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Draft Final Design Report

Menominee River Sediment Removal Project Adjacent to Tyco Fire Products LP Facility, Marinette, WI

Supplement 1 – Vertical Barrier Wall Sheet Pile Support

Prepared for

Tyco Fire Products LP

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Draft Final Design Report

Supplement 1 – Vertical Barrier Sheet Pile Support Design

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Executive Summary

This Supplement to Draft Final Design Report summarizes the results of the design for supporting the Vertical Barrier Wall during future dredging of Menominee River sediments adjacent to the Tyco Fire Products LP Facility, Marinette, Wisconsin.

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Acronyms and Abbreviations

EPRI	Electric Power Research Institute
FHWA	Federal Highway Administration
NAVD88	National America Vertical Datum 1998
SPT	Standard Penetration Test
SRWP	Sediment Removal Work Plan
Tyco	Tyco Fire Products LP
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
VBW	Vertical Barrier Wall
WDNR	Wisconsin Department of Natural Resources

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SECTION 1

Introduction

Tyco Fire Products LP (Tyco) installed a Vertical Barrier Wall (VBW) to contain impacted groundwater located on the facility property as part of remedial actions associated with an Administrative Order on Consent between Tyco and the U. S. Environmental Protection Agency (USEPA). The VBW consists of a slurry wall along the western, southern, and eastern portions of the site and a sheet pile wall along the northern property boundary. The northern property boundary is adjacent to the Menominee River; a portion of which is the subject of ongoing sediment removal. Based on existing sediment quality data (collected in 2010), it has been determined that removal of sediment to the depths required to meet remedial goals may result in failure of the VBW.

On behalf of Tyco, CH2M HILL reviewed existing subsurface information and evaluated geotechnical issues associated with dredging adjacent to the existing VBW along the Menominee River at the facility in Marinette, Wisconsin. This Supplement to the Draft Final Design Report summarizes the design analyses performed to determine the following:

1. An initial dredge surface to be performed in 2012 that would not compromise the existing sheet pile wall stability. This design was previously submitted to USEPA and Wisconsin Department of Natural Resources (WDNR) in April 2012.
2. Design of modifications to the existing sheet pile wall to facilitate dredging of arsenic impacted sediment at concentrations greater than or equal to 50 milligrams per kilogram.
3. Design of the final backfill with riprap armoring in front of the VBW following completion of dredging.

Construction drawings and specifications have been prepared to define the project for bidding purposes. These documents are considered to be supporting documents to this design report and will be referenced accordingly throughout this report. A copy of the plans and specifications are included in Appendix A.

This document is a supplement to the Draft Final Design Report - Menominee River Sediment Removal Project adjacent to the Tyco Facility (CH2M HILL, 2012). That Draft Final Design Report document was submitted to USEPA in January 2012.

The Draft Final Design Report, along with the supplement provided, presents the remedial actions required to meet the USEPA approved Sediment Removal Work Plan (SRWP) (CH2M HILL, 2010).

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SECTION 2

Background

A study was performed in April 2012 to evaluate the amount of sediment that could be removed from in front of the existing VBW without causing instability or excessive movement of the existing VBW in its current configuration. The results of this study are summarized in this report.

The current 2012 dredging program will remove a portion of the arsenic impacted sediment, but will leave a wedge of sediment in place to maintain stability of existing VBW.

The VBW will then be modified, as described in this report, to maintain bulkhead stability for future dredging of the remaining sediments requiring remedial action. Upon completion of the dredging, riprap bedding and riprap stone will be placed in front of the wall to protect the river bottom from erosion from prop wash in the Turning Basin and to provide additional long term stability of the VBW.

The portion of the existing VBW slated for modification consists of two sheet pile wall configurations as shown on Drawings C-5 through C-9 of the contract documents and as described below:

- The majority of the VBW was designed by AECOM and was constructed in 2010 using AZ 39-700 sheet piles. This portion includes two major segments: (1) an 675-foot long section west of the 8th Street Slip area (STA 20+15.34 to 26+90.73), which has a top of wall elevation of 584.4 feet (all elevations in this report are referenced to as National America Vertical Datum 1998 [NAVD88]); (2) east of the 8th Street Slip, the VBW includes a 657-foot long segment (STA 10+00 to 16+57.06) with a top of wall elevation of 582 feet. The interlocks/joints of the VBW sheet piles were sealed. Approximately 150 feet of the far western end of the first segment is currently tied back to H-pile deadman anchors. The remaining portion of this VBW is currently cantilevered.
- The 8th Street Slip portion of the bulkhead consists of two sets of AZ26 sheet piles installed in the late 1990s. The first set of sheet piles was installed along the riverfront as a cofferdam to isolate the 8th Street Slip from the river. Details regarding the penetration depth of these sheet piles is limited. The second sheet pile wall is located approximately 10 feet behind the riverfront sheet piles and extends along the northern boundary of the former Salt Vault area. Based on a Dames & Moore construction report from 1998 (Dames & Moore, 1998), these sheet piles were 45 to 50 feet deep and were all driven to refusal and are assumed to be sitting near the top of rock surface. This wall was constructed as a barrier wall with sealed joints around the entire 8th Street Slip Area. No information regarding design assumptions for earth retention is available.

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SECTION 3

Subsurface Conditions Included in the Analysis

Subsurface investigations performed at the site were reviewed to estimate the soil layering along the existing sheet pile wall. The data collected in the investigations were used to estimate geotechnical design parameters for each of the subsurface layers. These design parameters, along with the groundwater conditions, were used to evaluate the measures necessary to stabilize the wall during dredging.

3.1 Summary of Subsurface Investigations

Soil information at this site is available from the soil investigations performed by EarthTech in 2007, as well as the recent soil borings that were performed by CH2M HILL in 2011 and 2012. The EarthTech borings were performed to develop cross-sections for the design of the VBW that was previously installed at the Tyco Facility site. These borings were drilled around the perimeter of the site.

The CH2M HILL borings were performed for the purpose of installing groundwater monitoring wells and piezometers. These borings were drilled either on the shoreline, just in front of the existing sheet pile wall, or further out into the river. Some of these borings included rock coring to confirm the location, composition, and strength of the bedrock. The locations of the CH2M HILL borings used to determine the design parameters for this study are presented in the attached Figure 1 with the individual borings logs included in Appendix B.

The EarthTech borings located along the northern portion of the site along the Menominee River are shown in Figure 2. These borings were drilled on the land side of the existing sheet pile wall. Relevant EarthTech soil boring logs are also attached in Appendix B.

3.2 Subsurface Layers

Based on information derived from the subsurface investigations, it appears that there are five subsurface layers at this site. These are described as follows:

- Fill – imported fill material placed on the land side of the sheet pile wall for the purpose of reclaiming land. This layer consists of a mix of sand and silt with organic material and construction debris.
- Soft Sediments – recent river sediments made up of predominantly sandy material with some silt and organic debris.
- Semi-consolidated Material – older river deposits that have been consolidated over time and are now very dense. This layer consists of sandy and silty materials with some gravel. The upper portion of this layer was softer and was modeled as a separate layer for design purposes.

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- Glacial Till – this layer was encountered directly above the bedrock and is predominantly very hard, lean clay with some silty sand and gravel.
- Bedrock – the bedrock was identified in rock cores as a light green to gray dolomitic limestone.

Relevant boring logs and cross-sections used to develop this layering are contained in Appendix B.

3.3 Groundwater

The data collected from the piezometers installed in the Menominee River were used to assess the groundwater conditions at this site. Groundwater and river level readings were recorded over a period of six months. These data indicated river water elevations ranged between extremes of 576 and 580 feet with typical elevations ranging between 577 and 579 feet. The river elevation data from well cluster TB-01 are presented in Figure 3.

The 2-foot variation in river elevation occurred over a relatively short period of time. As such, it was conservatively assumed that there could be a 2-foot differential between the groundwater behind the sheet pile wall and the river level. The differential between the groundwater table and the river level can result in increased hydrostatic loading on the back of the wall.

3.4 Design Parameters for the Bulkhead Stability Analyses

The data collected in the subsurface investigations were used to estimate unit weight, strength, and deformation properties for the five subsurface layers. The design parameters were estimated from correlations with the Standard Penetration Test (SPT) N-values reported on the boring logs, the soil descriptions, and from laboratory test results.

The bulkhead stability analyses were performed at three design sections along the length of the VBW, which are representative of the major wall configurations. The design parameters are summarized in Table 1 for the three design sections. Figure 4 presents the SPT N-values plotted versus depth for each of the design sections, and shows how the layer breaks and average N-values were estimated. It is noted that preference was given to the data from soil borings drilled in front of the wall, since this soil provides the support of the wall, and is therefore more critical to wall stability. Soil layering was assumed to be horizontal within the limits of influence of the models, which was determined by comparing conditions encountered in borings drilled in front of and behind the wall. The relevant borings and laboratory test results are included in Appendix B.

Appendix C of this report contains the correlations used to estimate the unit weight, internal friction angle, undrained shear strength, and elastic modulus of the soil layers. A slight reduction was applied to the internal friction of the fill soil layer to account for variability of the soil, the presence of debris, and the high silt content. The undrained shear strength of the glacial till soil was also reduced based on experience with these soils.

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TABLE 1
Design Soil Parameters

Layer	Design Section	Top EL (feet)	USCS	SPT N-Value (bpf)	γ (pcf)	c_u (psf)	ϕ' (deg)	Elastic Modulus (ksf)
Fill/Soft Sediments	1 – C35	584.4	SP	5	115	0	28	50
	2 – D38	584.4	SP	3	115	0	28	30
	3 – SP1	582	SP-SM	5	115	0	28	50
Semi-Consolidated (Upper)	1 – C35	573	SP	24	125	0	34	240
	2 – D38	571	SP	24	125	0	34	240
	3 – SP1	578	SP	20	125	0	33	200
Semi-Consolidated (Lower)	1 – C35	567	SP	67	130	0	36	670
	2 – D38	567	SP	69	135	0	36	700
	3 – SP1	563	SM	65	135	0	36	650
Glacial Till	1 – C35	561	CL-ML	89	135	5000	0	1100
	2 – D38	556	CL-ML	100	135	5000	0	1100
	3 – SP1	550	CL-ML	27	130	3500	0	900

Notes:

Bedrock was not included in the models since failure will not occur through this layer.

bpf = blows per foot
γ = soil density
c_u = undrained shear strength
ϕ' = effective internal friction angle
deg = degrees
ksf = kips per square foot
pcf = pounds per cubic foot
psf = pounds per square foot
SPT-N = standard penetration test N-values
USCS = Uniform Soil Classification System

The correlations included in the Electric Power Research Institute (EPRI) Manual (Kulhawy & Mayne, 1990) and from the Federal Highway Administration (FHWA) Manual (Liang, 2002) were used to estimate the elastic modulus of the sandy and clayey soil layers. Because of the presence of silt in the sandy soils for conservativeness, the correlation for "sand with fines" was used for all of the cohesionless soil. A correlation of the SPT N-value to the pressuremeter test elastic modulus was used for the cohesive soil, since this modulus is generally considered to be close to the actual modulus of the soil.

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SECTION 4

Wall Analysis Procedure

The computer program DeepXcav by Deep Excavation, LLC was used to evaluate the stability of the existing bulkhead and proposed modifications. This program utilizes a finite element approach to model the retaining wall as a linear elastic beam. The beam is divided into discrete elements supported by non-linear soil springs allowing the program to estimate the displacement based on the load.

The DeepXcav program was selected since the program can analyze sloped ground in front of the wall, and can model staged construction where the wall deflections are cumulative for subsequent stages. This ability to model staged construction was important for this project because of the different dredging events and modification of the wall. The program also calculates a limit equilibrium solution, which allows for various factors of safety to be calculated to help compare to more traditional analyses. These features make this program a useful tool for modeling the impact of the dredging on the existing sheet pile wall and for designing wall modifications for this project.

The as-built tip elevations of the existing sheet pile wall and the soil layering interpreted from the relevant soil borings along the wall are presented in the plans in Appendix A.

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SECTION 5

Bulkhead Support Analysis

The bulkhead modification analyses included the following tasks:

- Determine global slope stability and overturning stability of the existing sheet pile wall systems.
- Determine a dredge depth that will not make the existing VBW unstable, and will not result in excessive VBW movement. This "safe" dredge depth will be incorporated into the target 2012 dredge surface.
- Evaluate stability determination of modification measures required to maintain overturning and rotational stability during the final dredge condition.
- Evaluation of long-term global stability of the sheet pile and river bank after final riprap armoring is placed.

The stability of each sheet pile wall section was evaluated by calculating the safety factor with respect to the overturning of the wall, rotation around anchor, bending moment, and shear stresses in the wall structure. The analyses included evaluation of earth pressure on the back of the wall, the resistance provided by the soil in front of the wall, and the resistance provided by anchors. In the DeepXcav software these analyses were performed as either a limit equilibrium analysis to provide estimated factors of safety, or by using more advanced elasto-plastic modeling procedures to estimate the deflection of the wall. Both approaches were used for this project.

The global stability analysis evaluated the potential for large-scale failures along potential slip surfaces that start from behind the wall, run under the wall, and end at a point out in the river.

The following typical sheet pile wall sections were analyzed for wall modifications:

- Cross Section C9 – station 26+88 to 25+32
- Cross Section C35* – station 25+32 to 24+24
- Cross Section D38* – station 24+24 to 21+77
- Cross Section 4 – station 21+77 to 16+55 (8th Street Slip)
- Cross Section SP1* – station 16+55 to 14+37
- Cross Section F9 – station 14+37 to 10+03

The sections identified with an asterisk in the above list are the only sections that were evaluated for wall stability during dredging without modifications.

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SECTION 6

Results and Design Recommendations

6.1 Determination of Safe Dredge Elevation

The results of the stability analyses to determine the safe dredge elevation without modifying the existing wall system are presented in Table 2. The safe dredge elevations presented in the table were selected as the point where the wall deflection was less than 2 percent of the exposed wall height and the passive factor of safety was greater than 1.5. The passive factor of safety is calculated by dividing the ultimate passive resistance by the total force applied to the wall. Figure 5 shows the relationship of the wall deflection to passive factor of safety and it can be seen that the wall quickly becomes unstable after the wall deflection reaches 2 percent of the wall height. The last column in Table 2 indicates how much additional dredging below the safe dredge elevation would result in wall failure. Output from the DeepXcav models are contained in Appendix D.

Slope stability analyses were performed to check the global stability of the overall wall system as well as the dredge slope alternatives. It was determined that all design sections were safe, with respect to global stability, since all wall sections analyzed were tipped into the very hard till layer. It was also determined that all of the dredge configurations in the sections analyzed were safe from local slope stability failures.

6.2 Determination of Wall Modifications

In order to determine the modifications that will be required to maintain stability during the final dredging condition, the existing wall was analyzed using the DeepXcav software for the planned dredge elevation shown on the plans, and for the case where the dredging continued down to the top of the glacial till layer. This was done to make sure that the modifications would be stable even if the impacted sediment extends deeper than planned based on the findings of the field sampling.

The analyses indicate that it will be necessary to add soldier piles to the entire wall primarily due to the shallow embedment of the existing sheet piles at the final dredge elevations. It is also necessary to provide anchor support to the walls that are currently cantilevered to provide the necessary resistance to overturning, limit lateral deflection at the top of the wall, and to reduce the structural demands for the soldier piles. A summary of the findings is presented in Table 3, and a separate discussion for each cross section is provided as follows. Output from the DeepXcav models are contained in Appendix D.

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TABLE 2
Summary of DeepXcav Results

Analysis Section	Dredge Alternative	Top of Sheeting (feet)	Tip of Sheeting (feet)	Safe Dredge Elevation (feet)	Exposed Wall Height (feet)	Deflection (inches)	Deflection/ Height (%)	Moment (kip-ft)	Shear (kips)	Passive FS	Dredge Elevation Failure[a] (feet)
C35	1 (5H:1V)	584.4	557.4	573	11.4	2.5	1.8	33.3	7.0	1.5	1.0
	2 (4H:1V)	584.4	557.4	574	10.4	1.8	1.5	30.4	6.2	1.6	1.0
	3 (3H:1V)	584.4	557.4	575	9.4	1.8	1.6	29.2	6.2	1.5	1.0
	4 (bench)	584.4	557.4	572	12.4	2.3	1.5	33.7	6.7	1.8	1.0
D38	1 (5H:1V)	584.4	553.9	572	12.4	2.8	1.9	44.8	7.1	2.0	2.0
	2 (4H:1V)	584.4	553.9	573	11.4	2.4	1.7	41.8	6.5	2.0	2.0
	3 (3H:1V)	584.4	553.9	574	10.4	2.5	2.0	41.1	6.7	1.8	2.0
	4 (bench)	584.4	553.9	571	13.4	2.7	1.6	44.3	6.8	2.3	1.0
SP1	1 (5H:1V)	582	544	565	17	4.1	2.0	72.0	9.4	1.8	2.0
	2 (4H:1V)	582	544	566	16	3.6	1.9	67.6	8.5	1.8	3.0
	3 (3H:1V)	582	544	567	15	3.6	2.0	65.7	8.5	1.7	2.0
	4 (bench)	582	544	564	18	4.0	1.9	72.5	9.0	2.1	3.0

[a] Failure is defined as the point where the design model would no longer converge on a solution.

Note:

FS = factor of safety

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TABLE 3
Summary of Wall Modifications

Design Section	Top of Till Elevation (feet)	Top of Bedrock Elevation (feet)	Existing Sheet Pile Type	Sheet Pile Tip Elevation (feet)	Soldier Pile Spacing (feet)	Soldier Pile Tip Elevation (feet)	Soldier Pile Length (feet)	Soldier Pile Rock Socket Length (feet)	Anchor Elevation (feet)
C9	561	547	AZ39-700	558	9.2	547	37	0	N/A
C35	561	547	AZ39-700	558	9.2	547	37	0	582
D38	556	548	AZ39-700	554	9.2	543	41	5	584
4 (8th St)	549	546	AZ26	546	8.3	538	46	8	584
SP1	550	540	AZ39-700	544	9.2	537	47	3	579.5
F9	544	540	AZ39-700	541.5	9.2	537	47	3	579.5

Notes:

All soldier piles are HP14x117 with a cutoff elevation matching the top of the existing sheet pile wall.

The soldier pile length is estimated based on a top of pile elevation of 584 feet, which is the typical top of sheet pile elevation.

It is noted that the layer elevations are estimated for the specific design sheet pile section only and will vary between sections.

6.2.1 Cross Section C9

The available records indicate that the AZ 39-700 sheet piles in the portion of the wall in the vicinity of Sheet Pile C9 were driven to refusal, which appears to be in the upper portion of the glacial till layer with toe elevations ranging from 548 to 560 feet. This portion of the wall includes existing anchors that consist of tie-rods that each extend to an H-pile deadman driven to a depth of 25 feet.

The top of the till is estimated to be at an elevation of 561 feet, and top of rock is estimated at Elevation 547 feet. The plans indicate a planned dredge surface ranging from 558 to 564 feet, which may be below the top of till in some areas. It is assumed that the dredging will be terminated once the glacial till layer is encountered. With the sheet piles seated near the top of the till layer, this will leave the sheet piles with only a few feet of embedment into the till layer.

The analysis for these piles indicates the sheet pile wall is not capable of supporting dredging to the till layer without adding modifications to the wall. Adding soldier piles in front of the sheet pile wall will provide the necessary stability of the toe of the sheeting to achieve the maximum dredge depth to the top of the till.

The analysis indicates that HP14x117 soldier piles, spaced 9.2 feet apart, will need to be installed to the top of the rock to provide the toe stability. The required spacing will result in piles installed at every other sheet pile set. This configuration will rely on the support of the existing deadman anchors.

6.2.2 Cross Section C35

The available records indicate that the AZ 39-700 sheet piles in the portion of the wall in the vicinity of Sheet Pile C35 were driven to refusal which appears to be in the upper portion of the glacial till layer with toe elevations ranging from 550 to 558 feet. This portion of the wall is currently cantilevered.

The top of the till is estimated to be at an elevation of 561 feet, and top of rock is estimated at Elevation 547 feet. The plans indicate a planned dredge surface ranging from 562 to 566 feet, which is above the top of the till layer. However, the analyses assumed that the dredging may be continued to the top of the glacial till layer. With the sheet piles seated near the top of the till layer, this will leave the sheet piles with only a few feet of embedment into the till layer.

The analysis of this section indicates the existing sheet pile wall is not capable of supporting dredging to the till layer without wall modifications. Adding soldier piles in front of the sheet pile wall will provide the necessary stability of the toe of the sheeting. However, in order to achieve wall stability to the maximum dredge depth, an anchor will also need to be added to the top of the wall to provide lateral stability and limit wall deflection.

The analysis indicates that HP14x117 soldier piles, spaced 9.2 feet apart, will need to be installed 3 feet into the top of the rock to provide adequate toe stability. The spacing will result in piles installed at every other sheet pile set. Anchors spaced 9.2 feet apart and tied to a new H-pile and waler deadman system with tie-rods will provide adequate lateral resistance and limit lateral wall deflection.

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6.2.3 Cross Section D38

The available records indicate that the AZ 39-700 sheet piles in the portion of the wall in the vicinity of Sheet Pile D38 were driven to refusal which appears to be in the upper portion of the glacial till layer with toe elevations ranging from 550 to 560 feet. This portion of the wall is currently cantilevered.

The top of the till is estimated to be between an elevation of 554 and 558 feet, and top of rock is estimated between elevations 545 and 549 feet. The drawings indicate a planned dredge surface of 566 feet, which is above the top of the till layer. However, the analyses assumed that dredging may be continued to the top of the glacial till layer. With the sheet piles seated near the top of the till layer, this will leave the sheet piles with only a few feet of embedment into the till layer.

The analysis for these piles indicates the sheet pile wall is not capable of supporting dredging to the till layer without adding modifications to the wall. Adding soldier piles in front of the sheet pile wall will provide the necessary stability of the toe of the sheeting. However, in order to maintain wall stability to the maximum dredge depth, an anchor will also need to be added to the top of the wall.

The analysis indicates that HP14x117 soldier piles, spaced 9.2 feet apart and installed 5 feet into the top of the rock will provide adequate toe stability. The required spacing will result in piles installed at every other sheet pile set. Anchors spaced 9.2 feet apart and tied to a new H-pile and waler deadman system with tie-rods will provide adequate lateral resistance and limit lateral wall deflection.

6.2.4 Cross Section 4 (8th St)

This section of the bulkhead consists of two AZ26 sheet pile walls installed in the late 1990s. There is limited information about the penetration depth of the outer sheet pile wall, but it is known that this section of wall is currently cantilevered and was installed to isolate the 8th Street Slip Area from the river. The inner wall was installed around the entire footprint of the former 8th Street Slip area. The available records from the Dames & Moore construction report for the inner wall indicate that the sheet piles in this portion of the wall were driven to refusal on the top of the rock.

There is limited subsurface information in this area. The best estimate is that the top of the till is located between an elevation of 549 and 556 feet, and top of rock is approximately at Elevation 545 feet. The drawings indicate a planned dredge surface between 549 and 565 feet which is above the top of the till layer. However, the analyses assumed that the dredging may be continued to the top of the glacial till layer. This will result in exposed wall heights ranging from 35 to 40 feet.

The analysis for these piles indicates the sheet pile wall is not capable of supporting dredging to the till layer without adding modifications to the wall. Adding soldier piles in front of the sheet pile wall will provide the necessary stability of the toe of the sheeting. However, in order to maintain wall stability to the maximum dredge depth, an anchor will also need to be added to the top of the wall.

The analysis indicates that HP14x117 soldier piles, spaced 8.3 feet apart and installed 8 feet into the top of the rock, will provide adequate toe stability. The required spacing will result

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in piles installed at every other sheet pile set. Anchors spaced 8.3 feet apart and tied to a new H-pile and waler deadman system with tie-rods will provide adequate lateral resistance and limit lateral wall deflection.

6.2.5 Cross Section SP1

The available records indicate that the AZ 39-700 sheet piles in the portion of the wall in the vicinity of Sheet Pile SP1 were driven to refusal, which appears to be to the top of the rock with toe elevations ranging from 542 to 545 feet. This portion of the wall is currently cantilevered.

The top of till is estimated to be between an elevation of 544 and 548 feet, and top of rock is estimated between elevations 540 and 546 feet. The till appears to be just a few feet thick in this area. The drawings indicate a planned dredge surface around Elevation 550 feet, which is above the top of the till layer. However, is the analyses assumed that the dredging may be continued to the top of glacial till layer. With the till thickness being relatively thin in this area, this will result in nominal wall embedment below the dredge depth.

The analysis for these piles indicates the sheet pile wall is not capable of supporting dredging to the till layer without adding modifications to the wall. Adding soldier piles in front of the sheet pile wall will provide the necessary stability of the toe of the sheeting. However, in order to maintain wall stability to the maximum dredge depth, an anchor will also need to be added to the top of the wall.

The analysis indicates that HP14x117 soldier piles, spaced 9.2 feet apart and installed 3 feet into the top of the rock, will provide adequate toe stability. The required spacing will result in piles installed at every other sheet pile set. Anchors spaced 9.2 feet apart and tied to a new H-pile and waler deadman system with tie-rods will provide adequate lateral resistance and limit lateral wall deflection.

6.2.6 Cross Section F9

The available records indicate that the AZ 39-700 sheet piles in the portion of the wall in the vicinity of Sheet Pile F9 were driven to refusal, which appears to be to the top of the rock with toe elevations ranging from 536 to 542 feet. This portion of the wall is currently cantilevered.

The top of the till appears to be very thin in this area and may not exist in some areas. The top of the rock is estimated between elevations 539 and 540 feet. The drawings indicate a maximum planned dredge surface around Elevation 556 feet at the western edge of this section and grades up to the far eastern end where the planned dredge operation terminates. Since this is the farthest section from the source of the impacts, and because this is the termination point of the dredging operation, it is assumed that the dredging may only extend to a maximum depth of 5 feet below the planned dredge surface.

The analysis for these piles indicate the sheet pile wall is not capable of supporting the planned dredging without adding modifications to the wall. Adding soldier piles in front of the sheet pile wall will provide the necessary stability of the toe of the sheeting. However, in order to maintain wall stability to the maximum dredge depth, an anchor will also need to be added to the top of the wall.

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The analysis indicates that HP14x117 soldier piles, spaced 9.2 feet apart, and installed 3 feet into the top of the rock will provide adequate toe stability. The required spacing will result in piles installed at every other sheet pile set. Anchors spaced 9.2 feet apart and tied to a new H-pile and waler deadman system with tie-rods will provide adequate lateral resistance and limit lateral wall deflection.

6.3 Dredging of Arsenic Impacted Sediments

After completing installation of an area of the VBW modification support system, the remaining wedge of arsenic impacted sediments can be removed. The material will consist primarily of semi-consolidated sediments. These sediments will be mechanically dredged as described in the Design Report for the project. The proposed dredged elevations are shown on the project drawings included in Appendix A. These elevations are consistent with dredge elevations presented in the Draft Final Design Report for removal of sediments with arsenic concentrations greater than or equal to 50 milligrams per kilogram.

The dredged sediments will be placed in barges, and transported to the sediment stabilization area for stabilization. After stabilization, the sediments will cure, be tested to verify they meet disposal criteria, and transported for offsite disposal as described in the Design Report.

Confirmation sampling will be conducted to verify sediments with arsenic concentration greater than or equal to 50 milligrams per kilogram have been removed. The confirmation sampling will be performed in accordance with the approved Confirmation Sampling Plan (CH2M HILL, 2012). As discussed above, the VBW support system is designed to allow dredging to the glacial till layer in the Turning Basin and 5 feet deeper than the planed dredge depth in the Transition Areas.

6.4 Final Backfill Placement

After completion of final dredging at the VBW, a wedge of rock backfill will be placed against the base of the VBW to provide long term support. This backfill will consist of two layers of material, a bedding material and a riprap armoring stone.

The bedding material provides the necessary support to the VBW. This material was also designed to support the riprap armoring stone, and meet filter criteria, to limit the loss or migration of fines from any remaining sediment that does not requiring dredging. The required gradation of the base material is provided in Table 4.

TABLE 4
Design Filter Band Gradation (from CH2M HILL Standard Specifications)

Sieve Size	Percent Passing by Weight
6 inch	100
4 inch	>85
No. 4	>10

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Riprap armoring stone will need to be placed over the bedding material to protect it from potential scour from the propulsion forces created by large ships in the Turning Basin. The riprap armoring stone material was designed based on information provided by the Marinette Marine Corporation regarding the thrust expected from ships maneuvering in the Turning Basin.

The results of the riprap armoring stone analysis indicate a 36-inch thick layer of riprap with a maximum size of 24-inches and a D_{50} of 12-inches (Class III) will provide adequate scour protection based on the anticipated ship use. The proposed gradation of the riprap is provided in Table 5.

TABLE 5
Class III Riprap Gradation Information (from CH2M HILL Standard Specifications)

Weight (lbs)	Percent Greater Than
800	0 to 5
400	30
200	75
25	90

Details and calculations regarding the analysis of the riprap armoring stone are presented in Appendix E.

6.5 Decontamination and Site Restoration

After mechanical dredging activities have been completed, decontamination activities will be performed. Equipment to be removed from the river will be power washed with water, in place or over the river, before transport, to remove sediment and invasive species such as mussels.

Land-based equipment will be washed on the decontamination pad with the wash water being captured and treated. Rinse water will be collected in a sump and will be pumped to the water treatment system. Following equipment decontamination, the decontamination pad will be washed to remove visible residual sediment. Any areas that have contacted arsenic impacted sediments will be decontaminated.

The effectiveness of the decomtamination will be verified using confirmation test as described in the approved Confirmation Testing Plan.

Any areas of pavement that have been removed or damaged by the dredging activities will be re-paved.

Previously vegetated areas that were impacted by the remediation activities will be restored to preconstruction grades and replanted with grasses.

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SECTION 7

References

CH2M HILL. 2010. *Draft Sediment Removal Workplan*. Prepared for Tyco Fire Products LP. December.

CH2M HILL. 2012. Draft Final Design Report. *Menominee River Sediment Removal Project Adjacent to Tyco Fire Products LP Facility*. Prepared for Tyco Fire Products LP. January.

Dames & Moore. 1998. Ansul Inc. *Interim Barrier Wall Construction Report*, Marinette, Wisconsin.

Kulhawy, F.H., & Mayne, P.W. 1990. *Manual on Estimating Soil Properties for Foundation Design, Report No. EL-6800.* Palo Alto, CA: Electric Power Research Institute.

Liang, R.Y. 2002. *Drilled Shaft Foundation for Noise Barrier Walls and Slope Stabilization.* FHWA/OH-2002/038.

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Figures

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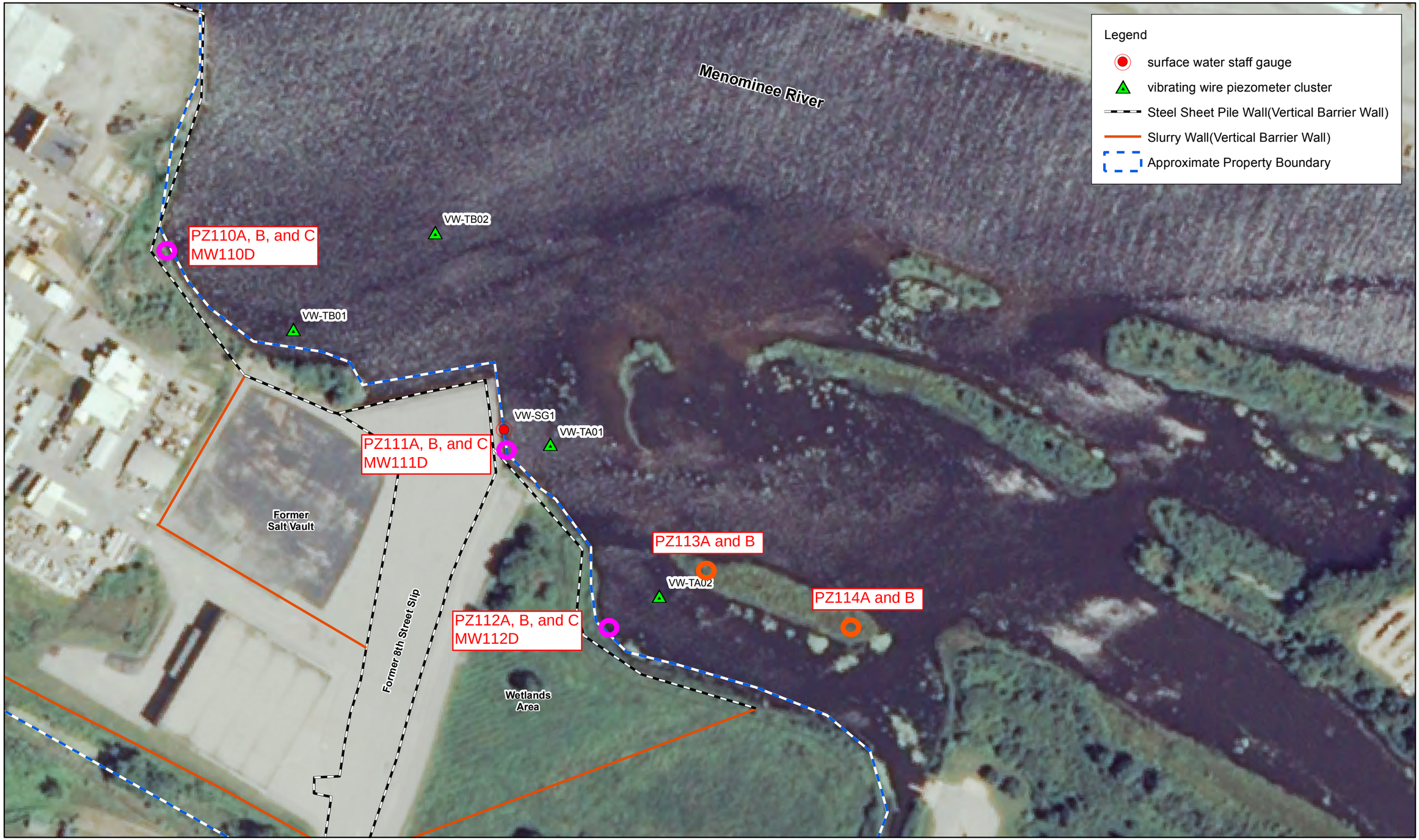

0 150 300
Feet

N

standpipe piezometer cluster drilled (4 depths)

standpipe piezometer cluster hand-driven (2-3 depths)

Figure 1
River Groundwater Investigation Locations
Tyco Fire Products LP Facility
Marinette, WI

E:\TYCO\MAPFILES\DF_2011REQUESTS\TYCO_RIVER GROUNDWATER INVESTIGATION LOCATIONS.MXD MPETERSH 12/6/2011 11:47:41 AM

CH2MHILL

Final Owner Review Set 12/2007

NOTES:

1. CPT-4, CPT-4B, CPT-6, CPT-7, CPT-8, CPT-9, CPT-11 AND CPT-19 WERE DRILLED AS AUGER PROBES DUE TO ACCESS ISSUES.
2. REFUSAL WAS ENCOUNTERED BEFORE TARGET DEPTH WAS REACHED AT CPT-4, CPT-17, SPT-12, AND AP-22. THE LOCATIONS WERE OFFSET AND ADVANCED TO THE TARGET DEPTH AT LOCATIONS CPT-4B, CPT-17B, SPT-12B, AND AP-22B, RESPECTIVELY.

