Geotechnical Report
Replacement of Bridge No. 03993
West Street Over P&W Railroad
Middletown, Connecticut

December 9, 2016
(Revised from September 23, 2016)

Freeman Project No.: 2016-0302

Prepared for:
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Vice President of Geotechnical Services
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1.0 INTRODUCTION

1.1 Summary

This report presents our evaluation of subsurface conditions and geotechnical engineering recommendations for the replacement of Bridge No. 03993, West Street over P&W Railroad, in Middletown, Connecticut.

Subsurface conditions consisted of fill and glacial till overlying decomposed bedrock and moderately hard bedrock. The depth to decomposed bedrock is approximately 15 to 17 feet below existing ground surface, which corresponds to approximately El. 55 to El. 58. P&W track grade is El. 55.4 which indicates the railroad is founded on decomposed bedrock. The depth to moderately hard bedrock is about 25 feet (approximately El. 47 to El. 49).

We recommend that the new Bridge 03993 be supported on spread footings bearing on the naturally deposited glacial till, decomposed bedrock, or on bedrock. Alternatives 2 and 3 are considered technically feasible and are recommended. Alternative 2, a single span bridge supported on two abutments, is the selected alternative.

Our detailed foundation design recommendations follow.

1.2 Scope of Work

Freeman Companies, LLC performed the following tasks:

- Engaged a subsurface exploration contractor to conduct test borings at the site;
- Provided technical monitoring of the explorations;
- Arranged for a testing laboratory to conduct laboratory soil and rock tests;
- Evaluated the subsurface conditions and prepared this report containing geotechnical design recommendations and construction considerations.

1.3 Authorization

The work was completed in accordance with our agreement dated March 25, 2016.

1.4 Project Vertical Datum

Elevations in this report refer to NGVD-29.

2.0 SITE AND PROJECT DESCRIPTION

2.1 Site Description

Bridge 03993 is located on West Street in Middletown, Connecticut, as indicated on Figure 1, Location Map. The bridge is a single-lane, four span, wood bridge with three piers and two stub abutments. West Street is a two-lane road north and south of the bridge, but the bridge is narrow and provides only single vehicle traffic. Northbound and southbound vehicles are required to stop and alternate. The approach embankments are relatively steep, resulting in poor visibility. The bridge is in poor condition and will be replaced.
The existing bridge grade varies from El. 76 to El 76.4. P&W railroad grade beneath the bridge is El. 55.4; ditches adjacent to the railroad are at about El. 53. Ground surface slopes downward to about El. 60 north of the bridge, and to about El. 72 south of the bridge.

Numerous underground and overhead utilities are present. A 12-inch-diameter Buckeye fuel oil pipeline passes beneath the bridge parallel to the railroad between two piers located north of the railroad. Invert grade for the pipeline is not presently known, but is believed to be about El. 51.

2.2 Project Description

Three alternatives were considered for replacement of Bridge 03993, and are described below. Drawings depicting the three alternatives are provided in Appendix A. Alternative 2, a single span bridge supported on two abutments, is the selected alternative. It is understood that the track may be lowered by about 4 feet in the future.

Alternative 1

- Single-span bridge supported on two stub abutments (bottom of abutment El. 65).
- Permanent 18-foot-high cantilever soldier pile and lagging wall immediately adjacent to the railroad. The permanent wall is designed in cantilever, rather than with a level of bracing to avoid tiebacks or deadman anchors above the Buckeye Pipeline.
- Stub abutments located immediately behind the soldier pile and lagging wall, founded on micropiles.

Alternative 2 (Selected)

- Single-span bridge supported on two abutments.
- Three-sided rigid frame supported on pedestal walls.
- Pedestal walls designed as spread footing foundations bearing at about El. 47, below the lowered (future) track grade.
- Temporary earth retention system during construction of foundations, to protect the railroad tracks, Buckeye Pipeline and other existing structures.

Alternative 3

- Two-span bridge supported on two abutments and one pier. Abutment 1 and Pier 1 are located on the north and south sides of the Buckeye Pipeline; Pier 1 and Abutment 2 are located on the north and south sides of the railroad.
- Full height abutments and center pier supported on spread footing foundations.
- Abutment 1 is founded at about El. 55. Pier 1 and Abutment 2 are founded at about El. 46.
- Abutment 1 will be an intermediate height abutment founded several feet above the Buckeye Pipeline; Pier 1 and Abutment 2 (full height abutment) will be founded below proposed lowered (future) track grade.
- Temporary earth retention system during construction of foundations, to protect the railroad tracks, Buckeye Pipeline and other existing structures.

3.0 SUBSURFACE EXPLORATIONS

3.1 Field Explorations

Four test borings (B1 through B4) were drilled by New England Boring Contractors, Inc., of Glastonbury, Connecticut, during the period May 10 to 11, 2016. Borings were drilled with 3-inch-diameter flush joint casing to depths ranging from 30 to 35 feet.
Standard Penetration Tests were conducted and soil samples were recovered at maximum 5-foot intervals in the overburden soil. A 10-foot-long NX-size bedrock core sample was recovered from each boring.

Exploration locations are shown on Figure 2, Subsurface Exploration Location Plan. As-drilled locations were located by taping from site features, and are considered approximate.

A Freeman Companies senior geologist monitored the drilling, classified the soil samples, and prepared the test boring logs included in Appendix B.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile

The site subsurface conditions generally consisted of fill and glacial till overlying decomposed and moderately hard bedrock. Subsurface conditions are known only at the boring locations and may differ significantly between borings. The generalized subsurface conditions follow. Refer to Table 1 for boring specific data. A subsurface profile drawn along the roadway alignment is provided in Figure 3.

<table>
<thead>
<tr>
<th>Thickness of Stratum (feet)</th>
<th>Generalized Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4 to 0.5</td>
<td>ASPHALT</td>
</tr>
<tr>
<td>7.5 to 11.6</td>
<td>FILL – Medium dense to dense, dark brown to light brown f SAND and SILT, some c-f gravel, some silt, trace roots.</td>
</tr>
<tr>
<td>5 to 8</td>
<td>GLACIAL TILL – Very dense, red-brown f SAND, little m-f gravel and silt, with cobbles and boulders</td>
</tr>
<tr>
<td>8 to 10</td>
<td>DECOMPOSED BEDROCK - Dark red-brown decomposed SANDSTONE. Rock Quality Designation (RQD) is 0%, which indicates very poor quality rock. BEDROCK –Moderately hard, moderately weathered, fine grained, red SANDSTONE, bedding and primary joints low angle ½ to 18-inch spacing, with occasional decomposed or soil-filled seams and slickensides. Occasional high angle joints result in fractured zones. RQD ranges from 20% to 70%, which indicates very poor to fair quality rock. Results of unconfined compressive testing indicate a uniaxial compressive strength of 9,560 and 9,770 pounds per square inch (psi).</td>
</tr>
</tbody>
</table>

4.2 Groundwater

Groundwater was encountered in the borings at depths of 21.3 to 25 feet below ground surface within about 30 minutes after the boreholes were completed, corresponding to about El. 48 to El. 51. Groundwater level measurements were made during or immediately following drilling and may not represent static conditions. Groundwater levels will fluctuate with season, precipitation, nearby construction activities, and other conditions.
4.3 Laboratory Testing

Laboratory testing consisted of four grain size distribution analyses on soil samples recovered from the borings, and two unconfined compression tests on bedrock core samples. Results of laboratory testing are presented in Appendix C.

5.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

5.1 Foundation Alternatives

A discussion of alternatives considered is provided below. Alternative 2 is the selected alternative.

Alternative 1

Alternative 1 includes an 18-foot-high cantilever soldier piles and lagging retaining wall. Typical cantilever walls are designed for retained heights of soil not exceeding about 10 to 12 feet. The proposed 18-foot height would typically require tiebacks or deadman anchors, but this is not feasible since the bracing would span over the Buckeye pipeline, which would compromise the ability to service the pipeline.

