# Attachment 15

## Soil Conditions Report

**SUBSURFACE EXPLORATION AND
FOUNDATION RECOMMENDATIONS
PROPOSED INDUSTRIAL PARK
FARMINGTON, MISSOURI**

Prepared for:

City of Farmington
1410 West Columbia
Farmington, Missouri 63640

Prepared by:

**HOLCOMB FOUNDATION ENGINEERING CO.**

Carbondale, Illinois

January 29, 2016

File H-16014

# TABLE OF CONTENTS

# SUBSURFACE EXPLORATION AND FOUNDATION RECOMMENDATIONS
# PROPOSED INDUSTRIAL PARK
# FARMINGTON, MISSOURI

## 1.0 Introduction

The City of Farmington, Missouri is planning construction of a new industrial park on the south side of the city. This report provides a summary of the subsurface exploration and engineering recommendations for foundation design of the proposed industrial park. This project was authorized by Mr. Gregory Beavers, Farmington City Administrator on January 14, 2016.

## 2.0 Scope and Purpose of Report

The purpose of this geotechnical exploration is to explore subsurface conditions at the specific locations of 25 soil borings, conduct field and laboratory tests to gather data necessary to perform an evaluation of the subsurface conditions, and prepare engineering recommendations relative to the following items:

- Subsurface conditions encountered in the soil borings, including material types to be expected at existing grades and their impact on the construction scheme.
- Bedrock or boulder depth across the site.
- Site preparation considerations relative to the subsurface conditions.
- Foundation support of the proposed structures, including acceptable bearing pressures, anticipated bearing levels, and settlement estimates.
- Anticipation and management of ground water during construction.
- Soil material and compaction requirements for support of the proposed buildings.
- Floor slab support and construction.

- Seismic design recommendations for the proposed structures.

## 3.0 Site Description

This site is located on the west side of Air Park Drive, bordered by New Perrine Road to the north, and Vargo Road to the south. The property consists of four lots configured as indicated on the enclosed Boring Location Diagram.

## 4.0 Project Description

This project is to consist of construction of a new industrial park at this location. The building configuration on this site was not determined at the time of this subsurface exploration. However, of concern for this report is the depth of rock or boulders at this site, and types of soils and their engineering characteristics pertaining to pavement subgrade, building pad and foundation design.

## 5.0 Field Exploration

From January 21 to 22, 2016, we drilled twenty-five soil borings at this site. Boring locations were staked by Taylor Engineering, LLC prior to our arrival on site.

### 5.1 Drilling and Sampling Procedures

The soil borings were drilled with a CME-750 ATV mounted drilling rig. Conventional 3.25 inch inside diameter hollow stem augers were used to advance the boreholes. Representative soil samples were obtained on 2.5 foot intervals employing split barrel sampling procedures in accordance with ASTM D-1586. Upon completion of drilling, the boreholes were backfilled with the soil cuttings.

### 5.2 Field Tests and Measurements

The following field tests and measurements were performed during the course of exploration activities at the site:

- Ground water readings were obtained during and upon completion of drilling at all soil boring locations.
- Standard penetration tests were performed and penetration resistances recorded during the recovery of all split barrel samples.
- Approximate measurements of undrained shear strength were taken on all cohesive soil samples with a calibrated hand penetrometer.

- All samples were visually classified according to the Unified Classification System by the boring technician in preparation of the field boring logs. The samples were then placed into glass jars for transport to our laboratory.

The field test data and measurements are summarized in the Boring Logs located in the appendix to this report.

## 6.0 Laboratory Tests

In addition to the field exploration, a laboratory-testing program was conducted to determine additional engineering characteristics of the foundation subsoils. All tests were performed in accordance with applicable ASTM specifications. The laboratory-testing program included the following tests:

### 6.1 Natural Moisture Content

Natural moisture content determinations were performed on all samples. Moisture content determinations aid in estimating the settlement potential of a soil strata. The in-situ moistures also yield information as to the workability of a soil type. Moisture content results are graphically presented on the Boring Logs.

### 6.2 Visual Classifications

All soil samples were visually classified by the geotechnical engineer in accordance with the Unified Classification System. The visual classifications are noted on the Boring Logs.

### 6.3 Unconfined Compressive Strengths

Cohesive soil samples were subjected to unconfined compressive strength tests. Unconfined compressive strengths are used to determine the undrained shear strength of a soil. Results of the compressive strength tests are plotted on the Boring Logs.

### 6.4 Sample Disposal

The soil samples are stored in our laboratory for further analysis, if desired. Unless notified to the contrary, the samples will be disposed of six months after the date of this report.

# 7.0 Subsurface Conditions

The types of subsurface materials encountered in the soil borings are briefly described on the Boring Logs in the appendix to this report. The general characteristics are described in the following paragraphs. The conditions represented by these test borings should be considered applicable only at the test boring locations on the dates shown. It is possible the conditions encountered may be different at other locations or at other times.

## 7.1 General Subsurface Profile

The subsurface profile at this site consists of about four inches of topsoil overlying brown to reddish-brown silty clay to clay (CL to CH classification). The clay extends down to depths ranging from about 2 to 16 feet, where gray to brown limestone and sandstone was encountered. The borings were terminated in the limestone and sandstone at depths ranging from 4 to 17 feet.

## 7.2 Silty Clay to Clay

The silty clay to fat clay is a medium to highly plastic soil deposit that ranges from soft to stiff, with unconfined compressive strengths of 0.2 to 4.4 tons per square foot, averaging 1.7 tsf. Moisture contents vary from 23 to 112 percent, averaging 36 percent. The clay has a relatively high potential for shrinkage and swell when subjected to moisture content variations due to the high plasticity of the subsoils.

## 7.3 Limestone and Sandstone

The limestone and sandstone bedrock are very dense with standard penetration test values in excess of 60 blows per foot. Based on previous borings in the Farmington area, some of the limestone may actually be limestone boulders. Moisture contents of the bedrock or boulders vary from 5 to 25 percent, averaging 11 percent. The limestone and sandstone have a very low settlement potential.

## 7.4 Ground Water

Ground water was encountered at six feet in depth in Boring #3. The remaining borings were dry during and upon completion of drilling operations.

# 8.0 Grading Considerations

## 8.1 Site Preparation

Prior to site preparation procedures, the topsoil should be stripped from the building pads and areas that will be paved. The topsoil may be wasted off-site, or used to grade landscaped areas.

It is recommended upon stripping the topsoil, the exposed subgrade that is at grade or that will be filled should be proofrolled with a loaded tandem dump truck. Should areas pump or rut during proofrolling, the soils may either be scarified and recompacted, or unstable soils may be removed and replaced with a select silty clay or sandy clay backfill. Any disturbed or pumping soils should be properly compacted prior to placement of fill soils or building construction.

If possible the site grading should be performed during hot, dry months of the year. If site grading is performed when the soils are wet, the subgrade may pump to such a degree that it may have to be removed and replaced, or require the addition of hydrated lime for drying prior to compaction.

8.2 Fill Placement

After proofroll of subsoils in the building areas and areas to be paved, fill soils may be placed to grade the building pads area. It is recommended the fill is placed in maximum eight inch loose lifts, with each lift compacted to a minimum of 95% of the maximum standard laboratory dry density. The fill should consist of a lean (low plastic) silty clay or sandy clay. If the fat clay soils on site are used for borrow, they should be treated with 5% by weight Code L lime prior to placement and compaction.

A sufficient number of in-place field density tests should be performed by an engineering technician to evaluate the contractor's performance during fill soil placement and compaction. The tests will also aid in determining whether project specifications are being met. A minimum of four compaction tests per every lift are recommended, with not less than one test per 2000 square feet of fill placed.

8.3 Subgrade Preparation of Floor Slabs

Environmental conditions and construction traffic often disturb even a well-prepared soil surface at the final grade elevation. Provisions should be made in the construction specifications for the contractor to restore the subgrade soils to a stable condition prior to placing the granular mat. Backfilling of utility trenches is often accomplished in an uncontrolled manner, leading to cracking of floor slabs and pavements. We recommend the utility trenches are backfilled with acceptable fill in eight inch loose lifts and compacted with piston tampers to the project requirements.

If the fat clay soils are encountered at the building subgrade elevations or in the exposed roadway subgrades, the upper one foot of clay should be treated with 5% by weight Code L lime. After treatment of the subgrade, it should be properly compacted as recommended in Section 8.2 of this report.

The concrete floor slabs may be supported upon a four-inch layer of free draining granular material. Generally, clean crushed limestone or coarse sand is used for this purpose. This is to provide a capillary break and a uniform leveling course beneath the slab.

### 8.4 Ground Water Control

During preparation of the subgrade near the existing ground surface, ground water is not anticipated. However, if free water is encountered in the footing excavations, the contractor should make provisions for temporary drainage through the use of sumps and/or interceptor ditches.

## 9.0 Engineering Recommendations

### 9.1 Building Foundations

Based upon results of the field and laboratory tests, the proposed structures at this site may be supported upon shallow foundations consisting of isolated column and continuous wall footings. A maximum net allowable soil bearing pressure of up to 2000 pounds per square foot may be used to dimension the footings. Should fat clay soils or limestone/boulders be encountered in the bottom of the excavations, the subsoils should be undercut two feet and replaced with a low plastic silty clay soil, crushed stone, or flowable fill material. The silty clay or crushed stone should be compacted as recommended in Section 8.2 of this report.

The exterior footings should be founded at a minimum depth of 2.5 feet for frost protection. Interior footings in heated areas may be founded at one foot below the final subgrade elevation if protected from frost. It is also recommended all footings have a minimum width of 24 inches to avoid a punching type failure of the foundation.

Total and differential settlements of a 100 kip column load are estimated to range from approximately 0.5 to 1.5 inch. We recommend the foundation excavations are tested for bearing pressure to a depth of two feet below the footing bottom elevations prior to placement of concrete. Should soils with less than the specified bearing pressure be encountered, it is recommended they are excavated and replaced with a properly compacted fill soil, crushed stone, or flowable fill.

### 9.2 Seismic Design

Based upon the seismic design criteria provided by the 2012 I.B.C., this site has a site classification type "D" profile. Based upon this profile, the spectral response acceleration coefficients have been determined as follows:

0.2 Second Period: $S_{Ms}$ = 0.599 g x 1.321 (Soil Factor $F_a$) = 0.791

1.0 Second Period: $S_{M1}$ = 0.222 g x 1.955 (Soil Factor $F_v$) = 0.434

The recommended design spectral response factors are as follows:

$S_{DS}$ = 0.527 g

$S_{D1}$ = 0.289 g

These values were obtained from the IBC Section 1615 and the USGS Earthquake Hazards Program based upon the latitude and longitude of this site. Due to the clayey soils encountered in the soil borings, liquefaction of the foundation soils is not a concern at this site.

### 9.3 Retaining Wall Design

Coefficients for active and passive pressures acting upon retaining walls in the upper ten feet of this site are estimated as follows:

| | |
|---|---|
| Coefficient of Active Pressure: | 0.39 |
| Coefficient of Passive Pressure: | 2.56 |
| Coefficient of At-Rest Pressure: | 0.56 |

The clayey subsoils encountered on this site have a wet soil density of approximately 120 pounds per cubic foot. It is recommended the retaining walls are backfilled with a free draining sand or crushed stone up to within one foot of the final ground line, with perforated PVC pipe at the base of the wall sloped to gravity drain or drain to a sump.

The recommended coefficient of friction between the concrete and soils which may be used for design is 0.33.

### 9.4 Floor Slab Design

The proposed concrete slabs on grade may be designed using a modulus of subgrade reaction estimated at approximately 100 psi per inch. The soil subgrade beneath the slab should be properly proofrolled or compacted per the recommendations in Section 8 of this report.

## 10.0 Summary

This subsurface exploration has been conducted at the site of a proposed industrial park in Farmington, Missouri. This report has been prepared for the exclusive use of the City of Farmington for the specific application to this project.

The following information has been discussed in this report:

- Soils encountered at this site consist of four inches of topsoil overlying a brown to reddish-brown silty clay to fat clay. Below the silty clay to clay lies gray to brown limestone and sandstone bedrock that extend down to at least the bottom of the borings.

- Site grading will include proofrolling the subgrade and grading the site for the proposed building pad. Any soft subsoils encountered during proofrolling may require undercut or processing prior to placement of fill to grade the building pad.

- If fat clay soils are encountered at the proposed building floor slab or road subgrade elevations, it should be treated with Code L lime to reduce the soil plasticity, and be properly compacted.

- Foundation design criteria have been discussed, and allowable soil bearing pressures have been recommended for shallow foundations.