REFERENCE:

TOPOGRAPHIC MAP PREPARED FOR DAMES & MOORE, INC., PREPARED BY AERO-METRIC ENGINEERING, INC. DATE OF PHOTOGRAPHY JULY 20, 1993.

EarthTech
A tyco International Ltd. Company

Figure 2
GEOTECHNICAL DRILLING LOCATION MAP

TYCO SAFETY PRODUCTS - ANSUL FACILITY
MARINETTE, WISCONSIN

Issued for CMI Work Plan
12/17/07

R-5

C:\WORK\90646\90646_045 VBW Geotech Boring Locations - Surveyed.dwg, 9/19/2007 10:27:22 AM, robert.stubblefield

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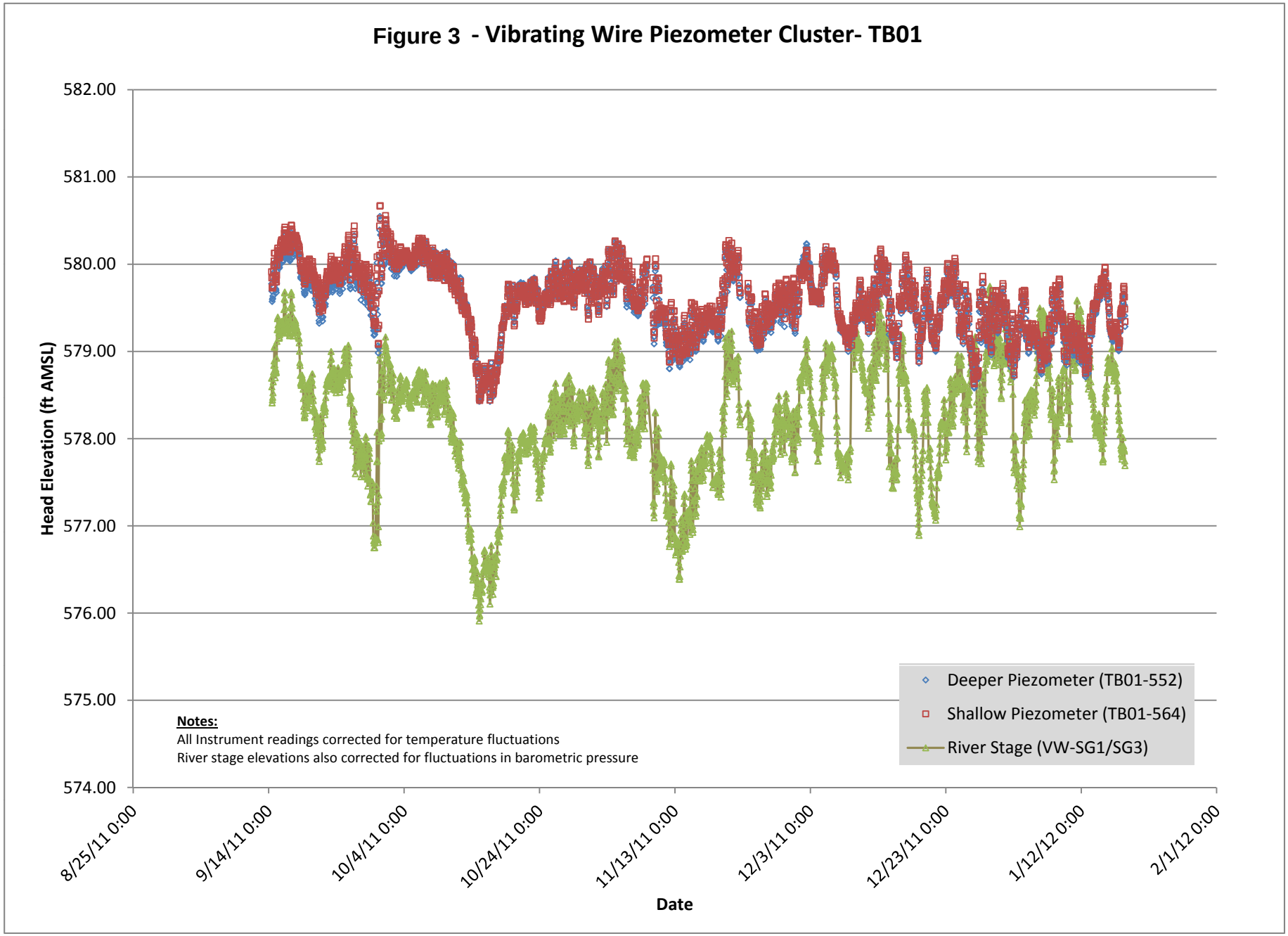

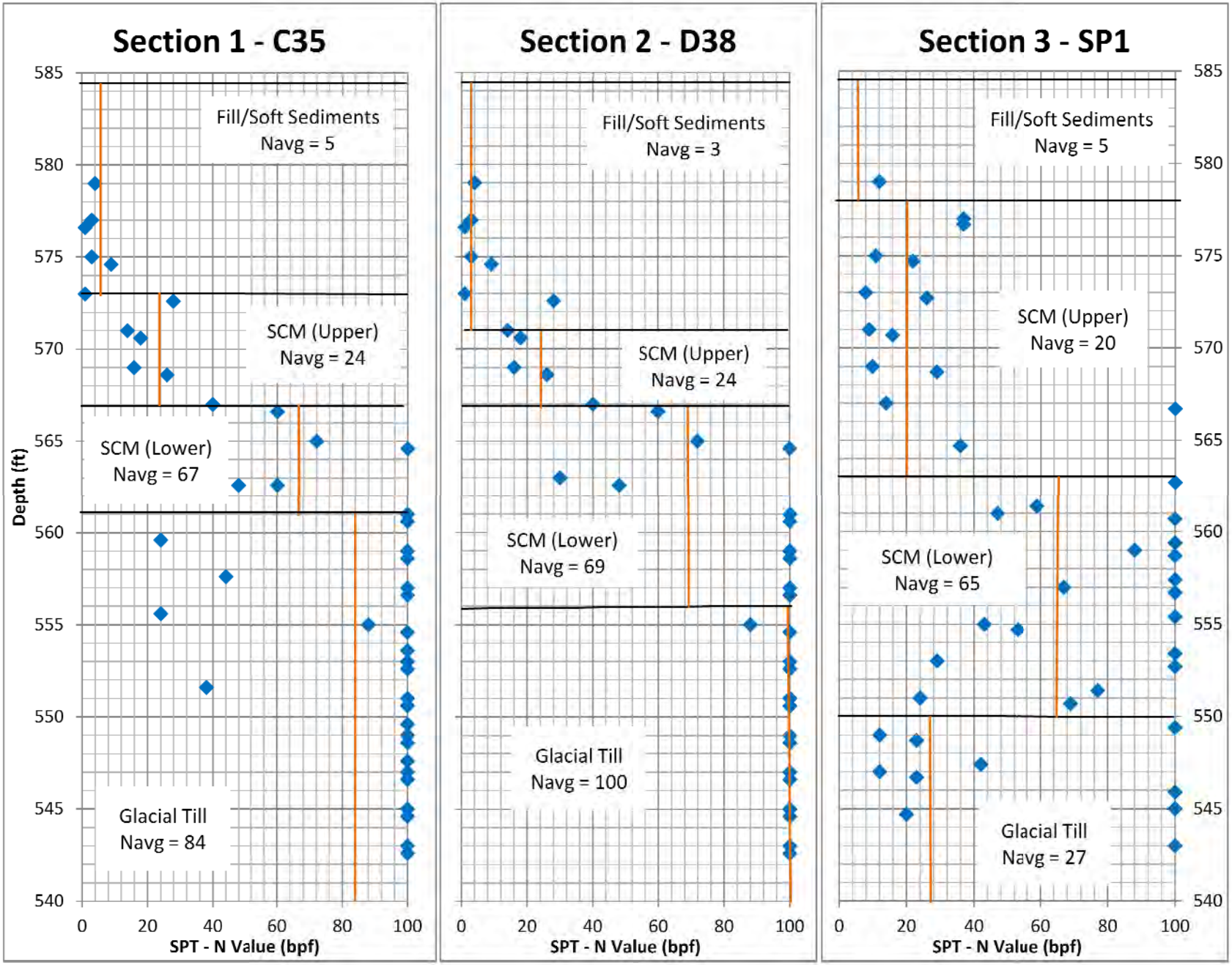
Section 1 - C35
Fill/Soft Sediments
Navg = 5
SCM (Upper)
Navg = 24
SCM (Lower)
Navg = 67
Glacial Till
Navg = 84
Section 2 - D38
Fill/Soft Sediments
Navg = 3
SCM (Upper)
Navg = 24
SCM (Lower)
Navg = 69
Glacial Till
Navg = 100
Section 3 - SP1
Fill/Soft Sediments
Navg = 5
SCM (Upper)
Navg = 20
SCM (Lower)
Navg = 65
Glacial Till
Navg = 27
Depth (ft)
585
580
575
570
565
560
555
550
545
540
0
20
40
60
80
100
SPT - N Value (bpf)

Figure 4

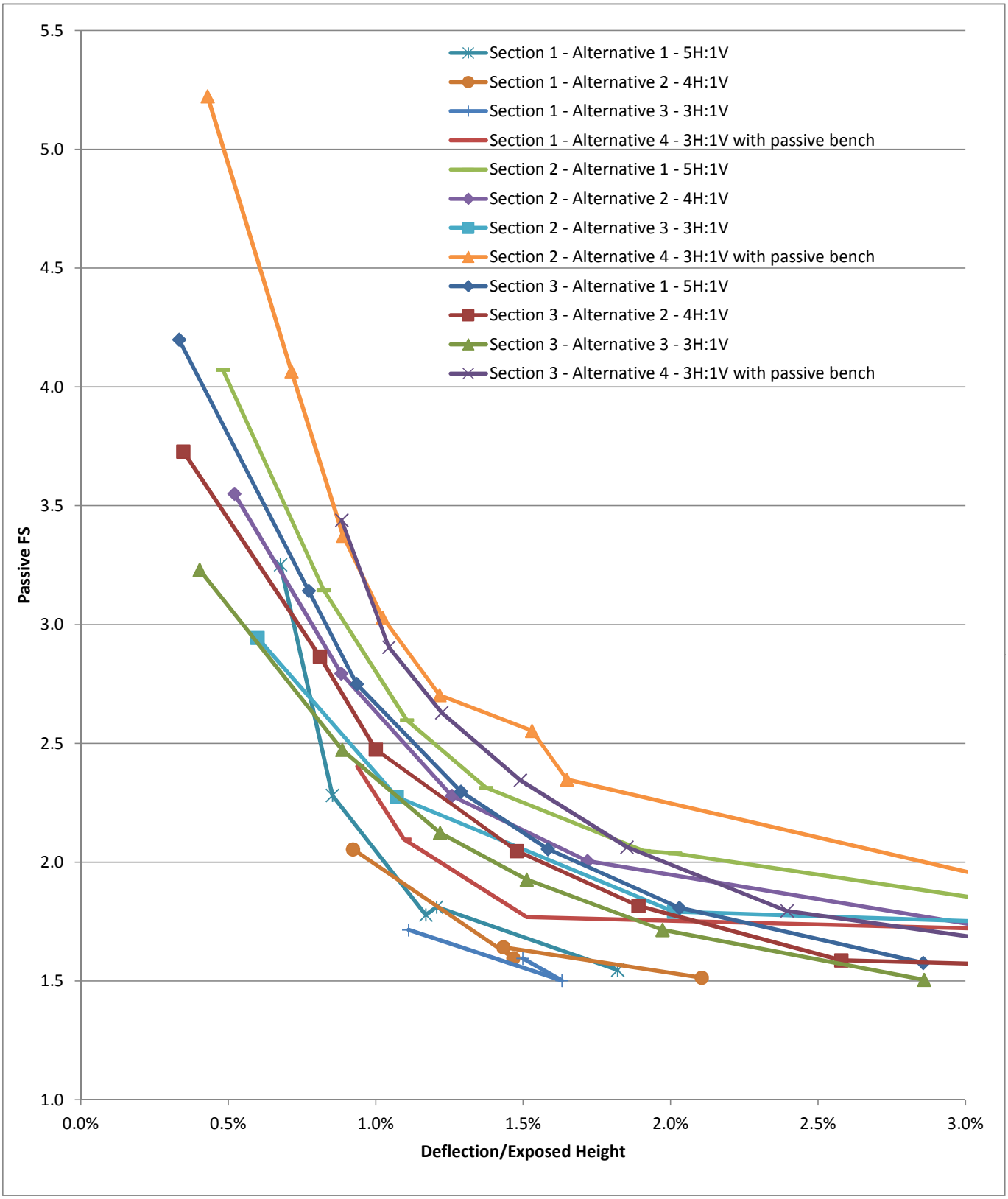

Figure 5

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Appendix A
Plans and Specifications

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Appendix B
Boring Logs and Laboratory Test Data

PROJECT NUMBER: 425171	BORING NUMBER: MW110D	SHEET 1 OF 3

SOIL BORING LOG

PROJECT : Tyco Fire Products LP, Marinette, WI — LOCATION : (469972.8 N, 2584942.9 E)

ELEVATION : — DRILLING CONTRACTOR : ATL

DRILLING METHOD AND EQUIPMENT : CME 850 Track

WATER LEVELS : --- — START : 1/18/12 13:00 — END : 1/18/12 17:10 — LOGGER : J. Butler

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0 – 2.0	0.0	1-SS	13-2-2-3 (4)	Ice and some gravel pieces; wood chip in shoe		CME Autohammer (140#), 14:55 SPT on SS-1, no arsenic sample Collected SS-1
	2.0 – 4.0	2.4	2-SS	2-2-1-0 (3)	**POORLY GRADED SAND (SP)** dark gray-brown, wet, very loose, wood pieces, diatoms		
5	4.0 – 6.0	2.4	3-SS	1-2-1-1 (3)	Continued **POORLY GRADED SAND (SP)** and wood chips stuck in shoe		No ziplock retained SS-1, SS-2, SS-3, SS-4
	6.0 – 8.0	0.0	4-SS	0-0-1-2 (1)	Wood chip and sandy silt, caught in shoe		No arsenic sample, collected SS-4
10	8.0 – 10.0	9.6	5-SS	6-7-7-8 (14)	Wood chips 8.5-9.0', then **POORLY GRADED SAND with SILT (SP-SM)** brown-tan, moist, medium dense, very fine		SS-5 at 15:45, cloudy, light SE breeze, 24 deg. F
	10.0 – 12.0	1.4	6-SS	5-7-9-16 (16)	Continued **POORLY GRADED SAND with SILT (SP-SM)** light brown-tan, moist, medium dense		SS-6 at 16:00
	12.0 – 14.0	21.6	7-SS	13-20-20-32 (40)	Continued **SAND with SILT (SP-SM)** light brown, becoming dense, estimate 5-15% fines, sand very fine grained, dilatent		SS-7 at 16:15, end of drilling 1/14/12
15	14.0 – 16.0	19.2	8-SS	18-39-33-24 (72)	**SILTY SAND (SM)** tan-brown, moist, very dense, interbedded with one 0.1' thick layer **FAT CLAY (CH)**, and green gravel pieces		SS-8 at 07:40, MiniRae. 1.1 ppm
	16.0 – 18.0	20.4	9-SS	14-17-13-50/2" (30)	**LEAN CLAY (CL) with INTERBEDS OF SILT (ML) and FAT CLAY (CH)** all brown, moist, stiff to hard		SS-9 at 08:10, PP > 4.5 ppm x 2, <= 4.5 ppm x 1
20	18.0 – 20.0	8.4	10-SS	6-50/5" (R)	**LEAN CLAY (CL) to FAT CLAY (CH)** brown, moist, hard, dolomite chip stuck in shoe		SS-10 at 08:20, PP > 4.5 ppm
	20.0 – 22.0	7.2	11-SS	32-44-75/3" (R)	Continued **LEAN CLAY (CL) and FAT CLAY (CH)** mixed with dolomite gravel pieces (TILL)		SS-11 at 08:43, slow going, advancing casing
	22.0 – 24.0				No Sample		
25	24.0 – 26.0	1.4	12-SS	14-22-66-100/4" (88)	**LEAN CLAY (CL)** brown, moist, hard, medium plasticity, mixed with subrounded mixed lithology gravel (TILL)		Still in rock, advance boring to 24.0', no SPT SS-12 at 09:40
	26.0 – 28.0	7.2	13-SS	5-24-50/3" (R)	Continued **CLAY (CL)** with gravel pieces		
30	28.0 –	13.2	14-SS	12-85-50/2" (R)	Continued **LEAN CLAY (CL)** with gravel pieces (TILL), then at 28.7' transition to **Silty SAND (SM)**, brown-gray, wet, dense		SS-14 at 11:40

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PROJECT NUMBER: 425171	BORING NUMBER: MW110D	SHEET 2 OF 3

SOIL BORING LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469972.8 N, 2584942.9 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
DRILLING METHOD AND EQUIPMENT : CME 850 Track
WATER LEVELS : ---
START : 1/18/12 13:00
END : 1/18/12 17:10
LOGGER : J. Butler

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 – 32.0	7.2	15-SS	3-100/5" (R)	Continued **Silty SAND with GRAVEL (SM)** gray-brown, wet to moist, very dense, ~30% fines		SS-15 at 12:00
	32.0 – 34.0	6.0	16-SS	15-100/4" (R)	**SILTY SAND (SM)** with Gravel, ~50/50, brown, wet, very dense, gravel is dolomite and angular		
35	34.0 – 36.0	14.4	17-SS	17-53-100/4" (R)	Mixed **LEAN CLAY (CL) and SILTY SAND (SM) with GRAVEL** brown, moist, hard/very dense (TILL)		SS-17 at 13:03, SS-18 at 13:33, driller estimates refusal at 37.2'
	36.0 – 37.5	9.6	18-SS	11-58-75/5" (R)	Continued **CLAY (CL) and SILTY SAND (SM) with GRAVEL (TILL)** dolomite chips in shoe		
					Begin Rock Coring at 37.5 ft below ground surface See the next sheet for the rock core log		
40							
45							
50							
55							
60							

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PROJECT NUMBER: 425171	BORING NUMBER: MW110D	SHEET 3 OF 3

ROCK CORE LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469972.8 N, 2584942.9 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
CORING METHOD AND EQUIPMENT : CME 850 Track, HQ-S Triple Tube
ORIENTATION :
WATER LEVELS : ---
START : 1/18/12 13:00
END : 1/18/12 17:10
LOGGER : J. Butler

DEPTH BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS)	SYMBOLLIC LOG	LITHOLOGY (ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS)	COMMENTS (SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.)
	37.5						top of rock at 37.5 ft bgs, tricore to 39.5' to set outer 4" steel casing and grout very slow drilling on rock at 38.0', end of drilling 1/16/12 begin coring 13:00 on HQ-19, on 1/18/12, gray fluid, good return, steady, slow coring, end run 15:05
40	39.5		2	joints, 75 to 90 degrees and vertical, rough, undulating, clean, loose to open		**DOLOMITE LIMESTONE** green-gray, slightly to non-weathered, R3-R5, massive	
	19-HQ 5.2 ft 100%	94	1				
			1				
			2				
			1				
			1				
45	44.7		0	all are mechanical breaks (very angular and tight, drill breaks)		**DOLOMITE LIMESTONE** green-gray, slightly weathered, R4-R5, massive	begin run 15:15, steady coring rate, good fluid return, slow, end run 17:10
	20-HQ 5 ft 100%	100	1				
			1				
			1				
			1				
			1				
50	49.7					Bottom of Core at 49.7 ft below ground surface on 1/18/12 17:10	
55							
60							
65							

US EPA ARCHIVE DOCUMENT

PROJECT NUMBER:	BORING NUMBER:	
425171	MW111D	SHEET 1 OF 3

SOIL BORING LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469679.3 N, 2585479.1 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
DRILLING METHOD AND EQUIPMENT : CME 850 Track
WATER LEVELS : ---
START : 1/15/12 08:20
END : 1/15/12 12:00
LOGGER : J. Butler

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0 – 2.0	4.0	1-SS	24-10-2-1 (12)	**SILTY SAND (SM)** light brown, moist, visible ice/from soil		14:13 - retrieve SS-1, recovered soil placed in jar
	2.0 – 4.0	7.0	2-SS	16-16-21-5 (37)	**SILTY SAND with GRAVEL (SM)** light brown, wet, angular gravel fragments up to 1"		SS-2 - shoe plugged with wood, wood at ~ 2.5' ~6" ice thickness, cloudy, 40 deg, calm, 14:30 - start drilling 0-4' after driving casing
5	4.0 – 6.0	10.0	3-SS	4-5-6-6 (11)	**POORLY GRADED SAND (SP)** gray, wet, medium to coarse-grained, micaceous, <5% nonplastic silt		14:49 retrieve SS-3
	6.0 – 8.0	10.0	4-SS	2-3-5-7 (8)	similar to SS-3		Driller rig setup on shore ~6' in front of sheet piles 14:56 retrieve SS-4
10	8.0 – 10.0	10.0	5-SS	2-4-5-7 (9)	gray, tan and white, wet, loose, medium-grained sand, ~5% nonplastic silt		15:10 retrieve SS-5
	10.0 – 12.0	9.0	6-SS	2-3-7-7 (10)	similar to SS-5 with occasional rounded coarse sand, loose, slight odor in SS-6		
	12.0 – 14.0	22.0	7-SS	2-6-8-33 (14)	upper 19" **POORLY GRADED SAND (SP)**, similar to SS-5, bottom 3" **SILTY SAND (SM)** light gray, wet, dense, fine-grained, 5-15% nonplastic silt, slight odor		15:27 retrieve SS-7
15	14.0 – 16.0	20.0	8-SS	28-50-53-50 (103)	**SILTY SAND (SM)** light gray, wet, very dense, fine-grained, 15-20% nonplastic silt, slight odor		15:56 retrieve SS-8
	16.0 – 18.0	20.0	9-SS	42-54-70-80/3" (124)	similar to SS-8 but increasing silt content, 40-50% nonplastic silt		16:05 retrieve SS-9, PP: 3.0, 5.0 TSF
20	18.0 – 20.0	18.0	10-SS	8-17-28-43 (47)	light gray, wet, very dense, fine-grained, 40-50% nonplastic silt, slight odor		16:15 retrieve SS-10
	20.0 – 22.0	20.0	11-SS	30-40-48-61 (88)	similar to SS-10		16:37 retrieve SS-11, 16:50 drive casing to 20', 17:00 end date at 20'
	22.0 – 24.0	16.0	12-SS	16-33-34-54 (67)	**SANDY SILT (ML)** tan, wet, hard, non-plastic, 30-40% fine sand, slight odor		resume drilling
25	24.0 – 26.0	17.0	13-SS	23-27-16-20 (43)	**SILTY SAND (SM)** tan, wet, dense, fine-grained sand, 30-40% nonplastic silt		08:30 overcast, 30 deg, light snow, breezy, 08:40 retrieve SS-13
	26.0 – 28.0	20.0	14-SS	13-14-15-15 (29)	**SAND with SILT (ML)** tan with light gray inclusions, wet, stiff, low plasticity, 15-25% fine sand		SS-14, PP: 0.5, 1.0, 1.0, 1.5 TSF
30		11.0	15-SS	13-14-10-10 (24)	**INTERLAYERED SILTY SAND and SANDY SILT (SM/ML)** tan, wet, medium dense/stiff, low plasticity, single rounded coarse sand 3/8" diameter in shoe		09:35 retrieve SS-15, PP: 1.0, 1.5, 2.0, TSF

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PROJECT NUMBER: 425171	BORING NUMBER: MW111D	SHEET 2 OF 3

SOIL BORING LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469679.3 N, 2585479.1 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
DRILLING METHOD AND EQUIPMENT : CME 850 Track
WATER LEVELS : ---
START : 1/15/12 08:20
END : 1/15/12 12:00
LOGGER : J. Butler

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 – 32.0	18.0	16-SS	6-4-8-19 (12)	**SANDY SILT with GRAVEL (ML)** tan, wet, stiff, low plasticity, fine-grained sand with single ~1" subangular gravel in shoe		09:50 retrieve SS-16, PP: 0.5, 1.0 TSF
	32.0 – 34.0	20.0	17-SS	4-4-8-11 (12)	**SANDY SILT with TRACE GRAVEL (SM/ML)** similar to SS-16 with 1" layer angular gravel fragments at ~33', ~1" subangular gravel in shoe		
35	34.0 – 36.0	3.0	18-SS	4-8-50/4" (58/4")	**SILTY SAND with GRAVEL (SM/GM)** angular granite gravel up to 1" at ~35' (alluvium)		rig chatter at ~35' to 36', 11:40 retrieve SS-18 refusal blowcount starting @ 35', very hard drilling
	36.0 – 37.5	3.0	19-SS	50/3" (50/3")	**POORLY GRADED GRAVEL with SAND (GP)** dolomite bedrock, angular fragments up to 1/2"		11:10 retrieve SS-19, 11:20 drill 36-38' with tricore bit - no casing
40	37.5				Begin Rock Coring at 37.5 ft below ground surface See the next sheet for the rock core log		
45							
50							
55							
60							

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PROJECT NUMBER: 425171	BORING NUMBER: MW111D	SHEET 3 OF 3

ROCK CORE LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469679.3 N, 2585479.1 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
CORING METHOD AND EQUIPMENT : CME 850 Track, HQ-S Triple Tube
ORIENTATION :
WATER LEVELS : ---
START : 1/15/12 08:20
END : 1/15/12 12:00
LOGGER : J. Butler

DEPTH BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS)	SYMBOLLIC LOG	LITHOLOGY (ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS)	COMMENTS (SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.)
	37.5						top of rock at 37.5 ft bgs, drilled to depth of 38' on 1/12/12, ~2' into dolomite bedrock, ~4" black iron pipe grouted into rock socket on 1/12/12 08:20 - black pipe (4" ID), reamed out - send down core barrel to start coring at 38' 09:25 - start run #1, lost circulation at 39.7', regain circulation at 42', end run #1 10:25 10:40 - start run #2, no circulation 12:00 - run #2 to ~47', rig ran out of fuel - down with equipment problem, core barrel stall down hole piezometer constructed in boring, 4" steel outer casing set in rock to 38', grouted in 2" PVC inner casing, 3/8" bentonite chip 37-40', silica sand 40'-48', 0.010 slot screen 42-47', above-ground monument and locking cover set in top hole
	38.0		1			**DOLOMITE LIMESTONE** light gray, lost circulation, fractured zone	
40	20-HQ 5 ft 94%	82	2	mechanical break, smooth, fresh			
			1				
			1				
			2				
	43.0						
45	21-HQ 5 ft 97%	97		joints, 75 to 90 degrees, rough, undulating, loose, clean		**DOLOMITE LIMESTONE** light green-gray, slightly weathered, R3-R4, massive	
	48.0						
50						Bottom of Core at 48.0 ft below ground surface on 1/15/12 12:00	
55							
60							
65							

US EPA ARCHIVE DOCUMENT

PROJECT NUMBER: 425171	BORING NUMBER: MW112D	SHEET 1 OF 3

SOIL BORING LOG

PROJECT : Tyco Fire Products LP, Marinette, WI — LOCATION : (469442.1 N, 2585581.0 E)

ELEVATION : — DRILLING CONTRACTOR : ATL

DRILLING METHOD AND EQUIPMENT : CME 850 Track

WATER LEVELS : --- — START : 1/20/12 16:20 — END : 1/23/12 14:10 — LOGGER : J. Butler

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0 – 2.0	24.0	1-SS	6-3-3-7 (6)	**POORLY GRADED SAND (SP)** tan, moist, loose, mixed with organic material and roots		SS-1 at 12:04
	2.0 – 4.0	6.0	2-SS	2-2-2-1 (4)	Continued **POORLY GRADED SAND (SP)** mixed with decomposed leaves and wood pieces, some frozen soil		SS-2 at 12:09
5	4.0 – 6.0	6.0	3-SS	1-1-1-2 (2)	**ORGANIC SOIL (OH) and wood pieces** dark brown, wet, very soft, ~50/50 mix		Level down ~1' today river, SS-3 at 12:15
	6.0 – 8.0	9.6	4-SS	2-2-7-7 (9)	**ORGANIC SOIL/WOOD (OH) then POORLY GRADED SAND (SP)** last 0.4', tan-brown, wet, loose		SS-4 at 12:18
10	8.0 – 10.0	10.8	5-SS	3-4-7-13 (11)	**POORLY GRADED SAND (SP)** tan-brown, wet, medium dense, trace wood chips		SS-5 at 12:40, SS-5 possibly heave?
	10.0 – 12.0	19.2	6-SS	8-13-17-19 (30)	Continued **POORLY GRADED SAND (SP)** brown, wet, medium dense, fine and medium grained with <5% gravel (fine to coarse, rounded)		SS-6 at 12:53
	12.0 – 14.0	16.8	7-SS	5-5-6-5 (11)	similar to SS-6		SS-7 at 13:04
15	14.0 – 16.0	21.6	8-SS	21-43-45-62 (88)	**SILTY SAND (SM)** light brown-tan, moist to wet, very dense, homogeneous		SS-8 at 13:35, PP: 1.25 x 2 TSF
	16.0 – 18.0	21.6	9-SS	36-54-100/5" (R)	similar to SS-8		SS-9 at 13:40, PP: 1.25 TSF
20	18.0 – 20.0	20.4	10-SS	21-29-44-52 (73)	**SILTY SAND (SM) to POORLY GRADED SAND with SILT (SP-SM)** light pink-tan, moist to wet, very dense, sand very fine ~15-20% fines		SS-10 at 13:55, PP: 3.0 TSF
	20.0 – 22.0	24.0	11-SS	16-21-43-50 (64)	**POORLY GRADED SAND with SILT (SP-SM)** similar to SS-10		SS-11 at 14:42, PP: 3.0 TSF, strong odor
	22.0 – 24.0	16.8	12-SS	47-50/2" (R)	**POORLY GRADED SAND with SILT (SP-SM)** tan-brown, wet, very dense, very fine grained, ~10-15% fines		SS-12 at 14:50, river level rising since ~ 13:00 (seidre?)
25	24.0 – 26.0	24.0	13-SS	27-33-47-24 (80)	Continued **POORLY GRADED SAND with SILT (SP-SM)** similar to SS-12		SS-13 at 15:05, PP: 2.75, 3.0 TSF, strong odor
	26.0 – 28.0	24.0	14-SS	7-11-11-10 (22)	Contact at 27.1' with **LEAN CLAY (CL)** brown, wet, firm to stiff, medium plasticity, slow dilatency		SS-14 at 15:15, PP: 1.25, 0.75, 1.0 TSF
30	28.0 –	24.0	15-SS	0-8-12-16 (20)	Continued **LEAN CLAY (CL)** brown, wet, firm to stiff, low to medium plasticity		SS-15 at 16:00, end of drilling, 1/19/12, PP: 1.25, 1.0 TSF

US EPA ARCHIVE DOCUMENT

PROJECT NUMBER: 425171	BORING NUMBER: MW112D	SHEET 2 OF 3

SOIL BORING LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469442.1 N, 2585581.0 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
DRILLING METHOD AND EQUIPMENT : CME 850 Track
WATER LEVELS : ---
START : 1/20/12 16:20
END : 1/23/12 14:10
LOGGER : J. Butler

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 – 32.0	22.8	16-SS	5-9-9-18 (18)	Continued **LEAN CLAY (CL)**, then contact at 31.6' with **SILTY SAND (SM)** brown-tan, wet, medium dense, rapidly dilatent		SS-16 at 10:02
	32.0 – 34.0	24.0	17-SS	10-12-20-20 (32)	32-32.8' **LEAN CLAY (CL)** brown, moist, stiff 32.8'-34.0' **SILTY SAND (SM)** brown, wet, dense, rapidly dilatent, ~20% fines		SS-17 at 10:10
35	34.0 – 36.0	24.0	18-SS	11-12-12-14 (24)	**SILTY SAND (SM)** brown, moist, medium dense, 15-30% fines, slow to no dilatency		SS-18 at 10:30, PP: 2.5 TSF
	36.0 – 37.5	24.0	19-SS	2-2-3-2 (5)	**LEAN CLAY (CL)** brown, wet, firm, medium plasticity, very sticky		SS-19 at 10:35, PP: 1.0, 0.75, 0.75 TSF
40	37.5 – 40.2	24.0	20-SS	0-0-3-4 (3)	**LEAN CLAY (CL)** then contact at 58.8' with **SILTY SAND (SM)** brown, wet, very loose, contact at 40.2' with rock - see rock core log		SS-20, driller notes gravelly at 40' - advanced
	40.2				Begin Rock Coring at 40.2 ft below ground surface See the next sheet for the rock core log		Switch to rock core bit at 40.2 ft bgs Top of Rock at 40.2 ft bgs, tricore to 46.0' to set outer 4" steel casing and grout
45							
50							
55							
60							

US EPA ARCHIVE DOCUMENT

PROJECT NUMBER: 425171	BORING NUMBER: MW112D	SHEET 3 OF 3

ROCK CORE LOG

PROJECT : Tyco Fire Products LP, Marinette, WI
LOCATION : (469442.1 N, 2585581.0 E)
ELEVATION :
DRILLING CONTRACTOR : ATL
CORING METHOD AND EQUIPMENT : CME 850 Track, HQ-S Triple Tube
ORIENTATION :
WATER LEVELS : ---
START : 1/20/12 16:20
END : 1/23/12 14:10
LOGGER : J. Butler

DEPTH BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS)	SYMBOLLIC LOG	LITHOLOGY (ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS)	COMMENTS (SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.)
	40.2						top of rock 40.2 ft bgs 16:20 - casing advanced to 42.6', rock very fractured, poor circulation, advance borehole via tricore to 46' 1/20/12, end of drilling 1/20/12 at 46', advance to 47', 1/21/12, grout 4" casing
45							
	47.0 21-HQ 4.8 ft 100% 51.8	89	2 2 1 1 1	mechanical breaks (very clean)		**DOLOMITE LIMESTONE** green-gray, non weathered, massive	begin coring on HQ-21 at 11:30 on 1/23/12, gray fluid, good return, end run 13:30
50							
	22-HQ 5.2 ft 100% 56.9	95	1 2 1 0 0	mechanical breaks, very tight and clean		**DOLOMITE LIMESTONE** green-gray, non weathered, massive	begin run 13:00, steady coring, gray-white fluid, good return, end run 14:10
55							
						Bottom of Core at 56.9 ft below ground surface on 1/23/12 14:10	
60							
65							
70							

US EPA ARCHIVE DOCUMENT

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION

Form 4400-122 Rev. 7-98

Route To: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Tyco Safety Products - Ansul / Marinette VBW		AP-1

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Gary Jones Boart Longyear	12/20/2006	12/20/2006	4.25 I.D. HSA / SPT

WI Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
			Feet MSL	584.41 Feet MSL	8.0 inches

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 469595.18 N, 2585511.19 E S/C/N
1/4 of 1/4 of Section , T N, R
Lat ___ ° ___ ' ___ "
Long ___ ° ___ ' ___ "
Local Grid Location
Feet ☒ N ☐ S Feet ☒ E ☐ W

Facility ID	County	County Code	Civil Town/City/ or Village
	Marinette	38	Marinette

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				ALLUVIUM Medium dense, dark yellowish brown (10YR 3/4) POORLY GRADED SAND (SP); moist; nonplastic; noncohesive; massive; alluvium.	SP			0						Hand augered to 5 feet to confirm no shallow utilities. Description made from hand auger cuttings.
			5	Drilled without sampling to 22.0 feet.										
			10					0						

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Earth Tech Inc.	Earth Tech Inc

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number AP-1 Use only as an attachment to Form 4400-122.

