SECTION 4 SCOUR ANALYSIS
(Supplement to Section 5 Hydraulics Report)

OCTOBER 31, 2011

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WILBUR SMITH ASSOCIATES

Prepared for:
PB AMERICAS, INC.
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1.0 INTRODUCTION

This report is a supplement to the Section 5 East End Bridge - Hydraulic and Scour Analysis Report, dated September 20, 2011. Its purpose is to document the scour analysis for the Section 4 approach span piers on the Kentucky Approach. These piers lie between stations 167+81.96 (End Bent 1) and 187+50.96 (Common Pier).

2.0 DATA COLLECTION

2.1 General

The hydraulic data necessary for the scour analysis was extracted from the 2-D SMS/FESWMS model (documented in the Hydraulic and Scour Report for Section 5). The representative pier configuration was obtained from Lochner for Section 4 (see Appendix A), and the geotechnical boring data for Section 4 was provided by Stantec (see Appendix B).

2.2 Soil Particle Sizes

Data from draft geotechnical borings was used in the scour analysis. The bed soil consists mainly of sands and clays with d50 ranging from 0.0039 mm to 0.13 mm and d95 from 0.049 mm to 12.0 mm, as shown in Table 1. The general soil boring plan is shown in Figure 1. This drawing was prepared from the Stantec boring log location information for this study and is for illustrative purposes only. Excerpts from the boring logs and lab testing pertinent to the bridge crossing are presented in Appendix B.

<table>
<thead>
<tr>
<th>Structure Element</th>
<th>Boring Number</th>
<th>Station</th>
<th>Offset</th>
<th>Sample Depth (ft)</th>
<th>d50 (mm)</th>
<th>d95 (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pier 1</td>
<td>B54</td>
<td>170+10</td>
<td>86' LT</td>
<td>1.2 / 3.5</td>
<td>0.13</td>
<td>12.0</td>
</tr>
<tr>
<td>Pier 2</td>
<td>B61</td>
<td>172+85</td>
<td>69' RT</td>
<td>3</td>
<td>0.0053</td>
<td>0.26</td>
</tr>
<tr>
<td>Pier 3</td>
<td>B64</td>
<td>175+60</td>
<td>6' RT</td>
<td>3</td>
<td>0.0065</td>
<td>0.079</td>
</tr>
<tr>
<td>Pier 4</td>
<td>B66</td>
<td>177+85</td>
<td>86' LT</td>
<td>4.6</td>
<td>0.041</td>
<td>0.31</td>
</tr>
<tr>
<td>Pier 5</td>
<td>B70</td>
<td>180+01</td>
<td>86' LT</td>
<td>3</td>
<td>0.007</td>
<td>0.2</td>
</tr>
<tr>
<td>Pier 6</td>
<td>B77</td>
<td>182+71</td>
<td>69' RT</td>
<td>3.6 / 5.0</td>
<td>0.069</td>
<td>0.32</td>
</tr>
<tr>
<td>Pier 7</td>
<td>B79</td>
<td>184+87</td>
<td>6' LT</td>
<td>3</td>
<td>0.0039</td>
<td>0.049</td>
</tr>
</tbody>
</table>
Figure 1: General Soil Boring Locations
The Section 4 piers (Kentucky approach) in the overbank area are typically dry at the normal pool stage and begin to experience flow before the 10-yr (10%) storm discharge. For purposes of scour analysis, Table 2 summarizes maximum velocities within the vicinity of each of the approach piers for the 100-yr (1%) and the 500-yr (0.2%) storms.

### Table 2: Summary of Maximum Velocities and Corresponding Flow Depths

<table>
<thead>
<tr>
<th>Pier No.</th>
<th>Node No.</th>
<th>100-Year Event</th>
<th>500-Year Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Velocity (ft/s)</td>
<td>Depth (ft)</td>
</tr>
<tr>
<td>Pier 1</td>
<td>4605</td>
<td>0.417</td>
<td>7.995</td>
</tr>
<tr>
<td>Pier 2</td>
<td>4113</td>
<td>1.076</td>
<td>24.685</td>
</tr>
<tr>
<td>Pier 3</td>
<td>4116</td>
<td>2.142</td>
<td>15.981</td>
</tr>
<tr>
<td>Pier 4</td>
<td>4120</td>
<td>3.563</td>
<td>6.601</td>
</tr>
<tr>
<td>Pier 5</td>
<td>4617</td>
<td>2.717</td>
<td>13.504</td>
</tr>
<tr>
<td>Pier 6</td>
<td>4626</td>
<td>3.005</td>
<td>19.996</td>
</tr>
<tr>
<td>Pier 7</td>
<td>5412</td>
<td>2.992</td>
<td>21.043</td>
</tr>
</tbody>
</table>

Figure 2 graphically depicts the calculated flow regimes of each pier, identified as 1-7 beginning at the bank on the Kentucky side of the Ohio River. The SMS/FESWMS output can be found in the SECTION 5 - Hydraulic and Scour Analysis Report, dated September 20, 2011. The hydraulic flow parameters are summarized in Table 2, and with the geotechnical particle sizes for each pier in Appendix B, Pier Drag Report chart.
3.0 SCOUR ANALYSIS

3.1 Methodology

The scour analysis was performed in accordance with the methodology outlined in the Federal Highway Administration (FHWA) Hydraulic Engineering Circular (HEC) No. 18. These methods were used to develop predictions of long-term, contraction, and local scour at piers and abutments. In accordance with general practice, the 100-yr (1%) storm was used as the scour analysis design event.

For this supplemental report, scour analysis was only performed for the Section 4 (Kentucky Approach) piers.

Hydraulic parameters necessary to complete the scour analysis were taken from the SMS/FESWMS model results. The FESWMS node numbers used to perform the scour analysis are shown in Appendix C in the Total Scour Inputs (from FESWMS) table.

3.2 Theoretical Predicted Scour

Total scour depths shown in Tables 3 and 4 are composed of three scour components: long-term, contraction, and local (which is composed of the pier scour). The total scour depths for the 100-year event are shown graphically in the scour plot in Figure 3. The detailed scour calculations are provided in Appendix C.

3.2.1 Long-term Scour Component

The USACE Louisville, Kentucky District was contacted to obtain available historical data documenting changes to streambed geometry and elevations over time. Both the Water Management Section of the Engineering Division and the Navigation Information Section of the Operations Division were consulted. Both offices indicated that historical streambed data is only available for a few specific sections of the Ohio River in the vicinity of the locks and dams where scour problems have occurred, and that none of those data sets would be applicable to the river reach requested.

A review of area mapping indicates that the nearest existing bridge crossing is the I-65 JFK Memorial Bridge at River Station 602.9. Due to the proximity of the I-65 bridge to the McAlpine dam and any influences caused by the dam structure, and since this crossing is 7.4 miles downstream, historical streambed surveys and inspection reports for that structure cannot be relied upon to provide a conclusion regarding streambed variations over time at the proposed bridge location. The nearest highway crossing upstream from the study site is in Trimble County which is much too far upstream to be used for guidance in making assumptions.
A level-three (HEC-20) analysis involving sediment routing within the contributing watersheds can sometimes be useful to predict sediment transport, but establishing a mathematical model would require a substantial historical data set as well as substantial analysis time. Lack of data coupled with the knowledge that the downstream control in place at the McAlpine Lock maintains the normal pool condition of the Ohio River a steady, slow velocity (less than 2.0 fps) led to the conclusion that aggradation or degradation of the streambed is likely negligible in comparison to other scour components, and that not enough data is available to develop a prediction based on mathematical analysis. For these reasons, the long-term scour component of the overall scour estimate was assumed to be zero feet.

### Table 3: Theoretical Scour Depths (ft) for the 100-yr Storm by Pier

<table>
<thead>
<tr>
<th>Pier</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring Number</td>
<td>B54</td>
<td>B61</td>
<td>B64</td>
<td>B66</td>
<td>B70</td>
<td>B77</td>
<td>B79</td>
</tr>
<tr>
<td>Modeled Bed Elevations***</td>
<td>430.5</td>
<td>427.9</td>
<td>432.3</td>
<td>434.3</td>
<td>437.6</td>
<td>434</td>
<td>430.2</td>
</tr>
<tr>
<td>Bed Rock Elevation***</td>
<td>330.5</td>
<td>331.4</td>
<td>333.8</td>
<td>333.3</td>
<td>334.3</td>
<td>335.8</td>
<td>334.7</td>
</tr>
<tr>
<td>Competent Rock Elevation***</td>
<td>329.7</td>
<td>331.4</td>
<td>331</td>
<td>333.1</td>
<td>334.3</td>
<td>335.5</td>
<td>334.5</td>
</tr>
<tr>
<td>Long-term (ft)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Contraction (ft)</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Local (ft)</td>
<td>2.5</td>
<td>10.7</td>
<td>14.5</td>
<td>15.9</td>
<td>15.8</td>
<td>17.3</td>
<td>11.7</td>
</tr>
<tr>
<td><strong>Total Scour (ft)</strong></td>
<td>3.0</td>
<td>11.1</td>
<td>14.9</td>
<td>16.3</td>
<td>16.3</td>
<td>17.7</td>
<td>12.1</td>
</tr>
<tr>
<td><strong>Total Scour Elevation</strong></td>
<td>427.5</td>
<td>416.8</td>
<td>417.4</td>
<td>418.0</td>
<td>421.3</td>
<td>416.3</td>
<td>418.1</td>
</tr>
</tbody>
</table>

*** from geotechnical data

### Table 4: Theoretical Scour Depths (ft) for the 500-yr Storm by Pier

<table>
<thead>
<tr>
<th>Pier</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring Number</td>
<td>B54</td>
<td>B61</td>
<td>B64</td>
<td>B66</td>
<td>B70</td>
<td>B77</td>
<td>B79</td>
</tr>
<tr>
<td>Modeled Bed Elevations***</td>
<td>430.5</td>
<td>427.9</td>
<td>432.3</td>
<td>434.3</td>
<td>437.6</td>
<td>434</td>
<td>430.2</td>
</tr>
<tr>
<td>Bed Rock Elevation***</td>
<td>330.5</td>
<td>331.4</td>
<td>333.8</td>
<td>333.3</td>
<td>334.3</td>
<td>335.8</td>
<td>334.7</td>
</tr>
<tr>
<td>Competent Rock Elevation***</td>
<td>329.7</td>
<td>331.4</td>
<td>331</td>
<td>333.1</td>
<td>334.3</td>
<td>335.5</td>
<td>334.5</td>
</tr>
<tr>
<td>Long-term (ft)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Contraction (ft)</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Local (ft)</td>
<td>11.0</td>
<td>14.5</td>
<td>17.4</td>
<td>18.8</td>
<td>18.4</td>
<td>19.6</td>
<td>13.3</td>
</tr>
<tr>
<td><strong>Total Scour (ft)</strong></td>
<td>12.9</td>
<td>16.3</td>
<td>19.2</td>
<td>20.6</td>
<td>20.3</td>
<td>21.4</td>
<td>15.1</td>
</tr>
<tr>
<td><strong>Total Scour Elevation</strong></td>
<td>417.6</td>
<td>411.6</td>
<td>413.1</td>
<td>413.7</td>
<td>417.3</td>
<td>412.6</td>
<td>415.1</td>
</tr>
</tbody>
</table>

*** from geotechnical data
Figure 3: Theoretical Scour for the 100-year Storm
3.2.2 Contraction Scour Component

Contraction scour was computed by spreadsheet using Laursen’s equations as recommended in HEC-18. Initially, critical velocity was completed using hydraulic properties for the bridge and approach sections from HEC-RAS output to determine whether the live-bed or clear-water scour equation was appropriate. The live-bed scour equation was determined to be applicable for the left overbank (Piers 1 - 7). The proposed bridge configuration spans the entire 100-yr floodplain and therefore does not contain abutment fills, so local abutment scour was not considered separately.

3.2.3 Local Scour Component

For the East End Bridge, local pier scour is clearly the controlling scour mechanism. Piers 1 - 7 each consist of two elliptical columns founded on drilled shafts to bedrock. For this reason, these piers were modeled as “simple” piers under the HEC-18 methodology.

The local pier scour equation recommended by HEC-18 contains correction factors for pier nose shape, angle of attack of flow, bed condition and armoring. The angle of attack for the piers was reported as resultant vectors in the two-dimensional FESWMS model relative to the centerline of the piers (see Pier Drag Report in Appendix B). Depending on the distance from the vector to the pier, the measured angle of attack varied from approximately 21 to 31 degrees.

The correction factor for bed condition ($K_3$) accounts for the fact that maximum scour may be 10 to 30 percent greater than computed by the local pier scour equation. The $K_3$ factor was set to 1.1, which corresponds to the most typical condition of plane-bed through small dunes (up to 9 m high).

HEC-18 recommends that new bridge piers and foundations be designed to accommodate the predicted scour, rather than attempt to protect the piers with scour countermeasures.
4.0 REFERENCES AND DATA SOURCES


APPENDIX A: BRIDGE AND APPROACH DRAWINGS
FIGURE 4
REVISED DESIGN OF SECTION 4 KY APPROACH STRUCTURE

RIVER APPROACH NORTH BOUND AND SOUTH BOUND
PIERS 1-4 PROPORTIONAL DESIGN AESTHETICS
APPENDIX B: GEOTECHNICAL DATA
## PIER DRAG REPORT

<table>
<thead>
<tr>
<th>Pier no.</th>
<th>Pier ID</th>
<th>Elem no.</th>
<th>Approach Flow Vel (m/s)</th>
<th>Approach Flow Depth (m)</th>
<th>Approach Flow Angle (deg)</th>
<th>Boring ID</th>
<th>Boring Depth (m)</th>
<th>D50 (mm)</th>
<th>D95 (mm)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Pier 1A</td>
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<td>0.098</td>
<td>1.709</td>
<td>28.237</td>
<td>B56</td>
<td>2.1 / 5.0</td>
<td>0.52</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Pier 1B</td>
<td>4605</td>
<td>0.127</td>
<td>2.437</td>
<td>24.615</td>
<td>B54</td>
<td>1.2 / 3.5</td>
<td>0.13</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Pier 2A</td>
<td>4113</td>
<td>0.328</td>
<td>7.524</td>
<td>21.329</td>
<td>B61</td>
<td>3</td>
<td>0.0053</td>
<td>0.26</td>
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<tr>
<td>4</td>
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<td>7.527</td>
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<td>B59/B62</td>
<td>3</td>
<td>0.0046</td>
<td>0.041</td>
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<td>5</td>
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<td>4.871</td>
<td>28.628</td>
<td>B64</td>
<td>3</td>
<td>0.0065</td>
<td>0.079</td>
</tr>
<tr>
<td>6</td>
<td>Pier 3B</td>
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<td>0.509</td>
<td>6.416</td>
<td>30.295</td>
<td>B66</td>
<td>4.6</td>
<td>0.041</td>
<td>0.31</td>
</tr>
<tr>
<td>7</td>
<td>Pier 4A</td>
<td>4120</td>
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<td>2.012</td>
<td>27.911</td>
<td>B66</td>
<td>3</td>
<td>0.007</td>
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<tr>
<td>8</td>
<td>Pier 4B</td>
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<td>4.672</td>
<td>25.462</td>
<td>B59/B62</td>
<td>3</td>
<td>0.0039</td>
<td>0.049</td>
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<td>Pier 5A</td>
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<td>0.818</td>
<td>3.537</td>
<td>26.507</td>
<td>B70</td>
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<td>0.04</td>
</tr>
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<td>10</td>
<td>Pier 5B</td>
<td>4617</td>
<td>0.828</td>
<td>4.156</td>
<td>30.134</td>
<td>B71</td>
<td>3</td>
<td>0.038</td>
<td>0.05</td>
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<td>11</td>
<td>Pier 6A</td>
<td>4626</td>
<td>0.916</td>
<td>6.095</td>
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<td>B72</td>
<td>3</td>
<td>0.069</td>
<td>0.32</td>
</tr>
<tr>
<td>12</td>
<td>Pier 6B</td>
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<td>27.062</td>
<td>B77</td>
<td>3</td>
<td>0.025</td>
<td>0.32</td>
</tr>
</tbody>
</table>