- The shallow foundations may be dimensioned using a maximum allowable soil bearing pressure of up to 2000 pounds per square foot.

- Probing of all foundation subsoils is recommended after the footings are excavated. Should soft subsoils, boulders, or fat clay soil be encountered, they may be excavated to at least two feet below the footings, and replaced with a well compacted fill or flowable fill material.

- The International Building Code indicates this site has a type "D" site classification, based upon the soil borings. The recommended design spectral response factors for this site are $S_{DS}$ = 0.527 g and $S_{D1}$ = 0.289 g.

The analyses, conclusions, and recommendations contained in this report are professional opinions based on the site conditions and project scope described herein. It is assumed the conditions observed in the exploratory borings are representative of subsurface conditions throughout the site. If during construction, subsurface conditions differ from those encountered in the exploratory borings are observed or appear to be present beneath excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary.

Unless specifically noted, the scope of our services did not include an assessment of the effects of flooding and natural erosion of creeks or rivers adjacent to the project site.

If there is a substantial lapse in time between the submittal of this report and the start of work at this site, or if site conditions are changed due to natural causes or construction operations, we recommend that this report be reviewed to determine the applicability of conclusions and recommendations considering the changed conditions and time lapse.

In order for us to provide a complete professional geotechnical engineering service, we should be retained to observe construction, particularly site grading, earthwork and foundation construction.

The scope of our services for this phase of the project does not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic material in the soil, surface or ground water or air, on or below this site. Any statements in this report or on the boring logs regarding any odors or unusual or suspicious items or conditions observed are strictly for the information of our client.

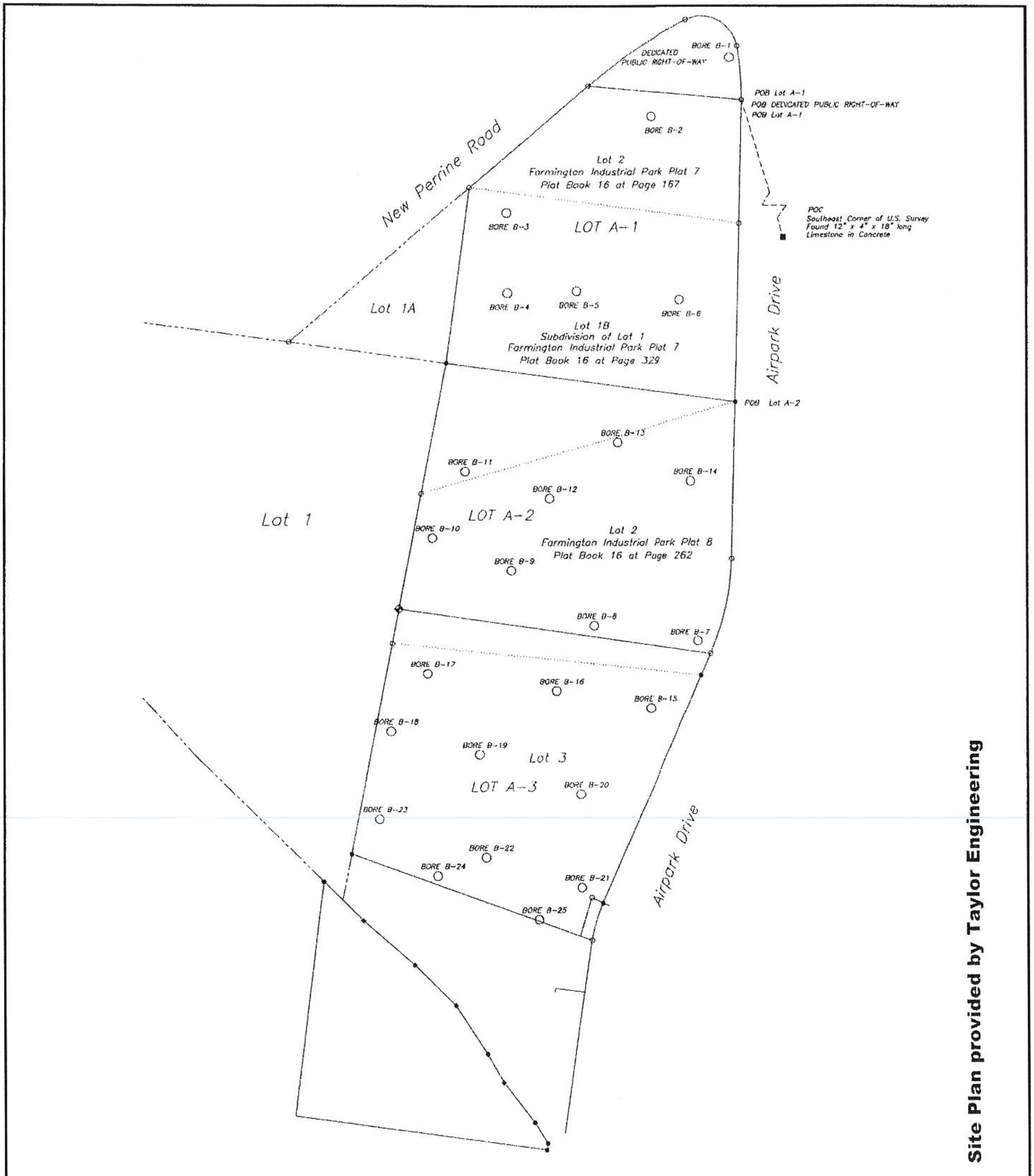
This report was prepared for the exclusive use of the owner, architect, or engineer for evaluating the design of the project as it relates to the geotechnical aspects discussed herein. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions included in this report. Unanticipated soil conditions or rock may require that additional expense be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

It is recommended that we be retained to review final project layout and those portions of plans and specifications which pertain to foundations and earthwork to determine if they are consistent with our findings and recommendations.

Scott G. Holcomb, E.I.

Timothy J. Holcomb, P.E.

STATE OF MISSOURI
TIMOTHY J.
HOLCOMB
NUMBER
E-2001009656
REGISTERED PROFESSIONAL ENGINEER




| | | |
|---|---|---|
| ***Project:***<br>**Farmington Industrial Park Site Analysis**<br>**Farmington, Missouri**<br>***Client:***<br>**The City of Farmington**<br>**Farmington, Missouri** | **Boring Location Diagram** | **North**<br>**Project No. H-16014**<br>**Not to Scale**<br>**January 22, 2016** |

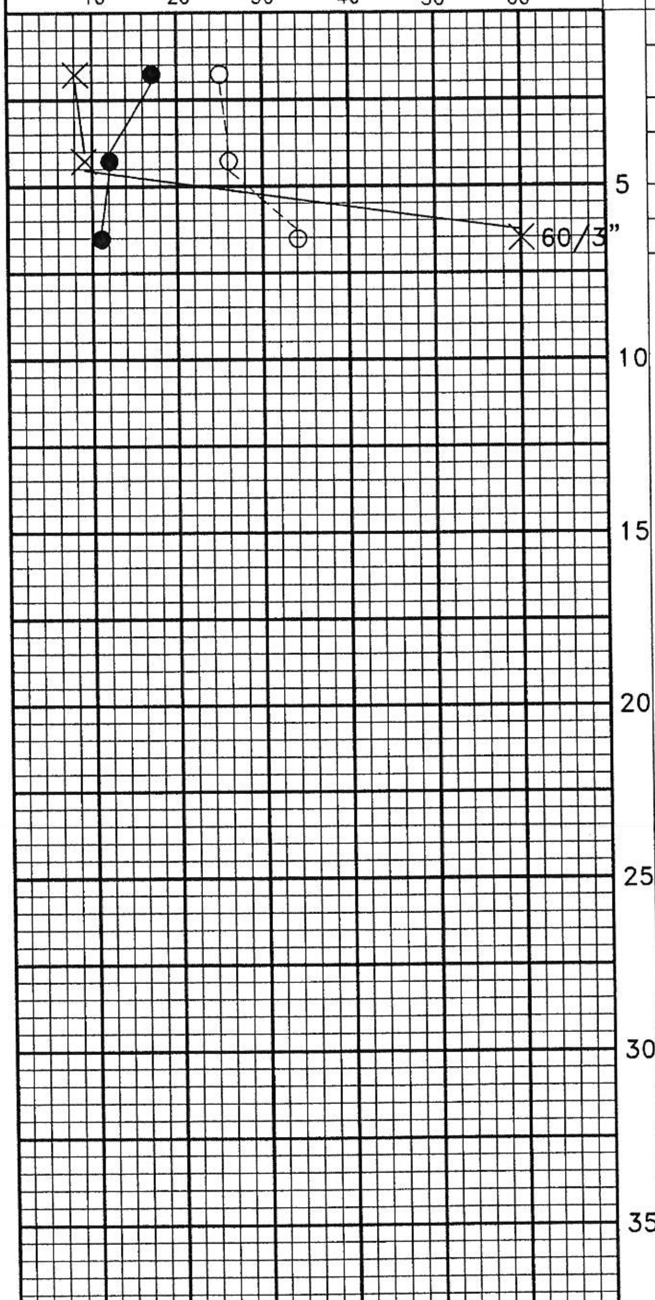
Holcomb Foundation Engineering Co.
PO Box 88 Carbondale, Illinois

# LOG of BORING 1

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY to CLAY (CL-CH) |
| | 2 | ss | / | Brown CLAY (CL-CH) |
| | 3 | ss | / | LIMESTONE |
| | | | | End of Boring @ -7.0' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 22, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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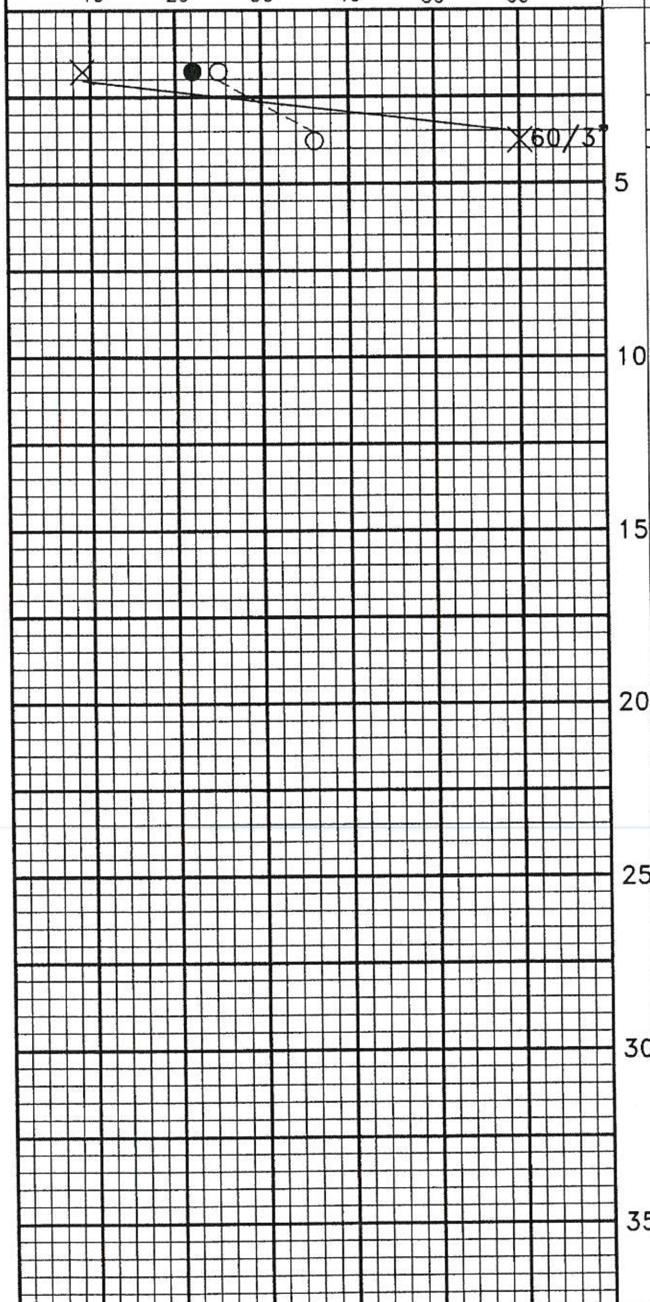
# LOG of BORING 2

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕
10 20 30 40 50 60




| Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|
| | | | Surface Elevation |
| | | | 4" Topsoil |
| 1 | ss | | Brown Silty CLAY to CLAY (CL-CH) |
| 2 | ss | | SANDSTONE |
| | | | End of Boring @ -4.0' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

Project: Farmington Industrial Park Site Analysis
Farmington, Missouri

Date of Boring
January 22, 2016

Client: The City of Farmington
Farmington, Missouri

Project No.
H-16014

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PO Box 88 Carbondale, Illinois