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				Drilled without sampling to 22.0 feet.				0						
			20											
1	0.5 / 2	15 19 40 50/4 N=>50		**LACUSTRINE UNIT 1** Hard, grayish brown (10YR 5/2) SILT (ML); wet; nonplastic; noncohesive; massive; lacustrine.				0						
2	0.5 / 2	50/4 N=>50	25	As above from 22.0 to 24.0 feet.				0						
3	0.5 / 2	50/5 N=>50		As above from 22.0 to 26.0 feet.	ML									
4	0.5 / 2	50/5 N=>50		As above from 22.0 to 28.0 feet.										
5	1 / 2	42 50/4 N=>50	30	As above from 22.0 to 30.0 feet.				0						
6	1 / 2	33 32 45 25 N=>50		**LACUSTRINE UNIT 2** Hard, reddish brown (5YR 5/3) LEAN CLAY (CL); moist; low plasticity; slightly cohesive; massive; lacustrine.	CL									
7	1 / 2	50/5 N=>50	35	As above from 32.0 to 34.0 feet.				0						
8	1 / 2	6 29 13 6 N=42		**GLACIAL DIAMICTON** Hard, reddish brown (5YR 5/2) LEAN CLAY (CL); moist; medium plasticity; cohesive; massive; little sand, trace gravel; diamicton.	CL			0						
9	0.5 / 2	50/6 N=>50		As above from 36.0 to 38.0 feet.				0						Auger refusal at 39.0 feet.
				END OF BORING AT 39.0 FEET.										

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION

Form 4400-122 Rev. 7-98

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Tyco Safety Products - Ansul / Marinette VBW		AP-20

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Joe Loubert RVT Corp	11/28/2006		3.25 I.D. HSA / SPT

WI Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
			Feet MSL	584.63 Feet MSL	7.0 inches

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 470278.45 N, 2584919.34 E S/C/N
1/4 of 1/4 of Section , T N, R
Lat ___ ° ___ ' ___ "
Long ___ ° ___ ' ___ "
Local Grid Location
Feet ☒ N ☐ S
Feet ☒ E ☐ W

Facility ID	County	County Code	Civil Town/City/ or Village
	Marinette	38	Marinette

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				FILL Black (10YR 2/1) POORLY GRADED SAND WITH GRAVEL (SP); moist; nonplastic; noncohesive; massive; little gravel; fill.	SP									Hand augered to 5 feet to confirm no shallow utilities. Description made from hand auger cuttings.
				ALLUVIUM Strong brown (7.5YR 5/6) POORLY GRADED SAND (SP); moist; nonplastic; noncohesive; massive; fine sand; alluvium.	SP									
			5	Drilled without sampling to 20.0 feet.										
			10											

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Signature	Firm
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SOIL BORING LOG INFORMATION SUPPLEMENT

Form 4400-122A

Boring Number AP-20 Use only as an attachment to Form 4400-122.

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				Drilled without sampling to 20.0 feet.										
1	1 / 2	18 38 22 26 N=>50	20	**LACUSTRINE UNIT 1** Hard; grayish brown (10YR 5/2) SANDY SILT (ML); wet; nonplastic; noncohesive; massive; lacustrine.	ML			0						
2	2 / 2	Shelby tube						0						Shelby tube sample from 22.0 to 24.0 feet.
3	1.75 / 2	7 10 14 22 N=24	25	**GLACIAL DIAMICTON** Very stiff, dark grayish brown (10YR 4/2) LEAN CLAY WITH GRAVEL (CL); moist; low plasticity; cohesive; massive; diamicton.	CL			0						
4	1.5 / 2	8 22 22 26 N=44		As above from 24.0 to 26.0 feet, but consistency changes to hard.				0						
5	1.75 / 2	7 10 14 17 N=24		Very stiff, reddish brown (5YR 4/3) LEAN CLAY WITH GRAVEL (CL); moist; low plasticity; cohesive; massive; diamicton.	CL			0						
6	0.5 / 2	50/6 N=>50	30	As above from 28.0 to 30.0 feet, but consistency changes to hard.										
7	1 / 2	3 5 33 38 N=38		Hard, brown (7.5YR 4/2) LEAN CLAY WITH GRAVEL (CL); moist; low plasticity; cohesive; massive; diamicton.	CL									
8	1.25 / 2	3 20 50/5 N=>50	35	As above from 32.0 to 34.0 feet. Silty sand lens from 35.5 to 35.7 feet.										
9	1.5 / 2	7 32 50/3 N=>50		Hard, dark reddish gray (5YR 4/2) LEAN CLAY WITH GRAVEL (CL); moist; low plasticity; cohesive; few gravel; diamicton.	CL									
				END OF BORING AT 37.4 FEET.										

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION

Form 4400-122 Rev. 7-98

Route To: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Tyco Safety Products - Ansul / Marinette VBW		CPT-19

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Gary Jones Boart Longyear	1/4/2007	1/4/2007	4.25 I.D. HSA / SPT

WI Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
			Feet MSL	581.55 Feet MSL	8.0 inches

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 470003.93 N, 2584901.52 E S/C/N
1/4 of 1/4 of Section , T N, R
Lat ___ ° ___ ' ___ "
Long ___ ° ___ ' ___ "
Local Grid Location
Feet ☒ N ☐ S
Feet ☒ E ☐ W

Facility ID	County	County Code	Civil Town/City/ or Village
	Marinette	38	Marinette

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				Drilled without sampling to 23.0 feet.				0						Hand augered to 5 feet to confirm no shallow untilities.
			5					0						
			10					0						Auger cuttings are wet at 10.0 feet.

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
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State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number CPT-19 Use only as an attachment to Form 4400-122.

Sample									Soil Properties					
Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				Drilled without sampling to 23.0 feet.										
								0						Augered through boulder at 16.0 feet.
			20					0						
				END OF BORING AT 23.0 FEET.										Auger refusal at 23.0 feet. Driller thinks auger may be on concrete or rebar.
			25											
			30											
			35											

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION

Form 4400-122 Rev. 7-98

Route To: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Tyco Safety Products - Ansul / Marinette VBW		SPT-1

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Gary Jones Boart Longyear	12/19/2006	12/20/2006	4.25 I.D. HSA / SPT

WI Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
			Feet MSL	583.66 Feet MSL	8.0 inches

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 469510.56 N, 2585542.08 E S/C/N
1/4 of 1/4 of Section , T N, R
Lat ° ' "
Long ° ' "
Local Grid Location Feet ☒ N ☐ S Feet ☒ E ☐ W

Facility ID	County	County Code	Civil Town/City/ or Village
	Marinette	38	Marinette

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				ALLUVIUM				0						Hand augered to 5 feet to confirm no shallow utilities. Description made from hand auger cuttings.
				Dark yellowish brown (10YR 3/4) CLAYEY SAND (SC); moist; low plasticity; slightly cohesive; massive; alluvium.	SC									
				Dark grayish brown (10YR 4/2) POORLY GRADED SAND (SP); moist; nonplastic; noncohesive; massive; alluvium.	SP			0						
			5											
1	0.5 / 2	23 22 15 18 N=37		Dense, dark gray (10YR 4/1) POORLY GRADED SAND (SP); wet; nonplastic; noncohesive; massive; fine to medium sand; alluvium.										Began split spoon sampling at 6.0 feet.
2	1.5 / 2	19 11 11 10 N=22		As above from 6.0 to 8.0 feet, but medium dense, trace gravel.				0						
			10											
3	1 / 2	10 11 15 10 N=26		As above from 8.0 to 10.0 feet.	SP									
4	2 / 2	6 5 11 28 N=16		As above from 8.0 to 12.0 feet.				0						
5	2 / 2	8 12 17		Medium dense, dark gray (10YR 4/1) POORLY GRADED SAND (SP); wet;	SP			0						

I hereby certify that the information on this form is true and correct to the best of my knowledge.

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SOIL BORING LOG INFORMATION SUPPLEMENT

Form 4400-122A

Boring Number SPT-1 Use only as an attachment to Form 4400-122.

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
		50/4 N=29		nonplastic; noncohesive; massive; fine to medium sand; alluvium.										
6	0.5 / 2	50/1 N=>50		As above from 14.0 to 16.0 feet, but density changes to very dense.	SP									
7	1.5 / 2	8 9 27 50/2 N=36		As above from 14.0 to 18.0 feet, but density changes to dense.				0						
8	1 / 2	50/3 N=>50	20	**LACUSTRINE UNIT 1** Very dense, grayish brown (10YR 5/2) SILTY SAND (SM); moist; nonplastic; noncohesive; massive; fine sand; lacustrine.	SM			0						
9	0.5 / 2	50/3 N=>50		Hard, grayish brown (10YR 5/2) SILT WITH SAND (ML); moist; nonplastic; noncohesive; massive; lacustrine.				0						Cobble at 22.0 feet.
10	0.5 / 2	50 50/3 N=>50	25	As above from 22.0 to 24.0 feet.				0						
11	0.5 / 2	30 50/1 N=>50		As above from 22.0 to 26.0 feet.				0						
12	1 / 2	10 11 42 50/1 N=>50		As above from 22.0 to 28.0 feet.	ML			0						
13	0.5 / 2	50/5 N=>50	30	As above from 22.0 to 30.0 feet.				0						
14	1 / 2	10 29 40 50/3 N=>50		As above from 22.0 to 32.0 feet.										
				Becomes clayey at bottom of sample.										
15	1.5 / 2	10 12 11 13 N=23	35	**LACUSTRINE UNIT 2** Very stiff, reddish gray (5YR 5/2) LEAN CLAY (CL); moist; low to medium plasticity; cohesive; faintly laminated; lacustrine.										
16	2 / 2	Shelby tube			CL			0	1900	26.6	38	20	94	Shelby tube sample from 36.0 to 38.0 feet.
17	1.9 / 2	10 8 12 50/4 N=20		As above from 34.0 to 38.0 feet.				0						
				GLACIAL DIAMICTON	CL									

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number SPT-1 Use only as an attachment to Form 4400-122.

Sample									Soil Properties					
Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				Very stiff, reddish brown (5YR 4/3) LEAN CLAY WITH SAND (CL); wet to moist; low plasticity; slightly cohesive; massive; little sand, trace gravel; diamicton.	CL									
				END OF BORING AT 40.5 FEET.										
			45											
			50											
			55											
			60											

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION

Form 4400-122 Rev. 7-98

Route To: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Tyco Safety Products - Ansul / Marinette VBW		SPT-12

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Gary Jones Boart Longyear	12/6/2006	12/6/2006	4.25 I.D. HSA / SPT

WI Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
			Feet MSL	583.58 Feet MSL	8.0 inches

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 470171.36 N, 2584878.48 E S/C/N
1/4 of 1/4 of Section , T N, R
Lat ° ' "
Long ° ' "
Local Grid Location Feet ☒ N ☐ S Feet ☒ E ☐ W

Facility ID	County	County Code	Civil Town/City/ or Village
	Marinette	38	Marinette

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				ALLUVIUM Very dark gray (10YR 3/1) POORLY GRADED SAND (SP); moist; nonplastic; noncohesive; massive; fine sand; alluvium.	SP									Hand augered to 5 feet to confirm no shallow utilities. Description made from hand auger cuttings.
				Strong brown (7.5YR 5/6) POORLY GRADED SAND (SP); moist; nonplastic; noncohesive; massive; fine sand; alluvium.	SP									
			5	Augered without sampling to 6.0 feet to begin continuous SPT sampling.										
1	0.6 / 2	1 0 1 0 N=1		Very loose, very dark grayish brown (10YR 3/2) POORLY GRADED SAND (SP); wet; nonplastic; noncohesive; massive; fine sand; alluvium.	SP									
2	0.7 / 2	1 1 8 6 N=9		Loose, black (10YR 2/1) SILTY SAND (SM); wet; nonplastic; noncohesive; thinly bedded; some silt; black wood fragments; alluvium.	SM									
3	1.2 / 2	4 8 20 16 N=28	10	Very stiff, black (10YR 2/1) SILT (ML); wet; nonplastic; noncohesive; massive; trace wood fragments; alluvium.	ML									
4	1.4 / 2	7 9 9 14 N=18		Medium dense, black (10YR 2/1) POORLY GRADED SAND (SP); wet; nonplastic; noncohesive; massive; medium sand; trace pebble gravel; alluvium.	SP			0						
5	2 / 2	4 9 17		As above from 10.5 to 14.0 feet.				0						

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Earth Tech Inc.	Earth Tech Inc

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

SOIL BORING LOG INFORMATION SUPPLEMENT

Form 4400-122A

Boring Number SPT-12 Use only as an attachment to Form 4400-122.

Sample Number and Type	Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
		30 N=26			SP			0						
6	2 / 2	22 30 30 35 N=>50		Medium dense, very dark gray (10YR 3/1) POORLY GRADED SAND (SP); wet; nonplastic; noncohesive; massive; fine sand; alluvium.	SP									
7	2 / 2	25 85 65/4 N=>50		Very dense, very dark gray (10YR 3/1) POORLY GRADED SAND (SP); wet; nonplastic; noncohesive; massive; medium sand; alluvium. As above from 16.0 to 18.0 feet.	SP					11.7				Jar sample from 18.0 to 20.0 feet.
8	2 / 2	26 24 24 25 N=48	20	As above from 16.0 to 20.0 feet, but dense.				0						
9	0.2 / 2	18 94/4 N=>50		**GLACIAL DIAMICTON** Very dense, reddish brown (5YR 5/3) SILTY SAND (SM); moist; low plasticity; trace gravel; some silt, few to little clay; glacial diamicton.	SM					6.8				
10	0.2 / 2	87/3 N=>50	25	As above from 21.7 to 24.0 feet, but low recovery because spoon tip clogged with dolomite gravel. Possible boulder for much of this interval.				0						SPT refusal at 24.3 feet.
1	0.25 / 6		30	Poor recovery: about 3" recovered including gravel fragments of dolomite and basalt; diamicton as above in core barrel bit. Refusal at 26.0 feet appears to have been on a boulder in the diamicton	ML			0						Auger refusal at 26.0 feet. Set up to do NX rock core. Coring rate approximately 0.5 to 1.0 feet per minute.
11		50/2 N=>50						0						No recovery. Switched back to HSA / SPT sampling.
12	0.8 / 2	15 50/5 N=>50	35	Hard, dark reddish gray (5YR 4/2) LEAN CLAY (CL); moist; medium to high plasticity; cohesive; massive; lean clay in glacial diamicton.	CL									Lean clay lens in the diamicton.
13	1 / 2	14 33 50/4 N=>50		Hard, reddish brown (5YR 4/3) SANDY SILT (ML); moist; low plasticity; cohesive; massive; trace gravel, little sand; glacial diamicton. Fine sand seam from 36.5 to 36.7 feet.	ML			0						
14	0.5 / 2	100/6 N=>50		As above from 36.0 to 38.0 feet, diamicton.				0						

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number SPT-12 Use only as an attachment to Form 4400-122.

Sample Number and Type	Sample Length Att. & Recovered (ft)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
15	0.4 / 2	50/3 N=>50		As above from 36.0 to 40.0 feet, diamicton.	ML			0						
				END OF BORING AT 41.0 FEET.										Auger refusal at 41.0 feet.
			45											
			50											
			55											
			60											

Tyco Fire Products LP
Sediment Investigationl N-Values
Menominee River, Marinette, WI

			Lithology Elevations (ft NAVD88)				N-value																																								
Sample Location	Water Elevation (ft NAVD88)	Water Depth (ft)	Sediment Surface Elevation	Top of Subsoil	Top of Till	Bedrock	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
SD-500	578.5	5.5	573.0	568.5	565.6	561.0		1				27				57				41				>100																					
SD-501	578.9	4.0	574.9	570.9	565.5	ND		1				14				65				>100																									
SD-502	578.8	24.5	554.3	553.8	ND	545.8		13				28				50				48																									
SD-504	578.8	21.5	557.3	552.3	557.3	549.3		>100				>100																																	
SD-506	578.8	6.5	572.3	571.8	561.8	ND		0				0				3				9				30				>100																	
SD-509	578.8	22.5	556.3	552.3	547.9	ND		20				52				49																													
SD-510	578.4	15.1	563.3	558.3	556.3	ND		70				68				>100																													
SD-511	578.6	23.5	555.1	554.5	550.6	548.6		47				>100				68																													
SD-512	578.9	20.5	558.4	553.4	558.4	ND		65				>100																																	
SD-513	578.4	10.5	567.9	566.9	551.2	ND		22				38				14				39				66				26				15				16			47					
SD-514	579.0	26.5	552.5	549.5	552.5	542.0		10				22				45				>100																									
SD-515	579.0	14.5	564.5	560.5	545.7	538.5		15				33				24				20				84				68				42				18			17				43	
SD-516	579.0	2.5	576.5	573.8	548.5	546.5		0				1				31				42				47				73				49				39			55				60	
SD-517	578.9	21.5	557.4	556.9	544.9	ND		32				43				14				8				20				4				13													
SD-519	579.0	2.5	576.5	571.5	547.2	542.7		3				4				5				25				34				60				66				63			47				29	
SD-577	579.0	2.3	576.7	568.7	ND	ND		8				28				25				43				77				>100				77				48									
SD-523	578.9	1.5	577.4	572.4	546.4	ND		3				3				3				3				9				26				17				10			54				71	
SD-574	578.6	1.9	576.7	571.7	546.7	543.9		3				4				21				53				77				49				39				86			52				>100	
SD-575	579.0	2.5	576.5	571.5	545.6	545.0		4				5				4				5				65				17				18				49			51				1	
SD-551	578.4	24.5	553.9	553.0	550.4	ND		0				44																																	
SD-552	578.7	24.0	554.7	554.1	549.9	547.7		0				47				26				>100																									
SD-553	578.6	23.5	555.1	552.6	549.6	548.6		19				52																																	
SD-554	578.7	24.5	554.2	550.7	548.2	540.2		63				43				22				85				18				>100																	
SD-555	578.7	25.5	553.2	550.2	543.2	ND		18				23				66				40																									
SD-556	578.7	21.5	557.2	556.9	548.7	541.7		27				12				12				12				25				33				32				>100									
SD-557	578.7	14.5	564.2	559.2	ND	542.7		13				5				37				31				72				>100				11				10									
SD-576	578.8	3.5	575.3	570.3	544.3	541.8		3				4				23				26				36				56				48				48			25				13	
SD-560	578.6	4.5	574.1	569.1	544.1	542.6		0				9				8				21				>100				79				32				15			59				7	
SD-561	578.5	4.5	574.0	569.0	542.2	539.5		0				0				0				24				48				72				30				33			7				33	
SD-562	578.9	5.5	573.4	568.4	542.4	540.9		14				25				36				25				31				57				58				59			36				heaving sar	
SD-563	578.7	2.5	576.2	571.2	ND	ND		2				10				11																													
SD-564	578.5	25.5	553.0	552.5	547.7	545.5		4				4				27				>100																									
SD-565	578.6	25.5	553.1	552.1	546.7	ND		4				22				24				50				>100																					
SD-566	578.5	25.5	553.0	552.1	547.0	ND		5				10				46				>100																									

semi-consolidated material
till
bedrock

US EPA ARCHIVE DOCUMENT

Tyco Fire Products LP
Sediment Investigationl N-Values
Menominee River, Marinette, WI

			N-value																			
Sample Location	**Water Elevation (ft NAVD88)**	**Water Depth (ft)**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**
SD-500	578.5	5.5																				
SD-501	578.9	4.0																				
SD-502	578.8	24.5																				
SD-504	578.8	21.5																				
SD-506	578.8	6.5																				
SD-509	578.8	22.5																				
SD-510	578.4	15.1																				
SD-511	578.6	23.5																				
SD-512	578.9	20.5																				
SD-513	578.4	10.5																				
SD-514	579.0	26.5																				
SD-515	579.0	14.5			>100																	
SD-516	579.0	2.5			17			10			19			>100								
SD-517	578.9	21.5																				
SD-519	579.0	2.5			4			6			7			0				>100				
SD-577	579.0	2.3																				
SD-523	578.9	1.5			>100			>100			54			43								
SD-574	578.6	1.9			94			90			16			50								
SD-575	579.0	2.5			21			3			5											
SD-551	578.4	24.5																				
SD-552	578.7	24.0																				
SD-553	578.6	23.5																				
SD-554	578.7	24.5																				
SD-555	578.7	25.5																				
SD-556	578.7	21.5																				
SD-557	578.7	14.5																				
SD-576	578.8	3.5			43			43			18			13								
SD-560	578.6	4.5			17			2			8											
SD-561	578.5	4.5			44			28			>100			13				>100				
SD-562	578.9	5.5	nds		64			78			95			>100								
SD-563	578.7	2.5																				
SD-564	578.5	25.5																				
SD-565	578.6	25.5																				
SD-566	578.5	25.5																				

semi-consolidated materi
till
bedrock

US EPA ARCHIVE DOCUMENT

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

LETTER OF TRANSMITTAL

DATE	JOB NO.
February 23, 2012	12009

ATTENTION: Kyle Block

RE: Tyco Fire Products, LP
Marinette, WI

TO: CH2M Hill Constructors, Inc.
P.O. Box 241329
Denver, CO 80224

WE ARE SENDING: ☒ Attached ☐ Under separate cover via _____ the following items:

COPIES	DATE	NO.	DESCRIPTION
1.	2/23/12	-	Moisture Content
			Mechanical
			Hydrometer
			Liquid and Plastic Limits
			Unconfined Compressive Strength-Intact Rock Core
			Splitting Tensile Strength-Intact Rock Core
			Chemistry Results

THE ABOVE TRANSMITTED as checked below:

☐ For approval ☐ As requested ☐ Other: _____

☐ For your use ☐ For review and comment _____

REMARKS:

COPY TO: _____

COLEMAN ENGINEERING COMPANY

SIGNED: Kelly Prevost

Kelly Prevost
Administrative Assistant

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

MOISTURE CONTENT DETERMINATION

ASTM D-2216

Project Name: Tyco Fire Products, LP

Client: CH2M Hill Constructors, Inc. Job No: GL-12009

Address: P.O. Box 241329, Denver, CO 80224

Location of Project: Tyco Fire Products, Marinette, WI Date: 2/13/2012

Boring No.	MW110D	MW110D	MW110D	MW111D	MW111D
Sample No.	S2 - S6	S10 - S13	S14 - S18	S3 - S6	S8 - S13
Depth (ft.)	F	18-28	28-38	4-12	14-26
Pan No.	64	55	67	68	50
Weight-Wet Sample & Tare (g)	520.9	619.4	726.5	656.7	695.5
Weight-Dry Sample & Tare (g)	489.9	588.9	701.5	606.9	648.4
Weight of Moisture (g)	31.0	30.5	25.0	49.8	47.1
Weight of Tare (g)	342.9	342.1	342.3	341.9	341.7
Weight of Dry Soil (g)	147.0	246.8	359.2	265.0	306.7
Moisture Content (%)	21.1	12.4	7.0	18.8	15.4

Boring No.	MW111D	MW112D	MW112D	MW112D	
Sample No.	S15 - S17	S1 - S4	S8 - S11	S19 - S20	
Depth (ft.)	28-34	0-8	14-22	36-40	
Pan No.	59	61	60	62	
Weight-Wet Sample & Tare (g)	722.9	637.0	752.9	477.1	
Weight-Dry Sample & Tare (g)	683.5	557.3	697.3	453.1	
Weight of Moisture (g)	39.4	79.7	55.6	24.0	
Weight of Tare (g)	342.4	341.2	341.1	341.8	
Weight of Dry Soil (g)	341.1	216.1	356.2	111.3	
Moisture Content (g)	11.6	36.9	15.6	21.6	

Remarks:

Tested By: MD Date: 2/14/2012

Submitted By: Date:

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (SM) Silty Sand, Fine Boring No. MW110D

Shape: Hardness: Sample No. S2-S6

Remarks: Pan #64 Depth: 2'-12'

Date Rec'd:

MECHANICAL ANALYSIS PORTION OF HYDROMETER ANALYSIS

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5			
1	25.4			
3/4	19.1			
1/2	12.7	0.0	0.0	100.0
4M	4.76	1.2	0.8	99.2
10M	2.00	1.5	1.0	98.2
40M	0.42	3.0	2.0	96.2
100M	0.149	7.7	5.2	91.0
200M	0.074	72.7	49.5	41.5
Pan		61.1	41.5	

***Percent Based on Total Sample**

Original Sample: 147.2

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

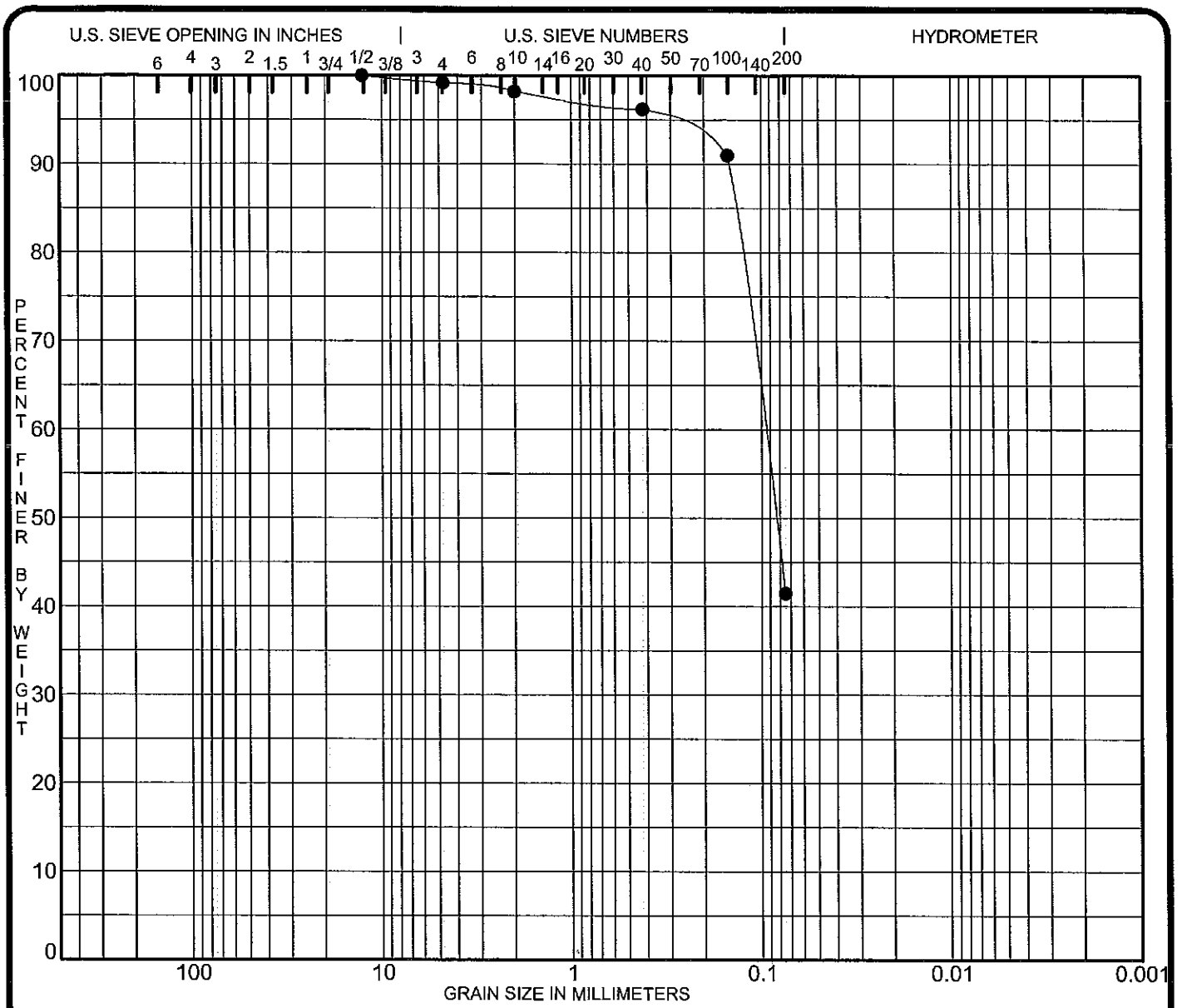
Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 147.2 gm

Weight After Wash = 103.2 gm

Form: D422A
Revision Date: 1/17/05

Tested By: J. Edlebeck Date: 2/21/2012
Submitted By: _____ Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW110D S2-S6 2.0**	**(SM) SILTY SAND, fine**						

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW110D S2-S6 2.0**	**12.70**	**0.10**			**0.8**	**57.7**	**41.5**	

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (SM-SC) Silty Clayey Sand Boring No. MW110D

Shape: Hardness: Sample No. S10-S13

Remarks: Pan #55 Depth: 18'-28'

Date Rec'd:

MECHANICAL ANALYSIS PORTION OF HYDROMETER ANALYSIS

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5			
1	25.4			
3/4	19.1	0.0	0.0	100.0
1/2	12.7	8.8	3.6	96.4
4M	4.76	20.3	8.2	88.2
10M	2.00	17.1	6.9	81.3
40M	0.42	21.6	8.7	72.6
100M	0.149	36.6	14.8	57.8
200M	0.074	27.9	11.3	46.5
Pan		114.6	46.5	

***Percent Based on Total Sample**

Original Sample: 246.9

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 246.9 gm

Weight After Wash = 136.2 gm

Form: D422A
Revision Date: 1/17/05

Tested By: J. Edlebeck
Submitted By: _____

Date: 2/21/2012
Date: _____

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

PARTICLE-SIZE ANALYSIS OF SOILS - HYDROMETER

(ASTM D422)

Project Name: Tyco Fire Products, LP — C.E.C Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Remarks: (SM-SC) Silty Clayey Sand

Boring No: MW 110D
Sample No: S10-S13
Depth: 18'-28'
Date Received: 2/10/2012

Dispersing Agent Used: Sodium Hexametaphosphate

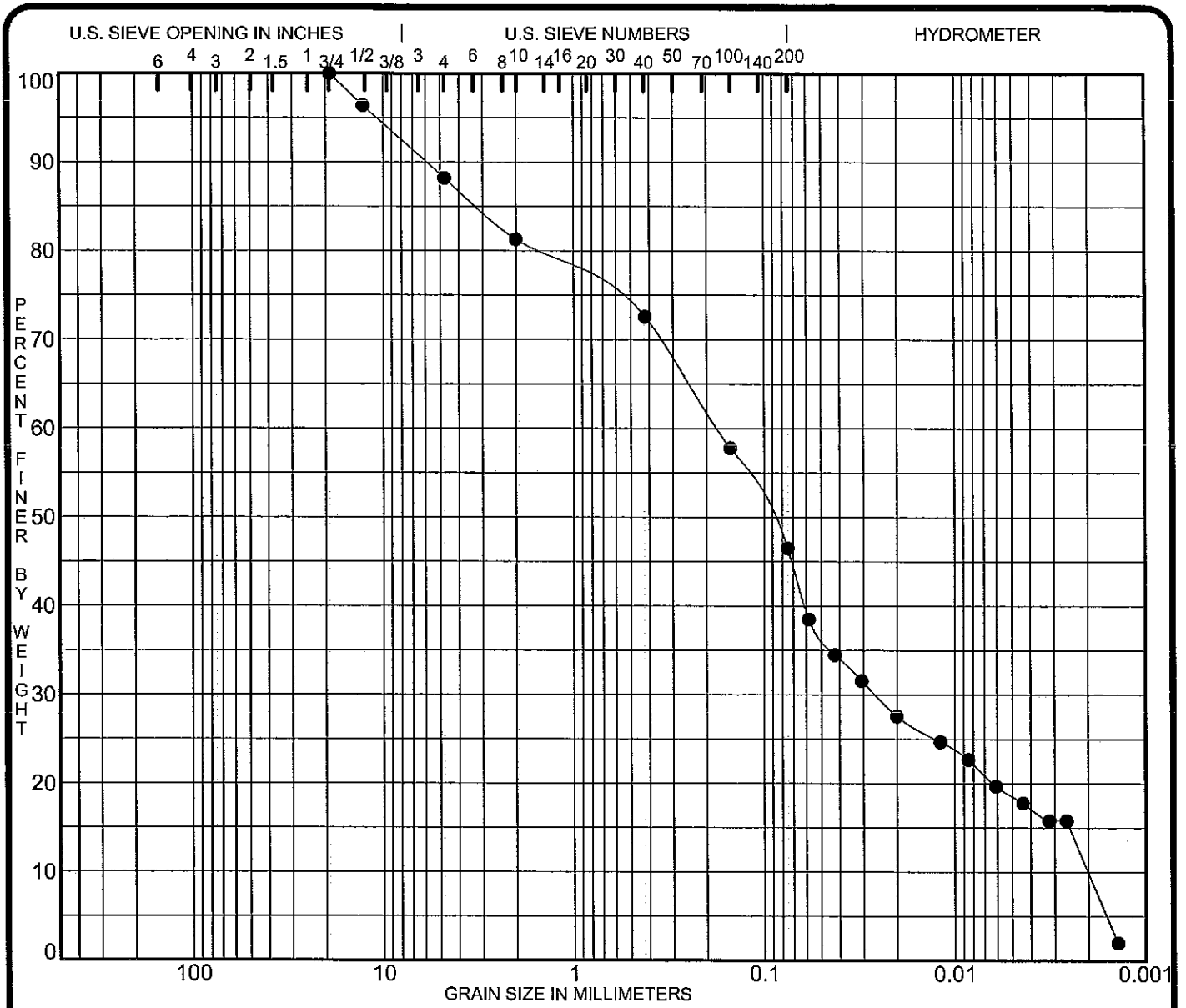
Amount: 125ml @ 4% solution
Hydrometer Number: 152H
Specific Gravity (G): 2.7
Starting Time: 10:29:00

% of Original Sample Used For Hydrometer Analysis: 81.3 %
Weight of Sample Dispersed: 81.61 g.

