
VDOT
Virginia Department of Transportation

# STATE ROUTE 92 OVER STAUNTON RIVER DRILLED SHAFTS

## STGEC 2025

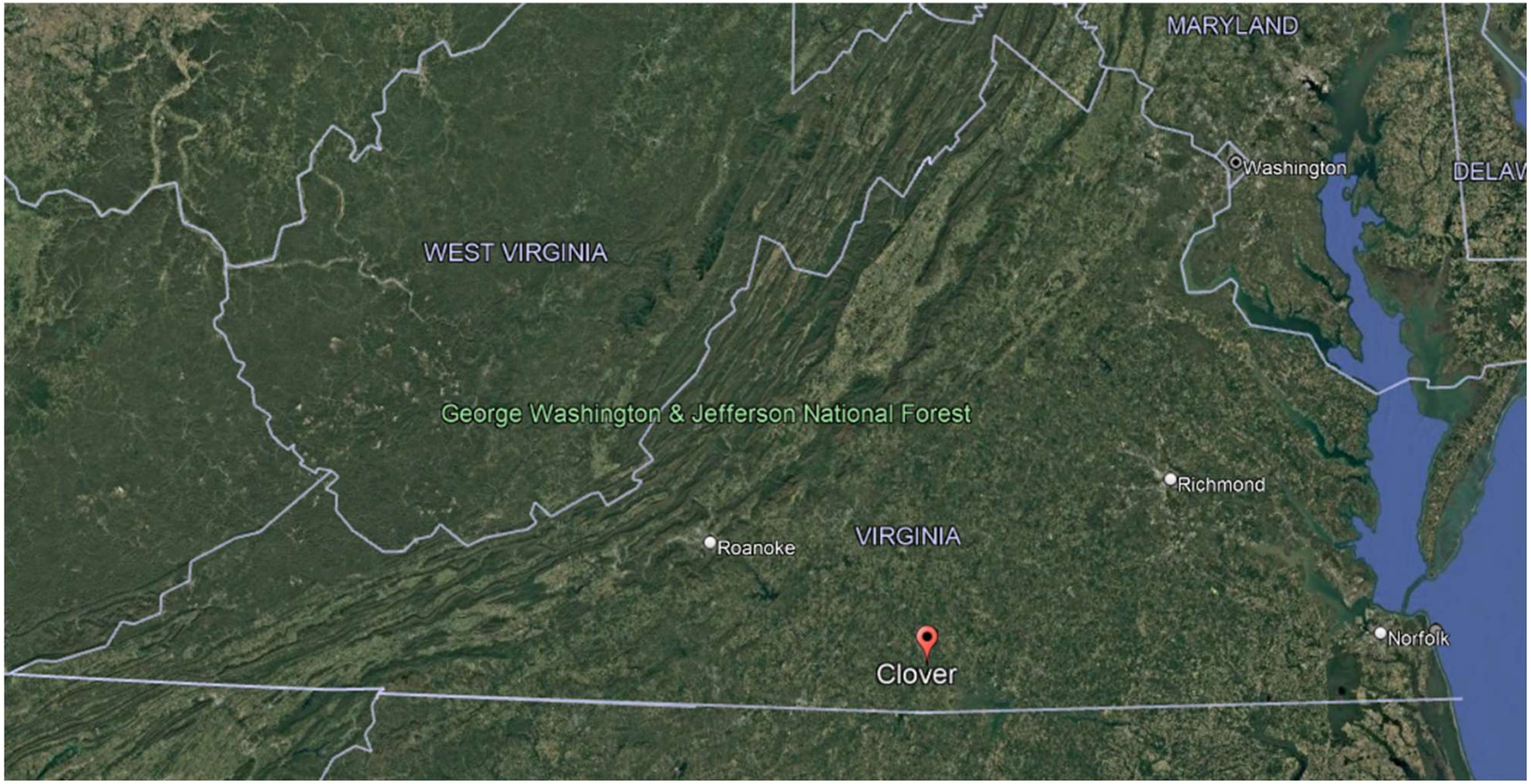
William W. Bassett, P.E.

