0.5 (wedge shape of affected soil remaining along the building wall).
- Approximately 3,000 yd^3 of impacted soil would remain along the electrical substation during an unsupported excavation based upon a wedge of impacted soil remaining along the fence with dimensions of approximately 120 feet length by 30 feet deep by 45 feet wide by 0.5 (wedge shape of affected soil remaining along the electrical substation fence).
- Approximately 5,300 yd^3 of impacted soil would remain beneath the underground electrical service to the building during an unsupported excavation based upon impacted soil remaining along electrical service alignment from the switch gear at the substation to the northwest corner of the building with dimensions of approximately 15 feet width at the surface (width of the concrete cut for the electric service installation that can be observed in aerial photographs) by 80 feet length by 30 feet deep by 45 feet wide on either side of the utility by 0.5 (i.e. the wedge of soil will be present on either side of the underground electric service for a total width of 105 feet at the base of the excavation).

[1] Bank refers to an undisturbed volume. Excavation will bulk the soil increasing the volume by 30%.

- Impacted soil would also remain beneath the asbestos-coated fire protection line present in Area 1. Although its precise location is not clearly understood, the fire protection line was encountered while performing the large diameter borings (LDBs) in October; confirming its presence.

In summary, nearly 60% of the affected soil would remain in Area 1 if an unsupported excavation was performed. As a result of the quantity of affected soil remaining in Area 1 after performance of an unsupported excavation, a containment remedy and institutional control would still be required. Since a majority of the affected soil still remains, no technical advantage for remediating onsite groundwater exists compared to the containment remedy.

The excavation efforts performed with LDBs were proposed to target soil exhibiting the highest TCE concentrations along the former linear drainage feature. Positioning and completion of the LDBs was challenging due to the underground utilities. Although the LDBs were proposed at 15-foot centers, the actual spacing between borings ranged from 8 to 30 feet to avoid underground utilities (i.e. electric service and fire protection line), existing monitoring wells and temporary and permanent ISCO injection locations along and near the former drainage feature. ISCO was performed in late October 2014 at 39 permanent injection wells and 36 temporary injection points throughout Area 1 and the linear drainage feature. The positioning of additional LDBs for consideration of additional limited hot spot excavation would be difficult due to underground utilities, existing LDBs, monitoring wells, permanent ISCO injection wells and temporary injection points in the linear drainage feature and Area 1.

It is premature at this time to consider additional LDBs to assess further soil removal and passive pH adjustment, since ISCO injection was performed in late October. In addition, further excavation is unwarranted since a containment remedy would still be required after implementation of additional excavation efforts due to underground utilities.

Moreover, for the reasons set forth in Section I, additional soil removal via excavation or performance of LDB would have no impact on the north groundwater plume. Thus it would not result in the achievement of groundwater RALs faster for the north plume.

3.2 Underground Utilities

Critical underground utilities in Area 1 include the main electrical service and the asbestos-coated fire protection line for the manufacturing building. Other utilities consist of surface water drainage features and other abandoned pipe systems that have been encountered in Area 1. The underground electrical service is present from the electrical switch gear along the fence of the substation to the northwest corner of the building. Any additional substantial soil removal effort in Area 1 will require relocation of the main electrical service for the manufacturing building. Relocation of the electric service is a significant complication to facilitate a significant soil removal effort in Area 1.

The asbestos coated fire protection line for the facility was encountered while performing the LDBs. The precise location and layout of the fire protection line needs to be assessed, but the fire protection line is located within the vicinity of the linear drainage feature and Area 1.

Relocation of this critical utility is required to perform a substantial soil removal effort. A slope failure or settlement of backfill in the vicinity of this critical utility could cause a catastrophic failure. Relocation of the fire protection line is a significant complication to facilitate a soil removal effort in Area 1.

3.3 Dewatering and Other Excavation Implementation Issues

Excavation will require dewatering to manage groundwater in the confined aquifer. The groundwater at the site is slightly confined; therefore, the groundwater will flow into the excavation under pressure.

Dewatering efforts may include:

- Further investigation and pump tests to assess dewatering requirements for extraction well design, well spacing and anticipated quantities of water to satisfactorily dewater Area 1 prior to commencing excavation and maintaining dry conditions during excavation and backfill efforts.
- Water treatment design based upon the anticipated groundwater extraction rate to dewater the planned excavation and to maintain dry conditions throughout the excavation and backfilling efforts. The treatment system design must include removal of solids/sediments and TCE to achieve discharge criteria.
- Permitting for discharge of the treated effluent is also required. Either a publicly owned treatment works (POTWs) discharge permit will be required for a discharge to the city of Fort Smith or an NPDES permit will be required for a point source discharge outfall to the drainage ditch at the northeast corner (discharge towards Mill Creek). Whirlpool has no certainty that a permit to discharge to the POTW would be granted nor are specific conditions that may apply for such a permit understood at this time (i.e. batch vs. continuous discharge, limitations on discharge flow rate, TCE discharge limits, etc.).

Miscellaneous other issues complicating performance of substantial soil removal efforts include:

- Truck traffic in the neighborhood would be increased during the excavation and backfilling activities. Assuming 40% of the impacted soil in Area 1 could be removed, approximately 645 truck trips would be required to remove excavated soil, and another 645 truck trips would be required to deliver to fill to backfill the excavation. Therefore, nearly 1,290 loaded trucks would be added to the surrounding roadways in the community (nearly 2,580 trucks if considering traffic while the trucks are empty). Both the excavation itself and the additional truck traffic increase the potential for workplace and roadway accidents.

Collectively, these complications would create significant delays in the completion of an expanded soil excavation effort. The likely result is that a containment remedy with institutional controls will still be required after performance of further excavation since access to all affected soil is not possible. Additional excavation remedies result in substantial additional cost to Whirlpool without commensurate environmental benefit or risk reduction compared to the remedy specified in the RADD.

4 Consideration of In-Situ Thermal Desorption

ISTD was also considered for Area 1. ISTD includes:

- Application of heat to subsurface soils to desorb and vaporize organic contaminants (i.e. TCE); and
- Vacuum to collect and treat vapors.

The ISTD application considered for the Whirlpool site consists of a vertical array of electric heating elements placed inside wells in Area 1 (vertical arrays of heating elements are the most common type of ISTD application). As the Vadose Zone and saturated soil (Basal Transmissive Zone) are heated, adsorbed and dissolved phase contaminants begin to vaporize. Contaminant vapors are recovered through a network of vapor extraction wells, and conveyed to a vapor treatment system prior to discharge to the atmosphere.

ISTD presents a number of logistical challenges that will limit its effectiveness, result in the continued need for a containment remedy, and call into question the cost-effectiveness of the approach. These complications include:

- Underground utilities which preclude access to treat all affected soil;
- Saturated soil conditions which reduce the effectiveness for treatment;
- Collection and treatment of soil vapors created as a result of the ISTD treatment process;
- Tight grid spacing for installation heater wells (i.e. heating elements); and
- Costs.