Time	Elapsed Time Minutes (T)	Hydrometer Reading	Temperature °C	Correction (DR)	Corr. Hydrometer Reading (R)	Percent Soil in Suspension (P)	K, Values from Table III	L, Values from Table II	Calculated Grain Diameter, mm (d)	Percent of Total Sample C.G.D.
10:29:30	0.5	44	19	5	39	47.3	0.01361	9.1	0.0581	38.5
10:30:00	1.0	40	19	5	35	42.5	0.01361	9.7	0.0424	34.5
10:31:00	2.0	37	19	5	32	38.8	0.01361	10.2	0.0307	31.6
10:34:00	5.0	33	19	5	28	34.0	0.01361	10.9	0.0201	27.6
10:44:00	15.0	30	19	5	25	30.3	0.01361	11.4	0.0119	24.7
10:59:00	30.0	28	19	5	23	27.9	0.01361	11.7	0.0085	22.7
11:29:00	60.0	25	19	5	20	24.3	0.01361	12.2	0.0061	19.7
12:29:00	120.0	23	19	5	18	21.8	0.01361	12.5	0.0044	17.8
14:29:00	240.0	21	19	5	16	19.4	0.01361	12.9	0.0032	15.8
16:19:00	351.0	21	19	5	16	19.4	0.01361	12.9	0.0026	15.8
10:29:00	1440.0	7	19	5	2	2.4	0.01361	15.2	0.0014	2.0

Tested By: D. Edlebeck — Date: 2/17/2012

Submitted By: _____ Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW110D S10-S13 18.0**	**(SM-SC) SILTY CLAYEY SAND**					**1.92**	**87.2**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW110D S10-S13 18.0**	**19.00**	**0.17**	**0.026**	**0.0020**	**11.8**	**41.7**	**28.0**	**18.5**

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

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REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (SC) Clayey Sand Boring No. MW110D

Shape: Hardness: Sample No. S14-S18

Remarks: Pan #67 Depth: 28'-38'

Date Rec'd:

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5	0.0	0.0	100.0
1	25.4	20.9	5.8	94.2
3/4	19.1	21.0	5.8	88.4
1/2	12.7	16.0	4.4	84.0
4M	4.76	15.9	4.4	79.6
10M	2.00	17.5	4.9	74.7
40M	0.42	29.5	8.2	66.5
100M	0.149	52.0	14.5	52.0
200M	0.074	39.4	11.0	41.0
Pan		147.5	41.0	

MECHANICAL ANALYSIS
PORTION OF HYDROMETER ANALYSIS

***Percent Based on Total Sample**

Original Sample: 359.7

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 246.9 gm

Weight After Wash = 218.1 gm

Form: D422A
Revision Date: 1/17/05

Tested By: J. Edlebeck Date: 2/21/2012
Submitted By: _____ Date: _____

COLEMAN ENGINEERING COMPANY
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PARTICLE-SIZE ANALYSIS OF SOILS - HYDROMETER

(ASTM D422)

Project Name: Tyco Fire Products, LP — C.E.C Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Remarks: (SC) Clayey Sand

Boring No: MW110D
Sample No: S14-S18
Depth: 28'-38'
Date Received: 2/16/2012

Dispersing Agent Used: Sodium Hexametaphosphate

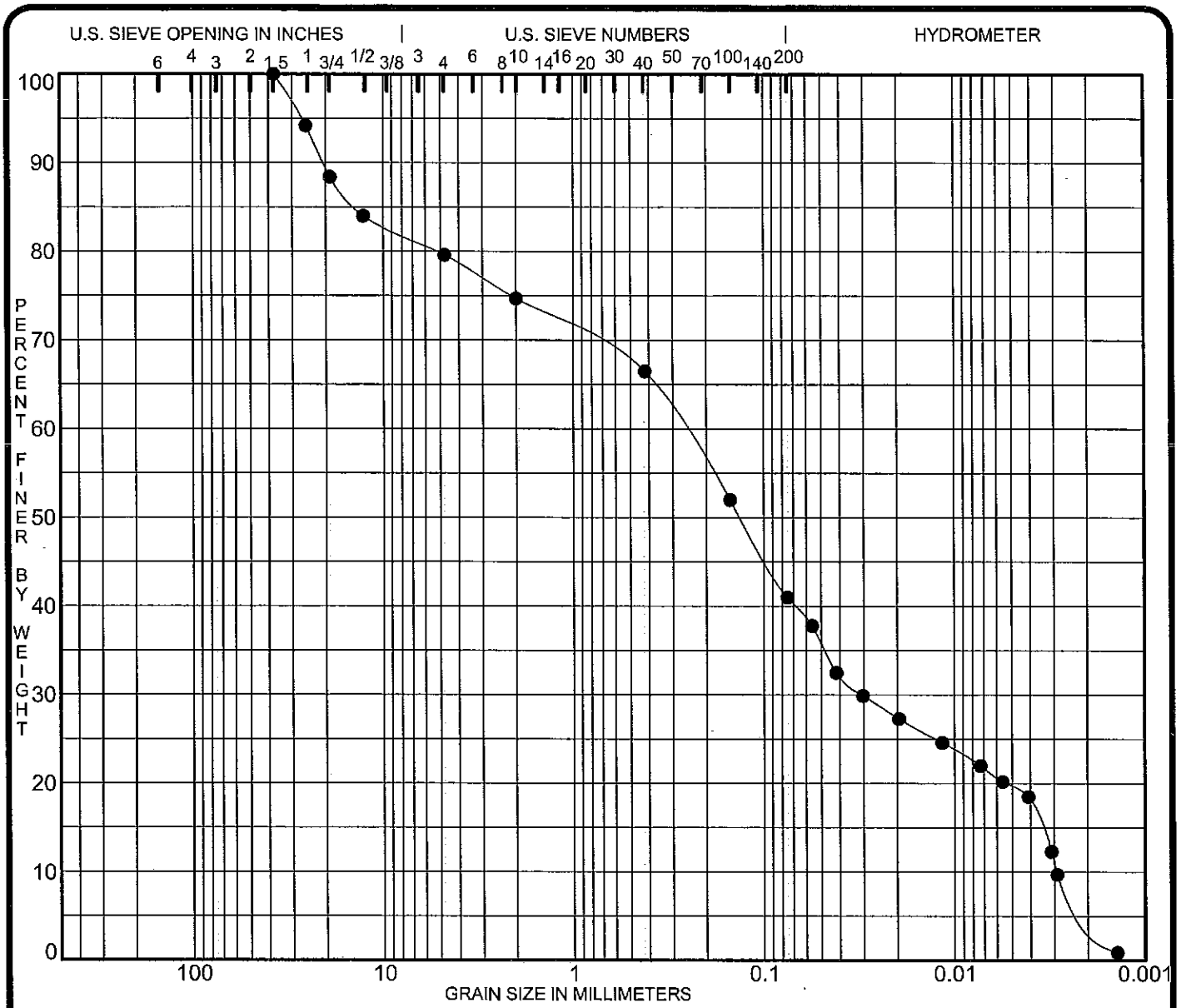
Amount: 125ml @ 4% solution
Hydrometer Number: 152H
Specific Gravity (G): 2.7
Starting Time: 11:28:00

% of Original Sample Used For Hydrometer Analysis: 74.7 %
Weight of Sample Dispersed: 84.07 g.

Time	Elapsed Time Minutes (T)	Hydrometer Reading	Temperature ° C	Correction (DR)	Corr. Hydrometer Reading (R)	Percent Soil in Suspension (P)	K, Values from Table III	L, Values from Table II	Calculated Grain Diameter, mm (d)	Percent of Total Sample C.G.D.
11:28:30	0.5	48	19	5	43	50.6	0.01361	8.4	0.0558	37.8
11:29:00	1.0	42	19	5	37	43.6	0.01361	9.4	0.0417	32.5
11:30:00	2.0	39	19	5	34	40.0	0.01361	9.9	0.0303	29.9
11:33:00	5.0	36	19	5	31	36.5	0.01361	10.4	0.0196	27.3
11:43:00	15.0	33	19	5	28	33.0	0.01361	10.9	0.0116	24.6
12:08:00	40.0	30	19	5	25	29.4	0.01361	11.4	0.0073	22.0
12:38:00	70.0	28	19	5	23	27.1	0.01361	11.7	0.0056	20.2
13:38:00	130.0	26	19	5	21	24.7	0.01361	12.0	0.0041	18.5
15:38:00	250.0	19	19	5	14	16.5	0.01361	13.2	0.0031	12.3
16:25:00	297.0	16	19	5	11	13.0	0.01361	13.7	0.0029	9.7
11:28:00	1440.0	6	19	5	1	1.2	0.01361	15.3	0.0014	0.9

Tested By: Dave Edlebeck — Date: 2/17/2012

Submitted By: _____ Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW110D S14-S18 28.0**	**(SC) CLAYEY SAND**					**1.22**	**90.6**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW110D S14-S18 28.0**	**37.50**	**0.26**	**0.031**	**0.0029**	**20.4**	**38.6**	**21.4**	**19.6**

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

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REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (SP) Sand, Fine to Medium, Trace of Silt Boring No. MW111D

Shape: Hardness: Sample No. S3-S6

Remarks: Pan #68 Depth: 4'-12'

Date Rec'd:

	Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
	3"	76.2			
	2"	50.8			
	1 1/2"	37.5			
	1	25.4			
	3/4	19.1			
	1/2	12.7	0.0	0.0	100.0
	4M	4.76	3.5	1.3	98.7
	10M	2.00	5.4	2.0	96.7
MECHANICAL ANALYSIS PORTION OF HYDROMETER ANALYSIS	40M	0.42	111.5	42.0	54.7
	100M	0.149	131.1	49.5	5.2
	200M	0.074	6.3	2.4	2.8
	Pan		7.3	2.8	

***Percent Based on Total Sample**

Original Sample: 265.1

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

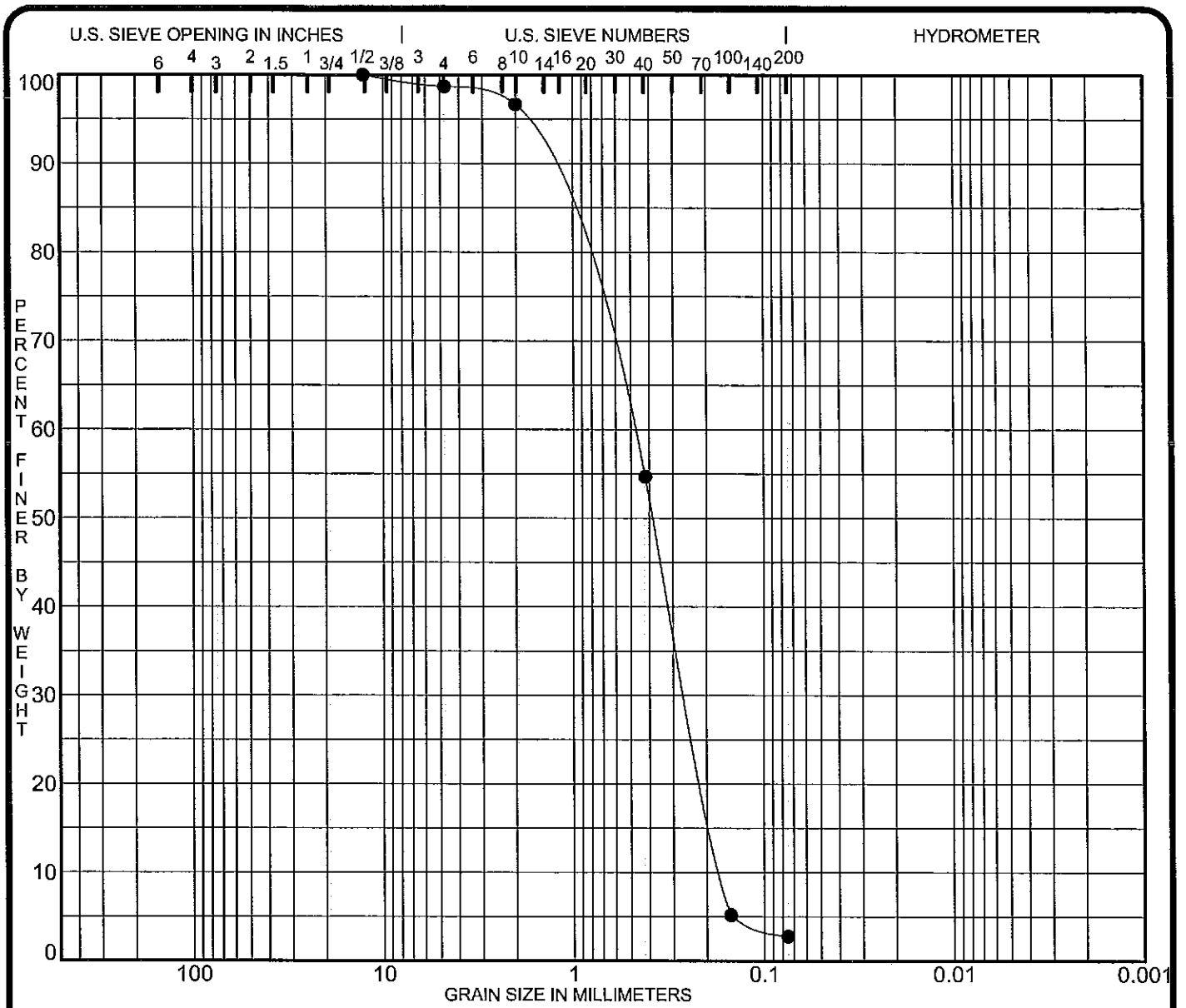
Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 265.1 gm
Weight After Wash = 258.9 gm

Form: D422A
Revision Date: 1/17/05

Tested By: J. Edlebeck
Submitted By: _____

Date: 2/21/2012
Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **MW111D S3-S6 4.0**	**(SP) SAND, fine to medium, trace silt**					**0.74**	**3.1**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **MW111D S3-S6 4.0**	**12.70**	**0.51**	**0.251**	**0.1657**	**1.3**	**95.9**	**2.8**	

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

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REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (ML) Silt, non-plastic with sand Boring No. MW111D

Shape: Hardness: Sample No. S8-S13

Remarks: Pan #50 Depth: 14'-26'

Date Rec'd:

	Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
	3"	76.2			
	2"	50.8			
	1 1/2"	37.5			
	1	25.4			
	3/4	19.1			
	1/2	12.7			
	4M	4.76	0.0	0.0	100.0
	10M	2.00	0.5	0.2	99.8
MECHANICAL ANALYSIS	40M	0.42	1.4	0.4	99.4
	100M	0.149	1.9	0.6	98.8
PORTION OF HYDROMETER ANALYSIS	200M	0.074	68.2	22.2	76.6
	Pan		234.9	76.5	0

***Percent Based on Total Sample**

Original Sample: 306.9

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 306.9 gm

Weight After Wash = 88.9 gm

Form: D422A
Revision Date: 1/17/05

Tested By: J. Edlebeck Date: 2/21/2012
Submitted By: _____ Date: _____

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
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PARTICLE-SIZE ANALYSIS OF SOILS - HYDROMETER

(ASTM D422)

Project Name: Tyco Fire Products, LP — C.E.C Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Remarks: (ML) Silt, Non-plastic

Boring No: MW111D
Sample No: S8-S13
Depth: 14'-26'
Date Received: 2/16/2012

Dispersing Agent Used: Sodium Hexametaphosphate

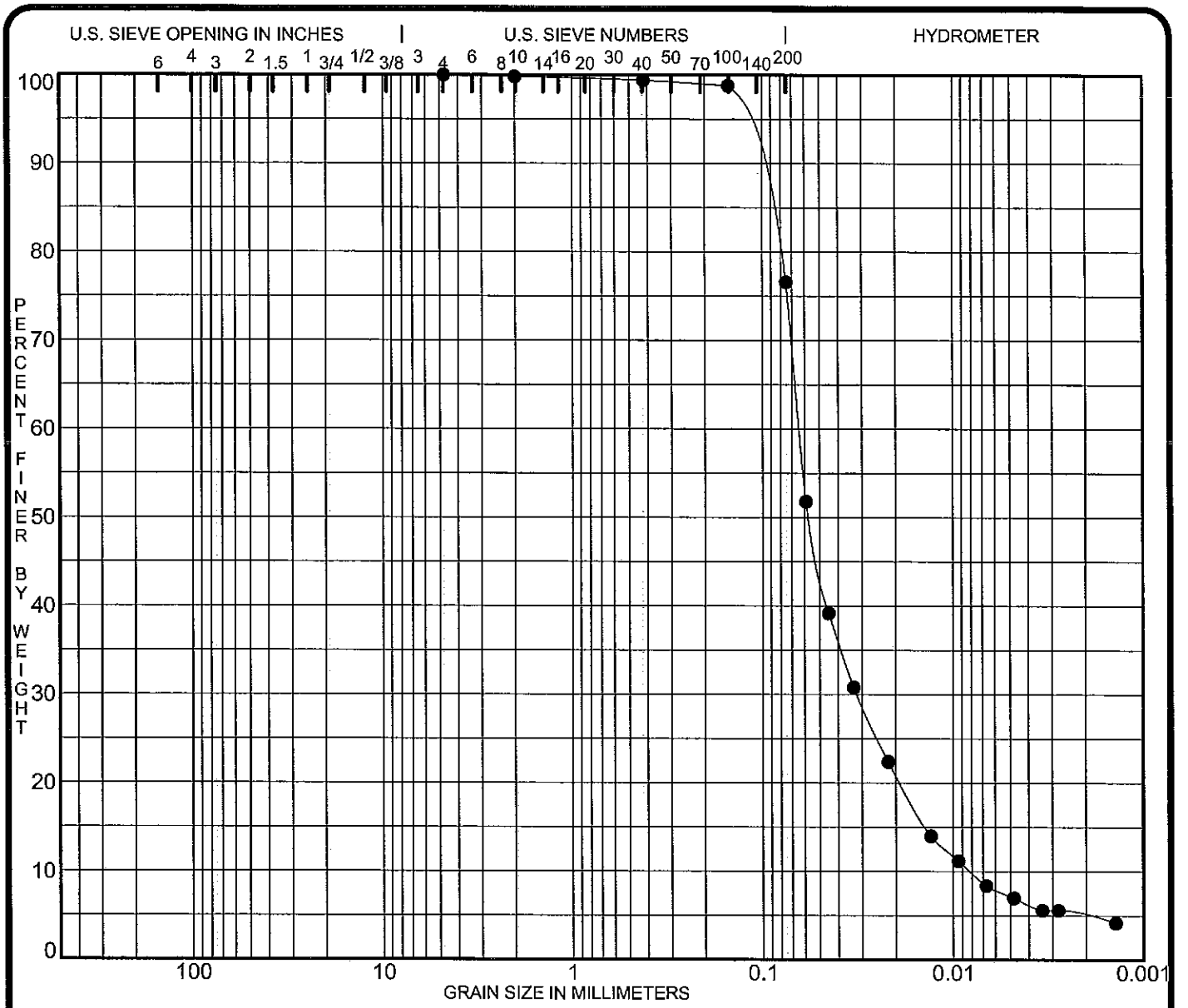
Amount: 125ml @ 4% solution
Hydrometer Number:
Specific Gravity (G): 2.70
Starting Time: 10:41:00

% of Original Sample Used For Hydrometer Analysis: 99.8 %
Weight of Sample Dispersed: 70.51 g.

Time	Elapsed Time Minutes (T)	Hydrometer Reading	Temperature °C	Correction (DR)	Corr. Hydrometer Reading (R)	Percent Soil in Suspension (P)	K, Values from Table III	L, Values from Table II	Calculated Grain Diameter, mm (d)	Percent of Total Sample C.G.D.
10:41:30	0.5	42	19	5	37	52.0	0.01361	9.4	0.0590	51.8
10:42:00	1.0	33	19	5	28	39.3	0.01361	10.9	0.0449	39.2
10:43:00	2.0	27	19	5	22	30.9	0.01361	11.9	0.0332	30.8
10:46:00	5.0	21	19	5	16	22.5	0.01361	12.9	0.0219	22.4
10:57:00	15.0	15	19	5	10	14.0	0.01361	13.8	0.0131	14.0
11:11:00	30.0	13	19	5	8	11.2	0.01361	14.2	0.0094	11.2
11:41:00	60.0	11	19	5	6	8.4	0.01361	14.7	0.0067	8.4
12:41:00	120.0	10	19	5	5	7.0	0.01361	14.7	0.0048	7.0
14:41:00	240.0	9	19	5	4	5.6	0.01361	14.8	0.0034	5.6
16:21:00	351.0	9	19	5	4	5.6	0.01361	14.8	0.0028	5.6
10:41:00	1440.0	8	19	5	3	4.2	0.01361	15.0	0.0014	4.2

Tested By: Dave Edlebeck — Date: 2/17/2012

Submitted By: — Date:



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW111D S8-S13 14.0**	**(ML) SILT, non-plastic, with sand**					**1.96**	**7.9**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW111D S8-S13 14.0**	**4.75**	**0.06**	**0.032**	**0.0081**	**0.0**	**23.4**	**69.4**	**7.2**

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

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REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (SM) Silty Sand, Fine to Medium, Trace of Gravel Boring No. MW111D

Shape: Hardness: Sample No. S15-S17

Remarks: Pan #59 Depth: 28'-34'

Date Rec'd:

MECHANICAL ANALYSIS PORTION OF HYDROMETER ANALYSIS

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5			
1	25.4			
3/4	19.1			
1/2	12.7	0.0	0.0	100.0
4M	4.76	32.1	9.4	90.6
10M	2.00	15.9	4.7	85.9
40M	0.42	27.7	8.1	77.8
100M	0.149	76.6	22.4	55.4
200M	0.074	46.6	13.6	41.8
Pan		142.8	41.8	

***Percent Based on Total Sample**

Original Sample: 341.7

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 341.7 gm

Weight After Wash = 203.4 gm

Form: D422A
Revision Date: 1/17/05

Tested By: J. Edlebeck Date: 2/21/2012
Submitted By: _____ Date: _____

COLEMAN ENGINEERING COMPANY
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PARTICLE-SIZE ANALYSIS OF SOILS - HYDROMETER

(ASTM D422)

Project Name: Tyco Fire Products, LP — C.E.C Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Remarks: (SM) Silty sand, fine to medium, trace gravel

Boring No: MW111D
Sample No: S15-S17
Depth: 28'-34'
Date Received: 2/16/2012

Dispersing Agent Used: Sodium Hexametaphosphate

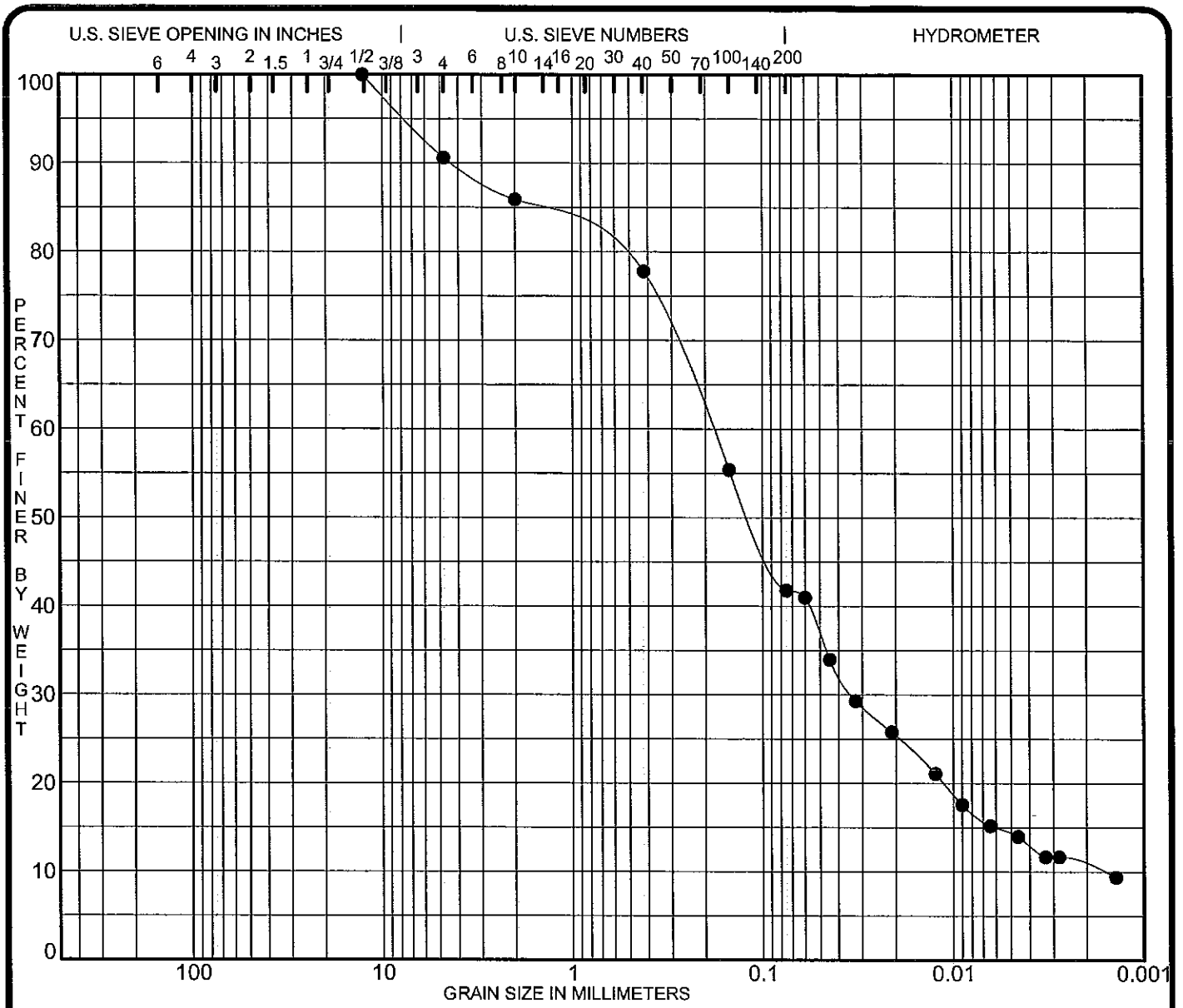
Amount: 125ml @ 4% solution
Hydrometer Number:
Specific Gravity (G): 2.70
Starting Time: 11:08:00

% of Original Sample Used For Hydrometer Analysis: 85.9 %
Weight of Sample Dispersed: 72.64 g.

Time	Elapsed Time Minutes (T)	Hydrometer Reading	Temperature ° C	Correction (DR)	Corr. Hydrometer Reading (R)	Percent Soil in Suspension (P)	K, Values from Table III	L, Values from Table II	Calculated Grain Diameter, mm (d)	Percent of Total Sample C.G.D.
11:08:00	0.5	40	19	5	35	47.7	0.01361	9.7	0.0599	41.0
11:09:00	1.0	34	19	5	29	39.5	0.01361	10.7	0.0445	34.0
11:10:00	2.0	30	19	5	25	34.1	0.01361	11.4	0.0325	29.3
11:13:00	5.0	27	19	5	22	30.0	0.01361	11.9	0.0210	25.8
11:23:00	15.0	23	19	5	18	24.5	0.01361	12.5	0.0124	21.1
11:38:00	30.0	20	19	5	15	20.4	0.01361	13.0	0.0090	17.6
12:09:00	61.0	18	19	5	13	17.7	0.01361	13.3	0.0064	15.2
13:08:00	120.0	17	19	5	12	16.4	0.01361	13.5	0.0046	14.0
15:08:00	240.0	15	19	5	10	13.6	0.01361	13.8	0.0033	11.7
16:24:00	316.0	15	19	5	10	13.6	0.01361	13.8	0.0028	11.7
11:08:00	1440.0	13	19	5	8	10.9	0.01361	14.2	0.0014	9.4

Tested By: Dave Edlebeck — Date: 2/17/2012

Submitted By: — Date:



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW111D S15-S17 28.0**	**(SM) SILTY SAND, fine to medium,**					**3.73**	**110.5**
		trace of gravel						

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW111D S15-S17 28.0**	**12.70**	**0.19**	**0.034**	**0.0017**	**9.4**	**48.8**	**27.5**	**14.3**

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

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REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL

(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (SP) Sand, Fine to Medium, Trace Silt Boring No. MW112D

Shape: Hardness: Sample No. S1-S4

Remarks: Pan # 61 Depth: 0-8'

Date Rec'd:

MECHANICAL ANALYSIS PORTION OF HYDROMETER ANALYSIS

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5			
1	25.4			
3/4	19.1			
1/2	12.7			
4M	4.76	0.0	0.0	100.0
10M	2.00	14.1	6.5	93.5
40M	0.42	51.6	23.8	69.7
100M	0.149	138.8	64.0	5.7
200M	0.074	7.0	3.2	2.5
Pan		5.5	2.5	

***Percent Based on Total Sample**

Original Sample:

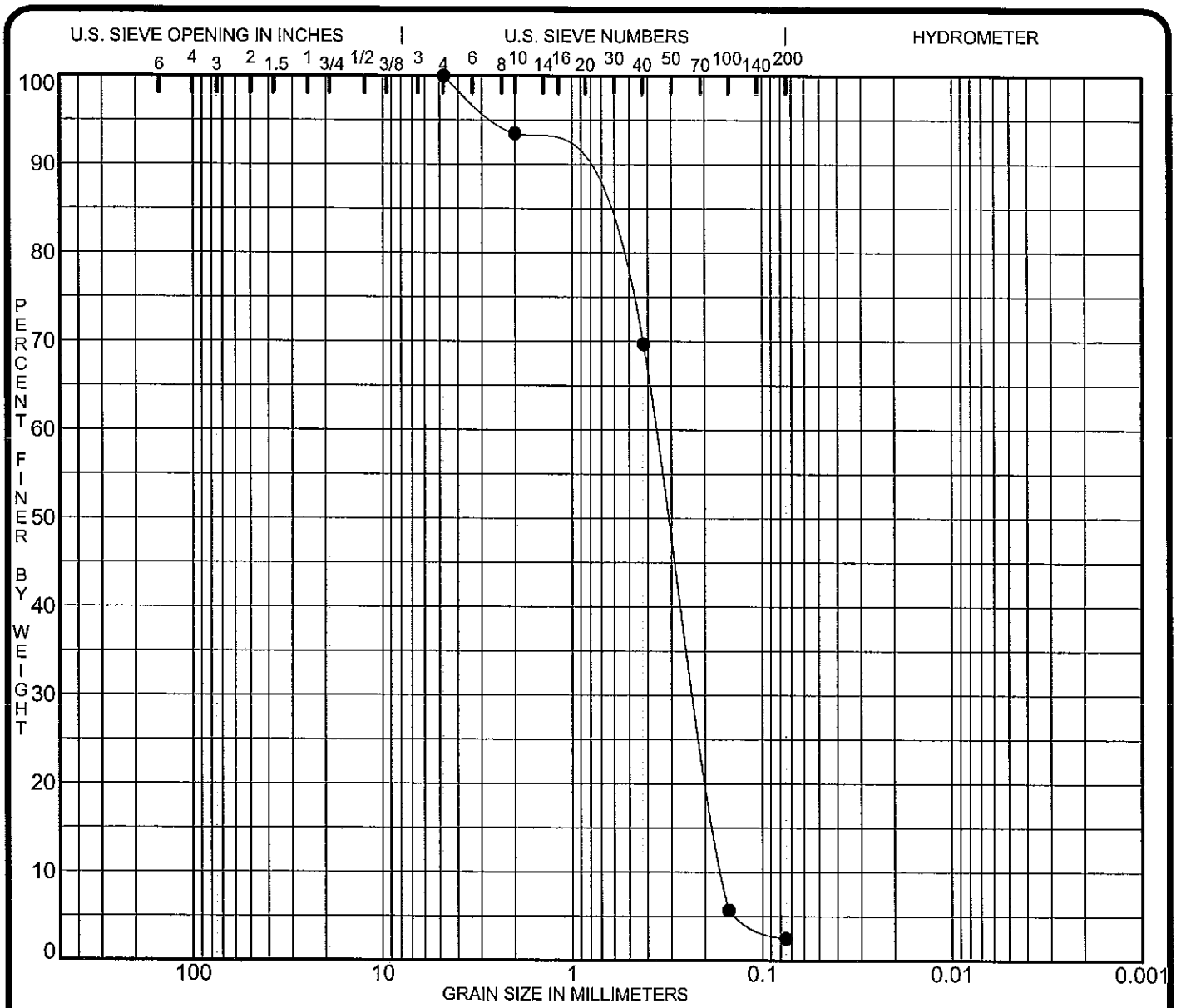
Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 217.0 gm
Weight After Wash = 211.8 gm

Form: D422A
Revision Date: 1/17/05

Tested By: _____ Date: _____
Submitted By: _____ Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW112D S1-S4**	**0.0**	**(SP) SAND, fine to medium, trace silt**					**0.85**	**2.2**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW112D S1-S4**	**0.0**	**4.75**	**0.36**	**0.222**	**0.1607**	**0.0**	**97.5**	**2.5**	