September 17, 2025

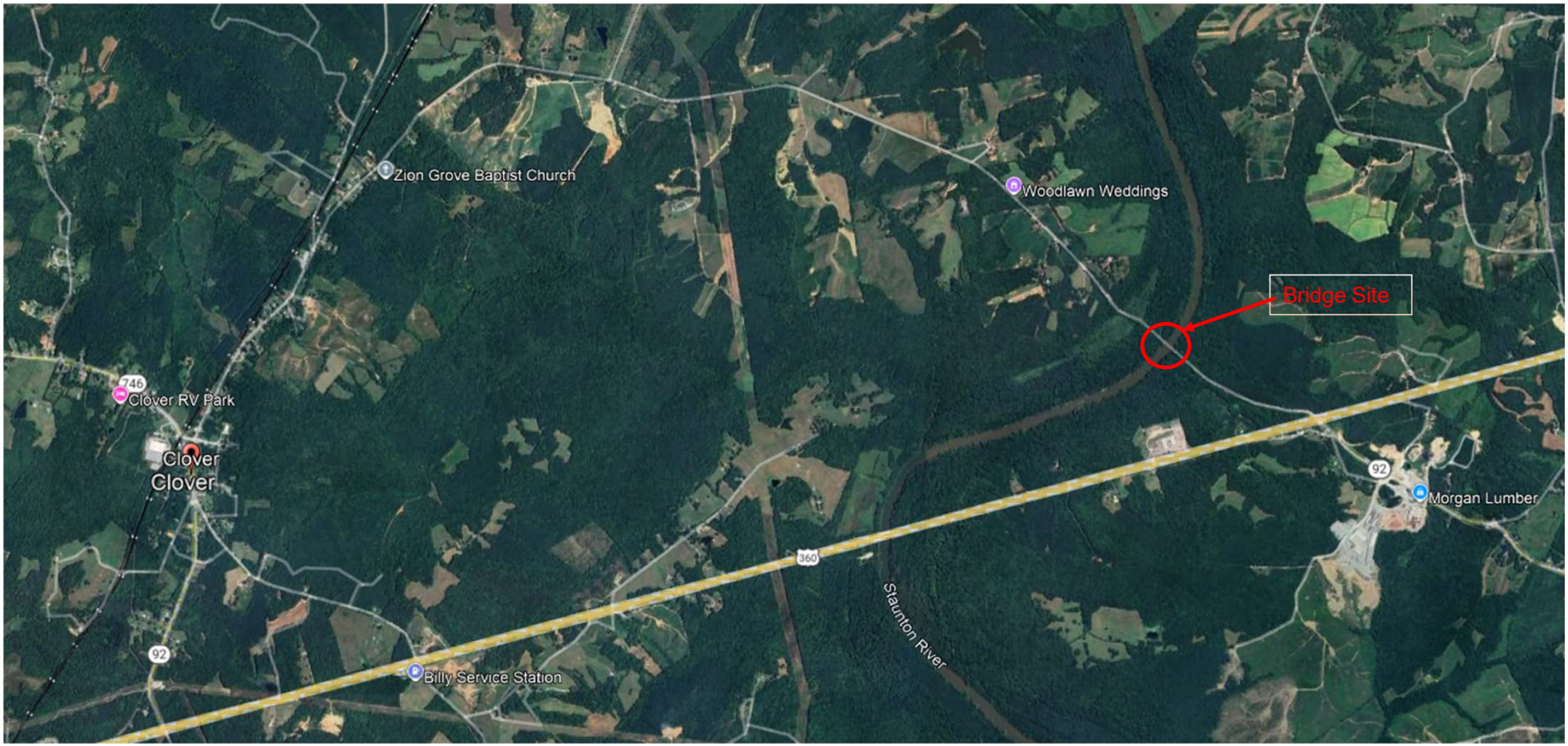
# The Project – Quick Facts

- **Existing bridge:**
  - Built in 1930, out of service since 2008 due to age and structural deficiency.
  - 960 feet long w/ 15 conventional concrete beam spans over land and 4 steel truss spans over the river.
  - All foundations are spread footings on IGM/Rock
- **New bridge**:
  - 975 feet long w/ 8 spans
  - Piers are column extensions of drilled shafts
  - 2 drilled shafts per pier, 5 drilled shafts per abutment
  - Schedule - NTP Sept 2024, est complete Aug 2027
  - Cost $22 million
  - Designed by Lynchburg District S&B/CO S&B Geotech

