GEOTECHNICAL ENGINEERING REPORT

Proposed Bay View Wetlands Culvert
100 South Marina Drive
Milwaukee, Wisconsin

GESTRA Project No.: 17059-10
March 21, 2017

Prepared For:
AECOM
1555 Rivercenter Drive, Suite 214
Milwaukee, WI 53212
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1.0 INTRODUCTION

GESTRA Engineering, Inc. (GESTRA) was authorized by AECOM to complete a subsurface exploration and geotechnical investigation for the proposed culvert at the Bay View Wetlands project in Milwaukee, Wisconsin. This report presents the results from the subsurface soil exploration and describes exploration, laboratory test results, and recommendations pertaining to the design and construction of the proposed culvert.

The engineering recommendations and analysis contained within this report are based on the following project information which is a projection of GESTRA’s understanding of the project. If for any reason the actual project information differs from what is reported below, GESTRA should be contacted so that we can review our recommendations in light of any new information.

1.1 Project Information

A new culvert is planned to replace an existing culvert over a drainage way at the north end of S. Marina Drive (approximate address 100 S. Marina Drive). The existing culvert is a 42-inch diameter pipe, and the new culvert is planned to be a concrete box culvert with a ten-foot span, a seven foot height and an open bottom. Structure loading information was not available at the time of this report. A driven pile foundation is planned for the new culvert.

2.0 SCOPE OF WORK

GESTRA has performed the following services for the project:

- Contacted Diggers Hotline to identify the utility locations prior to drilling.
- Completed one (1) standard penetration test (SPT) soil boring on March 02, 2017. The boring was drilled to a depth of 86 feet below ground surface (bgs). The boring location is shown on the Borehole Layout Plan. Our site work included abandonment of the borehole with bentonite grout per WDNR requirements.
- Performed laboratory soil tests to assign classification and engineering properties to the soils encountered. These tests included hand penetrometer, unconfined compressive strength, Atterberg limits, dry density, mechanical analysis, organic content, and moisture content.
- Prepared this Load Resistance Factor Design (LRFD) geotechnical engineering report presenting the results of the field exploration and laboratory testing, as well as providing recommendations pertaining to driven pile foundations, allowable foundation capacity, estimates of settlement, and construction considerations.

3.0 EXPLORATION RESULTS

3.1 Field Exploration and Laboratory Procedures

Field exploration work scope included one (1) soil boring to a depth of 86 feet bgs. Based on the contours shown on the Upland Improvement & Stormwater Management Plan provided by
AECOM dated 9/20/2016, existing ground surface elevation at boring B-1 was assumed at 585 feet. The soil boring location was selected by AECOM and was performed on the roadway approximately 10 feet south and 5 feet east of the southeast corner of the existing culvert. To avoid roadway traffic, drilling was performed behind an existing gate present at the site. GESTRA performed soil boring with a truck mounted CME 75 drill rig. The specific drilling method used including the depths, rig type, crew chief, and borehole abandonment are included on the boring log in Appendix I of this report.

The borehole was initiated and advanced by using 3¼ inch hollow stem augers to 20 feet and then converted to rotary wash boring (RWB) technique. During drilling, soil samples were collected at 2½ foot intervals to 16 feet and then at 5 foot intervals to the termination depth of the borings. All representative soil samples were taken in general accordance with the “Standard Method for Penetration Test and Split-Barrel Sampling of Soils” (ASTM D1586). The soil samples were visually and manually classified in the field by the crew in accordance with ASTM: D2487-93 and D2488-93. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification.

All of the retained soil samples were classified by a geotechnical engineer using the Unified Soil Classification System. A chart describing the classification system used is included in the Appendix of this report. The engineer assigned laboratory testing suited to extract important index properties of the soil layers. These tests included hand penetrometer, moisture content, organic content, P200, Atterberg limits, dry density and unconfined compressive strength and the individual lab test results can be found in Appendix II of this report on the attached boring logs.

3.2 Subsurface Soil Profile

The results of the field observations and laboratory tests are depicted on the test boring log included in Appendix I of this report. Soils were grouped together based on similar observed properties and stratification lines were estimated by the reviewing engineer based on the available data and experience. The actual in-situ changes between layers may differ slightly and may be more gradual than depicted on the boring log. Subsurface and groundwater conditions may vary in areas not explored by GESTRA.

The engineering analysis and foundation recommendations presented in this report are based on soil information obtained primarily from soil boring B-1. The surface elevation at the boring location was approximately 585 feet. Granular fill was encountered at the surface of the borehole to an elevation of 576 feet. The fill material was generally gray gravel with silt and sand to an elevation of 581 feet underlain by black sand fill to 576 feet.

Below fill material, very soft/very loose black organic peat was observed to an elevation of 571.8 feet; very soft greenish gray organic silt to an elevation of 563.1 feet; medium stiff to very stiff gray lean clay and/or silty clay to an elevation of 502.2 feet and dense gray silty sand to the termination depth at an elevation of 499 feet. Details of SPT N-values, and test results are presented in the boring log attached to this report.

It is important to note that the soil observations and thickness estimates were made in small diameter boreholes. Therefore, it should be understood that thicker or thinner deposits of the individual strata are likely to be encountered in the project area. Furthermore, the estimation of soil layer thickness at a particular location can differ from person to person due to sometime indistinct transition between the soils and the condition below the roadway will likely vary somewhat from our boring location due to previous construction.
3.3 Soil Parameters for Foundation Design

Soil parameters for the observed units are determined or estimated based on the field observation and laboratory tests performed by GESTRA Engineering (Appendix I and II) and our knowledge of the project area soils. The following Table 3-1 lists the recommended soil parameters for culvert foundations design:

Table 3-1: Recommended Soil Parameters for Axial Capacity Analysis

<table>
<thead>
<tr>
<th>Observed Soil Type (Ground surface elevation of B-1, 585 feet)</th>
<th>Approximate Bottom Elevation, (feet)</th>
<th>Estimated Soil Unit Weight (pcf)</th>
<th>Undrained</th>
<th>Drained</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Cohesion, c (psf)</td>
<td>Friction Angle</td>
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<tr>
<td>Fill*</td>
<td>576</td>
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<td>Peat*</td>
<td>572</td>
<td>90</td>
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<td>Organic Silt*</td>
<td>563</td>
<td>115</td>
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</tr>
<tr>
<td>Silty Clay</td>
<td>557</td>
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<td>135</td>
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<tr>
<td>Stiff Lean Clay</td>
<td>522</td>
<td>135</td>
<td>2000</td>
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<tr>
<td>Sandy Silty Clay</td>
<td>502</td>
<td>140</td>
<td>1000</td>
<td>-</td>
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<tr>
<td>Dense Sand</td>
<td>-</td>
<td>130</td>
<td>-</td>
<td>35</td>
</tr>
</tbody>
</table>

* No value assigned and layer is not considered part of the pile capacity evaluation.

3.4 Groundwater Observations

Groundwater measurements were performed during drilling prior to converting to mud rotary drilling techniques and groundwater was detected at an elevation of 580.5 feet. Please note the groundwater depth at completion of boring could not be determined because of the mud rotary drilling techniques used.

Groundwater level fluctuations may occur with time and seasonal changes due to variations in precipitation, evaporation, surface water runoff and local dewatering. Perched water pockets at higher elevations may also be encountered during wet weather periods, particularly in more permeable silt and sand seams or granular fill material overlying less permeable clays. Installation and monitoring of an observation well would be required to assess true groundwater elevation.

4.0 Analysis and Recommendations

The following sections provide geotechnical recommendations for the culvert foundations. These recommendations are based on the project information described in Section 1.1 of this report. If there are changes to the geometry, structural details or loading conditions, these recommendations should be reviewed by GESTRA and modified if required. It is our understanding that the culvert will be designed based on the WisDOT LRFD Bridge Manual (January 2017).