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (CL) Sandy Lean Clay Boring No. MW112D

Shape: Hardness: Sample No. S8-S11

Remarks: Pan #60 Depth: 14'-22'

Date Rec'd:

MECHANICAL ANALYSIS
PORTION OF HYDROMETER ANALYSIS

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5			
1	25.4			
3/4	19.1			
1/2	12.7	0.0	0.0	100.0
4M	4.76	1.1	0.3	99.7
10M	2.00	0.9	0.3	99.4
40M	0.42	2.0	0.6	89.8
100M	0.149	15.5	4.4	85.4
200M	0.074	125.9	35.3	59.1
Pan		210.8	59.0	

***Percent Based on Total Sample**

Original Sample:

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 356.2 gm
Weight After Wash = 162.8 gm

Form: D422A
Revision Date: 1/17/05

Tested By: _____ Date: _____
Submitted By: _____ Date: _____

COLEMAN ENGINEERING COMPANY
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PARTICLE-SIZE ANALYSIS OF SOILS - HYDROMETER

(ASTM D422)

Project Name: Tyco Fire Products, LP — C.E.C Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Remarks: (CL) Sandy Lean Clay

Boring No: MW112D
Sample No: S8-S11
Depth: 14'-22'
Date Received: 2/16/2012

Dispersing Agent Used: Sodium Hexametaphosphate

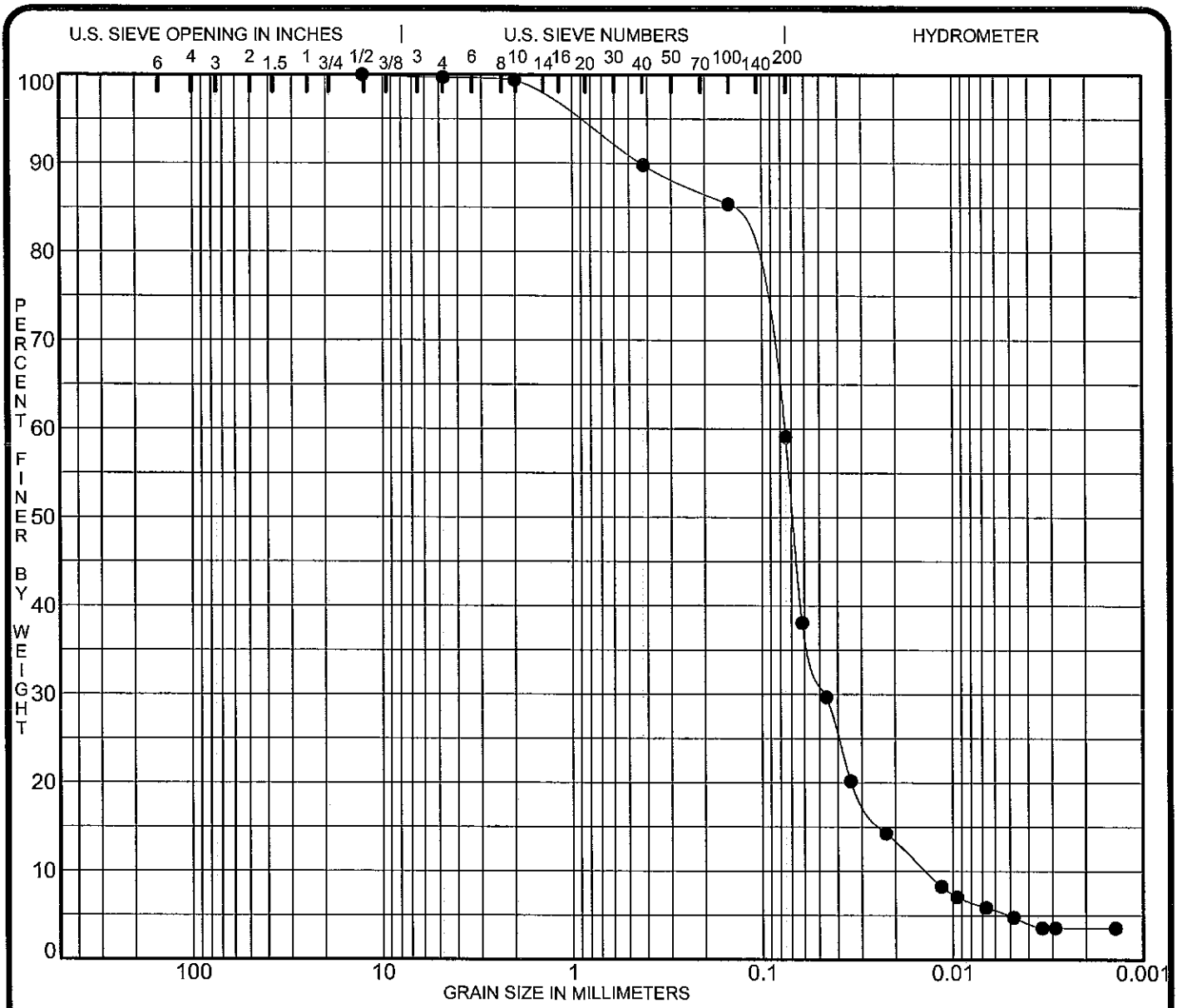
Amount: 125ml @ 4% solution
Hydrometer Number: 152H
Specific Gravity (G): 2.70
Starting Time: 10:51:00

% of Original Sample Used For Hydrometer Analysis: 99.4 %
Weight of Sample Dispersed: 82.73 g.

Time	Elapsed Time Minutes (T)	Hydrometer Reading	Temperature ° C	Correction (DR)	Corr. Hydrometer Reading (R)	Percent Soil in Suspension (P)	K, Values from Table III	L, Values from Table II	Calculated Grain Diameter, mm (d)	Percent of Total Sample C.G.D.
10:51:00	0.5	37	19	5	32	38.3	0.01361	10.2	0.0615	38.1
10:52:00	1.0	30	19	5	25	29.9	0.01361	11.4	0.0460	29.7
10:53:00	2.0	22	19	5	17	20.3	0.01361	12.7	0.0343	20.2
10:56:00	5.0	17	19	5	12	14.4	0.01361	13.5	0.0224	14.3
11:11:00	20.0	12	19	5	7	8.4	0.01361	14.3	0.0115	8.3
11:21:00	30.0	11	19	5	6	7.2	0.01361	14.7	0.0095	7.1
11:51:00	60.0	10	19	5	5	6.0	0.01361	14.7	0.0067	5.9
12:51:00	120.0	9	19	5	4	4.8	0.01361	14.8	0.0048	4.8
14:51:00	240.0	8	19	5	3	3.6	0.01361	15.0	0.0034	3.6
16:22:00	331.0	8	19	5	3	3.6	0.01361	15.0	0.0029	3.6
10:51:00	1440.0	8	19	5	3	3.6	0.01361	15.0	0.0014	3.6

Tested By: Dave Edlebeck — Date: 2/17/2012

Submitted By: _____ Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW112D S8-S11 14.0**	**(CL) SANDY LEAN CLAY**					**2.02**	**5.5**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW112D S8-S11 14.0**	**12.70**	**0.08**	**0.046**	**0.0139**	**0.3**	**40.6**	**54.2**	**4.9**

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**

DATE **2/22/12**

GRADATION CURVES

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REPORT OF: PARTICLE-SIZE ANALYSIS OF SOILS - MECHANICAL
(ASTM D422)

Job Name: Tyco Fire Products, LP C.E.C. Job #: GL-12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Soil Description: (CL) Lean Clay, with Sand Boring No. MW112D

Shape: Hardness: Sample No. S19-S20

Remarks: Pan #62 Depth: 36'-40'

Date Rec'd:

Sieve Size	Grain Diameter (mm)	Weight Retained	Percent Retained	Percent Finer
3"	76.2			
2"	50.8			
1 1/2"	37.5			
1	25.4			
3/4	19.1			
1/2	12.7	0.0	0.0	100.0
4M	4.76	0.1	0.1	99.9
10M	2.00	0.9	0.8	99.1
40M	0.42	3.1	2.8	96.3
100M	0.149	9.3	8.3	88.0
200M	0.074	6.3	5.7	82.3
Pan		91.7	82.3	

MECHANICAL ANALYSIS
PORTION OF HYDROMETER ANALYSIS

***Percent Based on Total Sample**

Original Sample:

Material retained on No. 10 mesh: weight = _____ gm = 0.0% %

Material passing No. 10 mesh: weight = _____ gm = 0.0% %

Weight of Total Sample = 111.4 gm
Weight After Wash = 20 gm

Form: D422A
Revision Date: 1/17/05

Tested By: _____ Date: _____
Submitted By: _____ Date: _____

COLEMAN ENGINEERING COMPANY
635 Circle Drive
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PARTICLE-SIZE ANALYSIS OF SOILS - HYDROMETER

(ASTM D422)

Project Name: Tyco Fire Products, LP — C.E.C Job #: GL12009

Client: CH2M Hill Constructors, Inc.

Address: P.O. Box 241329, Denver, CO 80224

Remarks: (CL) Lean Clay with sand

Boring No: MW112D
Sample No: S19-S20
Depth: 36'-40'
Date Received: 2/16/2012

Dispersing Agent Used: Sodium Hexametaphosphate

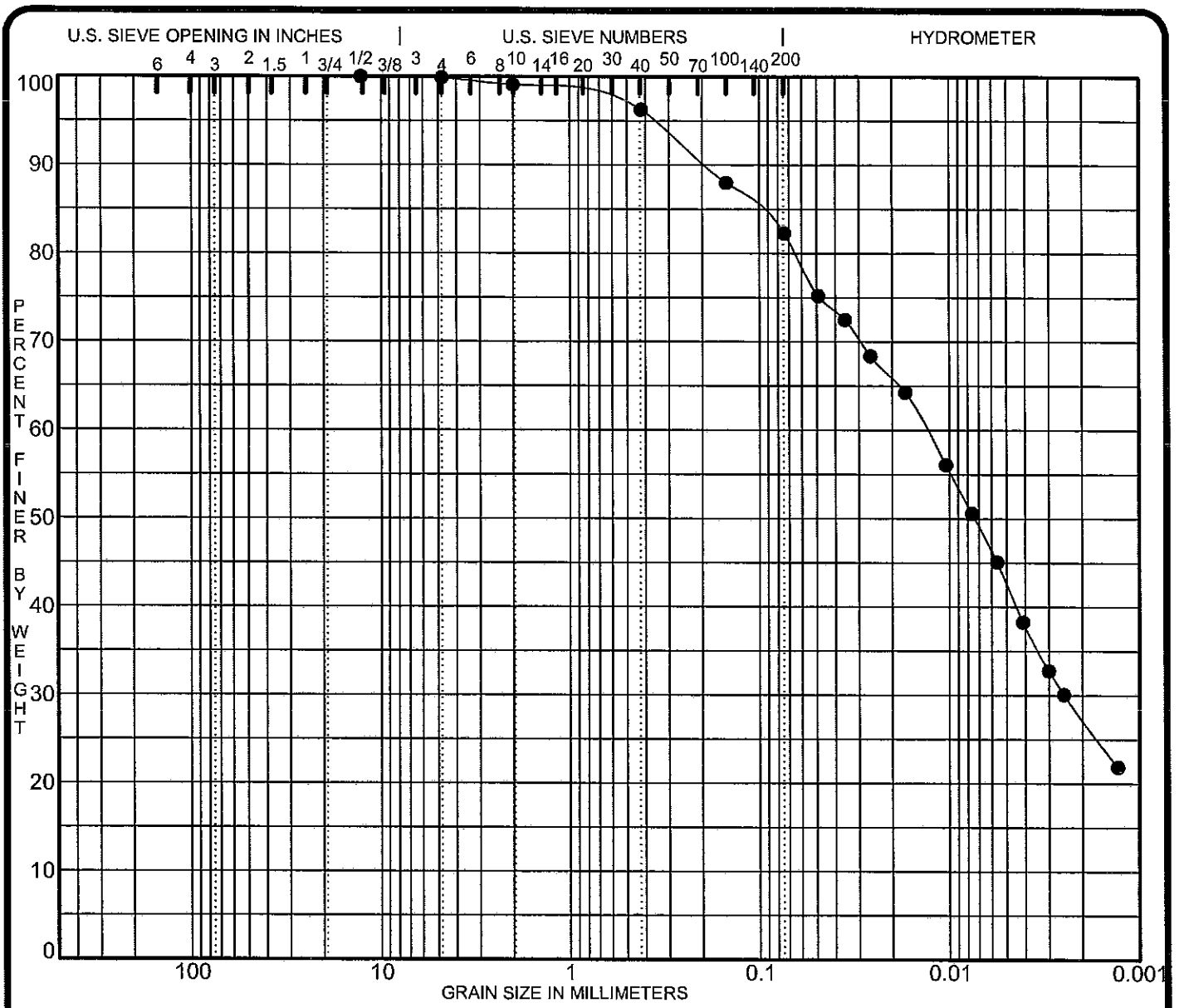
Amount: 125ml @ 4% solution
Hydrometer Number: 152H
Specific Gravity (G): 2.70
Starting Time: 10:34:00

% of Original Sample Used For Hydrometer Analysis: 99.1 %
Weight of Sample Dispersed: 71.72 g.

Time	Elapsed Time Minutes (T)	Hydrometer Reading	Temperature ° C	Correction (DR)	Corr. Hydrometer Reading (R)	Percent Soil in Suspension (P)	K, Values from Table III	L, Values from Table II	Calculated Grain Diameter, mm (d)	Percent of Total Sample C.G.D.
10:34:30	0.5	60	19	5	55	75.9	0.01361	6.5	0.0491	75.2
10:35:00	1.0	58	19	5	53	73.2	0.01361	6.8	0.0355	72.5
10:36:00	2.0	55	19	5	50	69.0	0.01361	7.3	0.0260	68.4
10:39:00	5.0	52	19	5	47	64.9	0.01361	7.8	0.0170	64.3
10:49:00	15.0	46	19	5	41	56.6	0.01361	8.8	0.0104	56.1
11:04:00	30.0	42	19	5	37	51.1	0.01361	9.4	0.0076	50.6
11:34:00	60.0	38	19	5	33	45.6	0.01361	10.1	0.0056	45.1
12:34:00	120.0	33	19	5	28	38.7	0.01361	10.9	0.0041	38.3
14:34:00	240.0	29	19	5	24	33.1	0.01361	11.5	0.0030	32.8
16:20:00	346.0	27	19	5	22	30.4	0.01361	11.9	0.0025	30.1
10:34:00	1440.0	21	19	5	16	22.1	0.01361	12.9	0.0013	21.9

Tested By: Dave Edlebeck — Date: 2/17/2012

Submitted By: _____ Date: _____



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **MW112D S19-S20 36.0**	**(CL) LEAN CLAY, with sand**						

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **MW112D S19-S20 36.0**	**12.70**	**0.01**	**0.002**		**0.1**			**42.6**

PROJECT **Tyco Fire Products - Ansul Facility - Marinette, WI**

JOB NO. **12009**
DATE **2/23/12**

GRADATION CURVES

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COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

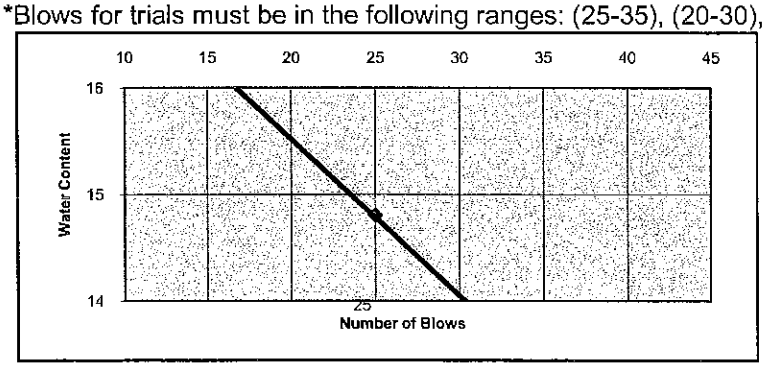
ASTM D-4318

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date Received:**
Address: P.O. Box 241329, Denver, CO 80224
Description of Soil: (SM-SC) Silty Clayey Sand
Depth of Sample: 18'-28' **Boring No.:** MW110D **Sample No.:** S10-S13

Liquid Limit Determination Bowl #25

Can No.	37	41	45			
Wt. of wet soil +can (g)	25.74	27.80	31.04			
Wt. of dry soil + can (g)	24.48	26.15	29.23			
Wt. of can (g)	15.99	15.92	15.93			
Wt of dry soil (g)	8.49	15.92	15.93			
Wt of moisture (g)	1.26	1.65	1.81			
* No of blows, N (g)	**25**	**16**	**33**			
Water content, *w* %	**14.8**	**16.1**	**13.6**			
K Values and Corrected Average					**Corrected Average**	

*Blows for trials must be in the following ranges: (25-35), (20-30), (15-25)



Est. Percentage Retained #40 = 27
Flow index Fi =
Liquid limit = 15.0
Plastic limit = 9.2
Plasticity index I_p = 5.8

Plastic Limit Determination

Can no.	39	40				
Wt. of wet soil + can (g)	29.05	29.12				
Wt. of dry soil + can (g)	27.92	28.03				
Wt. of can (g)	16.01	15.8				
Wt. of dry soil (g)	11.91	12.23				
Wt. of moisture (g)	1.13	1.09				
Water content, $w\% = w_p$	9.5	8.9				

Tested by: D. Edlebeck **Date:** 2/17/2012
Submitted By: **Date:**

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

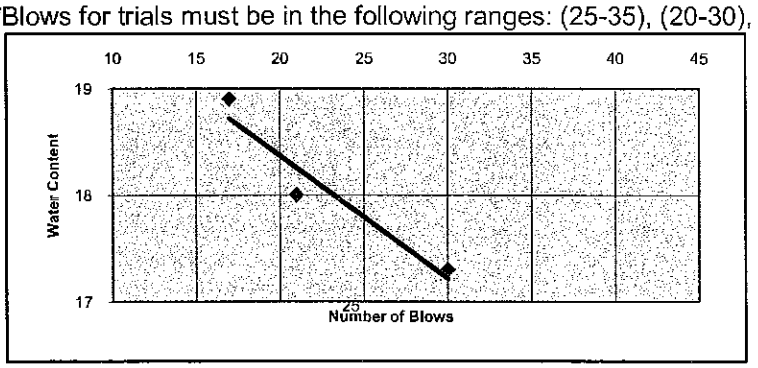
ASTM D-4318

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date Received:**
Address: P.O. Box 241329, Denver, CO 80224
Description of Soil: (SC) Clayey Sand
Depth of Sample: 28'-38' **Boring No.:** MW110D **Sample No.:** S14-S18

Liquid Limit Determination Bowl #8

Can No.	30	45	42			
Wt. of wet soil +can (g)	27.49	27.10	26.81			
Wt. of dry soil + can (g)	25.82	25.39	25.09			
Wt. of can (g)	16.17	15.89	15.98			
Wt of dry soil (g)	9.65	9.50	9.11			
Wt of moisture (g)	1.67	1.71	1.72			
* No of blows, N (g)	**30**	**21**	**17**			
Water content, *w* %	**17.3**	**18**	**18.9**			
K Values and Corrected Average					**Corrected Average**	

*Blows for trials must be in the following ranges: (25-35), (20-30), (15-25)



Est. Percentage Retained #40 = 25
Flow index *F*i =
Liquid limit = 17.7
Plastic limit = 9.6
Plasticity index I_p = 8.1

Plastic Limit Determination

Can no.	26	35				
Wt. of wet soil + can (g)	18.49	18.25				
Wt. of dry soil + can (g)	18.27	18.06				
Wt. of can (g)	16.1	15.94				
Wt. of dry soil (g)	2.17	2.12				
Wt. of moisture (g)	0.22	0.19				
Water content, $w\% = w_p$	10.1	9.0				

Tested by: M. Douglas **Date:** 2/15/2012
Submitted By: **Date:**

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

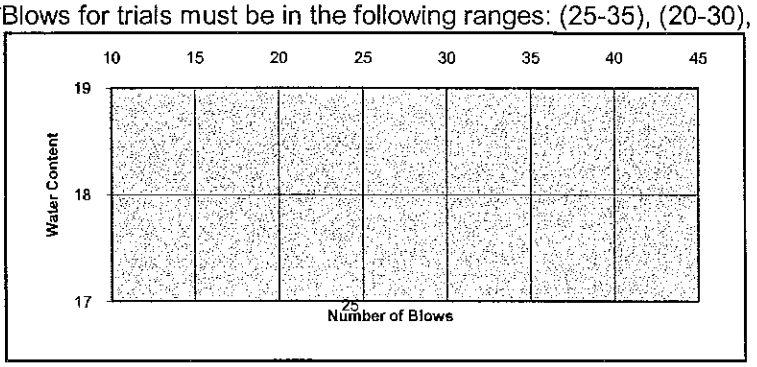
ASTM D-4318

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date Received:**
Address: P.O. Box 241329, Denver, CO 80224
Description of Soil: (SM) Silty Sand
Depth of Sample: 28'-34' **Boring No.:** MW111D **Sample No.:** S15-S17

Liquid Limit Determination Bowl B

Can No.						
Wt. of wet soil +can (g)						
Wt. of dry soil + can (g)						
Wt. of can (g)						
Wt of dry soil (g)						
Wt of moisture (g)						
* No of blows, N (g)						
Water content, *w* %						
K Values and Corrected Average					**Corrected Average**	

*Blows for trials must be in the following ranges: (25-35), (20-30), (15-25)



Est. Percentage Retained #40 = 22
Flow index *F*i =
Liquid limit = Could Not Be
Plastic limit = Determined
Plasticity index I_p = Nonplastic

Plastic Limit Determination

Can no.						
Wt. of wet soil + can (g)						
Wt. of dry soil + can (g)						
Wt. of can (g)						
Wt. of dry soil (g)						
Wt. of moisture (g)						
Water content, $w\% = w_p$						

Tested by: D. Edlebeck **Date:** 2/15/2012
Submitted By: **Date:**

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

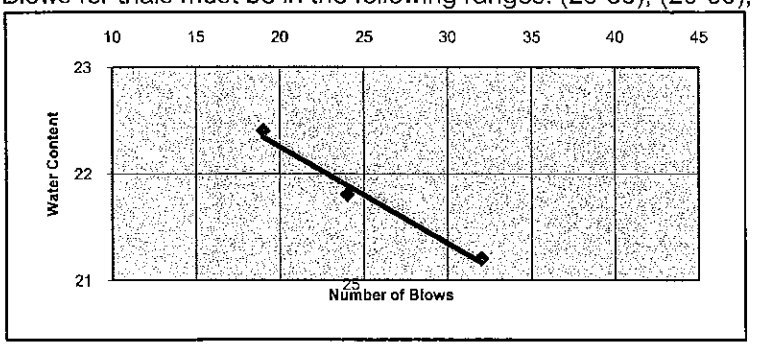
ASTM D-4318

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date Received:**
Address: P.O. Box 241329, Denver, CO 80224
Description of Soil: (CL) Lean Clay
Depth of Sample: 36'-40' **Boring No.:** MW112D **Sample No.:** S19-S20

Liquid Limit Determination Bowl #8

Can No.	46	33	12			
Wt. of wet soil +can (g)	28.77	27.42	25.79			
Wt. of dry soil + can (g)	26.44	25.37	24.06			
Wt. of can (g)	16.06	15.97	15.89			
Wt of dry soil (g)	10.38	9.40	8.17			
Wt of moisture (g)	2.33	2.05	1.73			
* No of blows, N (g)	**19**	**24**	**32**			
Water content, *w* %	**22.4**	**21.8**	**21.2**			
K Values and Corrected Average					**Corrected Average**	

*Blows for trials must be in the following ranges: (25-35), (20-30), (15-25)



Est. Percentage Retained #40 = 1
Flow index *F*i =
Liquid limit = 21.6
Plastic limit = 11.6
Plasticity index I_p = 10

Plastic Limit Determination

Can no.	32	21				
Wt. of wet soil + can (g)	22.81	22.76				
Wt. of dry soil + can (g)	22.07	22.07				
Wt. of can (g)	15.86	15.92				
Wt. of dry soil (g)	6.21	6.15				
Wt. of moisture (g)	0.74	0.69				
Water content, $w\% = w_p$	11.9	11.2				

Tested by: D. Edlebeck **Date:** 2/17/2012
Submitted By: **Date:**

COLEMAN ENGINEERING COMPANY
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Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

UNCONFINED COMPRESSIVE STRENGTH OF INTACT ROCK CORE SPECIMENS

ASTM D7012

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date :**
Address: P.O. Box 241329, Denver, CO 80224
Source: MW 110D and MW 111D
Lithologic Description: Dolomite, Dk Gray, Fine grained
Formation Name: Niagara Formation

Sample Identification	Straightness (in.)	End Flatness (in.)	Perpendicularity	Cross Sectional Dimensions (in.)		Moisture Condition	Area (sq. in.)	Load Rate (psi)	Load (lbs.)	Unit Strength (psi)
				Diameter	Length					
MW 110D	<0.020	<0.001	0.0069	2.490	5.125	as-received	4.87	200	128,540	26,390
MW 111D	<0.020	<0.001	0.0048	2.501	5.122	as-received	4.91	130.0	141,660	29,080

Remarks:

Tested By: J. Edlebeck **Date:** 2/16/2012 **Submitted By:** **Date:**

COLEMAN ENGINEERING COMPANY
635 Circle Drive
Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE SPECIMENS

ASTM D3967

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date :** 2/16/2012
Address: P.O. Box 241329, Denver, CO 80224
Source:
Lithologic Description: Dolomite
Formation Name: Niagara Formation

Sample Identification	Straightness (in.)	End Flatness (in.)	Perpendicularity	Cross Sectional Dimensions (in.)		Moisture Condition	Area (sq. in.)	Load Rate (psi)	Load (lbs.)	Splitting Tensile Strength (psi)
				Diameter	Length					
MW 110D-1	N/A	N/A	N/A	2.497	1.204	Dry	4.90	70	4,510	955
MW 110D-2	N/A	N/A	N/A	2.495	1.220	Dry	4.90	120	8,810	1,843
MW 110D-3	N/A	N/A	N/A	2.495	1.176	Dry	4.90	120	9,730	2,111
MW 110D-4	N/A	N/A	N/A	2.495	1.160	Dry	4.90	90	9,860	2,169
MW 110D-5	N/A	N/A	N/A	2.496	1.186	Dry	4.90	120	9,310	2,002

Splitting Tensile Strength = $2P/\pi LD$ **Average** **1816**

Remarks: Insufficient sample to conduct minimum of 10 trials

Tested By: J. Edlebeck **Date:** 2/16/2012 **Submitted By:** _____ **Date:** _____

COLEMAN ENGINEERING COMPANY
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Iron Mountain, Michigan 49801
Telephone: (906) 774-3440 Fax: (906) 774-7776

SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE SPECIMENS

ASTM D3967

Project: Tyco Fire Products, LP **Job No.:** GL-12009
Client: CH2M Hill Constructors, Inc. **Date :** 2/16/2012
Address: P.O. Box 241329, Denver, CO 80224
Source: Borings MW-110D and MW-111D
Lithologic Description: Dolomite
Formation Name: Niagara Formation

Sample Identification	Straightness (in.)	End Flatness (in.)	Perpendicularity	Cross Sectional Dimensions (in.)		Moisture Condition	Area (sq. in.)	Load Rate (psi)	Load (lbs.)	Splitting Tensile Strength (psi)
				Diameter	Length					
MW 111D-1	N/A	N/A	N/A	2.500	1.282	Dry	4.90	140	9,760	1,939
MW 111D-2	N/A	N/A	N/A	2.500	1.168	Dry	4.90	160	8,510	1,855
MW 111D-3	N/A	N/A	N/A	2.501	1.183	Dry	4.90	150	9,790	2,107
MW 111D-4	N/A	N/A	N/A	2.503	1.189	Dry	4.90	140	7,760	1,660
MW 111D-5	N/A	N/A	N/A	2.501	1.126	Dry	4.90	150	10,130	2,290

Splitting Tensile Strength = $2P/\pi LD$ **Average** **1970**

Remarks:

Tested By: J. Edlebeck **Date:** 2/16/2012 **Submitted By:** _____ **Date:** _____

ANALYTICAL REPORT

ECOLOGICAL CONSULTING AND
ENVIRONMENTAL LABORATORY SERVICES

WHITE WATER ASSOCIATES, INC.

Cover Page

Client: Coleman Engineering - Iron Mountain **WWA Job #:** 39232

Project: **Sample Matrix:** Soil
Date Received: 2/15/2012 **Date Reported:** 2/21/2012

Sample Number	Client Sample ID	Date Sampled
39232-001	MW110D	02/15/11
39232-002	MW111D	02/15/11
39232-003	MW112D	02/15/11

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ANALYTICAL REPORT

ECOLOGICAL CONSULTING AND
ENVIRONMENTAL LABORATORY SERVICES

WHITE WATER ASSOCIATES, INC.

Cover Page..continued

Client: Coleman Engineering - Iron Mountain **WWA Job #:** 39232

Comments (if any):

39232-001 High dilution due to matrix interference

Key to Laboratory Flags:

*: RPD exceeds limits.
B: The analyte was found in the associated blank as well as in the sample.
J+: The quantitation is an estimated value because the result exceeds the calibration range
J: The quantitation is an estimated value because the result is less than the sample quantitation limit but greater than the detection limit.
M: A matrix effect was present.
Q: Batch QC data associated with the analysis does not meet the stated objectives
H: Indicates analytical holding time exceedance.
U: The analyte was analyzed for, but not detected.
P: A manual peak selection or manual integration was performed to correct an erroneous software selection.

ND = Not Detected, MDL = Method Detection Limit, MQL = Method Quantitation Limit
ppm = mg/L (liquid) or mg/kg (solid), ppb = ug/L (liquid) or ug/kg (solid)
For coliform, Negative = No coliform bacteria detected, Positive = Coliform bacteria detected

Sample Types:
S = Solids, DW = Drinking water, D = Dissolved, T = Total, TC = TCLP extract, SP = SPLP extract

All samples were received intact and properly preserved unless otherwise noted. The results reported relate only to the samples tested. This report shall not be reproduced, except in full, without the written approval of this laboratory. The Chain of Custody is attached.

This report satisfies the requirements of your project but has not been prepared to comply with NELAP reporting requirements.

I certify that the data contained in this Final Report has been generated and reviewed in accordance with approved methods and White Water Associates Standard Operating Procedures. Exceptions, if any, are discussed in the accompanying sample narrative. Release of this Final Report is authorized by White Water Associates management, as is verified by the following signature.

Approved By: Bob J. Prem

WI DNR Lab Certification Number: 999971280
MI DEQ Certification Number: 9306
DoD-ELAP Accreditation Number: 65802

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ANALYTICAL REPORT

ECOLOGICAL CONSULTING AND
ENVIRONMENTAL LABORATORY SERVICES

WHITE WATER ASSOCIATES, INC.

Client: Coleman Engineering - Iron Mountain **WWA Job #:** 39232

Project: **Sample Matrix:** Soil
Date Received: 2/15/2012 **Date Reported:** 2/21/2012

Sample Results

Sample No. / ID / Description	Result	Flags	Units	Date	Method	MDL	MQL
39232-001 / MW110D / Marinette, WI							
General Chemistry Parameters							
Chloride (s)	ND		mg/Kg	2/20/2012	325.2	360	1200
ORP	160		mV	2/20/2012	2580B	1	1
pH	8.00		pH Units	2/20/2012	4500H+	0.10	0.20
Sulfate (s)	19,300 BM		mg/Kg	2/17/2012	375.4	7500	15,000
Total Solids	83.7		%	2/20/2012	2540G	0.1	0.1
39232-002 / MW111D / Marinette, WI							
General Chemistry Parameters							
Chloride (s)	920 J		mg/Kg	2/20/2012	325.2	340	1200
ORP	118		mV	2/20/2012	2580B	1	1
pH	8.22		pH Units	2/20/2012	4500H+	0.10	0.20
Sulfate (s)	610 B		mg/Kg	2/17/2012	375.4	290	570
Total Solids	87.1		%	2/20/2012	2540G	0.1	0.1
39232-003 / MW112D / Marinette, WI							
General Chemistry Parameters							
Chloride (s)	ND M		mg/Kg	2/20/2012	325.2	350	1200
ORP	130		mV	2/20/2012	2580B	1	1
pH	8.26		pH Units	2/20/2012	4500H+	0.10	0.20
Sulfate (s)	896 B		mg/Kg	2/17/2012	375.4	290	580
Total Solids	85.6		%	2/20/2012	2540G	0.1	0.1

39232-001 High dilution due to matrix interference

ND = Not Detected, MDL = Method Detection Limit, MQL = Method Quantitation Limit,
ppm = mg/l (liquid) or mg/kg (solid), ppb = ug/l (liquid) or ug/kg (solid)

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Login Checklist

WHITE WATER ASSOCIATES, INC.

Project No.:	39232	**Date logged in.:**	2/15/2012	**Login person's initials:**	TLH
Client:	Coleman Engineering - Iron Mountain			**Number of coolers:**	0
Project name:				**Courier/shipper:**	Client

- ☑ **1. Custody seals/original packing tape were intact.**
- ☑ **2. Samples are in good condition, i.e. not broken or leaking.**
- ☑ **3. Samples were received within holding times.**
- ☐ **4. Samples were received on ice (ice in direct contact with the samples).**
- ☐ **5. Temperature of the samples was between 2-6°C. Temp.:** 17

  NOTE: Samples not between 2-6°C that are received at the laboratory on the day of sample collections do not require client notification.
- ☑ **6. Samples matched the Chain of Custody (COC).**
- ☑ **7. Proper containers were used.**
- ☑ **8. Samples were collected in White Water lab containers.**
- ☑ **9. There is adequate sample volume for requested analyses and QC.**
- ☐ **10. For water VOC samples, headspace is less than the size of a pea.**
- See COC **11. Samples are preserved to the proper pH. Sample bottles and preservation are noted on COC.**
- ☑ **12. The COC is signed.**
- ☐ **13. Sub-sampling is required. (Note bottles created and preserved below.)**
- ☐ **14. For Dissolved Analysis, samples were filtered in the lab.**
- ☐ **15. For VOCs, encores were received.**
- ☐ **16. For Soil VOCs, samples were preserved with methanol in the lab.**
- ☐ **17. Client contact is necessary. Provide documentation below.**

COMMENTS/CORRECTIVE ACTION

CLIENT RESPONSE

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

J.O.# 39230

SAMPLER'S SIGNATURE

CLIENT NAME Coleman Engineering

ADDRESS Iron Mountain

PHONE # 906-774-3440

ANALYSIS TYPE REQUESTED: Lead (Pb)

SAMPLE LOCATION	SAMPLE I.D.#	TIME	DATE	SAMPLE TYPE: GRAB	SAMPLE TYPE: COMPOSITE	SAMPLE TYPE: MATRIX	NO. OF CONTAINERS	Lead (Pb)	REMARKS:
Marinette, WI	MW110D	1300 pm	2/15/12	↓		S	1		
"	MW 111D	↓	↓	↓		↓	1		
"	MW 112D	↓	↓	↓		↓	1		
									pres: none

RELINQUISHED BY	DATE	TIME	RECEIVED BY	RELINQUISHED BY	DATE	TIME	RECEIVED BY
Mark Douglas	2/15/12	pm					

RELINQUISHED BY	DATE	TIME	RECEIVED BY LABORATORY	DATE	TIME	REMARKS:
				2/15/12	15:10	

Customer retain pink; send white and yellow with samples. Original (white) will be returned with report.