**Data Sources**

Hydraulic: SMS/FESWMS 100yr and 500 yr, WSA 9/20/2011
Geotech: Draft Grain Size Summary Table/Boring Logs, Stantec, 10/4/2011

---

**East End Bridge-Section 4 Boring Plan**

![East End Bridge-Section 4 Boring Plan Image](image-url)
<table>
<thead>
<tr>
<th>Bearing Location</th>
<th>Depth Interval</th>
<th>Classification</th>
<th>Dn (mm)</th>
<th>D0 (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-65</td>
<td>177th to 186th</td>
<td>CL</td>
<td>4.6</td>
<td>1.7</td>
</tr>
<tr>
<td>B-70</td>
<td>186th to 192th</td>
<td>CL</td>
<td>4.6</td>
<td>1.7</td>
</tr>
<tr>
<td>B-75</td>
<td>192th to 198th</td>
<td>CL</td>
<td>4.6</td>
<td>1.7</td>
</tr>
<tr>
<td>B-77</td>
<td>198th to 204th</td>
<td>CL</td>
<td>4.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

1 NA = Represents 200 Wash Gradient, a complete classification was not performed.
### GEOLOGIST'S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Jefferson - LSIORB East End Approach**

**Project Manager:** Mark Litkenhus  
**Project Type:** Structure State Bridge

---

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Date</th>
<th>Rig Number</th>
<th>Log Type</th>
<th>Depth</th>
<th>Lithology</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>08/31/2011</td>
<td>1050 ATV</td>
<td>GO-1211</td>
<td>168.0'</td>
<td>Jefferson - Laurel Dolomite</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- **Overburden:**
  - Initial overburden, static water depth not recorded.
  - Static water depth not recorded.

**Location:**
- **Surface Elevation:** 463.6'
- **Total Depth:** 168.0'
- **Latitude:** 38.335918
- **Longitude:** -85.635784

**Static Water Depth:**
- NA

**Immediate Water Depth:**
- 32.2' (08/31/11)

---

**Printed:** 9/30/11  
**Page 2 of 4**
### GEOLOGIST'S SUBSURFACE LOG

**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Project Type:** Structure  
**State Bridge**  
**Project Manager:** Mark Litkenhus

---

**Hole Number 51**  
**Surface Elevation:** 465.4'  
**Total Depth:** 158.7'  
**Location:** 167+84.96  
**Latitude(83):** 38.336011  
**Longitude(83):** -85.635526  
**Driller:** Danny Jessie  
**Drilling mud added to the boring at a depth of 35.0 ft below the ground surface @ 35**

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (R)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overburden</td>
<td>Clay, brown, moist, some sand.</td>
<td>1</td>
<td>2.0-4.0</td>
<td>2.0</td>
<td>ST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.</td>
<td>2</td>
<td>5.0-7.0</td>
<td>2.0</td>
<td>ST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, right brown, moist, fine grained.</td>
<td>3</td>
<td>10.0-12.0</td>
<td>2.0</td>
<td>ST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.</td>
<td>4</td>
<td>30.0-31.5</td>
<td>0.6</td>
<td>3-3-2</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.</td>
<td>5</td>
<td>35.0-36.5</td>
<td>0.1</td>
<td>1-2-1</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.</td>
<td>6</td>
<td>40.0-41.5</td>
<td>0.1</td>
<td>0-0-0</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.</td>
<td>7</td>
<td>45.0-46.5</td>
<td>1.0</td>
<td>1-2-4</td>
<td>SPT</td>
<td></td>
</tr>
</tbody>
</table>

---

**Remarks**:
- Overburden: Clay, brown, moist, some sand.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
- Overburden: Sand, brown, moist, fine grained, very loose to dense, some silt, some gravel.
**Overburden:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

Limestone & Shale:
- Limestone (70%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (30%), gray, silty.

**Remarks:**
- **Vertical Fracture:** @ 129.3-129.7
- **RCS-1:** @ 145.6-146.2
- **RCS-2:** @ 153.3-154.8

**Lithology:**
- **Limestone & Shale:** Limestone (70%), gray, fine grained, hard; thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (30%), gray, silty.
### Overburden

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Overburden Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Lithology

- **Overburden:** overburden

#### Remarks

- Drilling mud added to the boring at a depth of 4.8 ft below the ground surface at 40 ft.
- Boring advanced with 4.25" augers @ 1 ft below the ground surface @ 3.

---

### Drilling Firm: Stantec

For: Division of Structural Design
Geotechnical Branch

---

### Project Information

**Project Type:** Structure State Bridge
**Project Manager:** Mark Litkenhus
**Project ID:** UNKNOWN
**Item Number:** 5-731.00

---

### Driller

Danny Jessie

---

### Drilling Parameters

- **Surface Elevation:** 465.5'
- **Total Depth:** 159.3'
- **End Date:** 09/07/2011
- **Location:** 167+84.96 6.0' Rt.
- **Latitude:** 38.336060
- **Longitude:** -85.635503

---

### Static Water Depth

- **NA**

---

### Immediate Water Depth

- **35.6 (09/07/11)**

---

### Top of Rock

- **128.6'**
- **Base Weathered Rock:** 131.2'
- **Elevation:** 334.7'

---

### Base Weathered Rock

- **131.2'**
- **Elevation:** 334.7'

---

### Hole Information

- **Hole Number:** 52
- **Reg. Number:** 556 ATV
- **Driller:** Danny Jessie
- **Geologist:** James Adams

---

### Drilling System

- **Drilling mud added to the boring at a depth of 4.8 ft below the ground surface at 40 ft.**
- **Boring advanced with 4.25" augers @ 1 ft below the ground surface @ 3.**

---

### Data Log

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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</tr>
</tbody>
</table>

---

### Lithology

- **Overburden:** overburden

---

### Remarks

- Drilling mud added to the boring at a depth of 4.8 ft below the ground surface at 40 ft.
### Lithology

<table>
<thead>
<tr>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone &amp; Shale</td>
<td>overburden</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
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</table>

### Overburden

- **Location**: 167+84.96 6.0' Rt.
- **Surface Elevation**: 465.5’
- **Total Depth**: 159.3’
- **Driller**: Danny Jessie
- **Geologist**: James Adams

### RQD Table

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>RQD</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone &amp; Shale</td>
<td></td>
<td>46 / 12</td>
<td>4.5</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 / 35</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 / 46</td>
<td>11.3</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 / 46</td>
<td>11.3</td>
<td>100</td>
</tr>
</tbody>
</table>

### Remarks

- **Base Weathered Rock**: 131.2’
- **Top of Rock**: 128.6’
- **Louisville Limestone**: Elevation = 334.7’
- **Laurel Dolomite**: Elevation = 334.7’

---

**DRAFT**
<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overburden</strong></td>
<td>Clay, brown, moist, sand.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Overburden</strong></td>
<td>Sand, brown to gray, wet to medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>1</td>
<td>15.0-15.5</td>
<td>1.1</td>
<td>2-4-2</td>
<td>SPT</td>
<td></td>
<td><strong>Overburden</strong></td>
<td>Silt, light brown, wet, fine grained,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>2</td>
<td>15.0-25.0</td>
<td>0.5</td>
<td>4-6-7</td>
<td>SPT</td>
<td></td>
<td><strong>Overburden</strong></td>
<td>Silt, light brown, wet, fine grained,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>3</td>
<td>25.0-35.0</td>
<td>0.5</td>
<td>3-4-3</td>
<td>SPT</td>
<td></td>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>4</td>
<td>30.0-35.0</td>
<td>0.7</td>
<td>0-1-0</td>
<td>SPT</td>
<td></td>
<td></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>5</td>
<td>35.0-35.0</td>
<td>0.6</td>
<td>0-1-0</td>
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<td>Sand, brown, fine to medium</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>6</td>
<td>40.0-41.5</td>
<td>1.0</td>
<td>6-8-10</td>
<td>SPT</td>
<td></td>
<td></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overburden</strong></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td>7</td>
<td>45.0-46.5</td>
<td>1.0</td>
<td>9-24-21</td>
<td>SPT</td>
<td></td>
<td></td>
<td>Sand, brown, fine to medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- **DRAFT:** Drilling mud added to the boring at a depth of 5.0 ft below the ground surface @ 55.
**Overburden**: Clay, gray, wet, fine-grained, stiff, some sand.

**Limestone & Shale**: Limestone (60%), gray, fine-grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.

---

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Elevation</th>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overburden</td>
<td>Clay, gray, wet, fine-grained, stiff, some sand.</td>
<td>105.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Sand, brown to gray, wet, fine to medium grained; medium dense to very dense, poorly grained, some gravel.</td>
<td>115.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Limestone & Shale**: Limestone (60%), gray, fine-grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.

**Remarks**: Fossiliferous @ 150.6-150.9

---

**RCS-2 @ 167.9'**

**Remarks**: Base Weathered Rock = 127.2'; Elevation = 336.0'.
### GEOLOGIST'S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**For:** Division of Structural Design  
**Geotechnical Branch**

**Hole Number:** 54  
**Start Date:** 09/12/2011  
**End Date:** 09/13/2011  
**Rig Number:** 1050 ATV

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST-1</td>
<td>2.0-4.0</td>
<td>2.0</td>
<td>ST</td>
<td></td>
</tr>
<tr>
<td>ST-2</td>
<td>10.0-11.5</td>
<td>0.9</td>
<td>6-2-2</td>
<td></td>
</tr>
<tr>
<td>ST-3</td>
<td>15.0-16.5</td>
<td>0.8</td>
<td>3-1-1</td>
<td></td>
</tr>
<tr>
<td>ST-4</td>
<td>30.0-31.5</td>
<td>0.7</td>
<td>4-6-7</td>
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<tr>
<td>ST-5</td>
<td>35.0-36.5</td>
<td>1.5</td>
<td>4-9-14</td>
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</tr>
<tr>
<td>ST-6</td>
<td>30.0-31.5</td>
<td>0.6</td>
<td>6-5-8</td>
<td></td>
</tr>
<tr>
<td>ST-7</td>
<td>35.0-36.5</td>
<td>0.7</td>
<td>9-8-7</td>
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<tr>
<td>ST-8</td>
<td>40.0-41.5</td>
<td>1.5</td>
<td>8-11-17</td>
<td></td>
</tr>
<tr>
<td>ST-9</td>
<td>45.0-46.5</td>
<td>1.5</td>
<td>10-13-17</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:** Boring was advanced with 4-2.5" auger @ 1
QW coring system utilized to sample bedrock @ 3
Boring was stalled on slopes, dozer work was needed to clear a path to stake, elevation change of 2.0’ due to dozer cut @ 6
Drilling mud added to the boring @ a depth of 2.0’ below ground surface @ 20

---

**Lithology:** Sand, brown, moist, fine to medium grained, very loose to medium dense, some clay, some gravel.

**Overburden:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
<td>ST-10</td>
<td>90.0-101.5</td>
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<td>9-16-16</td>
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<tr>
<td>ST-11</td>
<td>55.0-65.5</td>
<td>1.5</td>
<td>16-18-18</td>
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<td>ST-12</td>
<td>60.0-61.5</td>
<td>1.5</td>
<td>10-8-13</td>
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</tr>
<tr>
<td>ST-13</td>
<td>65.0-66.5</td>
<td>1.5</td>
<td>17-8-13</td>
<td></td>
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<tr>
<td>ST-14</td>
<td>70.0-71.5</td>
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<td>18-30-31</td>
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<td>ST-15</td>
<td>75.0-76.5</td>
<td>1.0</td>
<td>15-18-27</td>
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<td>ST-16</td>
<td>80.0-81.5</td>
<td>1.0</td>
<td>13-15-15</td>
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<tr>
<td>ST-17</td>
<td>85.0-86.5</td>
<td>1.5</td>
<td>12-13-13</td>
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<tr>
<td>ST-18</td>
<td>90.0-91.5</td>
<td>1.5</td>
<td>17-8-17</td>
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<tr>
<td>ST-19</td>
<td>95.0-96.5</td>
<td>1.5</td>
<td>10-8-30</td>
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</tr>
</tbody>
</table>

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Overburden:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

---

**Lithology:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.

**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel.
### GEOLOGIST'S SUBSURFACE LOG

#### Project ID: UNKNOWN  Item Number: 5-731,00

**Jefferson - LS1OB East End Approach**

**Project Type:** State Bridge  
**Project Manager:** Mark Litkenhus

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>End Date</th>
<th>Hole Type</th>
<th>RQD</th>
<th>Lithology</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>17.8</td>
<td>09/12/2011</td>
<td>09/12/2011</td>
<td>Core and sample</td>
<td>80</td>
<td>Limestone &amp; Shale: Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.</td>
<td></td>
</tr>
</tbody>
</table>

**Elevation Depth**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Rock Core</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>7.5</td>
<td>7.0</td>
<td>93</td>
</tr>
<tr>
<td>37</td>
<td>7</td>
<td>5.9</td>
<td>5.9</td>
<td>100</td>
</tr>
<tr>
<td>45</td>
<td>8</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>68</td>
<td>9</td>
<td>7.3</td>
<td>7.3</td>
<td>100</td>
</tr>
</tbody>
</table>

**Overburden:**

- Limestone & Shale: Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.

**Top of Rock:** 100.0' Base Weathered Rock = 100.8' VOD = 100.8'  
**Limestone:** Elevation = 330.5'  
**Laurel Dolomite:** Elevation = 330.5'  

---

**GEOLOGIST'S SUBSURFACE LOG**

#### Project ID: UNKNOWN  Item Number: 5-731,00

**Jefferson - LS1OB East End Approach**

**Project Type:** State Bridge  
**Project Manager:** Mark Litkenhus

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>End Date</th>
<th>Hole Type</th>
<th>RQD</th>
<th>Lithology</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>17.8</td>
<td>09/12/2011</td>
<td>09/12/2011</td>
<td>Core and sample</td>
<td>80</td>
<td>Limestone &amp; Shale: Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.</td>
<td></td>
</tr>
</tbody>
</table>

**Elevation Depth**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Rock Core</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>7.5</td>
<td>7.0</td>
<td>93</td>
</tr>
<tr>
<td>37</td>
<td>7</td>
<td>5.9</td>
<td>5.9</td>
<td>100</td>
</tr>
<tr>
<td>45</td>
<td>8</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>68</td>
<td>9</td>
<td>7.3</td>
<td>7.3</td>
<td>100</td>
</tr>
</tbody>
</table>

**Overburden:**

- Limestone & Shale: Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.