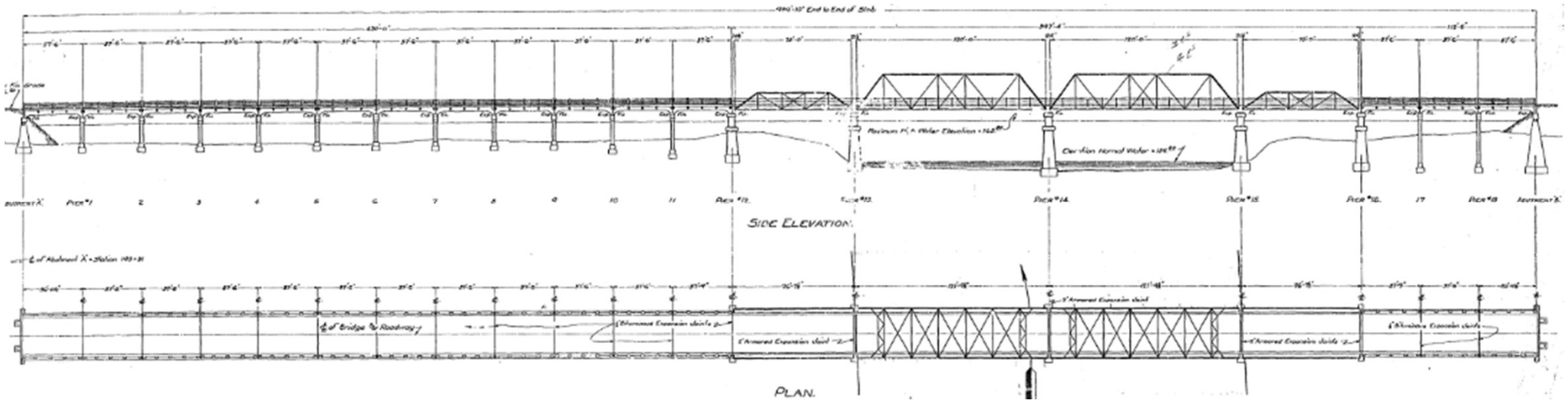
# Project Location



# Project Location

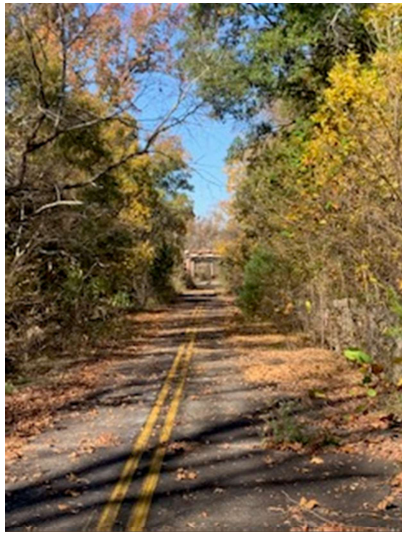


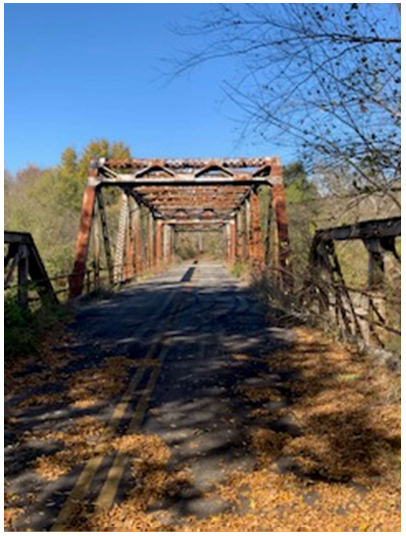
# Existing Bridge Plans

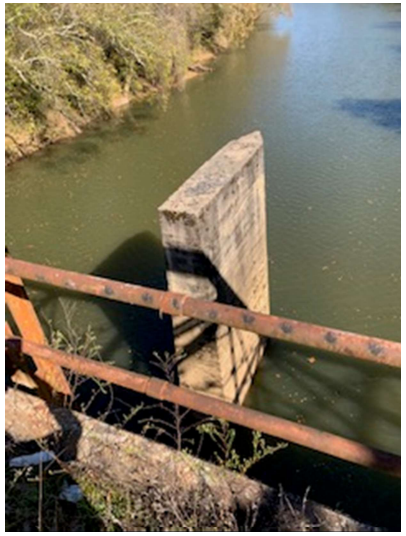



Note: all foundations are spread footings

# Existing Bridge Photos







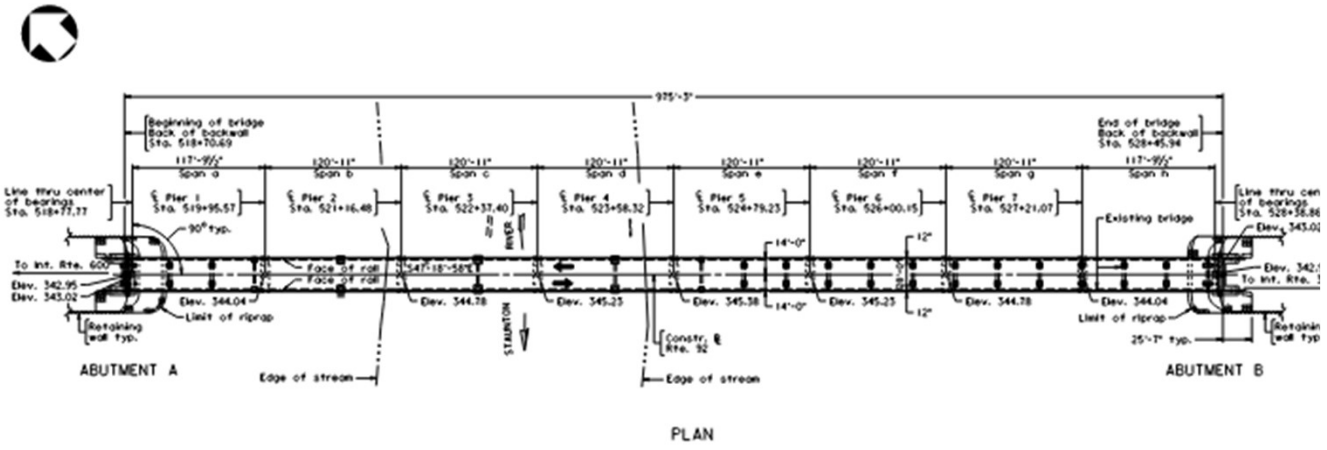
VR0

# Existing Bridge Demolition

**Slide 8**

**VR0** So how, there is no audio when I emailed it to myself.  I think it is ok without audio.
Vester, Robert (VDOT), 2025-09-05T15:09:54.931