Pilot testing would be necessary to assess heater well spacing and other factors affecting ISTD. Vertical heater wells must be installed to perform an ISTD remedy. These heater wells cannot be safely installed in the vicinity of the underground utilities and fire protection line unless these underground utilities are relocated.

Dewatering, groundwater treatment and permitting complications which were discussed earlier in this report apply to consideration of ISTD. To enhance effectiveness of ISTD, dewatering would be necessary to lower the water table to treat additional affected soil in the Basal Transmissive Zone.

Because in situ thermal desorption involves heating the soil and collecting the TCE vapors from the treatment area, an effective treatment and capture system must be designed. If the capture system is not effective in capturing all TCE vapors, thermal desorption can result in the release of vapor that could either build up under the former manufacturing building or be released to the atmosphere.

In areas where vertical heater wells can be installed, the initial spacing of the heater wells is anticipated to range from 5 to 7 feet; therefore, a greater number of wells per any given area is required to treat the soil than is required for ISCO injections.

These complications regarding ISTD treatment of soil would create significant delays in the completion of an expanded soil treatment effort. Since all affected soil cannot be accessed for treatment, the containment remedy with institutional controls will still be required after performance of thermal treatment of soil in Area 1. Additional soil treatment remedies also result in substantial additional cost to Whirlpool without commensurate environmental benefit or risk reduction compared to the remedy specified in the RADD.

5 Consideration of Containment

As set forth in the RADD, the containment based corrective measure for onsite TCE impacts provides protection of human health and the environment since it reduces exposure to the impacted soils. In addition, the containment remedy reduces surface water infiltration to prevent the downward migration of water through the contaminated soils; thus reducing the concentration of TCE transferred from soil to groundwater (Section 9, A. RADD). The containment remedy precludes onsite worker, visitor and trespasser contact with surface soil in the vicinity of the Area 1 and the former trench.

For all of the reasons set forth above, the containment remedy in the RADD remains the proper remedy for Area 1 and further excavation or other remedial action in the area is unwarranted.

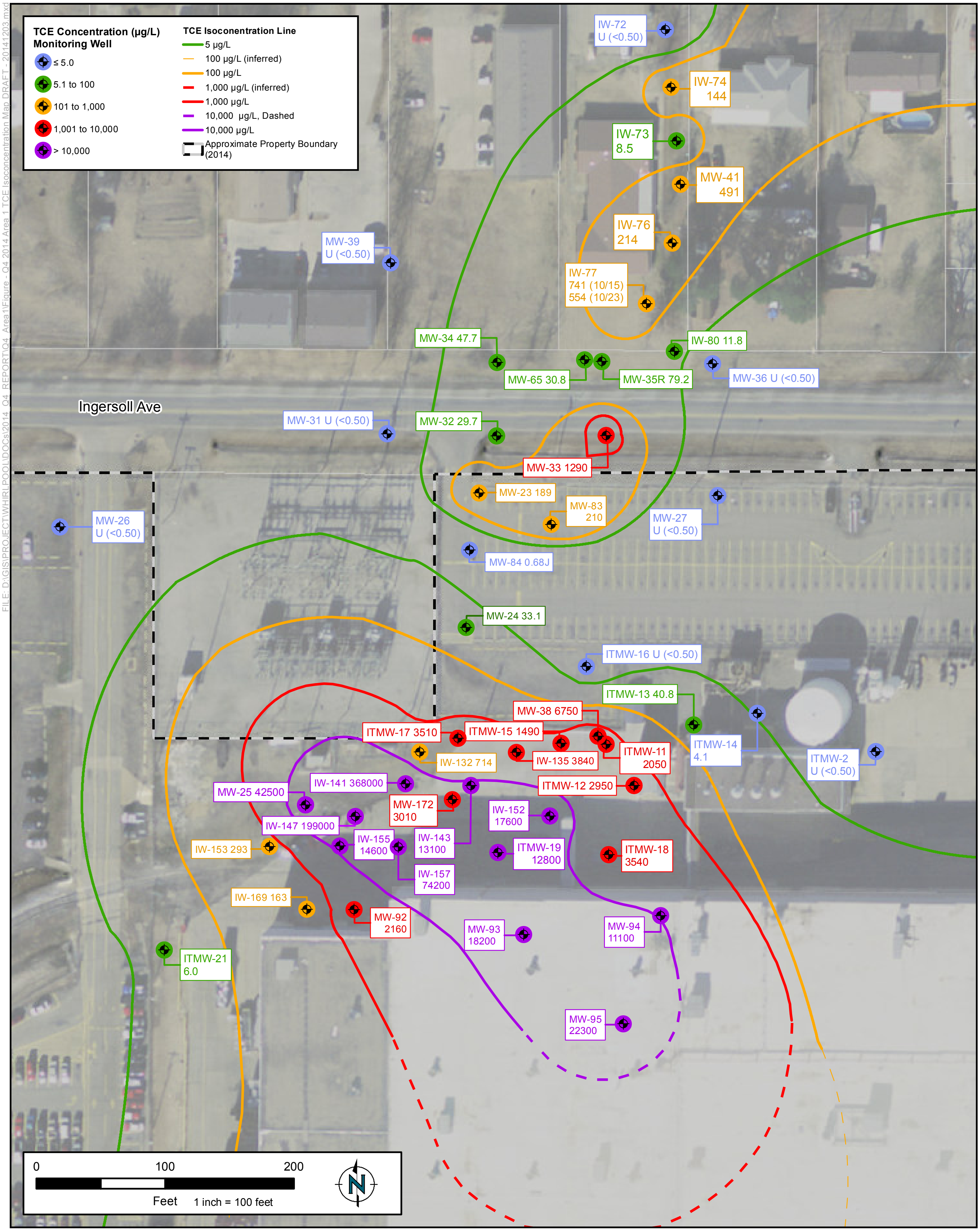
The RADD expressly provides for ongoing monitoring to allow remedy effectiveness data to be gathered for submission in December 2015 to evaluate the effectiveness of the remedy required by the RADD. This process of monitoring has been conducted concurrent with other remedial activities in 2014 and it is expected to continue in 2015. Any decision about further remedial actions should be made with the benefit of the full monitoring period anticipated in the RADD and with the benefit of the remedy effectiveness evaluation that will be completed in December 2015. Making further remedial decisions before December 2015 would be premature.

6 Conclusions

The containment remedy selected in the RADD is an effective means of addressing impacted soil in Area 1 and remains an effective approach to remediation of this industrial property. The supplemental remedy in Area 1 consisted of large diameter borings performed to quickly implement a limited hot spot soil removal effort at locations exhibiting the highest TCE concentrations and backfilling these borings with limestone gravel to assess increasing the native groundwater pH to enhance monitored natural attenuation. The combination of the RADD specified containment remedy and the supplemental remedy implemented in Area 1 (i.e. LDBs and Phase 3 ISCO) cause other remedial actions in the area to be unwarranted.