White Water Associates, Inc.
429 River Lane, P.O. Box 27
Amasa, Michigan 49903
Phone (906) 822-7373, Fax -7977

CJ #118522

Project Name: Tyco/Ansul
Location: Marinette, WI
Laboratory Test Assignment
CH2M HILL contact: Paul Landers 703-376-5168

Boring No.	Sample No.	Blow Counts (N_{SPT})	Depth (ft)	Sieve Analysis (ASTM D422)	Hydrometer Analysis (ASTM D422)	Moisture Content Test (ASTM D2216-05)	Atterberg Limits (ASTM D4318-05)	Corrosivity Test*
MW110D	S2-S6	composite	2-12	X		X		X
	S10-S13	composite	18-28	X	X	X	X	
	S14-S18	composite	28-38	X	X	X	X	
MW111D	S3-S6	composite	4-12	X		X		
	S8-S13	composite	14-26	X	X	X		X
	S15-S17	composite	28-34	X	X	X	X	
MW112D	S1-S4	composite	0-8	X		X		
	S8-S11	composite	14-22	X	X	X		
	S19-S20	composite	36-40	X	X	X	X	X
Total				9	6	9	4	3

* Perform pH, Sulfate Concentration, Chloride Concentration, ~~Resistivity,~~ and Redox Potential in accordance with AWWA C105

P/N - GL-12009

John Edlebeck
906-282-1900

US EPA ARCHIVE DOCUMENT

Appendix C
Soil Design Parameter Correlations

US EPA ARCHIVE DOCUMENT

Liang, R.Y., (2002) *Drilled Shaft Foundations for Noise Barrier Walls and Slope Stabilization* , Final Report, FHWA/OH-2002/038, ODOT.

Kulhawy, F.H. and Mayne, P.W. (1990). *Manual on Estimating Soil Properties for Foundation Design* , Report No. EL-6800, Electric Power Research Institute, Palo Alto, CA

Liang Tables:

Correlation to SPT for Cohesionless soils (After Liang 2002)							
N60		2 to 4	4 to 10	10 to 20	20 to 30	30 to 50	50 to 60
ϕ (°)		28 - 29	29 - 31	31 - 34	34 - 37	37 - 42	42 - 45
γ_{moist} (pcf)	Min	104 - 108	108 - 112	112 - 120	120 - 125	125 - 128	128 - 130
	Max	114 - 118	118 - 122	122 - 128	128 - 132	132 - 140	140 - 145

Correlation to SPT for Cohesive soils (After Liang 2002)						
N60	0 to 2	2 to 4	4 to 8	8 to 16	16 to 32	32 to 64
Su (psf)	0 to 270	270 to 540	540 to 1080	1080 to 2160	2160 to 4320	4320 to 8000
γ_{sat} (pcf)	100 to 120	110 to 130	110 to 130	120 to 135	130 to 145	140 to 145

US EPA ARCHIVE DOCUMENT

EPRI Manual Clay modulus

E = 19.3*Pa*N^0.63

The pressuremeter test (PMT) provides a measurement of the horizontal modulus in soils. In clays, it is assumed commonly that $E_{PMT} = E_u$. For practical use, attempts have been made to correlate E_{PMT} with the SPT N value, as shown in Figure 5-8. Based on these data, it is clear that more than an order of magnitude variation is possible when using N values as the sole predictor.

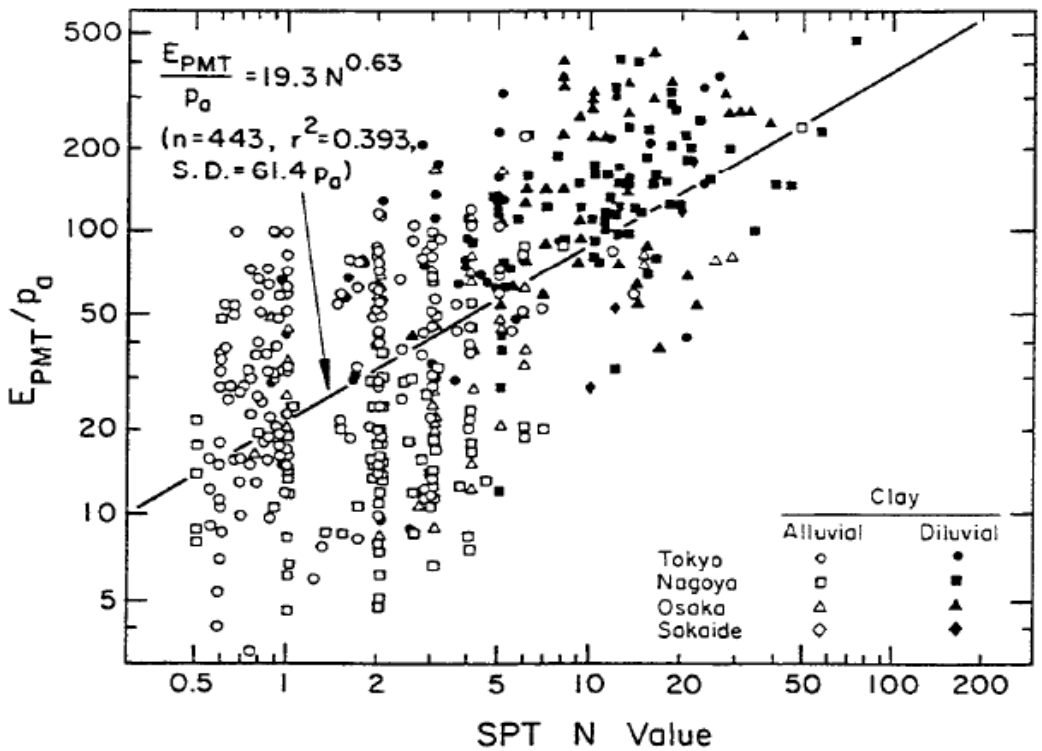


Figure 5-8. PMT Modulus of Clay versus N Value

Source: Ohya, et al. (11), p. 129.

US EPA ARCHIVE DOCUMENT

EPRI Modulus Sand
E = Pa*5*N

However, all attempts to date which correlate a modulus with N show considerable scatter. This lack of correlation is to be expected because the SPT N value varies with many factors, as described in Section 2, and these factors have yet to be incorporated in these correlations. Therefore, as a first order estimator, the following may be used:

$$E/p_a \approx 5\ N_{60} \quad \text{(sands with fines)} \tag{5-26a}$$

$$\approx 10\ N_{60} \quad \text{(clean NC sands)} \tag{5-26b}$$

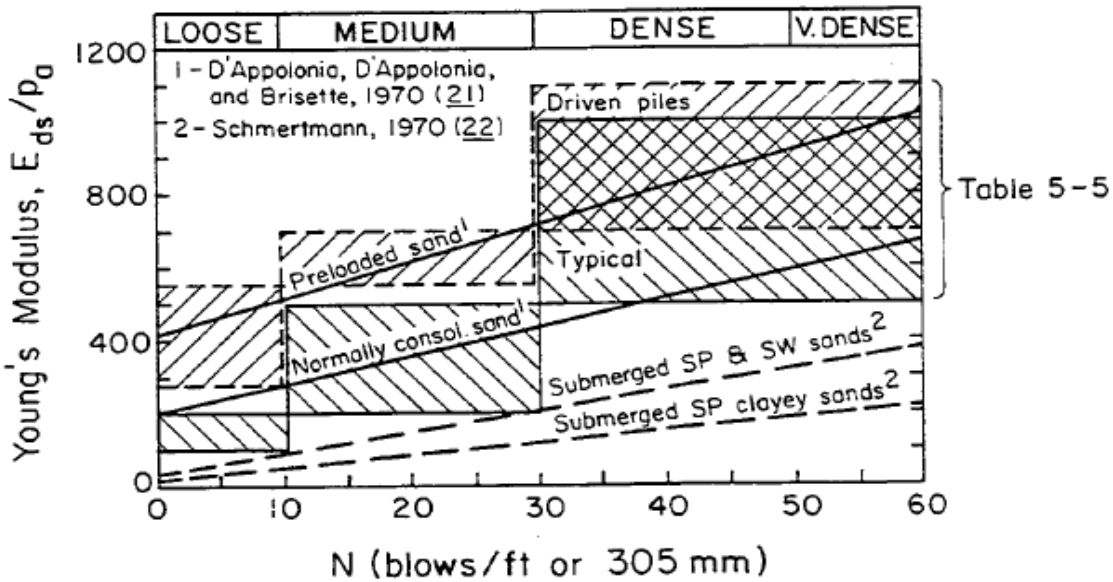


Figure 5-13. Comparative Plot of Drained Modulus Correlations for Sand

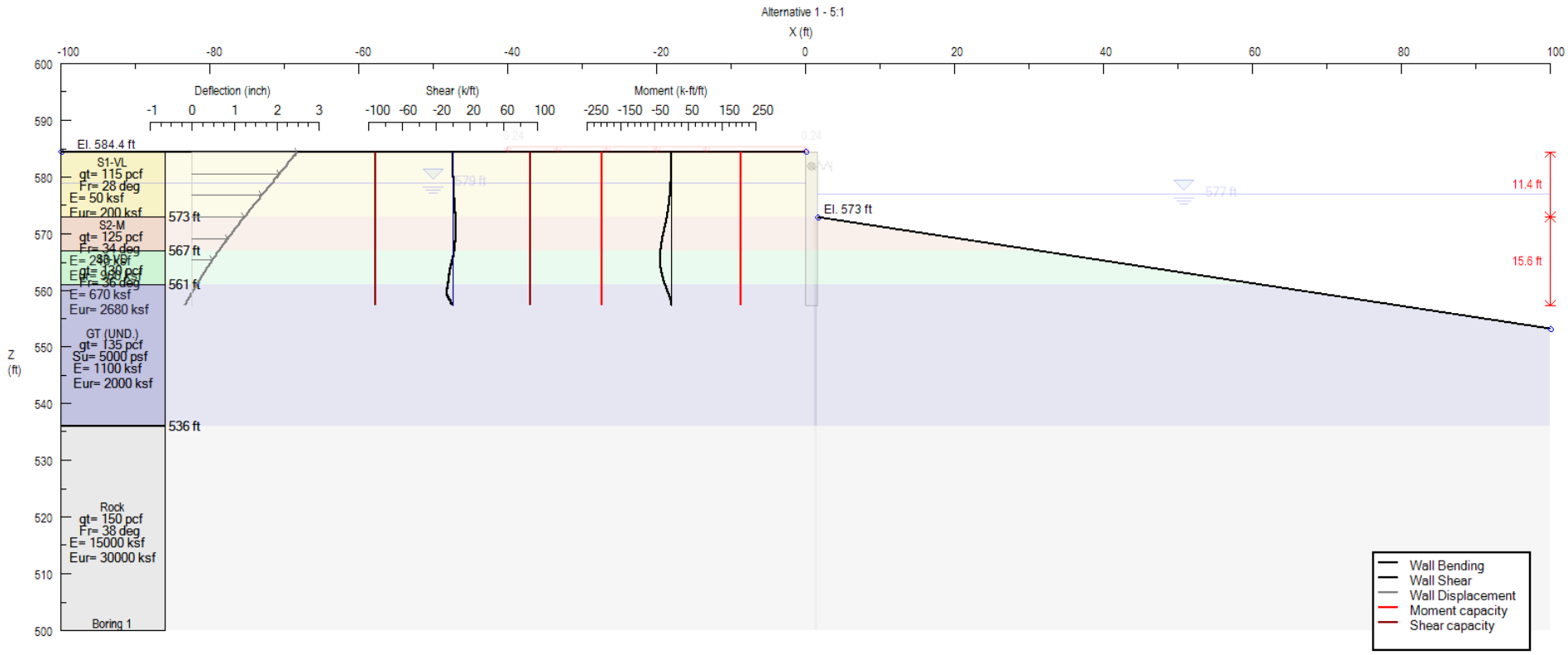
Source: Callanan and Kulhawy (13), p. 3-16.

US EPA ARCHIVE DOCUMENT

Appendix D
Output from DeepXcav Analyses

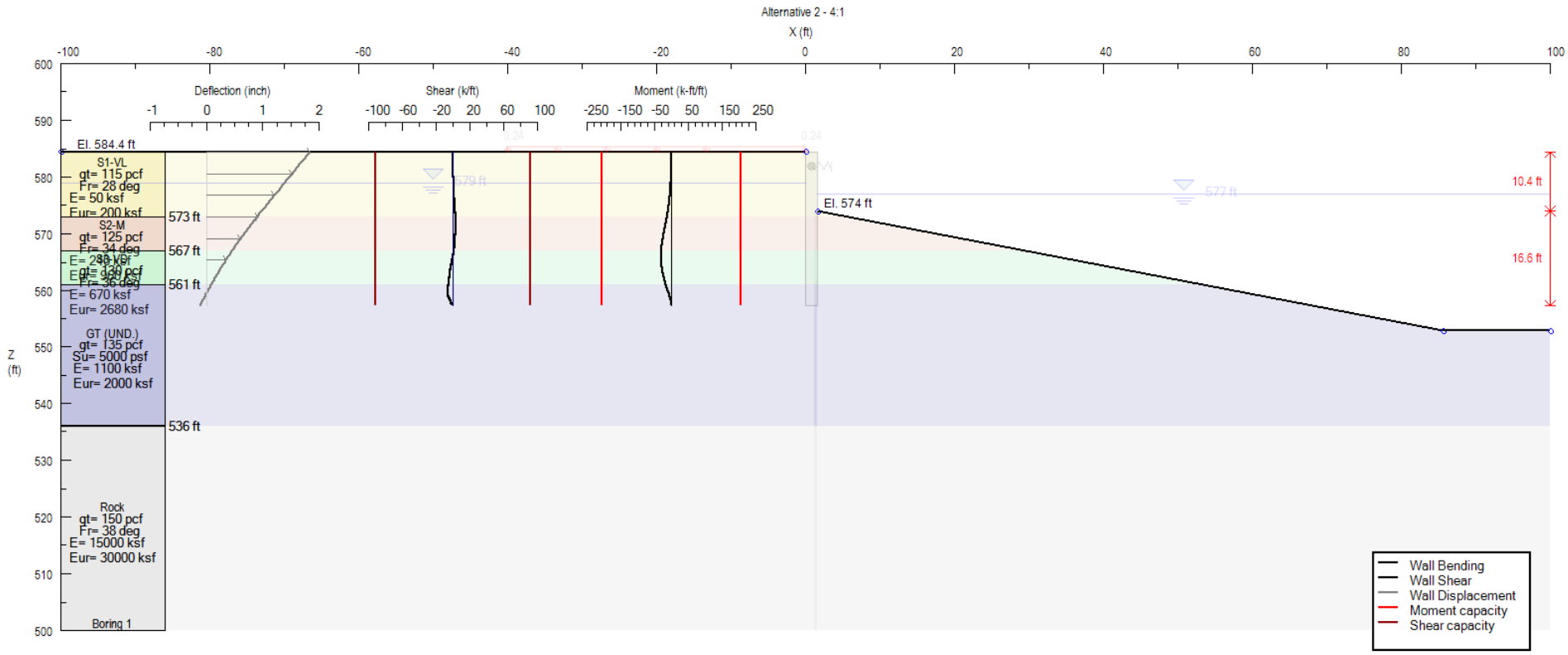
US EPA ARCHIVE DOCUMENT

Section 1 - C35 - 5H:1V



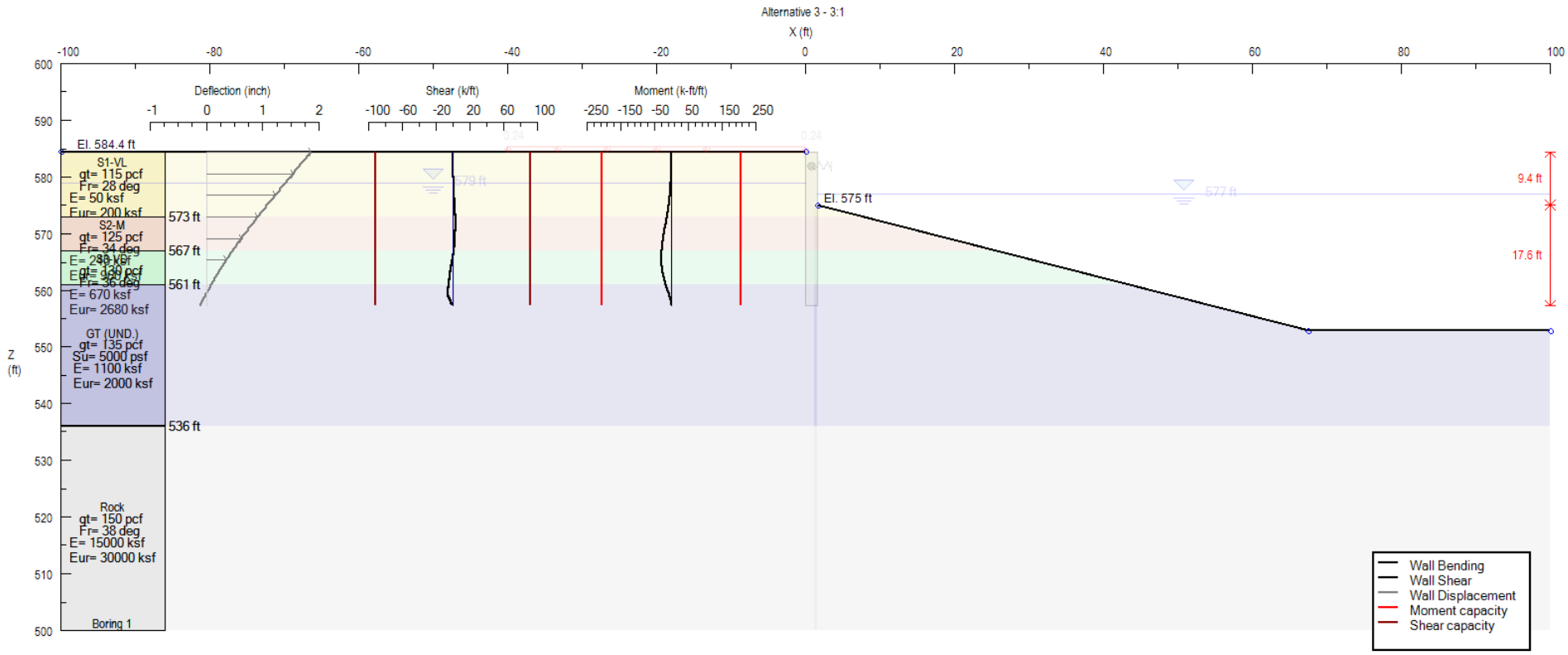
US EPA ARCHIVE DOCUMENT

Section 1 - C35 - 4H:1V



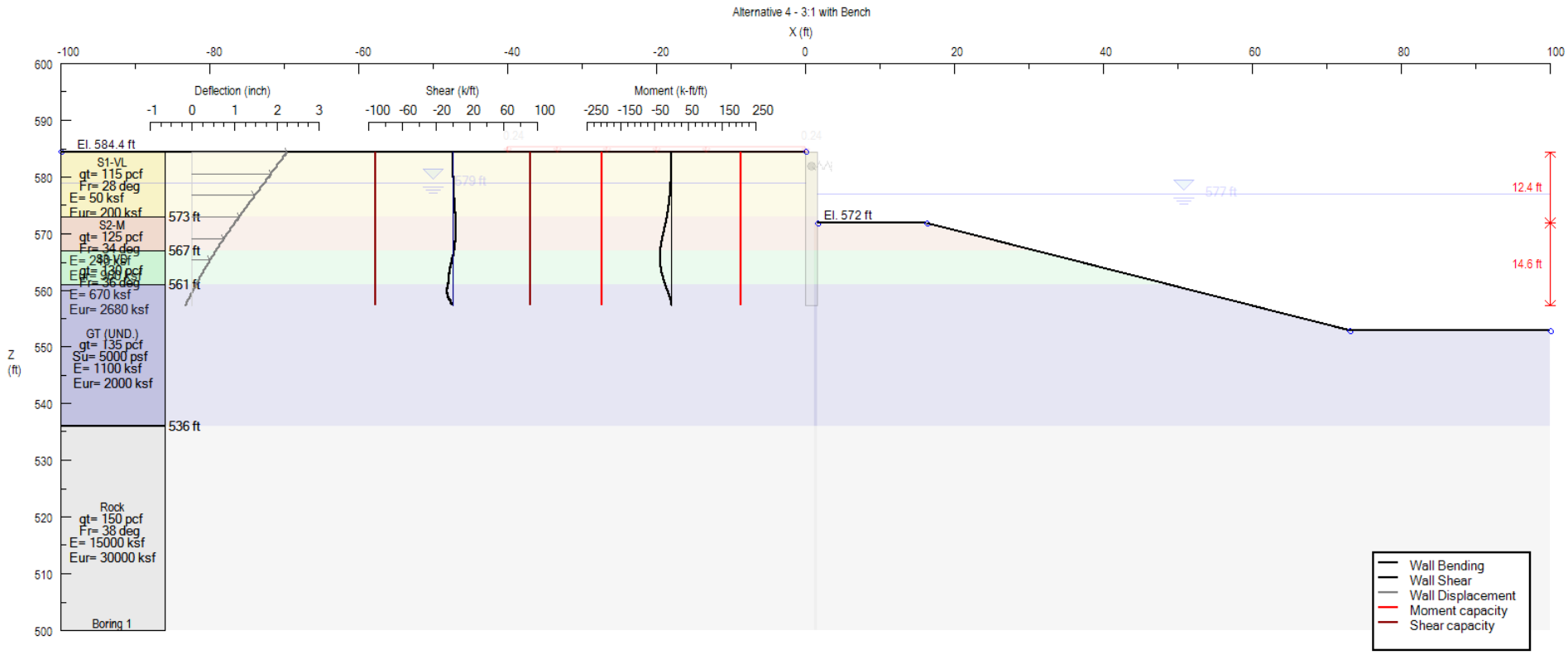
US EPA ARCHIVE DOCUMENT

Section 1 - C35 - 3H:1V



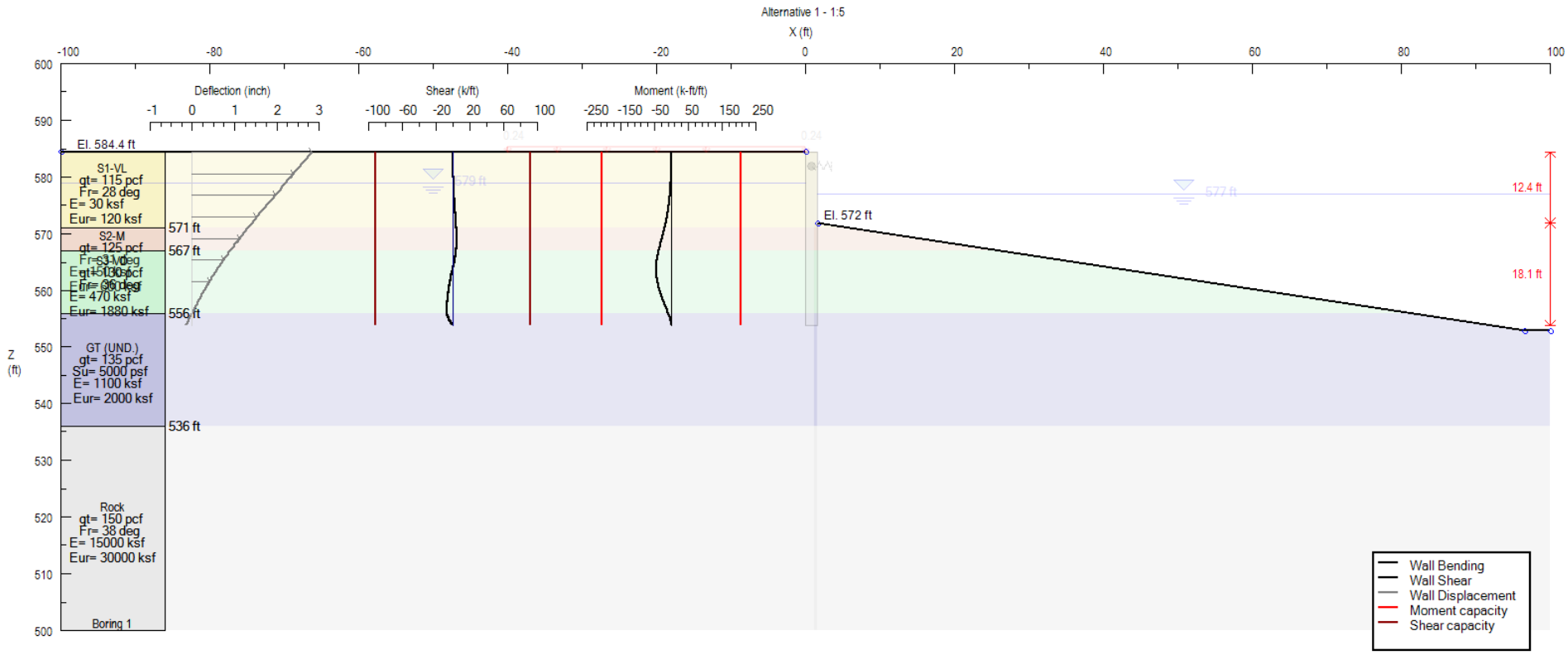
US EPA ARCHIVE DOCUMENT

Section 1 - C35 - 3H:1V with Bench



US EPA ARCHIVE DOCUMENT

Section 2 - D38 - 5H:1V



US EPA ARCHIVE DOCUMENT

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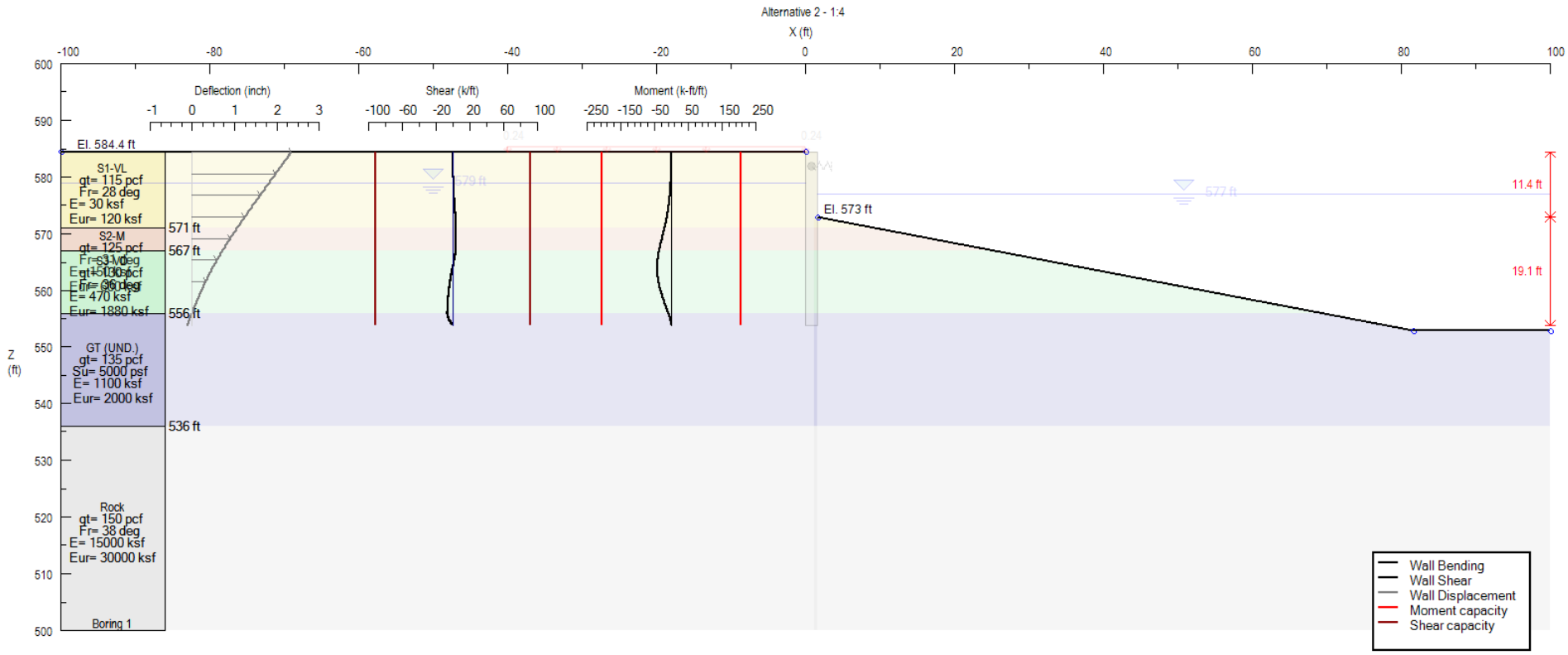

US EPA ARCHIVE DOCUMENT

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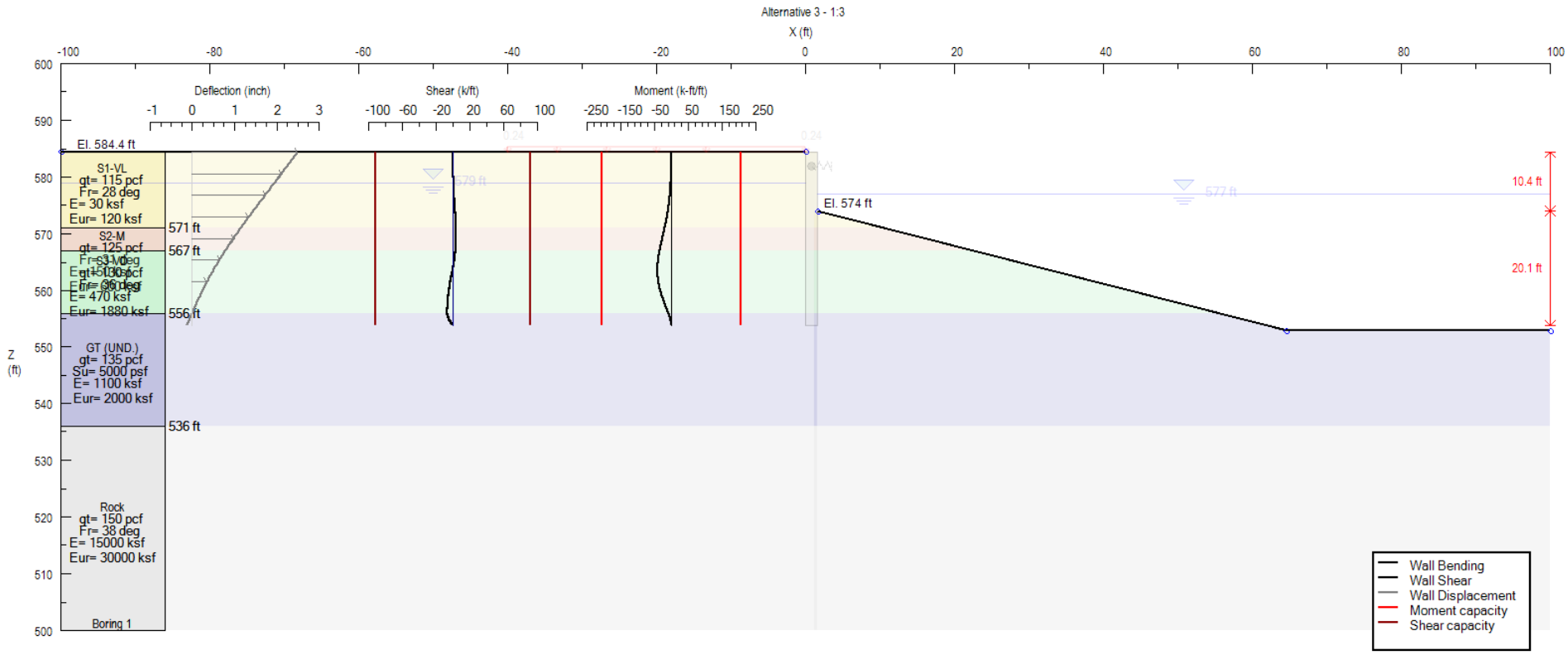
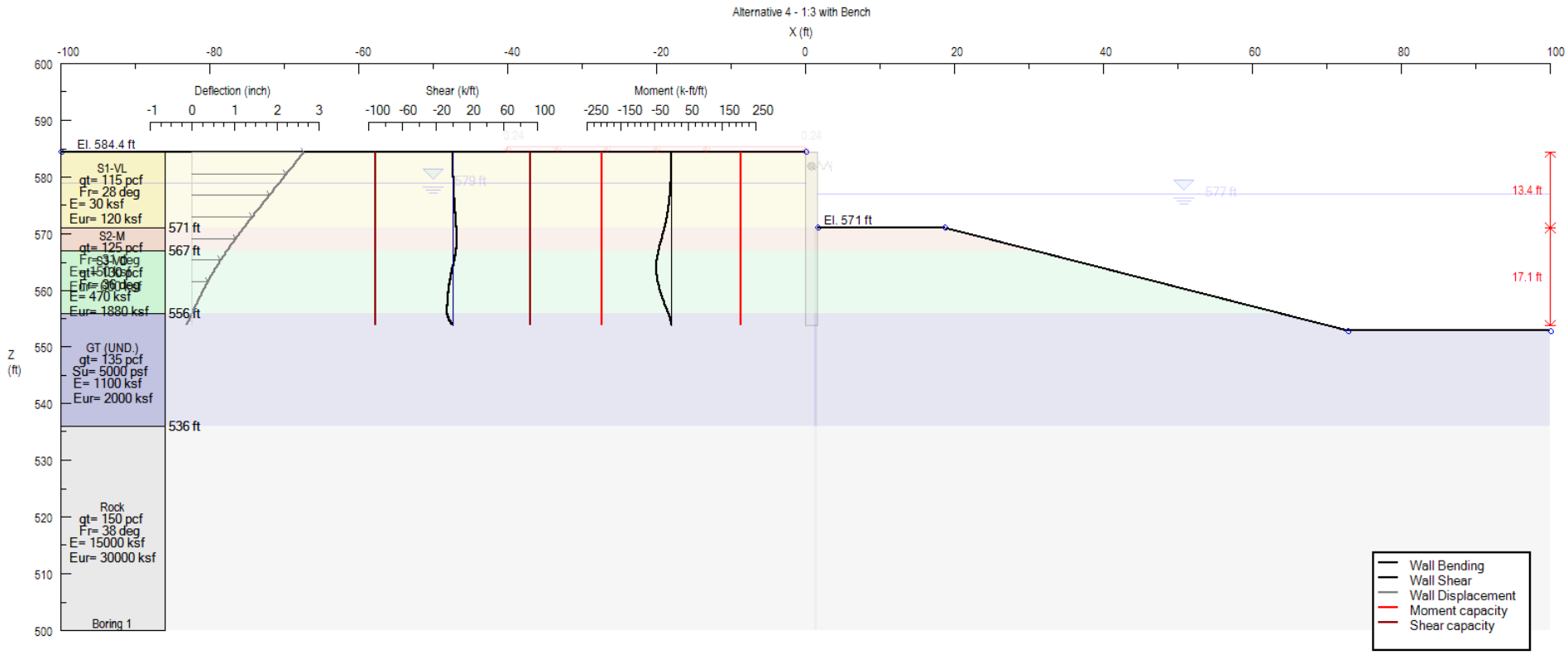