**Top of Rock:** 100.0' Base Weathered Rock = 100.8' VOD = 100.8'  
**Limestone:** Elevation = 330.5'  
**Laurel Dolomite:** Elevation = 330.5'  

---

**Remarks:**

- Drilling advanced with 4.25" auger @ 1 ft to collect sample bedrock @ 3 ft. Drilling was halted on slope, dozer work was needed to clear a path to stake. Drilling moved ahead a station 8.0' from stake to provide working area. Elevation change of 3.0' due to dozer cut @ 6 ft.

- Drilling mud added to the boring at a depth of 38.0 ft below the ground surface @ 30 ft.
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>RQD</th>
<th>Lithology</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-70</td>
<td></td>
<td>Limestone</td>
<td></td>
</tr>
<tr>
<td>75-100</td>
<td></td>
<td>Shale</td>
<td></td>
</tr>
</tbody>
</table>

**Lithology Description**

- **Overburden**: Limestone & Shale
  - Limestone (70%), gray, fine grained sand, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (30%), gray, silty.

**Sample Data**

- **Sample No.**: 38 / 38
- **Rec. (%)**: 7.8
- **SDI (JS)**: 10

**Location**: 170+17.96 6.0' Lt.

**Remarks**: Overburden: overburden.
## GEOLOGIST'S SUBSURFACE LOG

### Project ID: UNKNOWN

**For: Division of Structural Design**

**Geotechnical Branch**

**Printed: 9/30/11**

**Top of Rock: 106.2'**

**Base Weathered Rock: 106.2'**

**Elevation: 332.9'**

**Louisville Limestone**

**Laural Dolomite**

---

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>Rig Number</th>
<th>Hole Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>26.0 (09/09/11)</td>
<td>09/08/2011</td>
<td>1050 ATV</td>
<td>core and sample</td>
<td></td>
</tr>
</tbody>
</table>

### Immediate Water Depth

- **26.0 (09/09/11)**

### Surface Elevation

- **439.1'**

### Static Water Depth

- **NA**

### Total Depth

- **136.7'**

### Driller

- **Danny Jessie**

### Geologist

- **James Adams**

### Drilling Firm: Stantec

### Project Manager: Mark Likenhus

---

### Lithology

#### Overburden

- **Sand, brown, moist, fine to medium gravel, loose to medium dense, some clay, some gravel.**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0-4.0</td>
<td>1.5</td>
<td>ST</td>
<td></td>
</tr>
<tr>
<td>5.0-7.0</td>
<td>1.0</td>
<td>ST</td>
<td></td>
</tr>
<tr>
<td>7.0-8.5</td>
<td>1.0</td>
<td>7-4-6</td>
<td></td>
</tr>
<tr>
<td>10.0-11.5</td>
<td>1.0</td>
<td>12-8-1</td>
<td>SPT</td>
</tr>
<tr>
<td>15.0-16.5</td>
<td>0.5</td>
<td>3-2-5</td>
<td>SPT</td>
</tr>
<tr>
<td>20.0-21.5</td>
<td>0.5</td>
<td>4-2-2</td>
<td>SPT</td>
</tr>
<tr>
<td>25.0-26.5</td>
<td>1.2</td>
<td>4-5-5</td>
<td>SPT</td>
</tr>
<tr>
<td>30.0-31.5</td>
<td>1.5</td>
<td>7-5-7</td>
<td>SPT</td>
</tr>
<tr>
<td>35.0-36.5</td>
<td>1.5</td>
<td>13-10-10</td>
<td>SPT</td>
</tr>
<tr>
<td>40.0-41.5</td>
<td>1.5</td>
<td>10-6-8</td>
<td>SPT</td>
</tr>
<tr>
<td>45.0-46.5</td>
<td>1.5</td>
<td>10-9-10</td>
<td>SPT</td>
</tr>
</tbody>
</table>

---

**DRAFT**

---

**OLIVARI**

**Top of Rock = 106.2'**

**Base Weathered Rock = 106.2'**

**Elevation = 332.9'**

**Louisville Limestone**

**Laural Dolomite**
Overburden: Sand, brown to gray, wet, fine to medium grained, loose to very dense, poorly graded, some gravel.  

Limestone & Shale: Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.  

Boring advanced with 4.25" augers @ 1 NO. coring system utilized to sample bedrock @ 3.  
Boring was dislodged on slope, disassembled, work needed to clear a path to stake, boring offset 8.5' from stake to provide working area, elevation change 3.2' due to dozer cut @ 8.  

Drilling mud added to the boring at a depth of 45.0 ft below the ground.  

Top of Rock: 106.2' Base Weathered Rock: 106.2' TD = 106.2'  
Elevation = 312.9'  

Louisiana Limestones  
Laurin Dolomite  

RCS-1 @ 115.8-116.6  
Soft zone @ 116.6-116.8  
Fossiliferous @ 127-127.3  

RCS-2 @ 129.6-130.3  

Elevation Depth  
Std/Ky  

RQD  

Lithology  

Sample No.  
Depth (ft)  
Rec. (%)  
SPT Blows  
Sample Type  
Remarks  

Oberburden  

Rock Core SDI (JS)  

SPT  

DRAFT
### GEOLOGIST'S SUBSURFACE LOG

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Static Water Depth</th>
<th>End Date</th>
<th>Start Date</th>
<th>Rig Number</th>
<th>Hole Type</th>
<th>Project Type</th>
<th>Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>43.2'</td>
<td>NA</td>
<td>09/08/11</td>
<td>09/08/11</td>
<td>1050 ATV</td>
<td>Core</td>
<td>Structure</td>
<td>Mark Litkenhus</td>
</tr>
</tbody>
</table>

**Location:** 170+18.46 69.0' Rt.  
**Surface Elevation:** 443.9'  
**Total Depth:** 152.0'  
**Static Water Depth:** NA  
**Immediate Water Depth:** 43.2' (09/08/11)  
**Driller:** Danny Jessie  
**Geologist:** James Adams  
**Latitude:** 38.336661  
**Longitude:** -85.635917  
**Start Date:** 09/08/2011  
**End Date:** 09/08/2011  
**Driller:** Danny Jessie  
**Geologist:** James Adams  

### Description:

- **Overburden:** overburden.  
- **Louisville Limestone & Shale:** Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings, fossiliferous. Shale (40%), gray, silty.  

### Lithology:

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Rec. (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>0</td>
<td>105</td>
<td>105</td>
<td>105</td>
<td>SDI (JS)</td>
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</tr>
<tr>
<td>10</td>
<td>32.6</td>
<td>111.3</td>
<td>111.3</td>
<td></td>
<td>(Begin Core)</td>
</tr>
<tr>
<td>5</td>
<td>16/16</td>
<td>5.7</td>
<td>5.7</td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>40/35</td>
<td>10.0</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>64/58</td>
<td>10.0</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>88/88</td>
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<td>10.0</td>
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<tr>
<td>94</td>
<td>94/94</td>
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</table>
**Elevation Depth**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 / 20</td>
<td>10 / 10</td>
<td>SDI</td>
<td></td>
</tr>
<tr>
<td>42 / 34</td>
<td>10 / 10</td>
<td>RQD</td>
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</tr>
<tr>
<td>68 / 68</td>
<td>9.0 / 8.0</td>
<td>Rec. (%)</td>
<td></td>
</tr>
<tr>
<td>99.0</td>
<td>100</td>
<td>Rec. (%)</td>
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</table>

**Lithology**

<table>
<thead>
<tr>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overburden</td>
<td>0 / 15.3</td>
<td></td>
</tr>
<tr>
<td>Limestone &amp; Shale</td>
<td>96-97</td>
<td></td>
</tr>
</tbody>
</table>

**Geologist**

James Adams

**Rig Number**

1050 ATV

**Hole Number**

58

**Surface Elevation**

429.0’

**Total Depth**

136.0’

**Start Date**

08/26/2011

**End Date**

08/29/2011

**Static Water Depth**

NA

**Immediate Water Depth**

15.3 (08/29/11)

**Surface Elevation**

429.0’

**Total Depth**

136.0’

**Location**

172+84.96  86.0’ Lt.

**Latitude**

38.336929

**Longitude**

-85.636964

**Hole Type**

core

**Sample Type**

Rock Core SDI

**Run**

18 / 18

**Sample No.**

55 / 55

**Depth**

96.0

**Overburden**

Limestone (60%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings. Shale (40%), gray, silty.

**Remark**

Soft Zone @ 105.1-105.2

**RCS-1 @ 112-112.8

**RCS-2 @ 129.6-130.6

**Bottom of Hole 136.0’
# GEOLOGIST'S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Project Type:** Structure  
**State Bridge**  
**Start Date:** 08/29/2011  
**End Date:** 08/30/2011  
**Driller:** -631.00  
**Rig Number:** GQ-1211  
**Latitude:** 38.337077  
**Longitude:** -85.636758  

---

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>End Date</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>15.2 (08/29/11)</td>
<td></td>
<td></td>
<td>38</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td>57</td>
<td>2.0</td>
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<td>71</td>
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</tr>
<tr>
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<td></td>
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<td>125</td>
<td>2.0</td>
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</tr>
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<td></td>
<td></td>
<td>149</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>172</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**PROJECT MANAGER:** Mark Likenhus

---

## DRAFT

**Overburden:** Clay, brown, moist, very loose to stiff, some sand.

**Description:**

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth</th>
<th>Rock Core</th>
<th>StkY</th>
<th>RQD</th>
<th>Run (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>427.3</td>
<td>1.0</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>411.3</td>
<td>17.0</td>
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<td></td>
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<td>403.3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Overburden:** Sand, brown and gray, wet, fine to medium grained, very loose to dense, some clay.

**Depth:** 17.0 ft

**Remarks:**

- Boring: advanced with 4-2" auger & 1 HQ coring system utilized to sample bedrock @ 3
- Depth of 17.0 ft below the ground surface @ 17

---

**Overburden:** Clay, dark gray, wet, stiff to hard, some silt.

**Description:**

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth</th>
<th>Rock Core</th>
<th>StkY</th>
<th>RQD</th>
<th>Run (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>348.3</td>
<td>80.0</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>332.7</td>
<td>95.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Overburden:** Sand, brown to gray, wet, fine to medium grained, dense to very dense, poorly graded, some gravel.

**Depth:** 95-96 ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone & Shale: Limestone (40%), gray, fine grained sandstone, fine medium to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (40%), gray, very thin.

**Depth:** 96-98 ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 98+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in

---

**Overburden:** Limestone: Medium to coarse grained sandstone, fine to medium banded, shale breaks, stringers and partings, fossiliferous. Shale (20%), gray, very thin.

**Depth:** 100+ ft

**Remarks:**

- Rock in
DRAFT

Limestone & Shale: Limestone (85%), gray, fine grained, hard; shale (15%); medium bedded, shale interbeds, stringers and partings, fossiliferous, Sheep (45%), gray, stringer.

24 / 23
10.0 10.0 100

Highly fractured, soft zone @ 103.5-104.5

Bottom of Hole 125.7

Overburden: overburden.

DRAFT

Boring advanced with 4.25" auger @ 1 RQD system utilized to sample bedrock @ 3

Drilling mud aid to the boring at a depth of 17.0 ft below the ground surface @ 17
<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone &amp; Shale</td>
<td>Limestone (70%), gray, fine grained, firm to medium bedded, shale, shales, stringers and partings, fossiliferous. Shale (30%), gray, silt.</td>
<td>Overburden</td>
<td></td>
<td>105-110</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>115-120</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>125-130</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>overburden.</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Lithology:**

- Limestone & Shale:
  - Limestone (70%), gray, fine grained, firm to medium bedded, shale, shales, stringers and partings, fossiliferous. Shale (30%), gray, silt.

**Remarks:**

- Overburden: overburden.

---

**Lithology:**

- Base Weathered Rock + 96.2'
- ROZ = 96.2'
- LGZ = 96.2'
- Louisville Limestone
- Elevation = 331.7'

**Remarks:**

- Base Weathered Rock + 96.2'
- ROZ = 96.2'
- LGZ = 96.2'
- Louisville Limestone
- Elevation = 331.7'

---

**Lithology:**

- Top of Rock = 96.2'
- Base Weathered Rock + 96.2'
- ROZ = 96.2'
- LGZ = 96.2'
- Louisville Limestone
- Elevation = 331.7'

**Remarks:**

- Top of Rock = 96.2'
- Base Weathered Rock + 96.2'
- ROZ = 96.2'
- LGZ = 96.2'
- Louisville Limestone
- Elevation = 331.7'
<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>426.9</td>
<td>Sand, brown, moist, sandy</td>
<td>Overburden: Clay, brown, moist, sandy</td>
<td>1</td>
<td>2.0-4.0</td>
<td>2.0</td>
<td>ST</td>
<td></td>
<td></td>
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<tr>
<td>412.9</td>
<td>Sand, brown, wet, fine to medium</td>
<td>Overburden: Clay, brown, moist, sandy</td>
<td>2</td>
<td>5.0-7.0</td>
<td>2.0</td>
<td>ST</td>
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<tr>
<td>424.9</td>
<td>Sand, brown, wet, fine to medium</td>
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<td>3</td>
<td>10.0-12.0</td>
<td>2.0</td>
<td>ST</td>
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<td>452.9</td>
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<td>4</td>
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<td>ST</td>
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<td>424.9</td>
<td>Sand, brown, wet, fine to medium</td>
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<td>5</td>
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<tr>
<td>385.7</td>
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<td>30.0-31.5</td>
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<td>7-10-12</td>
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<tr>
<td>311.4</td>
<td>Sand, brown, wet, fine to medium</td>
<td>Overburden: Clay, brown, moist, sandy</td>
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<td>35.0-36.5</td>
<td>1.3</td>
<td>5-6-7</td>
<td>SPT</td>
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<tr>
<td>330.9</td>
<td>Sand, brown, wet, fine to medium</td>
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<td>40.0-41.5</td>
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<td>480</td>
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<tr>
<td>64</td>
<td>Limestone &amp; Shale</td>
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<tr>
<td>311.4</td>
<td>Limestone (60%)</td>
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<tr>
<td>64</td>
<td>Sandstone, (60%)</td>
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</tbody>
</table>
### Lithology

**Description**

- **Overburden**: Topsoil
- **Overburden**: Clay, brown, moist, sandy
- **Overburden**: Sand, brown, moist, fine to medium grained, very loose to medium dense, some gravel, some clay
- **Overburden**: Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly graded, some gravel.