Additional remedial actions in Area 1 (i.e. soil removal or soil treatment) will not result in the faster achievement of MCLs for the northern plume because based upon the hydraulic divide Area 1 is not a source of TCE for the northern plume. The best approach remains to implement the existing remedy, and monitor progress through the December 2015 Effectiveness Report as contemplated by the RADD.

FIGURES



ENVIRON

DRAFTED BY: KTS

DATE: 12/11/2014

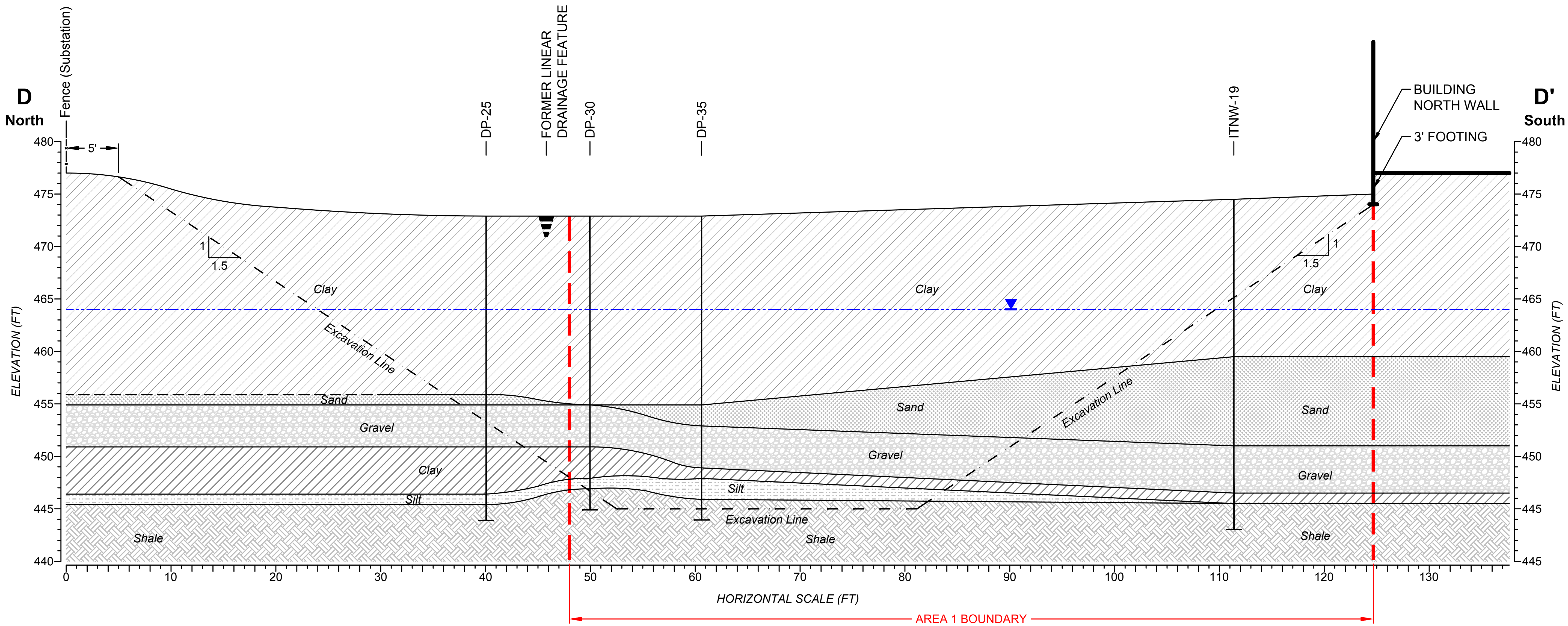
PRELIMINARY FOURTH QUARTER 2014 TCE ISOCONCENTRATION MAP

Whirlpool Facility - Fort Smith, Arkansas

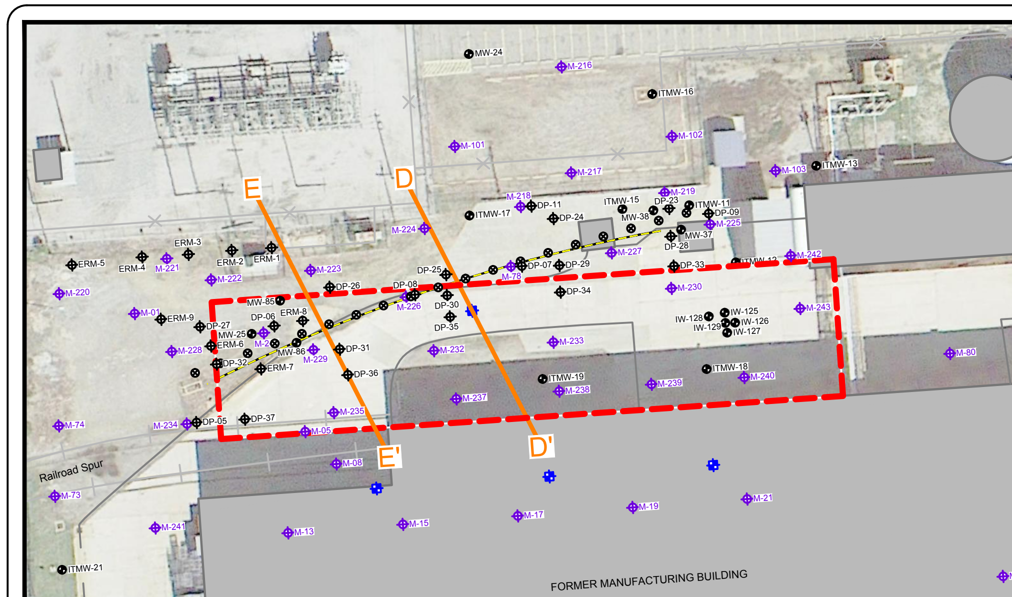
Figure

1

PROJECT: 2131344B



CROSS-SECTION D-D'