US EPA ARCHIVE DOCUMENT

Section 2 - D38 - 3H:1V with bench



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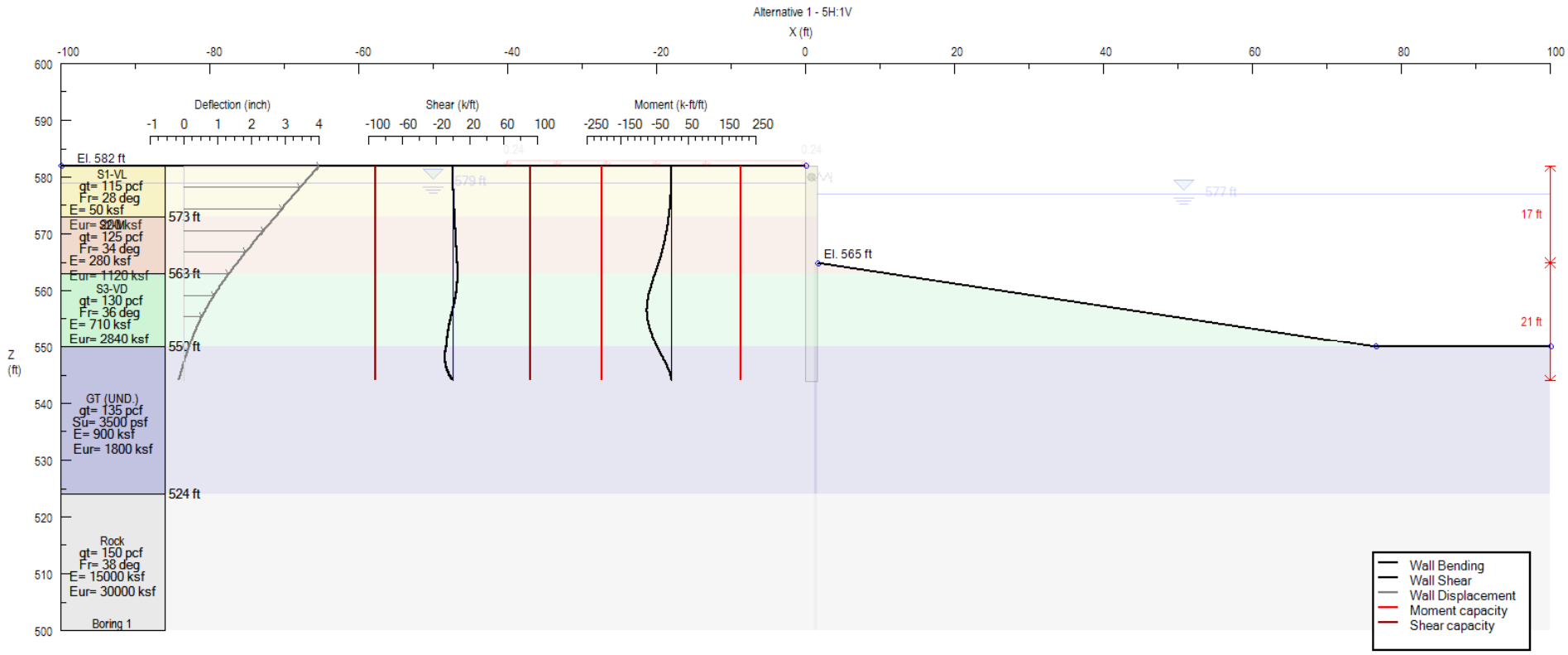
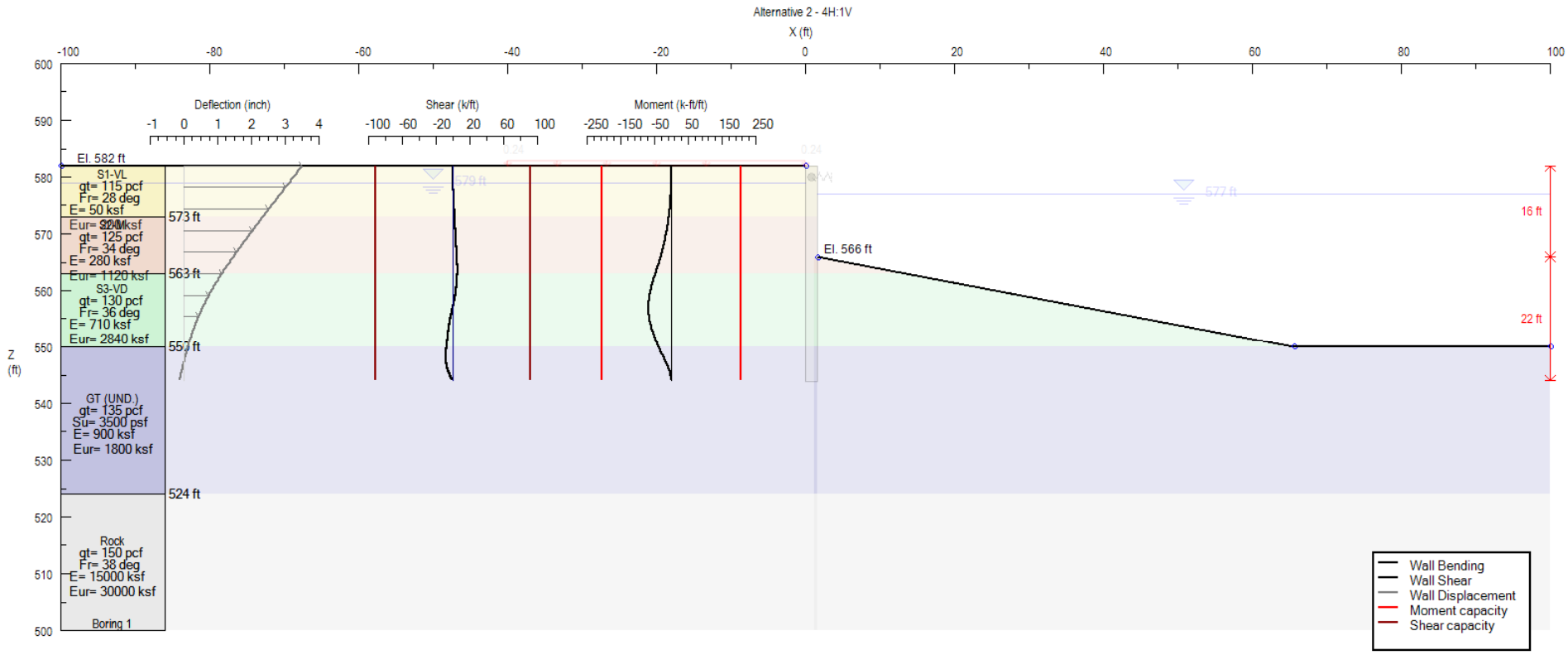
Section 3 - SP1 - 5H:1V

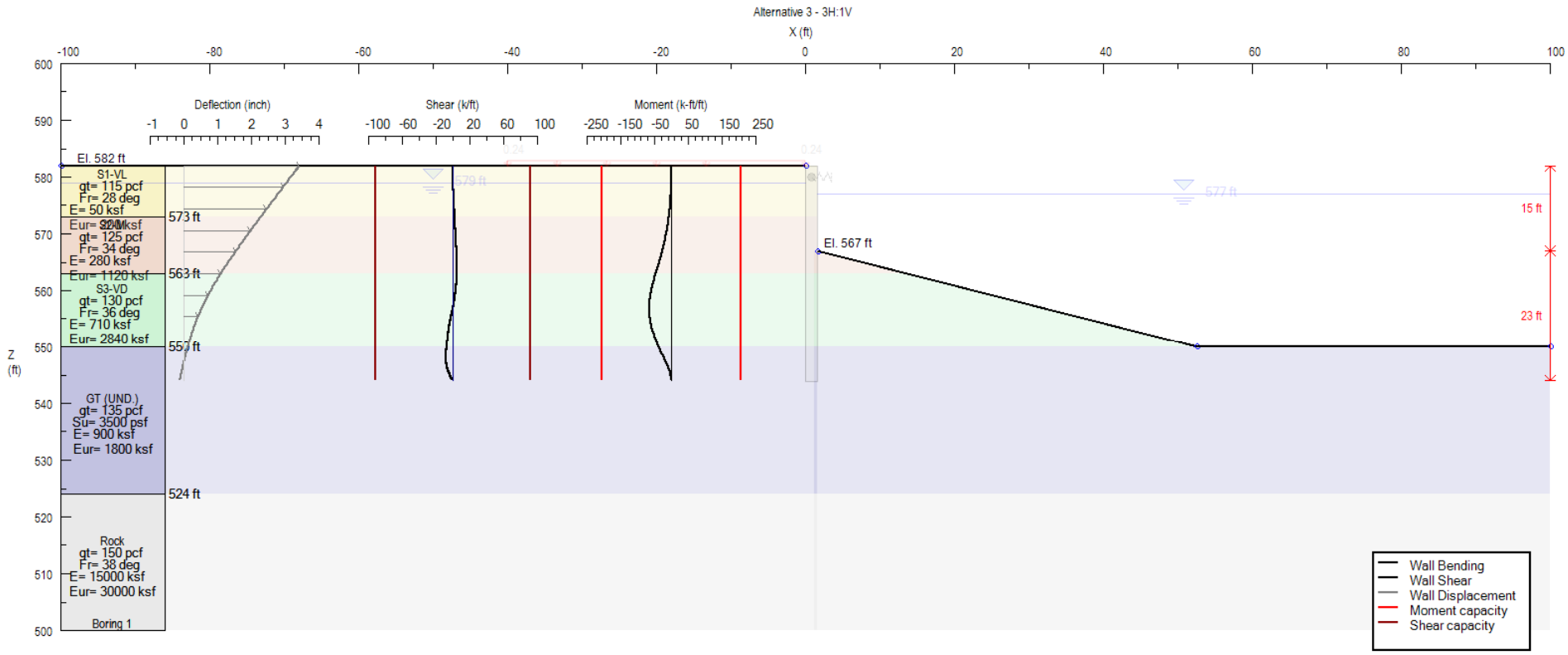


Section 3 4H:1V



US EPA ARCHIVE DOCUMENT

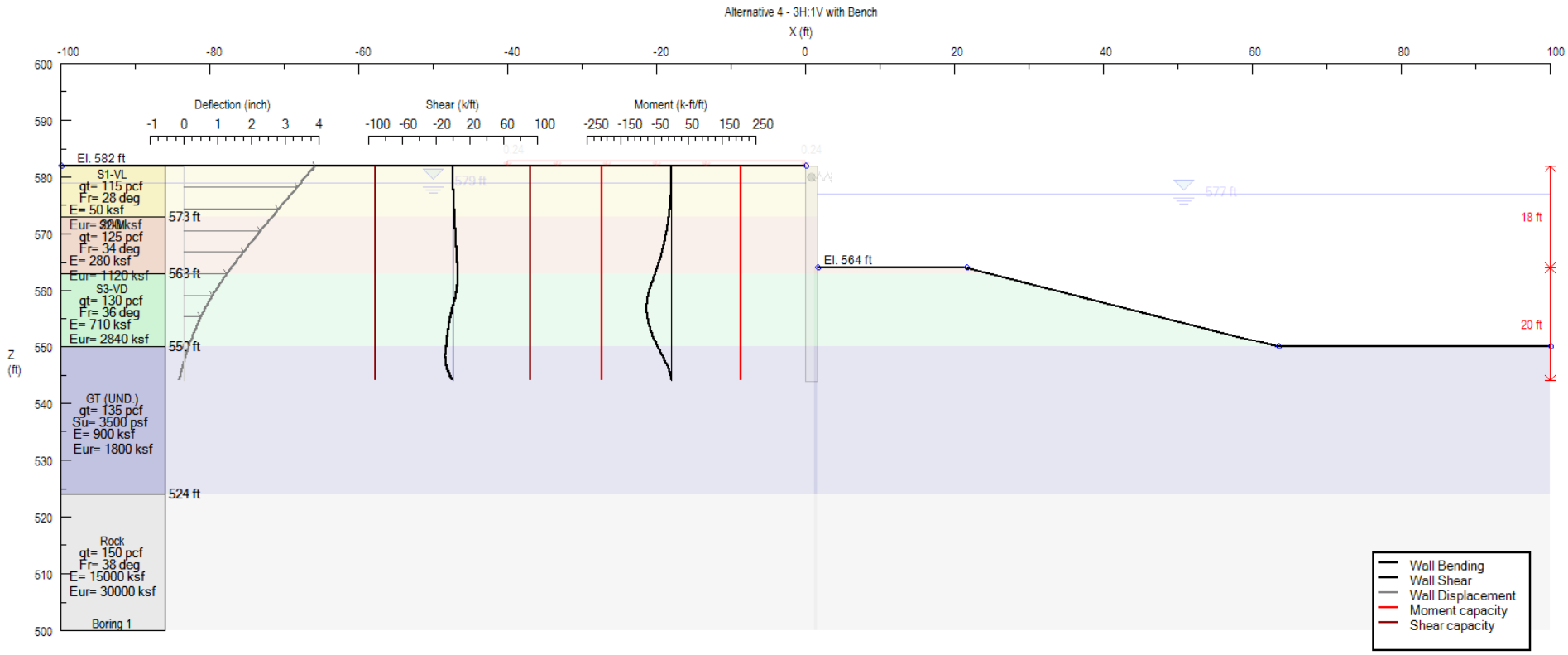
Section 3 - SP1 - 3H:1V



US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

Section 3 - SP1 - 3H:1V with Bench



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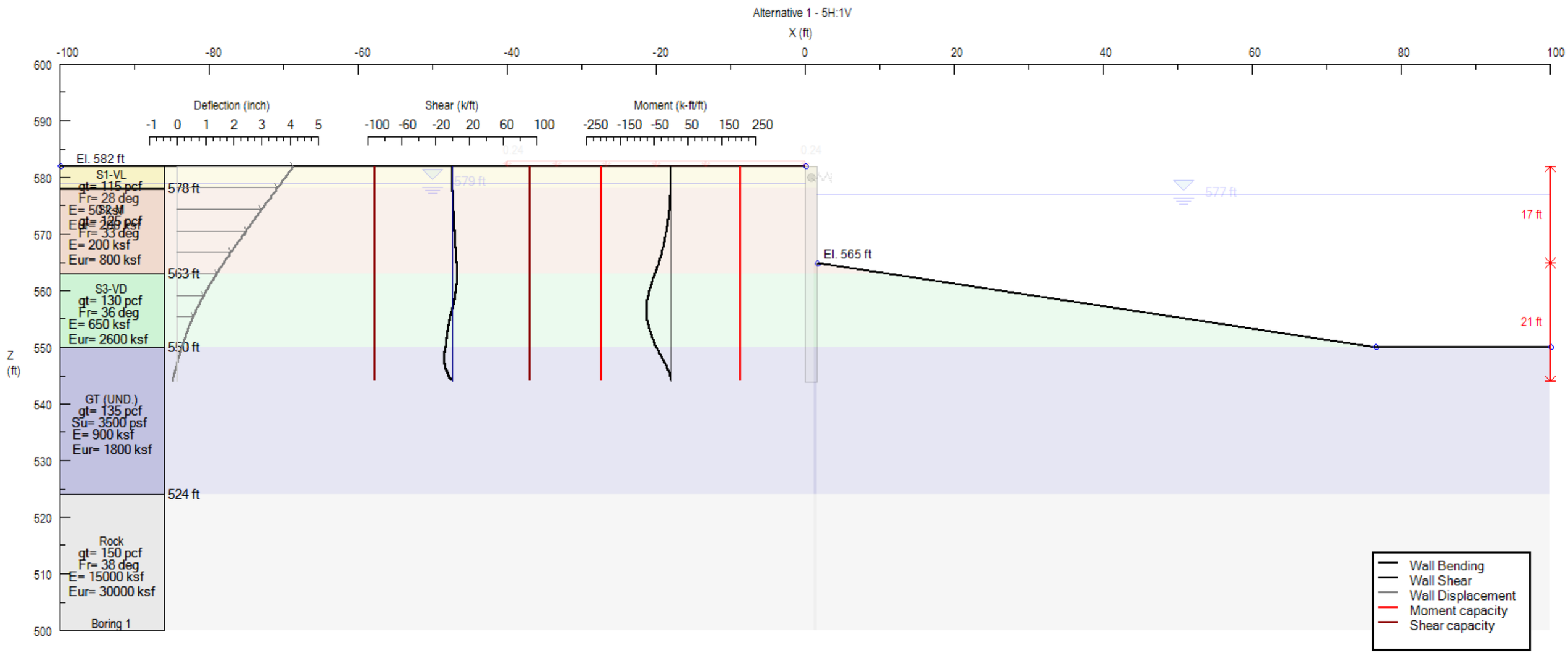

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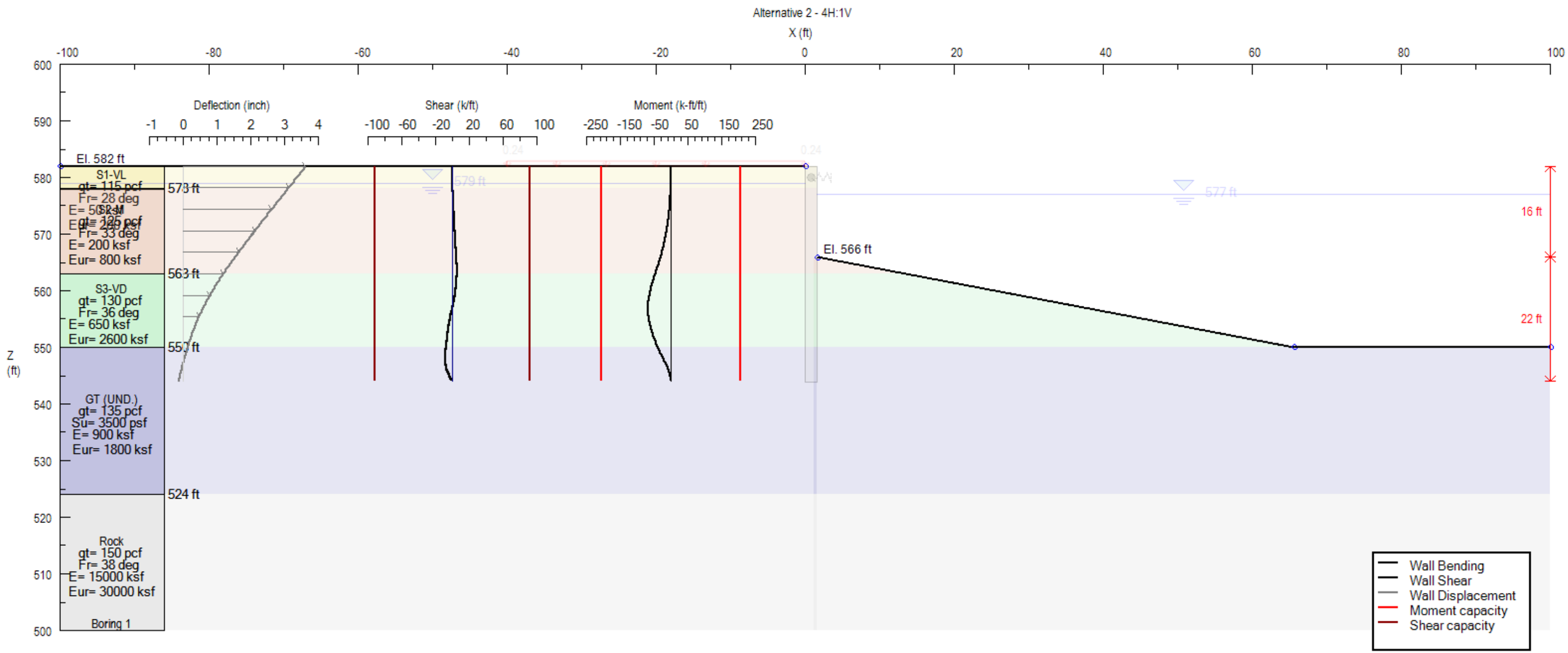

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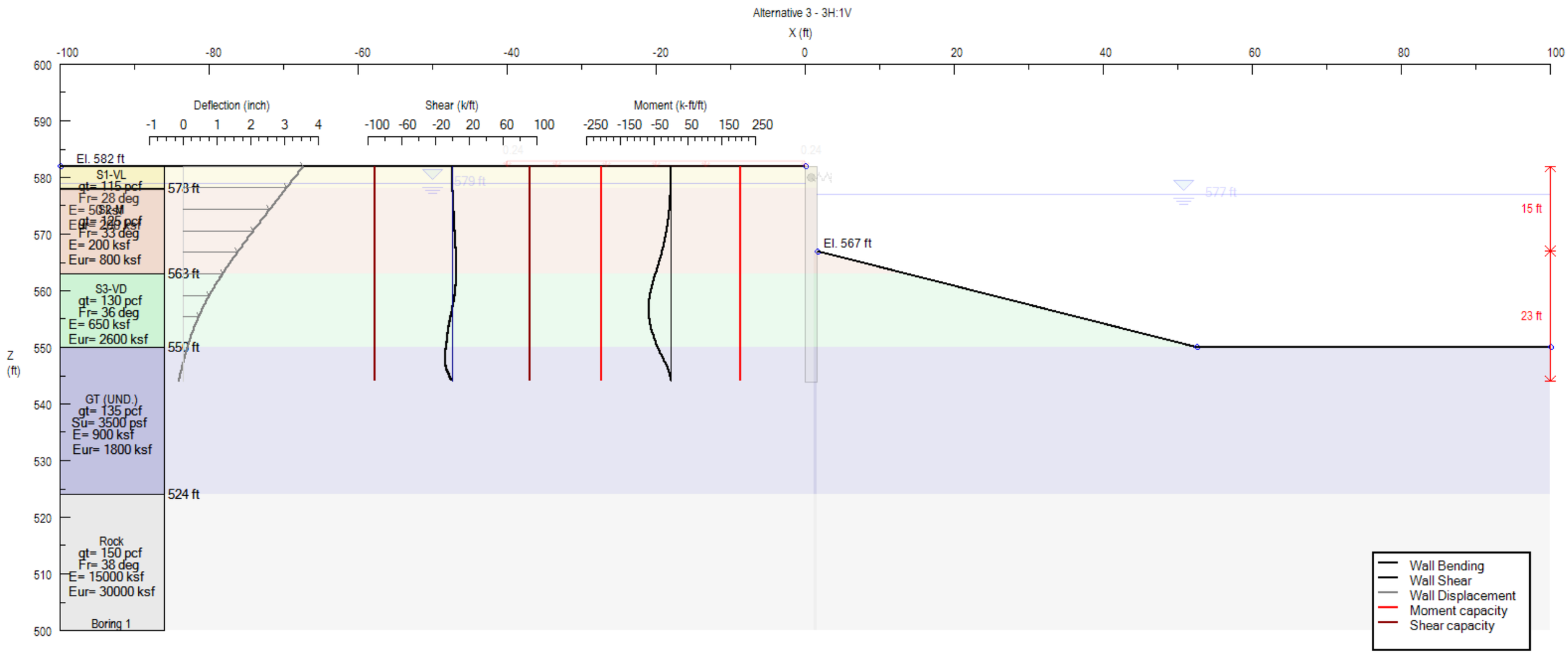

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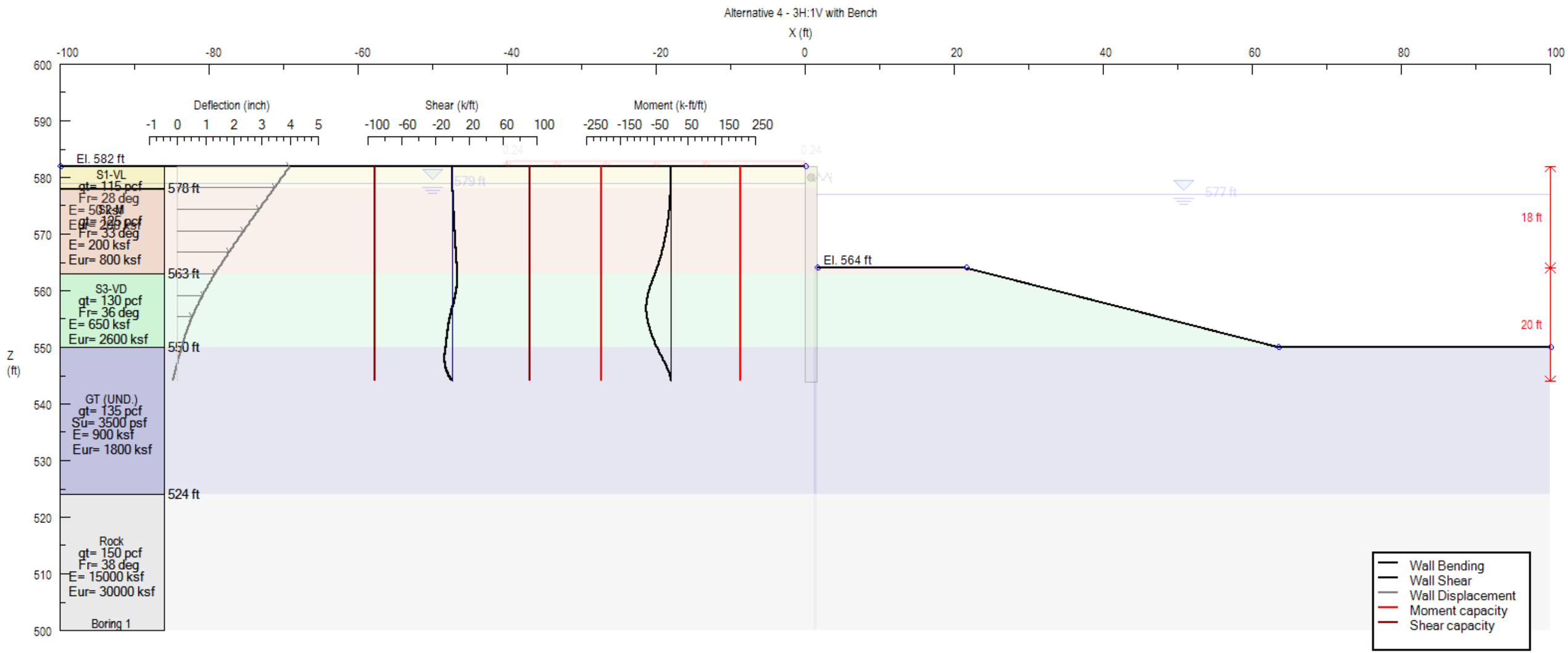

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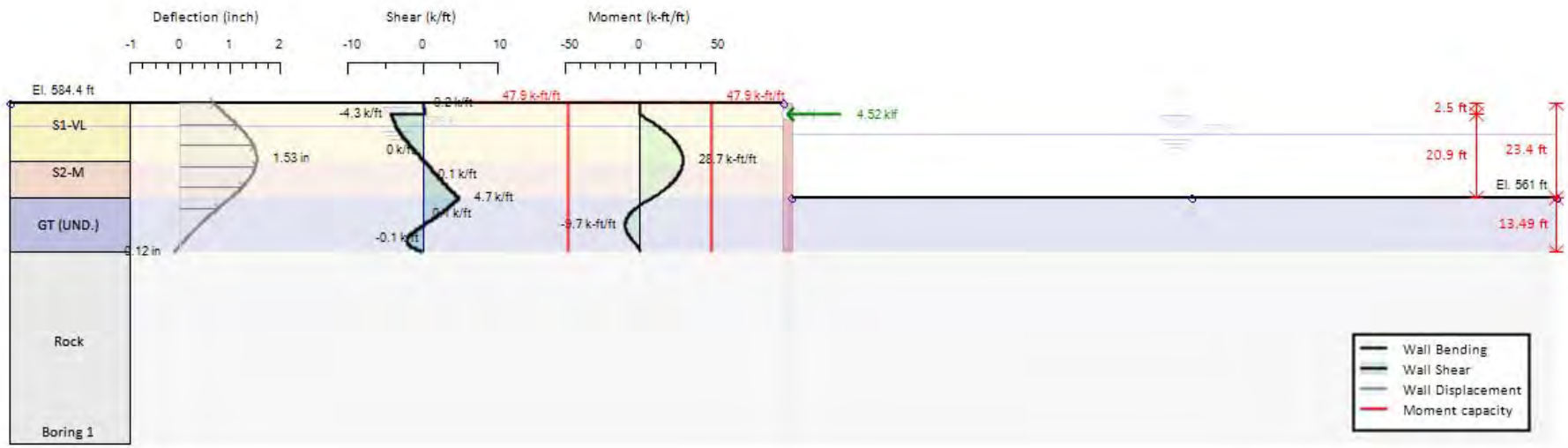
Section C9 – Dredge to Till



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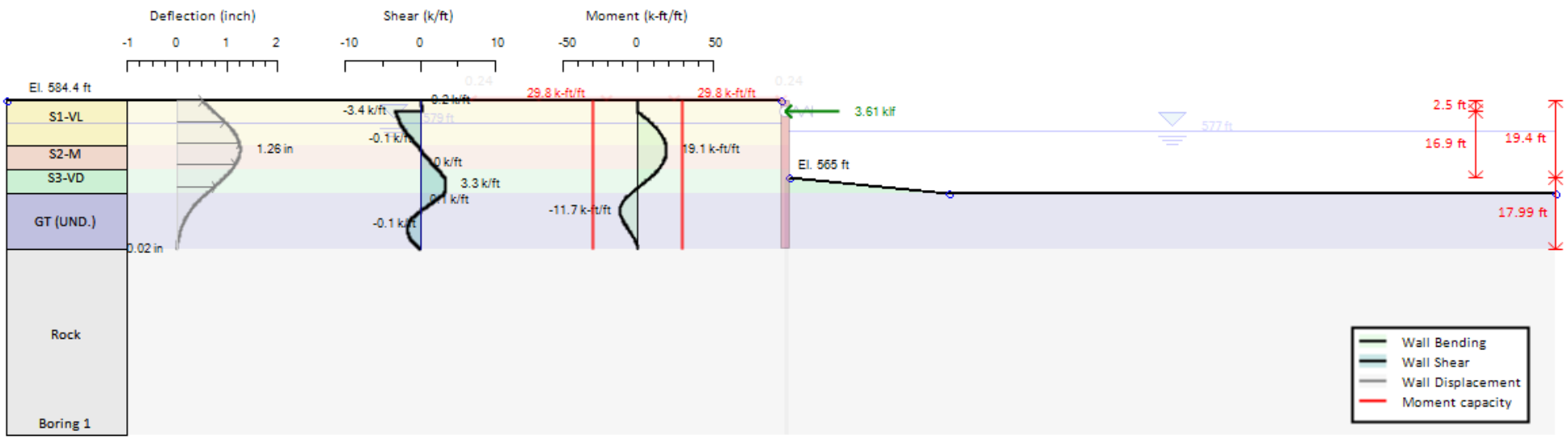
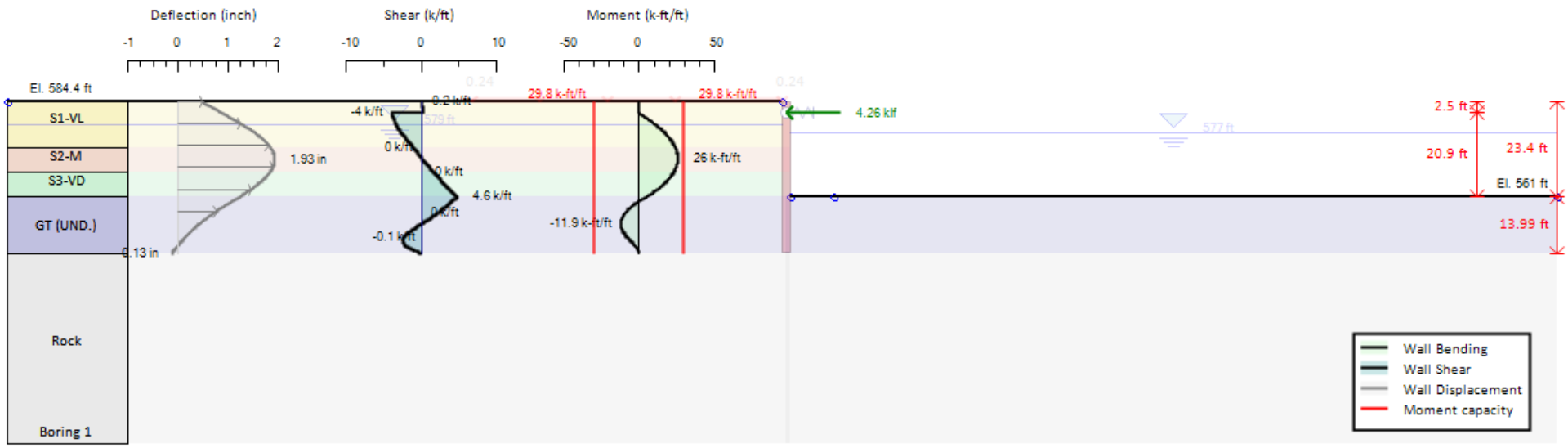
Cross Section C35 – Dredge to Plan Elevation