An 18-foot high soldier pile and lagging wall in cantilever is technically feasible, but carries more risk than the other alternatives. Large soldier piles (king piles) would be placed in predrilled holes (sockets) drilled into bedrock, and would rely primarily on the bedrock to resist lateral forces. Considering the decomposed nature of the rock and the large wall height, we recommend that this option not be pursued.

Alternative 2 (Selected)

Alternative 2 consists of a single span, 3-sided rigid frame supported on pedestal walls. The pedestal walls will be designed as spread footing foundations bearing on decomposed bedrock or bedrock at about El. 47.

Foundations for the pedestal walls will be below the Buckeye Pipeline. A temporary earth retaining system will be required to protect the pipeline.

Alternative 3

Alternative 3 consists of a two-span bridge supported on two abutments and one pier. Abutments and piers will be supported on spread footing foundations bearing on decomposed rock at El. 55 (Abutment 1) and on moderately hard rock at El. 46 (Pier 1 and Abutment 2). This alternative is considered to be feasible and should be considered further.

Foundations for Pier 1 foundation will be below the Buckeye pipeline. A temporary earth retaining system will be required to protect the pipeline.

5.2 Foundation Design Recommendations

General

- **Foundation Depth**: Minimum of 4 feet below the lowest adjacent ground surface
- **Seismic Design**: Soils are not susceptible to liquefaction. Seismic design is not required for simple-span bridges (AASHTO 2010 Article 4.7.4.2). Soil conditions at the site are defined as AASHTO Site Class C, Very Dense Soil and Soft Rock. Site coefficients are $S_s=0.13g$ and $S_i=0.036g$. Seismic design is not required for single span bridges (Alternative 2).
• **Backfill Material:** Place crushed stone (CTDOT Form 817 M.01.01 No. 6) overlying separation fabric (CTDOT Form 817 Sec. 7.55 M8.01-19) over the excavation subgrade until excavation is above water level. Place Pervious Structure Backfill (CTDOT Form 817 M.02.05) behind the abutments and abutment wingwalls above a line defined by a 1V:1.5H slope extending up from the heel of the footing to grade.

• **Weep Holes:** 4 inch dia. weep holes at maximum 10 foot spacing, installed according to CTDOT specifications.

• **Lateral Earth Pressures:** Refer to Figure 4, At-Rest Earth Pressures

• **Buckeye Pipeline:** Foundations should be located such the Buckeye Pipeline is outside (above) a 1 horizontal to 1 Vertical (1H:1V) line sloped outward and downward from the bottom edge of the foundation, so that the foundation does not apply pressure to the pipeline.

**Spread Footing Design Criteria**

• **Subgrade Preparation:** Alternative 2 includes two abutments founded at approximately El. 47. Abutments will bear on decomposed rock or bedrock. Remove unsuitable existing fill. Place a minimum 12-inch thick layer of granular fill over the decomposed rock, or bedrock subgrade.

• **Service Limit Bearing:** Nominal Bearing Resistance = 8,000 pounds per square foot (psf); Resistance Factor = 1.0 (per AASHTO 10.5.5.1); Allowable bearing capacity = 8,000 psf.

• **Strength Limit Bearing:** Strength unfactored bearing resistance = 40,000 psf. Resistance Factor = 0.55 (AASHTO Table 11.5.7-1).

• **Settlement at Recommended Bearing Pressure:** Estimated total settlement less than 1 inch; differential settlement less than ¾- inch.

• **Coefficient of Friction (tan δ) Along Bottom:** 0.50 (AASHTO Table 3.11.5.3-1); Resistance factor 0.8 (AASHTO Table 10.5.5.2.2-1).

### 6.0 CONSTRUCTION CONSIDERATIONS

#### 6.1 Excavation

Conventional heavy construction equipment should be suitable for excavation in existing soil materials. Excavation should conform to OSHA excavation regulations contained in 29 CFR Part 1926, latest edition, but should be confirmed at the time of excavation.

Excavation is expected to be in fill, glacial till, decomposed bedrock and bedrock. Cobbles and boulders should be expected in the glacial till. Controlled blasting is expected to be required for removal of decomposed bedrock and bedrock. Mechanical means may or may not be feasible for excavation of decomposed bedrock. Blast design should limit vibrations to avoid damage to the Buckeye Pipeline and nearby structures.

A preconstruction survey of residential and commercial structures within 150 feet of work should be completed prior to the start of construction. Vibration monitoring should be conducted for residential or commercial structures within 150 feet of the site, and for the Buckeye Pipeline. Vibration limits should be consistent with limits specified by the owner of the pipeline. A draft special provision for protection of building and property, preconstruction condition survey, and vibration monitoring is attached.
6.2 Dewatering

We anticipate that excavation dewatering may be accomplished by pumping from properly filtered sumps and be discharged according to federal, state, and local regulations. Surface water entering the construction area should be diverted away from excavations.

6.3 Utility Monitoring Points and Vibration Monitoring

We anticipate that the owner of the Buckeye Pipeline will require that utility monitoring points (UMPs) be established along the pipeline, so that movements of the pipeline can be measured during construction. We recommend that UMPs be established at 50 foot intervals along the pipeline. UMPs typically consist of hand- or vacuum-excavation to the pipeline, a flange placed on the pipeline, a steel rod bolted or welded to the flange extending upward to ground surface, and a roadway box placed at ground surface to protect the UMP. UMPs should be monitored by survey during construction to measure vertical and lateral movement. A draft UMP special provision is attached. Maximum vertical and lateral movement limits indicated in the draft special provision should be confirmed with the pipeline owner.

6.4 Temporary Excavation Support

Temporary lateral support of excavations will be required to protect the Buckeye Pipeline, adjacent structures, roadways, and utilities. Drilled rather than driven lateral support systems should be used (i.e., soldier piles and lagging, or another system) to avoid damage to the Buckeye Pipeline. Predrilled rock sockets backfilled with cement grout will likely be required for soldier piles. One or more levels of bracing such as tiebacks will likely be required.

Survey monitoring of the temporary lateral support system should be required at approximately 50 foot intervals opposite the UMPs, to measure lateral and vertical movement. Maximum lateral and vertical movement limits should be consistent with limits for UMPs provided in the attached draft special provision.

6.5 Subgrade Preparation

Subgrades in most areas will consist decomposed bedrock and bedrock. Decomposed bedrock subgrades should be compacted with a minimum of four passes of a walk behind vibratory compactor. If proof compaction proves detrimental to the subgrade due to the presence of groundwater, static rolling may be considered acceptable by the Engineer.

If construction is performed during freezing weather, special precautions will be required to prevent the subgrade from freezing. Freezing of soil beneath foundations during construction may result in settlement when the soil thaws.

Subgrades should be free of frost prior to placement of concrete for foundations. Frost-susceptible soils that have frozen should be removed and replaced with compacted granular fill. The footing and the soil adjacent to the footing should be protected from freezing until they are backfilled.

Soils placed as fill should be free of frost, as should be the ground on which it is placed.

6.6 Reuse of Existing Soils

Existing fill and glacial till deposits have a high fines content and may not be suitable for reuse. They may be reused as embankment fill however, the high fines content will make them difficult or impractical to place and compact to the required degree should they become excessively wet. Drying of the materials will be time consuming or impractical during wet or cold weather.
7.0 FUTURE SERVICES AND LIMITATIONS

We recommend that Freeman Companies be engaged during construction to observe:

- Preparation of subgrades
- Observe installation of pile foundations
- Verify that soil conditions exposed in excavations are in general conformance with design assumptions
- Verify that the geotechnical aspects of construction are consistent with the project specifications

This report was prepared for the exclusive use of BL Companies and the project design team. The recommendations provided herein are based on the project information provided at the time of this report and may require modification if there are any changes in the nature, design, location, or alignment of the structure.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report.