CROSS-SECTION OVERVIEW

APPROX. SCALE (ft.)
0 100

LEGEND			
	SHALE		GRAVEL
	CLAY		BORING
	SILT		WATER LEVEL
	SAND		

AREA 1 CROSS-SECTION D-D'
WHIRLPOOL FACILITY
FORT SMITH, ARKANSAS

ENVIRON

FIGURE

DRAFTED BY: ELS | DATE: 11/4/14 | 3433253A

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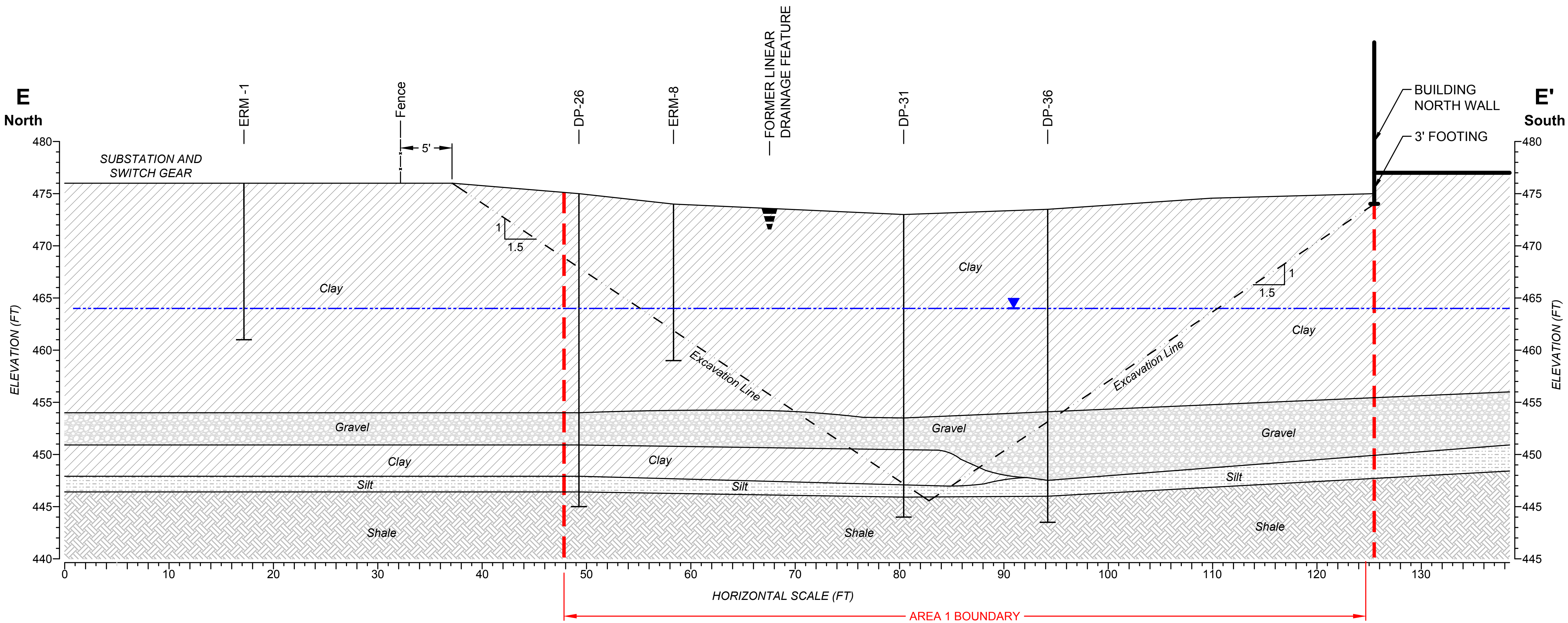

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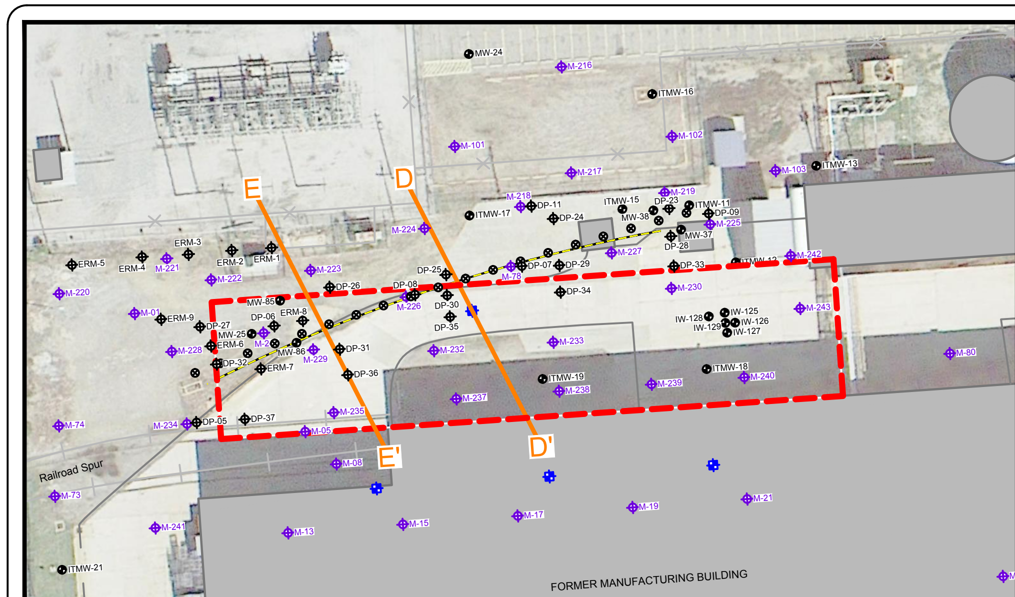

CROSS-SECTION OVERVIEW

APPROX. SCALE (ft.)

0 100

LEGEND			
	SHALE		GRAVEL
	CLAY		BORING
	SILT		WATER LEVEL
	SAND		

AREA 1 CROSS-SECTION E-E'

WHIRLPOOL FACILITY

FORT SMITH, ARKANSAS

ENVIRON

FIGURE

DRAFTED BY: ELS | DATE: 11/4/14 | 3433253A

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APPENDIX A:
OSHA Technical Manual
Section V, Chapter 2, Excavations: Hazard

<< Back to OSHA Technical Manual (OTM) Table of Contents

OSHA Technical Manual (OTM)
Section V: Chapter 2

Effective Date: 1/20/1999
Directive Number: TED 01-00-015 [TED 1-0.15A]

TOC | Chapter 1 | Chapter 2 | Chapter 3

EXCAVATIONS: HAZARD RECOGNITION IN TRENCHING AND SHORING

For problems with accessibility in using figures and illustrations in this document, please contact the Office of Science and Technology Assessment at (202) 693-2095.

I. INTRODUCTION

Excavating is recognized as one of the most hazardous construction operations. OSHA recently revised Subpart P, *Excavations,* of 29 CFR 1926.650, 1926.651, and 1926.652 to make the standard easier to understand, permit the use of performance criteria where possible, and provide construction employers with options when classifying soil and selecting employee protection methods.

This chapter is intended to assist *OSHA Technical Manual* users, safety and health consultants, OSHA field staff, and others in the recognition of trenching and shoring hazards and their prevention.

II. DEFINITIONS

A. **Accepted Engineering Practices** are procedures compatible with the standards of practice required of a registered professional engineer.

B. **Adjacent Structures Stability** refers to the stability of the foundation(s) of adjacent structures whose location may create surcharges, changes in soil conditions, or other disruptions that have the potential to extend into the failure zone of the excavation or trench.

C. **Competent Person** is an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to employees, and who *has authorization to take prompt corrective measures to eliminate or control these hazards and conditions.*

D. **Confined Space** is a space that, by design and/or configuration, has limited openings for entry and exit, unfavorable natural ventilation, may contain or produce hazardous substances, and is not intended for continuous employee occupancy.

