CEDAR LAKE AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

CEDAR LAKE, INDIANA

APPENDIX D
GEOTECHNICAL

U.S. Army Corps of Engineers
Chicago District

July 2016

CEDAR LAKE, INDIANA
CEDAR LAKE AQUATIC ECOSYSTEM RESTORATION
FEASIBILITY STUDY

APPENDIX D – GEOTECHNICAL

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APPENDIX D - GEOTECHNICALREPORT

Purpose and Scope

1. This appendix discusses the geotechnical investigations and analyses performed for the Cedar Lake Feasibility Report, summarizes the regional geology and groundwater conditions and various subsurface investigations performed relevant to the overall study. Short and long term shear strength parameters, recommendations for dike construction materials, excavation recommendations, preliminary analyses for slope stability and bearing capacity, and design recommendations are provided for the purpose of this feasibility study.

Site Description

2. Cedar Lake is located in the Town of Cedar Lake, in the west-central section of Lake County, in northwest Indiana. The Town of Cedar Lake is approximately 35 miles southeast of Chicago. The main roads that surround Cedar Lake are Parrish Avenue and US 41 to the west, Morse Street to the east, and Route 231 to the north. Cedar Lake can be found in the St. John and Lowell 7.5' USGS topographic quadrangle maps in sections 22, 23, 26, 27, 34 and 35 at T34N R9W.

3. The area designated for the Sediment Dewatering Facility is highlighted in Figure 1 to the South West of Cedar Lake.

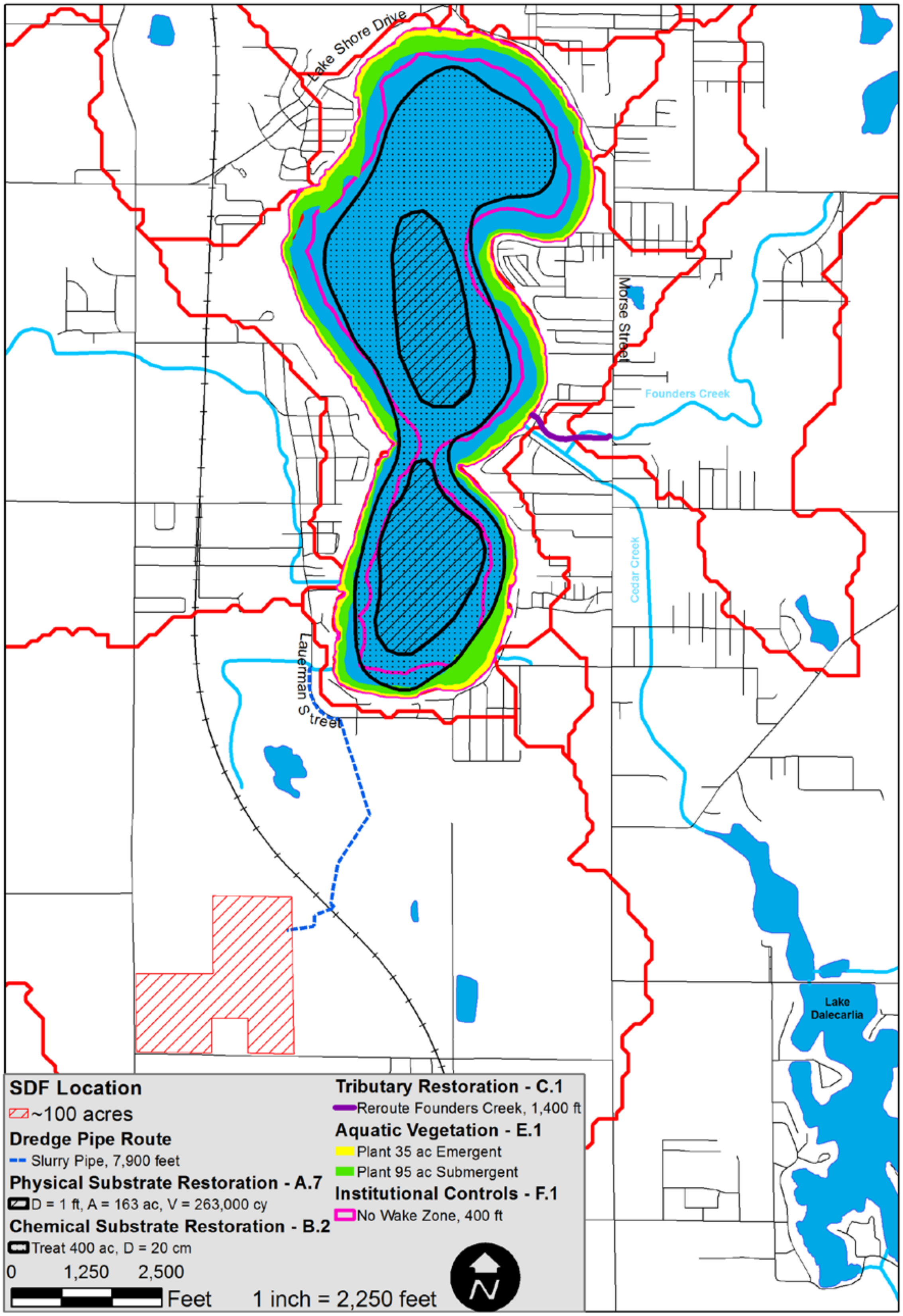


Figure 1. Plan View of Proposed Sediment Dewatering Facility Location

Regional and Site Geology

Physiography

4. Cedar Lake lies in the Valparaiso Morainal Area illustrated in Figure (Hartke et al., 1975). Hartke et al. indicate that the Valparaiso Morainal Area is a complex system of rolling hills extending as shown in Figure 2. The main crest of the moraine passes along a ridge about a quarter mile north of Cedar Lake. Hartke et al. indicate the Valparaiso Moraine is a composite of several end moraines, one superimposed on top of the other. The present stratigraphy is a result of minor fluctuations of the terminus of the Lake Michigan lobe of the Wisconsinan Age of glaciation approximately 14,000 years ago. The upper till composed of clay loam is on average 15 to 50 ft in thickness. Beneath this till lies an older till layer that is found to 15 to over 100 feet below the ground surface. Both upper and lower tills have similar lithology and texture. There is a coarse sediment that occurred as outwash between deposition of the lower and upper tills (Hartke et al. 1975).

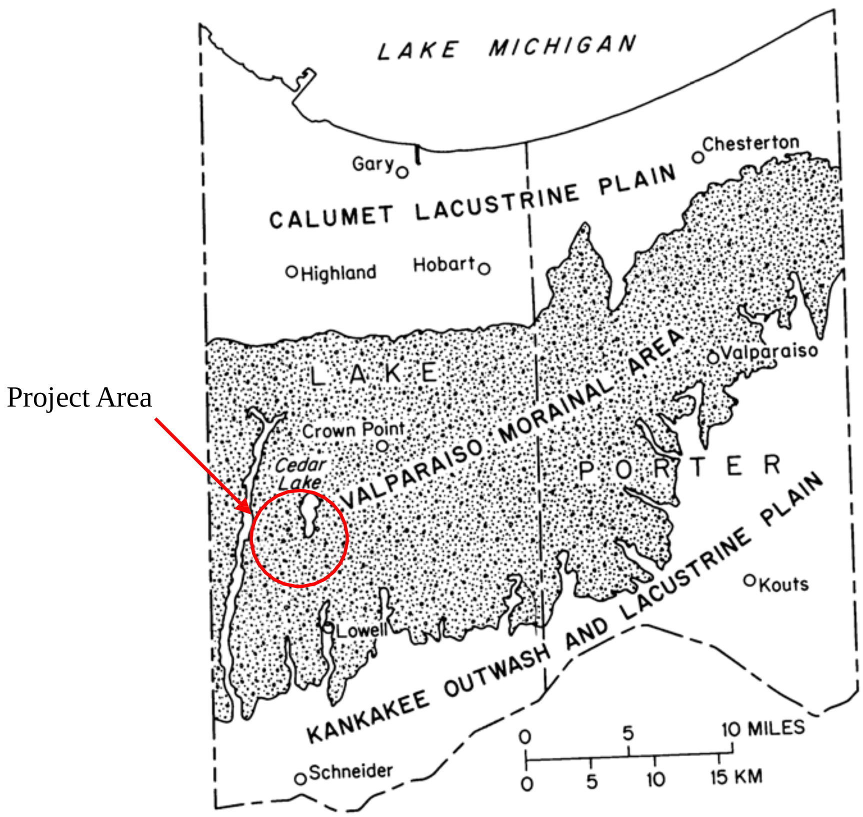


Figure 2. Map of Physiographic Units (Hartke et al., 1975)

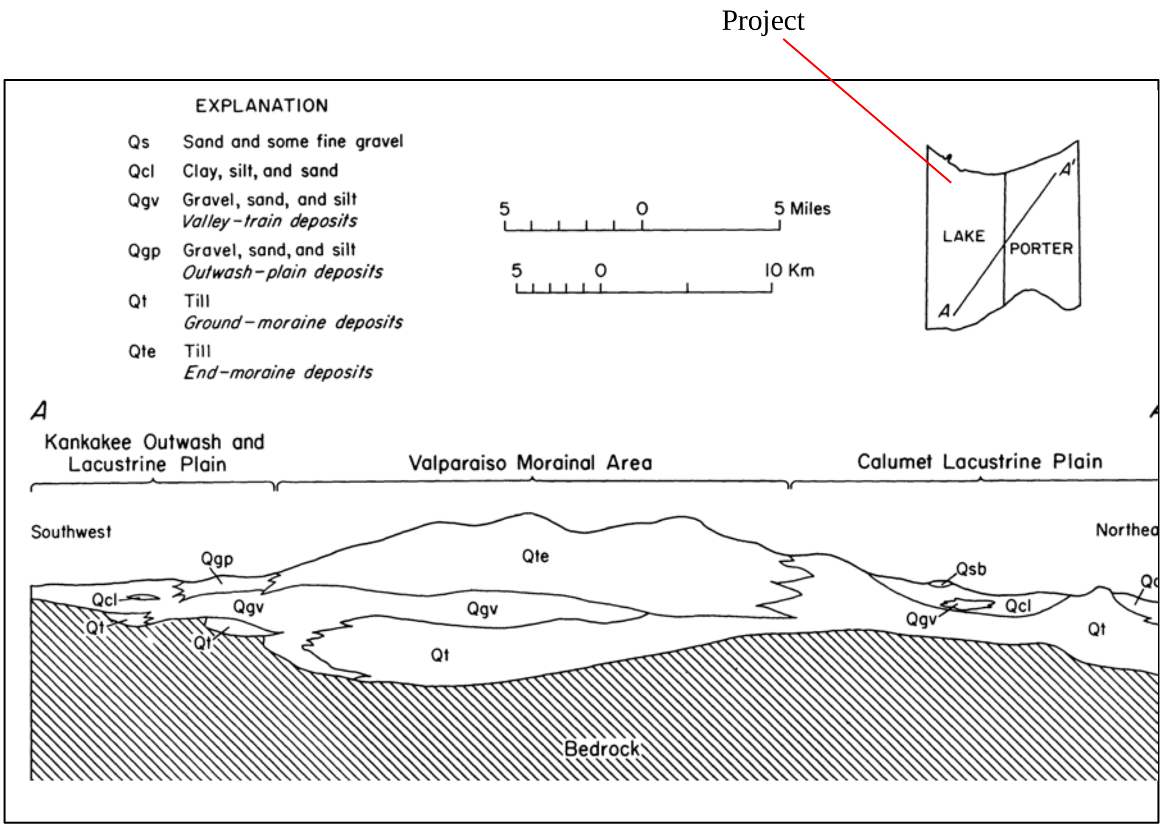


Figure 3. Generalized surficial geology of the Valparaiso Morainal Area (Hartke, et al., 1975)

Bedrock Geology

5. The bedrock beneath the till layers consists of limestone, dolomite, sandstone, and shale of Cambrian through Devonian age, and lie above granite of the Precambrian age. Figure 4 shows a simplified bedrock profile extending to a depth of 4,000 feet and indicates the approximate age, thickness, and lithology of the units in the bedrock sequence (Hartke, et al., 1975).

6. Structural dip, or inclination of the bedrock units, is generally southeastward, Average dip is about 5 to 7 feet per mile. The bedrock surface is found 15 to 270 feet below unconsolidated glacial material (Hartke et al., 1975).

SYSTEM	STRATIGRAPHIC UNITS		DOMINANT LITHOLOGY	THICKNESS IN FEET
QUATERNARY	Glacial drift		Sand, gravel, and clay	55 – 210
DEVONIAN	Antrim Shale		Shale	0 – 135
	Traverse Fm.		Limestone	0 – 135
SILURIAN	Detroit River Fm. Salina Fm. Wabash Fm. Louisville Ls. Salamonie Dol. Brassfield Ls.		Dolomite and limestone	380 – 555
ORDOVICIAN	Maquoketa Gr.		Shale and limestone	170 – 285
	Trenton Ls. Black River Ls.		Limestone and dolomite	320 – 370
	St. Peter Ss.		Sandstone	30 – 325
	Knox Dol.		Dolomite	65 – 625
CAMBRIAN	Galesville Ss.		Sandstone and dolomite	65 – 150
			Sandstone	165 – 215
	Eau Claire Fm.		Shale, dolomite, and sandstone	540 – 620
	"B" cap		Shale	
	Mount Simon Ss.		Sandstone	1,600 – 2,000
PRE-CAMBRIAN			Granite	

Figure 4. Generalized column showing lithology and names of bedrock formations (Hartke et al., 1975)

Surficial Geology

7. Numerous small kettle lakes can be found in the Valparasio moraine, the largest of which is Cedar Lake. The Valparaiso till plain in the area of Cedar Lake area is irregular and narrow with numerous divides and many short deep slopes. This is shown on the proposed sediment dewatering site, where soil boring surface elevations ranged from 727.1 to 735.9 over the site. Evert Kincaid and Associates (1964) report that approximately one-third of the area is depressed and does not have good outlets for water and is, consequently, covered with dark, poorly drained soils. This is also reflected in the proposed site, which has several areas of hydric soils as shown in the recent soil survey performed by CBBC (2 May 2008) and summarized in Figure 8 and Table 2. A generalized stratigraphy for the Cedar Lake drainage basin in presented in Figure 5.

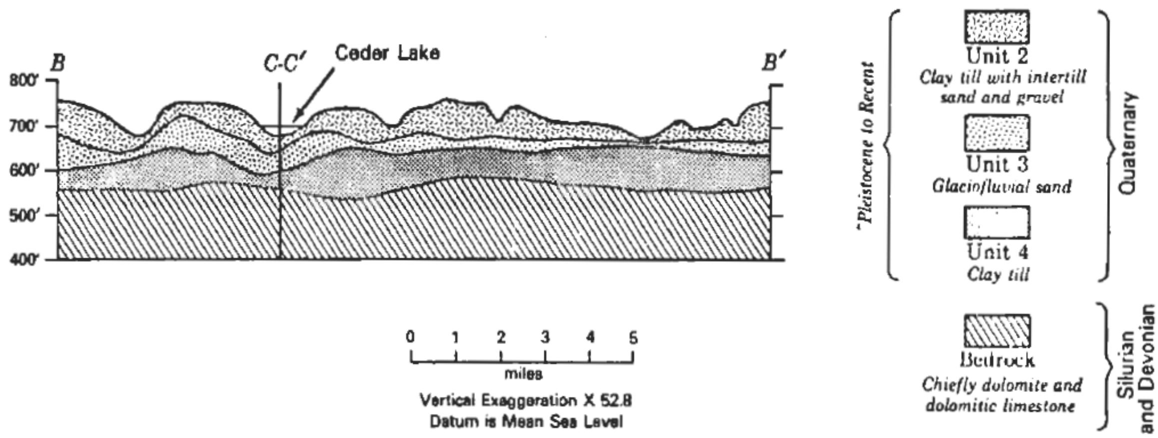


Figure 5. Generalized stratigraphy for the Cedar Lake drainage Basin

8. In Lake County the average depth to the sandy outwash zone is about 25 feet, which is reflected in the six site borings that found a sand outwash layer in each of the 20 ft borings except one (See Table 1). Pockets or blebs of sand and fine gravel are incorporated in the upper till throughout the moraine. The main outwash layer is actually part of the Kankakee outwash plain to the south and is hydraulically connected to it. An abundant supply of groundwater is therefore within the outwash layer below the Valparaiso till. Where the till is in contact with the saturated sand and gravel unit, it becomes saturated, thus sharply lowering both bulk density and strength of the till. In like manner, most of the outwash blebs within the till are saturated and serve to maintain the surrounding till in a state of near to complete saturation. The effective loss of till strength in close proximity to saturated sand and gravel bodies is commonly in excess of 50 percent, that is, sufficient to cause construction problems in areas affected. However, excavation is not expected to extend to this depth, and therefore is not presently anticipated to be problematic.

9. The Valparaiso Morainal Area is well suited for all types of construction from industrial to residential. The primary limiting factor in the eventual parceling off and zoning of land on the moraine is the availability of sufficient quantities of fresh water.

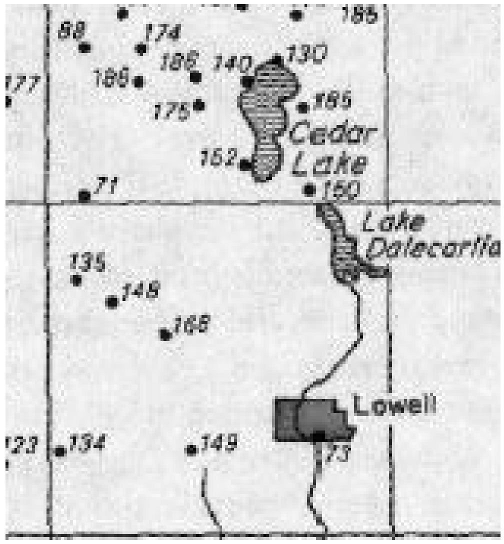


Figure 6. Map indicated depth in feet of drift surface at well locations

Groundwater Conditions

Site Groundwater Conditions

10. Groundwater is expected to be an issue for excavation only if sand seams are encountered. Sand and groundwater encountered are described in the following:

Table 1. Site Groundwater Elevations

Boring	Ground Elevation, ft	Groundwater Elevation, ft	Top Elevation of Gray Clay, ft	Depth to Gray Clay	Groundwater Depth, ft	Sand Seam Dept
B-01- 08	733.9	723.9	723.9	10	10	None found
B-02- 08	733.3	717.3	720.8	12.5	16	18.5 – 20’
B-03- 08	735.9	728.4	735.4	0.5	7.5	12.5 – 13.5’
B-04- 08	732.9	726	718.9	14	6.9	11.1 – 14
B-05- 08	727.1	709.6	714.6	12.5	17.5	19 – 20’
B-06- 08	734.6	729.1	722.1	12.5	5.5	9.5 – 12.5’

11. Though the water table was measured to be above the elevation of the sand seams, significant seepage into the excavation is only expected if excavation intercepts the sand seams. The current plan is for approximately 5 ft of excavation, which should not encounter significant groundwater flow issues. Should excavations encounter sand seams then it is recommended that seepage be managed via pumping from the bottom of the excavation.

Regional Groundwater Conditions

12. The centrally located, east -west-trending Valparaiso Morainal Area forms the divide between the two principal watersheds of the two counties. It is generally well drained except for some ice-depressional features. These saucer -shaped depressions may be lakes or bogs filled with muck and peat and are generally partly or totally isolated from the main surface drainage systems. In addition to the poor or nonexistent surface drainage of these features, the low permeability till beneath the muck and peat allows little water loss through infiltration. The result is a bog or marsh which remains wet even through extended dry periods. This is indicated on site by the presence of hydric soils (See Table 2 and Figure 8).

13. The runoff and infiltration from the major part of this central highland area feed the Little Calumet and Kankakee Rivers. As they flow to the Little Calumet River, streams on the north slope, such as Deep River and Salt Creek, follow tortuous routes dictated by irregular deposits of glacial drift. In contrast, streams on the south slope of the moraine, such as Eagle Creek, flow directly south to the Kankakee outwash plain through channels etched by glacial meltwater that poured off the leading edge of the ice sheet.

14. Flooding is not a major problem on the moraine because the rolling topography promotes adequate runoff. Flash floods can occur; however, as a result of high-intensity, short-duration rainfall. The frequency of such floods will increase as urban development spreads over the land and causes increased direct runoff.

15. <u>Unconsolidated System</u>: The unconsolidated system is composed of three heterogeneous sand and gravel aquifers, two of which are hydraulically connected. They are here designated the Calumet, Valparaiso, and Kankakee aquifers. There are other isolated minor aquifers in the heterogeneous glacial materials capable of providing supplies for small industries or farms. These small aquifers have neither the lateral extent nor the production capability of the three major ones. The Valparaiso aquifer of main concern to the project at hand and is discussed in further detail in the following section.

16. <u>Valparaiso Aquifer</u>*:* The central Valparaiso aquifer illustrated in Figure is in part a water table aquifer and in part an *artesian* aquifer. It is a confined heterogeneous layer of sand and gravel and intermixed clay and silt lenses lying on and covered by glacial till. The covering glacial till acts as an *aquitard, so* that a pressure head is developed in much of the Valparaiso aquifer. Where this occurs, water in a well drilled into the aquifer will rise above its confined level, although not necessarily to the ground surface.

17. This aquifer ranges from 10 to 90 feet in thickness and lies from 10 to 80 feet below the surface. The entire sequence is heterogeneous, for the upper and lower tills both contain lenses of sand and gravel. These lenses within the confining layers may produce small to moderate quantities of water, depending on their size and their location with respect to the piezometric surface.