### Comments

- **Remarks**: Boring advanced with 4.25" auger @ 1 HP, coring system utilized to sample bedrock @ 3
- **Remarks**: Drilling mud added to the boring at a depth of 24.0 ft below the ground surface @ 20
- **Remarks**: Top of Hole 137.0'
GEOLOGIST'S SUBSURFACE LOG

Project ID: UNKNOWN
Item Number: 5-731.00
Jefferson - LSIOB East End Approach
Project Type: Structure State Bridge
Project Manager: Mark Litkenhus

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>Hole Type</th>
<th>Reg Number</th>
<th>Surface Elevation</th>
<th>Static Water Depth</th>
<th>End Date</th>
<th>Rig Number</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>17.5 (08/29/11)</td>
<td>08/19/2011</td>
<td>core and sample</td>
<td>1050 ATV</td>
<td>421.5'</td>
<td>NA</td>
<td>08/22/2011</td>
<td>1050 ATV</td>
<td>175+59.96 86.9' LL</td>
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</tbody>
</table>

**Overburden**: Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly graded, some gravel.

**Lithology**: Rock Core SDI

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
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<td></td>
</tr>
<tr>
<td>10</td>
<td>0.5-15.5</td>
<td>1.5-10</td>
<td>100</td>
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</tbody>
</table>

**DRAFT**

**Remarks**

- **Limestone & Shale**: Limestone (60%), gray, fine grained, medium bedded, shale streaks, stringers and partings. Shale (40%), gray, shiny.

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>5.5-15.5</td>
<td>1.5-10</td>
<td>100</td>
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**Lithology**: Rock Core SDI

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>20</td>
<td>5.5-15.5</td>
<td>1.5-10</td>
<td>100</td>
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</table>

**DRAFT**

**Remarks**

- **Limestone & Shale**: Limestone (60%), gray, fine grained, medium bedded, shale streaks, stringers and partings. Shale (40%), gray, shiny.

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>5.5-15.5</td>
<td>1.5-10</td>
<td>100</td>
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</table>

**Lithology**: Rock Core SDI

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>5.5-15.5</td>
<td>1.5-10</td>
<td>100</td>
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</table>
Boring advanced with 4.25" augers @ 1 NQ coring system utilized to sample bedrock @ 3. Drilling mud added to the boring at a depth of 20.0 ft below the ground surface @ 20.

Overburden:

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Rec (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>9.0</td>
<td>99.6</td>
<td>100</td>
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</tr>
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Drilling Firm: Stantec
For: Division of Structural Design
Geotechnical Branch

Printed: 9/30/11
Page 1 of 3

Project ID: UNKNOWN
Item Number: 5-731.00
Jefferson - LSIOB East End Approach
Project Type: Structure State Bridge
Project Manager: Mark Litkenhus

Hole Number: 63
Surface Elevation: 432.2'
Immediate Water Depth: 19.3 (08/22/11)
End Date: 08/23/2011
Rig Number: 1050 ATV

Location: 175+59.96 6.0' Lt.
Geologist: James Adams

Overburden:

- Overburden
- Overburden

Base Weathered Rock = 99.6'
Elevation = 333.6'
Louisville Limestone

DRAFT

Printed: 9/30/11
Page 2 of 3

Project ID: UNKNOWN
Item Number: 5-731.00
Jefferson - LSIOB East End Approach
Project Type: Structure State Bridge
Project Manager: Mark Litkenhus

Hole Number: 63
Surface Elevation: 432.2'
Immediate Water Depth: 19.3 (08/22/11)
End Date: 08/23/2011
Rig Number: 1050 ATV

Location: 175+59.96 6.0' Lt.
Geologist: James Adams

Base Weathered Rock = 99.6'
Elevation = 333.6'
Louisville Limestone

DRAFT
### GEOLOGIST'S SUBSURFACE LOG

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>SPT Blows</th>
<th>Rock Core Sample No.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1-0</td>
<td>1-5</td>
<td>1</td>
<td>Overburden: Topsoil. Boring advanced with 4.25&quot; auger @ 1 ft, HQ coring system utilized to sample bedrock @ 3</td>
</tr>
<tr>
<td>1-2-1</td>
<td>6-10</td>
<td>2</td>
<td>Overburden: Clay, brown, moist, sandy.</td>
</tr>
<tr>
<td>2-3-3</td>
<td>11-15</td>
<td>3</td>
<td>Overburden: Sand, brown, wet, medium to fine grained, very loose, some clay.</td>
</tr>
<tr>
<td>3-4-3</td>
<td>16-20</td>
<td>4</td>
<td>Overburden: Sand, brown, wet, fine to medium grained, loose, some gravel.</td>
</tr>
<tr>
<td>4-5-3</td>
<td>21-25</td>
<td>5</td>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly graded, some gravel.</td>
</tr>
<tr>
<td>5-6-3</td>
<td>26-30</td>
<td>6</td>
<td>Overburden: Sand, brown, medium to fine grained, very loose, some clay.</td>
</tr>
</tbody>
</table>

#### Lithology
- **Limestone & Shale**: Limestone (70%), gray, medium grained, hard, thin to medium bedded, shale streaks, stringers and partings. Shale (30%), gray, silty.

#### Drilling Details
- **Rig Number**: 1050 ATV
- **Hole Number**: 64
- **Surface Elevation**: 432.3'
- **Total Depth**: 128.5'
- **End Date**: 08/24/2011
- **Latitude**: 38.337656
- **Longitude**: -85.637376
- **Start Date**: 08/23/2011
- **Driller**: Danny Jessie

---

**Diagram**: The diagram shows the drilling progress with various depths marked. The depth intervals and corresponding SPT blows are indicated, along with the rock core sample numbers and remarks.
**GEOLOGIST'S SUBSURFACE LOG**

**Project ID:** UNKNOWN
**Project Type:** Structure State Bridge
**Project Manager:** Mark Litkenhus

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>7</td>
<td>10.0-11.5</td>
<td>1.5</td>
<td>3-7-14</td>
<td>SPT</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>10.5-11.5</td>
<td>1.5</td>
<td>4-6-12</td>
<td>SPT</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10.0-11.5</td>
<td>1.5</td>
<td>10-18-25</td>
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<td></td>
<td>10</td>
<td>10.5-11.5</td>
<td>0.4</td>
<td>4-4-4</td>
<td>SPT</td>
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<td>10.0-11.5</td>
<td>1.0</td>
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<td>SPT</td>
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<tr>
<td></td>
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<td>10.0-11.5</td>
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<td>8-9-12</td>
<td>SPT</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>10.0-11.5</td>
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<td>SPT</td>
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<tr>
<td></td>
<td>14</td>
<td>85.0-86.5</td>
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<td>4-6-13</td>
<td>SPT</td>
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<td></td>
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<td>90.0-91.5</td>
<td>0.2</td>
<td>0-0-0</td>
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<td></td>
<td>16</td>
<td>95.0-96.5</td>
<td>0.8</td>
<td>3-3-5</td>
<td>SPT</td>
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</table>

**Lithology Description:**

- **Overburden:** Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly consolidated, some gravel.
- **Rock Core:**
  - SPT blow counts.
  - SPT type: Standard Penetration Test.

**Remarks:**

- **DRAFT**

---

**GEOLOGIST'S SUBSURFACE LOG**

**Project ID:** UNKNOWN
**Project Type:** Structure State Bridge
**Project Manager:** Mark Litkenhus

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>64</td>
<td>20</td>
<td>6.5-7.0</td>
<td>1.0</td>
<td>3-7-14</td>
<td>SPT</td>
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<tr>
<td></td>
<td>26</td>
<td>10.0</td>
<td>9.1</td>
<td>91</td>
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**Lithology Description:**

- **Limestone & Shale:** Limestone (80%), gray, medium grained sandstone, medium bedded, shale streaks, stringers and partings. Shale (40%), gray, silty.
- **Sand, dark brown, wet, fine grained, very loose to medium dense, some silt, some gravel.**

**Remarks:**

- **DRAFT**

---

**Lithology Description:**

- **Overburden:** Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly consolidated, some gravel.
- **Rock Core:**
  - SPT blow counts.
  - SPT type: Standard Penetration Test.

**Remarks:**

- **DRAFT**

---

**Lithology Description:**

- **Overburden:** Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly consolidated, some gravel.

**Remarks:**

- **DRAFT**

---

**Lithology Description:**

- **Overburden:** Sand, brown to gray, wet, fine to medium grained, very loose to very dense, poorly consolidated, some gravel.

**Remarks:**

- **DRAFT**
**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**

### GEOLOGIST'S SUBSURFACE LOG

<table>
<thead>
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<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Elevation</td>
<td>Depth</td>
<td>Rock Core</td>
<td>Std/Ky RQD</td>
<td>Run (%)</td>
<td>Rec (%)</td>
<td>SDI (%)</td>
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**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**

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**For:** Division of Structural Design  
**Geotechnical Branch**

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**For:** Division of Structural Design  
**Geotechnical Branch**

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**Geotechnical Branch**

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**For:** Division of Structural Design  
**Geotechnical Branch**

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**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**

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<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>Depth</td>
<td>Rock Core</td>
<td>Std/Ky RQD</td>
<td>Run (%)</td>
<td>Rec (%)</td>
<td>SDI (%)</td>
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**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**

### GEOLOGIST'S SUBSURFACE LOG

<table>
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<tr>
<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
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<tr>
<td>Elevation</td>
<td>Depth</td>
<td>Rock Core</td>
<td>Std/Ky RQD</td>
<td>Run (%)</td>
<td>Rec (%)</td>
<td>SDI (%)</td>
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**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**

### GEOLOGIST'S SUBSURFACE LOG

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<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
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<td>Elevation</td>
<td>Depth</td>
<td>Rock Core</td>
<td>Std/Ky RQD</td>
<td>Run (%)</td>
<td>Rec (%)</td>
<td>SDI (%)</td>
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### GEOLOGIST’S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Structure:** State Bridge  
**Project Type:** Structure  
**Geotechnical Branch:** Charlestown

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Surface Elevation</th>
<th>Total Depth</th>
<th>Location</th>
<th>Rig Number</th>
<th>Static Water Depth</th>
<th>Dynamic Water Depth</th>
<th>Driller</th>
<th>Geologist</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>437.7’</td>
<td>145.6’</td>
<td>177-46.6 66.6’ FL</td>
<td>1050 ATV</td>
<td>NA</td>
<td>7.6</td>
<td>Danny Jessie</td>
<td>James Adams</td>
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<td></td>
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<td></td>
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<td>0 / 0</td>
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<td></td>
<td></td>
<td></td>
<td>3.4 / 3.2 94</td>
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<td></td>
<td></td>
<td></td>
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<td>-85.637215</td>
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</table>

**Lithology:** Overburden

- **Elevation:** 333.1’
- **Depth:** 104.6’

**Limestone & Shale:** Limestone (70%), gray, medium grained, hard, 200 feet medium bedded, shale, shales, streaks and partings. Shale (30%), gray, soft.

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<thead>
<tr>
<th>Lithology</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth</th>
<th>Description</th>
<th>Rock Core</th>
<th>Remarks</th>
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<td>0 / 0</td>
<td>3.4</td>
<td>94</td>
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<td></td>
<td></td>
<td>38 / 63</td>
<td>10.0</td>
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<td>65 / 63</td>
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<td>100</td>
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<td>85 / 61</td>
<td>10.0</td>
<td>100</td>
<td></td>
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</table>

**Remarks:**
- Boring advanced with 42:1 system utilized to sample bedrock @ 3
- Drilling mud at a depth of 12.0 feet below the ground surface @ 20
- Sand, brown to gray, wet, fine to medium grained, very loose to loose, some clay.
- Sand, brown, wet, fine to medium grained, very loose to loose, some clay.
### GEOLOGIST'S SUBSURFACE LOG

**Jefferson - LSIORB East End Approach**

**Project Type:** Structure  State Bridge

**Project Manager:** Mark Litkenhus

**Driller:** Mark Martin

**Location:** 177+84.96  86.0' Lt.

**Hole Number:** 66

**Surface Elevation:** 434.3'

**Total Depth:** 141.0'

**End Date:** 08/23/2011

**Latitude:** 38.337940

**Longitude:** -85.638143

**Static Water Depth:** NA

**Immediate Water Depth:** 18.1 (08/23/11)

**Base Weathered Rock:** 101.2' Elevation = 333.1'

**Top of Rock:** 101.0

**Rig Number:** 750 ATV

**Drilling Firm:** Stantec

**For:** Division of Structural Design Geotechnical Branch

**Printed:** 9/30/11

**Page 2 of 3**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
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<th>Remarks</th>
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<td>150</td>
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</tbody>
</table>

**Overburden:** Sand, brown to gray, wet, fine to medium grained; medium dense to very dense, poorly gravelly, some gravel.

**Lithology:**
- **Limestone & Shale:** Limestone (60%), gray, medium grained sand, thin to medium bedded, shale shales, stringers and partings. Shale (40%), gray, wispy.