4.1 Driven Pile Foundations

WisDOT policy requires that deep foundations for bridges be designed in accordance with the WisDOT LRFD Bridge Manual. The maximum factored axial compressive resistances for the
selected pile sections have been estimated using procedures included in the WisDOT LRFD Bridge Manual (January, 2017). The maximum structural resistance is the function of pile section and material strength (i.e., mainly compressive strength). The maximum geotechnical resistance is dependent on the resistance of subsurface soils (shaft and tip resistances). Drivability is dependent on an interactive combination of the geotechnical resistance of the soils to penetration depth, and pile installation equipment (i.e., hammer type).

In consideration of the site subsurface conditions, both CIP (pipe piles) and H piles (HP) are considered suitable candidate for driven pile foundations option. Pile capacity and embedded lengths are estimated both for a closed end 10.75-inch diameter (shell thickness 0.25 inches) CIP pile and a HP 10x42 pile. The following sections estimate each of these limit states for both the pile types which are commonly used on WisDOT projects.

4.1.1 Maximum Factored Axial Compression Resistance

The maximum factored structural resistance (Pᵣ) of a pile section is defined as nominal structural resistance (Pₙ) multiplied by a resistance factor (φ) designated in WisDOT LRFD Bridge Manual. The nominal structural strengths are calculated differently by pile types as follows.

For H pile sections, (WisDOT LRFD manual Section 11.3.1.12.3.1):

Nominal structural resistance, Pₙ = fᵧ x A_ST

Where, fᵧ is specified steel yield strength and A_ST is gross area of steel section

For cast in place concrete (CIP) piles, (WisDOT LRFD manual Section 11.3.1.12.2.1):

Nominal structural resistance, Pₙ = 0.68fᶜ' x Ag

Where, fᶜ' is the concrete compressive strength and Ag is gross area of concrete pile section

Detailed pile specifications and values used in calculations are presented in Table 4-1.

<table>
<thead>
<tr>
<th>Table 4-1: Maximum Factored Axial Compression Resistance of Candidate Piles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pile Specifications</td>
</tr>
<tr>
<td>Gross Cross Sectional Area (in²)</td>
</tr>
<tr>
<td>Steel Sectional Area (A_ST for H piles)(in²)</td>
</tr>
<tr>
<td>Steel Yield Strength, fᵧ (ksi)</td>
</tr>
<tr>
<td>Concrete Compressive Strength, fᶜ’ (ksi)</td>
</tr>
<tr>
<td>Nominal Structural Axial Resistance, Pₙ (kip)</td>
</tr>
<tr>
<td>Resistance Factor in LRFD (φ)</td>
</tr>
<tr>
<td>Max. Factored Structural Axial Resistance, Pᵣ (kip)</td>
</tr>
<tr>
<td>WisDOT Rec. Max Factored Structural Resistance, Pᵣ (kip)</td>
</tr>
</tbody>
</table>

4.1.2 Maximum Geotechnical Resistance of Driven Piles

The maximum factored geotechnical resistance of a pile is defined as nominal (ultimate) geotechnical resistance (Rₙ) multiplied by a resistance factor (φ) that depends on the pile installation acceptance method. It is assumed that FHWA modified Gates formula will be used.
as the pile installation acceptance method, thus per WisDOT LRFD Bridge Manual, section 11.3.1.14, resistance factor (φ) is assumed to be 0.5 both for HP and CIP piles. The geotechnical pile resistances were computed using the computer program DRIVEN and the soil parameters presented in Table 3-1. Based on our evaluation, the maximum factored axial compression resistance of 180 kips for HP piles and 130 kips for CIP piles as defined in the WisDOT LRFD Bridge Manual can be used for the project design.

GESTRA estimated the embedded pile length for the maximum factored axial compression resistance per WisDOT LRFD Bridge Manual, section 11.3.1.17.7, Table 11.3-5 for both the HP (180 kips) and CIP (130 kips) piles. These are presented in the following Table 2.

### Table 4-2: Estimated Embedded Pile Lengths for Maximum Allowable Vertical Capacity

<table>
<thead>
<tr>
<th>Pile Driving Elevation (feet)</th>
<th>Pile Type</th>
<th>Maximum Allowable Vertical Capacity Per WisDOT Recommendation (kips)</th>
<th>Driving Resistance to Attain Maximum Allowable Vertical Capacity (kips)</th>
<th>Pile Tip Depth Below Driving Elevation (feet)</th>
<th>Estimated Pile Tip Elev. For Maximum Factored Geotechnical Resistance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>578</td>
<td>10 ¾” CIP</td>
<td>130</td>
<td>260</td>
<td>76</td>
<td>502</td>
</tr>
<tr>
<td>HP 10x42</td>
<td>180</td>
<td>360</td>
<td>78</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

a  Safety factor of 2.0 was used for estimating allowable bearing capacity of driven pile per WisDOT LRFD Bridge Manual, section 11.3.1.14.

b Allowable compressive stress during driving should not exceed 45 ksi for HP and 31.5 ksi for CIP (90% of the yield strength of steel).

c Pile driving elevations were assumed based on the contours shown on the Upland Improvement & Stormwater Management Plan provided by AECOM, dated 9/20/2016. Existing ground surface elevation at boring location was assumed at 585 feet.

If pile capacity requirement is different than listed in Table 4-2, GESTRA should be contacted for further evaluation of alternate capacities and pile length.

### 4.1.3 Maximum Driving Resistance (Drivability)

The maximum factored driving resistance was determined using the following equation:

\[ R_{rdr} = \phi_{dyn} \times R_{ndr} \]

Where, \( R_{ndr} \) is the ultimate end-of-initial-drive (EOID) resistance, \( \phi_{dyn} = 0.5 \), and using the assumption that pile installation acceptance will be determined by the modified FHWA Gates formula.

Maximum factored driving resistance (\( R_{rdr} \)) for both HP and CIP piles were estimated using Delmag D15 pile hammer.

The pile driving analysis was performed using GRLWEAP computer program. Soil profiles used for the analysis were based on the soil parameters in Table 3-1. The ultimate end of initial drive (EOID) is estimated for hammer operating at refusal. The refusal is considered to have 120 blows/feet or fractional equivalent. However, if at refusal compressive stress in the piles exceeds the allowable 45 ksi and 31.5 ksi for HP and CIP pile, respectively (90% of the steel yield strength of steel), the ultimate EOID is considered equal to the resistance value corresponding to steel compressive strength of 45 ksi and 31.5 ksi for HP and CIP piles, respectively. No excessive pile stress was predicted above the target depths and maximum blow counts were
observed below 25 blows per foot of penetration, which is below the minimum blow count requirement for set criteria. Therefore, drivability analysis results are not presented in this report.

Please note an actual refusal bearing layer was not encountered within the drilled depth. The majority of pile capacity is estimated from friction resistance. Drivability analysis indicated that minimum pile set requirement criteria per WisDOT LRFD Bridge Manual (25 blows per foot of penetration) will not be met during driving. Therefore, we recommend pile set criteria should be driven to the length presented in Table 4-2.

4.1.4 Downdrag Force on driven Pile Foundation

A grade change is not planned at the culvert location. Therefore downdrag force is not expected to be a concern for the piles.

4.1.5 Pile Spacing

The minimum and maximum pile spacing should be based on the recommendation provided in the WisDOT LRFD Bridge Manual, Section 11.3.1.2. According to the manual, the minimum pile spacing is 2 feet-6 inches or 2.5 pile diameters, whichever is greater. For displacement pile with estimated lengths ≥ 100 feet, the minimum pile spacing is 3.0 pile diameters. The maximum pile spacing is 8 feet for abutments, pile encased piers and pile bents, based on standard substructure designs.