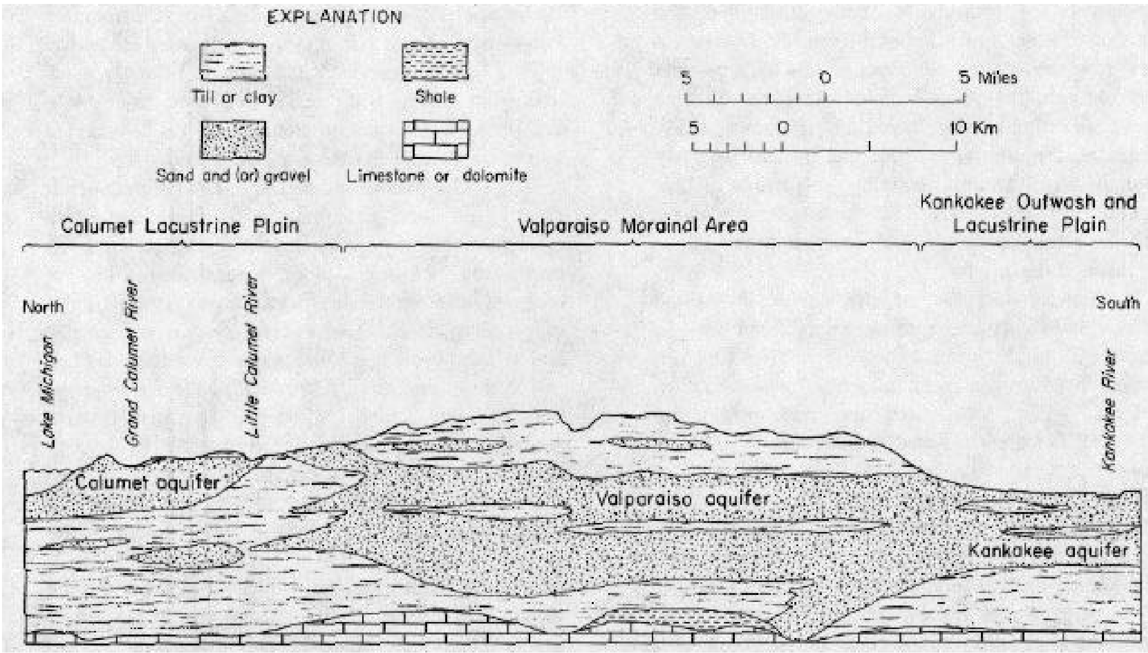


Figure 7. Idealized North South cross section through Lake County showing positions of unconsolidated aquifers.

18. The Valparaiso aquifer is recharged primarily from the confining layer above. The recharge rate presents one major limitation in the development potential of the aquifer. Therefore, the maximum sustained yield of the Valparaiso aquifer depends directly on the permeability and storage capacity of the overlying glacial till. The recharge rate is controlled by a combination of average annual infiltration, which determines the amount of water available for recharge, and the permeability of the confining or covering layer under ideal maximum *head* differential conditions. The average annual infiltration determines the total water available, and the permeability determines the rate at which it becomes available.

Completed Explorations

19. Figure 8 and Table 2 summarize the soil survey performed by CBBC (2 May 2008). Of relevance in the survey is the mapping of hydric soils on site as well as identification of additional soils not previously mapped by USDA. Though isolated hydric soils were found, the area is farmed, and not likely to qualify as wetland because of lack of wetland vegetation and depth of groundwater (5.5 – 17.5 ft).

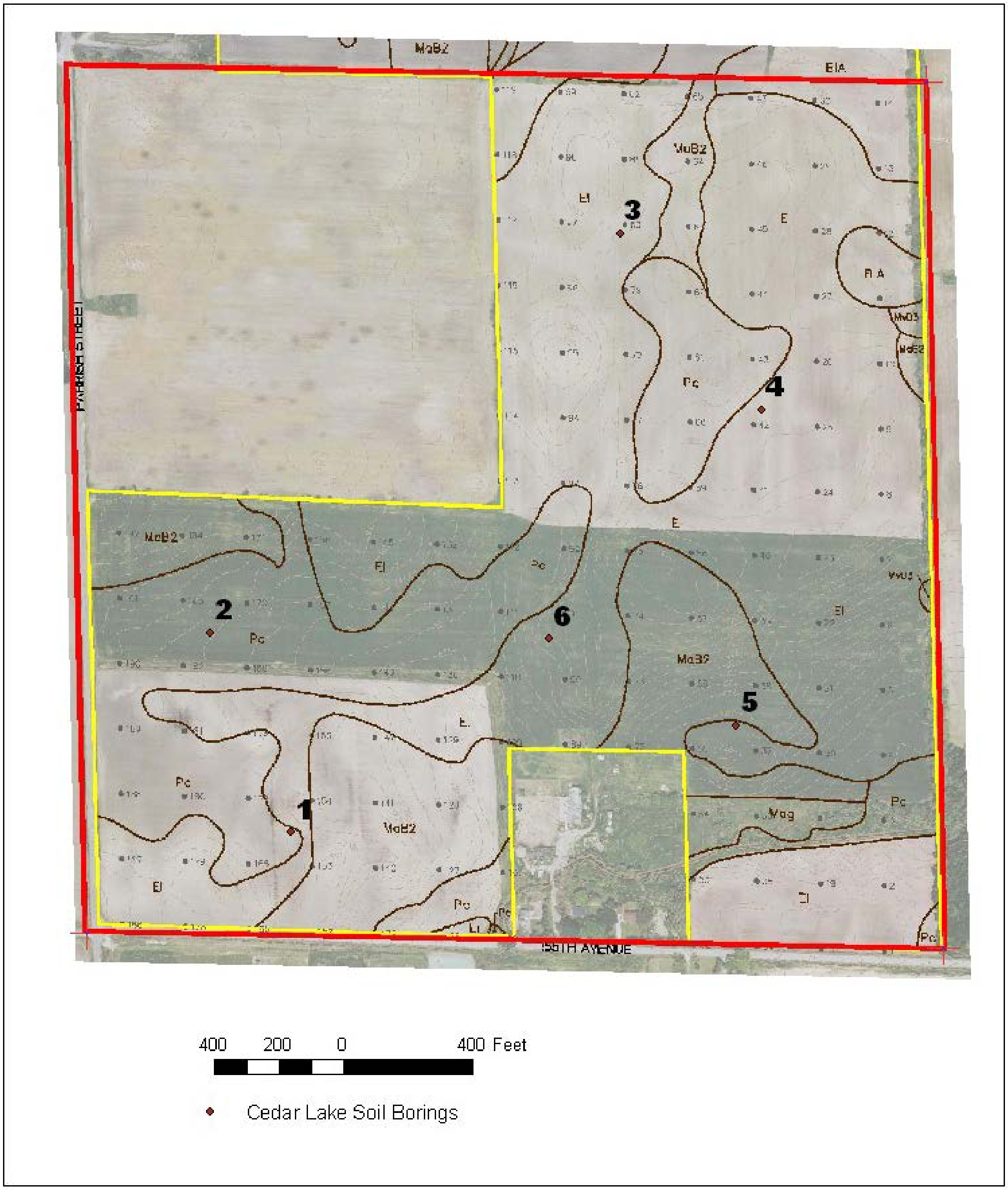


Figure 8. Soil Map at Cedar Lake Project Site

Table 2. Soil Survey Summary Indicating Presence of Hydric Soils and CBBC Updates from Previous USDA Survey.

Map Unit	Soil Name	Hydrologic Soil Group	Hydric	Previously Mapped
BLA	BLOUNT	C	N	N
El	ELLIOTT	C	N	Y
MaB2	MARKHAM	C	N	Y
Mag	MARKHAM, Gravely Substratum	C	N	N
MuB	MORLEY	C	N	Y
MuB2	MORLEY	C	N	Y
MuC2	MORLEY	C	N	Y
MvB3	MORLEY	C	N	Y
MvE3	MORLEY	C	N	Y
Pc	PEWAMO	C	Y	Y

Site Investigation

20. A site investigation was performed that consisted of drilling of six soil borings to the depths of 20 ft for the purposes of general geotechnical investigation and verification of current groundwater conditions. The geotechnical investigation report is located in Attachment D-1. The geotechnical investigation (Attachment D-1) showed topsoil thickness of 0.5 to 1.5 ft. The investigation found medium to stiff clays in the top 5 ft stiff to hard clays below 5 ft. In each boring except B-1 a sand seam was encountered. The depths of the sand seam are described in the boring logs and in Table 1.

Recommended Instrumentation

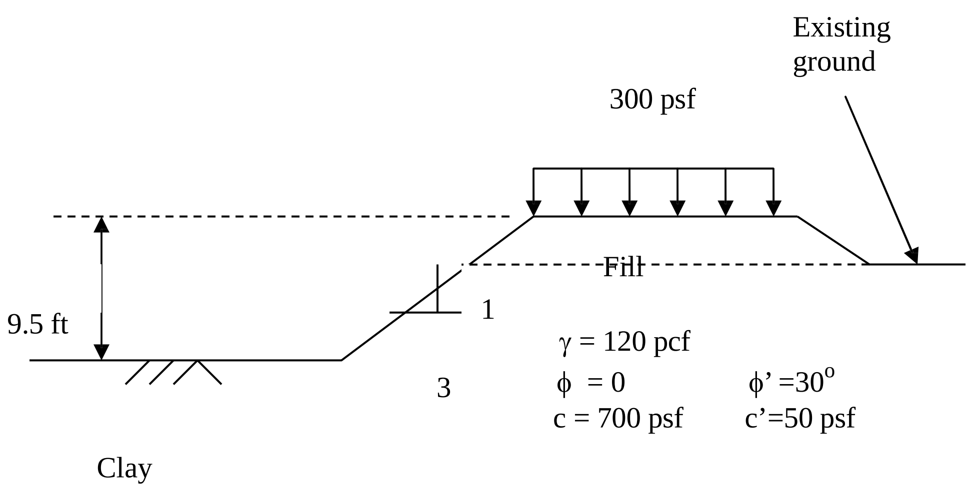
21. Given the relatively short expected height of the proposed dikes, the uniformity of the site, as well as preliminary analyses for slope stability and bearing capacity, geotechnical site instrumentation is not expected to be necessary for this project.

Preliminary Foundation Design

22. Bearing capacity is estimated to be 3000 psf. Prior to construction of any foundation a detailed analysis should be performed. Short term shear strength for site soils is estimated to be c = 1500 psf, phi = 0 deg. Long term shear strength is estimated to be c = 0, phi = 30 deg.

Slope Stability Analysis

23. It is assumed that the sediment will form a low permeability layer at the bottom of the dewatering facility so that seepage forces will not affect slope stability. A preliminary slop stability analysis was performed for short and long term loading considering a 5 ft tall dike, and 300 psf surcharge loading due to construction equipment. Short term shear strength was chosen to be 700 psf as an estimate of recompacted shear strength of soil compacted to 90% standard Proctor compaction. Friction for long term was estimated to be 30 degrees with a small cohesion (c=50 psf) input to allow a reasonable solution. Preliminary analyses performed per EM 1110-2-1902 indicate a short and long term factor of safety of 4.7 and 2.2, respectively. These exceed the short term FOS of 1.5 and long term FOS of 1.3 required by EM 1102-2-1902.



*Assume excavation cut will be used as fill. Therefore existing ground and fill are assumed to have same properties.

Figure 9. Cross Section Analyzed for Slope Stability

Table 3. Summary of Short Term Stability Analysis

Short term stability			
variable	value	unit	Notes
γ	120	pcf	
H	5	ft	
β	18.4	deg	3H:1V slope
q	300	psf	
D	9.5	ft	
$q/\gamma H$	0.5		
d	1.9		
c	700	psf	
No	6	Fig E-1	
$Pd = \gamma H + q$	900	psf	
FOS = No x c / Pd	4.7	> 1.3	

Table 4. Summary of Long Term Stability Analysis

Long Term Stability			
variable	value	unit	Notes
β	18.4	deg	
Pe	900	psf	
Pd	900	psf	
ϕ	30	deg	
c	50	psf	small friction assumed
$\lambda_{c\phi}$	10		
b	3		
Ncf	40	Fig E-5	
FOS =	2.2	>1.5	

Excavatability

24. The investigation revealed a thin layer of topsoil (0.5 – 1.5 ft) followed by medium to hard brown silty clay transitioning into grey silty clay to the bottom of the borings at 20 ft. Sand seams were encountered starting at depths of 9.5 to 18.5 ft. Each sand seam was only a few feet thick. These sand seams are expected to contain water and only impact excavation for excavations greater than approximately 9 ft. Since the proposed excavations are currently five feet, these sand layers and site groundwater are not expected to impact excavations. Should these sand layers be encountered seepage should be manageable through pumping with sumps at the bottom of the excavation.

25. It is not expected that given the current scope that excavations should penetrate the sand layer. However, should the scope change or excavations penetrate the sand layer, slopes should be kept at a level to maintain stability. Should excavation proceed below the sand layer be considered cuts should be kept relatively flat. Final cut slope recommendations for cuts below the sand

layer should be evaluated based on the final design considered.

Potential Borrow and Disposal Sites

26. The site consists primarily of medium to hard silty clay that this material can be used for construction of the clay dikes anticipated to be required around the perimeter of the site. Except for incidental rip rap likely required around structures exposed to water, no significant outside fill is not expected to be required.

Regulatory Requirements

27. Because the sediment dewatering facility will likely impound more than 100 acre ft of water, the site meets the definition of a dam. The hazard classification has yet to be determined. However, because the facility is a dam, a permit will be required from the Indiana Department of Natural Resources to construct as directed by IC 14-28-1-22 and inspections will be required at least once every two years by the IDNR as described by IC 14-27-7-4.

Recommendations

- It is not expected given the current investigation that excavations less than 9 ft should encounter water filled sand layers. However if water bearing strata are encountered seepage should be manageable via pumps at the base of the excavations. Excavations below the water table should be evaluated and limited in slope to maintain stability.

- The site consists of principally silty clay in the top 20 ft, which is considered suitable material for dike construction.

- Dike material should be compacted to a suitable maximum density and be tested per the judgment of the design engineer and specification writer.

- The shear strength, bearing capacity and estimated slopes are provided in this report for feasibility purposes and should be verified and modified as necessary based on more detailed design. Should the final design entail conduits through earth levees these conduits should be designed following guidance provided in EM 1110-2-2902. Slope stability should be verified for the final design following EM 1110-2-1902. Bearing capacity should be addressed for the final design following EM 1110-1-1905.

- Additional investigations targeted toward design parameters are recommended.

- Given the relatively homogeneous nature of the site, the relatively short height of dikes expected (5 ft), the likelihood that sediment will form a relatively impermeable barrier at the bottom of the proposed dewatering facility, and no that permanent structures are anticipated, it is believed that additional geotechnical investigation should not be necessary.

- It is assumed that excavations can proceed at a sufficiently shallow depth to avoid contacting pervious water bearing seams. If future design requires excavation into significant water bearing seams this will have a significant impact on the cost of keeping the interior of the facility dewatered during construction.

Reference

Edwin J. Hartke, John R. Hill, and Mark Reshkin (1975), “Environmental Geology of Lake and Porter Counties, Indiana An Aid to Planning” ENVIRONMENTAL STUDY 8. DEPARTMENT OF NATURAL RESOURCES GEOLOGICAL SURVEY SPECIAL REPORT 11.

ATTACHMENT D-1

Subsurface Exploration and Geotechnical Engineering Evaluation
Cedar Lake Subsurface Investigations Cedar Lake, Indiana STS
Project No.
200803121

STS | AECOM

Subsurface Exploration and Geotechnical Engineering Evaluation

Cedar Lake Subsurface Investigations
Cedar Lake, Indiana

STS Project No. 200803121

Prepared by:
Carlin Fitzgerald, E.I.T.
Assistant Project Engineer
STS|AECOM
(616) 940-3077

STS
3839 East Paris Ave., Ste. 301
Grand Rapids, MI 49512
(616) 940-3077 (p)
(616) 940-3760 (f)

August 1, 2008

Mr. Joseph W. Schulenberg, Ph.D., P.E.
Department of the Army
Chicago District, Corps of Engineers
111 North Canal Street, Suite 600
Chicago, IL 60606-7206

RE: Cedar Lake Subsurface Exploration,
Cedar Lake Ecosystem Restoration Project,
Cedar Lake, IN
Subsurface Investigation Report of Findings
Delivery Order No. DC 10, Contract No. W912P6-06-D-0001
STS Project No. 200803121

Dear Mr. Schulenberg:

STS has completed the Subsurface Investigation for the Cedar Lake Ecosystem Restoration Project and is pleased to submit a report of our findings.

This report includes a summary of the field activities and the investigation completed to evaluate the subsurface conditions at the site.

If you have any questions, or would like to further discuss the report or the project, please contact us.

Respectfully,

Carlin Fitzgerald, E.I.T.
Assistant Project Engineer

Ronald Erickson, P.G.
Technical Reviewer

Jamie S. Matus, C.P.G.
Regional Vice President

cc:

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Tables

Figures

Appendices

1.0 Introduction

In June 2008 the United States Army Corps of Engineers (USACE) - Chicago District contracted with STS|AECOM (STS) to complete an investigation of subsurface conditions near Cedar Lake for the Cedar Lake Ecosystem Restoration Project in Cedar Lake, IN. The results of this report will be used in the design of a sediment dewatering facility. The approximate location of the project site is shown on Figure 1: Site Location Diagram.

The purpose of this investigation was to collect soil samples and complete laboratory testing to evaluate groundwater conditions, index properties, and stratigraphy in the six boring locations as shown on Figure 2: Boring Location Diagram. This report outlines the field investigation and laboratory test procedures, details the conditions encountered in the borings, and summarizes the laboratory test results.

2.0 Scope of Work

The STS services were completed in general accordance with the Cedar Lake Subsurface Investigations; Scope of Work (USACE Delivery Order No. DC 08; Contract No. W912P6-06-D-0001). The Scope of Work included, but was not limited to, the following tasks:

- Preparing a Quality Control Plan, a Drilling Installation Plan and an Accident Prevention Plan.
- Coordinated utility clearance.
- Coordinating site access with USACE and land owners.
- Mobilizing a drill rig to the site to complete six (6) borings at the locations specified by USACE to a nominal depth of 20 feet below existing grade.
- Obtaining representative split spoon soil samples at 2.5-foot intervals or more frequently at each boring in general accordance with ASTM standards.
- Observing soil and groundwater conditions while drilling and sampling and preparing field logs documenting drilling methods, Standard Penetration Test (SPT) results, soil condition observations, groundwater measurements and other pertinent geotechnical-related observations.
- Performing laboratory moisture and index testing on representative samples, prepared final geotechnical boring logs, and issued this report of our findings.
- Abandoning the soil borings.
- Photographing of the drilling and sampling procedures.

3.0 Procedures

The borings were completed by an STS drill crew using a Diedrich D-50 and a Diedrich D-25 ATV drill rig at the approximate locations identified by USACE in the Scope of Work. The utilities were cleared by contacting the Indiana utility alert network. The actual locations were selected at the time of drilling based on utility locations, obstructions, and access. All borings were drilled within 1' of original location as defined by USACE. A map of the Approximate Project Site Location is shown on Figure 1: Site Location Diagram. The approximate as-drilled boring locations are shown on Figure 2: Boring Location Diagram.

The borings were advanced using augers with split spoon sampling techniques to the end of the boring. The use of casing and drilling fluid was not necessary due to the stability of the boring walls.

Soil samples were obtained using split-spoon sampling techniques in general accordance with American Society of Testing and Materials (ASTM) Standard D-1586. Upon completion of drilling and sampling, the borings were backfilled with bentonite pellets from the bottom of the hole to the surface. Soil samples were sealed in the field and returned to the STS laboratory for further examination and testing. Water level observations were completed at each borehole while drilling and sampling, and at a period ranging from 0.5 hours to 4 hours after the boring was completed. The results of these observations are shown on the final boring logs that are included in Appendix B and are in general conformance with "The Standard Guide for Field Logging Subsurface Exploration of Soil and Rock – ASTM D 5434". A copy of the STS Standard Boring Log Procedures is also included in Appendix A.

An STS field engineer was present during the drilling activities to prepare field logs documenting drilling methods, SPT results, soil conditions, groundwater measurements and other pertinent geotechnical-related observations. Copies of the daily field reports, daily logs, and photographs of the field activities are provided in Appendices C and D, respectively. It is important to note that the information included on the field logs is based on the initial interpretations of the soil conditions and soil types by the STS field engineer. These field logs were then refined following additional visual observations and the results of laboratory testing and laboratory classification for completing the final boring logs.

3.1 Laboratory Testing

Laboratory testing was completed on selected soil samples to characterize the physical properties of the soils encountered in the soil borings. The following table outlines the laboratory tests that were completed and their corresponding ASTM designation.

Laboratory Test
Moisture Content - ASTM D 2216
Atterburg Limits - ASTM D 4318

The unconfined compressive strength of selected cohesive samples was also estimated using a calibrated penetrometer. In conjunction with the laboratory testing program, the majority of the samples were classified in the laboratory on the basis of texture and plasticity in accordance with STS Soil Classification System. These descriptions and estimated group symbols are in general conformance with the Unified Soil Classification System which serves as the basis for the STS Soil Classification System, and are included on the soil boring logs.

A brief explanation of the classification of soil samples is included in Appendix A. The laboratory test results are included on separate data sheets in Appendix D. The laboratory test data is summarized on Table 1.

3.2 Elevation and Location Survey

The location and ground surface elevation of each boring was surveyed and staked by an STS survey crew referencing the Indiana State Plane based on NAD83 as the horizontal datum and NAVD88 as the vertical datum. Borings were completed within one foot of the surveyed location as defined by USACE. The boring locations are shown on Figure 2. A summary of the survey results is also provided in Table 2.

4.0 Exploration Results

4.1 Site Conditions

The Cedar Lake Subsurface Investigation Project is located in Cedar Lake, IN to the west of Cedar Lake, North of W 155th Avenue, East of Parish Avenue and to the south of the line extending east from W 151st Avenue. The site consists of agricultural fields currently planted with corn. The approximate location of the site is shown on Figure 1: Approximate Project Site Location.