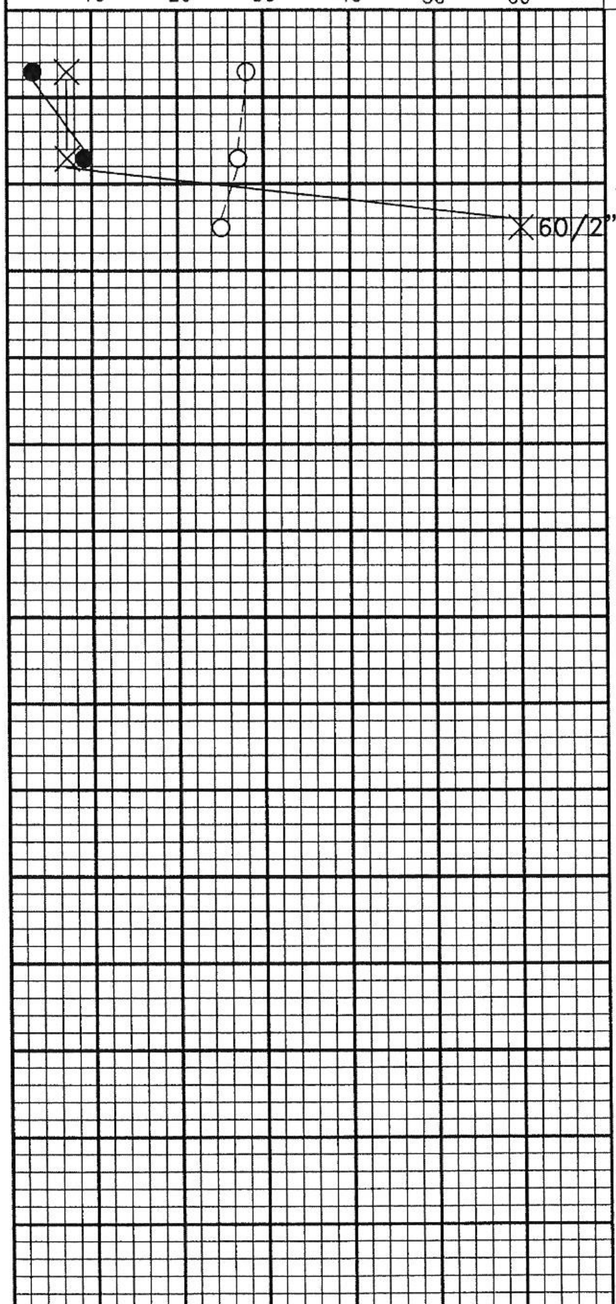
# LOG of BORING 3

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60

| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | | Brown Silty CLAY to CLAY (CL-CH) |
| 5 | 2 | ss | | |
| | 3 | ss | | LIMESTONE |
| | | | | End of Boring @ -6.5' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |




Ground Water Data
Ground Water Encountered @ -6.0' During Drilling and @ -4.0' Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 22, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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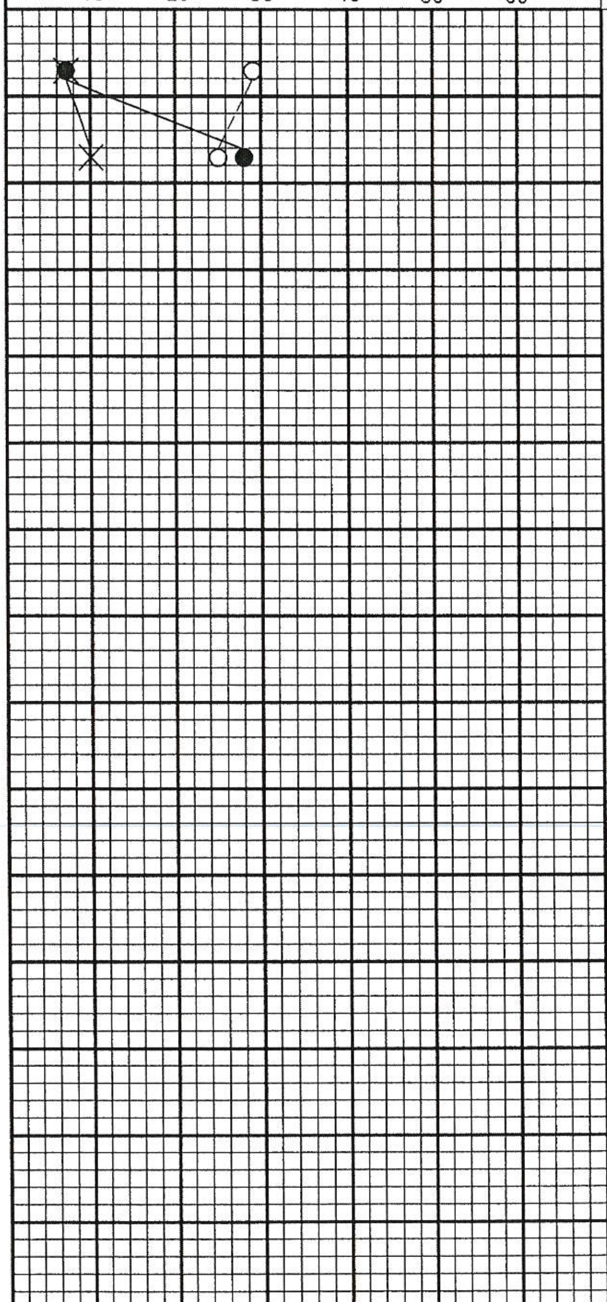
# LOG of BORING 4

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕
10 20 30 40 50 60



| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY to CLAY (CL–CH) |
| | 2 | ss | / | |
| 5 | | | | LIMESTONE |
| | | | | Auger Refusal<br>End of Boring @ –5.5' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 22, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No.<br>H–16014 |

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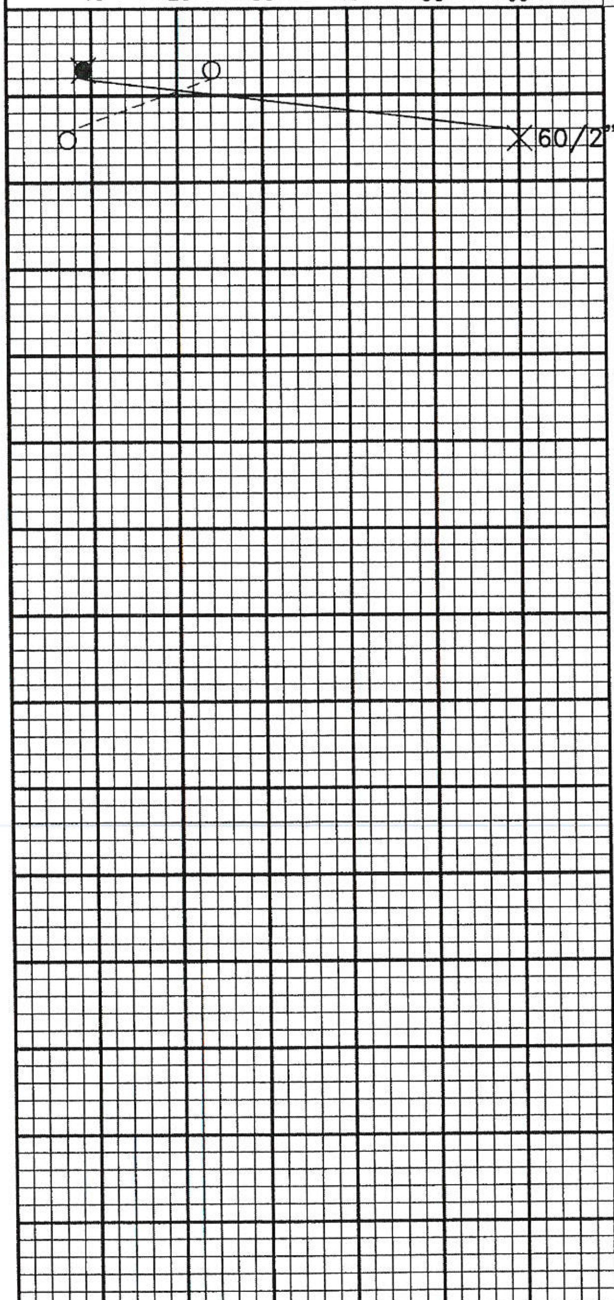
# LOG of BORING 5

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Reddish Brown CLAY (CL-CH) |
| | 2 | ss | / | LIMESTONE |
| 5 | | | | End of Boring @ -4.5' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 22, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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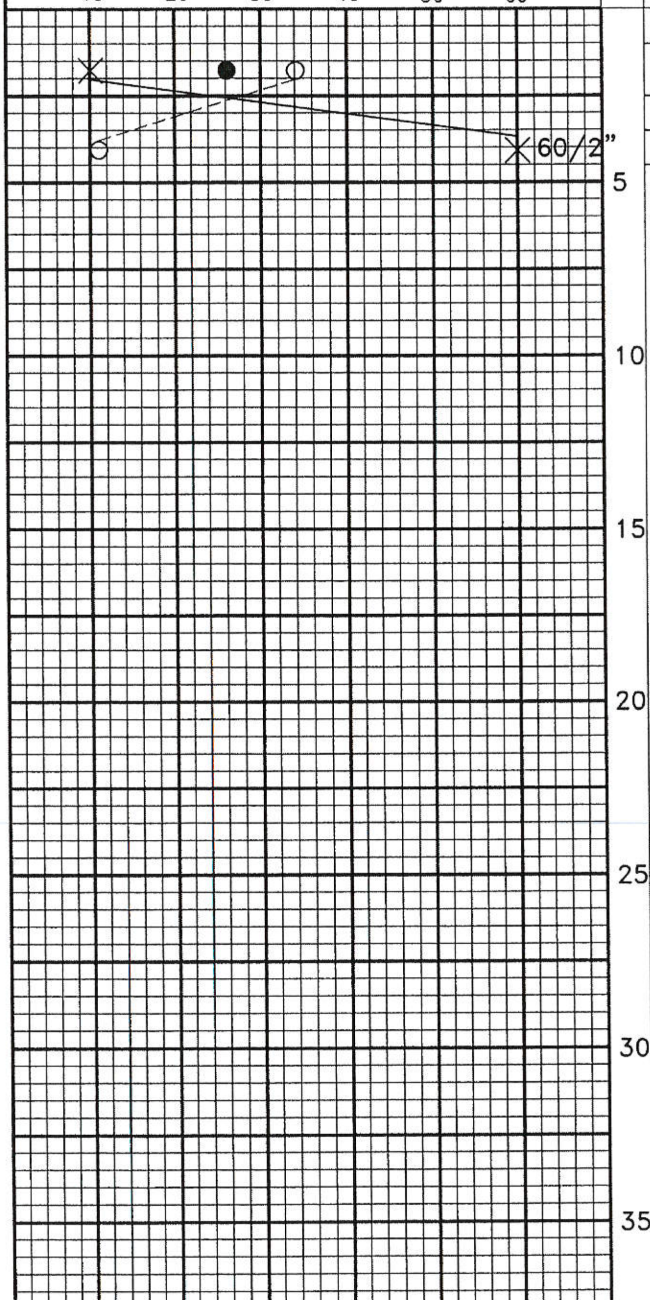
# LOG of BORING 6

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ╳
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Reddish Brown CLAY (CH) |
| | 2 | ss | / | LIMESTONE |
| 5 | | | | End of Boring @ -4.5' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