Our professional services for this project have been performed in accordance with generally accepted engineering practices; no warranty, expressed or implied, is made.
### Table 1 - Subsurface Data

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Ground Surface El.</th>
<th>Depth (ft.)</th>
<th>Pavement/Topsoil</th>
<th>Fill</th>
<th>Glacial Till</th>
<th>Decomposed Bedrock</th>
<th>Groundwater Depth (ft.)</th>
<th>Groundwater Elevation</th>
<th>Sound Bedrock Depth (ft.)</th>
<th>Sound Bedrock Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>73</td>
<td>35</td>
<td>0.5</td>
<td>7.5</td>
<td>7</td>
<td>10</td>
<td>25</td>
<td>48</td>
<td>25</td>
<td>48</td>
</tr>
<tr>
<td>B2</td>
<td>73.8</td>
<td>30</td>
<td>0.5</td>
<td>8.5</td>
<td>8</td>
<td>8</td>
<td>NR</td>
<td>---</td>
<td>25</td>
<td>48.8</td>
</tr>
<tr>
<td>B3</td>
<td>73.3</td>
<td>35</td>
<td>0.4</td>
<td>11.6</td>
<td>5</td>
<td>8</td>
<td>23.7</td>
<td>49.6</td>
<td>25</td>
<td>48.3</td>
</tr>
<tr>
<td>B4</td>
<td>71.7</td>
<td>35</td>
<td>0.4</td>
<td>9.6</td>
<td>7</td>
<td>8</td>
<td>21.3</td>
<td>50.4</td>
<td>25</td>
<td>46.7</td>
</tr>
</tbody>
</table>

**Notes:**
1. Ground surface elevations were provided by BL Companies
2. Groundwater levels were measured upon completion of drilling and are approximate
3. "NR" - Not Recorded
FIGURES
FIGURE 2

REPLACEMENT OF BRIDGE NO. 03993
WEST STREET OVER P&W RAILROAD
MIDDLETOWN, CONNECTICUT

LEGEND:

- TEST BORINGS

NOTES:

1. BASE PLAN PREPARED BY BL COMPANIES, INC.
2. EXPLORATION LOCATIONS WERE TAPED FROM EXISTING SITE FEATURES AND ARE APPROXIMATE
3. REFER TO THE TEXT AND APPENDICES FOR ADDITIONAL INFORMATION

SUBSURFACE EXPLORATION LOCATION PLAN
REPLACEMENT OF BRIDGE NO. 03993
WEST STREET OVER P&W RAILROAD
MIDDLETOWN, CONNECTICUT

DRAWN:
CHECKED:
APPROVED:
SCALE:
PROJECT NO.:
DATE:

2016-0302
06/08/2016
NOTES:
1. APPLIES TO WALLS THAT ARE RESTRAINED FROM MOVEMENT AND ASSUMES ACTIVE EARTH PRESSURES.
2. H IS MEASURED IN FEET.
3. THE WALL SHOULD BE DRAINED BY PERVIOUS STRUCTURE BACKFILL (FORM 817 M.02.05) WITH A UNIT WEIGHT OF 125 PCF AND WEEPHOLES THROUGH THE WALL. THEREFORE, HYDROSTATIC PRESSURE IS NOT INCLUDED.
4. THESE PRESSURE DISTRIBUTIONS ASSUME HORIZONTAL BACKFILL BEHIND THE WALL.
5. SLIDING:
   COEFFICIENT OF FRICTION BETWEEN FOOTING AND BASE= 0.50 (2012 AASHTO TABLE 3.11.5.3–1) RESISTANCE FACTOR= 0.8 (2012 AASHTO TABLE 10.5.5.2.2.1).
6. IGNORE PASSIVE RESISTANCE IN FRONT OF FOOTING.
7. SEISMIC LATERAL EARTH PRESSURES ARE NOT REQUIRED FOR SINGLE SPAN BRIDGES (AASHTO 2010 4.7.4.2).
PLAN
SCALE: 1"=20'

APPROXIMATE LOCATION OF
12" BUCKEYE PETROLEUM
FUEL PIPELINE

BR. NO.: 03993
DATE: AUGUST, 2016
FIGURE NO.: 1
RAILROAD SECTION

Scale: 1" = 10'

West St. over P&W Railroad
Middletown, Connecticut

Alternative 1
Single Span Bridge
On Stub Abutments
Railroad Section

BARRIER WALL
GUTTERLINE
TOP OF PARAPET
PRESTRESSED DECK UNITS
(4'-0" X 1'-3")

EL. 75.2
STUB ABUTMENT

MICROPILES (TYP.)
SOLDIER PILE AND
LAGGING WALL (TYP.)

EL. 55.4

APPROX. LOCATION
OF EXISTING PIER
APPROX.
EXISTING
GRADE
CONSTRUCTION
MAT

APPROX. LOCATION
OF 12" BUCKEYE
PETROLEUM
FUEL PIPELINE

APPROX. LOCATION
OF FUTURE LOWERED
TRACK

EL. 45.0

APPROX. BEDROCK

© Track

18'-1"
VERT. CLEARANCE
25'-0"
HORIZ. CLEARANCE

BR. NO.: 03993
DATE: AUGUST, 2016
FIGURE NO.: 2
BRIDGE ELEVATION

SCALE: 1" = 10'

WEST ST. OVER P&W RAILROAD
MIDDLETOWN, CONNECTICUT

ALTERNATIVE 1
SINGLE SPAN BRIDGE
ON STUB ABUTMENTS
ELEVATION

BR. NO.: 03993
DATE: AUGUST, 2016
FIGURE NO.: 4
BRIDGE ELEVATION

SCALE: 1"=10'

- PROTECTIVE FENCE
- METAL BEAM RAIL (TYPE R-B 350) (TYP-)
- 42" PARAPET
- GUTTERLINE
- PRESTRESSED DECK UNIT

WEST ST. OVER P&W RAILROAD
MIDDLETOWN, CONNECTICUT

ALTERNATIVE 3
TWO-SPAN BRIDGE ON
FULL HEIGHT ABUTMENTS
ELEVATION

BR. NO.: 03993
DATE: AUGUST, 2016
FIGURE NO.: 9
APPENDIX B

TEST BORING LOGS
## Connecticut DOT Boring Report
### Hole No.: B1

<table>
<thead>
<tr>
<th>Driller:</th>
<th>P. Schofeld</th>
<th>Engineer:</th>
<th>N. Whetten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspector:</td>
<td>G. Jacobsen</td>
<td>Start Date:</td>
<td>5-11-16</td>
</tr>
<tr>
<td>Town:</td>
<td>Middletown</td>
<td>Route No.:</td>
<td>West Street</td>
</tr>
<tr>
<td>Project No.:</td>
<td>2016-0302</td>
<td>Easting:</td>
<td>1021252.4</td>
</tr>
<tr>
<td>Finish Date:</td>
<td>5-11-16</td>
<td>Northing:</td>
<td>761737.9</td>
</tr>
<tr>
<td>Bridge No.:</td>
<td>03993</td>
<td>Surface Elevation:</td>
<td>73.0</td>
</tr>
</tbody>
</table>

### Project Description: Replacement of Bridge No. 03993, West St. over P&W RR

### Casing Size/Type: 4-in. Casing

### Sampler Type/Size: 1-3/8 inch ID

### Core Barrel Type: NX

### Hammer Wt.: 140

### Groundwater Observations: @25 after 0.5 hours

### Sample Type: S = Split Spoon  C = Core  UP = Undisturbed Piston  V = Vane Shear Test

### Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

### Hammer Wt.: Earth: 25ft  Rock: 10ft

### No. of Soil Samples: 7  Core Runs: 2

### Notes: Boring advanced through boulder from 10.5 to 11.5 ft using roller bit. Roller bit harder at 17 ft. Roller bit very hard from 22 to 25 ft