4.2 Soil Conditions

The general soil profile encountered as part of this geotechnical investigation at the site consisted of a layer of topsoil underlain by native granular and cohesive soils. A brief summary of the soils encountered is presented below. More detailed descriptions of the soil conditions encountered at each boring are provided on the individual boring logs in Appendix B.

<u>Surficial Fill Soils</u>

Topsoil composed of clayey to silty fine to medium sands with variable amounts of silt, gravel, clay, and organics were encountered in each of the borings. These deposits were encountered to 1.5 feet below existing grade. The condition of the granular soils ranged from loose to medium dense.

In Boring B-4 a clayey fine to medium sand was encountered just below a foot of topsoil to 1.5 feet below existing grade.

<u>Native Cohesive Soils</u>

Deposits of cohesive soils were encountered below the surficial fills at all boring locations. The cohesive soils consisted of stiff to hard brown to gray clays with variable amounts of silt, sand, gravel, and shale. In general, these deposits were encountered immediately below native granular soils to within one to two feet above the end of the boring.

<u>Native Granular Soils</u>

Deposits of native granular soils underlying the surficial fills and native cohesive soils were encountered ranging from 18 to 20 feet below the existing grade in each of the borings. Granular deposits composed of brown, loose to medium dense, fine to coarse deposits, becoming coarser with depth. Variable amounts of silt, fine gravel, and stone fragments were encountered.

Lenses of native granular soil in the native cohesive deposits were encountered from 9 to 13.5 feet below existing grade. These deposits composed of brown, fine to medium sands with trace silt, clay, gravel, and stone fragments. Relative density of these sands was typically medium dense.

4.3 Groundwater Conditions

Water level measurements were obtained in each of the land soil borings during drilling and sampling and 0.5 to 4 hours after drilling was completed. Water level elevation ranged from 709.6 feet to 729.1 feet. Based on review of the boring data and topographic map for the area, design water table elevation of 724 feet is recommended. This elevation is similar to the longer term measurements recorded at B-3 and B-4 and near the brown and gray transitional zone in boring B-1. This also correlates with adjacent surface water bodies and the likely southeast direction of groundwater flow in the area. The elevation of adjacent Cedar Lake is 693 feet and there is a small stream located to the north of the site just west of Parish Ave. that originates at an elevation of about 725-728 feet. This origin may be the location where the groundwater table intersects the land surface, forming a small stream.

Groundwater level fluctuations may occur with time and seasonal change due to variations in precipitation, evaporation, surface water runoff and local dewatering.

5.0 General Qualifications

The information presented in this report is based on data obtained from soil borings and laboratory testing completed. Variations can occur between borings; the nature and extent of which may not become evident until after construction. If variations are encountered, it may be necessary reevaluate the information contained in this report with respect to the design and construction.

Water level readings have been made in the borings at the time and under the conditions stated on the boring logs. This data has been reviewed and an interpretation made in the text of this report. However, it must be noted that the period of observation was relatively short, and that seasonal and annual fluctuations in the level of the groundwater will likely occur.

This report has been prepared in accordance with generally accepted soil and foundation engineering practices to aid in the evaluation of this property, and to assist in the design of this project. No other warranty, expressed or implied, is made. The scope of this report is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects relevant to soil characteristics. In the event any changes in the design or location of the structures as outlined in this report are planned, we should be informed so the changes can be reviewed, and the conclusions of this report modified as required.

As a check, we recommend that STS be authorized to review project plans and specifications to confirm that the recommendations of this report have been interpreted in accordance with our intent. Without this review, STS Consultants will not be responsible for misinterpretation of our data, our analyses, and/or our recommendations or how these are incorporated into the final design.

Table 1: Laboratory Data Summary
Moisture Content and Atterberg Limit Tests

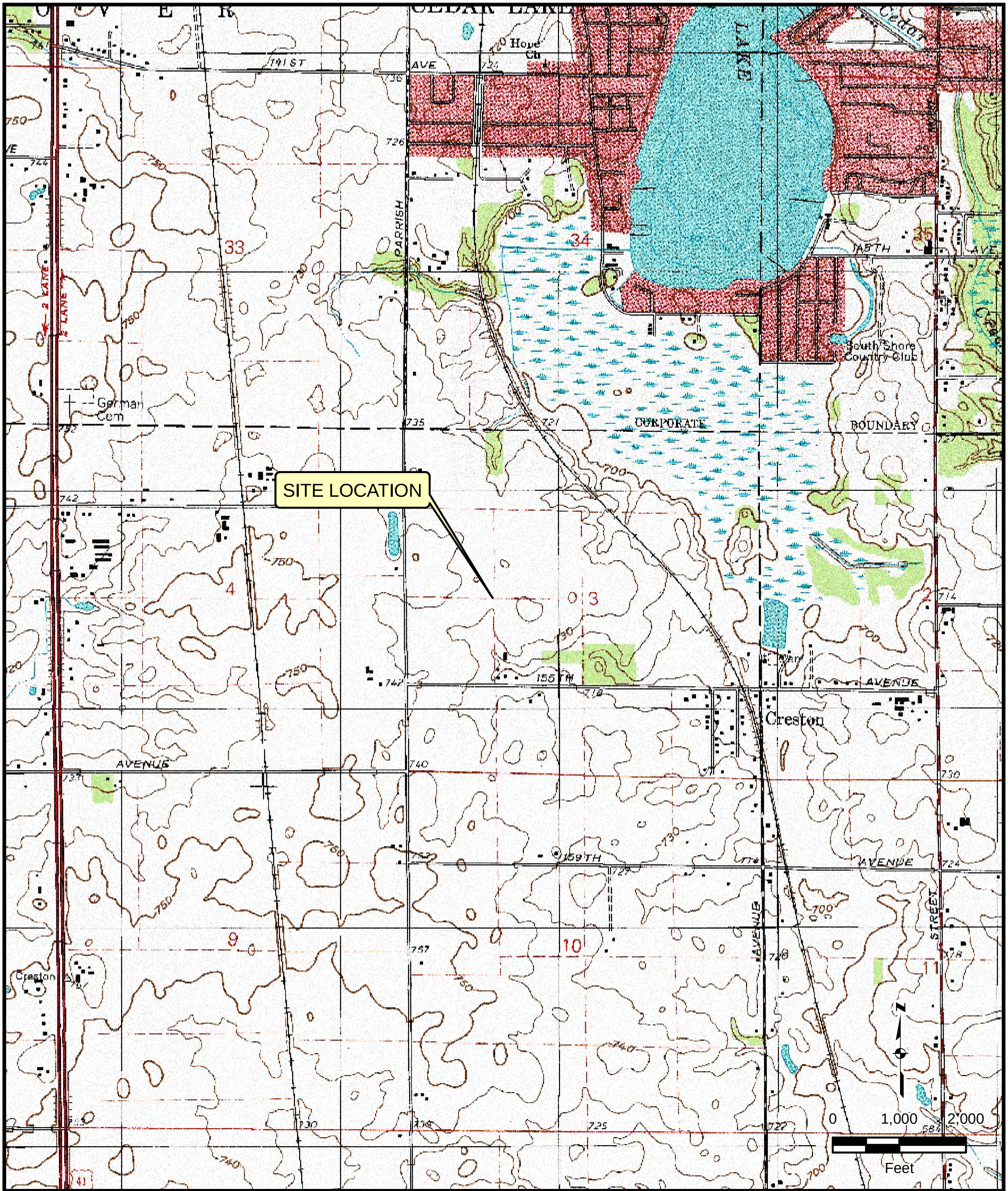
Boring #	Sample #	Depth (ft)	WC (%)	LL	PL	PI
1	1A	0.5-2.0	27.6			
1	2	2.5-4.5	18.5			
1	3	5.0-7.0	17.1	26	14	12
1	4	7.5-9.0	12.6			
1	5	10.0-11.5	13.7			
1	6	12.5-14.0	14.4			
1	7	15.0-16.5	16.0			
1	8	18.0-20.0	13.5			
2	1	0.0-1.5	16.7			
2	2	2.5-4.0	18.5			
2	3	5.0-6.5	14.9			
2	4	7.5-9.0	15.0			
2	5	10.0-11.5	14.1	23	13	10
2	6	12.5-14.0	16.5			
2	7	15.0-16.5	15.6			
2	8A	18.5-20.0	19.2			
3	1A	0.5-1.5	17.3			
3	2	2..5-4.0	17.4			
3	3	5.0-6.5	17.0			
3	4	7.5-9.0	18.6			
3	5	10.0-11.5	17.8			
3	6A	13.5-14.0	14.0			
3	7	15.0-16.5	13.9	21	12	9
3	8	18.0-20.0	14.5			
4	1A	1.0-1.5	14.2			
4	2	2.5-4.0	22.3			
4	3	5.0-6.5	15.5			
4	4	7.5-9.0	14.8			
4	5	10.0-11.0		25	13	12
4	5A	11.1-11.5	20.2			
4	6	12.5-14.0	21.1			
4	7	15.0-16.5	13.6			
4	8	18.0-20.0	16.8			
5	1A	1.5-2.0	23.4			
5	2	2.5-4.5	25.5	34	35	19
5	3A	6.0-7.0	15.7			
5	4	7.5-9.0	12.6			
5	5	10.0-11.5	19.5			
5	6	12.5-14.0	10.7			
5	7	15.0-16.5	14.9			
5	8	18.0-20.0	21.0			
6	1	0.0-1.5	15.4			
6	2	2.5-4.0	18.8			
6	3	5.0-6.5	17.9			
6	4	7.5-9.0	16.6			
6	5	10.0-11.5	25.7			
6	6	12.5-14.0	13.2	21	13	8
6	7	15.0-16.5	21.4			
6	8	18.0-20.0	17.6			

Table 2: Survey Results Summary

Project: Cedar Lake Subsurface Investigation
Location: Cedar Lake, IN
STS Job Number: 2000803121
Drilling Firm: STS Exploration

Description	Northing	Easting	Elevation	Depth	Date Drilled	Status
BOR1	2218500.05	2852580.12	733.88	19.50	7/18/2008	Completed
BOR2	2219120.01	2852330.05	733.27	20.00	7/19/2008	Completed
BOR3	2220355.10	2853599.98	735.85	20.00	7/23/2008	Completed
BOR4	2219810.01	2854040.11	734.94	20.00	7/22/2008	Completed
BOR5	2218830.01	2853959.91	727.15	20.00	7/21/2008	Completed
BOR6	2219099.77	2853383.03	734.61	20.00	7/20/2008	Completed

Horizontal: NAD83 Indiana West
Vertical Datum: NAVD 88



STS | AECOM

SITE LOCATION DIAGRAM
ACOE CHICAGO DISTRICT
CEDAR LAKE SUBSURFACE EXPLORATION
CEDAR LAKE, INDIANA

Drawn:	SJE	7/28/2008
Approved:	CF	7/28/2008
Scale:	AS SHOWN	
PROJECT NUMBER	200803121	
FIGURE NUMBER	1	

847.279.2500
www.sts.aecom.com

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www.sts.aecom.com

BORING LOCATION DIAGRAM
ACOE CHICAGO DISTRICT
CEDAR LAKE SUBSURFACE EXPLORATION
CEDAR LAKE, INDIANA

Drawn:	SJE	7/28/2008
Approved:	CF	7/28/2008
Scale:	AS SHOWN	
PROJECT NUMBER	200803121	
FIGURE NUMBER	2	

Appendix A

General Notes

Soil Classifications

Field and Laboratory Procedures

Boring Log Procedures

STS General Notes

Drilling and Sampling Symbols:

SS : Split Spoon - 1-3/8" I.D. 2" O.D. (Unless otherwise noted)	HS : Hollow Stem Auger
ST : Shelby Tube-2" O.D. (Unless otherwise noted)	WS : Wash Sample
PA : Power Auger	FT : Fish Tail
DB : Diamond Bit-NX, BX, AX	RB : Rock Bit
AS : Auger Sample	BS : Bulk Sample
JS : Jar Sample	PM : Pressuremeter Test
VS : Vane Shear	GS : Giddings Sampler
OS : Osterberg Sampler	

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch O.D. split spoon sampler, except where otherwise noted.

Water Level Measurement Symbols:

WL : Water Level	WCI : Wet Cave In
WS : While Sampling	DCI : Dry Cave In
WD : While Drilling	BCR : Before Casing Removal
AB : After Boring	ACR : After Casing Removal

Water levels indicated on the boring logs are the levels measured in the boring at the time indicated. In pervious soils, the indicated elevations are considered reliable groundwater levels. In impervious soils, the accurate determination of groundwater elevations may not be possible, even after several days of observations; additional evidence of groundwater elevations must be sought.

Gradation Description and Terminology:

Coarse grained or granular soils have more than 50% of their dry weight retained on a #200 sieve; they are described as boulders, cobbles, gravel or sand. Fine grained soils have less than 50% of their dry weight retained on a #200 sieve; they are described as clay or clayey silt if they are cohesive and silt if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their strength or consistency and their plasticity.

Major Component of Sample	Size Range	Description of Other Components Present in Sample	Percent Dry Weight
Boulders	Over 8 in. (200 mm)	Trace	1-9
Cobbles	8 inches to 3 inches (200 mm to 75 mm)	Little	10-19
Gravel	3 inches to #4 sieve (75 mm to 4.76 mm)	Some	20-34
Sand	#4 to #200 sieve (4.76 mm to 0.074 mm)	And	35-50
Silt	Passing #200 sieve (0.074 mm to 0.005 mm)		
Clay	Smaller than 0.005 mm		

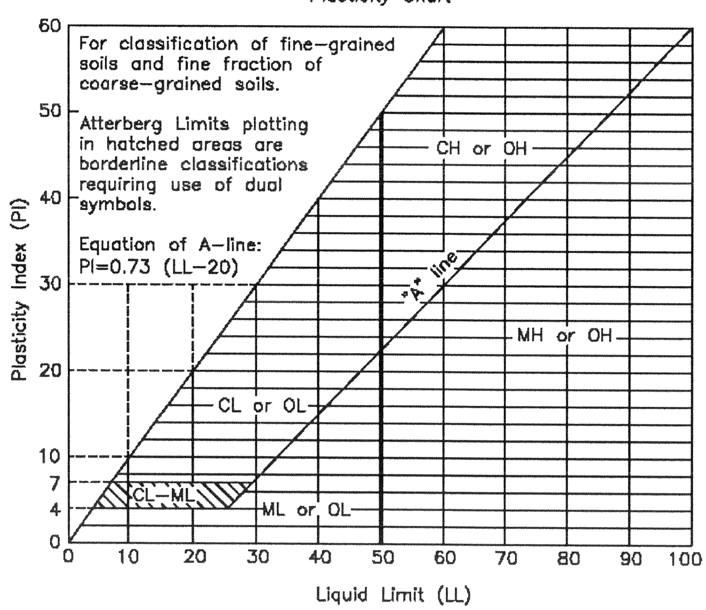
Consistency of Cohesive Soils: / Relative Density of Granular Soils:

Unconfined Compressive Strength, Qu, tsf	Consistency	N-Blows per foot	Relative Density
<0.25	Very Soft	0 - 3	Very Loose
0.25 - 0.49	Soft	4 - 9	Loose
0.50 - 0.99	Medium (firm)	10 - 29	Medium Dense
1.00 - 1.99	Stiff	30 - 49	Dense
2.00 - 3.99	Very Stiff	50 - 80	Very Dense
4.00 - 8.00	Hard	>80	Extremely Dense
>8.00	Very Hard		

STS Soil Classification System [1]

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is ***larger*** than No. 200 sieve size)	Gravel (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded, gravel, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 percent . . . . . GW, GP, SW, SP; More than 12 percent . . . . . GM, GC, SM, SC; 5 to 12 percent . . . . . Borderline cases ***requiring*** dual symbols[3]	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 & 3	
			GP	Poorly graded gravel, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravel, gravel-sand-silt mixtures		Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are ***borderline*** cases requiring use of dual symbols
			GC	Clayey gravel, gravel-sand-clay mixtures		Atterberg limits above "A" line or PI greater than 7	
	Sand (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sand (Little or no fines)	SW	Well-graded sand, gravelly sand, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 & 3	
			SP	Poorly graded sand, gravelly sand, little or no fines		Not meeting all gradation requirements for SW	
		Sand with fines (Appreciable amount of fines)	SM	Silty sand, sand-silt mixtures		Atterberg limits below "A" line or PI less than 4	Limits plotting in hatched zone with PI between 4 and 7 are ***borderline*** cases requiring use of dual symbols
			SC	Clayey sand, sand-clay mixtures		Atterberg limits above "A" line or PI greater than 7	
Fine-grained soils (More than half of material is ***smaller*** than No. 200 sieve size)	Silt and clay (Liquid limit less than 50)		ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or clayey silt with slight plasticity	Plasticity Chart [2]		
			CL	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay, silty clay, lean clay			
			OL	Organic silt and organic silty clay of low plasticity			
	Silt and clay (Liquid limit greater than 50)		MH	Inorganic silt, micaceous or diatomaceous fine sandy or silty soils, elastic silt			
			CH	Inorganic clay of high plasticity, fat clay			
			OH	Organic clay of medium to high plasticity, organic silt			
	Highly organic soils		PT	Peat and other highly organic soil			

Plasticity Chart [2]



1. See STS General Notes for component gradation terminology, consistency of cohesive soils and relative density of granular soils.
2. Reference: Unified Soil Classification Systems
3. Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

STS Field and Laboratory Procedures

Field Sampling Procedures

Auger Sampling (AS)

In this procedure, soil samples are collected from cuttings off of the auger flights as they are removed from the ground. Such samples provide a general indication of subsurface conditions; however, they do not provide undisturbed samples, nor do they provide samples from discrete depths.

Split-Barrel Sampling (SS) - (ASTM Standard D-1586-99)

In the split-barrel sampling procedure, a 2-inch O.D. split barrel sampler is driven into the soil a distance of 18 inches by means of a 140-pound hammer falling 30 inches. The value of the Standard Penetration Resistance is obtained by counting the number of blows of the hammer over the final 12 inches of driving. This value provides a qualitative indication of the in-place relative density of cohesionless soils. The indication is qualitative only, however, since many factors can significantly affect the Standard Penetration Resistance Value, and direct correlation of results obtained by drill crews using different rigs, drilling procedures, and hammer-rod-spoon assemblies should not be made. A portion of the recovered sample is placed in a sample jar and returned to the laboratory for further analysis and testing.

Shelby Tube Sampling Procedure (ST) - ASTM Standard D-1587-94

In the Shelby tube sampling procedure, a thin-walled steel seamless tube with a sharp cutting edge is pushed hydraulically into the soil and a relatively undisturbed sample is obtained. This procedure is generally employed in cohesive soils. The tubes are identified, sealed and carefully handled in the field to avoid excessive disturbance and are returned to the laboratory for extrusion and further analysis and testing.

Giddings Sampler (GS)

This type of sampling device consists of 5-foot sections of thin-wall tubing which are capable of retrieving continuous columns of soil in 5-foot maximum increments. Because of a continuous slot in the sampling tubes, the sampler allows field determination of stratification boundaries and containerization of soil samples from any sampling depth within the 5-foot interval.

STS Laboratory Procedures

Water Content (Wc)

The water content of a soil is the ratio of the weight of water in a given soil mass to the weight of the dry soil. Water content is generally expressed as a percentage.

Hand Penetrometer (Qp)

In the hand penetrometer test, the unconfined compressive strength of a soil is determined, to a maximum value of 4.5 tons per square foot (tsf) or 7.0 tsf depending on the testing device utilized, by measuring the resistance of the soil sample to penetration by a small, spring-calibrated cylinder. The hand penetrometer test has been carefully correlated with unconfined compressive strength tests, and thereby provides a useful and a relatively simple testing procedure in which soil strength can be quickly and easily estimated.

Unconfined Compression Tests (Qu)

In the unconfined compression strength test, an undisturbed prism of soil is loaded axially until failure or until 20% strain has been reached, whichever occurs first.

Dry Density (γd)

The dry density is a measure of the amount of solids in a unit volume of soil. Use of this value is often made when measuring the degree of compaction of a soil.

Classification of Samples

In conjunction with the sample testing program, all soil samples are examined in our laboratory and visually classified on the basis of their texture and plasticity in accordance with the STS Soil Classification System which is described on a separate sheet. The soil descriptions on the boring logs are derived from this system as well as the component gradation terminology, consistency of cohesive soils and relative density of granular soils as described on a separate sheet entitled "STS General Notes". The estimated group symbols included in parentheses following the soil descriptions on the boring logs are in general conformance with the Unified Soil Classification System (USCS) which serves as the basis of the STS Soil Classification System.

STS Field and Laboratory Procedures

Subsurface Exploration Procedures

Hand-Auger Drilling (HA)

In this procedure, a sampling device is driven into the soil by repeated blows of a sledge hammer or a drop hammer. When the sampler is driven to the desired sample depth, the soil sample is retrieved. The hole is then advanced by manually turning the hand auger until the next sampling depth increment is reached. The hand auger drilling between sampling intervals also helps to clean and enlarge the borehole in preparation for obtaining the next sample.

Power Auger Drilling (PA)

In this type of drilling procedure, continuous flight augers are used to advance the boreholes. They are turned and hydraulically advanced by a truck, trailer or track-mounted unit as site accessibility dictates. In auger drilling, casing and drilling mud are not required to maintain open boreholes.

Hollow Stem Auger Drilling (HS)

In this drilling procedure, continuous flight augers having open stems are used to advance the boreholes. The open stem allows the sampling tool to be used without removing the augers from the borehole. Hollow stem augers thus provide support to the sides of the borehole during the sampling operations.

Rotary Drilling (RB)

In employing rotary drilling methods, various cutting bits are used to advance the boreholes. In this process, surface casing and/or drilling fluids are used to maintain open boreholes.