# New Bridge Plans



# Geology

- Carolina Slate Belt (Piedmont Physiographic Province)
- Site underlain primarily by the Aaron Formation and the Hyco Formation on Halifax County (north) side.
  - Upper Aaron: phyllite & slate
  - Lower Aaron: primarily metaconglomerate & metasandstone.
  - Hyco: primarily schist, metatuff and greenstone.

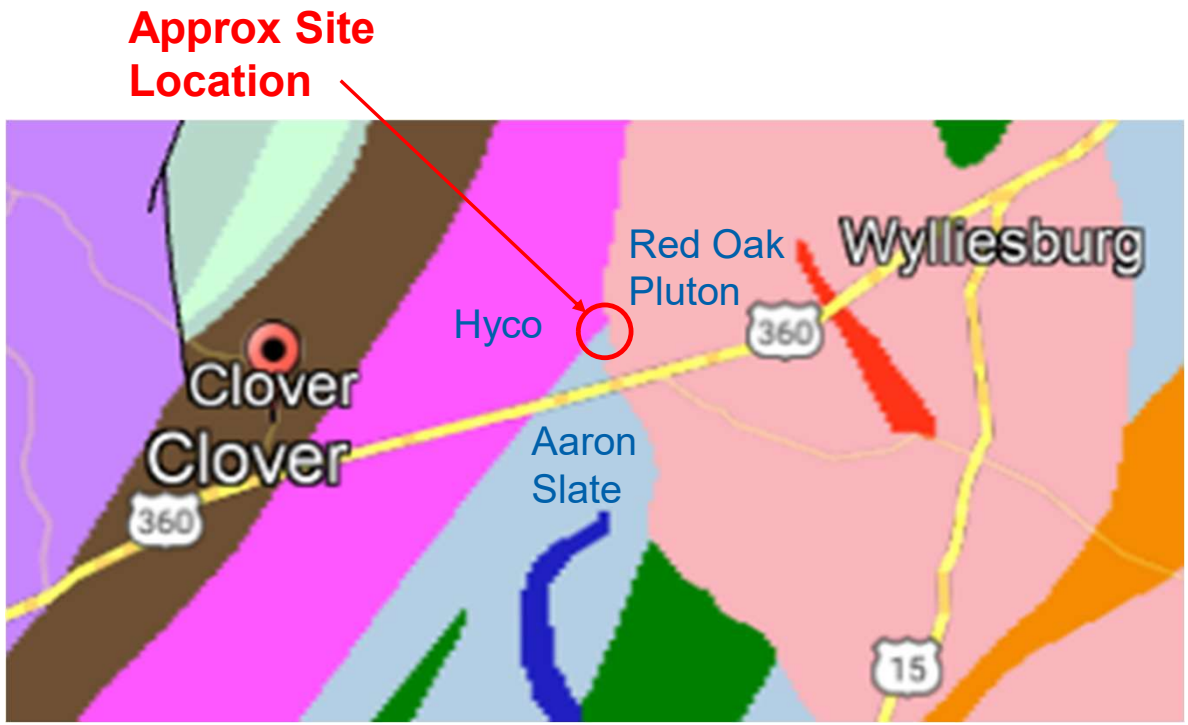
VR1

## Slide 10

**VR0** This statement is confusing.  Are we trying to say the Aaron formation is on the Charlotte County side (south side)?
Vester, Robert (VDOT), 2025-09-05T14:43:04.723

**VR1** Metastuff?
Vester, Robert (VDOT), 2025-09-05T14:43:15.645

# Geology


Approx Site Location
Red Oak
Pluton
Wylliesburg
Hyco
360
Clover
Clover
Aaron
Slate
360
15

# Subsurface Exploration

- 2 to 4 borings per substructure unit
  - Abutments: Depths 73 ft to 103 ft (avg 87 ft)
  - Piers: Depths 35 ft to 95 ft (avg 56 ft).
  - Rock coring length of 15 to 50 ft (avg 35 ft).
- Some discrepancies with differentiation of IGM and highly fractured rock were observed.
- Several supplemental borings were conducted to clarify this discrepancy.