E. **Excavation**. An **Excavation** is any man-made cut, cavity, trench, or depression in an earth surface that is formed by earth removal. A **Trench** is a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth of a trench is greater than its width, and the width (measured at the bottom) is not greater than 15 ft (4.6 m). If a form or other structure installed or constructed in an excavation reduces the distance between the form and the side of the excavation to 15 ft (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

F. **Hazardous Atmosphere** is an atmosphere that by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen-deficient, toxic, or otherwise harmful may cause death, illness, or injury to persons exposed to it.

G. **Ingress and Egress** mean "entry" and "exit," respectively. In trenching and excavation operations, they refer to the provision of safe means for employees to enter or exit an excavation or trench.

H. **Protective System** refers to a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, and from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

I. **Registered Professional Engineer** is a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer who is registered in any state is deemed to be a "registered professional engineer" within the meaning of Subpart P when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

J. **Support System** refers to structures such as underpinning, bracing, and shoring that provide support to an adjacent structure or underground installation or to the sides of an excavation or trench.

K. **Subsurface Encumbrances** include underground utilities, foundations, streams, water tables, transformer vaults, and geological anomalies.

L. **Surcharge** means an excessive vertical load or weight caused by spoil, overburden, vehicles, equipment, or activities that may affect trench stability.

M. **Tabulated Data** are tables and charts approved by a registered professional engineer and used to design and construct a protective system.

N. **Underground Installations** include, but are not limited to, utilities (sewer, telephone, fuel, electric, water, and other product lines), tunnels, shafts, vaults, foundations, and other underground fixtures or equipment that may be encountered during excavation or trenching work.

O. **Unconfined Compressive Strength** is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing, or it can be estimated in the field using a pocket penetrometer, by thumb penetration tests, or by other methods.

P. **Definitions That Are No Longer Applicable**. For a variety of reasons, several terms commonly used in the past are no longer used in revised Subpart P. These include the following:

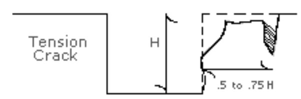
1. **Angle of Repose.** Conflicting and inconsistent definitions have led to confusion as to the meaning of this phrase. This term has been replaced by **Maximum Allowable Slope.**
2. **Bank, Sheet Pile, and Walls.** Previous definitions were unclear or were used inconsistently in the former standard.
3. **Hard Compact Soil** and **Unstable Soil.** The new soil classification system in revised Subpart P uses different terms for these soil types.

III. OVERVIEW: SOIL MECHANICS

A number of stresses and deformations can occur in an open cut or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following diagrams show some of the more frequently identified causes of trench failure.

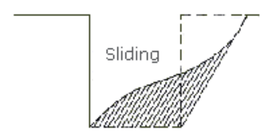
A. **Tension Cracks**. Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench. See the accompanying drawing for additional details.

FIGURE 5:2-1. TENSION CRACK



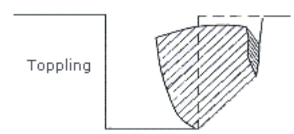
B. **Sliding** or sluffing may occur as a result of tension cracks, as illustrated below.

FIGURE 5:2-2. SLIDING



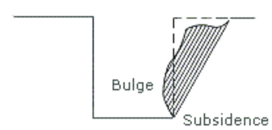
C. **Toppling**. In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.

FIGURE 5:2-3. TOPPLING



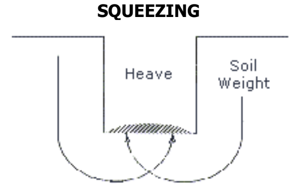
D. **Subsidence and Bulging**. An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.

FIGURE 5:2-4. SUBSIDENCE AND BULGING



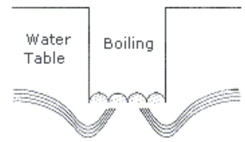
E. **Heaving or Squeezing**. Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut, as illustrated in the drawing above. Heaving and squeezing can occur even when shoring or shielding has been properly installed.

FIGURE 5:2-5. HEAVING OR SQUEEZING



F. **Boiling** is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.

FIGURE 5:2-6. BOILING



G. **Unit Weight of Soils** refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic foot of soil can weigh from 110 pounds to 140 pounds or more, and one cubic meter (35.3 cubic feet) of soil can weigh more than 3,000 pounds.

IV. DETERMINATION OF SOIL TYPE

OSHA categorizes soil and rock deposits into four types, A through D, as follows:

A. **Stable Rock** is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. It is usually identified by a rock name such as granite or sandstone. Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

B. **Type A Soils** are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) (144 kPa) or greater. Examples of Type A cohesive soils are often: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. (No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.

C. **Type B Soils** are cohesive soils with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa). Examples of other Type B soils are: angular gravel; silt; silt loam; previously disturbed soils unless otherwise classified as Type C; soils that meet the unconfined compressive strength or cementation requirements of Type A soils but are fissured or subject to vibration; dry unstable rock; and layered systems sloping into the trench at a slope less than 4H:1V (only if the material would be classified as a Type B soil).

D. **Type C Soils** are cohesive soils with an unconfined compressive strength of 0.5 tsf (48 kPa) or less. Other Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable. Also included in this classification is material in a sloped, layered system where the layers dip into the excavation or have a slope of four horizontal to one vertical (4H:1V) or greater.

E. **Layered Geological Strata**. Where soils are configured in layers, i.e., where a layered geologic structure exists, the soil must be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e., where a Type C soil rests on top of stable rock.

V. TEST EQUIPMENT AND METHODS FOR EVALUATING SOIL TYPE

Many kinds of equipment and methods are used to determine the type of soil prevailing in an area, as described below.

A. **Pocket Penetrometer**. Penetrometers are direct-reading, spring-operated instruments used to determine the unconfined compressive strength of saturated cohesive soils. Once pushed into the soil, an indicator sleeve displays the reading. The instrument is calibrated in either tons per square foot (tsf) or kilograms per square centimeter (kPa). However, Penetrometers have error rates in the range of ± 20-40%.

1. **Shearvane (Torvane)**. To determine the unconfined compressive strength of the soil with a shearvane, the blades of the vane are pressed into a level section of undisturbed soil, and the torsional knob is slowly turned until soil failure occurs. The direct instrument reading must be multiplied by 2 to provide results in tons per square foot (tsf) or kilograms per square centimeter (kPa).

2. **Thumb Penetration Test**. The thumb penetration procedure involves an attempt to press the thumb firmly into the soil in question. If the thumb makes an indentation in the soil only with great difficulty, the soil is probably Type A. If the thumb penetrates no further than the length of the thumb nail, it is probably Type B soil, and if the thumb penetrates the full length of the thumb, it is Type C soil. The thumb test is subjective and is therefore the least accurate of the three methods.

3. **Dry Strength Test**. Dry soil that crumbles freely or with moderate pressure into individual grains is granular. Dry soil that falls into clumps that subsequently break into smaller clumps (and the smaller clumps can be broken only with difficulty) is probably clay in combination with gravel, sand, or silt. If the soil breaks into clumps that do not break into smaller clumps (and the soil can be broken only with difficulty), the soil is considered unfissured unless there is visual indication of fissuring.