Diamond Core Drilling (DB)

Diamond core drilling is used to sample cemented formations. In this procedure, a double tube (or triple tube) core barrel with a diamond bit cuts an annular space around a cylindrical prism of the material sampled. The sample is retrieved by a catcher just above the bit. Samples recovered by this procedure are placed in sturdy containers in sequential order.

STS Standard Boring Log Procedures

In the process of obtaining and testing samples and preparing this report, standard procedures are followed regarding field logs, laboratory data sheets and samples.

Field logs are prepared during performance of the drilling and sampling operations and are intended to essentially portray field occurrences, sampling locations and procedures.

Samples obtained in the field are frequently subjected to additional testing and reclassification in the laboratory by experienced geotechnical engineers, and as such, differences between the field logs and the final logs may exist. The engineer preparing the report reviews the field logs, laboratory test data and classifications, and using judgment and experience in interpreting this data, may make further changes. It is common practice in the geotechnical engineering profession not to include field logs and laboratory data sheets in engineering reports, because they do not represent the engineer's final opinions as to appropriate descriptions for conditions encountered in the exploration and testing work. Results of laboratory tests are generally shown on the boring logs or are described in the text of the report, as appropriate.

Samples taken in the field, some of which are later subjected to laboratory tests, are retained in our laboratory for sixty days and are then discarded unless special disposition is requested by our client. Samples retained over a long period of time, even in sealed jars, are subject to moisture loss which changes the apparent strength of cohesive soil, generally increasing the strength from what was originally encountered in the field. Since they are then no longer representative of the moisture conditions initially encountered, observers of these samples should recognize this factor.

Appendix B

Boring Logs

Daily Field Reports

Field Logs

TECHNICIAN CF SUFACE ELEV. 733.9

DRILLER mark BORING STARTED 7-18-08

HELPER Chris BORING COMPLETED 7-18-08

RIG NO. D-25 STATION –

OFFSET –

STS
3839 East Paris Ave. Suite 301
Grand Rapids, MI 49512
(616) 940-3077

CASING USED ______ SIZE ______

SHEET 1 OF 1

WATER LEVEL OBSERVATIONS

WL: 10' (WS) OR WD

WL: ____ BCR ____ ACR

WL: Dry AB 1 Hr.AB

WL: ____ 24Hr.AB

JOB NO. 200803121 BORING NO. B-1 CLIENT ACOE-CHICAGO WEATHER Sunny 95°

CEDAR LAKE

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLING METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	Qp PENETROMETER TEST IN TSF	STRATA CHANGE	SAMPLE DESCRIPTION	PID* READING S.R.	PID* READING B.R.
1	0	0.5	SS	3				0.5			Brown Topsoil		
1A	0.5	2.0	SS		3	3	4	0.75	2.0	0.5	Silty Clay, brown		
	0	2.5	PA										
2	2.5	4.5	SS	3	3	4	5	0.8	2.0		Same		
	2.5	5.0	PA										
3	5.0	7.0	SS	3	5	7	7	1.2	2.5		Same		
	5.0	7.5	PA										
4	7.5	9.0	SS	6	8	14		1.2	4.5+		Same		
	7.5	10	PA										
5	10	11.5	SS	7	10	12		1.2	4.5+	10.0	Silty Clay, grey		
	10	12.5	PA										
6	12.5	14	SS	9	10	12		1.4	3.0		Same		
	12.5	15	PA										
7	15.0	16.5	SS	9	11	14		0.8	4.5+		Same		
	15	18	PA										
8	18	19.5	SS	8	8	55		1.2	1.5		Same		
											* 140 lb. Safety hammer		

ABBREVIATIONS

H.S. – HOLLOW STEM AUGER
W.O. – WASH OUT
S.T. – SHELBY TUBE
S.S. – SPLIT SPOON
D.B. – DIAMOND BIT
P.A. – POWER AUGER
R.B. – ROCK BIT
W.S. – WHILE SAMPLING
W.D. – WHILE DRILLING
B.C.R. – BEFORE CASING REMOVAL
A.C.R. – AFTER CASING REMOVAL
A.B. – AFTER BORING
B.R. – BACKGROUND READING
S.R. – SAMPLE READING

DRILL CREW CHECK LIST

TOPSOIL THICKNESS 0.5'

FILL THICKNESS none

CAVE IN LEVEL:

WHILE DRILLING AND SAMPLING ______

AFTER BORING COMPLETION ______

WATER LOSS:

AT ______ TO ______

PERCENT LOSS ______

AT ______ TO ______

PERCENT LOSS ______

BOULDERS OR OBSTRUCTIONS:

AT ______ TO ______

AT ______ TO ______

ARTESIAN PRESSURE:

DEPTH ______

HEIGHT OF RISE IN CASING ______

PIEZOMETER PVC OR SS

DIAMETER ______

SCREEN DEPTH ____ FT TO ____ FT

RISER PIPE ____ FT TO ____ FT

*PID READING ____ •VLAMP

STS
3839 East Paris Ave. Suite 301
Grand Rapids, MI 49512
(616) 940-3077

TECHNICIAN CF
DRILLER Bill
HELPER Scott
RIG NO. D-50

SUFACE ELEV. 733.27
BORING STARTED 7-18-08
BORING COMPLETED 7-18-08
STATION —
OFFSET —

CASING USED — SIZE

SHEET 1 OF 1

WATER LEVEL OBSERVATIONS
WL: Dry WS OR (WD)
WL: ____ BCR ____ ACR
WL: 16 AB 4 Hr.AB
WL: ____ 24Hr.AB

JOB NO 20080312 BORING NO. B-2 CLIENT ACOE - CHICAGO WEATHER Sunny 95°

CEDAR LAKE

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLING METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	Qp PENETROMETER TEST IN TSF	STRATA CHANGE	SAMPLE DESCRIPTION	PID* READING S.R.	PID* READING B.R.
1	0	1.5	SS	3	5	5		1.25		1.4'	Topsoil-organic sandy clay, bt-br, moist		
	0	2.5	PA										
2	2.5	4.0	SS	2	3	3		1.5	.5		Silty clay, tr gravel, brown		
	2.5	5.0	PA										
3	5.0	6.5	SS	2	3	5		1.25	4.0		Same		
	5.0	7.5	PA										
4	7.5	9.0	SS	3	5	5		1.5	4.0		Same		
	7.5	10	PA										
5	10	11.5	SS	5	6	9		1.5	4.0		Same		
	10	12.5	PA										
6	12.5	14	SS	5	7	9		1.5	4.5+	12.5	Silty clay, tr gravel, grey		
	12.5	15	PA										
7	15	16.5	SS	7	9	11		1.5	4.5+		Same		
	15	18	PA										
8	18	18.5	SS	10				0.5	4.5		Same		
8A	18.5	20	SS		7	9	9	1.0		18.5	Silty Fine sand, tr clay, grey, moist to wet		
											* 140 lb. automatic hammer		

ABBREVIATIONS
H.S. – HOLLOW STEM AUGER
W.O. – WASH OUT
S.T. – SHELBY TUBE
S.S. – SPLIT SPOON
D.B. – DIAMOND BIT
P.A. – POWER AUGER
R.B. – ROCK BIT
W.S. – WHILE SAMPLING
W.D. – WHILE DRILLING
B.C.R. – BEFORE CASING REMOVAL
A.C.R. – AFTER CASING REMOVAL
A.B. – AFTER BORING
B.R. – BACKGROUND READING
S.R. – SAMPLE READING

DRILL CREW CHECK LIST
TOPSOIL THICKNESS 15"
FILL THICKNESS ____

CAVE IN LEVEL:
WHILE DRILLING AND SAMPLING ____
AFTER BORING COMPLETION ____

WATER LOSS:
AT ____ TO ____
PERCENT LOSS ____
AT ____ TO ____
PERCENT LOSS ____

BOULDERS OR OBSTRUCTIONS:
AT ____ TO ____
AT ____ TO ____

ARTESIAN PRESSURE:
DEPTH ____
HEIGHT OF RISE IN CASING ____
PIEZOMETER PVC OR SS
DIAMETER ____
SCREEN DEPTH ____ FT TO ____ FT
RISER PIPE ____ FT TO ____ FT
*PID READING ____ •VLAMP

STS
3839 East Paris Ave. Suite 301
Grand Rapids, MI 49512
(616) 940-3077

TECHNICIAN CF
DRILLER Bill
HELPER Scott
RIG NO. D-50

SUFACE ELEV. 735.9
BORING STARTED 7-18-08
BORING COMPLETED 7-18-08
STATION –
OFFSET –

CASING USED – SIZE –

SHEET 1 OF 1

WATER LEVEL OBSERVATIONS
WL: 12.5 WS OR (WD)
WL: ____ BCR ____ ACR
WL: 7.5 AB 2 Hr.AB
WL: ____ 24Hr.AB

JOB NO. 20080321 BORING NO. B-3 CLIENT ACOE - CHICAGO WEATHER Sunny 95°

CEDAR LAKE

SAMPLE NO.	DEPTH OR ELEVATION FROM	TO	SAMPLING METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	Qp PENETROMETER TEST IN TSF	STRATA CHANGE	SAMPLE DESCRIPTION	PID* READING S.R.	B.R.
1	0	0.5	SS	2				0.25			Sandy Topsoil		
1A	0.5	1.5	SS		3	7		1.0	3.5	0.5	Silty clay, tr sand, br-grey		
	0	2.5	PA										
2	2.5	4.0	SS	2	2	4		1.5	1.5		same		
	2.5	5.0	PA										
3	5.0	6.5	SS	2	5	7		1.5	3.0		same		
	5.0	7.5	PA										
4	7.5	9.0	SS	5	7	10		1.5	4.5+		same		
	7.5	10	PA										
5	10	11.5	SS	5	8	13		1.5	4.5+		same		
	10	12.5	PA										
6	12.5	13.5	SS	8	10			1.0		12.5	F-m sand, tr gravel, brown, sat.		
6A	13.5	14	SS			15		0.5	1.5	13.5	Silty clay, tr gravel, gray		
	12.5	15	PA										
7	15	16.5	SS	5	8	6		0.5	1.0		same		
	15	18	PA										
8	18	20	SS	6	8	11	19	1.5	3.5		same		
											* 140 lb. automatic hammer		

ABBREVIATIONS
H.S. – HOLLOW STEM AUGER
W.O. – WASH OUT
S.T. – SHELBY TUBE
S.S. – SPLIT SPOON
D.B. – DIAMOND BIT
P.A. – POWER AUGER
R.B. – ROCK BIT
W.S. – WHILE SAMPLING
W.D. – WHILE DRILLING
B.C.R. – BEFORE CASING REMOVAL
A.C.R. – AFTER CASING REMOVAL
A.B. – AFTER BORING
B.R. – BACKGROUND READING
S.R. – SAMPLE READING

DRILL CREW CHECK LIST
TOPSOIL THICKNESS 6"
FILL THICKNESS none

CAVE IN LEVEL:
WHILE DRILLING AND SAMPLING ____
AFTER BORING COMPLETION ____

WATER LOSS:
AT ____ TO ____
PERCENT LOSS ____
AT ____ TO ____
PERCENT LOSS ____

BOULDERS OR OBSTRUCTIONS:
AT ____ TO ____
AT ____ TO ____

ARTESIAN PRESSURE:
DEPTH ____
HEIGHT OF RISE IN CASING ____
PIEZOMETER PVC OR SS
DIAMETER ____
SCREEN DEPTH ____ FT TO ____ FT
RISER PIPE ____ FT TO ____ FT
*PID READING ____ •VLAMP

TECHNICIAN CF | SUFACE ELEV. 732.9
DRILLER Bill | BORING STARTED 7-18-08
HELPER Scott | BORING COMPLETED 7-18-08
RIG NO. D-50 | STATION –
OFFSET –
CASING USED ______ SIZE ______

STS
3839 East Paris Ave. Suite 301
Grand Rapids, MI 49512
(616) 940-3077

WATER LEVEL OBSERVATIONS
WL: 11.1 (WS) OR WD
WL: ______ BCR ______ ACR
WL: 6.9' AB 0.5 Hr.AB
WL: ______ 24Hr.AB

JOB NO. 200803121 BORING NO. B-4 CLIENT ACOE - CHICAGO CEDAR LAKE WEATHER Sunny 95°

SAMPLE NO.	DEPTH OR ELEVATION FROM	TO	SAMPLING METHOD	SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	Qp PENETROMETER TEST IN TSF	STRATA CHANGE	SAMPLE DESCRIPTION	PID* READING S.R.	B.R.
1	0	1	SS	1	2			1.0			Topsoil - F-m sand, tr orgs, tr gravel, dark br. - moist		
1A	1	1.5	SS			2		0.5		1.0	Clayey f-m sand, tr silt, brown - moist		
	0	2.5	PA										
2	2.5	4.0	SS	2	3	7		1.5	2.5	2.5	Silty clay, tr sand, tr gravel, brown		
	2.5	5.0	PA										
3	5.0	6.5	SS	3	5	8		1.5	3.0		same		
	5.0	7.5	PA										
4	7.5	9.0	SS	5	8	11		1.5	4.0		Same - brown to grey		
	7.5	10	PA										
5	10	11.1	SS	6	8			1.1	4.5+		same		
5A	11.1	11.5	SS			9		0.4		11.1	Silty fine sand, tr gravel, brown, wet		
	10	12.5	PA										
6	12.5	14	SS	4	4	8		1.5			F-C silty sand, tr gravel, brown, sat.		
	12.5	15	PA							14	* Clay in tip		
7	15	16.5	SS	2	4	8		1.5	2.75		Silty clay, tr sand, tr gravel, grey		
	15	18	PA										
8	18	20	SS	7	10	13	18	2.0	4.0		same		
											* 140 lb. automatic hammer		

ABBREVIATIONS
- H.S. – HOLLOW STEM AUGER
- W.O. – WASH OUT
- S.T. – SHELBY TUBE
- S.S. – SPLIT SPOON
- D.B. – DIAMOND BIT
- P.A. – POWER AUGER
- R.B. – ROCK BIT
- W.S. – WHILE SAMPLING
- W.D. – WHILE DRILLING
- B.C.R. – BEFORE CASING REMOVAL
- A.C.R. – AFTER CASING REMOVAL
- A.B. – AFTER BORING
- B.R. – BACKGROUND READING
- S.R. – SAMPLE READING

DRILL CREW CHECK LIST
TOPSOIL THICKNESS 1.0
FILL THICKNESS none

CAVE IN LEVEL:
WHILE DRILLING AND SAMPLING ______
AFTER BORING COMPLETION ______

WATER LOSS:
AT ______ TO ______
PERCENT LOSS ______
AT ______ TO ______
PERCENT LOSS ______

BOULDERS OR OBSTRUCTIONS:
AT ______ TO ______
AT ______ TO ______

ARTESIAN PRESSURE:
DEPTH ______
HEIGHT OF RISE IN CASING ______
PIEZOMETER PVC OR SS
DIAMETER ______
SCREEN DEPTH ______ FT TO ______ FT
RISER PIPE ______ FT TO ______ FT
*PID READING ______ •VLAMP

TECHNICIAN CF
DRILLER Mark
HELPER Chris
RIG NO. D-25

SUFACE ELEV. 727.1
BORING STARTED 7-18-08
BORING COMPLETED 7-18-08
STATION -
OFFSET

STS
3839 East Paris Ave. Suite 301
Grand Rapids, MI 49512
(616) 940-3077

CASING USED - SIZE -

SHEET 1 OF 1

WATER LEVEL OBSERVATIONS
WL: 17.5 WS OR WD
WL: ____ BCR ____ ACR
WL: 17.5 AB 0.5 Hr.AB
WL: ____ 24Hr.AB

JOB NO. 200803121 BORING NO. B-5 CLIENT ACOE - CHICAGO WEATHER Sunny 95°

CEDAR LAKE

SAMPLE NO.	DEPTH OR ELEVATION FROM	TO	SAMPLING METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	Qp PENETROMETER TEST IN TSF	STRATA CHANGE	SAMPLE DESCRIPTION	PID* READING S.R.	B.R.
1	0	1.5	SS	3	3	3		1.5			Topsoil		
1A	1.5	2.0	SS				4	0.3		1.5	silty clay, brown		
2	2.5	4.5	SS	3	2	4	3	1			same		
	2.5	5.0	PA										
3	5.0	6.0	SS	2	3			0.75	2.0		same		
3A	6.0	7.0	SS			5	9	0.75	4.5+	6.0	silty clay, brown		
	5.0	7.5	PA										
4	7.5	9.0	SS	8	9	13		1.2	4.5+		same		
	7.5	10	PA										
5	10	11.5	SS	9	11	10		1.2	4.5+		same		
	10	12.5	PA										
6	12.5	14	SS	5	6	7		1.3	1.5	12.5	same, density change		
	12.5	15	PA										
7	15	16.5	SS	4	6	8		1.2	1.5		same		
	15	18	PA										
8	18	20	SS	4	9	12	13	1.5		19.0	f-m sand, brown		
											140 lb. safety hammer		

ABBREVIATIONS
H.S. – HOLLOW STEM AUGER
W.O. – WASH OUT
S.T. – SHELBY TUBE
S.S. – SPLIT SPOON
D.B. – DIAMOND BIT
P.A. – POWER AUGER
R.B. – ROCK BIT
W.S. – WHILE SAMPLING
W.D. – WHILE DRILLING
B.C.R. – BEFORE CASING REMOVAL
A.C.R. – AFTER CASING REMOVAL
A.B. – AFTER BORING
B.R. – BACKGROUND READING
S.R. – SAMPLE READING

DRILL CREW CHECK LIST
TOPSOIL THICKNESS 1.5'
FILL THICKNESS none
CAVE IN LEVEL:
WHILE DRILLING AND SAMPLING ____
AFTER BORING COMPLETION ____
WATER LOSS:
AT ____ TO ____
PERCENT LOSS ____
AT ____ TO ____
PERCENT LOSS ____
BOULDERS OR OBSTRUCTIONS:
AT ____ TO ____
AT ____ TO ____

ARTESIAN PRESSURE:
DEPTH ____
HEIGHT OF RISE IN CASING ____
PIEZOMETER PVC OR SS
DIAMETER ____
SCREEN DEPTH ____ FT TO ____ FT
RISER PIPE ____ FT TO ____ FT
*PID READING ____ •VLAMP

TECHNICIAN CF | SUFACE ELEV. 734.6
DRILLER Bill | BORING STARTED 7-18-08
HELPER Scott | BORING COMPLETED 7-18-08
RIG NO. D-50 | STATION –
OFFSET –

STS
3839 East Paris Ave. Suite 301
Grand Rapids, MI 49512
(616) 940-3077

CASING USED ______ SIZE ______

SHEET 1 OF 1

WATER LEVEL OBSERVATIONS
WL: 9.5 WS OR (WD)
WL: ____ BCR 8' ACR
WL: 5.5' AB 4 Hr.AB
WL: ____ 24Hr.AB

JOB NO. 20080312I BORING NO. B-6 CLIENT ACOE - CHICAGO WEATHER Sunny 95°

CEDAR LAKE

SAMPLE NO.	DEPTH OR ELEVATION FROM	TO	SAMPLING METHOD	SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	Qp PENETROMETER TEST IN TSF	STRATA CHANGE	SAMPLE DESCRIPTION	PID* READING S.R.	B.R.
1	0	1.5	SS	3	5	3		1.5			Topsoil-clayey F-m sand, brown		
	0	2.5	PA										
2	2.5	4.0	SS	2	3	3		1.25	1.5	2.5	silty clay, tr sand, tr gravel brown		
	2.5	5.0	PA										
3	5.0	6.5	SS	2	4	5		1.5	4.5+		same		
	5.0	7.5	PA										
4.	7.5	9.0	SS	4	5	7		1.5	4.5		same		
	7.5	10	PA							9.5			
5	10	11.5	SS	3	3	3		1.5			silty F-m sand, brown, tr gravel Sat.		
	10	12.5	PA							12.5	* clay in tip		
6	12.5	14	SS	8	5	10		1.5	1.5		silty clay, grey, tr gravel		
	12.5	15	PA										
7	15	16.5	SS	5	9	13		1.5	3.0		same		
	15	18	PA										
8	18	20	SS	3	5	10	17	1.0		18	clayey F-m sand, tr gravel, brown and red, moist		
8A			SS								silty F-m sand, brown, moist (in tip)		
											* 140 lb. automatic hammer		

ABBREVIATIONS
H.S. – HOLLOW STEM AUGER
W.O. – WASH OUT
S.T. – SHELBY TUBE
S.S. – SPLIT SPOON
D.B. – DIAMOND BIT
P.A. – POWER AUGER
R.B. – ROCK BIT
W.S. – WHILE SAMPLING
W.D. – WHILE DRILLING
B.C.R. – BEFORE CASING REMOVAL
A.C.R. – AFTER CASING REMOVAL
A.B. – AFTER BORING
B.R. – BACKGROUND READING
S.R. – SAMPLE READING

DRILL CREW CHECK LIST
TOPSOIL THICKNESS 14"
FILL THICKNESS none

CAVE IN LEVEL:
WHILE DRILLING AND SAMPLING ______
AFTER BORING COMPLETION ______

WATER LOSS:
AT ______ TO ______
PERCENT LOSS ______
AT ______ TO ______
PERCENT LOSS ______

BOULDERS OR OBSTRUCTIONS:
AT ______ TO ______
AT ______ TO ______

ARTESIAN PRESSURE:
DEPTH ______
HEIGHT OF RISE IN CASING ______
PIEZOMETER PVC OR SS
DIAMETER ______
SCREEN DEPTH ____ FT TO ____ FT
RISER PIPE ____ FT TO ____ FT
*PID READING ____ •VLAMP

RIG NO: D-50

DRILL CREW DAILY

DATE: 7-18-08

JOB NUMBER:

JOB NAME: CEDER LAKE

PERSONNEL	TIME IN	ARRIVAL TIME	MEALS	DEPARTURE TIME	TIME OUT	TOTAL
BILL	6:30	9:30	.5	4:00	5:00	10.0
SCOTT	6:00	9:30	.5	4:00	5:30	11.0

TIME DISTRIBUTION

EMPLOYEE	JOB PREPARATION	OBTAINING WATER	TRAVEL	SET UP TIME	BORING OPERATIONAL	SPECIAL TESTING	CLEAN UP	SITE SAFETY PLAN	STEAM CLEANING	SAMPLE UNLOADING	# DAILY REPORTS	UTILITIES AND LAYOUT BY CREW	STUCK IN MUD OR SNOW	SHOP TIME		TOTAL
BILL	1.0		2.0		7.0											10.0
SCOTT	1.0		3.0		7.0											11.0
CHARGEABLE HOURS																

DESCRIPTION OF DAYS OPERATION

SCOTT LOADED SUPPLIES AND WATER WAITED FOR PEMITS AND DROVE TO MEET BILL ON ROAD. BILL MOBILIZED D-50 FROM NORTH SIDE WAITED FOR SCOTT - MET AND DROVE TO SITE ONCE @ SITE DRILLED 4 BORINGS TO 20' SAMPLING @ 2.5' INTERVALS LEFT HOLES OPEN THEN WENT BACK TO ALL HOLES AND BACKFILLED AND TOOK WATER LEVELS SECURED EQUIPMENT MOBILIZED BACK TO CHICAGO SCOTT TO SHOP.