US EPA ARCHIVE DOCUMENT

Cross Section C35 – Dredge to Till (4 ft Below Plan Elevation)



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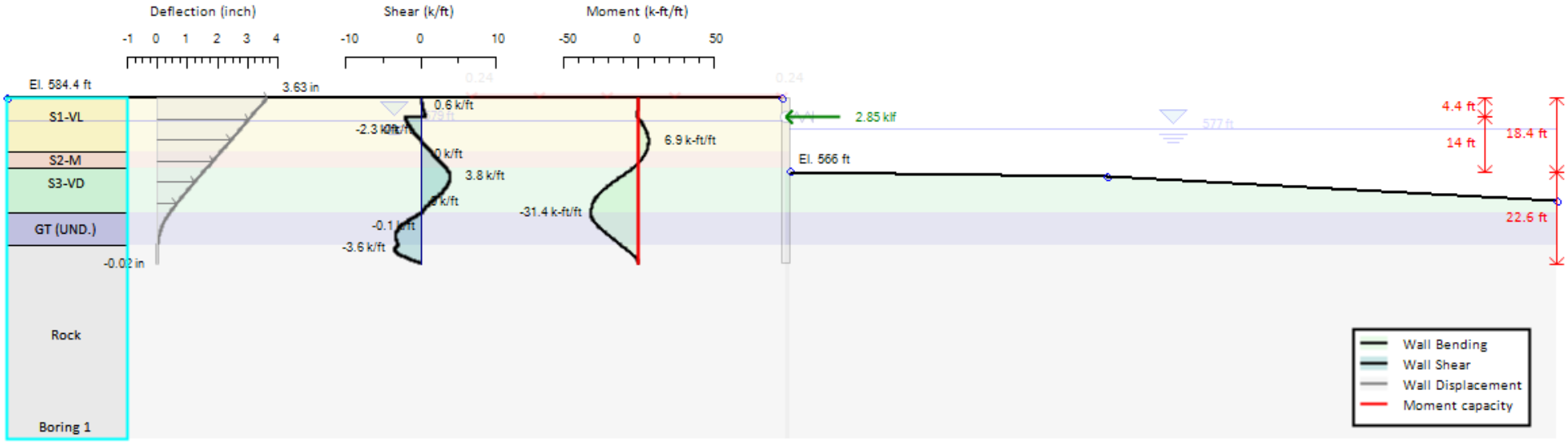
Cross Section D38 – Dredge to Plan Elevation



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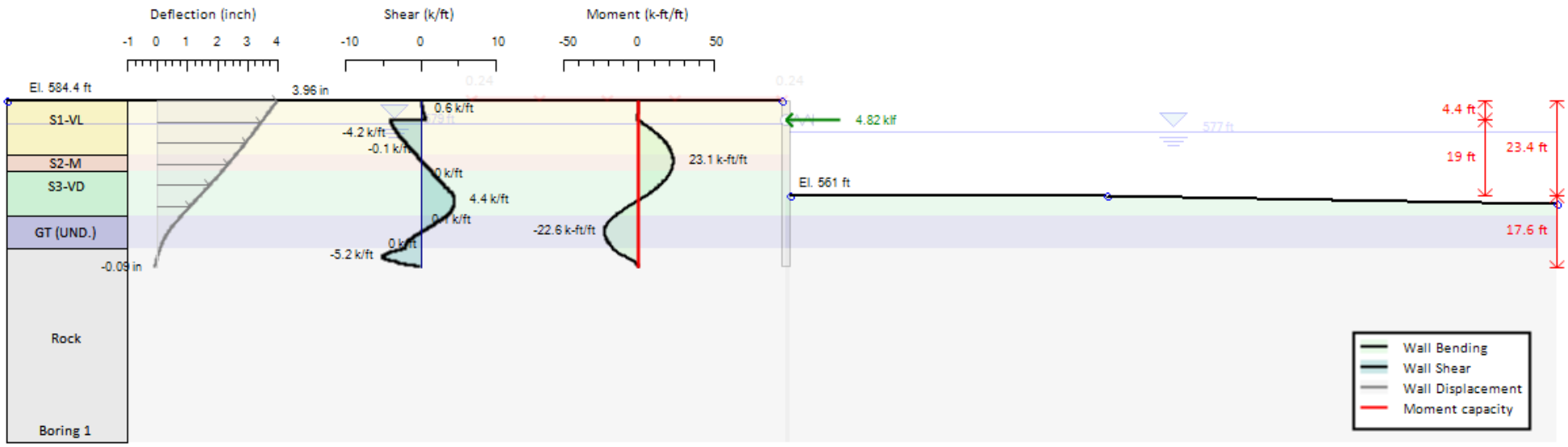
Cross Section D38 – Dredge to 5 ft Below Plan Elevation



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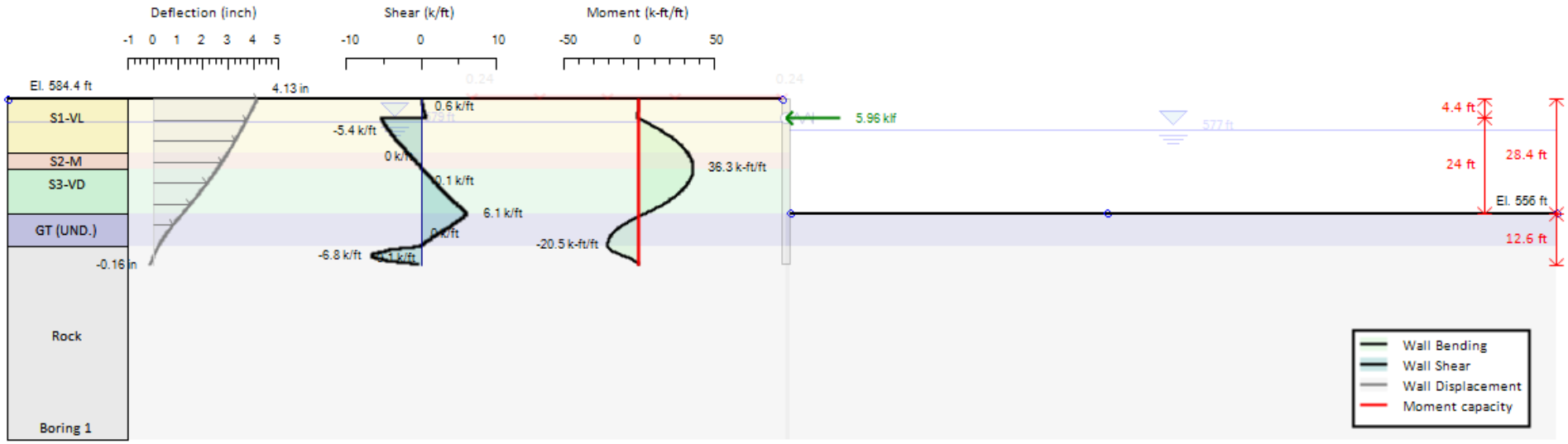
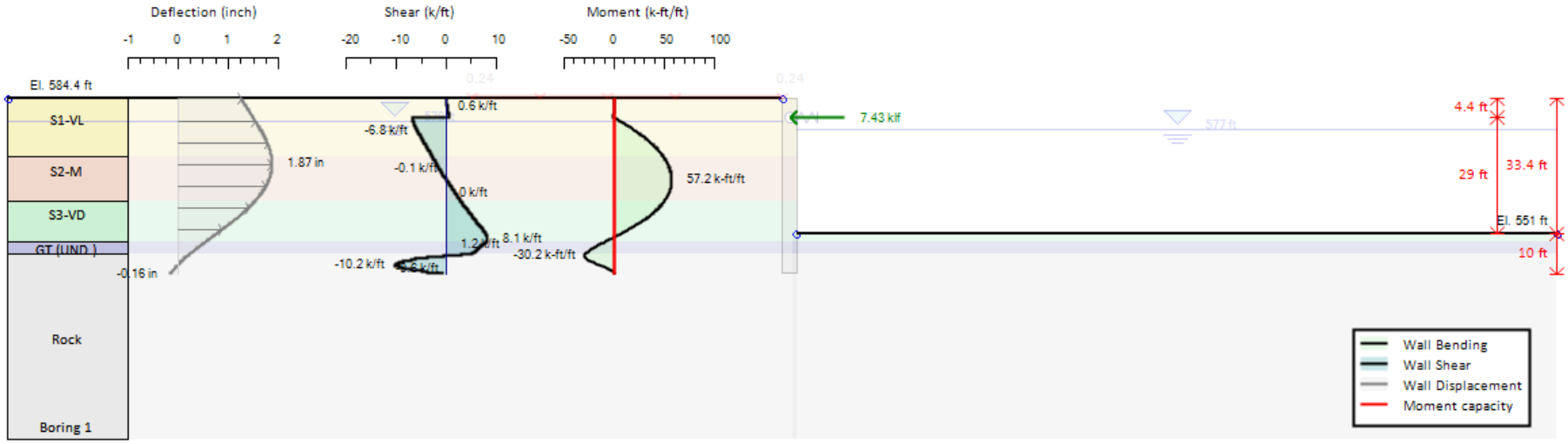
Cross Section D38 – Dredge to Till



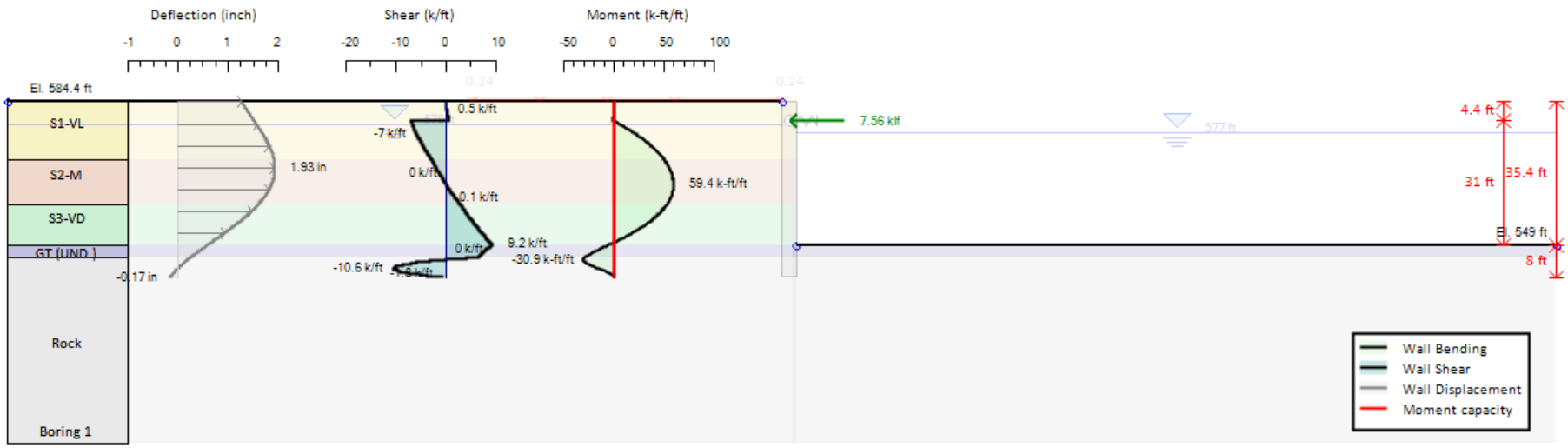
US EPA ARCHIVE DOCUMENT

Eight Street Slip Cross Section – Dredge to Plan Elevation



US EPA ARCHIVE DOCUMENT

Eighth Street Slip Cross Section – Dredge to Till, 2 ft Below Plan Elevation

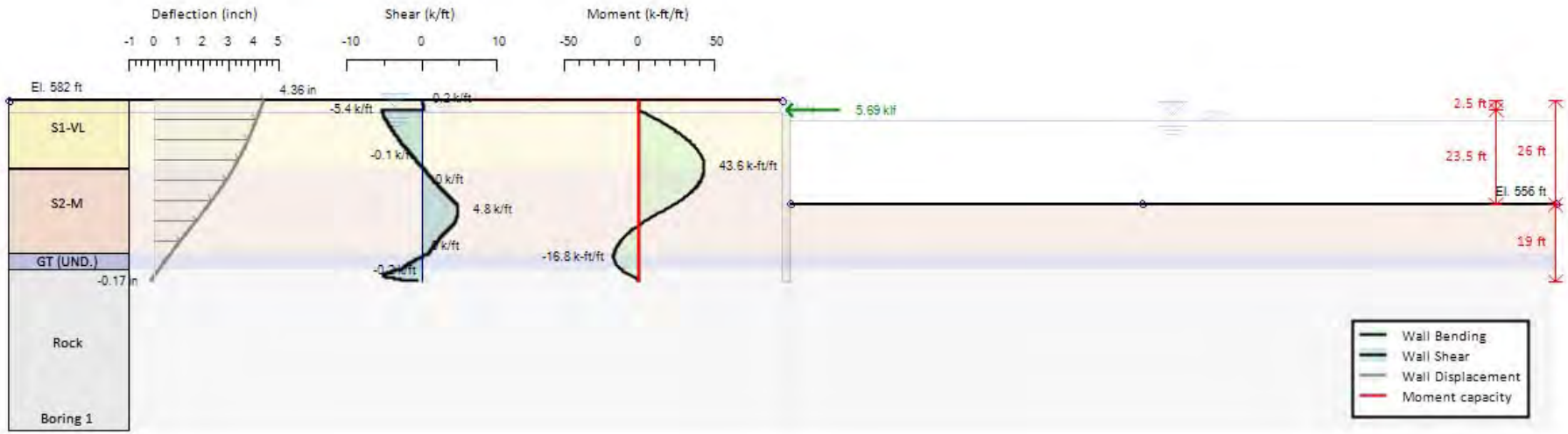


US EPA ARCHIVE DOCUMENT

Section SP1 – Dredge to Plan Elevation at Till

US EPA ARCHIVE DOCUMENT

Section F9 – Dredge to Plan Elevation



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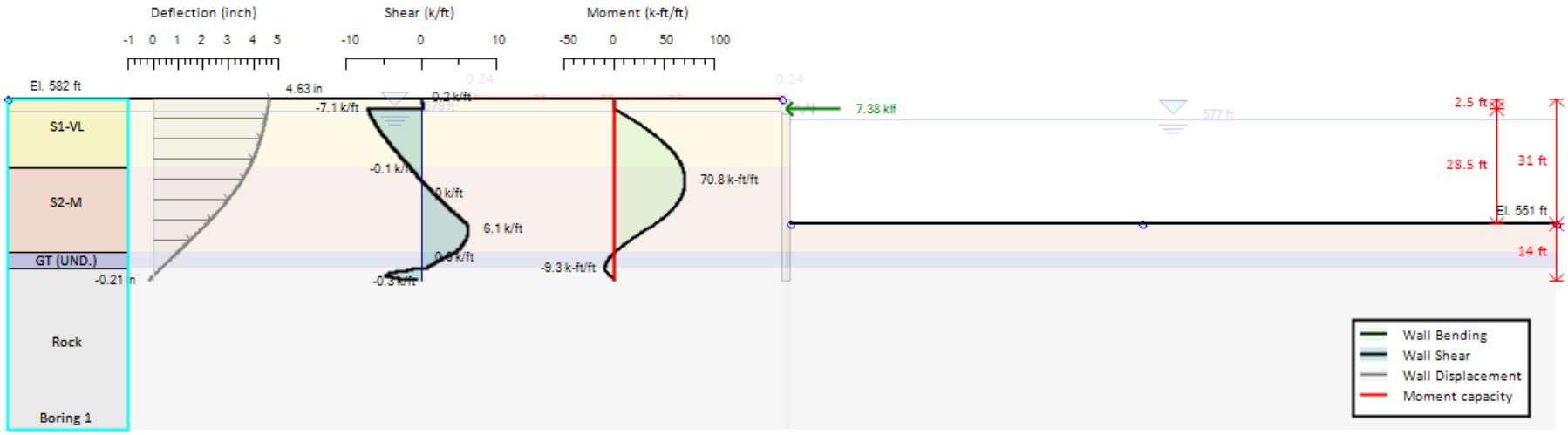
Section F9 – Dredge to 5 ft Below Plan Dredge Elevation



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Appendix E
Riprap Armoring Design

Basis of Design for Armor Stone Revetment for the Menominee River VBW Bulkhead Support Design

PREPARED FOR: Dave Allard/PHX

PREPARED BY: Mark Anderson/PDX
Brittany Hughes/PDX

DATE: July 17, 2012

PROJECT NUMBER: 436069

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The purpose of the Vertical Barrier Wall (VBW) Bulkhead Support Design Project is to design the support for an existing sheet pile bulkhead at the Tyco One Stanton Street Facility to allow a wedge of arsenic-contaminated sediment to be removed from the base of the sheet pile bulkhead in the Menominee River. The bulkhead serves as a barrier to the movement of groundwater from the site to the Menominee River. This memo focuses on the assumptions and design method used to determine appropriate size, gradation, material, and placement for armor stone revetment based on scour potential from expected propulsion forces.

Existing Conditions

The project is located within the city of Marinette, Marinette County, Wisconsin on the southern side of the Menominee River at the Tyco One Stanton Street Facility. The facility is bordered to the west-northwest by the Marinette Marine facility, to the east by Marinette city property, to the south by railroad tracks and to the north by the Menominee River, the midpoint of which represents the boundary between Wisconsin and the Upper Peninsula of Michigan. Figure 1 below shows an aerial view of the project area.

Figure 1: Aerial view of Project Area

The project area is split into 4 main parts: the turning basin, transition area, south channel, and the main navigation channel of the Menominee River. Since 1996, investigations have been performed in these areas to characterize arsenic in the river sediment and several corrective action measures have been implemented. One

such corrective action measure included the construction of a steel sheet pile bulkhead as part of a VBW along the north side of the property to contain groundwater flow from the site. A slurry wall was constructed along the northwest, southwest, and southeastern portions of the site to form the other portions of the VBW. Currently, dredging is being performed within the project area to remove some of the contaminated sediments. Once the current dredging project is finished, a wedge of arsenic-contaminated sediment will still remain at the base of the VBW bulkhead. When this sediment is removed during the next phase of dredging, backfill will need to be placed at the base of the VBW bulkhead to provide support to the wall. Armor stone will need to be placed over the backfill to protect it from potential scour from the propulsion forces created by large ships in the turning basin.

Determining Rock Size and Gradation

Engineering calculations to determine the size and gradation of armor stone follow the methodology provided in *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments; Appendix A: Armor Layer Design*, as prepared by Steve Maynord of the US Army Engineer Waterways Experiment Station for the United States Environmental Protection Agency. This guidance is written for propeller propulsion and therefore has been adapted for waterjet propulsion. It should be noted that the equations are empirical and their applicability to different propulsion systems is unknown.

Data Collection

Information was provided to CH2M HILL on Tuesday, July 3, 2012 through an email communication with Scott Wellens from Marinette Marine Corporation regarding the thrust expected from ships maneuvering in the turning basin.

> "The LCS [Littoral Combat Ship] typically goes in/out of the channel under low speed and therefore doesn't develop full thrust. In fact, it generally runs on diesels only (20,000 hp max) and not the gas turbines. The technical information is as follows: LCS-3 operations at very low speeds (<7kt) are conducted at a constant shaft speed and idle power on the main diesels, utilizing (2) steerable waterjets, only. For throttle settings, ship speed is controlled by reversing bucket position. At this shaft speed, each shaft is absorbing approximately 500-600 hp. (I personally think the HP absorbed is higher.) I did some quick calculations and came up with a volumetric flow rate of 208 ft^3/sec with a jet velocity of 27.3 ft/sec. (This is to be considered a low value in my opinion.)
>
> … Keep in mind, it's safe to assume that we would only operate within the turning basin buoys which are some distance away from the dock. Anything closer and we would risk running aground.
>
> Also note, that while these values are being provided as guidance, MMC cannot guarantee these values will not be exceeded for future unknown projects."

Information was also gathered on the LCS from internet articles and manufacturer's cut sheets. One article notes that the waterjets on the LCS can pump water at a combined rate of 25,000 gallons per second, using marine gas turbines (model MT30) developed by Rolls-Royce that operate at 36 megawatts. Pictures of the LCS show a total of 4 waterjets.

Calculations

Detailed calculations are located in Attachment A. Using the data provided by Scott Wellens (a jet velocity of 27.3 ft/sec), the maximum bottom velocity when the LCS is maneuvering in the turning basin is 3.39 ft/sec. In order to protect the VBW from a 3.39 ft/sec propulsion force, the resulting D_{50} rock size is 9 inches.

Due to the uncertainties surrounding the types of ships and jet velocities in the turning basin, "future unknown projects", and the unknown applicability of the empirical equations to different propulsion systems, a factor of safety is recommended. By applying a factor of safety, the recommended riprap size should have a D_{50} of 12 inches. This is consistent with Class III riprap (D_{100} of 24 inches) as listed in CH2M HILL standard specifications. The table below lists the gradation information for Class III riprap.

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TABLE 1
Class III Riprap Gradation Information
From CH2M HILL Standard Specifications

Weight (lbs)	% Greater Than
800	0 to 5
400	30
200	75
25	90

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Design Recommendations

The following sections discuss the design recommendations for the filter design, riprap design, toe treatment, and edge treatment.

Filter Layer Design

The filter layer in riprap design serves 2 main purposes: limiting the loss or migration of fines between the riprap and base material and providing support or load distribution to riprap if placed on poorly consolidated soil. In addition to minimizing particle migration, filter layers must have enough permeability to allow unimpeded flow of water from the underlying soil through the filter layer to minimize hydrostatic pressure build-up caused by seasonal changes in the water table. The permeability of the filter layer should never be less than the permeability of the underlying soil.

If the project area is dredged down to the glacial till layer, a filter layer may not be needed. Glacial till has an extremely low permeability and tends to be well-consolidated. However, if some backfill is needed to support the VBW bulkhead, it is recommended that the backfill have a gradation that matches that listed in table 2 below. If this gradation is used for backfill, it can also act as a filter layer for the riprap.

TABLE 2
Design Filter Band Gradation
From CH2M HILL Standard Specifications

Sieve size	% passing by weight
6 inch	100
4 inch	>85
No. 4	>10

If the material used for backfill differs in gradation from that listed in table 2, then a filter layer needs to be placed. Guidance documents on filter design recommend a layer thickness of 4 times the D_{50} of the filter rock, or 6 inches, whichever results in the greatest thickness. This would result in a filter layer thickness of 6 inches. It is also recommended that if the filter layer is to be placed underwater, the thickness should be increased by 50-percent to accommodate for the uncertainties associated with placement of the material. Thus the recommended resulting design thickness of the filter layer is 9 inches.

Riprap Layer Design

Guidance documents on riprap design recommend a layer thickness of the D_{100} or $1.5D_{50}$, whichever results in the greatest thickness. This would result in a riprap thickness of 24 inches. It is also recommended that if the riprap is to be placed underwater, the thickness of the riprap layer should be increased by 50-percent to accommodate for the uncertainties associated with placement of the material. Thus the recommended resulting design thickness of the riprap layer is 36 inches.

Toe Treatment

Guidance documents on riprap design recommend that riprap be toed down below the toe of the bank slope. However, it is assumed that digging a toe trench into the glacial till would be extremely difficult, so the alternative to digging a toe trench would be to use a mounded toe. It is assumed that the toe of the slope will be placed on glacial till and that the slope for riprap and backfill is assumed to be a 3H:1V slope. If backfill is used, the toe of the riprap will need to extend out from the backfill so that it rests on glacial till. The mounded toe thickness is required to be 2 times the thickness of the riprap on the slope, a thickness of 72 inches.

Edge Treatment

Guidance documents on riprap design recommend that the edge of the riprap extend out a distance 3 times the thickness of the riprap layer, a distance of 108 inches.

References

1. Arneson, L.A., Clopper, P.E., Girard L.G., Lagasse, P.F., Pagán-Ortiz, J.E., Schall, J.D., Zevenbergen, L.W. 2009. “Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance Volume 2, Third Edition,” Hydraulic Engineering Circular No. 23, FHWA NHI 09-112, Washington, D.C.

2. Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Attachments

Attachment A- Riprap Rock Size Design Calculations

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Calculation Cover Sheet

CH2MHILL

Project	Menominee River Sediment Removal- VBW Bulkhead Support Design		
Client	Tyco Fire Products LP	Project No.	436069

Calculation Title:	Riprap Sizing Calculations
Calculation Identifier:	

Rev. No.	Originator Signature/Date		Checker Signature/Date		Seal and Signature (if Req'd)
0	Brittany Hughes	3-Jul-12	Morgan Ruark	18-Jul-12	

Comments:

QC Check has been completed. Resolution has been reached on all QC comments.

Information Requiring Confirmation:

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Armor Layer Design Calculations

Project: Menominee River Sediment Removal Project- VBW Bulkhead Support Design
Client: Tyco Fire Products LP
PN: 436069
Date: 7/3/2012
References: 1. Arneson, L.A., Clopper, P.E., Girard L.G., Lagasse, P.F., Pagán-Ortiz, J.E., Schall, J.D., Zevenbergen, L.W. 2009. "Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance Volume 2, Third Edition," Hydraulic Engineering Circular No. 23, FHWA NHI 09-112, Washington, D.C.
2. Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

LCS Thrust Calculations

Data Provided:
1. Flow from LCS is 25000 gal/sec from 4 water jets.
2. Email states that only 2 waterjets are used in the turning basin.
3. Dimensions of waterjet calculated based on email = 7.62 ft^2
4. Volumetric flow rate of 208 ft^3/sec with a jet velocity of 27.3 ft/sec. (Used as a basis for comparison in determining amount of throttle used in the turning basin.)

Assumptions:
1. Height and width of water jet is square.
2. Reduction in throttle is proportional to reduction in flow across all jets.

Calculations:

Flow from 4 water jets	3342 ft^3/sec
Flow from single jet	836 ft^3/sec
Cross sectional area of water jet	7.6 ft^2
Velocity from single jet at full throttle	109.65 ft/sec
Velocity from single jet at half throttle	54.82 ft/sec
Velocity from single jet at 1/3 throttle	36.55 ft/sec
Velocity from single jet at 1/4 throttle	27.41 ft/sec
Velocity from single jet at 1/8 throttle	13.71 ft/sec
Velocity from single jet at 1/10 throttle	10.96 ft/sec
Velocity from single jet at 1/20 throttle	5.48 ft/sec

In comparing to the numbers provided in the email from Scott Wellens, it appears that when a ship is manuevering in the turning basin, it is operating at 1/4 throttle.

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Armor Layer Design Calculations

Project: Menominee River Sediment Removal Project- VBW Bulkhead Support Design
Client: Tyco Fire Products LP
PN: 436069
Date: 7/3/2012
References: 1. Arneson, L.A., Clopper, P.E., Girard L.G., Lagasse, P.F., Pagán-Ortiz, J.E., Schall, J.D., Zevenbergen, L.W. 2009. "Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance Volume 2, Third Edition," Hydraulic Engineering Circular No. 23, FHWA NHI 09-112, Washington, D.C.
2. Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Velocity at coordinates x, z

$$V_x = 2.78 * \left(\frac{D_o}{x}\right) * \exp\left[-15.43 * \left(\frac{z}{x}\right)^2\right] * U_o$$

V_x= 3.38759321 ft/sec

Variable		Input	Units	Description	Notes
D_o	=	2.76	ft	= 0.71D_p for non ducted propeller	
				= D_p for ducter propeller	
D_p	=	2.76	ft	propeller diameter	Based on data in LCS Water Jet and Thrust Calcs Worksheet
x	=	38	ft	horizontal distance from propeller	
z	=	6.75	ft	radial distance from axis of propeller	Added 3 feet to waterjet radius to account for edge of ship around waterjets.
U_o	=	27.3	ft/sec	jet velocity exiting the propeller in ft/sec	Based on data in LCS Water Jet and Thrust Calcs Worksheet

Where U_O = 109.7 ft/sec (Full Throttle)

x	z	V_x
1	6.75	0.00
5	6.75	0.00
10	6.75	0.07
15	6.75	2.47
20	6.75	7.26
25	6.75	10.93
30	6.75	12.85
35	6.75	13.55
36	6.75	13.59
37	6.75	13.61
38	6.75	13.61
39	6.75	13.59
40	6.75	13.56
45	6.75	13.22

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Armor Layer Design Calculations

Project: Menominee River Sediment Removal Project- VBW Bulkhead Support Design
Client: Tyco Fire Products LP
PN: 436069
Date: 7/3/2012

Where U_O = 54.8 ft/sec (Half Throttle)

x	z	V_x
1	6.75	0.00
5	6.75	0.00
10	6.75	0.04
15	6.75	1.23
20	6.75	3.63
25	6.75	5.46
30	6.75	6.42
35	6.75	6.77
36	6.75	6.79
37	6.75	6.80
38	6.75	6.80
39	6.75	6.79
40	6.75	6.77
45	6.75	6.60

Where U_O = 36.6 ft/sec (1/3 Throttle)

x	z	V_x
1	6.75	0.00
5	6.75	0.00
10	6.75	0.02
15	6.75	0.82
20	6.75	2.42
25	6.75	3.65
30	6.75	4.29
35	6.75	4.52
36	6.75	4.53
37	6.75	4.54
38	6.75	4.54
39	6.75	4.54
40	6.75	4.52
45	6.75	4.41

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Armor Layer Design Calculations

Project: Menominee River Sediment Removal Project- VBW Bulkhead Support Design
Client: Tyco Fire Products LP
PN: 436069
Date: 7/3/2012

Where U_O = 27.3 ft/sec (1/4 Throttle, also jet velocity when turning in turning basin)

x	z	V_x
1	6.75	0.00
5	6.75	0.00
10	6.75	0.02
15	6.75	0.61
20	6.75	1.81
25	6.75	2.72
30	6.75	3.20
35	6.75	3.37
36	6.75	3.38
37	6.75	3.39
38	6.75	3.39
39	6.75	3.38
40	6.75	3.37
45	6.75	3.29

Thus, maxiumum bottom velocity occurs at a point on the shore 38 feet from the ship. The max bottom velocity when the ship is turning in the turning basin is 3.39 ft/sec.

Rock Size Equation

$$D_{50} = \left(\frac{V_b(\max)}{C_3 * \left(g * \left(\frac{a_s - a_w}{a_w} \right) \right)^{1/2}} \right)^2$$

D_{50} = 0.751149767 ft

Variable		Input	Units	Description	Notes
C_3	=	0.55		= 0.55 for channel protection where repeat attack is expected and no movement can be allowed	
				= 0.6 -0.7 for channel protection when infrequent attack is expected	
a_w	=	62.24	lb/ft^3	unit weight of water at 60°F	
a_s	=	160	lb/ft^3	unit weight of stone (as provided in CH2M HILL Standard Specification)	
V_b(max)	=	3.39	ft/sec		From calculations above
g	=	32.2	ft/sec^2	gravitational constant	

Thus, the max bottom velocity is 3.39 ft/sec, this results in a D_{50} of 0.75 ft or 9-inch rock. To be conservative in design due to assumptions made, will use a D_{50} of 12 inches, or Class III Riprap (as specified in CH2M HILL standard specifications).

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Armor Layer Design Calculations

Project: Menominee River Sediment Removal Project- VBW Bulkhead Support Design
Client: Tyco Fire Products LP
PN: 436069
Date: 7/10/2012
References: 1. Arneson, L.A., Clopper, P.E., Girard L.G., Lagasse, P.F., Pagán-Ortiz, J.E., Schall, J.D., Zevenbergen, L.W. 2009. "Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance Volume 2, Third Edition," Hydraulic Engineering Circular No. 23, FHWA NHI 09-112, Washington, D.C.
2. Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Rock Size Equation

$$V_b(\max) = C_3 * (g * \left(\frac{a_s - a_w}{a_w}\right) * D_{50})^{1/2}$$

V_b(max) = 3.911438 ft/sec

Variable		Input	Units	Description
C_3	=	0.55		= 0.55 for channel protection where repeat attack is expected and no movement can be allowed
				= 0.6 -0.7 for channel protection when infrequent attack is expected
a_w	=	62.24	lb/ft^3	unit weight of water at 60°F
a_s	=	160	lb/ft^3	unit weight of stone (as provided in CH2M HILL Standard Specification)
D_{50}	=	1	ft	characteristic riprap size of which 50 percent is finer by weight
g	=	32.2	ft/sec^2	gravitational constant

Rock size versus maximum allowable bottom velocity

D_{50} (ft)	V_b(max) (ft/sec)
0.5	2.77
0.75	3.39
1.0	3.91
1.25	4.37
1.5	4.79

Calculation of maximum bottom velocity a class of riprap (as specified in CH2M HILL standard specs) can withstand without any movement occurring.

CH2M HILL Specification Riprap Classifications	D_{50} (ft)	V_b(max) (ft/sec)	Maximum Throttle Riprap can withstand without movement
Class I	0.5	2.77	Quarter
Class II	0.75	3.39	Quarter
Class III	1.0	3.91	Third
Class IV	1.33	4.37	Third
Class V	1.5	4.79	Third

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Armor Layer Design Calculations

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References: 1. Arneson, L.A., Clopper, P.E., Girard L.G., Lagasse, P.F., Pagán-Ortiz, J.E., Schall, J.D., Zevenbergen, L.W. 2009. "Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance Volume 2, Third Edition," Hydraulic Engineering Circular No. 23, FHWA NHI 09-112, Washington, D.C.
2. Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Riprap Thickness Calculations

Riprap Class	D_{50} (in)	$1.5*D_{50}$ (in)	D_{100} (in)	Riprap Thickness (in)	Factor for underwater placement	New Riprap Thickness (in)
I	6	9	12	12	1.5	18
II	9	13.5	18	18	1.5	27
III	12	18	24	24	1.5	36
IV	15	22.5	30	30	1.5	45
V	18	27	36	36	1.5	54

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