B. **Plasticity or Wet Thread Test**. This test is conducted by molding a moist sample of the soil into a ball and attempting to roll it into a thin thread approximately 1/8 inch (3 mm) in diameter (thick) by 2 inches (50 mm) in length. The soil sample is held by one end. If the sample does not break or tear, the soil is considered cohesive.

C. **Visual Test**. A visual test is a qualitative evaluation of conditions around the site. In a visual test, the entire excavation site is observed, including the soil adjacent to the site and the soil being excavated. If the soil remains in clumps, it is cohesive; if it appears to be coarse-grained sand or gravel, it is considered granular. The evaluator also checks for any signs of vibration.

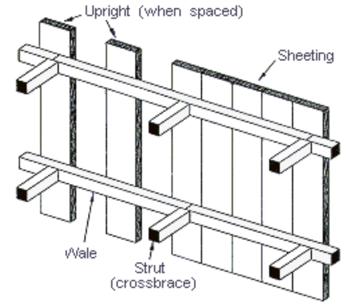
During a visual test, the evaluator should check for crack-line openings along the failure zone that would indicate tension cracks, look for existing utilities that indicate that the soil has previously been disturbed, and observe the open side of the excavation for indications of layered geologic structuring.

The evaluator should also look for signs of bulging, boiling, or sluffing, as well as for signs of surface water seeping from the sides of the excavation or from the water table. If there is standing water in the cut, the evaluator should check for "quick" conditions (see Paragraph III. F in this chapter). In addition, the area adjacent to the excavation should be checked for signs of foundations or other intrusions into the failure zone, and the evaluator should check for surcharging and the spoil distance from the edge of the excavation.

VI. SHORING TYPES

Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways, and foundations. Shoring or shielding is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. Shoring systems consist of posts, wales, struts, and sheeting. There are two basic types of shoring, timber and aluminum hydraulic.

FIGURE V:2-7. TIMBER SHORING

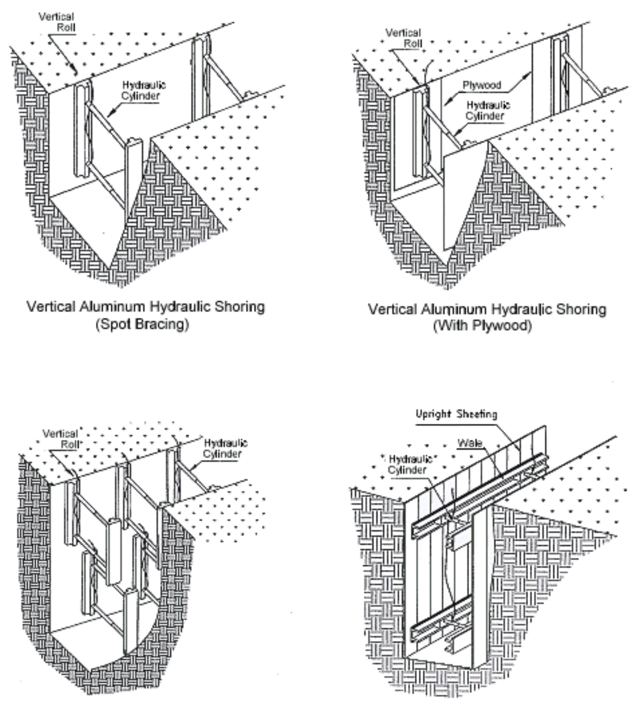


A. **Hydraulic Shoring**. The trend today is toward the use of hydraulic shoring, a prefabricated strut and/or wale system manufactured of aluminum or steel. Hydraulic shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install or remove hydraulic shoring. Other advantages of most hydraulic systems are that they:

   - Are light enough to be installed by one worker;
   - Are gauge-regulated to ensure even distribution of pressure along the trench line;
   - Can have their trench faces "preloaded" to use the soil's natural cohesion to prevent movement; and
   - Can be adapted easily to various trench depths and widths.

   All shoring should be installed from the top down and removed from the bottom up. Hydraulic shoring should be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

FIGURE V:2-8. SHORING VARIATIONS: TYPICAL ALUMINUM HYDRAULIC SHORING INSTALLATIONS



Vertical Aluminum Hydraulic Shoring (Spot Bracing)

Vertical Aluminum Hydraulic Shoring (With Plywood)

Vertical Aluminum Hydraulic Shoring (Stacked)

Aluminum Hydraulic Shoring Waler System (Typical)

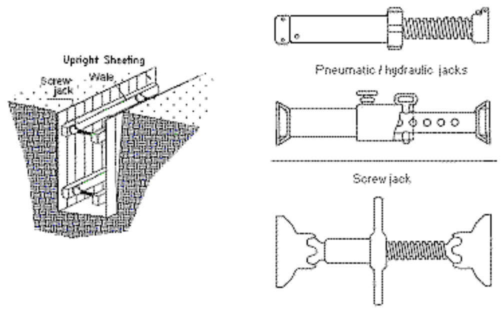
B. **Pneumatic Shoring** works in a manner similar to hydraulic shoring. The primary difference is that pneumatic shoring uses air pressure in place of hydraulic pressure. A disadvantage to the use of pneumatic shoring is that an air compressor must be on site.

   1. **Screw Jacks**. Screw jack systems differ from hydraulic and pneumatic systems in that the struts of a screw jack system must be adjusted manually. This creates a hazard because the worker is required to be in the trench in order to adjust the strut. In addition, uniform "preloading" cannot be achieved with screw jacks, and their weight creates handling difficulties.

   2. **Single-Cylinder Hydraulic Shores**. Shores of this type are generally used in a water system, as an assist to timber shoring systems, and in shallow trenches where face stability is required.

   3. **Underpinning**. This process involves stabilizing adjacent structures, foundations, and other intrusions that may have an impact on the excavation. As the term indicates, underpinning is a procedure in which the foundation is physically reinforced. Underpinning should be conducted only under the direction and with the approval of a registered professional engineer.

FIGURE V:2-9. SHORING VARIATIONS



VII. **SHIELDING TYPES**

A. **Trench Boxes** are different from shoring because, instead of shoring up or otherwise supporting the trench face, they are intended primarily to protect workers from cave-ins and similar incidents. The excavated area between the outside of the trench box and the face of the trench should be as small as possible. The space between the trench boxes and the excavation side are backfilled to prevent lateral movement of the box. Shields may not be subjected to loads exceeding those which the system was designed to withstand.