4.1.6 Lateral Squeeze Potential

It is our understanding that the final grade on the roadway on top of the culvert will be similar to the existing elevation, so that no new fill loads will be added. The facing slope in front of the culvert wall is assumed vertical and the piles will be installed at depth below the bottom of culvert. No grade change is planned at the existing culvert location; therefore, pile lateral squeeze is not a concern at these locations.

4.1.7 Estimated Settlement

No grade change is planned at the proposed culvert foundation locations. Therefore, settlement is not expected to be significant at culvert foundation locations.

4.2 Construction Consideration

4.2.1 Excavation Safety

Caving is a common issue for excavation side walls during construction, especially if fill material, granular soils, and/or water seepage is observed. An excavation plan should be developed and the length of excavation left open should be limited to prevent caving soil from covering the suitable bearing soils. The contractor must comply with the federal, state, local and updated OSHA regulations in retention system design to ensure excavation safety.

Occupational Safety and Health Act (OSHA) has instituted strict standards for temporary construction excavations. These standards are outlined in 29 CFR Part 1926 Subpart P. Excavations within unstable soil conditions or extending five feet or more in depth should be adequately sloped or braced according to these standards. Excavation safety is the responsibility of the contractor. Material stockpiles or heavy equipment should not be placed near the edge of
the excavation slopes. The actual stable slope angle should be determined during construction by
the contractor and will depend upon the loading, soil, and groundwater conditions encountered.

4.2.2 Construction Dewatering

Based on the observed soil and groundwater conditions, dewatering is expected to be required
during the excavation and construction of the culvert structure foundations. The contractor
should provide a construction dewatering system plan adequate for proper construction of the
structure and submit it to the Design Engineer for approval.

4.2.3 Temporary Soil Retention System

The expected bottom of foundation grade at 578 feet is about 7 feet lower than the existing
roadway elevation. Therefore, the excavation is expected to extend through variable soil
conditions. A portion of the excavation is anticipated to be extended below the groundwater
level (assumed water at elevation 580.5 feet based on the exploration results).

Based on the observed soil profile and depth to groundwater, the excavation may require a
temporary soil retention system for the proposed construction. The details of the retention
system, if required, shall be designed by the installation contractor and should be reviewed by the
project team for completeness and adequacy. The presence, if any, of any underground utilities
must be considered in the design of the temporary retention system.

4.2.4 Limitations

This report was prepared for the specific project discussed herein. The project details are unique relative to the structure location, size, configuration
and elevations. Where specific information was not available, assumptions have been made,
and are noted as such. These assumptions need to be reviewed by the engineer and other
design professionals working on this project to confirm that these are correct for the planned
use and project. If these assumptions are not correct, GESTRA geotechnical engineers
should be informed and allowed to modify this report, its conclusions, and
recommendations.

The accuracy and completeness of any documents or information provided by others as to
project specifics have been reasonably relied on by GESTRA in providing its evaluation. In
addition, if details of the planned construction change from those outlined in this report,
GESTRA geotechnical engineers must be notified to determine if the changes affect the
recommendations. Supplemental recommendations may then need to be made.

The analysis, conclusions, and recommendations in this report are based on the
subsurface conditions present at the boring location and the engineering characteristics of the
soil as determined through field and laboratory testing at this point in time, as defined in the
current work scope. Subsurface conditions can change over time due to both natural and
human forces, including changes in condition or use of adjacent properties.

Variations in soil conditions should be expected between or beyond the borings, or between
sample intervals, the nature and extent of which might not become evident until construction
is undertaken. It is recommended observation and testing of the construction be performed
by a GESTRA geotechnical engineer or authorize competent personnel to determine if the
subsurface conditions are as indicated by the boring and perform as anticipated.

If the conditions encountered during construction are different from those inferred by the
borings or the project details and information changes, the geotechnical engineer must be
contacted to determine if modification to the recommendations presented in this report are required. The recommendations found in this report are related and are not mutually exclusive of each other. Therefore, no single portion of this report should be removed or be considered as a stand-alone recommendation. The boring logs must also remain with the report, as it is not to be interpreted on its own.

The geotechnical recommendations presented herein are an evaluation of subsoil performance based on the geotechnical engineers' experience and professional opinion. Analysis in this report is specific to the structure location as provided to us. If the location is revised, we must be given the opportunity to evaluate conditions at the revised location. These services were performed with the degree of skill and care normally utilized by other members of the geotechnical engineering profession practicing at this location at this time. No warranty is either expressed or implied.

This report is intended for structure design and construction purposes only and does not document the presence or absence of any environmental and hydrological impacts at the site. Environmental and hydrological services were specifically beyond the authorized scope of services.

Any use or reuse of this report for any purpose other than as specifically intended hereunder without written verification by the geotechnical engineer shall be at the user's own risk.

Sincerely,

GESTRA Engineering, Inc.
Report Prepared By:          ReportReviewed By:

Razaul Haque, P.E.          Douglas Dettmers, P.E.
Project Engineer            Senior Engineer
APPENDIX I

BOREHOLE LAYOUT PLAN, TEST BORING LOGS, AND NOMENCLATURE
### SOIL BORING LOG

**Bay View Wetlands Culvert Boring and Report**

**PROJECT NAME:** Bay View Wetlands Culvert Boring and Report  
**DATE DRILLING STARTED:** 3/2/2017  
**BORING NUMBER:** B-1  
**PROJECT LOCATION:** Milwaukee, WI  
**DATE DRILLING ENDED:** 3/2/2017  
**PROJECT NUMBER:** 17059-10  
**DRILLING RIG:** 3¾" HSA w/ RW

**FIELD LOG**

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<tr>
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<th>Blow Counts</th>
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<th>Elevation</th>
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<td>18</td>
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</table>

**Soil Description and Geological Origin for Each Major Unit**

- **GRAVEL WITH SAND WITH SILT, gray, moist, with pieces of broken concrete, (FILL)**
- **SAND, black, wet, trace gravel, (possible foundry sand), (FILL)**
- **6" Lean Clay seam noted in SS-4**
- **PEAT, black, very moist**
- **ORGANIC ELASTIC SILT, greenish gray, wet, with sand seams and shells, very soft**

**USCS Classification**

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<tr>
<th>Number and Type</th>
<th>Recovery</th>
<th>Blow Counts</th>
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</table>

**Comments**

**WATER & CAVE-IN OBSERVATION DATA**

- **WATER ENCOUNTERED DURING DRILLING:** 4.5 ft.
- **CAVE DEPTH AT COMPLETION:** N.M.R.
- **WATER LEVEL AT COMPLETION:** N.M.R.
- **CAVE DEPTH AFTER 0 HOURS:** N.M.R.
- **WATER LEVEL AFTER 0 HOURS:** N.M.R.