### Blows on Sampler per 6 inches:

### Generalized Strata Description:
- ASPHALT FILL: 0-0.5 Asphalt Pavement. 0.5-1 Gray gravel; 1-2 ft. mixed dark brown to light brown fine gravel.
- Intermixed dark brown to light brown fine sand and silt, some c-f gravel.
- Intermixed dark brown to light brown fine sand and silt, some c-f gravel.
- Red-brown sand, some c-f gravel, little silt
- Red-brown fine sand, some silts, moist
- Red-brown fine sand, little m-f gravel and silt
- Boulder detected 10.5 ft to 11.5 ft
- 14-15 ft: Red-brown fine sand, little m-f gravel and silt; 15-15.6: Red-brown decomposed sandstone
- Dark red-brown decomposed sandstone
- Medium hard, moderately weathered, red-brown, fine grained sandstone, bedding and primary joint set is low angle 1/2 to 18 in. spacing. Coring rates (min/ft): 3, 3, 3, 4, 4
- Medium hard, moderately weathered, red-brown, fine grained sandstone, bedding and primary joint set is low angle 1/2 to 6 in. spacing, several high angle joints contribute to extensive fractured zones. Coring rates (min/ft): 2, 4, 4, 4, 5

### Surface Elevation:

### Fall:

### Sampler Type/Size:

### Total Penetration in:

### Notes: Replacement of Bridge No. 03993, West St. over P&W RR
# Connecticut DOT Boring Report

**Driller:** P. Schofeld  
**Inspector:** G. Jacobsen  
**Engineer:** N. Whetten

**Start Date:** 5-10-16  
**Finish Date:** 5-10-16  
**Route No.:** West Street  
**Bridge No.:** 03993  
**Project No.:** 2016-0302  
**Town:** Middletown  
**Easting:** 1021248.5  
**Northing:** 761757.5  
**Surface Elevation:** 73.8  
**Stat./Offset:** 15+33/5  
**Hammer Wt.:** 140  
**Fall: in.**

**Sample Type:** S = Split Spoon  
**Sample Type:** C = Core  
**Sample Type:** UP = Undisturbed Piston  
**Sample Type:** V = Vane Shear Test

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type/No.</th>
<th>Blows on Sampler per 6 inches</th>
<th>Pen. (in.)</th>
<th>Rec. (in.)</th>
<th>RQD %</th>
<th>Generalized Strata Description</th>
<th>Material Description and Notes</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>S-1 20 27 31</td>
<td>18</td>
<td>10</td>
<td></td>
<td></td>
<td>ASPHALT FILL</td>
<td>0-0.5 ft. Asphalt Pavement 0.5-1.5 ft Gray c GRAVEL; 1.5-2 ft. Dark brown to gray f SAND and SILT, some c-f gravel Dark brown c-f SAND, some silt</td>
</tr>
<tr>
<td>5</td>
<td>S-2 19 12 12 15</td>
<td>24</td>
<td>12</td>
<td></td>
<td></td>
<td>Intermixed dark brown to light brown f SAND and SILT, trace f gravel Intermixed dark brown to light brown f SAND, some silt, little f gravel</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>S-3 7 6 5 10</td>
<td>24</td>
<td>8</td>
<td></td>
<td></td>
<td>GLACIAL TILL</td>
<td>Red-brown f GRAVEL, some silt, little c-f sand, top 8&quot; moist, bottom dry</td>
</tr>
<tr>
<td></td>
<td>S-4 10 13 6 5</td>
<td>24</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S-5 14 13 26 40</td>
<td>24</td>
<td>14</td>
<td></td>
<td></td>
<td>DECOMPOSED BEDROCK</td>
<td>Red-brown c-f SAND, little silt and m-f gravel</td>
</tr>
<tr>
<td></td>
<td>S-6 15 36 44 41</td>
<td>24</td>
<td>16</td>
<td></td>
<td></td>
<td>BEDROCK</td>
<td>Soft, extremely weathered, fine-grained, red-brown SANDSTONE, bedding and primary joint set low angle 1/4 to 2 in spacing, with soil filled seams to 1/2 inch thick. Coring rates (min/ft): 0, 4, 5, 2, 3, 3</td>
</tr>
<tr>
<td></td>
<td>C-1 60 48 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>END OF BORING 30ft</td>
<td>Moderately hard, moderately weathered, fine grained red SANDSTONE, bedding and primary joint set low angle 1/2 to 8 in spacing, one high angle joint. Coring rates (min/ft): 2, 2, 2, 2, 2</td>
</tr>
</tbody>
</table>

**NOTES:** Roller bit 17 to 20 ft., steady, sandstone cuttings  
Coring times high due to core barrel clogging or jamming in soil seams

**Total Penetration in Earth:** 20ft  
**Total Penetration in Rock:** 10ft  
**No. of Soil Samples:** 6  
**No. of Core Runs:** 2  
**Sheet 1 of 1**
### Connecticut DOT Boring Report

<table>
<thead>
<tr>
<th>Hole No.:</th>
<th>B3</th>
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<tbody>
<tr>
<td>Inspector:</td>
<td>G. Jacobsen</td>
</tr>
<tr>
<td>Driller:</td>
<td>T. Roe</td>
</tr>
<tr>
<td>Engineer:</td>
<td>N. Whetten</td>
</tr>
<tr>
<td>Start Date:</td>
<td>5-10-16</td>
</tr>
<tr>
<td>Route No.:</td>
<td>West Street</td>
</tr>
<tr>
<td>Finish Date:</td>
<td>5-10-16</td>
</tr>
<tr>
<td>Bridge No.:</td>
<td>03993</td>
</tr>
<tr>
<td>Town:</td>
<td>Middletown</td>
</tr>
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<td>Project No.:</td>
<td>2016-0302</td>
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<td>Nothing:</td>
<td>761889.5</td>
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<tr>
<td>Easting:</td>
<td>1021219.8</td>
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<td>Northing:</td>
<td>13+98/8</td>
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<tr>
<td>Surface Elevation:</td>
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</table>

**Project Description:** Replacement of Bridge No. 03993, West St. over P&W RR

**Casing Size/Type:** 4-in. Casing

**Sampler Type/Size:** 1-3/8 inch ID

**Core Barrel Type:** NX

**Hammer Wt.:** 140

**Fall:** 30 in.

**Sample Type:** S = Split Spoon  C = Core  UP = Undisturbed Piston  V = Vane Shear Test

**Proportions Used:** Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

**Blows on Sampler per 6 inches**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type/No.</th>
<th>Blows on Sampler per 6 inches</th>
<th>Pen. (in.)</th>
<th>Rec. (in.)</th>
<th>RQD %</th>
<th>Generalized Strata Description</th>
<th>Material Description and Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.4 ft.</td>
<td>Asphalt Pavement 0.5-1.6 ft. Gray c GRAVEL; 1.6-2 Dark brown to gray f SAND, little silt and c-f gravel</td>
<td>24 14</td>
<td>ASPHALT FILL</td>
<td>0-0.4 ft. Asphalt Pavement 0.5-1.6 ft. Gray c GRAVEL; 1.6-2 Dark brown to gray f SAND, little silt and c-f gravel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5-1.6 ft.</td>
<td>Dark brown f SAND and SILT, trace f gravel</td>
<td>24 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6-2.0 ft.</td>
<td>Dark brown c-f SAND, some silt, trace m-f gravel</td>
<td>24 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0-2.4 ft.</td>
<td>Dark brown c-f SAND, some silt, trace m-f gravel</td>
<td>24 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2.4-2.7 ft.</td>
<td>Dark brown c-f SAND, some silt, trace m-f gravel</td>
<td>24 6</td>
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<td></td>
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<tr>
<td>2.7-3.0 ft.</td>
<td>Dark brown c-f SAND, some silt, trace m-f gravel</td>
<td>24 9</td>
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</tr>
<tr>
<td>3.0-3.5 ft.</td>
<td>Red-brown f SAND and SILT, trace m gravel</td>
<td>24 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3.5-4.0 ft.</td>
<td>Dark red-brown SILT and fine SAND, trace m gravel</td>
<td>24 18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0-4.2 ft.</td>
<td>Dark red-brown decomposed SANDSTONE</td>
<td>24 24</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>4.2-4.4 ft.</td>
<td>Moderately hard, moderately weathered, fine grained red SANDSTONE, bedding and primary joints low angle 1 to 6 in spacing. Coring rates (min/ft): 4, 4, 2, 2, 2</td>
<td>24 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4-4.6 ft.</td>
<td>Moderately hard, moderately weathered, fine grained red SANDSTONE, bedding and primary joints low angle 1 to 6 in spacing, several decomposed seams up to 2&quot; thick. Coring rates (min/ft): 2, 2, 3, 3, 4</td>
<td>24 36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**END OF BORING 35ft**