FIGURE V:2-10. TRENCH SHIELD

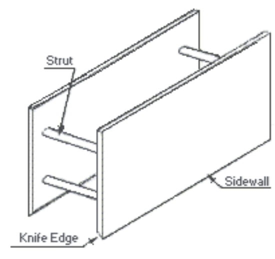
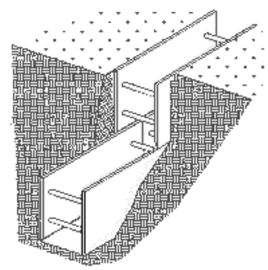


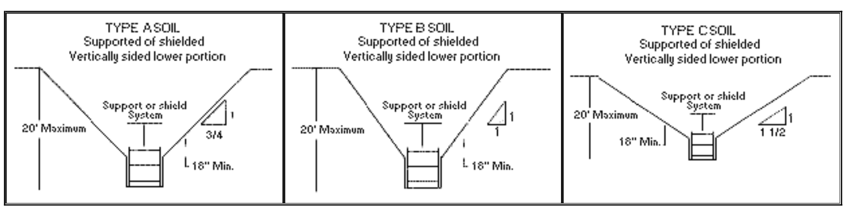
FIGURE V:2-11. TRENCH SHIELD, STACKED



B. **Combined Use**. Trench boxes are generally used in open areas, but they also may be used in combination with sloping and benching. The box should extend at least 18 in (0.45 m) above the surrounding area if there is sloping toward excavation. This can be accomplished by providing a benched area adjacent to the box.

Earth excavation to a depth of 2 ft (0.61 m) below the shield is permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of possible loss of soil from behind or below the bottom of the support system. Conditions of this type require observation on the effects of bulging, heaving, and boiling as well as surcharging, vibration, adjacent structures, etc., on excavating below the bottom of a shield. Careful visual inspection of the conditions mentioned above is the primary and most prudent approach to hazard identification and control.

FIGURE V:2-12. SLOPE AND SHIELD CONFIGURATIONS



VIII. **SLOPING AND BENCHING**

A. **Sloping**. Maximum allowable slopes for excavations less than 20 ft (6.09 m) based on soil type and angle to the horizontal are as follows:

TABLE V:2-1. ALLOWABLE SLOPES

Soil type	**height/Depth ratio**	**Slope angle**
Stable Rock	Vertical	90°
Type A	¾:1	53°
Type B	1:1	45°
Type C	1½:1	34°
Type A (short-term)	½:1	63°
(For a maximum excavation depth of 12 ft)		

FIGURE V:2-13. SLOPE CONFIGURATIONS: EXCAVATIONS IN LAYERED SOILS

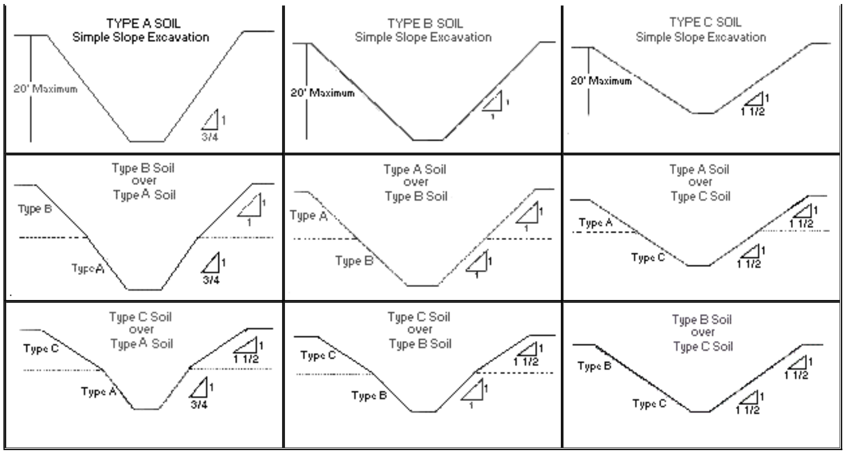
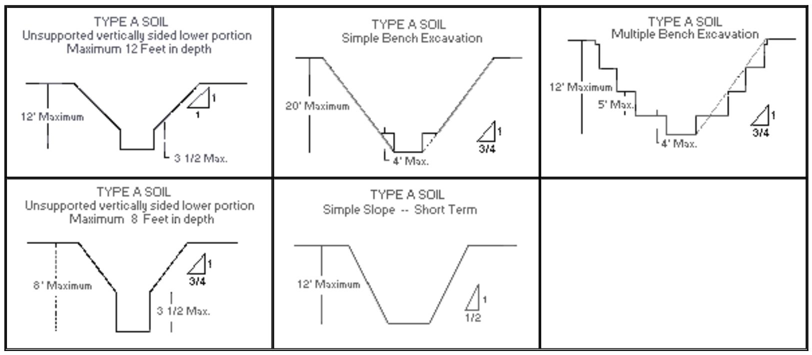


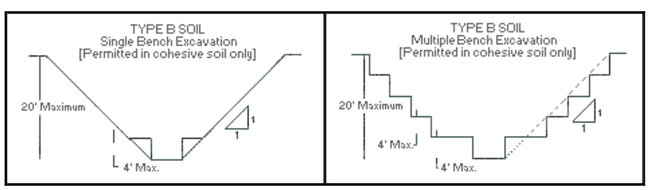
FIGURE V:2-14. EXCAVATIONS MADE IN TYPE A SOIL



B. **Benching.** There are two basic types of benching, simple and multiple. The type of soil determines the horizontal to vertical ratio of the benched side.

As a general rule, the bottom vertical height of the trench must not exceed 4 ft (1.2 m) for the first bench. Subsequent benches may be up to a maximum of 5 ft (1.5 m) vertical in Type A soil and 4 ft (1.2 m) in Type B soil to a total trench depth of 20 ft (6.0 m). All subsequent benches must be below the maximum allowable slope for that soil type. For Type B soil the trench excavation is permitted in cohesive soil only.

FIGURE V:2-15. EXCAVATIONS MADE IN TYPE B SOIL

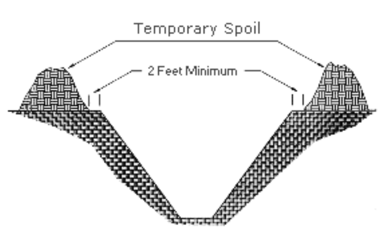


IX. **SPOIL**

A. **Temporary Spoil**. Temporary spoil must be placed no closer than 2 ft (0.61 m) from the surface edge of the excavation, measured from the nearest base of the spoil to the cut. This distance should not be measured from the crown of the spoil deposit. This distance requirement ensures that loose rock or soil from the temporary spoil will not fall on employees in the trench.

Spoil should be placed so that it channels rainwater and other run-off water away from the excavation. Spoil should be placed so that it cannot accidentally run, slide, or fall back into the excavation.

FIGURE V:2-16. TEMPORARY SPOIL



B. **Permanent Spoil**. Permanent spoil should be placed at some distance from the excavation. Permanent spoil is often created where underpasses are built or utilities are buried. The improper placement of permanent spoil, i.e. insufficient distance from the working excavation, can cause an excavation to be out of compliance with the horizontal-to-vertical ratio requirement for a particular excavation. This can usually be determined through visual observation. Permanent spoil can change undisturbed soil to disturbed soil and dramatically alter slope requirements.