Project: Farmington Industrial Park Site Analysis
Farmington, Missouri

Date of Boring
January 22, 2016

Client: The City of Farmington
Farmington, Missouri

Project No.
H-16014

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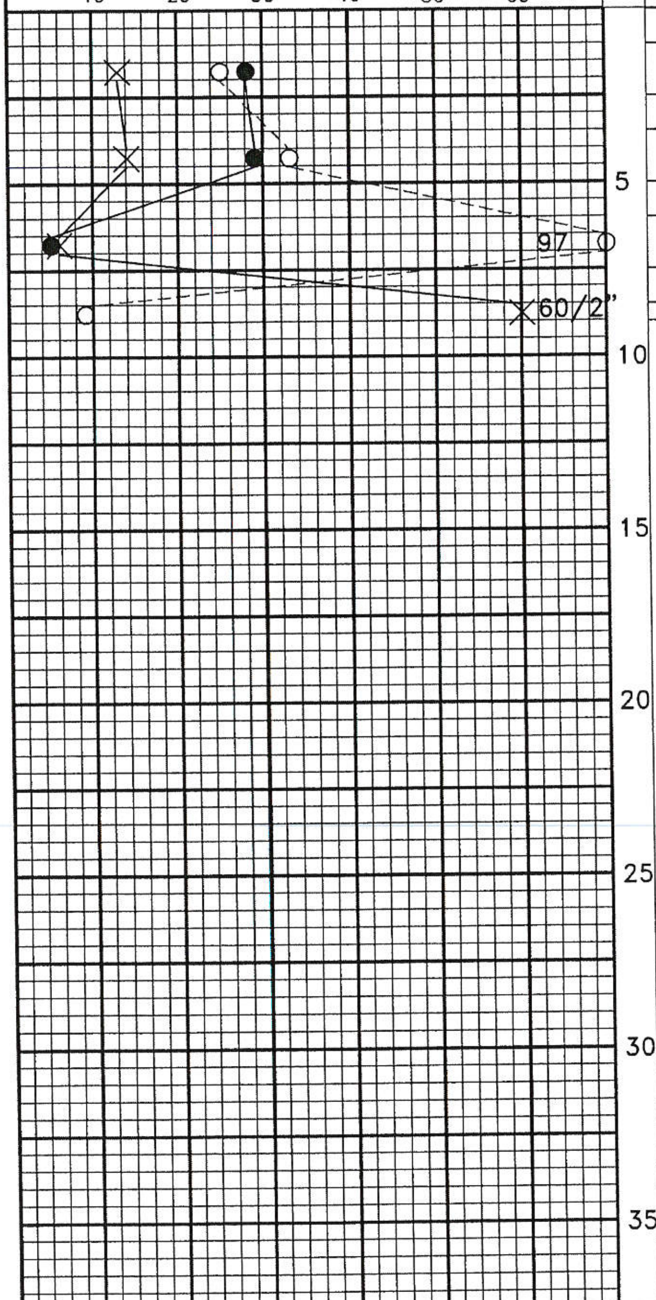
# LOG of BORING 7

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Reddish Brown CLAY (CL-CH) |
| 5 | 2 | ss | / | |
| | 3 | ss | / | Reddish Brown CLAY (CH) |
| | 4 | ss | / | Gray Limestone |
| 10 | | | | End of Boring @ -9.0' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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# LOG of BORING 8

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ╳
10 20 30 40 50 60

| Standard N Penetration | Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|---|
| | | | | | Surface Elevation |
| | | | | | 4" Topsoil |
| ○ ╳ 60/4" | | 1 | SS | | Brown SANDSTONE |
| ╳ 60/1" | | 2 | SS | | Gray LIMESTONE |
| | | | | | End of Boring @ -3.5' |
| | 5 | | | | |
| | 10 | | | | |
| | 15 | | | | |
| | 20 | | | | |
| | 25 | | | | |
| | 30 | | | | |
| | 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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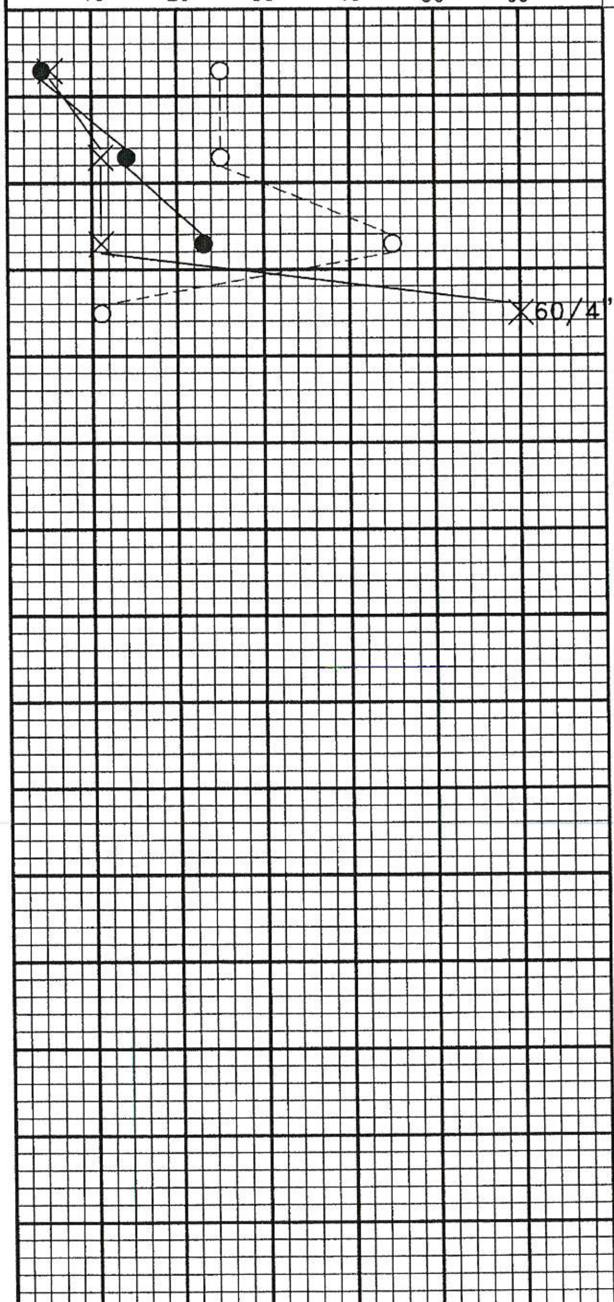
PO Box 88 Carbondale, Illinois

# LOG of BORING 9

Unconfined Compressive Strength (Tons/Sq. Ft.) ● 1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕ 10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Mottled Gray Silty CLAY to CLAY (CL-CH) |
| 5 | 2 | ss | / | |
| | 3 | ss | / | Reddish Brown CLAY (CH) |
| | 4 | ss | / | Brown LIMESTONE |
| 10 | | | | End of Boring @ -9.0' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

Project: Farmington Industrial Park Site Analysis
Farmington, Missouri

Date of Boring
January 21, 2016

Client: The City of Farmington
Farmington, Missouri

Project No.
H-16014

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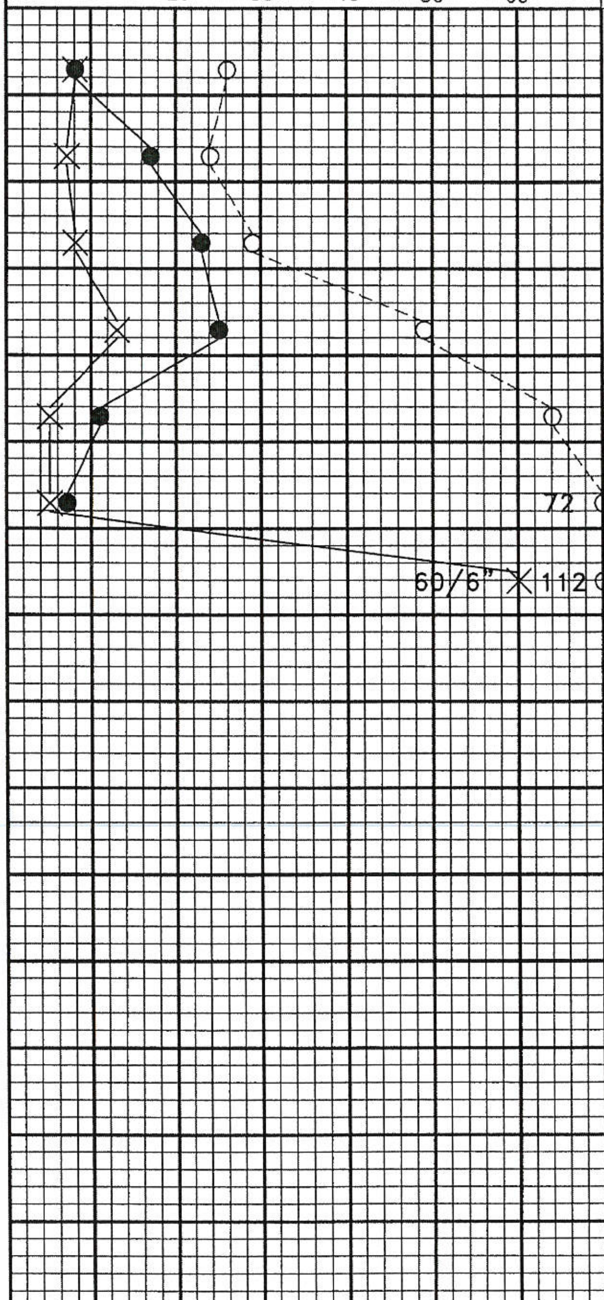
# LOG of BORING 10

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4' Topsoil |
| | 1 | ss | / | Reddish Brown Silty CLAY to CLAY (CL–CH) |
| 5 | 2 | ss | / | |
| | 3 | ss | / | |
| | 4 | ss | / | Reddish Brown CLAY (CH) |
| 10 | 5 | ss | / | |
| | 6 | ss | / | |
| 15 | 7 | ss | / | Tan LIMESTONE |
| | | | | End of Boring @ –17.0' |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No.<br>H–16014 |

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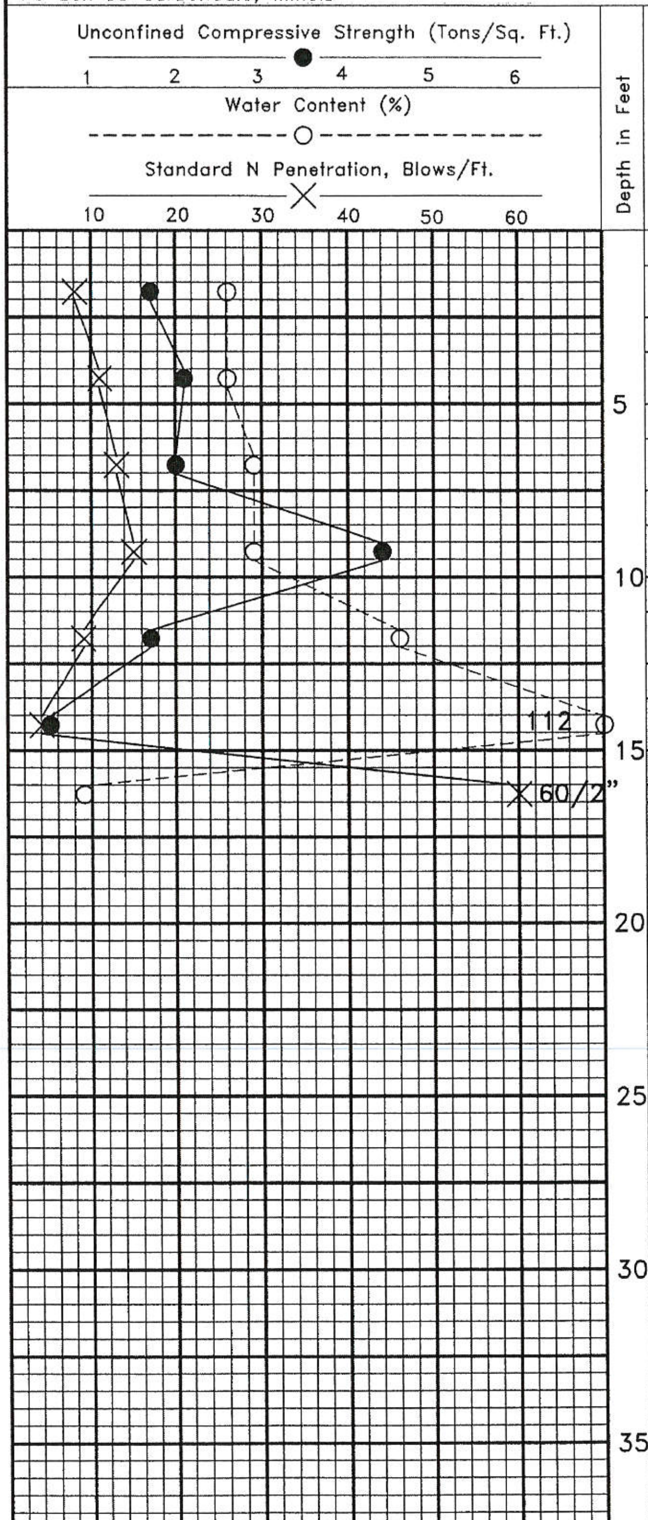
# LOG of BORING 11




| Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|
| | | | Surface Elevation |
| | | | 4" Topsoil |
| 1 | ss | | Reddish Brown CLAY (CL-CH) |
| 2 | ss | | |
| 3 | ss | | |
| 4 | ss | | |
| 5 | ss | | Reddish Brown CLAY (CH) |
| 6 | ss | | |
| 7 | ss | | LIMESTONE |
| | | | End of Boring @ -16.5' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | | |
|---|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring | January 22, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No. | H-16014 |