**NOTES:** Roller bit steady below 17.3 ft.  
Roller bit hard and steady 20 to 24.5; harder 24.5 to 25 ft

**Sheet:** 1 of 1

**SM-001-M REV. 1/02**
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type/No.</th>
<th>Blows on Sampler per 6 inches</th>
<th>Pen. (in.)</th>
<th>Rec. (in.)</th>
<th>RQD %</th>
<th>Generalized Strata Description</th>
<th>Material Description and Notes</th>
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<tr>
<td>0</td>
<td>S-1</td>
<td>18 19 12 10</td>
<td>24</td>
<td>8</td>
<td></td>
<td>PAVEMENT FILL</td>
<td>0.0-0.4 ft. Asphalt Pavement; Gray c GRAVEL</td>
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<tr>
<td>5</td>
<td>S-2</td>
<td>6 11 20 13</td>
<td>24</td>
<td>8</td>
<td></td>
<td>Red-brown c-f SAND, some silt, trace m-f gravel</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>S-3</td>
<td>5 3 3 2</td>
<td>24</td>
<td>20</td>
<td></td>
<td>Red-brown f GRAVEL, some c-f SAND, some silt</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>S-4</td>
<td>4 5 5 17</td>
<td>24</td>
<td>14</td>
<td></td>
<td>Red-brown c-f SAND, some silt, trace m-f gravel</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>S-5</td>
<td>16 40 28 22</td>
<td>24</td>
<td>14</td>
<td></td>
<td>GLACIAL TILL</td>
<td>Red-brown f SAND and SILT, some f gravel</td>
</tr>
<tr>
<td>15</td>
<td>S-6</td>
<td>17 19 23 42</td>
<td>24</td>
<td>18</td>
<td></td>
<td>DECOMPOSED BEDROCK</td>
<td>Red-brown f SAND, some silt, little m-f gravel</td>
</tr>
<tr>
<td>20</td>
<td>S-7</td>
<td>50/3&quot;</td>
<td>3 3</td>
<td></td>
<td></td>
<td>Dark red-brown decomposed SANDSTONE</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BEDROCK</td>
<td>Moderately hard, moderately weathered, fine grained red SANDSTONE, bedding and primary joints low angle 1/2 to 5 in spacing. Coring rates (min/ft): 2, 3, 3, 3, 3</td>
</tr>
<tr>
<td>30</td>
<td>C-1</td>
<td>60 60 23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Moderately hard, moderately weathered, fine grained red SANDSTONE, bedding and primary joints low angle 1 to 12 in spacing, one high angle joint at 34.5 has slickensides. 4, 4, 2, 2, 2</td>
</tr>
<tr>
<td>35</td>
<td>C-2</td>
<td>60 60 50</td>
<td></td>
<td></td>
<td></td>
<td>END OF BORING 35ft</td>
<td></td>
</tr>
</tbody>
</table>

Sample Type: S = Split Spoon  C = Core  UP = Undisturbed Piston  V = Vane Shear Test
Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

NOTES: Roller bit moderately hard 20 to 25 ft.

Total Penetration in Earth: 25ft  Rock: 10ft

Driller: T. Roe  Inspector: G. Jacobsen
Engineer: N. Whetten  Start Date: 5-10-16

Project Description: Replacement of Bridge No. 03993, West St. over P&W RR

Connecticut DOT Boring Report  Hole No.: B4

Sheet 1 of 1
APPENDIX C

RESULTS OF LABORATORY TESTING
Particle Size Analysis - ASTM D422

<table>
<thead>
<tr>
<th>Sieve Name</th>
<th>Sieve Size, mm</th>
<th>Percent Finer</th>
<th>Spec. Percent</th>
<th>Complies</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 in</td>
<td>12.50</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.375 in</td>
<td>9.50</td>
<td>98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>4.75</td>
<td>94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>2.00</td>
<td>89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#20</td>
<td>0.85</td>
<td>83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#40</td>
<td>0.42</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#60</td>
<td>0.25</td>
<td>66</td>
<td></td>
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</tr>
<tr>
<td>#100</td>
<td>0.15</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#200</td>
<td>0.075</td>
<td>46</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% Cobble: --
% Gravel: 5.9
% Sand: 48.4
% Silt & Clay Size: 45.7

Coefficients:
- $D_{85} = 1.1616 \text{ mm}$
- $D_{60} = 0.1849 \text{ mm}$
- $D_{50} = 0.1003 \text{ mm}$
- $C_u = N/A$
- $C_c = N/A$

Classification:
- ASTM: N/A
- AASHTO: Silty Soils (A-4 (0))

Sample/Test Description:
- Sand/Gravel Particle Shape: ROUNDED
- Sand/Gravel Hardness: HARD
Particle Size Analysis - ASTM D422

<table>
<thead>
<tr>
<th>Sieve Name</th>
<th>Sieve Size, mm</th>
<th>Percent Finer</th>
<th>Spec. Percent</th>
<th>Complies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 in</td>
<td>37.50</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 in</td>
<td>25.00</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75 in</td>
<td>19.00</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 in</td>
<td>12.50</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.375 in</td>
<td>9.50</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>4.75</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>2.50</td>
<td>43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#20</td>
<td>0.85</td>
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<td></td>
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<tr>
<td>#40</td>
<td>0.42</td>
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<td></td>
</tr>
<tr>
<td>#60</td>
<td>0.25</td>
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<tr>
<td>#100</td>
<td>0.15</td>
<td>22</td>
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</tr>
<tr>
<td>#200</td>
<td>0.075</td>
<td>28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% Cobble | % Gravel | % Sand | % Silt & Clay Size
--- | --- | --- | ---
--- | 52.1 | 19.6 | 28.3

Coefficients

$D_{S5} = 26.5821 \text{ mm}$  $D_{20} = 0.1022 \text{ mm}$  
$D_{50} = 11.6727 \text{ mm}$  $D_{15} = \text{N/A}$  
$D_{50} = 5.6749 \text{ mm}$  $D_{10} = \text{N/A}$  
$C_u = \text{N/A}$  $C_c = \text{N/A}$

Classification

ASTM  N/A
AASHTO  Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR
Sand/Gravel Hardness : HARD
### Particle Size Analysis - ASTM D422

#### Visual Description:
Moist, dark reddish brown silty gravel with sand

#### Test Comment:
---

#### Particle Size Analysis

<table>
<thead>
<tr>
<th>Sieve Name</th>
<th>Sieve Size, mm</th>
<th>Percent Finer</th>
<th>Spec. Percent</th>
<th>Complies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 in</td>
<td>37.50</td>
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<td>1 in</td>
<td>25.00</td>
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<td>0.75 in</td>
<td>19.00</td>
<td>72</td>
<td></td>
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<tr>
<td>0.5 in</td>
<td>12.50</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0.375 in</td>
<td>9.50</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>4.75</td>
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<tr>
<td>#20</td>
<td>0.85</td>
<td>50</td>
<td></td>
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<tr>
<td>#40</td>
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<td></td>
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<tr>
<td>#60</td>
<td>0.25</td>
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<tr>
<td>#200</td>
<td>0.075</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Coefficients