**Slide 12**

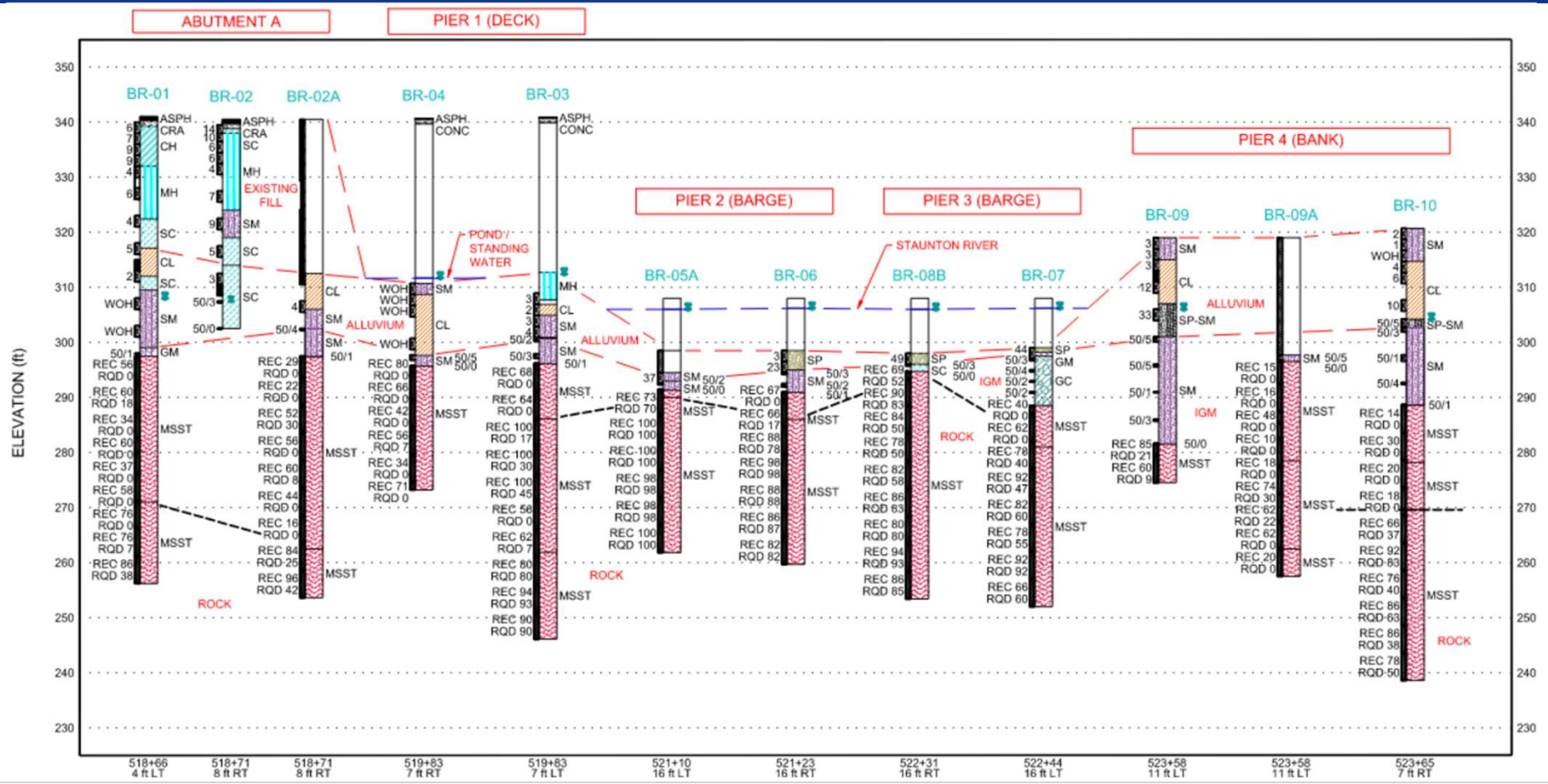
**VR0** As an aside during the presentation, may want to further discuss how drilling technique is important in exploration of this type of rock. Fast drilling with large crowd can break down the material into an IGM. Slower, less crowd tends to produce more fragmented rock. The inclusion of water has an effect as well.
Vester, Robert (VDOT), 2025-09-05T14:50:22.028