(ADDITION COMMENTS ON BACK)

DELAY TIME	HRS	CHARGEABLE HRS.
STS DELAY		
CLIENT DELAY		
WEATHER DELAY		
BREAKDOWN		

EXPENDABLE MATERIAL	AMT.
BENTONITE POWDER	
BENTONITE ~~PELLETS~~ CHIPS	4
CEMENT	
VOLCLAY GROUT	
PEA GRAVEL	
SAND	
EPA BARRELS	
CORE BOXES	
SPOON LINERS	
INCLINOMETER CASING	
PVC ☐ S.S. ☐ SIZE: 1.5", 2", 4"	
SCREEN	
RISER	
CAP & PLUG	
PROTECTOR COVER	

FOOTAGE COMPLETED:

BORING NO.	REGULAR	CORING	
B-2	20'	EVERY 2.5' SAMPLING	
B-3	20'		
B-4	20'		
B-6	20'		

CLIENT SIGNATURE

DRILLER'S SIGNATURE

[signature]

OPERATION'S SIGNATURE

(VERSION 2: 05/90 - MHDRAW)

DRILL CREW DAILY

RIG NO: D25

DATE: 7-18-08 Fri

JOB NUMBER: 803121

JOB NAME: Cedar Lake

PERSONNEL	TIME IN	ARRIVAL TIME	MEALS	DEPARTURE TIME	TIME OUT	TOTAL
Mark B.	8:00	9:00	-.50	1:30	4:30	8.0
Chris F.	8:00	9:00	-.50	1:30	4:30	8.0

TIME DISTRIBUTION

EMPLOYEE	JOB PREPARATION	OBTAINING WATER	TRAVEL	SET UP TIME	BORING OPERATIONAL	SPECIAL TESTING	CLEAN UP	SITE SAFETY PLAN	STEAM CLEANING	SAMPLE UNLOADING & DAILY REPORTS	UTILITIES AND LAYOUT BY CREW	STUCK IN MUD OR SNOW	SHOP TIME			TOTAL
Mark B.			4.0	1.0	2.0						1.0					8.0
Chris F.			4.0	1.0	2.0						1.0					8.0
CHARGEABLE HOURS																

DESCRIPTION OF DAYS OPERATION

Drove to site met Carlin F. and located borings & access. All location in 7' high corn planned access & routing to minimize damage. Sampled every 2.5 for total depth secured rig for demob. & returned to shop.

(ADDITION COMMENTS ON BACK)

DELAY TIME	HRS	CHARGEABLE HRS.
STS DELAY		
CLIENT DELAY		
WEATHER DELAY		
BREAKDOWN		

EXPENDABLE MATERIAL	AMT.
BENTONITE POWDER	
BENTONITE PELLETS	
CEMENT	
VOLCLAY GROUT	
PEA GRAVEL	
SAND	
EPA BARRELS	
CORE BOXES	
SPOON LINERS	
INCLINOMETER CASING	
PVC ☐ S.S. ☐ SIZE: 1.5", 2", 4"	
SCREEN	
RISER	
CAP & PLUG	
PROTECTOR COVER	

FOOTAGE COMPLETED:

BORING NO.	REGULAR	CORING	Every 2.5
B-1			20.0
B-5			19.5

CLIENT SIGNATURE

DRILLER'S SIGNATURE

Mark A. Baker

OPERATION'S SIGNATURE

(VERSION 2: 05/90 - M11DRAW)

Hole No. B-1

DRILLING LOG	DIVISION: Great Lakes and Ohio River Division	INSTALLATION: Chicago District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cedar Lake Restoration Project	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): Cedar Lake, IN N 2,852,580.0 E 2,218,500.0	11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*: NAD83
3. DRILLING AGENCY: STS Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: D-25
4. HOLE NO. *(As shown on drawing title and file number)*: B-1	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER: M. Baker	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: 723.9
	16. DATE HOLE — STARTED: 7/18/2008 — COMPLETED: 7/18/2008
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE: +733.9
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 19.5	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth weathering, etc., if significant)* g
+733.4	0.5		TOPSOIL - brown	100	1	
			silty CLAY, trace to little fine to coarse sand, trace fine gravel, trace shale - brown - very stiff to hard (CL)	50	0.0 0.5	3, 3, 3, 4 N=7 Qp=2.0 tsf
					1A 0.5 2.0	
				42	2 2.5 4.5	3, 3, 4, 5 N=7 Qp=2.0 tsf
				58	3 5.0 7.0	3, 5, 7, 7 N=12 Qp=2.5 tsf
				78	4 7.5 9.0	6, 8, 14 N=22 Qp=4.5+ tsf
+723.9	10.0		silty CLAY, trace fine to coarse sand, trace fine gravel, trace shale - grey - hard to very stiff (CL)	78	5 10.0 11.5	7, 10, 12 N=22 Qp=4.5+ tsf
				89	6 12.5 14.0	9, 10, 12 N=22 Qp=3.0 tsf
+718.9	15.0		silty CLAY, trace fine to coarse sand, trace fine gravel, trace shale - grey - hard to stiff (CL)	56	7 15.0 16.5	9, 11, 14 N=25 Qp=4.5+ tsf
				78	8 18.0 19.5	8, 8, 55 Qp=1.5 tsf
+714.4	19.5		End of Boring @ 19.5' Boring backfilled with bentonite chips to surface.			*Samples taken using a 140 lb Safety Hammer dropping 30"*

Hole No. B-2

DRILLING LOG	DIVISION: Great Lakes and Ohio River Division	INSTALLATION: Chicago District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cedar Lake Restoration Project	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): Cedar Lake, IN N 2,852,330.0 E 2,219,120.0	11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*: NAD83
3. DRILLING AGENCY: STS Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: D-50
4. HOLE NO. *(As shown on drawing title and file number)*: B-2	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER: Bill McCarthy	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: 717.3
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED 7/18/2008; COMPLETED 7/18/2008
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE: +733.3
9. TOTAL DEPTH OF HOLE: 20.0	18. TOTAL CORE RECOVERY FOR BORING: %
	19. SIGNATURE OF INSPECTOR

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOV-ERY (e)	BOX OR SAMPLE NO. (f)	REMARKS *(Drilling time, water loss, depth weathering, etc., if significant)* (g)
+733.3	0.0		TOPSOIL - organic sandy clay, blackish brown, moist	83	1 0.0 1.5	3, 5, 5 N=10
+731.9	1.4		silty CLAY, trace fine gravel - brown - medium (CL)			
				100	2 2.5 4.0	2, 3, 3 N=6 Qp=0.5 tsf
+728.3	5.0		silty CLAY, little fine to coarse sand, trace fine gravel - brown to brownish grey - hard (CL)	8	3 5.0 6.5	2, 3, 5 N=8 Qp=4.0 tsf
				100	4 7.5 9.0	3, 5, 5 N=10 Qp=4.0 tsf
				100	5 10.0 11.5	5, 6, 9 N=15 Qp=4.0 tsf
+720.8	12.5		silty CLAY, trace fine gravel - grey - hard (CL)	100	6 12.5 14.0	5, 7, 9 N=16 Qp=4.5+ tsf
				100	7 15.0 16.5	7, 9, 11 N=20 Qp=4.5+ tsf
+714.8	18.5		silty fine SAND, trace clay - grey - medium dense - moist to wet (SM)	100 100	8 18.0 18.5 8A 18.5 19.5	10, 7, 9, 9 N=18 Qp=4.5 *Samples taken using a 140 lb Automatic Hammer dropping 30"*
+713.3	20.0		End of Boring @ 20' Boring backfilled with bentonite chips to surface.			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: Cedar Lake Restoration Project | HOLE NO. B-2

Hole No. B-3

DRILLING LOG	DIVISION: Great Lakes and Ohio River Division	INSTALLATION: Chicago District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cedar Lake Restoration Project	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): Cedar Lake, IN N 2,853,600.0 E 2,220,355.0	11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*: NAD83
3. DRILLING AGENCY: STS Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: D-50
4. HOLE NO. *(As shown on drawing title and file number)*: B-3	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER: Bill McCarthy	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: 728.4
	16. DATE HOLE — STARTED: 7/18/2008 — COMPLETED: 7/18/2008
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE: +735.9
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 20.0	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth weathering, etc., if significant)* g
+735.4	0.5		TOPSOIL - sandy	50	1	2
			silty CLAY, trace fine to medium sand - brownish grey - very stiff to stiff (CL)	100	0.0 0.5	3, 7 N=10
					1A 0.5 1.5	Qp=3.5 tsf
				100	2 2.5 4.0	2, 2, 4 N=6 Qp=1.5 tsf
+731.4	4.5		silty CLAY, trace fine to medium sand - brownish grey - stiff to very stiff (CL)			
				100	3 5.0 6.5	2, 5, 7 N=12 Qp=3.0 tsf
+728.9	7.0		silty CLAY, trace fine to medium sand - brownish grey - hard (CL)			
				100	4 7.5 9.0	5, 7, 10 N=17 Qp=4.5+ tsf
				100	5 10.0 11.5	5, 8, 13 N=20 Qp=4.5+ tsf
+723.4	12.5		fine to medium SAND, trace fine gravel - brown - medium dense - saturated (SP)	100	6 12.5 13.5	8, 10, 15 N=25
+722.4	13.5		silty CLAY, some fine to coarse sand, trace fine gravel - grey - stiff to very stiff (CL)	100	6A 13.5 14.0	Qp=1.5 tsf
				33	7 15.0 16.5	5, 8, 6 N=14 Qp=1.0 tsf
				75	8 18.0 20.0	6, 8, 11, 19 N=19 Qp=3.5 tsf
+715.9	20.0		End of Boring @ 20' Boring backfilled with bentonite chips to surface.			*Samples taken using a 140 lb Automatic Hammer dropping 30"*

Hole No. B-4

DRILLING LOG	DIVISION: Great Lakes and Ohio River Division	INSTALLATION: Chicago District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cedar Lake Restoration Project	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): Cedar Lake, IN N 2,854,040.0 E 2,219,810.0	11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*: NAD83
3. DRILLING AGENCY: STS Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: D-50
4. HOLE NO. *(As shown on drawing title and file number)*: B-4	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER: Bill McCarthy	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: 726.0
	16. DATE HOLE — STARTED: 7/18/2008 — COMPLETED: 7/18/2008
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE: +732.9
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 20.0	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth weathering, etc., if significant)* g
+732.9 +731.9	0.0 1.0		TOPSOIL - fine to medium sand, trace organics, trace fine gravel, dark brown - moist	100	1 0.0 1.0	1, 2, 2 N=4
+730.4	2.5		clayey fine to medium SAND, trace silt - brown - loose - moist (SC-SP)	100	1A 1.0 1.5	
+721.8	11.1		silty CLAY, trace to little fine to coarse sand, trace fine gravel - brown to brownish grey - very stiff to hard (CL)	100	2 2.5 4.0	2, 3, 7 N=10 Qp=2.5 tsf
				100	3 5.0 6.5	3, 5, 8 N=13 Qp=3.0 tsf
				100	4 7.5 9.0	5, 8, 11 N=19 Qp=4.0 tsf
				98	5 10.0 11.1	6, 8, 9 N=17 Qp=4.5+ tsf
+718.9	14.0		silty fine (becoming more coarse) SAND, trace fine gravel - brown medium dense - wet to saturated (SM)	104	5A 11.1 11.5	
				100	6 12.5 14.0	4, 4, 8 N=12
+712.9	20.0		silty CLAY, trace sand, trace fine gravel - grey - very stiff to hard (CL)	100	7 15.0 16.5	2, 4, 8 N=12 Qp=2.75 tsf
				100	8 18.0 20.0	7, 10, 13, 18 N=23 Qp=4.0 tsf
			End of Boring @ 20' Boring backfilled with bentonite chips to surface.			*Samples taken using a 140 lb Automatic Hammer dropping 30"*

Hole No. B-5

DRILLING LOG	DIVISION: Great Lakes and Ohio River Division	INSTALLATION: Chicago District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cedar Lake Restoration Project
2. LOCATION (Coordinates or Station): Cedar Lake, IN N 2,853,960.0 E 2,218,830.0
3. DRILLING AGENCY: STS Exploration
4. HOLE NO. *(As shown on drawing title and file number)*: B-5
5. NAME OF DRILLER: M. Baker
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED --- DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 20.0
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*: NAD83
12. MANUFACTURER'S DESIGNATION OF DRILL: D-25
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER: 709.6
16. DATE HOLE: STARTED 7/18/2008 COMPLETED 7/18/2008
17. ELEVATION TOP OF HOLE: +727.1
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR:

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
+727.1	0.0		TOPSOIL - clayey topsoil, little silt, trace fine to coarse sand, trace fine gravel, trace organics - black	100	1 0.0 1.5	3, 3, 3, 4 N=6
+725.6	1.5		silty CLAY, trace to little fine to coarse sand, trace fine gravel - brown - stiff to very stiff (CL)	67	1A 1.5 2.0	
				50	2 2.5 4.5	3, 2, 4, 3 N=6
+722.1	5.0		silty CLAY, trace fine to coarse sand, trace fine gravel - brown - very stiff to hard (CL)	67	3 5.0 6.0	2, 3, 5, 9 N=8 Qp=2.0 tsf
				67	3A 6.0 7.0	Qp=4.5+ tsf
				78	4 7.5 9.0	8, 9, 13 N=22 Qp=4.5+ tsf
				78	5 10.0 11.5	9, 11, 10 N=21 Qp=4.5+ tsf
+714.6	12.5		silty CLAY, trace fine to coarse sand, trace fine gravel, trace shale - grey - stiff (CL)	83	6 12.5 14.0	5, 6, 7 N=13 Qp=1.5 tsf
				78	7 15.0 16.5	4, 6, 8 N=14 Qp=1.5 tsf
				75	8 18.0 20.0	4, 9, 12, 13 N=21
+708.1	19.0		silty fine SAND - brown - medium dense - saturated (SM)			*Samples taken using a 140 lb Safety Hammer dropping 30"*
+707.1	20.0		End of Boring @ 20' Boring backfilled with bentonite chips to surface.			

Hole No. B-6

DRILLING LOG	DIVISION Great Lakes and Ohio River Division	INSTALLATION Chicago District	SHEET 1 OF 1 SHEETS

1. PROJECT Cedar Lake Restoration Project	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) Cedar Lake, IN N 2,853,390.0 E 2,219,095.0	11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)* NAD83
3. DRILLING AGENCY STS Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL D-50
4. HOLE NO. *(As shown on drawing title and file number)* B-6	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER Bill McCarthy	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER 729.1
	16. DATE HOLE — STARTED 7/18/2008 — COMPLETED 7/18/2008
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE +734.6
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 20.0	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth weathering, etc., if significant)* g
+734.6	0.0		TOPSOIL - clayey fine to medium sand - brown	100	1 0.0 1.5	3, 5, 3 N=8
+733.4	1.2		silty CLAY, trace fine to coarse sand, trace fine gravel - brown - stiff (CL)			
				83	2 2.5 4.0	2, 3, 3 N=6 Qp=1.5 tsf
+730.1	4.5		silty CLAY, trace fine to coarse sand, trace fine gravel - brown - hard (CL)	100	3 5.0 6.5	2, 4, 5 N=9 Qp=4.5+ tsf
				100	4 7.5 9.0	4, 5, 7 N=12 Qp=4.5
+725.1	9.5		silty fine to medium SAND, trace fine gravel - brown - loose - saturated (SM)	100	5 10.0 11.5	3, 3, 3 N=6
+722.1	12.5		silty CLAY, little fine to coarse sand, trace fine gravel - grey - stiff to very stiff (CL)	100	6 12.5 14.0	8, 5, 10 N=15 Qp=1.5 tsf
				100	7 15.0 16.5	5, 9, 13 N=22 Qp=3.0 tsf
+716.6	18.0		clayey fine to medium SAND, trace fine gravel - brown and red - medium dense - moist (SC)	50	8 18.0 20.0	3, 5, 10, 17 N=15 *Samples taken using a 140 lb Automatic Hammer dropping 30"*
+714.6	20.0		End of Boring @ 20' Boring backfilled with bentonite chips to surface.			

Appendix C

Photo Log of Field Activities

Photograph 1

View south looking across a corn field at B-1.

Photograph 2

View of drilling operations at B-6.

Photograph 3

Waterlevel measurements being taken after the augers were removed at B-6.

Photograph 4

View across corn field from B-6 toward B-3 taken from the top of the support truck.

Photograph 5

The samples were removed from the split-spoon and sealed in labeled air-tight jars to be brought to our Vernon Hills lab for further evaluation.

Photograph 6

Cohesive samples were tested using a calibrated hand penetrometer in the field to determine unconfined shear strength.

Photograph 7

View of boring B-4 after backfill of bentonite chips.

Photograph 9

STS utilized the same path to and from each boring location whenever possible in order to minimize damage to crops.

Appendix D

Lab Test Results

STS Consultants Ltd.
Consulting Engineers

Moisture Content Data Sheet
ASTM D 2216

STS Project No.: 200803121
Project Name: CEDAR LAKE SUBSURFACE INVESTIGATION
Date: 7/25/2008

Boring Number	Sample No. Number	Depth (ft)	WC (%)
1	1	0.0-0.5	NA
1	1A	0.5-2.0	27.6
1	2	2.5-4.5	18.5
1	3	5.0-7.0	17.1
1	4	7.5-7.0	12.6
1	5	10.0-11.5	13.7
1	6	12.5-14.0	14.4
1	7	15.0-16.5	16.0
1	8	18.0-19.5	13.5

Techncian: EMR

Checked By: WPQ

STS Consultants Ltd.
Consulting Engineers

Moisture Content Data Sheet
ASTM D 2216

STS Project No.: 200803121
Project Name: CEDAR LAKE SUBSURFACE INVESTIGATION
Date: 7/25/2008

Boring Number	Sample No. Number	Depth (ft)	WC (%)
2	1	0.0-1.5	16.7
2	2	2.5-4.0	18.5
2	3	5.0-6.5	14.9
2	4	7.5-9.0	15.0
2	5	10.0-11.5	14.1
2	6	12.5-14.0	16.5
2	7	15.0-16.5	15.6
2	8	18.0-18.5	NA
2	8A	18.5-20.0	19.2

Techncian: EMR

Checked By: WPQ

STS Consultants Ltd.
Consulting Engineers

Moisture Content Data Sheet
ASTM D 2216

STS Project No.: 200803121
Project Name: CEDAR LAKE SUBSURFACE INVESTIGATION
Date: 7/25/2008

Boring Number	Sample No. Number	Depth (ft)	WC (%)
3	1	0.0-0.5	NA
3	1A	0.5-1.5	17.3
3	2	2.5-4.0	17.4
3	3	5.0-6.5	17.0
3	4	7.5-9.0	18.6
3	5	10.0-11.5	17.8
3	6	12.5-13.5	NA
3	6A	13.5-14.0	14.0
3	7	15.0-16.5	13.9
3	8	18.0-20.0	14.5

Techncian: EMR

Checked By: WPQ

STS Consultants Ltd.
Consulting Engineers

Moisture Content Data Sheet
ASTM D 2216

STS Project No.: 200803121
Project Name: CEDAR LAKE SUBSURFACE INVESTIGATION
Date: 7/25/2008

Boring Number	Sample No. Number	Depth (ft)	WC (%)
4	1	0.0-1.0	NA
4	1A	1.0-1.5	14.2
4	2	2.5-4.0	22.3
4	3	5.0-6.5	15.5
4	4	7.5-9.0	14.8
4	5	10.0-11.1	NA
4	5A	11.1-11.5	20.2
4	6	12.5-14.0	21.1
4	7	15.0-16.5	13.6
4	8	18.0-20.0	16.8

Techncian: EMR

Checked By: WPQ

STS Consultants Ltd.
Consulting Engineers

Moisture Content Data Sheet
ASTM D 2216

STS Project No.: 200803121
Project Name: CEDAR LAKE SUBSURFACE INVESTIGATION
Date: 7/25/2008

Boring Number	Sample No. Number	Depth (ft)	WC (%)
5	1	0.0-1.5	NA
5	1A	1.5-2.0	23.4
5	2	2.5-4.5	25.5
5	3	5.0-6.0	NA
5	3A	6.0-7.0	15.7
5	4	7.5-9.0	12.6
5	5	10.0-11.5	19.5
5	6	12.5-14.0	10.7
5	7	15.0-16.5	14.9
5	8	18.0-20.0	21.0