**NOTE:** Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.
### Soil Boring Log

**Project Name:** Bay View Wetlands Culvert Boring and Report  
**Location:** Milwaukee, WI  
**Date Drilling Started:** 3/2/2017  
**Date Drilling Ended:** 3/2/2017

**Firm:** Geutra  
**Crew Chief:** A. Woerpel

---

**Soil Description and Geological Origin for Each Major Unit**

<table>
<thead>
<tr>
<th>Number and Type</th>
<th>Recovery</th>
<th>Blow Counts</th>
<th>N - Value</th>
<th>Depth (ft)</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS - 11</td>
<td>18</td>
<td>2 4 8</td>
<td></td>
<td>30</td>
<td>555.0</td>
</tr>
<tr>
<td>SS - 12</td>
<td>18</td>
<td>2 3 4 7</td>
<td></td>
<td>35</td>
<td>550.0</td>
</tr>
<tr>
<td>SS - 13</td>
<td>18</td>
<td>2 3 5 8</td>
<td></td>
<td>40</td>
<td>545.0</td>
</tr>
<tr>
<td>SS - 14</td>
<td>18</td>
<td>3 5 7 12</td>
<td></td>
<td>45</td>
<td>540.0</td>
</tr>
<tr>
<td>SS - 15</td>
<td>18</td>
<td>3 7 11 18</td>
<td></td>
<td>50</td>
<td>535.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Classification</th>
<th>Unconfined Comp. Strength (Qp) (tsf)</th>
<th>Plasticity Index</th>
<th>Moisture Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SILTY CLAY, gray, moist, stiff</td>
<td>CL-ML</td>
<td>27.4 (557.6)</td>
<td>D</td>
<td>1.25</td>
</tr>
<tr>
<td>LEAN CLAY, gray, moist, medium stiff to very stiff</td>
<td></td>
<td></td>
<td></td>
<td>19.1</td>
</tr>
</tbody>
</table>

---

**Comments**

- Sample disturbed no Qp possible

---

**WATER & CAVE-IN OBSERVATION DATA**

- **Water Encountered During Drilling:** 4.5 ft. (YES)
- **WATER LEVEL AT COMPLETION:** NMR (YES)
- **CAVE DEPTH AFTER 0 HOURS:** NMR (YES)

**Note:** Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.
### SOIL BORING LOG

**Project Name:** Bay View Wetlands Culvert Boring and Report  
**Date Drilling Started:** 3/2/2017  
**Boring Number:** B-1  
**Project Location:** Milwaukee, WI  
**Date Drilling Ended:** 3/2/2017  
**Drilling Rig:** 3½” HSA w/ RW

**Boring Drilled By:** Gestra Engineering Inc.  
**Company Address:** 151 W. Edgerton Avenue  
**Phone/Fax:** 414-933-7444  
**Crew Chief:** A. Woerpel

#### Soil Description and Geological Origin for Each Major Unit

<table>
<thead>
<tr>
<th>Number and Type</th>
<th>Recovery</th>
<th>Blow Counts</th>
<th>N-value</th>
<th>Depth (ft)</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS - 16</td>
<td></td>
<td></td>
<td></td>
<td>75 500.0</td>
<td>55 530.0</td>
</tr>
<tr>
<td>SS - 17</td>
<td></td>
<td></td>
<td></td>
<td>70 515.0</td>
<td>60 525.0</td>
</tr>
<tr>
<td>SS - 18</td>
<td></td>
<td></td>
<td></td>
<td>65 520.0</td>
<td>55 530.0</td>
</tr>
<tr>
<td>SS - 19</td>
<td></td>
<td></td>
<td></td>
<td>70 515.0</td>
<td>55 530.0</td>
</tr>
<tr>
<td>SS - 20</td>
<td></td>
<td></td>
<td></td>
<td>75 510.0</td>
<td>55 530.0</td>
</tr>
</tbody>
</table>

**Comments:** LEAN CLAY, gray, moist, medium stiff to very stiff

**Soil Description and Geological Origin:**
- **LEAN CLAY, gray, moist, medium stiff to very stiff**
- **SANDY SILTY CLAY, gray, very moist, very soft to stiff**

**Unconfined Comp. Strength**

<table>
<thead>
<tr>
<th>Unit</th>
<th>(Q&lt;sub&gt;u&lt;/sub&gt; or Q&lt;sub&gt;p&lt;/sub&gt;) (tsf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>1.50 - 2.50</td>
</tr>
<tr>
<td>CL-ML</td>
<td>&lt;0.25</td>
</tr>
</tbody>
</table>

**Moisture Content (%)**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Moisture Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>20.8</td>
</tr>
<tr>
<td>CL-ML</td>
<td>&lt;0.25</td>
</tr>
</tbody>
</table>

**Liquid Limit**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Liquid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>21</td>
</tr>
</tbody>
</table>

**Plasticity Index**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Shear Strength**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Shear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>121.5 pcf</td>
</tr>
<tr>
<td>CL-ML</td>
<td>139.2 pcf</td>
</tr>
</tbody>
</table>

### WATER & CAVE-IN OBSERVATION DATA

- **Water Encountered During Drilling:** 4.5 ft.
- **Cave Depth at Completion:** NMR
- **Water Level at Completion:** NMR
- **Cave Depth After 0 Hours:** NMR
- **Water Level After 0 Hours:** NMR

**Note:** Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.
# SOIL BORING LOG

**Bay View Wetlands Culvert Boring and Report**  
**DATE DRILLING STARTED:** 3/2/2017  
**DATE DRILLING ENDED:** 3/2/2017  
**PROJECT LOCATION:** Milwaukee, WI  
**BORING NUMBER:** B-1  
**PROJECT NUMBER:** 17059-10

## Soil Description and Geological Origin for Each Major Unit

<table>
<thead>
<tr>
<th>Number and Type</th>
<th>Recovery (in)</th>
<th>N - Value</th>
<th>Depth (ft)</th>
<th>Elevation</th>
<th>Soil Description and Geological Origin</th>
<th>USCS Classification</th>
<th>Graphic</th>
<th>Well Diagram</th>
<th>Unconfined Comp. Strength</th>
<th>Plasticity Index</th>
<th>Moisture Content (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS - 21</td>
<td>18</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>SANDY SILTY CLAY, gray, very moist, very soft to stiff</td>
<td>CL-ML</td>
<td>80</td>
<td>505.0</td>
<td>(1.2)</td>
<td>16 4</td>
<td>13.9 14</td>
<td>y_s = 125.2 pcf</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SILTY SAND, gray, moist, dense</td>
<td>SM</td>
<td>85</td>
<td>500.0</td>
<td>82.8 (502.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>11</td>
<td>16</td>
<td>19</td>
<td>End of Boring at 86.0 ft.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## WATER & CAVE-IN OBSERVATION DATA

- **WATER ENCOUNTERED DURING DRILLING:** 4.5 ft.
- **CAVE DEPTH AT COMPLETION:** NMR
- **WATER LEVEL AT COMPLETION:** NMR
- **CAVE DEPTH AFTER 0 HOURS:** NMR
- **WATER LEVEL AFTER 0 HOURS:** NMR

**NOTE:** Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.
### GENERAL NOTES

#### DRILLING AND SAMPLING SYMBOLS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSA</td>
<td>Hollow Stem Auger</td>
</tr>
<tr>
<td>RWB</td>
<td>Rotary Wash Boring (Mud Drilling)</td>
</tr>
<tr>
<td>_FA</td>
<td>4&quot;, 6&quot; or 10&quot; Diameter Flight Auger</td>
</tr>
<tr>
<td>_HA</td>
<td>2&quot;, 4&quot; or 6&quot; Hand Auger</td>
</tr>
<tr>
<td>_DC</td>
<td>2 1/2&quot;, 4&quot;, 5&quot; or 6&quot; Steel Drive Casing</td>
</tr>
<tr>
<td>_RC</td>
<td>Size A, B, or N Rotary Casing</td>
</tr>
<tr>
<td>PD</td>
<td>Pipe Drill or Cleanout Tube</td>
</tr>
<tr>
<td>CS</td>
<td>Continuous Split Spoon Sampling</td>
</tr>
<tr>
<td>JW</td>
<td>Jetting Water</td>
</tr>
<tr>
<td>SS</td>
<td>2&quot; O.D. Split Spoon Sample</td>
</tr>
<tr>
<td>_L</td>
<td>2 1/2&quot; or 3 1/2&quot; O.D. SB Liner Sample</td>
</tr>
<tr>
<td>ST</td>
<td>3&quot; Thin Walled Tube Sample (Shelby Tube)</td>
</tr>
<tr>
<td>3TP</td>
<td>3&quot; Thin Walled Tube (Pitcher Sampler)</td>
</tr>
<tr>
<td>_TO</td>
<td>2&quot; or 3&quot; Thin Walled Tube (Osterberg Sampler)</td>
</tr>
<tr>
<td>W</td>
<td>Wash Sample</td>
</tr>
<tr>
<td>B</td>
<td>Bag Sample</td>
</tr>
<tr>
<td>P</td>
<td>Test Pit Sample</td>
</tr>
<tr>
<td>_Q</td>
<td>BQ, NQ, or PQ Wireline System</td>
</tr>
<tr>
<td>_X</td>
<td>AX, BX, or NX Double Tube Barrel</td>
</tr>
<tr>
<td>_CR</td>
<td>Core Recovery – Percent</td>
</tr>
<tr>
<td>_NSR</td>
<td>No Sample Recovered, classification based on action of drilling, equipment and/or material noted in drilling fluid or on sampling bit.</td>
</tr>
<tr>
<td>_NMR</td>
<td>No Measurement Recorded, primarily due to presence of drilling or coring fluid.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>Moisture Content - % of Dry Wt. – ASTM D 2216</td>
</tr>
<tr>
<td>OC</td>
<td>Organic Content - % of Dry Wt. – ASTM D 2974</td>
</tr>
<tr>
<td>DD</td>
<td>Dry Density – Pounds Per Cubic Foot</td>
</tr>
<tr>
<td>LL, PL</td>
<td>Liquid and Plastic Limit – ASTM D 4318</td>
</tr>
</tbody>
</table>