# Subsurface Exploration

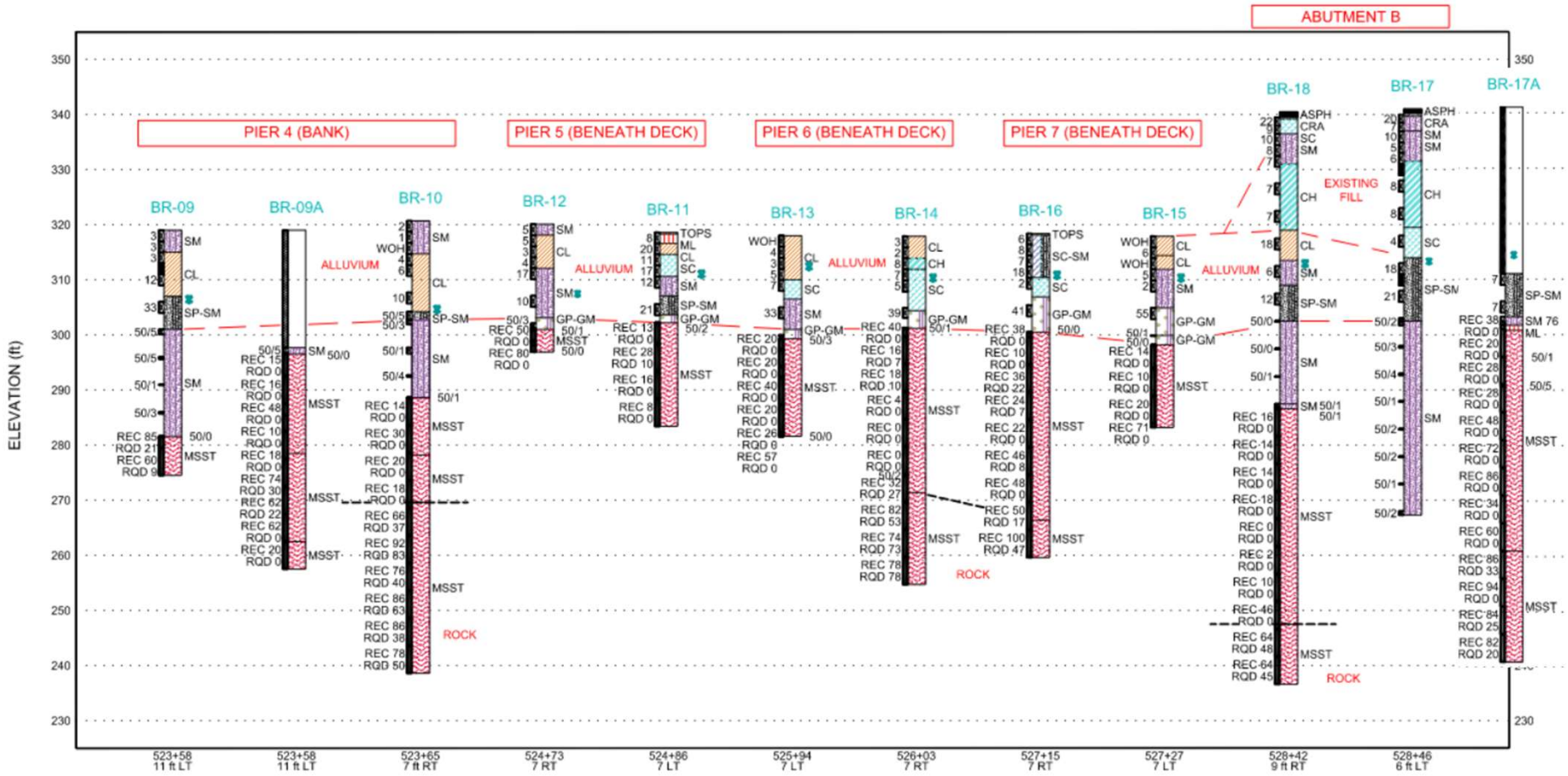
# Subsurface Exploration – Rock Quality

- Upper 20 to 30 feet (Abutments and Pier 1, 4, 5, 6, and 7):
  - highly fractured
  - RQDs ranging 0 to ~40%, predominantly zero RQD in this upper zone indicating poor quality rock.
- Below 20 to 30 feet:
  - Rock quality improvement
  - RQDs generally >40%.
- Pier 2 and 3 borings
  - RQDs predominantly >50% below 5 feet depth of rock.

# Subsurface Exploration – Sample Fence Diagrams



# Subsurface Exploration – Sample Fence Diagrams



# Subsurface Exploration - representative rock cores

| BORING: | DEPTH (FT): | DRILL DATE(S): | PHOTO DATE: | BOX: |
|---|---|---|---|---|
| BR-03 | 44.8 - 94.8 | 07/26/2021 - 07/27/2021 | 09/17/2021 | 1 of 4 |

| BORING: | DEPTH (FT): | DRILL DATE(S): | PHOTO DATE: | BOX: |
|---|---|---|---|---|
| BR-03 | 44.8 - 94.8 | 07/26/2021 - 07/27/2021 | 09/22/2021 | 2 of 4 |

# Geology – GDR comments

## From GDR (consultant): VR0

- ***The IGM/rock is highly fragmented with interbedded strata that are more or less susceptible to wash out during coring.***
- ***This can be attributed to: presence of phyllite (relatively soft and susceptible to washout); fracturing and differential weathering in metasandstone.***
- ***We have differentiated IGM and rock using core recovery and RQD rather than auger/sampler refusal.***

**Slide 18**

**VR0** If this is directly from the GDR then these statements should have quotes around them.
Vester, Robert (VDOT), 2025-09-05T14:46:19.885

# Design - general considerations

- Due to relatively high loads, the presence of rock, the anticipated scour depths and the desired column extension pier design, drilled shafts were determined to be the most appropriate foundation type.
- Scour and the highly fractured rock were the major drivers in drilled shaft design.
- Only side resistance was used for axial resistance. Design required 30 ft rock socket length for all except Pier 2 and 3 that required 22 ft rock socket length. Rock socket diameter is 5.5 ft for all shafts.
- Permanent steel casing specified for all drilled shafts in river per design requirement (Piers 2,3,4 added for Pier 1 during CN)