**Sample Type:** Rock Core SDI

**SPT Blows:**
- 7: 90.0-91.5  1.0  5-5-6  SPT
- 8: 90.0-91.5  1.3  10-20-20  SPT
- 9: 90.0-91.5  1.1  5-7-9  SPT
- 10: 90.0-91.5  1.5  5-10-10  SPT
- 11: 90.0-91.5  1.0  5-5-6  SPT
- 12: 90.0-91.5  1.3  15-20-25  SPT
- 13: 90.0-91.5  1.3  10-18-21  SPT
- 14: 90.0-91.5  1.5  10-14-16  SPT
- 15: 90.0-91.5  1.1  5-7-8  SPT
- 16: 90.0-91.5  1.0  12-15-16  SPT

**Run:** (Bottom of Hole 141.0')

**Remarks:**
- **DRAFT**
- **RCS-1 @ 113.8-114.6**
- **RCS-2 @ 134.3-135.2**

**GEOLOGIST'S SUBSURFACE LOG**

**Jefferson - LSIORB East End Approach**

**Project Type:** Structure  State Bridge

**Project Manager:** Mark Litkenhus

**Driller:** Mark Martin

**Location:** 177+84.96  86.0' Lt.

**Hole Number:** 66

**Surface Elevation:** 434.3'

**Total Depth:** 141.0'

**End Date:** 08/23/2011

**Latitude:** 38.337940

**Longitude:** -85.638143

**Static Water Depth:** NA

**Immediate Water Depth:** 18.1 (08/23/11)

**Base Weathered Rock:** 101.2' Elevation = 333.1'

**Top of Rock:** 101.0

**Rig Number:** 750 ATV

**Drilling Firm:** Stantec

**For:** Division of Structural Design Geotechnical Branch

**Printed:** 9/30/11

**Page 3 of 3**

**Project ID:** UNKNOWN
**Item Number:** 5-731.00

**Geologist:** James Adams

**Hole Type:** core and sample

**Run:** 17  15 / 15

**Remarks:**
- **DRAFT**
- **RCS-1 @ 113.8-114.6**
- **RCS-2 @ 134.3-135.2**

**GEOLOGIST'S SUBSURFACE LOG**

**Jefferson - LSIORB East End Approach**

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**Drilling Firm:** Stantec

**For:** Division of Structural Design Geotechnical Branch

**Printed:** 9/30/11

**Page 3 of 3**

**Project ID:** UNKNOWN
**Item Number:** 5-731.00

**Geologist:** James Adams

**Hole Type:** core and sample

**Run:** 17  15 / 15

**Remarks:**
- **DRAFT**
- **RCS-1 @ 113.8-114.6**
- **RCS-2 @ 134.3-135.2**

**GEOLOGIST'S SUBSURFACE LOG**

**Jefferson - LSIORB East End Approach**

**Project Type:** Structure  State Bridge

**Project Manager:** Mark Litkenhus

**Driller:** Mark Martin

**Location:** 177+84.96  86.0' Lt.

**Hole Number:** 66

**Surface Elevation:** 434.3'

**Total Depth:** 141.0'

**End Date:** 08/23/2011

**Latitude:** 38.337940

**Longitude:** -85.638143

**Static Water Depth:** NA

**Immediate Water Depth:** 18.1 (08/23/11)

**Base Weathered Rock:** 101.2' Elevation = 333.1'

**Top of Rock:** 101.0

**Rig Number:** 750 ATV

**Drilling Firm:** Stantec

**For:** Division of Structural Design Geotechnical Branch

**Printed:** 9/30/11

**Page 3 of 3**

**Project ID:** UNKNOWN
**Item Number:** 5-731.00

**Geologist:** James Adams

**Hole Type:** core and sample

**Run:** 17  15 / 15

**Remarks:**
- **DRAFT**
- **RCS-1 @ 113.8-114.6**
- **RCS-2 @ 134.3-135.2**

**GEOLOGIST'S SUBSURFACE LOG**

**Jefferson - LSIORB East End Approach**

**Project Type:** Structure  State Bridge

**Project Manager:** Mark Litkenhus

**Driller:** Mark Martin

**Location:** 177+84.96  86.0' Lt.

**Hole Number:** 66

**Surface Elevation:** 434.3'

**Total Depth:** 141.0'

**End Date:** 08/23/2011

**Latitude:** 38.337940

**Longitude:** -85.638143

**Static Water Depth:** NA

**Immediate Water Depth:** 18.1 (08/23/11)

**Base Weathered Rock:** 101.2' Elevation = 333.1'

**Top of Rock:** 101.0

**Rig Number:** 750 ATV

**Drilling Firm:** Stantec

**For:** Division of Structural Design Geotechnical Branch

**Printed:** 9/30/11

**Page 3 of 3**

**Project ID:** UNKNOWN
**Item Number:** 5-731.00

**Geologist:** James Adams

**Hole Type:** core and sample

**Run:** 17  15 / 15

**Remarks:**
- **DRAFT**
- **RCS-1 @ 113.8-114.6**
- **RCS-2 @ 134.3-135.2**
Drilling Firm: Stantec
For: Division of Structural Design
Geotechnical Branch

GEOLOGIST'S SUBSURFACE LOG
Printed: 9/30/11
Page 1 of 3

Project ID: UNKNOWN
Item Number: 5-731.00
Jefferson - LS1ORB East End Approach
Project Type: Structure State Bridge
Project Manager: Mark Litkenhus

Hole Number: 67
Initial Water Depth: 19.3 ft
Start Date: 08/24/2011
Hole Type: core
Reg. Number: 750 ATV
End Date: 08/25/2011

Surface Elevation: 438.8' (83)
Location: 177+84.96 31.0' Lt.
Driller: Mark Martin

Total Depth: 134.5' (83)
Latitude: 38.338088
Longitude: -85.637938

Geologist: James Adams

Overburden

Elevation Depth

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Overburden Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
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<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

Remarks:
- Boring advanced with 4.25" augers @ 1'
- Drilling mud added to the boring at a depth of 20.0' below the ground surface to avoid toe of embankment @ 20
- Boring offset an additional 25.0' left of centerline to avoid toe of embankment @ 20

Static Water Depth: NA
Immediate Water Depth: 19.3 (08/25/11)

Project Type: Structure State Bridge
Project Manager: Mark Litkenhus

Hole Number: 67
Initial Water Depth: 19.3 ft
Start Date: 08/24/2011
Hole Type: core
Reg. Number: 750 ATV
End Date: 08/25/2011

Surface Elevation: 438.8' (83)
Location: 177+84.96 31.0' Lt.
Driller: Mark Martin

Total Depth: 134.5' (83)
Latitude: 38.338088
Longitude: -85.637938

Geologist: James Adams

Overburden

Elevation Depth

<table>
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<th>Lithology</th>
<th>Description</th>
<th>Overburden Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
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</tr>
</tbody>
</table>

Remarks:
- Boring advanced with 4.25" augers @ 1'
- Drilling mud added to the boring at a depth of 20.0' below the ground surface to avoid toe of embankment @ 20
- Boring offset an additional 25.0' left of centerline to avoid toe of embankment @ 20

Static Water Depth: NA
Immediate Water Depth: 19.3 (08/25/11)
### GEOLOGIST'S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Project:** Jefferson - LSIORB East End Approach  
**Project Manager:** Mark Litkenhus  

**Hole Number:** 67  
**Total Depth:** 134.5'  
**Start Date:** 08/24/2011  
**End Date:** 08/25/2011  
**Rig Number:** 750 ATV  
**Geologist:** James Adams  

**Lithology:**

<table>
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<tr>
<th>Elevation</th>
<th>Depth</th>
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<th>Overburden</th>
<th>Remarks</th>
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<tbody>
<tr>
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<td>134.5</td>
<td>(Bottom of Hole)</td>
<td>Overburden:</td>
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#### Remarks

- **Overburden:** Overburden:
  - Topsoil
  - **DRAFT**
  - Overburden: Clay, brown, moist, sandy.
  - **DRAFT**
  - Overburden: Sand, brown, wet, medium to fine graded, very loose, some clay.
  - **DRAFT**
  - Overburden: Sand, brown, wet, medium to fine graded, very loose, some gravel.
  - **DRAFT**
  - Overburden: Sand, brown, gray, wet, fine to medium grained, very dense, poorly graded, some gravel.

---

**Lithology:**

- **Overburden:** Overburden:
  - Topsoil
  - **DRAFT**
  - Overburden: Clay, brown, moist, sandy.
  - **DRAFT**
  - Overburden: Sand, brown, wet, medium to fine graded, very loose, some clay.
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  - **DRAFT**
  - Overburden: Sand, brown, gray, wet, fine to medium grained, very dense, poorly graded, some gravel.

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**Geological Branch**

**Printed:** 9/30/11

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**For:** Division of Structural Design

**Geotechnical Branch**

**Printed:** 9/30/11

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**For:** Division of Structural Design

**Geotechnical Branch**

**Printed:** 9/30/11

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**For:** Division of Structural Design

**Geotechnical Branch**

**Printed:** 9/30/11

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**For:** Division of Structural Design

**Geotechnical Branch**

**Printed:** 9/30/11

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**For:** Division of Structural Design

**Geotechnical Branch**

**Printed:** 9/30/11
Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel.

**Lithology**

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<th>Elevation</th>
<th>Depth (ft)</th>
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<th>Sample Type</th>
<th>Remarks</th>
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<td>12-14-15 SPT</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>80.0-81.5</td>
<td>1.5</td>
<td>9-11-16 SPT</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>85.0-86.5</td>
<td>1.5</td>
<td>10-12-14 SPT</td>
<td></td>
</tr>
</tbody>
</table>

DRAFT

```
138.0 199.6
```

(Bottom of Hole 138.0')

---

**Lithology**

**Overburden:** Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel.

---

**Limestone & Shale:** Limestone (65%), gray, fine grained, hard, thin to medium bedded, shale streaks, stringers and partings. Shale (40%), gray, silty.
**GEOLOGIST'S SUBSURFACE LOG**

**Jefferson - LSIORB East End Approach**

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Lithology</th>
<th>Description</th>
<th>Overburden</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>Overburden</td>
<td>Overburden:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>107.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>107.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>107.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>107.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks**
- Drilling must advanced with 4.25" augers @ 1 NQ coring system utilized to sample bedrock @ 3 boring moved an additional 18.0' left of centerline to avoid toe of embankment. Approximate elevation change of 5.0' @ 8
- Drilling mud added to the boring at a depth of 20.0' below ground surface @ 20

---

**Overburden:**

- Overburden overburden.
### Lithology

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Rec. (%)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.1</td>
<td>107.1</td>
<td>65 / 48</td>
<td>9.7</td>
<td>9.0</td>
<td>93</td>
<td>Rock Core</td>
<td>Overburden</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46 / 37</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.1</td>
<td>137.1</td>
<td>65 / 65</td>
<td>10.3</td>
<td>10.3</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Overburden

- **Overburden**: Overburden

### Remarks

- **Overburden overburden.**

---

**DRAFT**
### Overburden

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lithology

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- Overburden: overburden.
### GEOLOGIST'S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Structure:** Jefferson - LSIORB East End Approach  
**Project Manager:** Mark Litkenhus

#### Drilling Firm: Stantec

**Printed:** 9/30/11  
**Page:** 1 of 3

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>Static Water Depth</th>
<th>End Date</th>
<th>Rig_Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>13.2 (08/16/11)</td>
<td>08/16/2011</td>
<td>NA</td>
<td>08/16/2011</td>
<td>1050 ATV</td>
</tr>
</tbody>
</table>

**Geotechnical Branch**

#### Hole Number 75

**Hole Type:** core and sample  
**Driller:** Danny Jessie  
**Surface Elevation:** 433.3'  
**Immediate Water Depth:** 13.2 (08/16/11)  
**Location:** Jeffersonville, New Albany, and Charlestown  
**Latitude(83):** 38.339071  
**Longitude(83):** -85.639085

| Elevation Depth | Topsoil | Overburden: Clay, brown, moist, some sand:  
**Remarks:** Drilling mud added to the boring at a depth of 15.0 ft below the ground surface @ 15  
**Description:** Sand, brown, very loose to medium grained, very loose to medium dense, some clay  
**Remarks:** **Remarks:** Rock in split-spoon drive shoe @ 50-50-50/0.50'  
**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel  
**Remarks:** Drum core SDI  
**Remarks:** Basal Weathered Rock = 98.0'Elevation = 335.3'  
**Remarks:** Top of Rock = 98.0'Elevation = 335.1'

| Elevation Depth | Topsoil | Overburden: Clay, brown, moist, some sand:  
**Remarks:** Drilling mud added to the boring at a depth of 15.0 ft below the ground surface @ 15  
**Remarks:** **Remarks:** Rock in split-spoon drive shoe @ 50-50-50/0.50'  
**Remarks:** Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel  
**Remarks:** Drum core SDI  
**Remarks:** Basal Weathered Rock = 98.0'Elevation = 335.3'  
**Remarks:** Top of Rock = 98.0'Elevation = 335.1'

---

**Lithology**

<table>
<thead>
<tr>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overburden: Topsoil</td>
<td>1</td>
<td>2.0-4.0</td>
<td>2.0</td>
<td>ST</td>
<td>DRAFT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Clay, brown, moist, some sand:</td>
<td>2</td>
<td>5.0-7.0</td>
<td>1.5</td>
<td>ST</td>
<td>DRAFT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown, very loose to medium grained, very loose to medium dense, some clay:</td>
<td>3</td>
<td>10.0-12.0</td>
<td>2.0</td>
<td>ST</td>
<td>DRAFT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>4</td>
<td>30.0-31.5</td>
<td>0.6</td>
<td>7-19-18</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>5</td>
<td>45.0-46.5</td>
<td>1.1</td>
<td>5-8-9</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>6</td>
<td>50.0-51.5</td>
<td>0.5</td>
<td>3-9-13</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>7</td>
<td>55.0-56.5</td>
<td>0.5</td>
<td>6-9-12</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>8</td>
<td>60.0-61.5</td>
<td>1.5</td>
<td>9-11-13</td>
<td>SPT</td>
<td></td>
</tr>
</tbody>
</table>

---

**Lithology**

<table>
<thead>
<tr>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overburden: Topsoil</td>
<td>1</td>
<td>2.0-4.0</td>
<td>2.0</td>
<td>ST</td>
<td>DRAFT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Clay, brown, moist, some sand:</td>
<td>2</td>
<td>5.0-7.0</td>
<td>1.5</td>
<td>ST</td>
<td>DRAFT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown, very loose to medium grained, very loose to medium dense, some clay:</td>
<td>3</td>
<td>10.0-12.0</td>
<td>2.0</td>
<td>ST</td>
<td>DRAFT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>4</td>
<td>30.0-31.5</td>
<td>0.6</td>
<td>7-19-18</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>5</td>
<td>45.0-46.5</td>
<td>1.1</td>
<td>5-8-9</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>6</td>
<td>50.0-51.5</td>
<td>0.5</td>
<td>3-9-13</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>7</td>
<td>55.0-56.5</td>
<td>0.5</td>
<td>6-9-12</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense to very dense, poorly graded, some gravel:</td>
<td>8</td>
<td>60.0-61.5</td>
<td>1.5</td>
<td>9-11-13</td>
<td>SPT</td>
<td></td>
</tr>
</tbody>
</table>

---

**Geologist’s Subsurface Log**

---

**Geologist: James Adams**  
**Driller:** Danny Jessie  
**Remarks:** Rock in split-spoon drive shoe @ 50-50-50/0.50'  
**Remarks:** Basal Weathered Rock = 98.0'Elevation = 335.3'  
**Remarks:** Top of Rock = 98.0'Elevation = 335.1'

---

**Geologist: James Adams**  
**Driller:** Danny Jessie  
**Remarks:** Rock in split-spoon drive shoe @ 50-50-50/0.50'  
**Remarks:** Basal Weathered Rock = 98.0'Elevation = 335.3'  
**Remarks:** Top of Rock = 98.0'Elevation = 335.1'
**DRAFT**

**GEOLOGIST'S SUBSURFACE LOG**

---

**Project ID:** UNKNOWN  **Item Number:** 5-731.00  **Hole Number:** 75  **Surface Elevation:** 433.7'  **Static Water Depth:** NA  **End Date:** 08/15/2011  **Reg Number:** 350 ATV  **Location:** 182+70.96 6.0' Lt.