X. **SPECIAL HEALTH AND SAFETY CONSIDERATIONS**

A. **Competent Person**. The designated competent person should have and be able to demonstrate the following:

- Training, experience, and knowledge of:
  - soil analysis;
  - use of protective systems; and
  - requirements of 29 CFR Part 1926 Subpart P.
- Ability to detect:
  - conditions that could result in cave-ins;
  - failures in protective systems;
  - hazardous atmospheres; and
  - other hazards including those associated with confined spaces.
- Authority to take prompt corrective measures to eliminate existing and predictable hazards and to stop work when required.

B. **Surface Crossing of Trenches**. Surface crossing of trenches should be discouraged; however, if trenches must be crossed, such crossings are permitted only under the following conditions:

- Vehicle crossings must be designed by and installed under the supervision of a registered professional engineer.
- Walkways or bridges must be provided for foot traffic. These structures shall:
  - have a safety factor of 4;
  - have a minimum clear width of 20 in (0.51 m);
  - be fitted with standard rails; and
  - extend a minimum of 24 in (.61 m) past the surface edge of the trench.

C. **Ingress and Egress**. Access to and exit from the trench require the following conditions:

- Trenches 4 ft or more in depth should be provided with a fixed means of egress.
- Spacing between ladders or other means of egress must be such that a worker will not have to travel more than 25 ft laterally to the nearest means of egress.
- Ladders must be secured and extend a minimum of 36 in (0.9 m) above the landing.
- Metal ladders should be used with caution, particularly when electric utilities are present.

D. **Exposure to Vehicles**. Procedures to protect employees from being injured or killed by vehicle traffic include:

- Providing employees with and requiring them to wear warning vests or other suitable garments marked with or made of reflectorized or high-visibility materials.
- Requiring a designated, trained flagperson along with signs, signals, and barricades when necessary.

E. **Exposure to Falling Loads**. Employees must be protected from loads or objects falling from lifting or digging equipment. Procedures designed to ensure their protection include:

- Employees are not permitted to work under raised loads.
- Employees are required to stand away from equipment that is being loaded or unloaded.
- Equipment operators or truck drivers may stay in their equipment during loading and unloading if the equipment is properly equipped with a cab shield or adequate canopy.

F. **Warning Systems for Mobile Equipment**. The following steps should be taken to prevent vehicles from accidentally falling into the trench:

- Barricades must be installed where necessary.
- Hand or mechanical signals must be used as required.
- Stop logs must be installed if there is a danger of vehicles falling into the trench.
- Soil should be graded away from the excavation; this will assist in vehicle control and channeling of run-off water.

G. **Hazardous Atmospheres and Confined Spaces**. Employees shall not be permitted to work in hazardous and/or toxic atmospheres. Such atmospheres include those with:

- Less than 19.5% or more than 23.5% oxygen;
- A combustible gas concentration greater than 20% of the lower flammable limit; and
- Concentrations of hazardous substances that exceed those specified in the *Threshold Limit Values for Airborne Contaminants* established by the ACGIH (American Conference of Governmental Industrial Hygienists).

All operations involving such atmospheres must be conducted in accordance with OSHA requirements for occupational health and environmental controls (see Subpart D of 29 CFR 1926) for personal protective equipment and for lifesaving equipment (see Subpart E of 29 CFR 1926). Engineering controls (e.g., ventilation) and respiratory protection may be required.

When testing for atmospheric contaminants, the following should be considered:

- Testing should be conducted before employees enter the trench and should be done regularly to ensure that the trench remains safe.
- The frequency of testing should be increased if equipment is operating in the trench.
- Testing frequency should also be increased if welding, cutting, or burning is done in the trench.

Employees required to wear respiratory protection must be trained, fit-tested, and enrolled in a respiratory protection program. Some trenches qualify as confined spaces. When this occurs, compliance with the Confined Space Standard is also required.

H. **Emergency Rescue Equipment**. Emergency rescue equipment is required when a hazardous atmosphere exists or can reasonably be expected to exist. Requirements are as follows:

- Respirators must be of the type suitable for the exposure. Employees must be trained in their use and a respirator program must be instituted.
- Attended (at all times) lifelines must be provided when employees enter bell-bottom pier holes, deep confined spaces, or other similar hazards.
- Employees who enter confined spaces must be trained.

I. **Standing Water and Water Accumulation**. Methods for controlling standing water and water accumulation must be provided and should consist of the following if employees are permitted to work in the excavation:

- Use of special support or shield systems approved by a registered professional engineer.
- Water removal equipment, i.e. well pointing, used and monitored by a competent person.
- Safety harnesses and lifelines used in conformance with 29 CFR 1926.104.
- Surface water diverted away from the trench.
- Employees removed from the trench during rainstorms.
- Trenches carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench.

J. **Inspections**. Inspections shall be made by a competent person and should be documented. The following guide specifies the frequency and conditions requiring inspections:

- Daily and before the start of each shift;
- As dictated by the work being done in the trench;
- After every rainstorm;
- After other events that could increase hazards, e.g. snowstorm, windstorm, thaw, earthquake, etc.;
- When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom, or other similar conditions occur;
- When there is a change in the size, location, or placement of the spoil pile; and
- When there is any indication of change or movement in adjacent structures.

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APPENDIX V: 2-1. SITE ASSESSMENT QUESTIONS

During first and subsequent visits to a construction or facility maintenance location, the compliance officer (or the site's safety officer or other competent person) may find the following questions useful.

1. Is the cut, cavity, or depression a *trench* or an *excavation*?
2. Is the cut, cavity, or depression more than 4 ft (1.2 m) in *depth*?
3. Is there *water* in the cut, cavity, or depression?
4. Are there adequate means of *access* and *egress*?
5. Are there any *surface encumbrances*?
6. Is there exposure to *vehicular traffic*?
7. Are *adjacent structures stabilized*?
8. Does *mobile equipment* have a *warning system*?
9. Is a *competent person in charge* of the operation?
10. Is *equipment operating* in or around the cut, cavity, or depression?
11. Are procedures required to monitor, test, and *control hazardous atmospheres*?
12. Does a competent person *determine soil type*?
13. Was a *soil testing device* used to determine soil type?
14. Is the *spoil* placed 2 ft (0.6 m) or *more from the edge* of the cut, cavity, or depression?
15. Is the *depth* 20 ft (6.1 m) *or more* for the cut, cavity, or depression?
16. Has a *registered professional engineer* approved the procedure if the depth is more than 20 ft (6.1 m)?
17. Does the procedure require *benching* or *multiple benching*? *Shoring*? *Shielding*?
18. If provided, *do shields extend at least 18 in (0.5 m) above* the surrounding area if it is sloped toward the excavation?
19. If shields are used, is the depth of the cut *more than 2 ft (0.6 m) below the bottom of the shield*?

20. Are any required *surface crossings* of the cut, cavity, or depression the *proper width and fitted with hand rails*?
21. Are means of *egress* from the cut, cavity, or depression *no more than 25 ft (7.6m) from the work*?
22. Is *emergency rescue equipment* required?
23. Is there *documentation of the minimum daily excavation inspection*?