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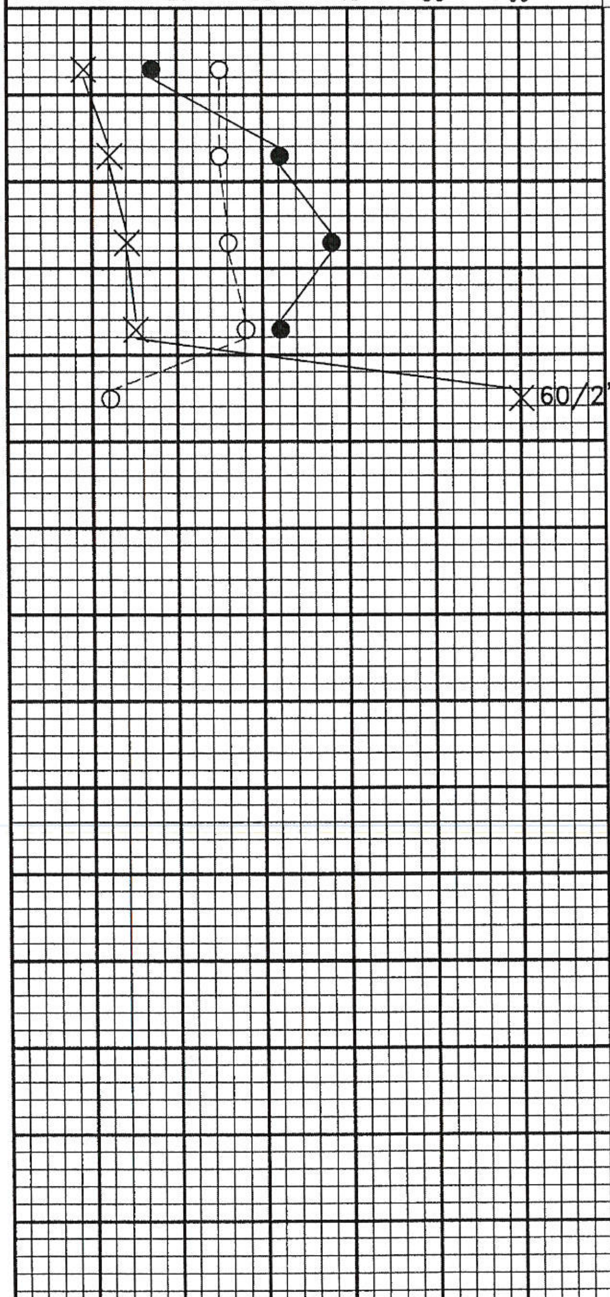
# LOG of BORING 12

Unconfined Compressive Strength (Tons/Sq. Ft.) ● — 1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. X — 10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Reddish Brown CLAY (CL-CH) |
| 5 | 2 | ss | / | |
| | 3 | ss | / | |
| 10 | 4 | ss | / | |
| | 5 | ss | / | LIMESTONE |
| | | | | End of Boring @ -11.5' |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data

No Ground Water Encountered During Drilling and Dry Upon Completion.

Project: Farmington Industrial Park Site Analysis
Farmington, Missouri

Date of Boring: January 22, 2016

Client: The City of Farmington
Farmington, Missouri

Project No. H-16014

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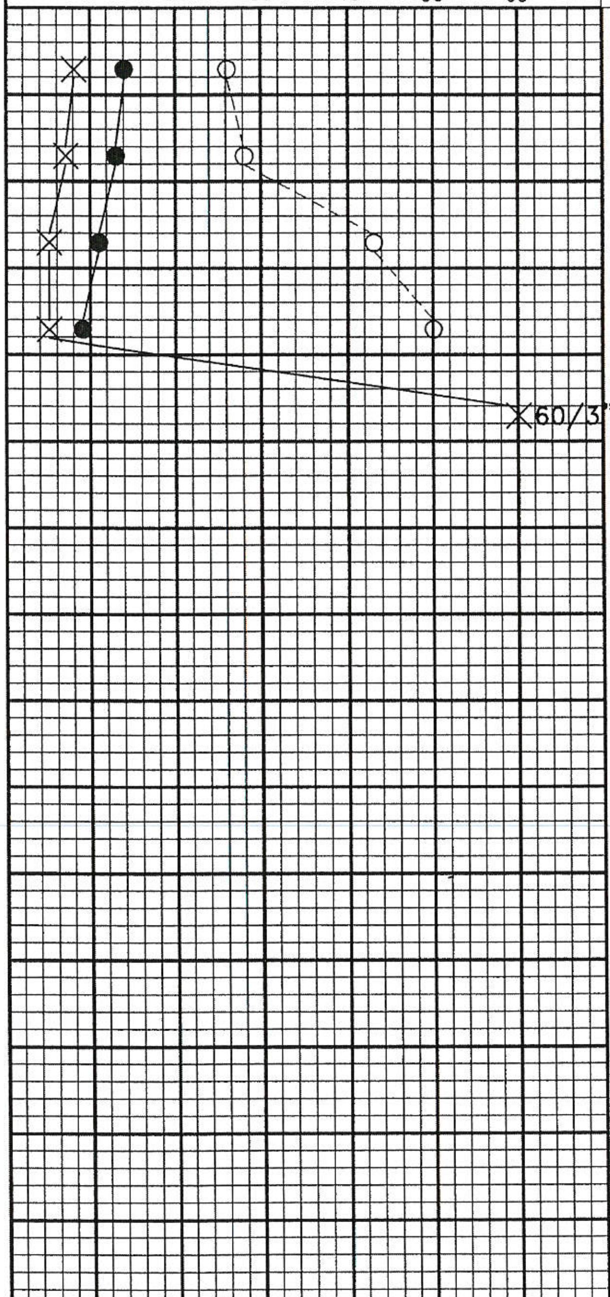
PO Box 88 Carbondale, Illinois

# LOG of BORING 13

Unconfined Compressive Strength (Tons/Sq. Ft.) ● — 1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. X — 10 20 30 40 50 60




Surface Elevation

| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | 4" Topsoil |
| | 1 | ss | / | Reddish Brown CLAY (CL-CH) |
| 5 | 2 | ss | / | |
| | 3 | ss | / | Reddish Brown CLAY (CH) |
| 10 | 4 | ss | / | |
| | 5 | ss | / | LIMESTONE |
| | | | | End of Boring @-12.5' |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

Project: Farmington Industrial Park Site Analysis
Farmington, Missouri

Date of Boring
January 22, 2016

Client: The City of Farmington
Farmington, Missouri

Project No.
H-16014

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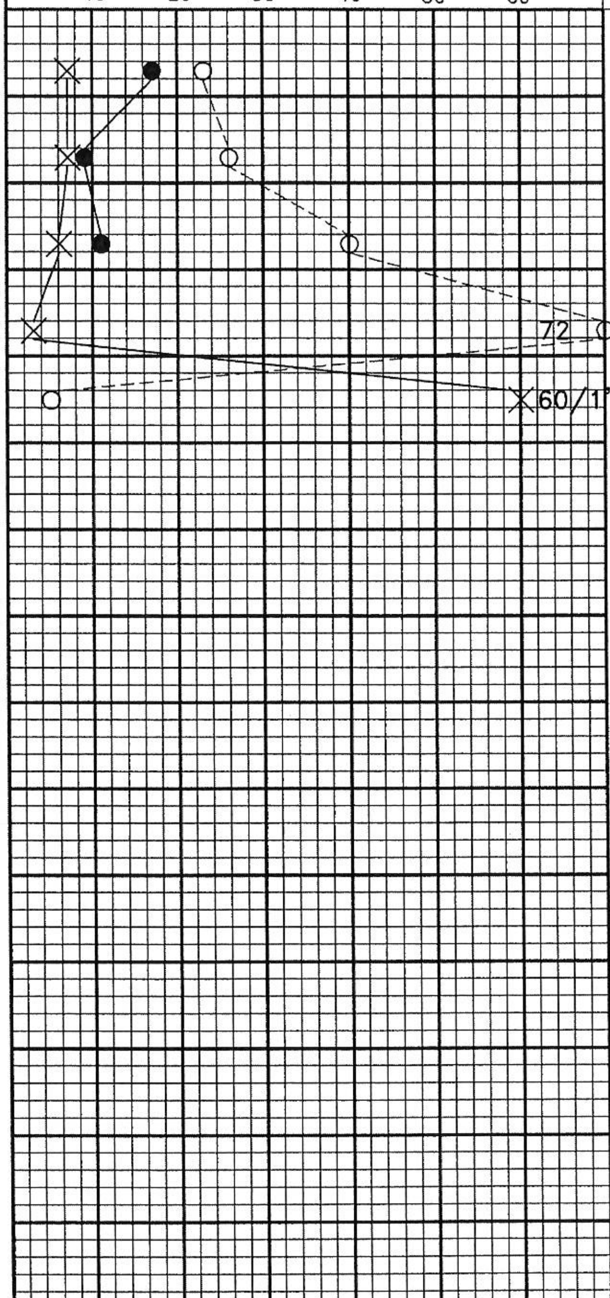
# LOG of BORING 14

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Reddish Brown CLAY (CL-CH) |
| | 2 | ss | / | |
| 5 | | | | |
| | 3 | ss | / | Reddish Brown CLAY (CL-CH) |
| | 4 | ss | / | |
| 10 | | | | |
| | 5 | ss | / | LIMESTONE |
| | | | | End of Boring @ -11.5' |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 22, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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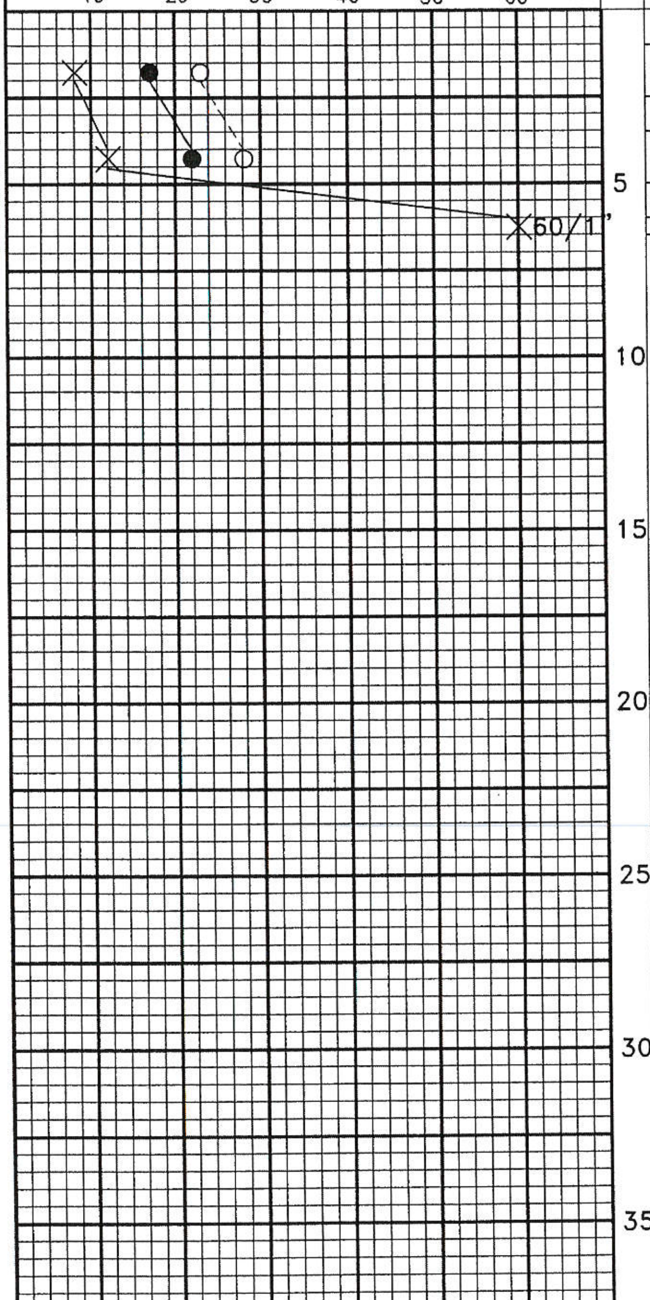
# LOG of BORING 15

Unconfined Compressive Strength (Tons/Sq. Ft.) ● — 1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. X — 10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Mottled Gray Silty CLAY (CL) |
| | 2 | ss | / | Reddish Brown CLAY (CH) |
| | 3 | ss | / | LIMESTONE |
| | | | | End of Boring @ -6.5' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | | |
|---|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring | January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No. | H-16014 |