**Lithology:** Overburden

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Rock Core</th>
<th>SPT Blows</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 / 0</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>105.0</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>110.0</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>115.0</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>120.0</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- 100% water loss throughout 3 runs @ 100
- Boring advanced with 4.25" auger @ 1 ft below the ground surface @ 15
- Drilling must be deepened at a depth of 15 ft below the ground surface @ 15

---

**Limestone & Shale:** Limestone (60%), gray, fine grained, shale streaks, stringers and partings. Shale (40%), dark gray, silt.  **Geologist:** James Adams  **Run:** 17 / 17

**Overburden:**

---

**Base Weathered Rock:**

---

**Louisville Limestone:**

---

**RCS-1 at 125.6-126.3 RCS-2 at 128.0-129.3

**Remarks:**
- Overburden:
- Base Weathered Rock:
- Louisville Limestone:
- Laurel Dolomite
### Lithology

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth (ft)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>335.1</td>
<td>98.1</td>
<td>Overburden: overlain by overburden.</td>
</tr>
</tbody>
</table>

### Overburden

- Description: Overburden
- Run (ft): 30
- Rec. (%): 100
- SPT Blows: 30.0
- SDI (JS): 87

### Rock Core

- Sample Type: Rock Core
- SPT Blows: 30.0
- SDI (JS): 87

### Remarks

- Top of Rock = 98.1
- Base Weathered Rock = 98.1
- RDZ = 98.1

---

### DRAFT

- Top of Rock = 98.1
- Base Weathered Rock = 98.1
- RDZ = 98.1

- Lithology: Limestone & Shale
- Description: Limestone (60%), gray, fine grained, thin, bit layered, shale streaks, stringers and partings. Shale (40%), dark gray, silty.
- SPT Blows: 28.0
- SDI (JS): 100

- Remarks: void, 90%, water loss @ 105-105.8

---

### DRAFT

- Top of Rock = 334.7
- Base Weathered Rock = 334.7
- RDZ = 334.7

- Lithology: Laurel Dolomite
- Description: Laurel Dolomite
- SPT Blows: 46.0
- SDI (JS): 100

- Remarks: void, 100%

---

### Drilling Firm: Stantec

- For: Division of Structural Design
- Geotechnical Branch
### GEOLOGIST'S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Project Type:** Structure  
**State Bridge**  
**Project Manager:** Mark Litkenhus  
**Geotechnical Branch**  

**Hole Number:** 77  
**Start Date:** 08/17/2011  
**Rig Number:** 1050 ATV  
**Location:** 182+70.96 69.0' Rt.  
**Geologist:** James Adams  

**Lithology**  

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth</th>
<th>Description</th>
<th>Overburden</th>
<th>Sample</th>
<th>Depth (ft)</th>
<th>Rec (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>433.0</td>
<td>1.0</td>
<td>Overburden: Topsoil</td>
<td></td>
<td></td>
<td>2.0-4.0</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>422.0</td>
<td>2.0</td>
<td>Overburden: Clay, brown, moist, some sand</td>
<td></td>
<td></td>
<td>10.0-12.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Overburden: Clay, brown, wet, very soft, some sand</td>
<td></td>
<td></td>
<td>12.0-13.5</td>
<td>1.5</td>
<td>0-0-0</td>
<td>2.0-5.0</td>
<td>SPT</td>
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<tr>
<td></td>
<td>1</td>
<td>Overburden: Clay, gray, wet, soft, some sand</td>
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<td>15.0-16.5</td>
<td>1.5</td>
<td>0-1-0</td>
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<td></td>
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<tr>
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<td>1</td>
<td>Overburden: Clay, gray, wet, soft, some sand</td>
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<td></td>
<td>20.0-21.5</td>
<td>1.5</td>
<td>0-1-0</td>
<td>2.0-5.0</td>
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<tr>
<td></td>
<td>1</td>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense, poorly graded, some gravel</td>
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<td>25.0-26.5</td>
<td>1.5</td>
<td>5-1-1</td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense, poorly graded, some gravel</td>
<td></td>
<td></td>
<td>30.0-31.5</td>
<td>0.4</td>
<td>3-10-14</td>
<td>SPT</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Overburden: Clay, gray, wet, very soft, some sand</td>
<td></td>
<td></td>
<td>35.0-36.5</td>
<td>0.8</td>
<td>9-10-15</td>
<td>SPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense, poorly graded, some gravel</td>
<td></td>
<td></td>
<td>40.0-41.5</td>
<td>1.0</td>
<td>8-16-15</td>
<td>SPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Overburden: Sand, brown to gray, wet, fine to medium grained, medium dense, poorly graded, some gravel</td>
<td></td>
<td></td>
<td>45.0-46.5</td>
<td>0.6</td>
<td>6-13-16</td>
<td>SPT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**DRAFT**

**Top of Rock:** 98.2'  
**Base Weathered Rock:** 98.5'  
**ROZ:** 98.5'  
**Elevation:** 335.5'  
**Limestone:** Louisville  
**Dolomite:** Laurel  

---

**Top of Rock:** 98.2'  
**Base Weathered Rock:** 98.5'  
**ROZ:** 98.5'  
**Elevation:** 335.5'  
**Limestone:** Louisville  
**Dolomite:** Laurel
### Drilling Firm: Stantec

#### GEOLOGIST’S SUBSURFACE LOG

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Structure:** State Bridge  
**Project Manager:** Mark Litkenhus

<table>
<thead>
<tr>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Static Water Depth</th>
<th>Total Depth</th>
<th>Static Water Depth</th>
<th>Immediate Water Depth</th>
<th>Location</th>
<th>Start Date</th>
<th>End Date</th>
<th>Rig Number</th>
<th>Driller</th>
<th>Driller</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>96.6 (08/17/11)</td>
<td>NA</td>
<td>138.6'</td>
<td>96.6 (08/17/11)</td>
<td>96.6 (08/17/11)</td>
<td>182+70.96</td>
<td>08/17/2011</td>
<td>08/17/2011</td>
<td>105110</td>
<td>Danny Jessie</td>
<td>Muriell Wethington</td>
<td>DRAFT</td>
</tr>
</tbody>
</table>

**Location:** Jeffersonville, New Albany, and Charlestown  
**Elevation Depth:** 434.0'  
**Static Water Depth:** NA  
**Driller:** Danny Jessie  
**Rig Number:** 105110  
**Surface Elevation:** 428.1'  
**Latitude(83):** 38.339210  
**Longitude(83):** -85.638892  
**Remarks:** Boring advanced with 3.25" augers @ 1 HQ, coring system utilized to sample bedrock @ 3

---

**Lithology:** Overburden  
**Sample No.** 9 / 4  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 10.4  
**Rec:** 10.0  
**Rec:** 96  
**Run:** 105.6

---

**Lithology:** Overburden  
**Sample No.** 31 / 28  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 10.0  
**Rec:** 10.0  
**Rec:** 100  
**Run:** 116.6

---

**Lithology:** Overburden  
**Sample No.** 110.8  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 9.4  
**Rec:** 94  
**Run:** 110.8

---

**Lithology:** Overburden  
**Sample No.** 30 / 24  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 9.4  
**Rec:** 94  
**Run:** 30 / 24

---

**Lithology:** Overburden  
**Sample No.** 119.3-120.2  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 10.0  
**Rec:** 10.0  
**Rec:** 100  
**Run:** 119.3

---

**Lithology:** Overburden  
**Sample No.** 130-130.7  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 9.4  
**Rec:** 94  
**Run:** 130-130.7

---

**Lithology:** Overburden  
**Sample No.** 295.4  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, brown, moist, some sand  
**Depth:** 10.0  
**Rec:** 10.0  
**Rec:** 100  
**Run:** 295.4

---

**Lithology:** Overburden  
**Sample No.** 394.1  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, grey, wet, very stiff, some sand  
**Depth:** 10.0  
**Rec:** 10.0  
**Rec:** 100  
**Run:** 394.1

---

**Lithology:** Overburden  
**Sample No.** 409.1  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, grey, wet, very stiff, some sand  
**Depth:** 10.0  
**Rec:** 10.0  
**Rec:** 100  
**Run:** 409.1

---

**Lithology:** Overburden  
**Sample No.** 455  
**Sample Type:** Rock Core  
**Remarks:** Overburden: Topsoil

**Description:** Clay, grey, wet, fine to medium grained, medium dense to dense, poorly graded, some gravel  
**Depth:** 10.0  
**Rec:** 10.0  
**Rec:** 100  
**Run:** 455
**Lithology**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
</table>

- **Overburden**: Sand, brown to gray, fine to medium grained, medium dense to dense, poor graded, some gravel.

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>0-10.5</td>
<td>6-10-12</td>
<td>SPT</td>
</tr>
<tr>
<td>110</td>
<td>11-15.5</td>
<td>3-7-13</td>
<td>SPT</td>
</tr>
<tr>
<td>115</td>
<td>16-20.5</td>
<td>4-6-10</td>
<td>SPT</td>
</tr>
<tr>
<td>120</td>
<td>21-25.5</td>
<td>11-14-11</td>
<td>SPT</td>
</tr>
<tr>
<td>125</td>
<td>26-30.5</td>
<td>1-4-9</td>
<td>SPT</td>
</tr>
<tr>
<td>130</td>
<td>31-35.5</td>
<td>9-21-32</td>
<td>SPT</td>
</tr>
<tr>
<td>135</td>
<td>36-40.5</td>
<td>4-5-7</td>
<td>SPT</td>
</tr>
<tr>
<td>140</td>
<td>41-45.5</td>
<td>4-6-13</td>
<td>SPT</td>
</tr>
<tr>
<td>145</td>
<td>46-50.5</td>
<td>5-7-9</td>
<td>SPT</td>
</tr>
<tr>
<td>150</td>
<td>51-55.5</td>
<td>7-9-14</td>
<td>SPT</td>
</tr>
<tr>
<td>155</td>
<td>56-60.5</td>
<td>8-10-12</td>
<td>SPT</td>
</tr>
<tr>
<td>160</td>
<td>61-65.5</td>
<td>9-12-16</td>
<td>SPT</td>
</tr>
<tr>
<td>165</td>
<td>66-70.5</td>
<td>10-13-20</td>
<td>SPT</td>
</tr>
<tr>
<td>170</td>
<td>71-75.5</td>
<td>11-14-23</td>
<td>SPT</td>
</tr>
<tr>
<td>175</td>
<td>76-80.5</td>
<td>12-15-27</td>
<td>SPT</td>
</tr>
<tr>
<td>180</td>
<td>81-85.5</td>
<td>13-16-30</td>
<td>SPT</td>
</tr>
<tr>
<td>185</td>
<td>86-90.5</td>
<td>14-17-33</td>
<td>SPT</td>
</tr>
<tr>
<td>190</td>
<td>91-95.0</td>
<td>15-18-36</td>
<td>SPT</td>
</tr>
</tbody>
</table>

**Remarks**

- **Limestone & Shale**: Limestone (70%), gray, fine grained, thin bedded, fossiliferous shale streaks, stringers and partings. Shale (30%), dark gray, silt.

**Top of Rock**: 334.1’

**Base Weathered Rock**: 95.0’

**ROZ**: 95.0’

**Elevation**: 334.7’

**Louisville Limestone**

**Laural Dolomite**

**Printed**: 9/30/11

**Page 3 of 3**
### GEOLOGIST'S SUBSURFACE LOG

**Drilling Firm:** Stantec  
**For:** Division of Structural Design  
**Geotechnical Branch**  
**Printed:** 9/30/11

#### Project ID: UNKNOWN  
**Jefferson - LSIORB East End Approach**  
**Project Type:** Structure  
**Project Manager:** Mark Litkenhus

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Item Number</th>
<th>Hole Number</th>
<th>Immediate Water Depth</th>
<th>Start Date</th>
<th>End Date</th>
<th>Rig Number</th>
<th>Surface Elevation</th>
<th>Static Water Depth</th>
<th>Latitude(83)</th>
<th>Longitude(83)</th>
<th>Immediate Water Depth (08/11/11)</th>
<th>Surface Elevation</th>
<th>Static Water Depth</th>
<th>Location</th>
</tr>
</thead>
</table>

#### Lithology

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth</th>
<th>Description</th>
<th>Remarks</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec. (%)</th>
<th>Rec. (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>429.2</td>
<td>1.0</td>
<td>Overburden: Topsoil</td>
<td>Boring advanced with 3.25&quot; auger @ 1 ft below ground surface @ 15 ft</td>
<td>1</td>
<td>2.0-4.0</td>
<td>2.0</td>
<td></td>
<td>ST</td>
<td></td>
</tr>
<tr>
<td>430.2</td>
<td>10.0</td>
<td>DRAFT</td>
<td>Drilling mud added to the boring at a depth of 15.0 ft below the ground surface @ 15 ft</td>
<td>3</td>
<td>10.0-12.0</td>
<td>1.0</td>
<td></td>
<td>ST</td>
<td></td>
</tr>
<tr>
<td>395.0</td>
<td>30.7</td>
<td>Overburden: Sand, brown, wet, fine to medium grained; very dense to dense, poorly graded, some clay.</td>
<td>Drilling mud added to the boring at a depth of 15.0 ft below the ground surface @ 15 ft</td>
<td>3</td>
<td>15.0-16.5</td>
<td>1.5</td>
<td></td>
<td>3-2-3</td>
<td>SPT</td>
</tr>
<tr>
<td>350.0</td>
<td>31.5</td>
<td>Overburden: Clay, brown, moist, some sand.</td>
<td></td>
<td>4</td>
<td>30.0-31.5</td>
<td>0.8</td>
<td></td>
<td>12-13</td>
<td>SPT</td>
</tr>
<tr>
<td>325.0</td>
<td>36.5</td>
<td>Overburden: Sand, brown to dark gray, wet, fine to medium grained; medium dense to very dense, poorly graded, some gravel.</td>
<td></td>
<td>5</td>
<td>30.0-36.5</td>
<td>0.8</td>
<td></td>
<td>5-6-6</td>
<td>SPT</td>
</tr>
</tbody>
</table>

#### Remarks

- DRAFT
- Overburden: Sand, brown to dark gray, wet, fine to medium grained; medium dense to very dense, poorly graded, some gravel.
RCS-1 @ 118.1
Fossiliferous
100% water
loss at 117.0
RCS-2 @ 122.5
Limestone & Shale:
Limestone (70%), gray, fine
grained, hard, thin bedded, fossiliferous shale streaks,
stringers and partings. Shale (30%), gray, silty.

Elevation Depth
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200

(Bottom of Hole 126.1)

Drilling must add on to the boring at a
depth of 18.0
ft below the
ground surface @ 15

Overburden: overburden.

Boring advanced
with 3.25"
sugar @ 1 NQ, coring
system utilized to
take samples of bedrock @ 3

Overburden

Limestone & Shale: Limestone (70%), gray, fine
grained, hard, thin bedded, fossiliferous shale streaks,
stringers and partings. Shale (30%), gray, silty.

Elevation Depth
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200

(Draft)

Overburden

Limestone & Shale: Limestone (70%), gray, fine
grained, hard, thin bedded, fossiliferous shale streaks,
stringers and partings. Shale (30%), gray, silty.