VR0

**Slide 19**

**VR0** We may be asked whether we considered a combination of side and end bearing. My answer for that is that you can't maintain a clean bottom to count on mobilizing the end bearing due to the highly fragmented rock.
Vester, Robert (VDOT), 2025-09-05T15:13:49.763

# Design - parameters for highly fractured rock and rock

**Highly fractured rock parameters for all substructures except Pier 2 and 3:**

- **RQD = 0 (Joint Modification Factor, $\alpha_E$ = 0.3)** (AASHTO 10.8.3.5.4b)
- **Rock Compressive Strength = 2,900 psi** (lab tests)
- **Rock Unit Weight = 140 pcf** (lab tests, a*ll substructures*)
- **Rock Mass Elastic Modulus = 1758 ksi** (lab tests, *all substructures*)

**Rock parameters for Pier 2 and Pier 3:**

- **RQD = 50 (Joint Modification Factor, $\alpha_E$ = 0.55)** (AASHTO 10.8.3.5.4b)
- **Rock Compressive Strength = 7,400 psi** (5,000 psi A5 concrete controls)

# Design - skin friction in highly fractured rock

- **Unit Skin Friction ($q_s$) is based on RQD and joint conditions (AASHTO LRFD 8th Ed. Section 10.8.3.5.4b)**

$$\frac{q_S}{p_a} = 0.65\alpha_E\sqrt{\frac{q_u}{p_a}}$$

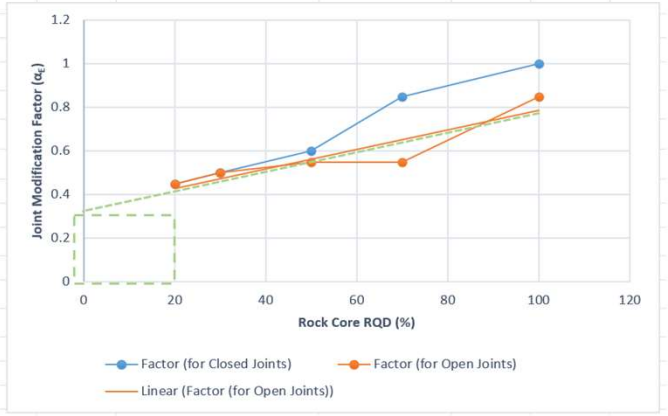
$p_a$ = atmospheric pressure taken as 2.12 ksf

qu = uniaxial compressive strength of rock or concrete, whichever is less, ksf

- **AASHTO Table 10.8.3.5.4b-1 used to determine value of $\alpha_E$**

**Table 10.8.3.5.4b-1—Estimation of $\alpha_E$ (O'Neill and Reese, 1999)**

| RDQ (%) | Joint Modification Factor, $\alpha_E$ | |
|---|---|---|
| | Closed Joints | Open or Gouge-Filled Joints |
| 100 | 1.00 | 0.85 |
| 70 | 0.85 | 0.55 |
| 50 | 0.60 | 0.55 |
| 30 | 0.50 | 0.50 |
| 20 | 0.45 | 0.45 |