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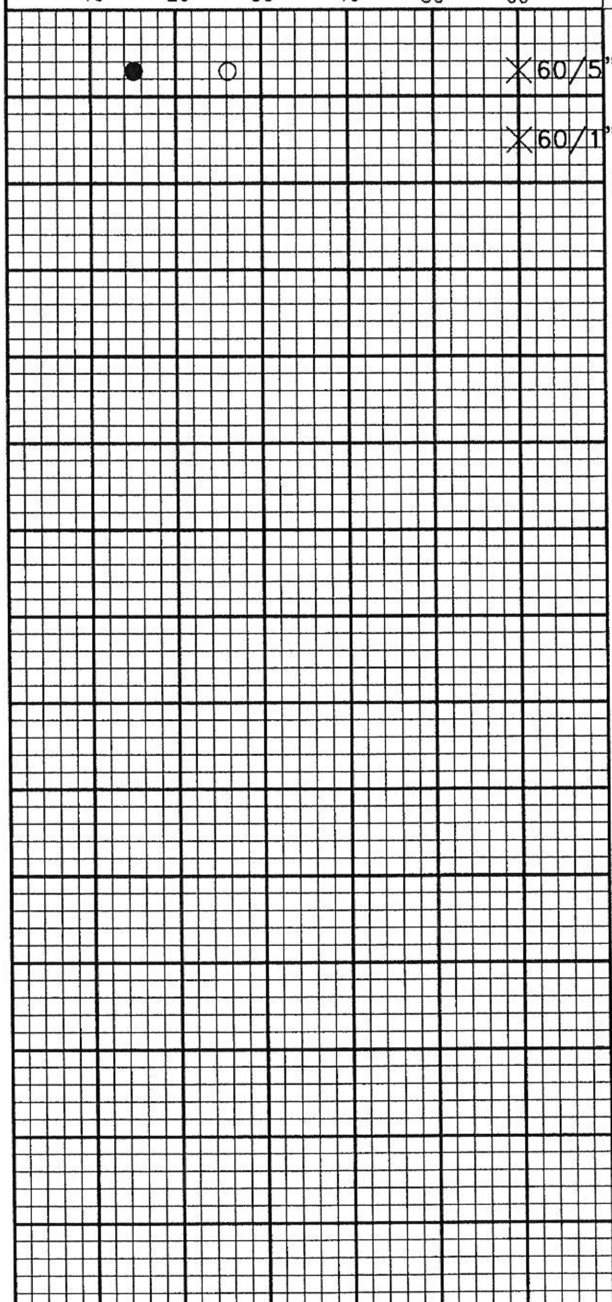
# LOG of BORING 16

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | | Brown Silty CLAY to CLAY (CL-CH) |
| | | | | LIMESTONE |
| | 2 | ss | | |
| 5 | | | | End of Boring @ -4.0' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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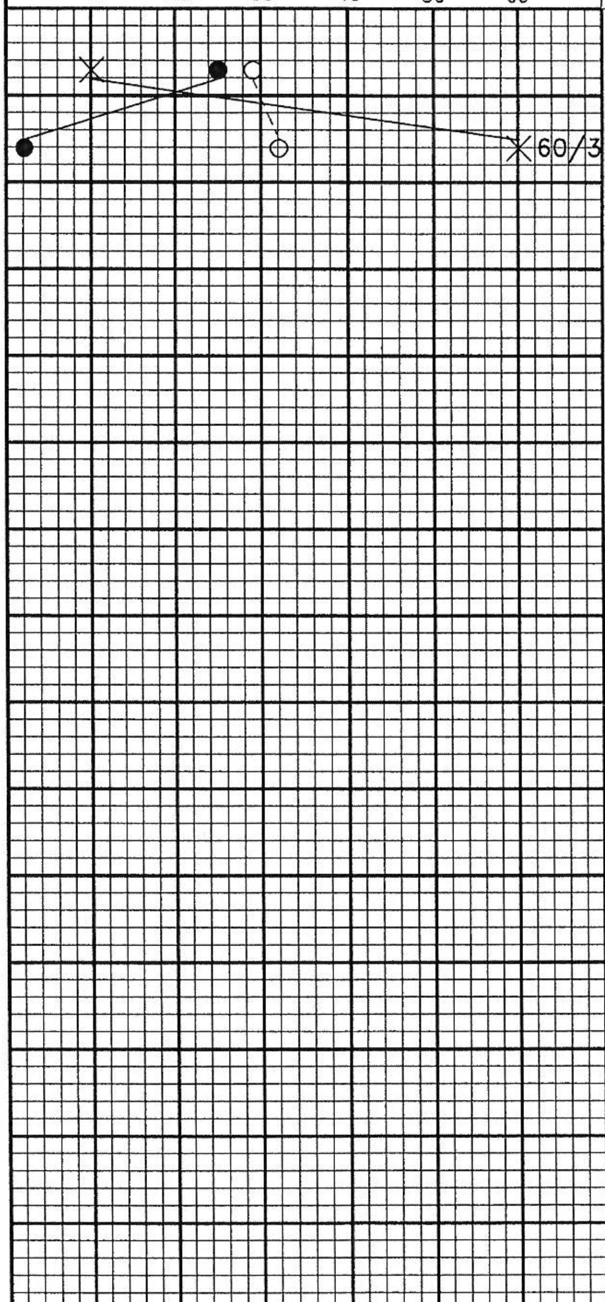
# LOG of BORING 17

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY to CLAY (CL-CH) |
| | 2 | ss | / | Brown Sandy CLAY (CL-SC) |
| | | | | LIMESTONE |
| 5 | | | | End of Boring @ -4.5' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | | **Date of Boring**<br>January 21, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | | **Project No.**<br>H-16014 |

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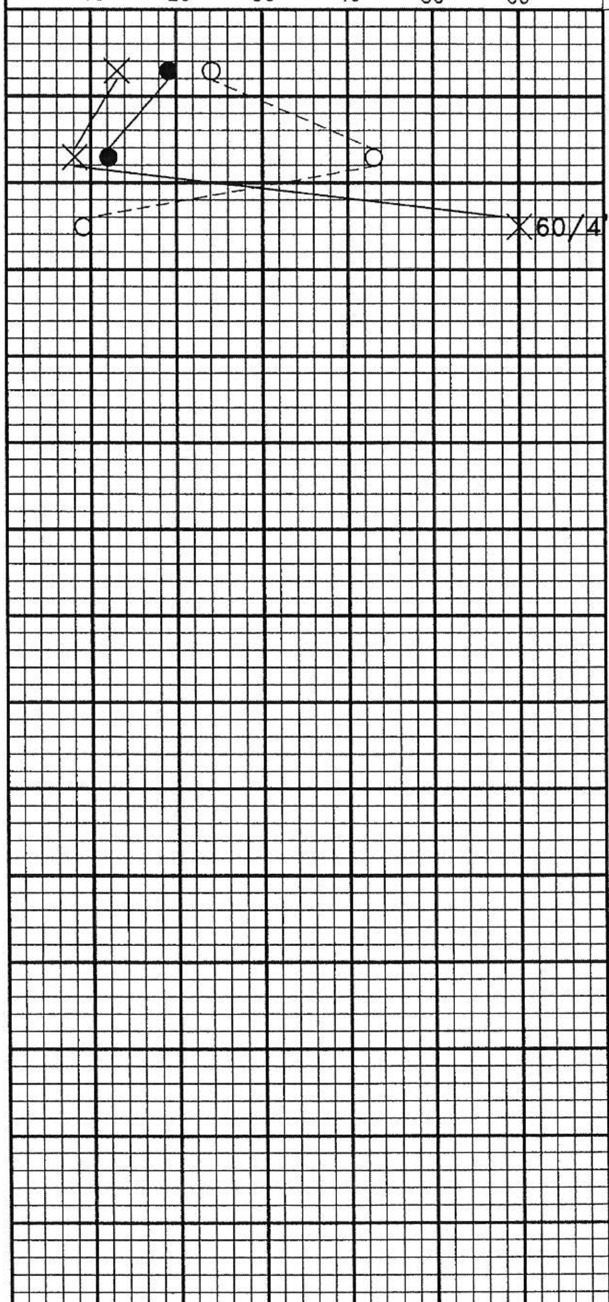
# LOG of BORING 18

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | | Brown Silty CLAY to CLAY (CL–CH) |
| 5 | 2 | ss | | |
| | 3 | ss | | LIMESTONE |
| | | | | End of Boring @ –6.5' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H–16014 |

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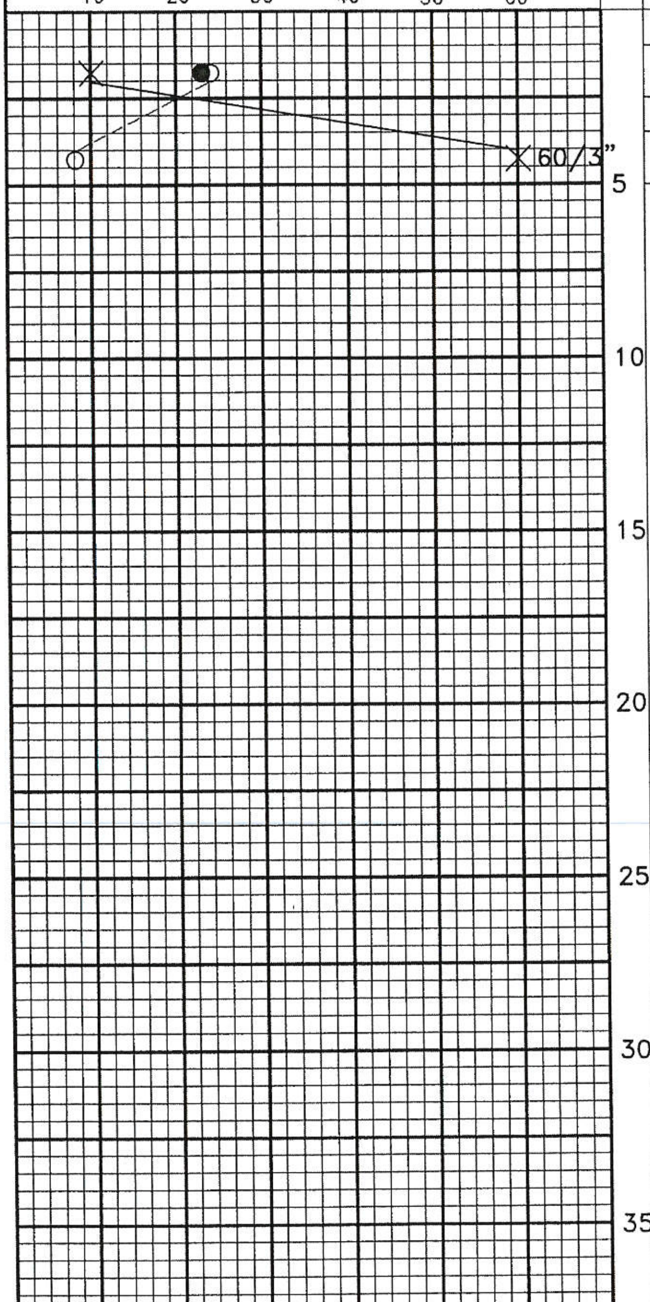
# LOG of BORING 19