Techncian: EMR

Checked By: WPQ

STS Consultants Ltd.
Consulting Engineers

Moisture Content Data Sheet
ASTM D 2216

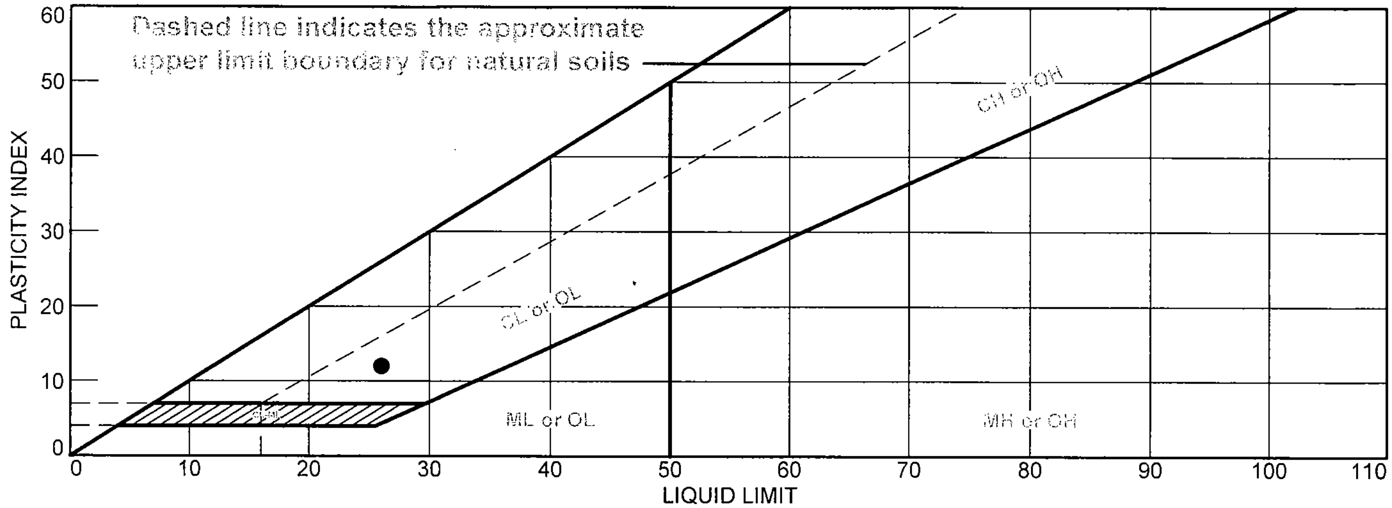
STS Project No.: 200803121
Project Name: CEDAR LAKE SUBSURFACE INVESTIGATION
Date: 7/25/2008

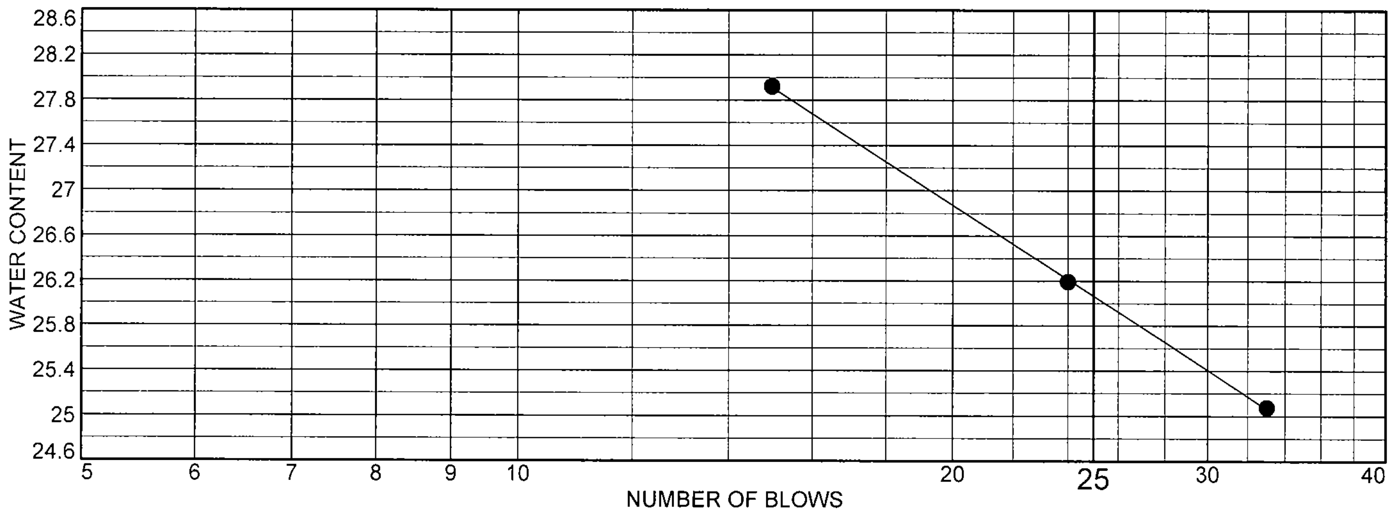
Boring Number	Sample No. Number	Depth (ft)	WC (%)
6	1	0.0-1.5	15.4
6	2	2.5-4.0	18.8
6	3	5.0-6.5	17.9
6	4	7.5-9.0	16.6
6	5	10.0-11.5	25.7
6	6	12.5-14.0	13.2
6	7	15.0-16.5	21.4
6	8	18.0-20.0	NA
6	8A	20	17.6

Techncian: EMR

Checked By: WPQ

LIQUID AND PLASTIC LIMITS ASTM D 4318





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILTY CLAY LITTLE F-C SAND TRACE F GRAVEL - BROWN	26	14	12			CL

Project No. 200803121 **Client:** U.S. ARMY CORPS OF ENGINEERS

Project: CEDAR LAKE, IN

● **Source of Sample:** B-1 **Depth:** 5.0'-7.0' **Sample Number:** 3

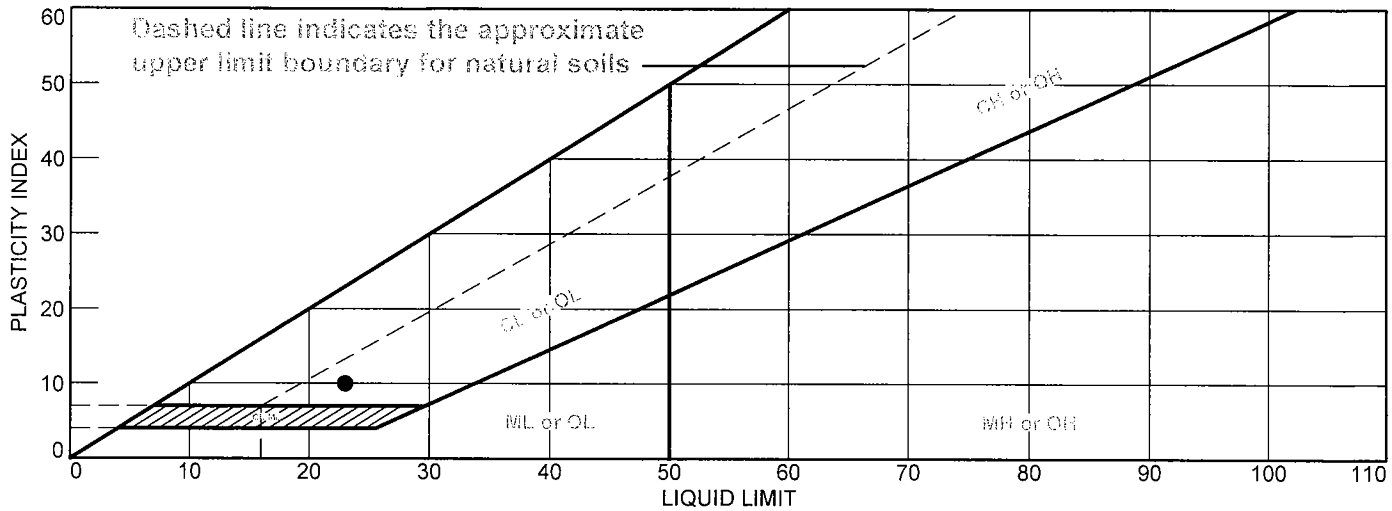
Remarks:

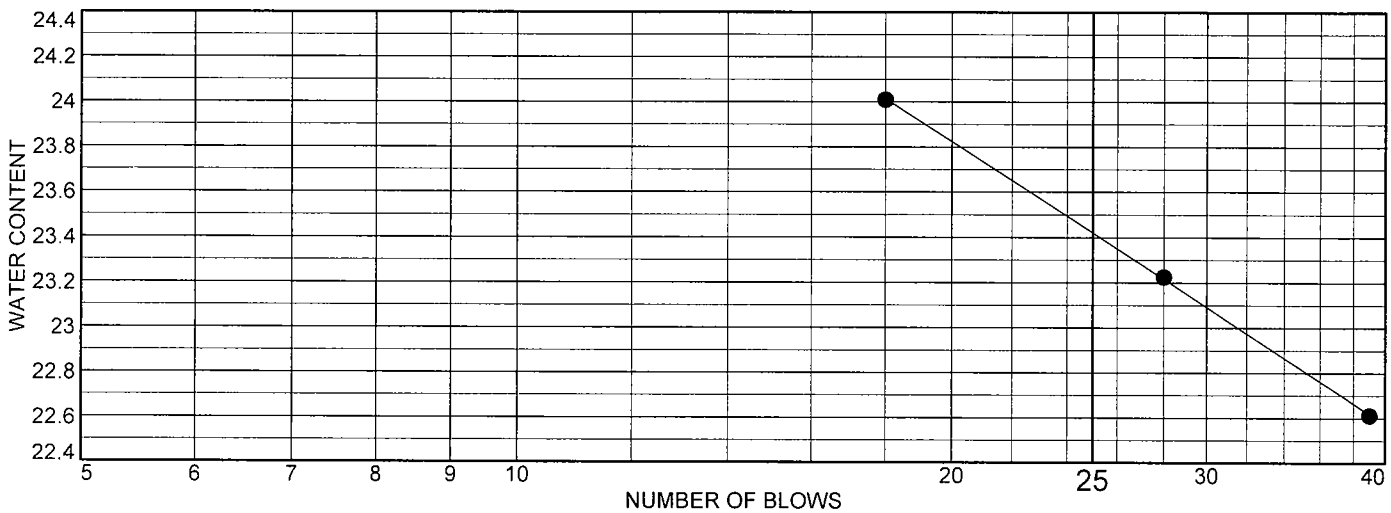
STS

Figure

Tested By: BCM **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D 4318





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILTY CLAY LITTLE F-C SAND TRACE F GRAVEL - BROWNISH GRAY	23	13	10			CL

Project No. 200803121 **Client:** U.S. ARMY CORPS OF ENGINEERS

Project: CEDAR LAKE, IN

● **Source of Sample:** B-2 **Depth:** 10.0'-11.5 **Sample Number:** 5

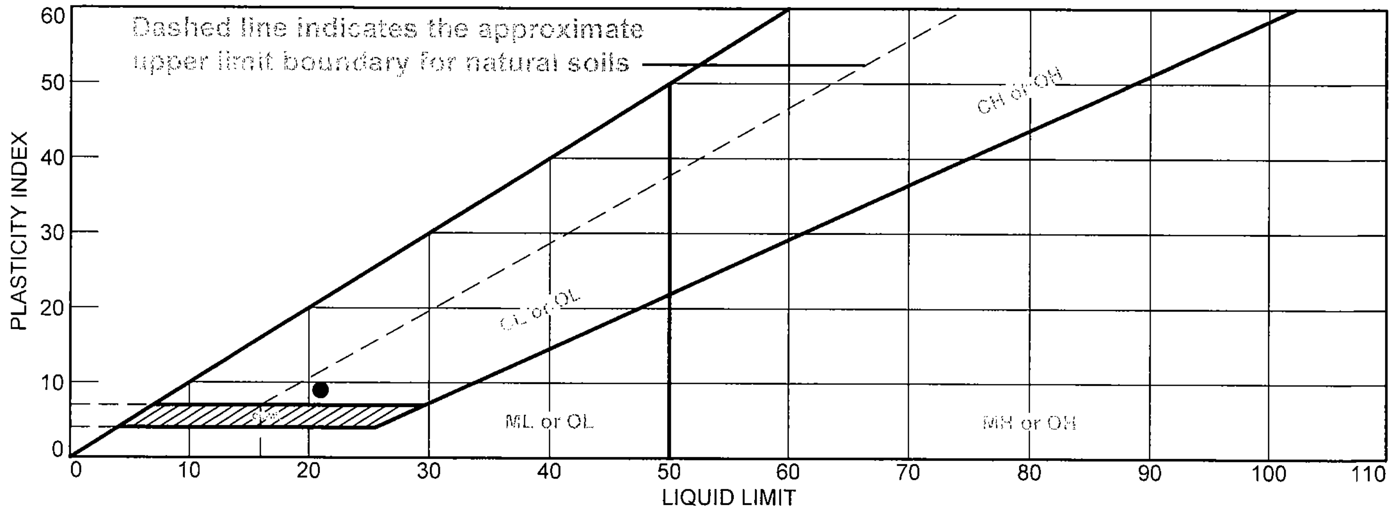
STS

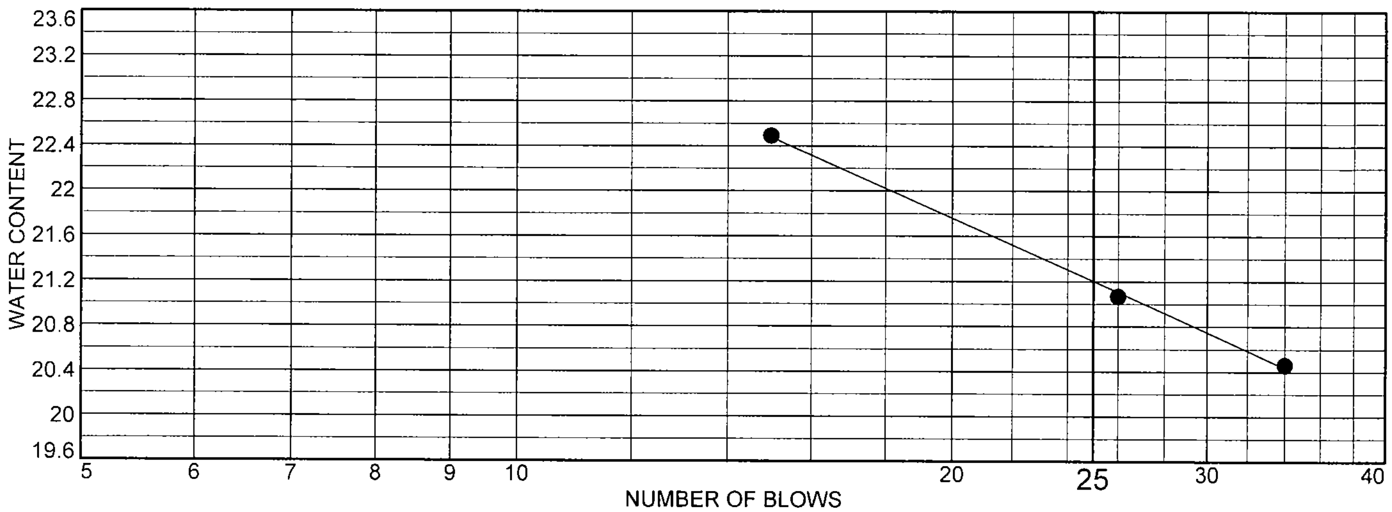
Remarks:

Figure

Tested By: BCM **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D 4318





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILTY CLAY SOME F-C SAND TRACE F GRAVEL - GRAY	21	12	9			CL

Project No. 200803121 **Client:** U.S. ARMY CORPS OF ENGINEERS

Project: CEDAR LAKE, IN

● **Source of Sample:** B-3 **Depth:** 15.0'-16.5' **Sample Number:** 7

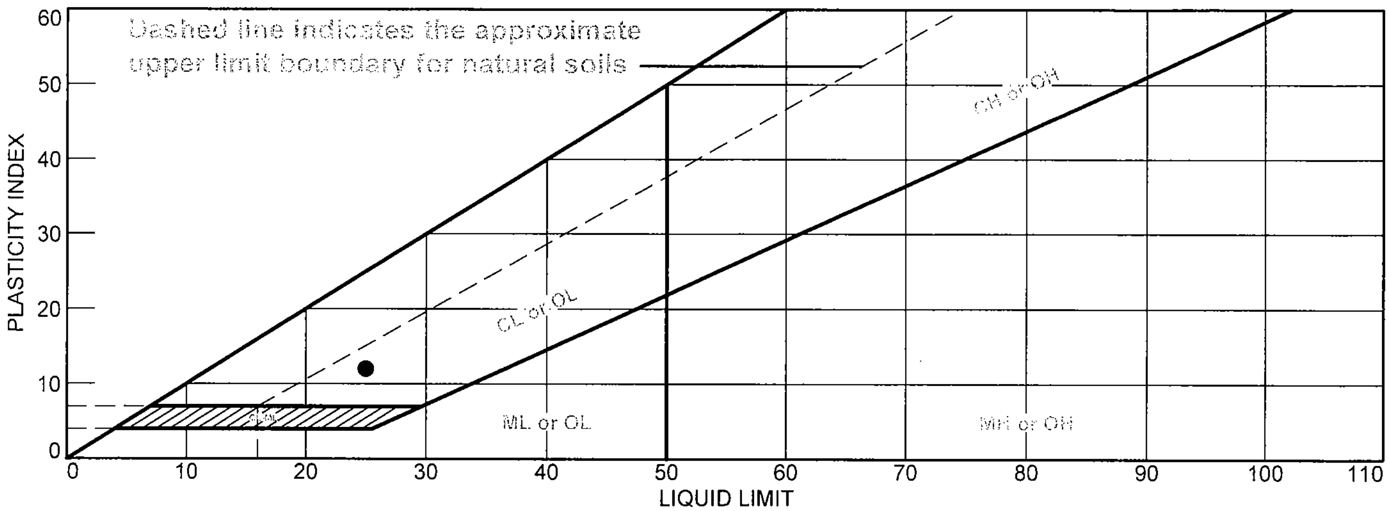
STS

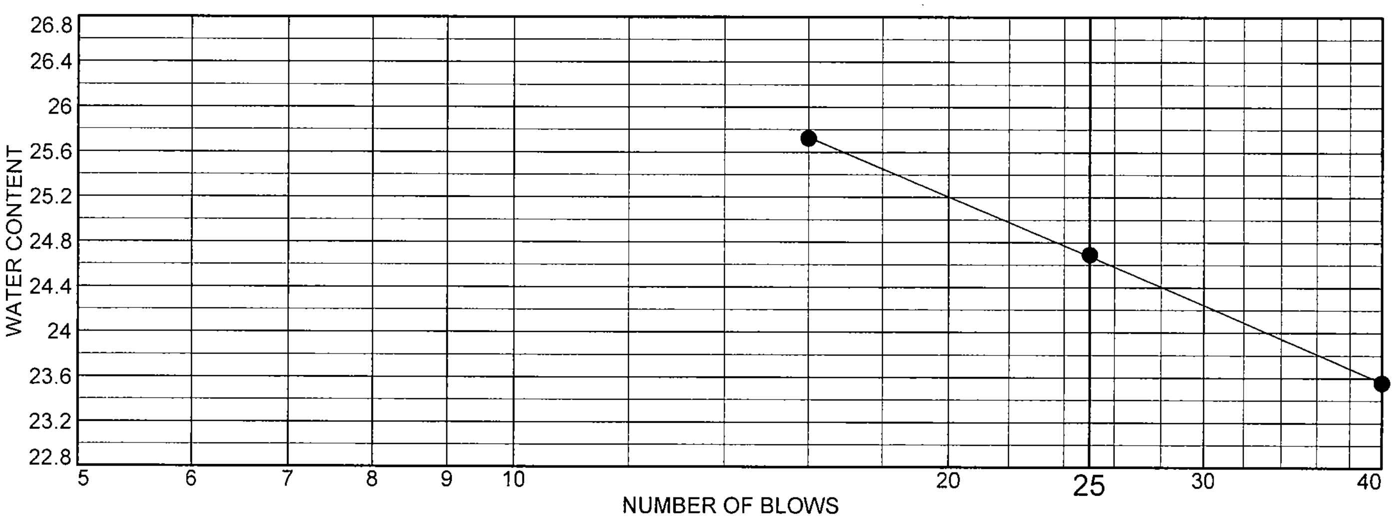
Remarks:

Figure

Tested By: BCM **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D 4318





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILTY CLAY LITTLE F-C SAND TRACE F GRAVEL - BROWNISH GRAY	25	13	12			

Project No. 200803121 **Client:** U.S. ARMY CORPS OF ENGINEERS

Project: CEDAR LAKE, IN

● **Source of Sample:** B-4 **Depth:** 10.0'-11.0' **Sample Number:** 5

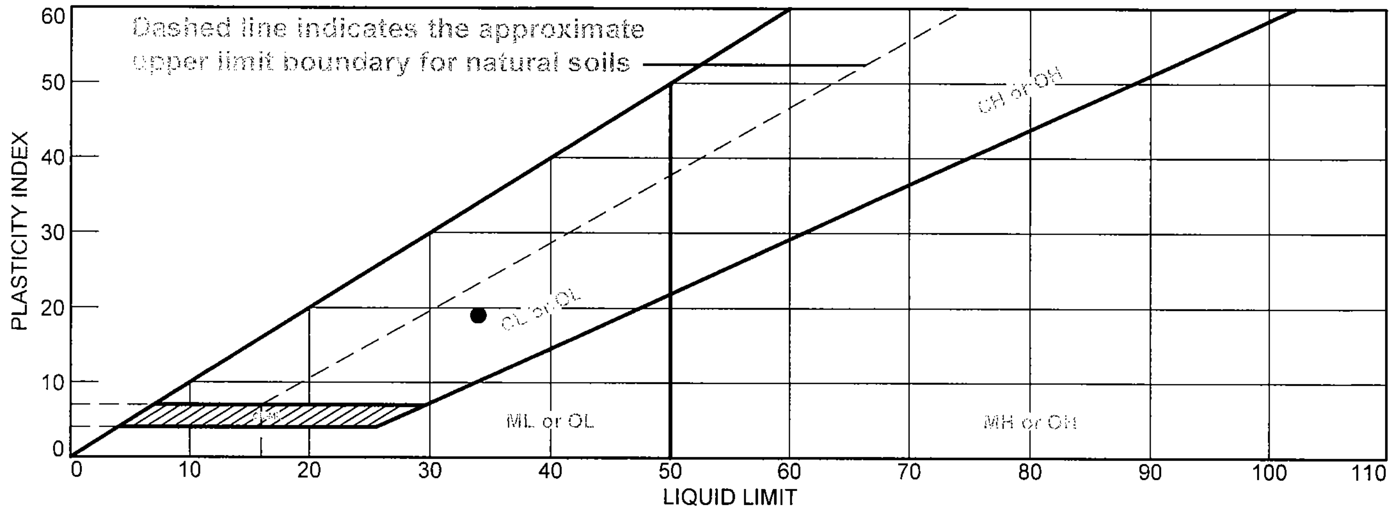
STS

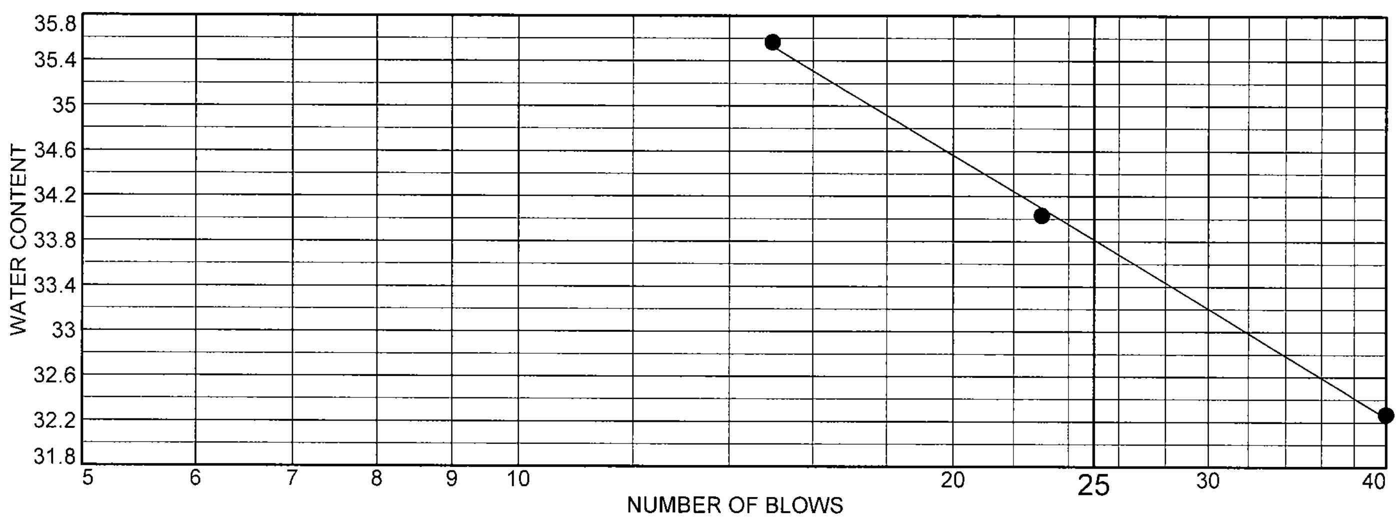
Remarks:

Figure

Tested By: BCM **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D 4318





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILTY CLAY LITTLE F-C SAND TRACE F GRAVEL - BROWN	34	15	19			CL

Project No. 200803121 **Client:** U.S. ARMY CORPS OF ENGINEERS

Project: CEDAR LAKE, IN

● **Source of Sample:** B-5 **Depth:** 2.5'-4.5' **Sample Number:** 2

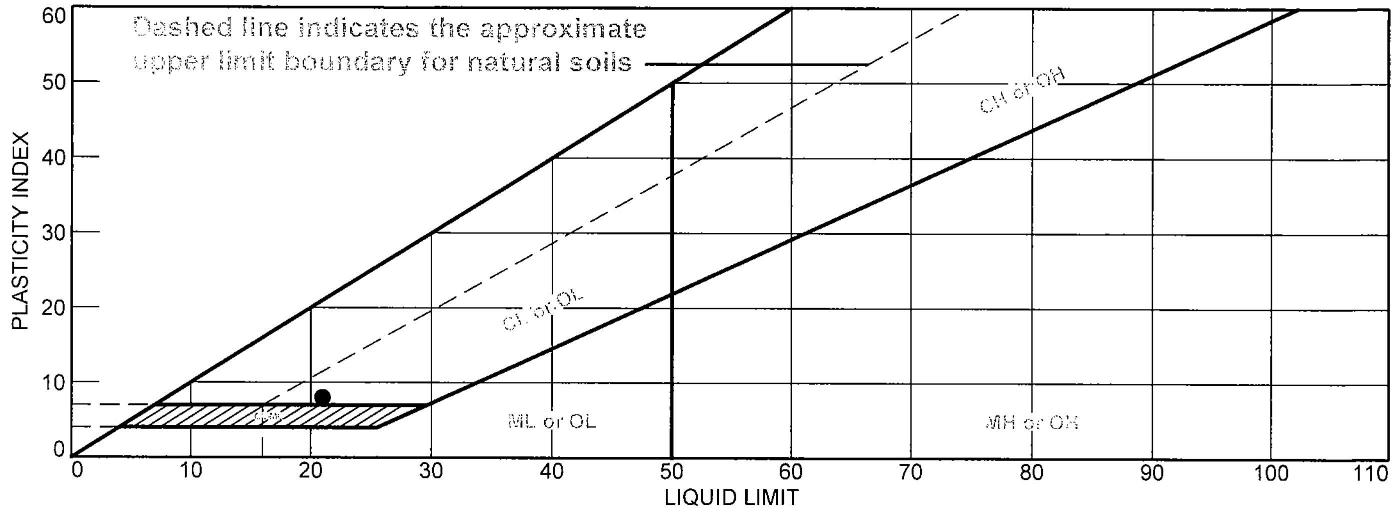
STS

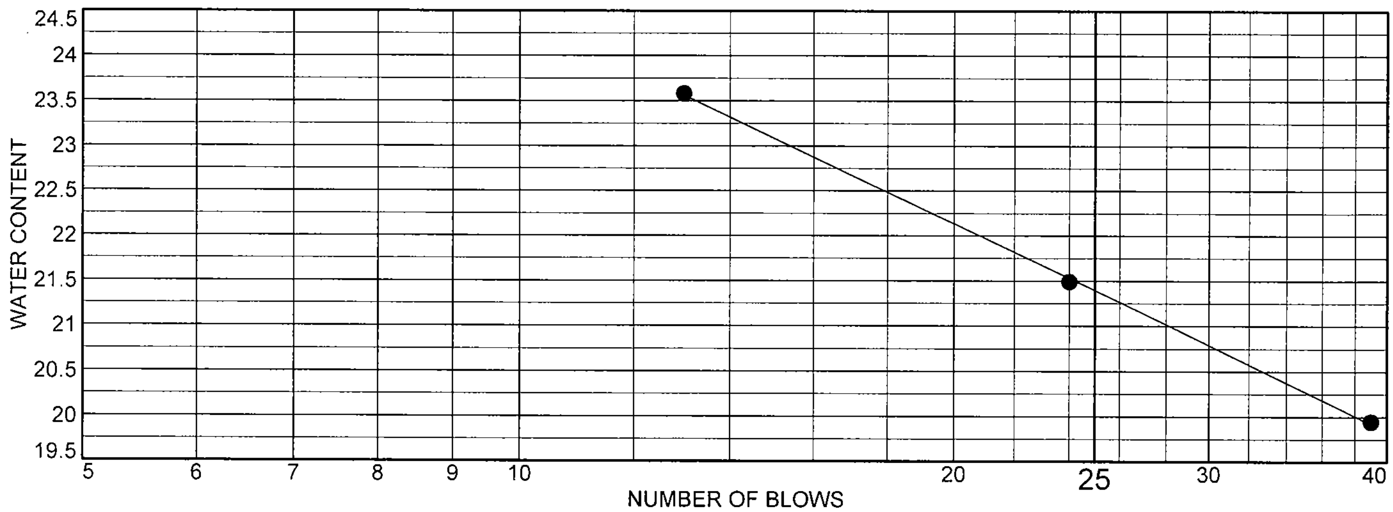
Remarks:

Figure

Tested By: BCM **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D 4318





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILTY CLAY LITTLE F-C SAND TRACE F GRAVEL - GRAY	21	13	8			

Project No. 200803121 **Client:** U.S. ARMY CORPS OF ENGINEERS

Project: CEDAR LAKE, IN

● **Source of Sample:** B-6 **Depth:** 12.5'-14.0' **Sample Number:** 6

STS

Remarks:

Figure

Tested By: BCM **Checked By:** WPQ

ATTACHMENT D-2

Soil Reconnaissance Mapping for Cedar Lake Seiment De-Watering Facility, Town of Cear Lake, IN (CBBEL Project No. 06-0015) (2 May 2008)

CHRISTOPHER B. BURKE ENGINEERING WEST, LTD.
116 West Main Street • Suite 201 • St. Charles, Illinois 60174-1854 • TEL (630) 443-7755 • FAX (630) 443-0533

May 2, 2008

Ms. Casey Pitman
Environmental Engineer
U.S. Army Corps of Engineers
111 North Canal Street
Suite 600
Chicago, IL 60606

RE: Soil Reconnaissance Mapping for Cedar Lake Sediment De-Watering Facility, Town of Cedar Lake, IN
(CBBEL Project No. 06-0015)

Dear Ms. Pitman:

Christopher B. Burke Engineering, Ltd. performed a reconnaissance soil survey to confirm the types and locations of soils on the proposed Cedar Lake Sediment De-watering Facility in the Town of Cedar Lake, Lake County, Indiana. To accomplish the reconnaissance survey, a 200 foot grid was laid out across the entire property, resulting in 193 potential soil boring locations. Soils were mapped utilizing standard landscape mapping analyses following the standards of the National Cooperative Soil Survey (NCSS), but applied at a higher intensity.

In landscape mapping, strategic landscape positions are mapped to confirm the presence of the soil boundary relative to the geomorphic position within the landscape. A soil profile is then classified. Approximately 60 borings were taken throughout the property, most at the grid intercept positions, and however, some were taken in intermediate landscape positions. All locations were identified by using a global positioning system (Trimble XVH).

The soils mapped on the site are generally consistent with the soils mapped in the Soil Survey of Lake County Indiana (1972; 1992). We identified 10 map units including:

Map Unit	Soil Name	Hydrologic Soil Group	Hydric	Previously Mapped
BLA	BLOUNT	C	N	N
El	ELLIOTT	C	N	Y
MaB2	MARKHAM	C	N	Y
Mag	MARKHAM, Gravely Substratum	C	N	N
MuB	MORLEY	C	N	Y
MuB2	MORLEY	C	N	Y
MuC2	MORLEY	C	N	Y
MvB3	MORLEY	C	N	Y
MvE3	MORLEY	C	N	Y
Pc	PEWAMO	C	Y	Y

Of the ten map units we identified on the site, nine of these map units were previously identified by the, then Soil Conservation Service, now Natural Resources Conservation Service.

The soils on this site have thin to no Aeolian silty deposits over silty clay loam and clay loam glacial till. In several areas of property, gravely substratum was identified as lenses within the soils. This occurred in the Markham, Elliott and Pewamo map units. I have included copies of the official series descriptions for the soil series that correspond to the units mapped. A number of soil map boundaries were modified as a result of drainage patterns exhibiting wetter conditions within the property than were previously identified. These boundary adjustments are on the order of tens of feet from the original map unit.

We have concluded that the mapping that was previously performed clearly characterized the conditions that were present on the project site. Several differences exist in the mapping in drainageways that caused additional hydric soil of the Pewamo map unit to be mapped on this property. Either the NRCS map or the revised map adequately characterizes the soil conditions present on the proposed Cedar Lake Sediment Dewatering Facility.

The minor gravel lenses that were identified warrant examination of soils at greater depth through a geotechnical investigation. There was no evidence in our mapping that any of these gravelly zones in the silty clay loam till were continuous, however, no soils were examined below a depth of 72". Thus, earth work may result in exposure of additional lensing at greater depths. We would recommend that strategic geotechnical borings be made in the Elliott and Pewamo units to determine whether lenses of materials are present at greater depths.

Should you have any questions concerning this reconnaissance mapping, please contact me at your earliest convenience.

Respectfully submitted,

Patrick Kelsey, RPSS
Vice President
State of Indiana Registered Professional Soil Scientist #97

LOCATION BLOUNT OH+IL IN MI WI

Established Series
Rev. RAR
04/2008

BLOUNT SERIES

The Blount series consists of very deep soils that are moderately deep or deep to dense till. They are somewhat poorly drained, slowly permeable soils. They formed in till. These soils are on till plains and have slopes ranging from 0 to 6 percent. Mean annual temperature is 51 degrees F, and mean annual precipitation is 33 inches.

TAXONOMIC CLASS: Fine, illitic, mesic Aeric Epiaqualfs

TYPICAL PEDON: Blount silt loam - on a northwest-facing, concave, 1 percent slope in a cultivated field at an elevation of 867 feet. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 7 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; moderate fine and medium granular structure; friable; common roots; 3 percent pebbles; slightly acid; abrupt smooth boundary. (5 to 10 inches thick)

Btg--7 to 12 inches; grayish brown (10YR 5/2) silty clay; moderate medium subangular blocky structure; firm; common roots; common distinct dark grayish brown (10YR 4/2) clay films on surfaces of peds; common distinct light gray (10YR 7/1) (dry) clay depletions on vertical surfaces of peds; many distinct yellowish brown (10YR 5/4) masses of iron accumulation with clear boundaries in the matrix; 3 percent pebbles; strongly acid; clear wavy boundary.

Bt--12 to 23 inches; dark yellowish brown (10YR 4/4) clay; weak fine and medium prismatic structure parting to moderate medium subangular blocky; firm; few roots; many distinct grayish brown (10YR 5/2) clay films on faces of peds; many distinct dark grayish brown (10YR 4/2) iron depletions with clear boundaries in the matrix; common prominent gray (10YR 5/1) iron depletions with clear boundaries and distinct yellowish brown (10YR 5/6) masses of iron accumulation with diffuse boundaries in the matrix; 4 percent pebbles; slightly acid; clear wavy boundary. (Combined thickness of the Btg and/or Bt horizons is 12 to 35 inches.)

BCtg--23 to 30 inches; grayish brown (10YR 5/2) silty clay loam; weak medium subangular blocky structure; firm; few faint dark grayish brown (10YR 4/2) clay films on vertical surfaces of peds; few distinct light gray (10YR 7/2) calcium carbonate coatings on vertical surfaces of peds; many distinct dark yellowish brown (10YR 4/4) and common prominent yellowish brown (10YR 5/6) masses of iron accumulation with clear boundaries in the matrix; 8 percent pebbles; slightly effervescent; slightly alkaline; clear wavy boundary. (0 to 18 inches thick)

CBd--30 to 42 inches; brown (10YR 4/3) clay loam; weak medium platy structure; very firm; common distinct white (10YR 8/1) calcium carbonate coatings on surfaces; common faint grayish brown (10YR 5/2) iron depletions with diffuse boundaries in the matrix; 10 percent pebbles; strongly effervescent; moderately alkaline; gradual wavy boundary. (0 to 16 inches thick)

Cd1--42 to 54 inches; brown (10YR 5/3) clay loam; massive; very firm; common distinct light gray (10YR 7/1) calcium carbonate coatings on surfaces; few distinct dark gray (10YR 4/1) iron depletions with diffuse boundaries in the matrix; 10 percent pebbles; strongly effervescent; moderately alkaline; gradual wavy boundary.

Cd2--54 to 80 inches; brown (10YR 4/3) clay loam; massive; very firm; 10 percent pebbles; strongly effervescent; moderately alkaline.

TYPE LOCATION: Mercer County, Ohio; approximately 1.25 miles east of Wabash; in Washington Township; 130 feet west and 1880 feet south of the northeast corner of sec. 3, T. 6 S., R. 1 E.; Erastus Quadrangle; lat. 84 degrees 46 minutes 45 seconds N. and long. 40 degrees 33 minutes 35 seconds W., NAD 1927.

RANGE IN CHARACTERISTICS: The depth to the base of the argillic horizon ranges from 20 to 45 inches. The depth to carbonates ranges from 19 to 40 inches. Depth to the densic horizon is greater than 30 inches. The particle-size control section averages between 35 and 45 percent clay. Rock fragments are predominantly igneous, limestone, and dolomite pebbles.

The Ap horizon has a hue of 10YR, value of 3 or 4 (6 or more dry), and chroma of 1 to 3. Some pedons have an A horizon less than 5 inches in thickness that has color value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. The Ap or A horizon typically is silt loam but includes loam texture in some pedons. Some eroded pedons are silty clay loam. Rock fragment content ranges from 0 to 5 percent. Reaction ranges from strongly acid to neutral.

Some pedons have an E, BE or an EB horizon 3 to 6 inches thick. The E horizon has a hue of 10YR or 2.5Y, value of 4 or 5, and chroma 1 to 3.

The BE or EB horizon has color in the same range as the Bt horizon. It typically is silty clay loam but includes silt loam. Rock fragment content ranges from 0 to 10 percent. It ranges from strongly acid to neutral.

The Bt and Btg horizons have hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 4. They are silty clay loam, clay loam, clay, or silty clay. The clay content ranges from 35 to 48 percent in individual subhorizons. The sand content averages 10 to 25 percent. Rock fragment content ranges from 3 to 10 percent. They range from slightly acid to very strongly acid in the upper part and from moderately acid to slightly alkaline in the lower part.

The BCtg horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 6. It is silty clay loam, clay loam, or silty clay. Rock fragment content ranges from 3 to 15 percent. Reaction ranges from slightly acid to slightly alkaline and contains carbonates in some pedons. Some pedons have secondary carbonates (Bk horizon) as masses or as coatings on the underside of rock fragments in the lower B horizons. Some pedons do not have a BCtg horizon

The CBd and Cd horizons have hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 to 4. They are silty clay loam or clay loam. Clay content ranges from 27 to 40 percent. Rock fragment content ranges from 5 to 15 percent. They are slightly alkaline or moderately alkaline. They have 22 to 35 percent calcium carbonate equivalent. Some pedons do not have a CBd horizon.

COMPETING SERIES: These are the Bennington, Brockport, Caneadea, Churchville, Del Rey, Fulton, Lockport, Kimmell, Mahoning, Nappanee, Odessa, Remsen, and Rhinebeck soils. Bennington and Mahoning soils have a calcium carbonate equivalent less than 22 percent and rock fragments that are dominantly shale, siltstone, or sandstone. Brockport and Lockport soils have a lithic or paralithic contact within 40 inches. Caneadea, Del Rey, Fulton, Odessa, and Rhinebeck soils contain less than 10 percent sand and generally less than 5 percent rock fragments in the lower part of the series control section. Churchville soils are formed in lacustrine deposits in the upper part of the series control section and have more rock fragments in the lower part of the series control section than Blount soils. Kimmell soils contain less than 5 percent rock fragments in the lower part of the series control section. Nappanee soils average more than 45 percent clay in the particle-size control section. Remsen soils contain more than 40 percent clay in the lower part of the series control section.

GEOGRAPHIC SETTING: Blount soils are on till plains of Wisconsinan Age. Slopes commonly are 1 to 3 percent and range from 0 to 6 percent. The soils formed in silty clay loam or clay loam till. Some areas have a mantle of loess or other silty material as much as 18 inches thick. Elevation ranges from 600 to 1500 feet. Mean annual temperature ranges from 45 to 55 degrees F, and mean annual precipitation ranges from 29 to 42 inches. The frost-free period is 130 to 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Ashkum, Beecher, Glynwood, Lybrand, Morley, and Pewamo soils. The poorly drained Ashkum and Pewamo soils are in depressions and drainageways. The Beecher soils have a darker colored surface layer and are on similar nearby landforms. The moderately well drained Glynwood soils and well drained Lybrand and Morley soils are nearby on slightly higher or more sloping parts of the landform.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained. The potential for surface runoff is low to medium. Permeability is slow. An intermittent perched seasonal high water table is at a depth of 0.5 to 2.0 feet in most years.

USE AND VEGETATION: Almost all areas of Blount soils are cultivated. Corn, soybeans, small grain, and meadow are the principal crops. Native vegetation is hardwood forest.

DISTRIBUTION AND EXTENT: Blount soils are in northern Illinois, Indiana, Michigan, Ohio, and Wisconsin. Dominant acreage is in MLRA 111, with lesser acreages in MLRA's 95B, 97, 98, 108, and 110. The extent of Blount soils is large; the acreage more than 2,500,000.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana.

SERIES ESTABLISHED: Vermilion County, Illinois, 1931.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
ochric epipedon - the zone from the surface of the soil to a depth of 7 inches (Ap horizon);
argillic horizon - the zone from approximately 7 to 30 inches (Btg, Bt, and BCtg horizons);
aquic conditions - 7 to 54 inches (Btg, Bt, BCtg, CBd, Cd1 horizons);
densic contact - 30 inches.

Supporting laboratory data is needed to confirm the presence of densic materials in the CBd and Cd horizons. Densic horizon is defined with this revision as being at depths of greater than 30 inches. Blount series is in major land region M and Churchville series is entirely in major land region R. There is some overlap in rock fragments in the lower part of the series control section but Churchville series is usually greater 15 percent and Blount series is less than 10 percent in most cases.

ADDITIONAL DATA: Laboratory characterization data is available for MC-20, the typical pedon. Other data are given in SSSA proc. 28: 674-679, Morley and Blount soils: A Statistical Summary of Certain Physical and Chemical Properties of some Selected Profiles in Ohio.