Elevation Depth
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200

(Draft)
### Overburden

- **Description:** Limestone & Shale
- **Sample:** Rock Core SDI
- **Depth:** 125.9' (Bottom of Hole)

### Limestone & Shale

- **Description:** Limestone (60%), gray, fine grained, hard, thin bedded, shale streaks, stringers and partings. Shale (40%), gray, silty.
- **Sample:** Core
- **Depth:** 125.9' (Bottom of Hole)

### Lithology Table

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth</th>
<th>Overburden</th>
<th>Sample No.</th>
<th>Depth (ft)</th>
<th>Rec (%)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>333.7</td>
<td>96.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>333.7</td>
<td>96.5</td>
<td>Overburden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>87 / 73</td>
<td>9.4</td>
<td>3.5</td>
<td></td>
<td>97 / 73</td>
<td>9.4</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>105.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RCS-1 @ 91.1-92.2</td>
</tr>
<tr>
<td>115.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RCS-2 @ 122.1-133.1</td>
</tr>
</tbody>
</table>

### Remarks

- **Remarks:**
  - **RCS-1:** 10/11/05
  - **RCS-2:** 12/11/02

---

**Geologist:** James Adams

**Hole Type:** Core

**Run:** 9

**Remarks:**
- **Rig Number:** 750 ATV
- **Hole Number:** 80
- **Surface Elevation:** 430.2'
- **Total Depth:** 125.9'
- **Location:** 184+86.96 6.0' Rt.
**GEOLGIST’S SUBSURFACE LOG**

**Project Name:** Jefferson - LSOB East End Approach  
**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Hole Number:** 81  
**Surface Elevation:** 431.5’  
**Total Depth:** 138.5’  
**Start Date:** 08/08/2011  
**End Date:** 08/08/2011  
**Latitude:** 38.339647  
**Longitude:** -85.639402  
**Driller:** Muriell Wethington  
**Geologist:** James Adams  
**Rig Number:** 750 ATV  

**Drilling Firm:** Stantec  
**For:** Division of Structural Design 
Geotechnical Branch  

**Location:** 184+86.96 69.0’ Rt.  
**Elevation:** 332.5’  
**Top of Rock:** 98.0’ Elevation = 333.5’  
**Base Weathered Rock:** 99.0’ Elevation = 332.5’  

**Static Water Depth:** NA  
**Immediate Water Depth:** 12.3 (08/09/11)  

**Lithology:**  
- Louisville Limestone  
- Laurel Dolomite  

**Description:**  
- Overburden  
- Rock Core SDI (JS)  

**Drilling System:** Utilized to sample bedrock at 3 ft below the ground surface @ 15. Drilling mud added to the boring at a depth of 15.0 ft below the ground surface @ 15.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>SPT Blows</th>
<th>Sample Type</th>
<th>Rec. (ft)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Printed:** 9/30/11  
**Page 2 of 3**
**Geologist's Subsurface Log**

**Project ID:** UNKNOWN  
**Item Number:** 5-731.00  
**Project:** Jefferson - LSORB East End Approach  
**Geotechnical Branch**

**Hole Number:** 81  
**Surface Elevation:** 431.5'  
**Total Depth:** 138.5'  
**Location:** 144+96.96, 69.0' Rt.  
**Driller:** Muriell Wethington  
**Geologist:** James Adams  
**Reg. Number:** 750 ATV  
**GQ-1211**

**Lithology**

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth</th>
<th>Sample No.</th>
<th>Rec. (ft)</th>
<th>SPT Bore</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>0</td>
<td>98 / 47</td>
<td>7.4</td>
<td>7.4</td>
<td>100</td>
</tr>
<tr>
<td>110</td>
<td>0</td>
<td>11 / 11</td>
<td>10.0</td>
<td>2.8</td>
<td>28</td>
</tr>
<tr>
<td>115</td>
<td>0</td>
<td>73 / 64</td>
<td>5.0</td>
<td>5.0</td>
<td>100</td>
</tr>
<tr>
<td>120</td>
<td>0</td>
<td>100 / 90</td>
<td>5.0</td>
<td>5.0</td>
<td>100</td>
</tr>
<tr>
<td>125</td>
<td>0</td>
<td>92 / 84</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>130</td>
<td>0</td>
<td>0 / 0</td>
<td>3.1</td>
<td>1.6</td>
<td>52</td>
</tr>
<tr>
<td>135</td>
<td>0</td>
<td>230.0</td>
<td>138.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- Rock not recovered, ground up by core barrel @ 108.1-115.4
- Rock not recovered, ground up by core barrel @ 137-138.5

**Limestone & Shale:** Limestone (60%) gray, fine grained, hard, thin bedded, shale streaks, stringers and partings. Shale (40%), gray, silty.

**Location:**
- Base Weathered Rock = 98.0'
- Top of Rock = 98.0'
- Immediate Water Depth = 12.3 (08/09/11)
- Static Water Depth = N/A
- Base Weathered Rock = 98.0'
- Top of Rock = 98.0'
- Latitude (33) = 38.339647
- Longitude (33) = -85.639402
- Start Date: 08/08/2011
- End Date: 08/08/2011
- Driller: Muriell Wethington
- Geologist: James Adams
- Rig Number: 750 ATV
- Reg. Number: 750 ATV
- Location: 144+96.96, 69.0' Rt.
- Elevation = 332.5' - Base Weathered Rock = 99.0'
- Elevation = 332.5' - Top of Rock = 98.0'
- Elevation = 333.5' - Total Depth = 138.5'
- Elevation = 334.5' - Overburden = 99.0'
- Elevation = 335.5' - Core Barrel SDI = 99.0'
- Elevation = 336.5' - Hole Type = core
- Surface Elevation = 431.5'
- Total Depth = 138.5'
APPENDIX C: DETAILED SCOUR CALCULATIONS
**100 YEAR SIMPLE PIER SCOUR COMPUTATIONS**

A simple pier is a single shaft, column, or multiple columns exposed to the flow. The pier itself is socketed into rock, and no footing is needed.

**Project:** Louisville Southern Indiana Ohio River East End Bridge  
**Date:** 9/20/2011  
**Prepared By:** LAM  
**Flow Type:** Steady  
**Methodology:** HEC-18, 4th Edition, Section 6.1  
**No. of Piers:** 7  
**Scour Case:** Simple  
**Units:** English

### Bed Conditions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>d_50</td>
<td>Diameter at which 50% of the sediments pass</td>
<td>4.27E-04</td>
<td>1.76E-05</td>
<td>2.13E-05</td>
<td>1.35E-04</td>
<td>2.39E-05</td>
<td>2.86E-04</td>
<td>1.86E-05</td>
<td>ft</td>
</tr>
<tr>
<td>D_60</td>
<td>Diameter at which 60% of the sediments pass</td>
<td>9.45E-02</td>
<td>6.53E-04</td>
<td>2.36E-04</td>
<td>1.05E-04</td>
<td>6.95E-04</td>
<td>1.35E-03</td>
<td>1.91E-04</td>
<td>ft</td>
</tr>
<tr>
<td>BC</td>
<td>Bed condition (clear water, plane bed, small dunes, medium dunes, large dunes)</td>
<td>small dunes</td>
<td>small dunes</td>
<td>small dunes</td>
<td>small dunes</td>
<td>small dunes</td>
<td>small dunes</td>
<td>small dunes</td>
<td></td>
</tr>
</tbody>
</table>

### Flow Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Flow depth directly upstream of the pier</td>
<td>8.0</td>
<td>24.7</td>
<td>16.0</td>
<td>6.6</td>
<td>13.5</td>
<td>20.0</td>
<td>21.0</td>
<td>ft</td>
</tr>
<tr>
<td>V</td>
<td>Mean velocity of flow directly upstream of the pier</td>
<td>8.42</td>
<td>1.068</td>
<td>2.14</td>
<td>3.26</td>
<td>2.72</td>
<td>2.72</td>
<td>3.91</td>
<td>ft/s</td>
</tr>
<tr>
<td>a</td>
<td>Acceleration of gravity</td>
<td>32.2</td>
<td>9.82</td>
<td>19.2</td>
<td>32.3</td>
<td>10.3</td>
<td>32.2</td>
<td>10.3</td>
<td>ft/s²</td>
</tr>
</tbody>
</table>

### Pier Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_p</td>
<td>Pier cross area</td>
<td>8.0</td>
<td>8.8</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>ft²</td>
</tr>
<tr>
<td>l_p</td>
<td>Length of pier stem</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>8.0</td>
<td>ft</td>
</tr>
<tr>
<td>C</td>
<td>Number of columns per pier</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Columns spaced</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
<td>8.0</td>
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### Simple Pier Scour Calculations

<table>
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<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_b</td>
<td>Resistance of bed</td>
<td>0.37</td>
<td>0.81</td>
<td>0.00</td>
<td>0.00</td>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>ft/s</td>
</tr>
<tr>
<td>V_0</td>
<td>Mean velocity of flow</td>
<td>5.37</td>
<td>1.81</td>
<td>1.13</td>
<td>1.54</td>
<td>1.50</td>
<td>1.87</td>
<td>1.01</td>
<td>ft/s</td>
</tr>
</tbody>
</table>

### Methodology

**Configuration:** Multiple Column Pier Scour - Raudkivi Method  
**Date:** N/A  
**Return Period (yrs):** 100  
**Flow Type:** Steady

**Equations**

\[ F_{1} = \frac{v_{c}}{v_{c}} \]

\[ K = (C_{w} + \theta) \]

\[ V_{c} = 0.645 \left( \frac{D_{w}}{a_{c}} \right)^{0.66} \]

\[ K = 2 \left( \frac{v_{c}}{v_{c}^{*}} \right) F_{1}^{0.66} \]

Equivalence Per Method:

\[ y = 2 \pi K \frac{d_{a}}{y} F_{1}^{0.66} \]

**Tables**

**Table A.1:** Approximation (k) for Per Nae Slope

<table>
<thead>
<tr>
<th>Per Nae Slope</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
<td>4.5</td>
</tr>
<tr>
<td>Gentle</td>
<td>1.6</td>
</tr>
<tr>
<td>Steep</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Table A.2:** Increase in Equilibrium Pier Scour Depths (a) for Bed Condition

<table>
<thead>
<tr>
<th>Bed Condition</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Water</td>
<td>1</td>
</tr>
<tr>
<td>Plane Bed</td>
<td>1.1</td>
</tr>
<tr>
<td>Small Dunes</td>
<td>1.5</td>
</tr>
<tr>
<td>Medium Dunes</td>
<td>2.0</td>
</tr>
<tr>
<td>Large Dunes</td>
<td>2.5</td>
</tr>
</tbody>
</table>
### 100-YR CONTRACTION SCOUR

Determine if Live-Bed or Clear-Water Contraction Scour is occurring.

**Critical Velocity** ($V_C$) is the velocity of the approach flow that will begin to move the bed material.

- If $V_C < V_1$, then Live-Bed Contraction Scour is occurring.
- If Live-Bed Contraction Scour is not occurring, use Clear-Water Contraction Scour equation.

#### Live-Bed Contraction Scour

<table>
<thead>
<tr>
<th>LOC</th>
<th>CHAN</th>
<th>ROB</th>
<th>$V_1$</th>
<th>$V_C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obj</td>
<td>9.27</td>
<td>0.0666</td>
<td>0.03</td>
<td>1.89</td>
</tr>
<tr>
<td>Depth</td>
<td>6.90</td>
<td>0.0666</td>
<td>0.03</td>
<td>0.00058</td>
</tr>
<tr>
<td>Average depth of the upstream approach, (m, ft)</td>
<td>3.29</td>
<td>11.17</td>
<td>11.17</td>
<td>1.11</td>
</tr>
<tr>
<td>Critical Velocity for the flow that you are using, (m, ft)</td>
<td>Calculated</td>
<td>Calculated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_C &gt; V_1$</td>
<td>2.97</td>
<td>1.49</td>
<td>1.49</td>
<td>0.48</td>
</tr>
</tbody>
</table>

#### Clear-Water Contraction Scour

<table>
<thead>
<tr>
<th>LOC</th>
<th>CHAN</th>
<th>ROB</th>
<th>$Q$</th>
<th>$Q_2$</th>
<th>$Q_1$</th>
<th>$y_2$</th>
<th>$y_0$</th>
<th>$W_1$</th>
<th>$W_2$</th>
<th>$D_{50}$</th>
<th>$K_U$</th>
<th>$V_s$</th>
<th>$y_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obj</td>
<td>136.78</td>
<td>1947.04</td>
<td>35822.20</td>
<td>54614.55</td>
<td>2047.90</td>
<td>15.13</td>
<td>12.04</td>
<td>71.69</td>
<td>1699.48</td>
<td>0.00755</td>
<td>0.00777</td>
<td>0.000068</td>
<td>0.42</td>
</tr>
<tr>
<td>Discharge through the bridge or on the set back overbank area at the bridge associated with W</td>
<td>Approach Section</td>
<td>Section BR U</td>
<td>Approach Section</td>
<td>Section BR U</td>
<td>Section BR U</td>
<td>Section BR U</td>
<td>Section BR U</td>
<td>Section BR U</td>
<td>Section BR U</td>
<td>Calculated</td>
<td>Calculated</td>
<td>HEC-18 Table</td>
<td>3.17</td>
</tr>
<tr>
<td>$y_s$</td>
<td>$y_s = y_2 - y_0 = Scour Depth Below Bed$</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>
</tbody>
</table>
### TOTAL 100 YEAR SCOUR COMPUTATIONS

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeled Bed Elevation***</td>
<td>430.5</td>
<td>427.9</td>
<td>432.3</td>
<td>434.3</td>
<td>437.6</td>
<td>434</td>
<td>430.2</td>
</tr>
<tr>
<td>Bed Rock Elevation***</td>
<td>329.7</td>
<td>331.4</td>
<td>331.1</td>
<td>333.1</td>
<td>334.3</td>
<td>335.8</td>
<td>334.5</td>
</tr>
<tr>
<td>Competent Rock Elevation***</td>
<td>303.5</td>
<td>331.4</td>
<td>333.8</td>
<td>333.3</td>
<td>334.3</td>
<td>335.8</td>
<td>334.5</td>
</tr>
<tr>
<td>Long-term (ft)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Contraction (ft)</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Local (ft)</td>
<td>2.5</td>
<td>10.7</td>
<td>14.5</td>
<td>15.9</td>
<td>15.6</td>
<td>17.3</td>
<td>11.7</td>
</tr>
<tr>
<td>Total Erosion (ft)</td>
<td>3.9</td>
<td>11.1</td>
<td>14.9</td>
<td>16.3</td>
<td>16.3</td>
<td>17.7</td>
<td>12.1</td>
</tr>
<tr>
<td>Total Erosion (m)</td>
<td>1.2</td>
<td>3.4</td>
<td>4.5</td>
<td>5.1</td>
<td>5.2</td>
<td>5.9</td>
<td>3.7</td>
</tr>
</tbody>
</table>

*** from geotechnical data

### TOTAL 100 YEAR SCOUR INPUTS (From FESWMS)

<table>
<thead>
<tr>
<th>Node</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node #</td>
<td>4605</td>
<td>4113</td>
<td>4116</td>
<td>4120</td>
<td>4617</td>
<td>4626</td>
<td>5412</td>
</tr>
<tr>
<td>Velocity (m/s)</td>
<td>0.1</td>
<td>0.3</td>
<td>0.7</td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Velocity (ft/s)</td>
<td>0.4</td>
<td>1.1</td>
<td>2.1</td>
<td>3.6</td>
<td>2.7</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>2.4</td>
<td>7.5</td>
<td>4.9</td>
<td>2.0</td>
<td>4.1</td>
<td>6.1</td>
<td>6.4</td>
</tr>
<tr>
<td>Depth (ft)</td>
<td>8.0</td>
<td>24.7</td>
<td>16.0</td>
<td>6.6</td>
<td>13.9</td>
<td>20.0</td>
<td>21.3</td>
</tr>
</tbody>
</table>
500 YEAR SIMPLE PIER SCOUR COMPUTATIONS

A single pier is a single shaft, column, or multiple columns exposed to the flow. The pier itself is socketed into rock, and no footing is needed.