- $D_{85} = 30.2422$ mm
- $D_{50} = 6.8559$ mm
- $D_{50} = 0.9377$ mm
- $C_u = N/A$
- $C_c = N/A$

#### Classification
- ASTM: N/A
- AASHTO: Stone Fragments, Gravel and Sand (A-1-b (0))

#### Sample/Test Description
- Sand/Gravel Particle Shape: ANGULAR
- Sand/Gravel Hardness: HARD
Particle Size Analysis - ASTM D422

<table>
<thead>
<tr>
<th>Sieve Name</th>
<th>Sieve Size, mm</th>
<th>Percent Finer</th>
<th>Spec. Percent</th>
<th>Complies</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75 in</td>
<td>19.00</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 in</td>
<td>12.50</td>
<td>93</td>
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</tr>
<tr>
<td>0.375 in</td>
<td>9.50</td>
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</tr>
<tr>
<td>#200</td>
<td>0.075</td>
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</tr>
</tbody>
</table>

% Cobble 20.4
% Gravel 44.3
% Sand 35.3
% Silt & Clay Size 35.3

Coefficients
- $D_{65} = 6.9813$ mm
- $D_{50} = 0.6201$ mm
- $D_{50} = 0.2663$ mm
- $C_u = N/A$
- $C_c = N/A$

Classification
- ASTM N/A
- AASHTO Silty Soils (A-4 (0))

Sample/Test Description
- Sand/Gravel Particle Shape: ROUNDED
- Sand/Gravel Hardness: HARD
**Bulk Density and Compressive Strength of Rock Core Specimens by ASTM D7012 Method C**

<table>
<thead>
<tr>
<th>Boring ID</th>
<th>Sample Number</th>
<th>Depth</th>
<th>Bulk Density, pcf</th>
<th>Compressive strength, psi</th>
<th>Failure Type</th>
<th>Meets ASTM D4543</th>
<th>Note(s)</th>
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<tr>
<td>B2</td>
<td>C2</td>
<td>26.5-27 ft</td>
<td>147</td>
<td>9559</td>
<td>1</td>
<td>Yes</td>
<td>---</td>
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<tr>
<td>B4</td>
<td>C2</td>
<td>33-33.5 ft</td>
<td>156</td>
<td>9770</td>
<td>1</td>
<td>Yes</td>
<td>---</td>
</tr>
</tbody>
</table>

**Notes:**
- Density determined on core samples by measuring dimensions and weight and then calculating.
- All specimens tested at the approximate as-received moisture content and at standard laboratory temperature.
- The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
- Failure Type: 1 = Intact Material Failure; 2 = Discontinuity Failure; 3 = Intact Material and Discontinuity Failure
  (See attached photographs)
UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

<table>
<thead>
<tr>
<th>Specimen Length, in:</th>
<th>1</th>
<th>2</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.37</td>
<td>4.37</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Specimen Diameter, in:
- 1: 1.99
- 2: 1.98

Specimen Mass, g: 523.78

Bulk Density, lb/ft³: 147

Length to Diameter Ratio:
- 1: 2.2

Minimum Diameter Tolerance Met? YES

Length to Diameter Ratio Tolerance Met? YES Straightness Tolerance Met? YES

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
- Is the maximum gap ≤ 0.02 in.? YES

Specimen Mass, g:
- Minimum Diameter Tolerance Met? YES

Maximum difference must be < 0.020 in.

Length to Diameter Ratio:
- Minimum Diameter Tolerance Met? YES

Maximum difference must be < 0.020 in.

END FLATNESS AND PARALLELISM (Procedure FP1)

Difference between max and min readings, in:
- 0° = 0.00010
- 90° = 0.00000

Maximum difference must be < 0.0020 in.

Difference = 0.00005

Flatness Tolerance Met? YES

DIAMETER 1

Slope of Best Fit Line: 0.0003
Angle of Best Fit Line: 0.00172

Parallelism Tolerance Met? YES

DIAMETER 2

Slope of Best Fit Line: 0.0000
Angle of Best Fit Line: 0.00000

Maximum Angular Difference: 0.00012

Parallelism Tolerance Met? YES

PERPENDICULARITY (Procedure P1)

Maximum angle of departure must be ≤ 0.25°

[Graphs and data tables for End Flatness and Parallelism measurements above]
Client: Freeman Companies, LLC
Project Name: West Street over P&W RR
Project Location: Hartford, CT
GTX #: 304731
Test Date: 6/8/2016
Tested By: daa
Checked By: jsc
Boring ID: B2
Sample ID: C2
Depth, ft: 26.5-27

After cutting and grinding

After break
UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

### BULK DENSITY

<table>
<thead>
<tr>
<th>Specimen Length, in:</th>
<th>4.33</th>
<th>4.33</th>
<th>4.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen Diameter, in:</td>
<td>1.98</td>
<td>1.98</td>
<td>1.98</td>
</tr>
<tr>
<td>Specimen Mass, g:</td>
<td>566.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk Density, lb/ft³</td>
<td>156</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length to Diameter Ratio:</td>
<td>2.3</td>
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<td></td>
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</tbody>
</table>

### DEVIATION FROM STRAIGHTNESS (Procedure S1)

- **Maximum gap between side of core and reference surface plate:**
  - YES
- **Specimen Mass, g:**
  - YES
- **Minimum Diameter Tolerance Met?**
  - YES
- **Length to Diameter Ratio Tolerance Met?**
  - YES
- **Maximum difference must be < 0.020 in.**
  - YES

### END FLATNESS AND PARALLELISM (Procedure FP1)

<table>
<thead>
<tr>
<th>Diameter 1, in</th>
<th>0.00020</th>
<th>0.00020</th>
<th>0.00020</th>
<th>0.00020</th>
<th>0.00020</th>
<th>0.00020</th>
<th>0.00010</th>
<th>0.00000</th>
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<th>0.00000</th>
<th>0.00000</th>
<th>0.00000</th>
<th>0.00000</th>
<th>0.00000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter 2, in (rotated 90°)</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
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<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
</tbody>
</table>

| Difference between max and min readings, in: | 0° = 0.00030 | 90° = 0.00010 |
|----------------------------------------------|-----------------|

### END 2

<table>
<thead>
<tr>
<th>Diameter 1, in</th>
<th>0.00010</th>
<th>0.00010</th>
<th>0.00010</th>
<th>0.00010</th>
<th>0.00010</th>
<th>0.00010</th>
<th>0.00000</th>
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<th>0.00000</th>
<th>0.00000</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Diameter 2, in (rotated 90°)</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
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<td>0.00010</td>
<td>0.00010</td>
<td>0.00010</td>
<td>0.00010</td>
</tr>
</tbody>
</table>

| Difference between max and min readings, in: | 0° = 0.0002 | 90° = 0.0001 |
|----------------------------------------------|-----------------|

### PERPENDICULARITY (Procedure P1)

<table>
<thead>
<tr>
<th>Diameter 1, in</th>
<th>0.00023</th>
<th>1.980</th>
<th>0.00005</th>
<th>0.003</th>
<th>YES</th>
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</thead>
<tbody>
<tr>
<td>Diameter 2, in (rotated 90°)</td>
<td>0.000010</td>
<td>1.980</td>
<td>0.00005</td>
<td>0.003</td>
<td>YES</td>
</tr>
</tbody>
</table>

### END 2

<table>
<thead>
<tr>
<th>Diameter 1, in</th>
<th>0.00020</th>
<th>1.980</th>
<th>0.00010</th>
<th>0.006</th>
<th>YES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter 2, in (rotated 90°)</td>
<td>0.000010</td>
<td>1.980</td>
<td>0.00005</td>
<td>0.003</td>
<td>YES</td>
</tr>
</tbody>
</table>

### DIAMETER 1

| Slope of Best Fit Line | -0.00019 |
| Angle of Best Fit Line | -0.03096 |
| Maximum Angular Difference | 0.00046 |

### DIAMETER 2

| Slope of Best Fit Line | 0.00007 |
| Angle of Best Fit Line | 0.00046 |
| Maximum Angular Difference | 0.00000 |

### Flattening and Parallelism Met?**

- YES

### Parallelism Tolerance Met?**

- Spherically Seated

### Parallelism Tolerance Met?**

- YES

### Maximum angle of departure must be ≤ 0.25°
After cutting and grinding

After break
APPENDIX D

DRAFT SPECIAL PROVISIONS
CONNDOT Form 817, SECTION 2.03, Structure Excavation, shall apply with the following additional items:

**Description:** This item consists of installing Utility Monitoring Points (UMPs) and monitoring movement of the Buckeye Pipeline during construction. The monitoring program shall be adequate to document any settlement or horizontal movement of the pipeline during construction activities. The monitoring program shall be in conformance with the minimum requirements detailed in this specification or as noted on the plans for quantity of monitoring points, intervals for recording data, procedures and period of time for reporting to the Engineer, maintenance of points, and removal of points after the completion of the work.