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY (CL-CH) |
| | 2 | ss | / | |
| 5 | | | | SANDSTONE |
| | | | | End of Boring @ -5.0' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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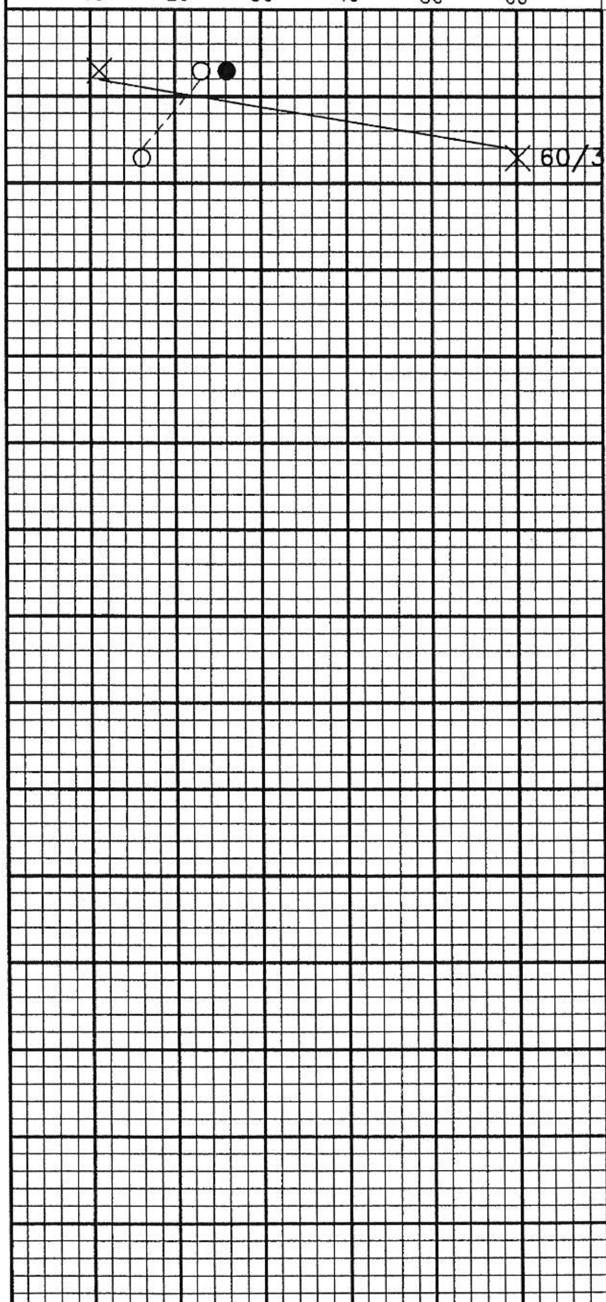
# LOG of BORING 20

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY (CL) |
| | 2 | ss | / | |
| 5 | | | | SANDSTONE |
| | | | | End of Boring @ −5.0' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | **Date of Boring**<br>January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | **Project No.**<br>H−16014 |

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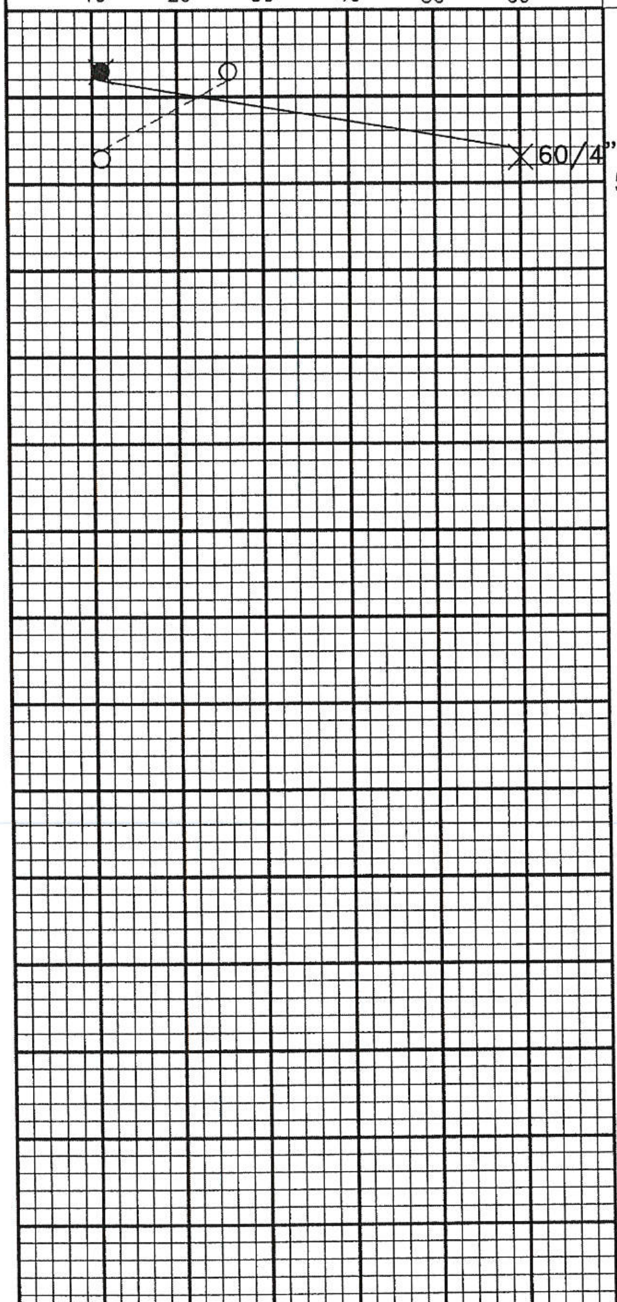
# LOG of BORING 21

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY (CL) |
| | 2 | ss | / | |
| 5 | | | | Brown SANDSTONE |
| | | | | End of Boring @ –5.0' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | | |
|---|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring | January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No. | H–16014 |

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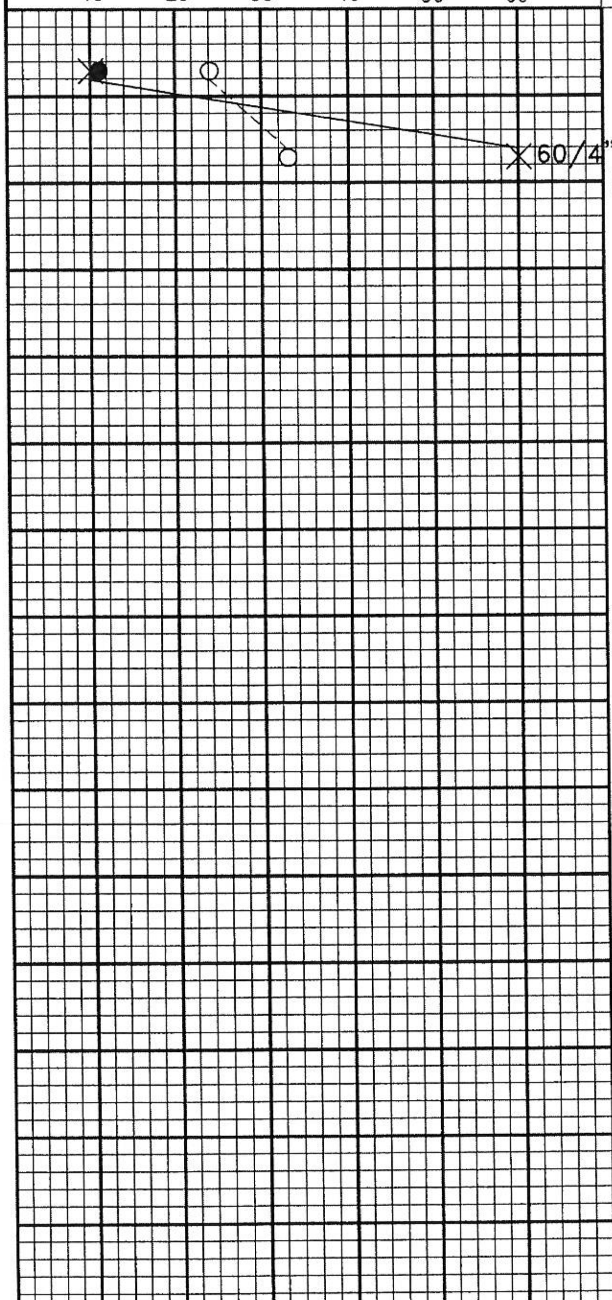
# LOG of BORING 22

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Mottled Gray Silty CLAY (CL) |
| | 2 | ss | / | Brown Silty CLAY (CL) |
| 5 | | | | LIMESTONE |
| | | | | End of Boring @ -5.0' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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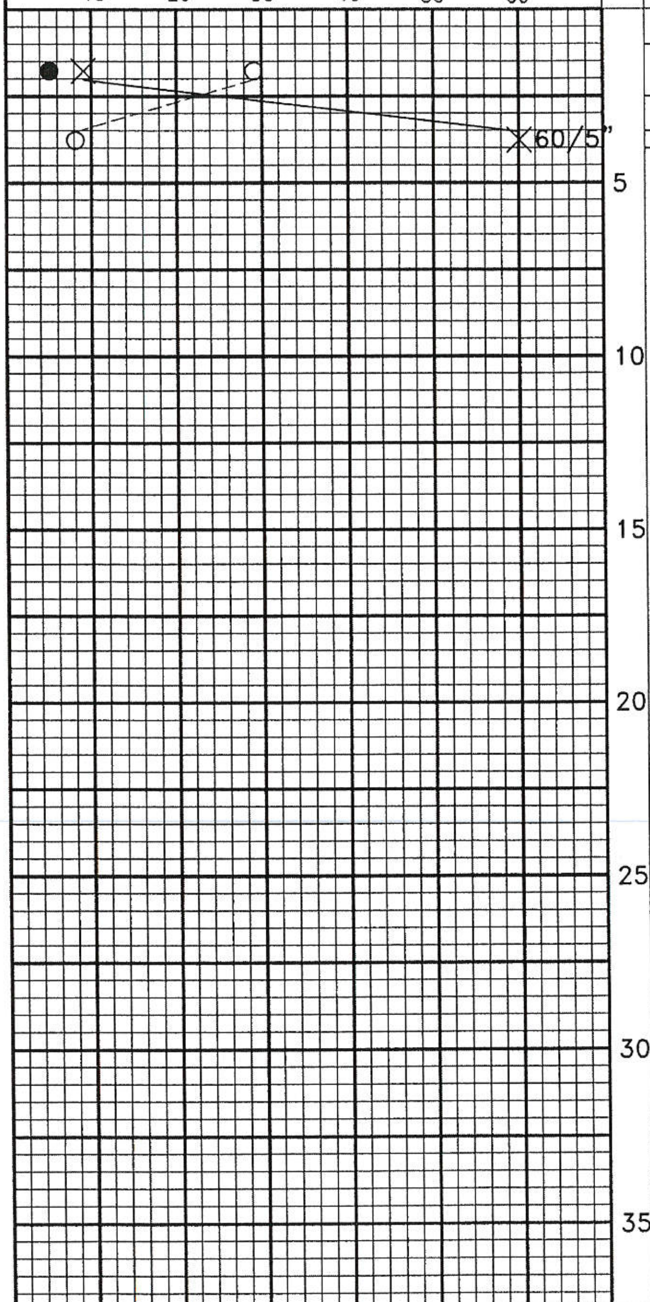
# LOG of BORING 23

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ╳
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | | Brown Silty CLAY (CL) with sand |
| | 2 | ss | | LIMESTONE |
| 5 | | | | End of Boring @ -4.0' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | |
|---|---|
| Project: Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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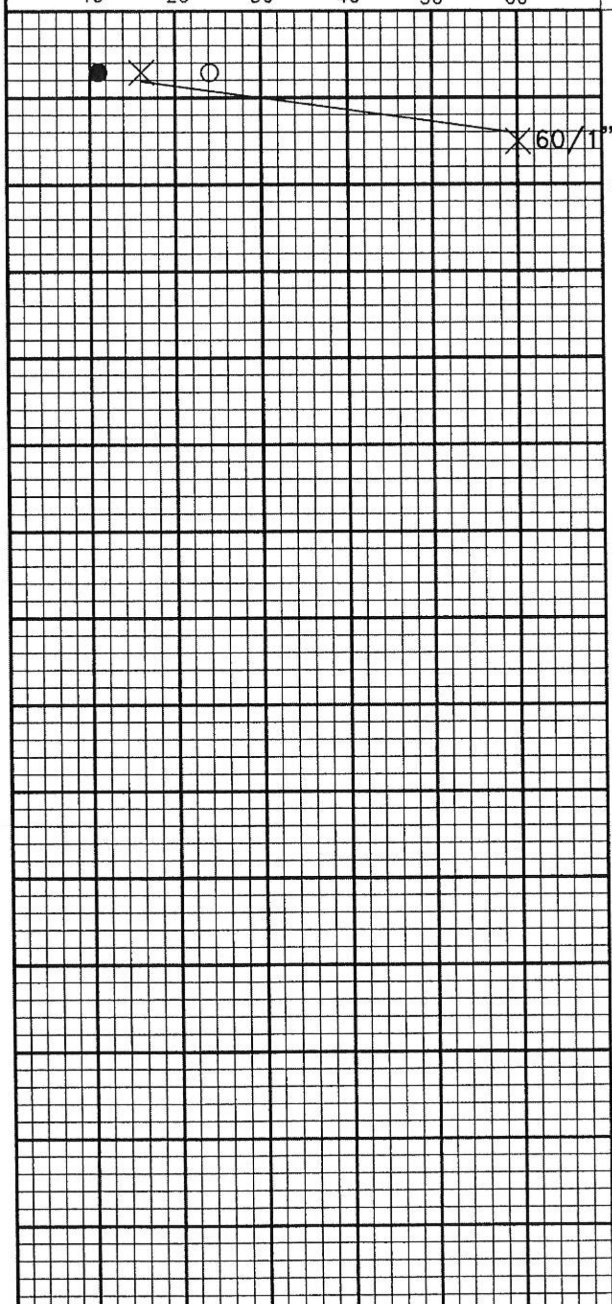
PO Box 88 Carbondale, Illinois