#### TEST SYMBOLS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qu</td>
<td>Unconfined Comp. Strength-psf – ASTM D 2166</td>
</tr>
<tr>
<td>Qp</td>
<td>Penetrometer Reading – Tons/Square Foot</td>
</tr>
<tr>
<td>Ts</td>
<td>Torvane Reading – Tons/Square Foot</td>
</tr>
<tr>
<td>G</td>
<td>Specific Gravity – ASTM D 554</td>
</tr>
<tr>
<td>SL</td>
<td>Shrinkage Limits – ASTM D 427</td>
</tr>
<tr>
<td>OC</td>
<td>Organic Content – Combustion Method</td>
</tr>
<tr>
<td>SP</td>
<td>Swell Pressure - Tons/Square Foot</td>
</tr>
<tr>
<td>PS</td>
<td>Percent Swell</td>
</tr>
<tr>
<td>FS</td>
<td>Free Swell – Percent</td>
</tr>
<tr>
<td>pH</td>
<td>Hydrogen Ion Content. Meter Method</td>
</tr>
<tr>
<td>SC</td>
<td>Sulfate Content – Parts/ Million, same as mg/L</td>
</tr>
<tr>
<td>C*</td>
<td>One Dimensional Consolidation – ASTM D 2453</td>
</tr>
<tr>
<td>Qe*</td>
<td>Triaxial Compression</td>
</tr>
<tr>
<td>D.S.*</td>
<td>Direct Shear – ASTM D 3080</td>
</tr>
<tr>
<td>K*</td>
<td>Coefficient of Permeability – cm/sec</td>
</tr>
<tr>
<td>D*</td>
<td>Dispersion test</td>
</tr>
<tr>
<td>DH*</td>
<td>Double Hydrometer – ASTM D 4221</td>
</tr>
<tr>
<td>MA*</td>
<td>Particle Size Analysis – ASTM D 422</td>
</tr>
<tr>
<td>R</td>
<td>Laboratory Receptivity, in ohm – cm – ASTM G 57</td>
</tr>
<tr>
<td>E*</td>
<td>Pressuremeter Deformation Modulus – TSF</td>
</tr>
<tr>
<td>PM*</td>
<td>Pressuremeter Test</td>
</tr>
<tr>
<td>VS*</td>
<td>Field Vane Shear – ASTM D 2573</td>
</tr>
<tr>
<td>IR*</td>
<td>Infiltrometer Test – ASTM D 3385</td>
</tr>
<tr>
<td>RQD</td>
<td>Rock Quality Designation – Percent</td>
</tr>
</tbody>
</table>

#### WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels may be considered reliable ground water levels. In clay soil, it may not be possible to determine the ground water level within the normal time required for test borings, except where lenses or layers of more pervious waterbearing soil are present. Even then, an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the log sheet.

#### DESCRIPTIVE TERMINOLOGY

<table>
<thead>
<tr>
<th>DENSITY</th>
<th>“N” TERM</th>
<th>“N” VALUE</th>
<th>CONSISTENCY</th>
<th>Unconfined Compressive Strength, (tsf)</th>
<th>N&lt;sup&gt;°&lt;/sup&gt;</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0-4</td>
<td>Very Soft</td>
<td>&lt;0.25</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loose</td>
<td>4-10</td>
<td>Soft</td>
<td>0.25 - 0.49</td>
<td>2-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10-30</td>
<td>Medium Stiff</td>
<td>0.5 - 0.99</td>
<td>4-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense</td>
<td>30-50</td>
<td>Stiff</td>
<td>1.0 - 1.99</td>
<td>8-16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Dense</td>
<td>Over 50</td>
<td>Very Stiff</td>
<td>2.0 - 3.99</td>
<td>16-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard</td>
<td></td>
<td>Hard</td>
<td>4.0+</td>
<td>Over 30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard “N” Penetration: Blows per Foot of a 140 Pound Hammer Falling 30 inches on a 2 inch OD Split Barrel Sampler

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>RELATIVE GRAVEL PROPORTIONS</th>
<th>RELATIVE SIZES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Grained Soils</td>
<td>2-14% with gravel</td>
<td>Boulder Over 12”</td>
</tr>
<tr>
<td>Fine Grained Soils</td>
<td>2-14% with gravel</td>
<td>3” - 12”</td>
</tr>
<tr>
<td>15-29% + No. 200</td>
<td>2-14% with gravel</td>
<td>Gravel</td>
</tr>
<tr>
<td>30% + No. 200</td>
<td>2-14% with gravel</td>
<td>Coarse 3/4” - 3”</td>
</tr>
<tr>
<td>30% + No. 200</td>
<td>2-14% with gravel</td>
<td>Fine #4 – 3/4”</td>
</tr>
<tr>
<td>30% + No. 200</td>
<td>2-14% with gravel</td>
<td>Sand #4 - #10</td>
</tr>
<tr>
<td>30% + No. 200</td>
<td>2-14% with gravel</td>
<td>Coarse #10 - #40</td>
</tr>
<tr>
<td>30% + No. 200</td>
<td>2-14% with gravel</td>
<td>Fine #40 - #200</td>
</tr>
<tr>
<td>30% + No. 200</td>
<td>2-14% with gravel</td>
<td>Silt &amp; Clay - # 200, Based on Plasticity</td>
</tr>
</tbody>
</table>