**Materials:** UMPs shall be constructed of materials suitable for use as survey reference points and as approved by the Engineer. The material shall be dimensionally stable and the points installed in a manner to allow for easily repeatable survey readings to be taken at the points. Settlement monitoring points for the Buckeye Pipeline shall consist of a metal flange placed over the pipeline in a hand- or vacuum-excavated excavation, and a steel rod bolted or welded to the flange that extends upward to ground surface, as shown on the attached detail.

**Construction Methods:** UMPs shall be established at 50-foot intervals along the Buckeye Pipeline within the limits of construction a minimum of two days prior to the commencement of any construction. Initial readings shall be recorded both at the time of point installation and prior to the commencement of construction activities, to establish baseline readings.

UMPs shall be established by the Contractor for the specific purpose of providing a reliable, reproducible reference point compatible with the survey equipment to be used by the Contractor for the monitoring program. The Contractor shall take location readings on the established UMPs using survey equipment capable of reading to a precision of 1/16-inch in both the horizontal and vertical dimension. The monitoring points shall be monitored at the following minimum intervals:

- Prior to commencement of construction activities near each UMP location.
- Immediately following blasting
- Daily during active construction on the adjacent Pier or Abutment 1.
- Weekly during work on Abutment 2 and away from Abutments 1 and 2.
- After the completion of construction activities near a UMP location.
- The next working day after rainfall in excess of 1-inch in a 24-hour period on site.
- As directed by the Engineer.

Any points that have measured movement exceeding ¼-inch shall be immediately brought to the attention of the Engineer, and construction activities in the immediate vicinity of the movement shall be ceased until any necessary corrective action has been taken or as ordered by the Engineer. The Contractor shall modify the means and methods associated with any construction activities that result in movement exceeding ½-inch.

Survey data shall be reduced and tabulated by the Contractor, in a format approved by the Engineer, and shall be submitted to the Engineer in hard copy format. Tabulated data shall be submitted weekly except for locations with measured movement at or exceeding ¼-inch, where the reduced data shall be submitted daily.

The Contractor shall maintain the UMPs during the construction phase and shall be able to re-establish or replace UMPs for all locations damaged during the time periods when monitoring is required at a given location. New
baseline UMP reference data shall be established for replacement points prior to resuming construction activities at a
given location.

Upon completion of the construction at a given location, the Contractor shall remove UMPs installed and restore the
original condition of the affected location, unless the Engineer and Buckeye Pipeline approve abandonment of the
UMPs in place.

**Method of Measurement:** The item, being paid for on a lump sum basis, will not be measured for payment.

**Basis for Payment:** This work will be paid for at the contract lump sum price for the following pay item, which price
shall include the furnishing and installation of UMPs, survey monitoring of UMPs at the required intervals, maintenance
and protection of UMPs, replacement of damaged UMPs, removal of UMPs, the recording and processing of data, the
transfer of data to the Engineer and all transportation, materials, equipment, tools and labor incidental thereto:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTILITY MONITORING POINTS</td>
<td>LS</td>
</tr>
</tbody>
</table>

Attachment: UMP Detail
UTILITY MONITORING POINT UMP

NOT TO SCALE
ITEM #0203xxxA – PROTECTION OF BUILDING AND PROPERTY
ITEM #0203xxxA – CONDITION SURVEY (SITE NO. 1)
ITEM #0203xxxA – CONDITION SURVEY (SITE NO. 2)
ITEM #0203xxxA – CONDITION SURVEY (SITE NO. 3)

Description:

Under these items, the Contractor shall conduct a vibration monitoring control plan during construction for protection of building and property, and also provide condition surveys of the identified sites.

Vibration producing activities (such as controlled blasting, mechanical rock breaking, excavation, pile installation, vibratory compaction, pavement breaking or operation of heavy construction equipment) are required for construction of this project.

Work under these items include:

1. Structure/Building Condition Surveys and Reports. Performing surveys and preparing associated reports: a) prior to commencement of work; b) after completion of work; c) and at locations and times during construction as directed by the Engineer.
   a. Conditions surveys shall document the existing conditions of the building including but not limited to cracks, settlements, holes or other deterioration.

   a. Preparing a vibration and movement monitoring plan.
      i. Establish monitoring points for horizontal and vertical controls.
      ii. Install crack monitoring gages.
      iii. Install vibration monitoring sensors
   b. Conduct monitoring and take readings before, during and after anticipated vibration or movement producing activities including but not limited to:
      i. Site excavation activities and demolition including pavement breaking
      ii. Controlled blasting for rock excavation
      iii. Bedrock fragmentation by mechanical means
      iv. Vibratory compaction
      v. Installation of steel piles
      vi. Cutting and demolition associated with removal of concrete substructure
      vii. Or until sufficient information has been collected to prove that no differing condition exists.

3. Additional protective measures as required to prevent damage to the existing buildings, appurtenances, the Buckeye Pipeline, structures or features within the influence of any construction related activities, including construction-induced vibrations and movement.
Locations requiring condition surveys and vibration and movement monitoring include:

1. Site No./Building No. 1: 42 West St. Middletown, CT
2. Site No./Building No. 2: 46 West St. Middletown, CT
3. Site No./Building No. 3: 53 West St. Middletown, CT

Locations requiring vibration and movement monitoring include:

1. Buckeye Pipeline

**Submittals**

**Prior to Construction**: Provide the following:

1. Qualifications of a vibration monitoring consultant and seismologist, structure/building condition survey consultant, and movement/settlement consultant
2. Condition Survey. At a minimum include the following:
   a. Sealed and signed by the consultant.
   b. Site inspection shall evaluate the interior and exterior condition of the existing structures/buildings including interior sub-grade and above-grade accessible walls, ceilings, floors, roof, and visible exterior as viewed from the grade level.
      i. Document extents and locations of existing signs of structure/building distress such as cracks, spalling, signs of settlement, flooding, leaking, and other existing damage or defects.
      ii. Detail any existing structural, cosmetic, plumbing or electrical damage.
   c. Written report shall include color photographs, engineering sketches, and drawings and other pertinent information including the following:
      i. Summarize the pre-construction condition of the structures.
      ii. Fully describe the existing condition of each feature potentially affected by construction induced vibrations.
      iii. Identify areas of concern, including potential personnel hazards (falling debris) and structural elements that may require support or repair.
      iv. Identify locations requiring crack monitoring gages.
      v. Identify points on structures to be monitored in relation to the horizontal and vertical controls.
      vi. Specify the value of maximum peak particle velocity for each existing structure and surveyed feature that might be impacted by construction-induced vibration. Document methodology used for establishing vibration acceptance criteria.