# LOG of BORING 24

Unconfined Compressive Strength (Tons/Sq. Ft.) ●
1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ×
10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY (CL) with sandstone |
| | 2 | ss | / | LIMESTONE |
| 5 | | | | End of Boring @ -4.0' |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

| | | |
|---|---|---|
| Project: | Farmington Industrial Park Site Analysis<br>Farmington, Missouri | Date of Boring<br>January 21, 2016 |
| Client: | The City of Farmington<br>Farmington, Missouri | Project No.<br>H-16014 |

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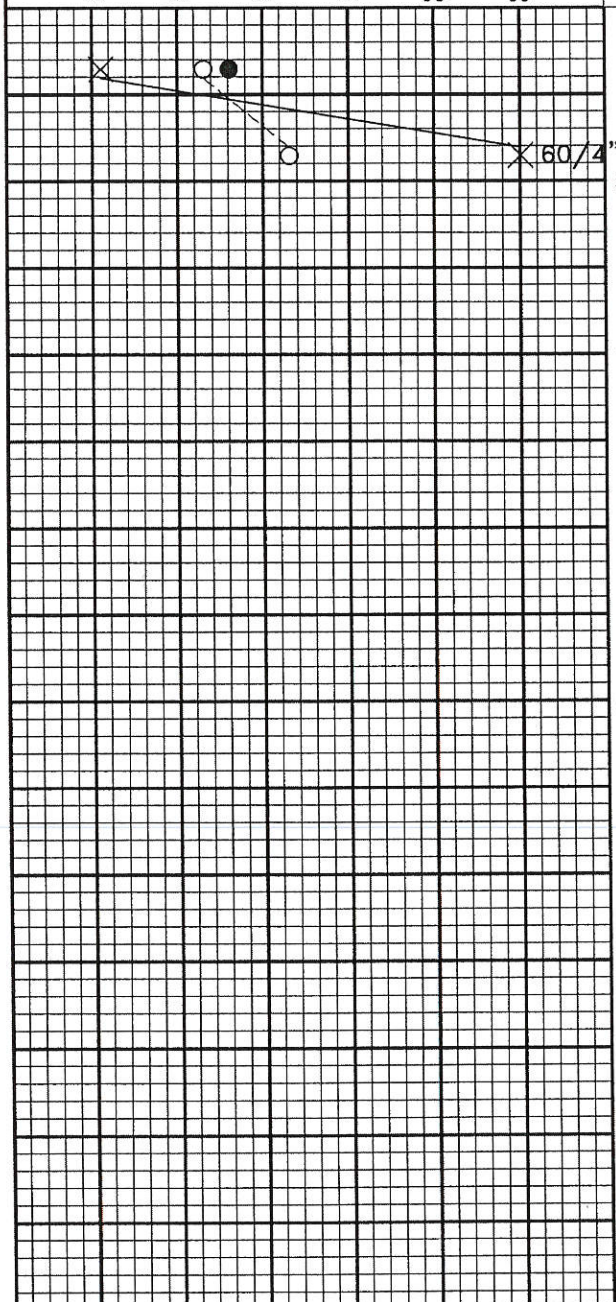
# LOG of BORING 25

Unconfined Compressive Strength (Tons/Sq. Ft.) ● 1 2 3 4 5 6

Water Content (%) ○

Standard N Penetration, Blows/Ft. ✕ 10 20 30 40 50 60




| Depth in Feet | Sample No. | Type Sample | Sample Distance | Description of Material |
|---|---|---|---|---|
| | | | | Surface Elevation |
| | | | | 4" Topsoil |
| | 1 | ss | / | Brown Silty CLAY to CLAY (CL) |
| 5 | 2 | ss | / | LIMESTONE |
| | | | | End of Boring @ -4.5' |

Ground Water Data
No Ground Water Encountered During Drilling and Dry Upon Completion.

Project: Farmington Industrial Park Site Analysis
Farmington, Missouri

Date of Boring: January 21, 2016

Client: The City of Farmington
Farmington, Missouri

Project No.: H-16014

# USGS Design Maps Summary Report

## User–Specified Input

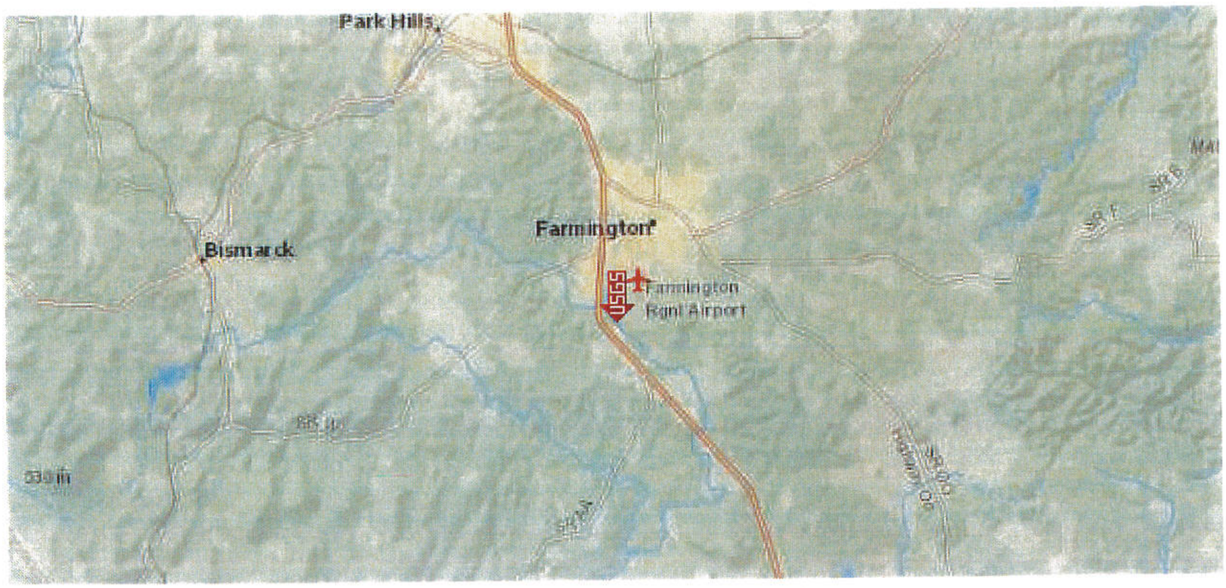
**Report Title** Farmington Industrial Park
Wed January 27, 2016 19:27:43 UTC

**Building Code Reference Document** 2012 International Building Code
(which utilizes USGS hazard data available in 2008)

**Site Coordinates** 37.75529°N, 90.43878°W

**Site Soil Classification** Site Class D – "Stiff Soil"

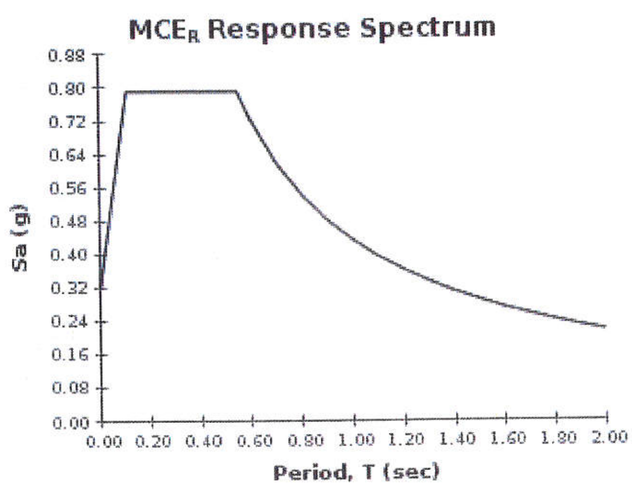
**Risk Category** I/II/III

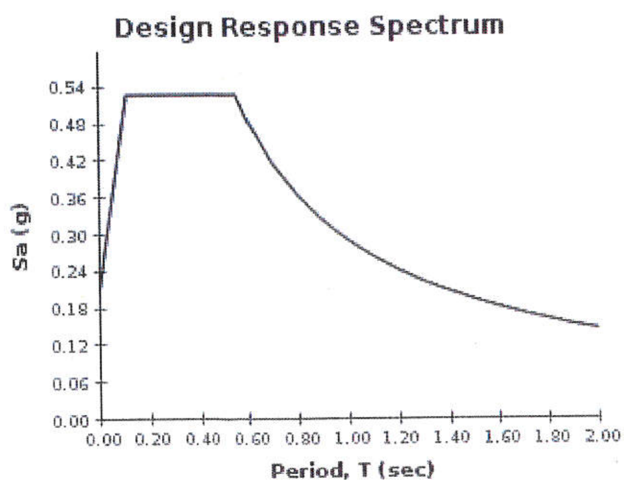



## USGS–Provided Output

| | | | | | |
|---|---|---|---|---|---|
| $S_S$ = | 0.599 g | $S_{MS}$ = | 0.791 g | $S_{DS}$ = | 0.527 g |
| $S_1$ = | 0.222 g | $S_{M1}$ = | 0.434 g | $S_{D1}$ = | 0.289 g |

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.



## GENERAL NOTES

**SAMPLE INDENTIFICATION**

The Unified Classification System is used to indentify the soil unless othwerwise noted.

**RELATIVE DENSITY & CONSISTENCY CLASSIFICATION**

| TERM (NON-COHESIVE SOILS) | BLOWS PER FOOT |
|---|---|
| Very Loose | 0-4 |
| Loose | 5-10 |
| Firm | 11-30 |
| Dense | 31-50 |
| Very Dense | Over 50 |

| TERM (COHESIVE SOILS) | QU (tsf) |
|---|---|
| Very Soft | 0.00- 0.25 |
| Soft | 0.25-0.50 |
| Firm | 0.50-1.00 |
| Stiff | 1.00-2.00 |
| Very Stiff | 2.00-4.00 |
| Hard | 4.00+ |

**DRILLING & SAMPLING SYMBOLS**

| | | |
|---|---|---|
| ss: | Split Spoon- | 1 3/8" I.D., 2" O.D. |
| st: | Shelby Tube- | 2.80" I.D., 3" O.D. |
| au: | Auger Samples | |
| cs: | Continuous Sampling | 2.0" I.D |

**SOIL PROPERTY SYMBOLS**

| | |
|---|---|
| ● | Unconfined Compressive Strength, Qu (tsf) |
| + | Penetrometer Value, (tsf) |
| | Plastic Limit (%) |
| o | Water Content (%) |
| | Liquid Limit (%) |
| X | Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2" O.D. Split Spoon |

**PARTICLE SIZE**

| | | | |
|---|---|---|---|
| Boulders | 8in + | Medium Sand | 0.6mm to 0.2mm |
| Cobbles | 8in to 3in | Fine Sand | 0.2mm to 0.74 mm |
| Gravel | 3in. to 5mm | Silt | 0.074mm to 0.0005mm |
| Coarse Sand | 5mm to 0.6mm | Clay | Less Than 0.005mm |

## UNIFIED SOIL CLASSIFICATIONS

| MAJOR DIVISIONS | | | SYMBOL | TYPICAL DESCRIPTION |
|---|---|---|---|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS | CLEAN GRAVELS | GW | Well graded gravels, gravel-sand mixtures |
| | | | GP | Poorly graded gravels, gravel-sand mixtures |
| | | GRAVELS WITH FINES | GM | Silty gravels, gravel-sand silt mixtures |
| | | | GC | Clayey gravels, gravel-sand clay mixtures |
| | SANDS AND SANDY SOILS | CLEAN SANDS | SW | Well-graded sands, gravelly sands |
| | | | SP | Poorly graded sands, gravelly sands |
| | | SANDS WITH FINES | SM | Silty sands, sand-silt mixtures |
| | | | SC | Clayey sands, clay-sand mixtures |
| FINE GRAINED SOILS | SILTS AND CLAYS LOW PLASTICITY | | ML | Inorganic silts of clayey silts with slight plasticity |
| | | | CL | Inorganic clays of low to medium plasticity |
| | | | OL | Organic silts and organic silty clays of low plasticity |
| | SILTS AND CLAYS HIGH PLASTICITY | | MH | Inorganic silts of high plasticity |
| | | | CH | Inorganic clays of high plasticity |
| | | | OH | Organic clays of medium to high plasticity |
| HIGHLY ORGANIC SOILS | | | PT | Peat, humus, swamp soils with high organic contents |