Project: Louisville Southern Indiana Ohio River East End Bridge
Configuration: Final
Date: 9/20/2011
Prepared by: LAM Child: FYVG
Flow Type: Steady
Methodology: HEC-18, 4th Edition, Section 6.1
No. of Piers: 7
Scour Case: Simple
Units: English

BED CONDITIONS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>D50</td>
<td>Diameter at which 50% of the soil grains pass (inches)</td>
<td>2.05</td>
<td>2.05</td>
<td>2.05</td>
<td>2.05</td>
<td>2.05</td>
<td>2.05</td>
<td>2.05</td>
<td>inches</td>
</tr>
<tr>
<td>D90</td>
<td>Diameter at which 90% of the soil grains pass (inches)</td>
<td>3.045</td>
<td>3.045</td>
<td>3.045</td>
<td>3.045</td>
<td>3.045</td>
<td>3.045</td>
<td>3.045</td>
<td>inches</td>
</tr>
<tr>
<td>BC</td>
<td>Bed Condition (clear-water, planebed, smalldunes, mediumdunes, laredunes)</td>
<td>smalldunes</td>
<td>smalldunes</td>
<td>smalldunes</td>
<td>smalldunes</td>
<td>smalldunes</td>
<td>smalldunes</td>
<td>smalldunes</td>
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FLOW DATA

<table>
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<th>Description</th>
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<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Angle of attack (degrees)</td>
<td>11.7</td>
<td>11.7</td>
<td>11.7</td>
<td>11.7</td>
<td>11.7</td>
<td>11.7</td>
<td>11.7</td>
<td>degrees</td>
</tr>
<tr>
<td>V</td>
<td>Flow depth directly upstream of the pier (ft)</td>
<td>20.2</td>
<td>20.2</td>
<td>20.2</td>
<td>20.2</td>
<td>20.2</td>
<td>20.2</td>
<td>20.2</td>
<td>ft</td>
</tr>
<tr>
<td>Vc</td>
<td>Mean velocity of flow directly upstream of the pier (ft/s)</td>
<td>4.27E-04</td>
<td>4.27E-04</td>
<td>4.27E-04</td>
<td>4.27E-04</td>
<td>4.27E-04</td>
<td>4.27E-04</td>
<td>4.27E-04</td>
<td>ft/s</td>
</tr>
<tr>
<td>V0</td>
<td>Acceleration of gravity (ft/s^2)</td>
<td>32.2</td>
<td>32.2</td>
<td>32.2</td>
<td>32.2</td>
<td>32.2</td>
<td>32.2</td>
<td>32.2</td>
<td>ft/s^2</td>
</tr>
</tbody>
</table>

PIER DATA

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pier shape (Square, Round, Cylindrical, Group, Sharp)</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
</tr>
<tr>
<td>Lp</td>
<td>Length of pier stem (ft)</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>ft</td>
</tr>
<tr>
<td>C</td>
<td>Number of columns per bent</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>columns</td>
</tr>
<tr>
<td>S</td>
<td>Column spacing (ft)</td>
<td>83.0</td>
<td>83.0</td>
<td>83.0</td>
<td>83.0</td>
<td>83.0</td>
<td>83.0</td>
<td>83.0</td>
<td>ft</td>
</tr>
</tbody>
</table>

SIMPLE PIER SCOUR CALCULATIONS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Pier 1</th>
<th>Pier 2</th>
<th>Pier 3</th>
<th>Pier 4</th>
<th>Pier 5</th>
<th>Pier 6</th>
<th>Pier 7</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Single Column Pier Scour (ft)</td>
<td>9.2</td>
<td>12.1</td>
<td>14.5</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>ft</td>
</tr>
</tbody>
</table>

EQUATIONS

\[ F_{1} = \frac{V}{D_{s}} \]

\[ K_{e} = (\cos \theta + \frac{\sin \theta}{\tan \phi})^{0.5} \]

\[ K_{s} = 0.4 V_{c}^{0.12} \] for \( V_{c} > 0 \)

\[ \sin \theta = \frac{V_{c}}{V_{c}^{0.6}} \]

\[ V_{c} = \frac{V_{c}}{V_{c}^{0.6}} > 0 \]

\[ K_{s} = 2 \frac{D_{s}}{V_{c}^{0.6}} \] for \( V_{c} > D_{s} \)

\[ K_{s} = 2 \frac{D_{s}}{V_{c}^{0.6}} \]

\[ \tan \phi = \frac{D_{s}}{V_{c}^{0.6}} \]

Raudkivi Method: \( s > D_{s} \)

\[ s_{m} = 1.2 s \]

TABLES

<table>
<thead>
<tr>
<th>Pier Nose Shape</th>
<th>K</th>
<th>Bed Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square</td>
<td>1.5</td>
<td>Clear-Water</td>
<td>Clear-Water</td>
</tr>
<tr>
<td>Round</td>
<td>1.8</td>
<td>Planebed</td>
<td>Planebed</td>
</tr>
<tr>
<td>Cylindrical</td>
<td>1.3</td>
<td>Medium Dunes</td>
<td>Medium Dunes</td>
</tr>
<tr>
<td>Group</td>
<td>1.4</td>
<td>Large Dunes</td>
<td>Large Dunes</td>
</tr>
<tr>
<td>Sharp</td>
<td>1.9</td>
<td>Very Wide Pier</td>
<td>Very Wide Pier</td>
</tr>
</tbody>
</table>

\[ K_{e} = \cos \theta + \frac{\sin \theta}{\tan \phi} \]

\[ V_{c} = \frac{V_{c}}{V_{c}^{0.6}} > 0 \]

\[ K_{s} = 0.4 V_{c}^{0.12} \]

\[ D_{s} = \frac{2 \frac{D_{s}}{V_{c}^{0.6}}} {\tan \phi} \]

\[ \sin \theta = \frac{V_{c}}{V_{c}^{0.6}} \]

\[ V_{c} = \frac{V_{c}}{V_{c}^{0.6}} > 0 \]

\[ K_{s} = 2 \frac{D_{s}}{V_{c}^{0.6}} \] for \( V_{c} > D_{s} \)

\[ s_{m} = 1.2 s \]

\[ \tan \phi = \frac{D_{s}}{V_{c}^{0.6}} \]

\[ K_{e} = (\cos \theta + \frac{\sin \theta}{\tan \phi})^{0.5} \]

\[ K_{s} = 0.4 V_{c}^{0.12} \] for \( V_{c} > 0 \)

\[ \sin \theta = \frac{V_{c}}{V_{c}^{0.6}} \]

\[ V_{c} = \frac{V_{c}}{V_{c}^{0.6}} > 0 \]

\[ K_{s} = 2 \frac{D_{s}}{V_{c}^{0.6}} \]

\[ \tan \phi = \frac{D_{s}}{V_{c}^{0.6}} \]

\[ s_{m} = 1.2 s \]

\[ \sin \theta = \frac{V_{c}}{V_{c}^{0.6}} \]

\[ V_{c} = \frac{V_{c}}{V_{c}^{0.6}} > 0 \]

\[ K_{s} = 0.4 V_{c}^{0.12} \] for \( V_{c} > 0 \)

\[ \sin \theta = \frac{V_{c}}{V_{c}^{0.6}} \]

\[ V_{c} = \frac{V_{c}}{V_{c}^{0.6}} > 0 \]

\[ K_{s} = 2 \frac{D_{s}}{V_{c}^{0.6}} \] for \( V_{c} > D_{s} \)

\[ \tan \phi = \frac{D_{s}}{V_{c}^{0.6}} \]

\[ s_{m} = 1.2 s \]
Determine if Live-Bed or Clear-Water Contraction Scour is occurring.

Critical Velocity ($V_c$) is the velocity of the approach flow that will begin to move the bed material. If $V_c > V_1$, then Live-Bed Contraction Scour is occurring. If Live-Bed Contraction Scour is not occurring, use Clear-Water Contraction Scour equation.

![Critical Velocity equation](image)

**Live-Bed Contraction Scour**

- $V_1$: Velocity of the flow at the upstream approach, (m/s, ft/s)
- $y_1$: Average depth of flow upstream of the bridge, (m, ft)
- $D_50$: Particle size in a mixture of which 50 percent are smaller, (m, ft)
- $K_U$: (Metric Units = 6.19, English Units = 11.17)
- $D_c$: Critical Diameter for the flow that you are using, (m, ft)
- $V_c$: Critical velocity above which bed material of size $D_x$ and smaller will be transported (m/s, ft/s)

<table>
<thead>
<tr>
<th>Live-Bed</th>
<th>Clear-Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_1$ = 14.41</td>
<td>$y_1$ = 14.41</td>
</tr>
<tr>
<td>$y_0$ = 19.84</td>
<td>$y_0$ = 19.84</td>
</tr>
<tr>
<td>$Q_1$ = 63387.94</td>
<td>$Q_1$ = 63387.94</td>
</tr>
<tr>
<td>$Q_2$ = 87910.19</td>
<td>$Q_2$ = 87910.19</td>
</tr>
<tr>
<td>$W_1$ = 2064.56</td>
<td>$W_1$ = 2064.56</td>
</tr>
<tr>
<td>$g$ = 32.2</td>
<td>$g$ = 32.2</td>
</tr>
<tr>
<td>$V_1$ = 2.13</td>
<td>$V_1$ = 2.13</td>
</tr>
<tr>
<td>$D_50$ = 0.00079</td>
<td>$D_50$ = 0.00079</td>
</tr>
<tr>
<td>$K_U$ = 0.0077</td>
<td>$K_U$ = 0.0077</td>
</tr>
</tbody>
</table>

**Clear-Water Contraction Scour**

- $Q$: Discharge through the bridge or on the set back overbank area at the bridge associated with $W$
- $D_m$: Diameter of the smallest nontransportable particle in the bed material (1.25$D_50$), (m, ft)
- $K_U$: (Metric Units = 0.025, English Units = 0.0077)
- $x_0$: $x_0 = y_0 + (Q/D_50^{0.75}W^{0.25})$

<table>
<thead>
<tr>
<th>Clear-Water</th>
<th>Live-Bed</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_2$ = 21.71</td>
<td>$y_2$ = 21.71</td>
<td>N/A</td>
</tr>
<tr>
<td>$y_s$ = 6.46</td>
<td>$y_s$ = 6.46</td>
<td>Feet</td>
</tr>
</tbody>
</table>

**Fill in highlighted cells**

- US: Enter SI for Metric or US for English Units
- Critical Velocity: $V_c = \frac{\sqrt{g y_1 S_1}}{\left(\frac{K_U Q_2}{D_m^{0.75}}W^{0.5}\right)^{0.7}}$

**Critical Velocity Calculation**

- $V_c = \frac{\sqrt{32.2 \times 14.41 \times 0.00079}}{\left(\frac{0.0077 \times 87910.19}{0.00079^{0.75}} \times 2064.56^{0.5}\right)^{0.7}}$
- $V_c = 0.52$ m/s

**Clear-Water Scour Calculation**

- $y_s = y_2 - y_0 = 6.46$ Feet

**Live-Bed Scour Calculation**

- $y_s = y_2 - y_0 = 6.46$ Feet
### TOTAL 500 YEAR SCOUR COMPUTATIONS

<table>
<thead>
<tr>
<th>Pier</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring Number</td>
<td>854</td>
<td>861</td>
<td>864</td>
<td>896</td>
<td>870</td>
<td>877</td>
<td>879</td>
</tr>
<tr>
<td>Modeled Bed Elevations***</td>
<td>430.5</td>
<td>427.9</td>
<td>432.3</td>
<td>434.3</td>
<td>437.6</td>
<td>434</td>
<td>430.2</td>
</tr>
<tr>
<td>Bed Rock Elevation***</td>
<td>330.5</td>
<td>331.4</td>
<td>333.8</td>
<td>333.3</td>
<td>334.3</td>
<td>335.8</td>
<td>334.6</td>
</tr>
<tr>
<td>Competent Rock Elevation***</td>
<td>329.7</td>
<td>331.4</td>
<td>331.1</td>
<td>333.1</td>
<td>334.3</td>
<td>335.5</td>
<td>334.7</td>
</tr>
<tr>
<td>Long-term (ft)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Contraction (ft)</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Local (ft)</td>
<td>11.0</td>
<td>14.5</td>
<td>17.4</td>
<td>18.8</td>
<td>18.4</td>
<td>19.6</td>
<td>13.3</td>
</tr>
<tr>
<td>Total Scour (ft)</td>
<td>12.9</td>
<td>16.3</td>
<td>19.2</td>
<td>20.6</td>
<td>20.3</td>
<td>21.4</td>
<td>15.1</td>
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<tr>
<td>Total Scour Elevation</td>
<td>417.6</td>
<td>411.9</td>
<td>413.1</td>
<td>413.7</td>
<td>417.3</td>
<td>412.9</td>
<td>415.1</td>
</tr>
</tbody>
</table>

*** from geotechnical data

### TOTAL 500 YEAR SCOUR INPUTS (From FESWMS)

<table>
<thead>
<tr>
<th>Pier #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node #</td>
<td>4088</td>
<td>4133</td>
<td>4175</td>
<td>4184</td>
<td>4075</td>
<td>4500</td>
<td>5411</td>
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<tr>
<td>Velocity (m/s)</td>
<td>0.4</td>
<td>0.6</td>
<td>0.9</td>
<td>1.3</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Velocity (ft/s)</td>
<td>1.4</td>
<td>2.0</td>
<td>3.0</td>
<td>4.4</td>
<td>3.5</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Surface Elevation (m)</td>
<td>140.0</td>
<td>140.0</td>
<td>140.0</td>
<td>140.0</td>
<td>140.0</td>
<td>140.0</td>
<td>140.0</td>
</tr>
<tr>
<td>Surface Elevation (ft)</td>
<td>460.3</td>
<td>460.3</td>
<td>460.3</td>
<td>460.3</td>
<td>460.3</td>
<td>460.3</td>
<td>460.3</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>4.0</td>
<td>9.1</td>
<td>6.4</td>
<td>3.6</td>
<td>5.7</td>
<td>7.7</td>
<td>8.6</td>
</tr>
<tr>
<td>Depth (ft)</td>
<td>13.2</td>
<td>29.9</td>
<td>21.1</td>
<td>11.7</td>
<td>18.9</td>
<td>25.2</td>
<td>28.2</td>
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</tbody>
</table>