National Cooperative Soil Survey
U.S.A.

LOCATION MARKHAM IL+IN WI

Established Series
Rev. GOW-JBF-DEC
07/2007

MARKHAM SERIES

The Markham series consists of very deep, moderately well drained soils on Wisconsin till plains. They formed in a thin layer of loess or silty material and in the underlying silty clay loam till. Slopes range from 0 to 20 percent. Mean annual precipitation is about 890 mm (35 inches), and mean annual air temperature is about 10 degrees C (50 degrees F).

TAXONOMIC CLASS: Fine, illitic, mesic Mollic Oxyaquic Hapludalfs

TYPICAL PEDON: Markham silt loam on a north-facing slope of 3 percent at an elevation of 236 meters (775 feet) above mean sea level. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 13 cm (0 to 5 inches); very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; common very fine roots; moderately acid; clear smooth boundary.

A--13 to 20 cm (5 to 8 inches); very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine subangular blocky structure parting to weak fine granular; friable; common very fine roots; moderately acid; abrupt smooth boundary. [Combined thickness of the A horizon is 15 to 23 cm (6 to 9 inches).]

BA--20 to 30 cm (8 to 12 inches); brown (10YR 4/3) silty clay loam; moderate fine subangular blocky structure; friable; common very fine roots; common distinct very dark grayish brown (10YR 3/2) organic coatings on faces of peds; moderately acid; clear wavy boundary. [0 to 15 cm (0 to 6 inches) thick]

2Bt1--30 to 53 cm (12 to 21 inches); dark yellowish brown (10YR 4/4) silty clay loam; moderate fine and medium prismatic structure parting to moderate fine subangular blocky; friable; common very fine and fine roots; few distinct very dark gray (10YR 3/1) organic coatings on faces of peds; common distinct brown (10YR 4/3) clay films on faces of peds; common fine strong brown (7.5YR 4/6) very weakly cemented iron oxide concretions throughout; 2 percent gravel; slightly acid; clear wavy boundary.

2Bt2--53 to 66 cm (21 to 26 inches); yellowish brown (10YR 5/4) silty clay loam; weak medium subangular blocky structure; friable; common very fine and fine roots; few distinct brown (10YR 4/3) clay films on faces of peds and in pores; common fine yellowish red (5YR 4/6) very weakly cemented iron oxide concretions throughout; common fine distinct grayish brown (10YR 5/2) iron depletions in the matrix; 7 percent gravel; slightly effervescent; slightly alkaline; gradual wavy boundary. [Combined thickness of the 2Bt horizon is 25 to 89 cm (10 to 35 inches).]

2BC--66 to 81 cm (26 to 32 inches); yellowish brown (10YR 5/4) silty clay loam; weak medium and coarse angular blocky structure; firm; common very fine roots; common fine yellowish red (5YR 5/6) very weakly cemented iron oxide concretions throughout; common fine distinct grayish brown (10YR 5/2) iron depletions in the matrix; 6 percent gravel; strongly effervescent; slightly alkaline; gradual wavy boundary. [0 to 25 cm (0 to 10 inches) thick]

2Cd1--81 to 99 cm (32 to 39 inches); yellowish brown (10YR 5/4) silty clay loam; massive; very firm; few very fine roots; common fine yellowish red (5YR 5/6) very weakly cemented iron oxide concretions throughout; 6 percent gravel; violently effervescent; moderately alkaline; gradual wavy boundary.

2Cd2--99 to 152 cm (39 to 60 inches); brown (10YR 5/3) silty clay loam; massive; very firm; common fine yellowish red (5YR 5/6) very weakly cemented iron oxide concretions throughout; 7 percent gravel; violently effervescent; moderately alkaline.

TYPE LOCATION: DuPage County, Illinois; 648 meters (2,125 feet) south and 419 meters (1,375 feet) east of the northwest corner of sec. 16, T. 40 N., R.9 E.; USGS West Chicago topographic quadrangle; lat. 41 degrees 57 minutes 09 seconds N. and long. 88 degrees 13 minutes 04 seconds W., NAD 27; UTM Zone 16, 399060E, 4645222N, NAD 83.

RANGE IN CHARACTERISTICS: Depth to the base of soil development is 51 to 140 cm (20 to 55 inches). Illite is the dominant clay mineral.

The upper part of the series control section (Ap or A horizon) has 10YR hue, value of 2 or 3 and chroma of 1 or 2. It is silt loam or silty clay loam.

Some pedons have an E horizon with hue of 10YR, value of 4 or 5, and chroma of 2 or 3.

The middle part of the series control section (Bt or 2Bt horizon) has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 8. It is silty clay loam or silty clay. The particle-size control section of the Bt horizon averages between 35 and 45 percent clay and contains less than 50 percent clay in any subhorizon. Reaction ranges from strongly acid to slightly acid in the upper part and from slightly acid to moderately alkaline in the lower part.

The lower part of the series control section (BC, 2BC, Cd or 2Cd horizon) has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 8. It is silty clay loam or clay loam. It is slightly to moderately alkaline and commonly contains carbonates.

COMPETING SERIES: There are no competing series.

GEOGRAPHIC SETTING: Markham soils are typically in transition areas between the Mollisols and Alfisols on Wisconsin till plains. Slopes are dominantly between 3 and 12 percent, and they range from 0 to 20 percent. The soils are formed in silty clay loam till of Wisconsin Age that has, in some places, mantles of less than 46 cm (18 inches) of loess or other silty material. Mean annual air temperature ranges from 7 to 11 degrees C (45 to 52 degrees F.), mean annual precipitation is 740 to 1020 mm (29 to 40 inches), frost free days is 140 to 180 days, and the elevation ranges from 165 to 311 meters (540 to 1020 feet) above sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Ashkum, Beecher, Elliott, Morley, Ozaukee, and Varna soils. The poorly drained Ashkum soils have a mollic epipedon and are lower positions on the landform. The somewhat poorly drained Beecher and Elliott soils are on slightly lower landform positions. Morley, Ozaukee, and Varna soils are also on similar landform positions. Morley and Ozaukee soils have surface layers with moist color values of 4 or more, and Varna soils have mollic epipedons.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Moderately well drained. The depth to a perched seasonal high water table is 61 to 107 cm (2.0 to 3.5 feet) at some time during the spring in most years. The potential for surface runoff is low to high. Saturated hydraulic conductivity is moderately low to moderately high (0.42 to 1.41 micrometers per second). Permeability is slow.

USE AND VEGETATION: Largely cropped to corn, soybeans, small grains, and hay. Native vegetation was probably prairie grass having recent encroachment of hardwood trees.

DISTRIBUTION AND EXTENT: Northern Illinois, southeastern Wisconsin, northern Indiana, and southern Michigan.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana.

SERIES ESTABLISHED: Lake County, Illinois, 1961.

REMARKS: Diagnostic horizons and features recognized in this pedon are: ochric epipedon (mollic intergrade) - the zone from the surface to 30 cm (12 inches) (Ap, A and BA horizons); argillic horizon - the zone from 30 to 66 cm (12 to 26 inches) (2Bt1 and 2Bt2 horizons); udic moisture regime.

National Cooperative Soil Survey
U.S.A.

LOCATION MORLEY IN+IL MI OH WI

Established Series
Rev. JAG-SLM-TJE
05/2007

MORLEY SERIES

The Morley series consists of very deep, moderately well drained soils that are moderately deep to dense till. The Morley soils formed in as much as 46 cm (18 inches) of loess and in the underlying clay loam or silty clay loam till. They are on till plains and moraines. Slope ranges from 1 to 18 percent. Mean annual precipitation is about 940 mm (37 inches), and mean annual air temperature is about 11 degrees C (51 degrees F).

TAXONOMIC CLASS: Fine, illitic, mesic Oxyaquic Hapludalfs

TYPICAL PEDON: Morley silty clay loam, on a convex, 9 percent slope in a cultivated field at an elevation of 259 meters (850 feet) above mean sea level. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 23 cm (0 to 9 inches); 80 percent dark grayish brown (10YR 4/2) and 20 percent dark yellowish brown (10YR 4/4) silty clay loam, pale brown (10YR 6/3) dry; moderate medium granular structure; friable; common fine roots; 1 percent gravel; moderately acid; abrupt smooth boundary. [8 to 30 cm (3 to 12 inches) thick]

Bt1--23 to 43 cm (9 to 17 inches); dark yellowish brown (10YR 4/4) clay; weak coarse prismatic structure parting to moderate medium subangular blocky; very firm; common fine roots; many distinct brown (10YR 4/3) clay films on faces of peds; few distinct grayish brown (10YR 5/2) silt coatings on faces of peds; 1 percent gravel; very strongly acid; clear smooth boundary.

Bt2--43 to 51 cm (17 to 20 inches); dark yellowish brown (10YR 4/4) clay; weak coarse prismatic structure parting to moderate medium subangular blocky; very firm; common fine roots; many distinct brown (10YR 4/3) clay films on faces of peds; 2 percent gravel; neutral; clear wavy boundary.

Bt3--51 to 74 cm (20 to 29 inches); yellowish brown (10YR 5/4) clay loam; moderate medium subangular blocky structure; firm; few fine roots; few distinct dark grayish brown (10YR 4/2) clay films on faces of peds; common medium distinct yellowish brown (10YR 5/6) masses of iron oxide accumulation in the matrix; few medium distinct grayish brown (10YR 5/2) iron depletions in the matrix; 5 percent gravel; strongly effervescent; slightly alkaline; clear wavy boundary. [Combined thickness of the Bt horizon is 30 to 76 cm (12 to 30 inches).]

Cd1--74 to 91 cm (29 to 36 inches); yellowish brown (10YR 5/4) clay loam; weak very coarse prismatic structure parting to weak very thick platy; very firm; very few distinct dark grayish brown (10YR 4/2) clay films and common distinct light gray (10YR 7/2) carbonate coatings on vertical faces of cracks; common medium distinct grayish brown (10YR 5/2) iron depletions in the matrix; 9 percent gravel; strongly effervescent; moderately alkaline. [13 to 38 cm (5 to 15 inches) thick]

Cd2--91 to 203 cm (36 to 80 inches); yellowish brown (10YR 5/4) clay loam; weak very coarse prismatic structure; very firm; few distinct light gray (10YR 7/2) carbonate coatings on vertical faces of cracks; common medium distinct grayish brown (10YR 5/2) iron depletions in the matrix; 9 percent gravel; strongly effervescent; moderately alkaline.

TYPE LOCATION: Adams County, Indiana; about 2 1/4 miles southeast of Berne; 1,580 feet west and 1,360 feet south of the northeast corner of sec. 15, T. 25 N., R. 14 E.; USGS Berne, Ind. topographic quadrangle; lat. 40 degrees 37 minutes 16 seconds N. and long. 84 degrees 55 minutes 24 seconds W., NAD 27; UTM Zone 16, 675653 easting and 4498771 northing, NAD 83.

RANGE IN CHARACTERISTICS:
Depth to the base of the argillic horizon: 51 to 102 cm (20 to 40 inches)
Depth to carbonates: 51 to 102 cm (20 to 40 inches)
Depth to densic contact: 51 to 102 cm (20 to 40 inches)
Thickness of the loess: 0 to 46 cm (0 to 18 inches)
Particle-size control section: averages 35 to 50 percent clay, 15 to 25 percent sand, and 1 to 5 percent rock fragments

Ap horizon:
Hue: 10YR
Value: 4
Chroma: 2 or 3
Texture: silt loam, loam, silty clay loam, or clay loam
Reaction: strongly acid to neutral

A horizon: (where present)
Thickness: less than 15 cm (6 inches)
Hue: 10YR
Value: 2 or 3
Chroma: 1 or 2
Texture: silt loam, loam, silty clay loam, or clay loam
Reaction: strongly acid to neutral

Bt horizon:
Hue: 10YR
Value: 4 or 5
Chroma: 3 to 6
Texture: clay loam or clay, or less commonly silty clay loam or silty clay
Rock fragment content: 1 to 10 percent
Reaction: very strongly acid to slightly alkaline

Cd horizon:
Hue: 10YR
Value: 5
Chroma: 3 or 4
Texture: clay loam or less commonly silty clay loam
Clay content: averages 27 to 35 percent
Silt content: less than 50 percent
Sand content: 18 to 30 percent
Rock fragment content: 1 to 10 percent
Moist bulk density: 1.70 to 2.00 g/cc
Calcium carbonate equivalent: 20 to 30 percent
Reaction: slightly acid to moderately alkaline

COMPETING SERIES: These are the Alexandria, Brushcreek, Lairdsville, Lucas, Ozaukee, Schoharie, and St. Clair series. Alexandria soils do not have a densic contact within 102 cm (40 inches). Brushcreek soils have a paralithic contact between 102 and 152 cm (40 and 60 inches). Lairdsville soils have a lithic or paralithic contact within 102 cm (40 inches). Lucas soils have more than 35 percent clay in the lower part of the series control section. Ozaukee soils average more than 50 percent silt in the lower part of the series control section. Schoharie soils have hue redder than 10YR in the middle and lower parts of the series control section. St. Clair soils average more than 50 percent clay in the particle-size control section.

GEOGRAPHIC SETTING: Morley soils are on till plains and moraines of Wisconsinan age. Slope ranges from 1 to 18 percent. The soils formed in as much as 46 cm (18 inches) of loess and in the underlying clay loam or silty clay loam till. Mean annual precipitation ranges from 762 to 1016 mm (30 to 40 inches). Mean annual air temperature ranges from 7 to 11 degrees C (44 to 52 degrees F). Frost-free period ranges from 130 to 180 days. Elevation ranges from 177 to 466 meters (580 to 1,530 feet) above mean sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Blount, Glynwood, Lybrand, and Pewamo soils. The somewhat poorly drained Blount soils and the moderately well drained Glynwood soils are on slightly higher lying swells on dissected till plains or on lower lying shoulders and backslopes of moraines. The well drained Lybrand soils are on more sloping backslopes. The very poorly drained Pewamo soils are in depressions on till plains.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Moderately well drained. The depth to the top of an intermittent perched high water table ranges from 61 to 107 cm (2 to 3.5 feet) between January and April in normal years. The potential for surface runoff is low to very high. Saturated hydraulic conductivity is moderately high or moderately low in the solum and low in the substratum. Permeability is moderate to slow in the solum and very slow in the substratum.

USE AND VEGETATION: Most areas are used to grow corn, soybeans, and small grain. Some areas are used for hay and pasture, and a few areas are used for woodland. Native vegetation is mixed deciduous hardwood forest.

DISTRIBUTION AND EXTENT: Northern Indiana, southern Michigan, northwestern Ohio, eastern Illinois, and southeastern Wisconsin; mainly in MLRAs 111, 110, and 99, and less extensively in MLRAs 95A, 95B, 97, 98, 108A, and 115C. The type location is in MLRA 111B. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana.

SERIES ESTABLISHED: Will County, Illinois, 1952.

REMARKS: There is limited data available on the clay mineralogy which shows both illitic and mixed. This series will be classified with illitic mineralogy, but as additional data is analyzed it could be changed to mixed.

Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon: from the surface to a depth of 23 cm (Ap horizon).
Argillic horizon: from a depth of 23 to 74 cm (Bt horizon).
Densic contact: at 74 cm (top of the Cd1 horizon).
Aquic conditions: redox features present in horizons below a depth of 51 cm.

NASIS Data Mapunit ID 401649 represents the 12 to 18 percent slope, severely eroded phase in northern Indiana.
NASIS Data Mapunit ID 401647 represents the silt loam surface, 2 to 6 percent slope, eroded phase in northern Indiana.
NASIS Data Mapunit ID 401648 represents the silt loam, eroded phase in northern Indiana.

ADDITIONAL DATA: Lab characterization data is available for the typical pedon (AD8003) from the Purdue University Soil Characterization Laboratory, AES Bulletin No. 360, Vol. 7, Pg. 93.

National Cooperative Soil Survey
U.S.A.

LOCATION PEWAMO MI+IN OH

Established Series
Rev. RWJ-WEF-RAR
09/2003

PEWAMO SERIES

The Pewamo series consists of very deep, very poorly drained soils formed in till on moraines and lake plains. Permeability is moderately slow. Slope ranges from 0 to 2 percent. Mean annual precipitation is about 33 inches, and mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Fine, mixed, active, mesic Typic Argiaquolls

TYPICAL PEDON: Pewamo clay loam, on a concave, 1 percent slope in a cultivated field at an elevation of 760 feet. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 10 inches; very dark brown (10YR 2/2) clay loam, grayish brown (10YR 5/2) dry; weak medium granular structure; firm; 3 percent gravel; slightly acid; abrupt smooth boundary. (8 to 12 inches thick)

A--10 to 13 inches; very dark brown (10YR 2/2) clay loam; weak medium angular blocky structure; firm; 3 percent gravel; slightly acid; gradual wavy boundary. (0 to 5 inches thick)

Btg1--13 to 25 inches; dark gray (10YR 4/1) silty clay; moderate medium angular blocky structure; firm; many faint dark gray (10YR 4/1) clay films on faces of peds; common medium faint very dark gray (10YR 3/1) organic masses; common medium prominent strong brown (7.5YR 5/6) masses of iron oxide accumulation in the matrix; about 2 percent gravel; slightly acid; gradual wavy boundary.

Btg2--25 to 37 inches; gray (10YR 5/1) silty clay; moderate medium angular blocky structure; firm; many faint gray (10YR 5/1) clay films on faces of peds; common medium prominent yellowish brown (10YR 5/6) masses of iron oxide accumulation in the matrix; common medium faint gray (N 5/0) iron depletions in the matrix; about 2 percent gravel; neutral; gradual wavy boundary. (Combined thickness of the Btg horizon is 8 to 37 inches.)

Cg--37 to 60 inches; grayish brown (10YR 5/2) silty clay loam; massive; firm; common medium prominent brownish yellow (10YR 6/6) masses of iron oxide accumulation; common medium faint gray (10YR 6/1) iron depletions; about 4 percent gravel; strongly effervescent; slightly alkaline.

TYPE LOCATION: Washtenaw County, Michigan; about 4 miles northeast of Ypsilanti; 100 feet south and 300 feet west of the northeast corner of sec. 26, T. 2 S., R. 7 E.; U.S.G.S. Denton topographic quadrangle; lat. 42 degrees 17 minutes 27 seconds N. and long. 83 degrees 33 minutes 56 seconds W., NAD 27; UTM Zone 17, 288494 easting and 4685258 northing, NAD 83.

RANGE IN CHARACTERISTICS: Thickness of the mollic epipedon ranges from 10 to 17 inches. Depth to the base of the argillic horizon ranges from 28 to 60 inches. Depth to carbonates ranges from 28 to 60 inches. The particle-size control section commonly averages 40 to 50 percent clay, but some pedons average as low as 35 percent. Rock fragments are primarily glacial erratics of mixed lithology. Mean annual soil temperature ranges from 49 to 56 degrees F.

The A or Ap horizon has hue of 10YR, value of 2 or 3 (5 or less dry), and chroma of 1 or 2 (moist or dry). Texture is loam, clay loam, silty clay loam, silt loam, or silty clay. Rock fragment content ranges 0 to 10 percent. Reaction ranges from moderately acid to neutral.

The Btg or Bt horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 to 4.

Texture is clay loam, clay, silty clay, or silty clay loam. Rock fragment content ranges from 1 to 10 percent. Reaction ranges from moderately acid to neutral in the upper part, and slightly acid to slightly alkaline in the lower part.

Some pedons have a BC, BCg, BCt, or BCtg horizon.

The Cg or C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 to 4. Texture is clay loam or silty clay loam. Clay content ranges from 27 to 40 percent. Rock fragment content ranges from 1 to 14 percent. Reaction is slightly alkaline or moderately alkaline.

COMPETING SERIES: These are the Lippincott and Millsdale series. Lippincott soils have less than 27 percent clay in the lower part of the series control section. Millsdale soils have a lithic contact within a depth of 40 inches.

GEOGRAPHIC SETTING: The Pewamo soils formed in till on moraines and lake plains. Slope gradients range from 0 to 2 percent. Mean annual precipitation ranges from 29 to 40 inches, mean annual temperature ranges from 47 to 54 degrees F., frost-free period ranges from 130 to 180 days, and elevation ranges from 580 to 1,530 feet above sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: The somewhat poorly drained Blount soils, the moderately well drained Glynwood and Morley soils, and the well drained Lybrand soils are in a toposequence with Pewamo soils. They are on swells and higher lying areas. None of these soils have a mollic epipedon.

DRAINAGE AND PERMEABILITY: Very poorly drained. The potential for surface runoff is negligible to low. Permeability is moderately slow. Depth to an apparent seasonal high water table ranges from 1 foot above the surface to 1 foot below the surface from December to May in normal years.

USE AND VEGETATION: Most areas are used to grow corn, soybeans, small grains, and hay. A small part, especially areas that lack adequate drainage, is in permanent pasture or forest. Native vegetation is forest of red maple, American elm, white ash, and American basswood.

DISTRIBUTION AND EXTENT: MLRA's 97, 98, 99, and 111 of southern Michigan, central and northwestern Ohio, and central and northern Indiana. The series is of large extent, about 1.8 million acres.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana.

SERIES ESTABLISHED: Lenawee County, Michigan, 1957.

REMARKS: The 6/98 revision narrowed the series concept by limiting the parent material to till only, and removing the lacustrine materials from the concept.

More laboratory work, especially thin sections, is needed to determine if clay increases are pedogenic. Overwash phases are recognized.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - from the surface to 13 inches (Ap and A horizons); argillic horizon - from 13 to 37 inches (Btg1 and Btg2 horizons); aquic conditions - from 0 to 60 inches (Ap, A, Btg1, Btg2, and Cg horizons).

ADDITIONAL DATA: Soil Interpretation Record: MI0042, MI0518. Soil characterization data is available from the National Soil Survey Laboratory, Lincoln, NE.

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