GESTRA Engineering, Inc
### Soil Classification for Engineering Purposes

**ASTM Designation: D 2487 - 83**

*(Based on Unified Soil Classification System)*

#### Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests

<table>
<thead>
<tr>
<th>Coarse-Grained Soils</th>
<th>Gravels</th>
<th>More than 50% retained on No. 200 sieve</th>
<th>Clean Gravels</th>
<th>Less than 12% fines</th>
<th>Cu&lt; 4 and/or (1) Cc &gt; 3</th>
<th>GW Well graded gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>More than 50% coarse fraction retained on No. 4 sieve</td>
<td>Gravels with Fines</td>
<td>More than 12% fines</td>
<td>Cu&lt; 4 and/or (1) Cc &gt; 3</td>
<td>Fines classify as CL or CH</td>
<td>GC Clayey gravel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sands</th>
<th>Clean sands</th>
<th>Cu&lt; 4 and/or (1) Cc &gt; 3</th>
<th>SW Well graded sand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 5% fines</td>
<td>Cu&lt; 4 and/or (1) Cc &gt; 3</td>
<td>SW Well graded sand</td>
</tr>
<tr>
<td></td>
<td>Sands with Fines</td>
<td>More than 12% fines</td>
<td>SW Well graded sand</td>
</tr>
<tr>
<td></td>
<td>Fines classify as CL or CH</td>
<td>Fines classify as CL or CH</td>
<td>SW Well graded sand</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fine-Grained Soils</th>
<th>Silts and Clays</th>
<th>Liquid Limit less than 50</th>
<th>Inorganic</th>
<th>PI &gt; 7 and plots on or above &quot;A&quot; line</th>
<th>CL Lean clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Organic</td>
<td>Liquid limit - oven dried</td>
<td>Silt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Liquid limit - not dried</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Silts and Clays</th>
<th>Liquid Limit 50 or more</th>
<th>Organic</th>
<th>PI plots on or above &quot;A&quot; line</th>
<th>CH Fat clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Liquid limit - oven dried</td>
<td>OH Organic clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liquid limit - not dried</td>
<td>Organic Silt</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highly organic Soils</th>
<th>Fabric Peat &gt; 67% Fibers</th>
<th>Primarily organic matter, dark in color, and organic odor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hemic Peat</td>
<td>PT Peat</td>
</tr>
<tr>
<td></td>
<td>33 % - 67 % Fibers</td>
<td>sapric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Peat &lt; 33% Fibers</td>
</tr>
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</table>

#### Particle Size Analysis

![Sieve Analysis Diagram](https://example.com/sieve_analysis_diagram.png)

**For classification of fine-grained soils and fine-grained fraction of coarse-grained soils**

- **Equation of "A" Line**
  - Horizontal at PI = 4 to LL = 25.5
  - Then PI = 0.75 (LL = 20)

- **Equation of "U" Line**
  - Vertical at LL = 16 to PI = 7
  - Then PI = 0.9 (LL = 4)

---

**Geotechnical - Structural - Pavement - Construction Materials**

GESTRA Engineering, Inc

ASTM D2487-83, Classification.xls
APPENDIX II

LABORATORY TEST RESULTS
## Laboratory Test Results of Moisture Content, Organic Content, and Density of Soil

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Sample Number</th>
<th>Cup Number</th>
<th>Weight of Cup (g)</th>
<th>Weight of Wet Soil and Cup (g)</th>
<th>Weight of Dry Soil and Cup (g)</th>
<th>Weight of Soil and Cup After Burn (g)</th>
<th>Moisture Content (%)</th>
<th>Organic Content (%)</th>
<th>Wet Density (pcf)</th>
<th>Dry Density (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>4</td>
<td>P4</td>
<td>25.64</td>
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<td>26.76</td>
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<td>52.33</td>
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<td>B-1</td>
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<tr>
<td>B-1</td>
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<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Sample Number</th>
<th>Cup Number</th>
<th>Weight of Cup (g)</th>
<th>Weight of Wet Soil and Cup (g)</th>
<th>Weight of Dry Soil and Cup (g)</th>
<th>Weight of Soil and Cup After Burn (g)</th>
<th>Moisture Content (%)</th>
<th>Organic Content (%)</th>
<th>Wet Density (pcf)</th>
<th>Dry Density (pcf)</th>
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<tbody>
<tr>
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<td>18</td>
<td>N2</td>
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<td>V2</td>
<td>22.83</td>
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<td>61.96</td>
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**Performed by:** JB  
**Reviewed by:** VS

*Geotechnical-Structural-Pavement-Construction Material*
# Laboratory Test Results of
## Moisture Content, Organic Content, and Density of Soil

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Bay View Wetlands Culvert</th>
<th>Date:</th>
<th>March 6, 2017</th>
</tr>
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<tbody>
<tr>
<td>Project Number:</td>
<td>17059-10</td>
<td>Report To:</td>
<td>AECOM</td>
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<tr>
<td>Project Location:</td>
<td>Milwaukee, WI</td>
<td></td>
<td></td>
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<tr>
<td>ASTM Designation:</td>
<td>D2216, D2974</td>
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<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Sample Number</th>
<th>Cup Number</th>
<th>Weight of Cup (g)</th>
<th>Weight of Wet Soil and Cup (g)</th>
<th>Weight of Dry Soil and Cup (g)</th>
<th>Weight of Soil and Cup After Burn (g)</th>
<th>Wet Density (pcf)</th>
<th>Dry Density (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>SH-6 Peat</td>
<td>PC A</td>
<td>70.42</td>
<td>137.37</td>
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<td>2.40</td>
<td>137.37</td>
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<td>PC B</td>
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<td>100.79</td>
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<td>153.78</td>
<td>164.44</td>
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<table>
<thead>
<tr>
<th>Moisture Content (%)</th>
<th>Organic Content (%)</th>
<th>Wet Density (pcf)</th>
<th>Dry Density (pcf)</th>
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<tbody>
<tr>
<td>150.8</td>
<td>109.9</td>
<td>17.6</td>
<td>11.1</td>
</tr>
</tbody>
</table>

Performed by BJB
Reviewed by VS
## Laboratory Test Results of Atterberg Limits of Soil

**Project Name:** Bay View Wetlands Culvert  
**Project Number:** 17059-10  
**Project Location:** Milwaukee, WI  
**ASTM Designation:** D4318

### Sample Information

<table>
<thead>
<tr>
<th>Type of Sample</th>
<th>Shelby Tube</th>
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<tbody>
<tr>
<td>Boring Number</td>
<td>B-1</td>
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<tr>
<td>Sample Number</td>
<td>6</td>
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<tr>
<td>Depth of Sample</td>
<td>12'-14'</td>
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</tbody>
</table>

### Determination of Liquid Limit

<table>
<thead>
<tr>
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<th>L20</th>
<th>D17</th>
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<tr>
<td>Weight of Cup (g)</td>
<td>14.21</td>
<td>14.64</td>
<td>14.49</td>
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<td>Weight of Wet Soil and Cup (g)</td>
<td>35.15</td>
<td>35.16</td>
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</tr>
<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>26.15</td>
<td>26.19</td>
<td>24.51</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>75.4</td>
<td>77.7</td>
<td>78.7</td>
</tr>
<tr>
<td>Blow Counts</td>
<td>35</td>
<td>24</td>
<td>19</td>
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### Determination of Plastic Limit

<table>
<thead>
<tr>
<th>Cup Number</th>
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<th>D19</th>
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<tbody>
<tr>
<td>Weight of Cup (g)</td>
<td>7.40</td>
<td>7.22</td>
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<tr>
<td>Weight of Wet Soil and Cup (g)</td>
<td>13.55</td>
<td>13.32</td>
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<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>11.55</td>
<td>11.32</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>48.2</td>
<td>48.8</td>
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</table>

### Compilation of Test Results

![Graph showing Atterberg limits](image)

**Liquid Limit:** 77  
**Plastic Limit:** 48  
**Plasticity Index:** 29  
**USCS Symbol:** MH

**Performed by:** BJB  
**Reviewed By:** VS
# Laboratory Test Results of Atterberg Limits of Soil

**Project Name:** Bay View Wetlands Culvert  
**Project Number:** 17059-10  
**Project Location:** Milwaukee, WI  
**ASTM Designation:** D4318  
**Date:** March 7, 2017  
**Client:** AECOM

## Sample Information
- **Type of Sample:** Split Spoon
- **Boring Number:** B-1
- **Sample Number:** 8
- **Depth of Sample:** 19.5'–21'