3. Movement/Settlement Monitoring Plan. At a minimum include the following
   a. Plan with locations for movement monitoring points and gages
      i. Identify locations of control points/benchmarks located on-site (and off-site if required) to be used for monitoring horizontal and vertical controls.
      ii. Note points on structures to be monitored in relation to the horizontal and vertical controls.
4. Vibration Monitoring Plan. At a minimum include the following:
   a. Contract Designations
      i. Name of vibration monitoring specialist.
      ii. Scheduled start date and length of construction operations which require vibration monitoring.
      iii. Location of underground utilities in proximity to the construction operation.
   b. Plan with locations of the vibration monitoring sensors and equipment.
      i. Note maximum peak particle velocity limits for each specified structure and surveyed features, as identified by the Structure/Building Condition Survey Consultant.
      ii. Identify anticipated vibration levels at the structure and surveyed feature locations.
   c. List construction operations and equipment that require vibration monitoring.
   d. List vibration monitoring equipment to be utilized for site monitoring.

**During Construction:** Provide the following:

1. Movement/Settlement Monitoring Data. Include the following:
   a. Monitoring Gage Data. Submit weekly reports in a format approved by the Engineer.
   b. Settlement/Movement Data. Submit weekly reports in a format approved by the Engineer.

2. Vibration Records and Associated Construction Activity Data. Submit daily and weekly summary reports in a format approved by the Engineer.
   a. Provide results of daily vibration monitoring, one work day after the readings are taken.

**After Construction:** Provide the following:

1. Post-construction condition survey, sealed and signed by the Structure/Building consultant.
   a. Identify any changes to building conditions.

2. Settlement/movement readings taken at existing structures

**Quality Assurance – Qualifications**

**Vibration Monitoring Consultant and Seismologist:** Submit proof and details, as references, of ten projects in the past five years where the vibration monitoring consultant satisfactorily installed and monitored construction operations by recording maximum peak particle velocities (PPVs). Include contact information for each reference.

**Movement/Settlement Consultant:** Licensed as a professional surveyor in the State of Connecticut. The surveyor may be a consultant or one of the Contractor's employees.

**Structure/Building Condition Survey Consultant - Professional Structural Engineer:** Licensed as a professional engineer in the State of Connecticut, and experienced in performing condition surveys of structures/buildings comparable in construction and age to the existing
structures/buildings. The licensed professional engineer shall be required to attend all condition survey site inspections.

**Construction Methods:**

**General**

Make every effort to avoid damage to the existing structures/buildings, underground utilities, appurtenances, structures or features within the influence of any construction-induced vibrations including the use of site access routes.

The Contractor is responsible for all construction related damages caused by, but not limited to, movement/settlement, vibration, or air blast from his construction operations. Any damage caused by the Contractor's operations shall be repaired by the Contractor, at his own expense, to the satisfaction of the Engineer.

Vibration monitoring is required for any vibration producing activity associated with this project and shall be performed by the approved vibration monitoring Consultant.

**Public Relations**

1. At least 45 days before starting any construction activities which will induce vibrations, the Structure/Building Condition Survey Consultant shall notify, in writing by certified mail, all residents or owners of structures located within the hereinbefore noted limits.

2. Maintain a complaint log and make this available to the Engineer on request. Notify occupants/owners of adjacent structures/buildings at least 2 weeks prior to commencement of any vibration producing activity that might affect the structure or inhabitants.

**Condition Surveys**

**Pre-Construction Condition Survey:** Complete condition survey prior to start of on-site construction activity.

1. Pre-condition survey and site visit shall be performed by the Structure/Building Survey Consultant
   a. Inform Engineer 48 hours (minimum) prior to Consultant's site visit.
   b. Engineer shall accompany Consultant during all or portions of the structure/building condition site visits.
   c. Engineer may require Contractor to also accompany Engineer and Consultant during all or portions of the structure/building condition site visits.

2. Document condition of any existing structure/building features that may be affected by construction-induced vibration, and at a minimum the following:
   a. Areas of concern, including potential personnel hazards (falling debris) and structural elements that may require support or repair.
   b. Locations requiring crack monitoring gages.
   c. Points on structures to be monitored in relation to the horizontal and vertical controls.
d. Provide digitally-recorded observations including video and still photography, and sketches as needed.

Post-Construction Condition Survey

Following completion of vibration producing activities, the Structure/Building Survey Consultant shall perform a post-construction condition survey for each location that received a pre-construction condition survey.

Compare current condition of buildings with the detailed pre-construction survey information to determine if any damage occurred during construction activities, and whether any of the changes noted were a direct result of construction activities.

Document changes in the condition of features with video, still photographs, sketches and a detailed narration, and include as part of the submittal.

Movement/Settlement Monitoring

Crack Monitoring Gages. Install crack displacement monitoring gages as appropriate across any significant existing cracks to help verify any additional building distress that may develop. The appropriate location, number, and type of gages will be established by the Structure/Building Survey Consultant and approved by the Engineer.

Structure/Building Damage

Upon the discovery of any damage, cease construction operations and immediately inform the Engineer.

1. The "Structure/Building Condition Survey Consultant" shall document and assess damage to structures and submit such documentation to the Engineer. Documentation shall include plans, drawings, sketches, photographs and videos. Include proposed methods and procedures for repairing damaged areas.
2. The "Structure/Building Condition Survey Consultant" shall identify cause(s) of such damage and the Contractor shall modify construction operations appropriately to prevent further damage.
3. The Contactor shall repair damages to the satisfaction of the Engineer.
4. Construction shall resume upon completion of repairs and written authorization of the Engineer.

Vibration Monitoring

Provide necessary equipment to monitor potential vibrations that occur during construction.

1. Vibration monitoring equipment shall be capable of continuously recording the peak particle velocity, providing a permanent record of the entire vibration event.
2. Provide additional equipment when directed by the Engineer at no additional cost to the Owner.

Install seismographs at structure locations that are nearest to the vibration-inducing source. Immediately recalibrate or replace seismographs if the seismograph monitors/equipment show any indication of damage or vandalism.

Perform continuous vibration monitoring during listed construction operations included in the approved "Vibration Monitoring Plan" and when adjacent activities make monitoring prudent. The Contractor shall review vibration data on a daily basis for as long as vibration-producing activities are being conducted.

Obtain baseline or ambient readings a minimum of two weeks prior to the start of the listed activities.

Vibration readings shall not exceed the following:

1. The maximum peak particle velocity for each specified structure is identified in the approved "Preconstruction Condition Survey".
2. In no case, shall the peak particle velocity (PPV) readings at the structures being monitored exceed 0.5 inches per second.
3. The PPV readings at the Buckeye Pipeline shall not exceed the maximum allowable value specified by the Owner of the Pipeline.

If measured velocities exceed the maximum allowable PPV, stop operations immediately and revise equipment and procedures to reduce vibrations to allowable levels. The "Structure/Building Condition Survey Consultant" shall assess the structures for any damage. If damage to structures is identified, follow the procedures specified under the Article "Movement/Settlement Monitoring", subparagraph "Structure/Building Damage."

**Repairs**

Site Restoration: Any areas or items disturbed by the Contractor's operations shall be restored to pre-existing conditions or replaced by the Contractor at no additional cost. The costs for any site restoration or replacement of items damaged as a result of the Contractor's work shall be included in the specific bid item for which the work is required.

**Method of Measurement:**

This work, being paid on a lump sum basis, will not be measured for payment.

**Basis of Payment:**

The Work will be paid for at the Contract lump sum prices for the items listed below, complete in place and accepted, which prices shall include all materials, equipment, tools, labor, accessories, transportation, field inspections, documentation, photographs, video, sketches and
final report for each structure identified, and inclusive of all items of work required to successfully complete the work.

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Payment Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection of Building and Property</td>
<td>LS</td>
</tr>
<tr>
<td>Condition Survey (Site No. 1)</td>
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</tr>
<tr>
<td>Condition Survey (Site No. 2)</td>
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<tr>
<td>Condition Survey (Site No. 3)</td>
<td>LS</td>
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</table>