## Determination of Liquid Limit

<table>
<thead>
<tr>
<th>Cup Number</th>
<th>L12</th>
<th>D9</th>
<th>D28</th>
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<tbody>
<tr>
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<td>14.45</td>
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<tr>
<td>Weight of Wet Soil and Cup (g)</td>
<td>35.82</td>
<td>33.85</td>
<td>35.80</td>
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<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>31.09</td>
<td>29.42</td>
<td>30.82</td>
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<tr>
<td>Moisture Content (%)</td>
<td>28.4</td>
<td>29.2</td>
<td>31.0</td>
</tr>
<tr>
<td>Blow Counts</td>
<td>32</td>
<td>25</td>
<td>18</td>
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</table>

## Determination of Plastic Limit

<table>
<thead>
<tr>
<th>Cup Number</th>
<th>L18</th>
<th>L10</th>
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<tbody>
<tr>
<td>Weight of Cup (g)</td>
<td>7.32</td>
<td>7.14</td>
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<tr>
<td>Weight of Wet Soil and Cup (g)</td>
<td>13.64</td>
<td>13.77</td>
</tr>
<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>12.51</td>
<td>12.59</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>21.8</td>
<td>21.7</td>
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</table>

## Compilation of Test Results

<table>
<thead>
<tr>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>Plasticity Index</th>
<th>USCS Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>22</td>
<td>8</td>
<td>CL</td>
</tr>
</tbody>
</table>

![Atterberg Limits Graph](image)

**Performed by:** BJB  
**Reviewed By:** VS

*Geotechnical-Structural-Pavement-Construction Material*
# Laboratory Test Results of Atterberg Limits of Soil

**Project Name:** Bay View Wetlands Culvert  
**Date:** March 7, 2017  
**Client:** AECOM  
**Project Location:** Milwaukee, WI  
**ASTM Designation:** D4318

<table>
<thead>
<tr>
<th>Sample Information</th>
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<tbody>
<tr>
<td>Type of Sample</td>
<td>Split Spoon</td>
</tr>
<tr>
<td>Boring Number</td>
<td>B-1</td>
</tr>
<tr>
<td>Sample Number</td>
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<tr>
<td>Depth of Sample</td>
<td>24.5’-26’</td>
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</table>

## Determination of Liquid Limit

<table>
<thead>
<tr>
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<th>D25</th>
<th>B2</th>
<th>B32</th>
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<tbody>
<tr>
<td>Weight of Cup (g)</td>
<td>14.21</td>
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<tr>
<td>Weight of Wet Soil and Cup (g)</td>
<td>38.48</td>
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<td>35.82</td>
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<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>34.87</td>
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<td>Moisture Content (%)</td>
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<td>18.4</td>
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<tr>
<td>Blow Counts</td>
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## Determination of Plastic Limit

<table>
<thead>
<tr>
<th>Cup Number</th>
<th>D27</th>
<th>D6</th>
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<tbody>
<tr>
<td>Weight of Cup (g)</td>
<td>7.16</td>
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<tr>
<td>Weight of Wet Soil and Cup (g)</td>
<td>13.82</td>
<td>13.66</td>
</tr>
<tr>
<td>Weight of Dry Soil and Cup (g)</td>
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<td>12.94</td>
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<tr>
<td>Moisture Content (%)</td>
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<td>12.6</td>
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</table>

## Compilation of Test Results

- **Liquid Limit:** 18
- **Plastic Limit:** 13
- **Plasticity Index:** 5
- **USCS Symbol:** CL-ML

Performed by: BJB  
Reviewed By: VS

*Geotechnical-Structural-Pavement-Construction Material*
Laboratory Test Results of Atterberg Limits of Soil

Project Name: Bay View Wetlands Culvert          Date: March 7, 2017
Project Number: 17059-10                        Client: AECOM
Project Location: Milwaukee, WI
ASTM Designation: D4318

Sample Information
Type of Sample: Split Spoon
Boring Number: B-1
Sample Number: 14
Depth of Sample: 44.5'-46'

<table>
<thead>
<tr>
<th>Determination of Liquid Limit</th>
<th>Determination of Plastic Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cup Number</td>
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<tr>
<td>Weight of Cup (g)</td>
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Compilation of Test Results

![Graph showing Atterberg limits]

Liquid Limit: 25
Plastic Limit: 13
Plasticity Index: 12
USCS Symbol: CL

Performed by: BJB     Reviewed by: VS

Geotechnical-Structural-Pavement-Construction Material
Sample Information

<table>
<thead>
<tr>
<th>Type of Sample</th>
<th>Split Spoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring Number</td>
<td>B-1</td>
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<tr>
<td>Sample Number</td>
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</tr>
<tr>
<td>Depth of Sample</td>
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**Determination of Liquid Limit**

<table>
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<th>Weight of Cup (g)</th>
<th>Weight of Wet Soil and Cup (g)</th>
<th>Weight of Dry Soil and Cup (g)</th>
<th>Moisture Content (%)</th>
<th>Blow Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>B11</td>
<td>14.38</td>
<td>35.42</td>
<td>31.82</td>
<td>20.6</td>
<td>32</td>
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<td>B19</td>
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**Determination of Plastic Limit**

<table>
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<tr>
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<th>Weight of Cup (g)</th>
<th>Weight of Wet Soil and Cup (g)</th>
<th>Weight of Dry Soil and Cup (g)</th>
<th>Moisture Content (%)</th>
<th>Blow Counts</th>
</tr>
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<tbody>
<tr>
<td>D19</td>
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<td>12.2</td>
<td>12</td>
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<td>G7</td>
<td>7.22</td>
<td>13.78</td>
<td>13.08</td>
<td>11.9</td>
<td>9</td>
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</tbody>
</table>

**Compilation of Test Results**

- **Liquid Limit**: 21
- **Plastic Limit**: 12
- **Plasticity Index**: 9
- **USCS Symbol**: CL

Performed by: BJB  
Reviewed By: VS  

Geotechnical-Structural-Pavement-Construction Material
# Laboratory Test Results of Atterberg Limits of Soil

**Project Name:** Bay View Wetlands Culvert  
**Project Number:** 17059-10  
**Project Location:** Milwaukee, WI  
**ASTM Designation:** D4318  
**Date:** March 8, 2017  
**Client:** AECOM  

## Sample Information

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<tbody>
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<td>Boring Number</td>
<td>B-1</td>
</tr>
<tr>
<td>Sample Number</td>
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</tr>
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<td>Depth of Sample</td>
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## Determination of Liquid Limit

<table>
<thead>
<tr>
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<th>B2</th>
<th>D17</th>
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<tr>
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<td>14.63</td>
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<td>36.10</td>
</tr>
<tr>
<td>Weight of Dry Soil and Cup (g)</td>
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<td>Moisture Content (%)</td>
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<td>16.7</td>
</tr>
<tr>
<td>Blow Counts</td>
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<td>24</td>
<td>15</td>
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## Determination of Plastic Limit

<table>
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<td>Weight of Wet Soil and Cup (g)</td>
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<td>13.64</td>
</tr>
<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>13.18</td>
<td>12.96</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>12.0</td>
<td>11.9</td>
</tr>
</tbody>
</table>

## Compilation of Test Results

![Atterberg Limits Diagram](image)

<table>
<thead>
<tr>
<th>Moisture Content (%)</th>
<th>12.0</th>
<th>11.9</th>
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<tbody>
<tr>
<td>Liquid Limit</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Plastic Limit</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>4</td>
<td></td>
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<tr>
<td>USCS Symbol</td>
<td>CL-ML</td>
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**PERFORMED BY:** BJB  
**REVIEWED BY:** VS
# Laboratory Test Results of Atterberg Limits of Soil

**Project Name:** Bay View Wetlands Culvert  
**Project Number:** 17059-10  
**Project Location:** Milwaukee, WI  
**ASTM Designation:** D4318  
**Date:** March 9, 2017  
**Client:** AECOM

### Sample Information
- **Type of Sample:** Shelby Tube
- **Boring Number:** B-1
- **Sample Number:** 9
- **Depth of Sample:** 22'-23'

### Determination of Liquid Limit

<table>
<thead>
<tr>
<th>Cup Number</th>
<th>D10</th>
<th>L20</th>
<th>L14</th>
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<tbody>
<tr>
<td>Weight of Cup (g)</td>
<td>14.80</td>
<td>14.20</td>
<td>14.44</td>
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<tr>
<td>Weight of Wet Soil and Cup (g)</td>
<td>33.34</td>
<td>28.98</td>
<td>32.72</td>
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<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>29.81</td>
<td>26.08</td>
<td>29.11</td>
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<tr>
<td>Moisture Content (%)</td>
<td>23.5</td>
<td>24.4</td>
<td>24.6</td>
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<tr>
<td>Blow Counts</td>
<td>35</td>
<td>27</td>
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### Determination of Plastic Limit

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<th>D30</th>
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</tr>
<tr>
<td>Weight of Dry Soil and Cup (g)</td>
<td>13.96</td>
<td>13.34</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>12.4</td>
<td>12.6</td>
</tr>
</tbody>
</table>

### Compilation of Test Results

![Atterberg Limits Graph](image)

- **Liquid Limit:** 24
- **Plastic Limit:** 12
- **Plasticity Index:** 12
- **USCS Symbol:** CL

**Performed by:** JB  
**Reviewed By:** VS

*Geotechnical-Structural-Pavement-Construction Material*
Laboratory Test Results of
Unconfined Compressive Strength of Soil

Project Name: Bay View Wetlands Culvert
Project Number: 17059-10
Project Location: Milwaukee, WI
ASTM Designation: D2166

Test Data

<table>
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<th>Deformation dial reading (0.001 in.)</th>
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Sample Information

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<tbody>
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<td>Diameter (in):</td>
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<td>Area (sq. in.):</td>
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<tr>
<td>Depth of Soil:</td>
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<td>Height (in.):</td>
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<td>Description of Soil:</td>
<td>ORGANIC ELASTIC SILT, gray, moist with shells and roots</td>
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<td>Strain Rate (in/min):</td>
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</table>

UC Strength, $Q_u$ (tsf): **0.35**
Wet Density (pcf): **88.5**
Dry Density (pcf): **42.2**
Moisture Content (%): **109.9**

Remarks

Performed By: BJB
Reviewed By: VS

Geotechnical-Structural-Pavement-Construction Material
Laboratory Test Results of
Unconfined Compressive Strength of Soil

Project Name: Bay View Wetlands Culvert
Project Number: 17059-10
Project Location: Milwaukee, WI
ASTM Designation: D2166

Date: March 9, 2017
Report To: AECOM
Due Calibration: 06/2017
Form Updated on 7/1/2016

Test Data

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<thead>
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<th>Deformation dial reading (0.001 in.)</th>
<th>Sample stress (psf)</th>
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Sample Information

Boring no.: B-1
Sample no.: 9
Diameter (in): 2.84
Area (sq. in.): 6.35
Depth of Soil: 22'-23'
Height: (in.): 5.76
Description of Soil: LEAN CLAY, gray, moist
Strain Rate (in/min): 0.050

Remarks

UC Strength, Q_u (tsf) 0.66
Wet Density (pcf) 142.0
Dry Density (pcf) 121.9
Moisture Content (%) 16.5

Performed By: JB
Reviewed By: VS

Geotechnical-Structural-Pavement-Construction Material
Laboratory Test Results of Unconfined Compressive Strength of Soil

Project Name: Bay View Wetlands Culvert
Project Number: 17059-10
Project Location: Milwaukee, WI
ASTM Designation: D2166

Test Data

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<td>Diameter (in): 1.49</td>
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<td>Description of Soil: LEAN CLAY, gray, moist</td>
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<td></td>
<td>Strain Rate (in/min): 0.050</td>
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</table>

<table>
<thead>
<tr>
<th>Stress (psf)</th>
<th>Unit Strain, %</th>
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</table>

UC Strength, $Q_u$ (tsf) 0.63
Wet Density (pcf) 137.9
Dry Density (pcf) 119.1
Moisture Content (%) 15.8

Remarks
Performed By: BJB
Reviewed By: VS

Geotechnical-Structural-Pavement-Construction Material
# Laboratory Test Results of Unconfined Compressive Strength of Soil

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Bay View Wetlands Culvert</th>
<th>Date</th>
<th>March 6, 2017</th>
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<td>06/2017</td>
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<td>ASTM Designation</td>
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<td>Form Updated on</td>
<td>7/1/2016</td>
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## Test Data

<table>
<thead>
<tr>
<th>Deformation dial reading (0.001 in.)</th>
<th>Sample stress (psf)</th>
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<tbody>
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<td>0</td>
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## Sample Information

- **Boring no.:** B-1
- **Diameter (in):** 1.48
- **Sample no.:** 14
- **Area (sq. in.):** 1.72
- **Depth of Soil:** 44.5'-66'
- **Height (in.):** 2.82
- **Description of Soil:** LEAN CLAY, gray, moist
- **Strain Rate (in/min):** 0.050

## Remarks

<table>
<thead>
<tr>
<th>UC Strength, $Q_c$ (tsf)</th>
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<tbody>
<tr>
<td>Wet Density (pcf)</td>
<td>134.1</td>
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<td>Dry Density (pcf)</td>
<td>114.7</td>
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<tr>
<td>Moisture Content (%)</td>
<td>16.9</td>
</tr>
</tbody>
</table>

- **Performed By:** BJB
- **Reviewed By:** VS

Geotechnical-Structural-Pavement-Construction Material
## Laboratory Test Results of

### Unconfined Compressive Strength of Soil

**Project Name:** Bay View Wetlands Culvert  
**Project Number:** 17059-10  
**Project Location:** Milwaukee, WI  
**ASTM Designation:** D2166

### Test Data

<table>
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<th>Deformation dial reading (0.001 in.)</th>
<th>Sample stress (psf)</th>
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### Sample Information

- **Boring no.:** B-1  
- **Area (sq. in.):** 1.89  
- **Depth of Soil:** 64.5'-66'  
- **Height: (in.):** 2.84  
- **Strain Rate (in/min):** 0.050

- **UC Strength, \( Q_u \) (tsf):** **1.10**  
- **Wet Density (pcf):** 139.2  
- **Dry Density (pcf):** 121.5  
- **Moisture Content (%):** 14.5

### Remarks

- **Performed By:** BJB  
- **Reviewed By:** VS

---

**Sketch/photo**

**Geotechnical-Structural-Pavement-Construction Material**
Laboratory Test Results of
Unconfined Compressive Strength of Soil

Project Name: Bay View Wetlands Culvert
Project Number: 17059-10
Project Location: Milwaukee, WI
ASTM Designation: D2166
Date: March 6, 2017
Report To: AECOM
Due Calibration: 06/2017
Form Updated on 7/1/2016

Test Data

<table>
<thead>
<tr>
<th>Deformation dial reading (0.001 in.)</th>
<th>Sample stress (psf)</th>
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Sample Information

- Boring no.: B-1
- Diameter (in): 1.57
- Sample no.: 21
- Area (sq. in.): 1.93
- Depth of Soil: 79.5'-81'
- Height (in.): 2.81
- Description of Soil: LEAN CLAY, gray, very moist with sand
- Strain Rate (in/min): 0.050

Remarks

UC Strength, Qₜ (tsf): 1.24
Wet Density (pcf): 142.7
Dry Density (pcf): 125.2
Moisture Content (%): 13.9

Performed By: BJB
Reviewed By: VS

GESTRA Engineering, Inc.