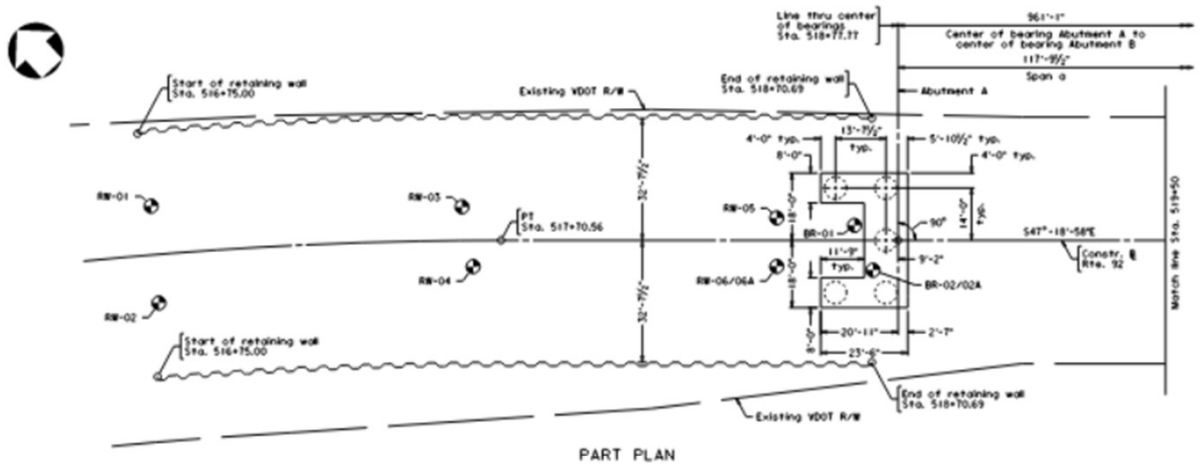



- **For RQD of zero, $\alpha_E$ = 0.3 based on graphical extrapolation**

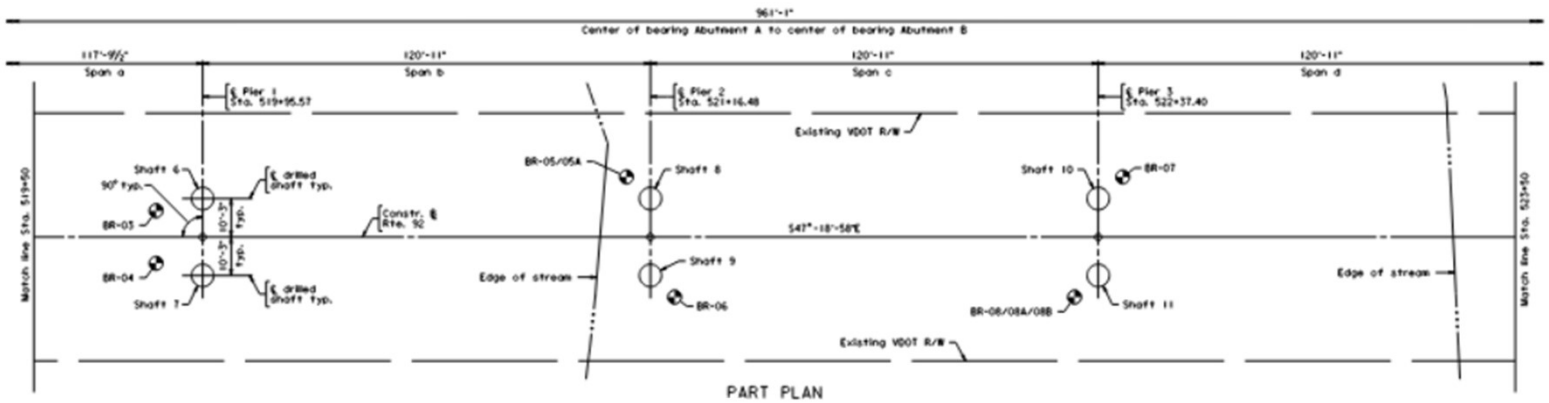
# Design - scour considerations

- Current VDOT scour policy is per HEC-18 and assumes rock with RQD<50% is scourable.
- Total design scour depths (100 yr flood):
  - Abut A = 29 ft
  - Piers 2,3,4 = 23 to 42 ft
  - All others = 8 to 12 ft

# Drilled Shaft Plans (North half of bridge)

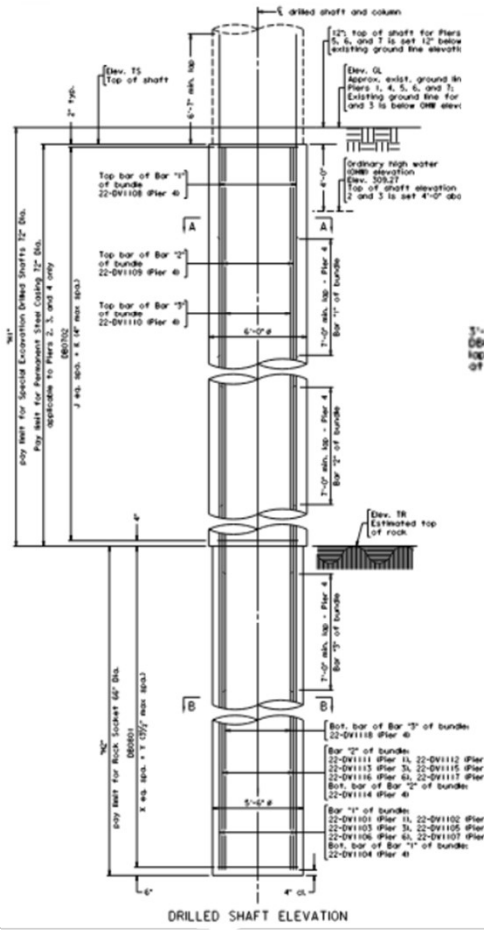


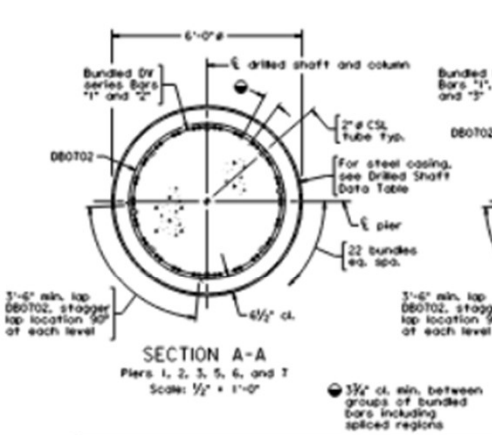

PART PLAN

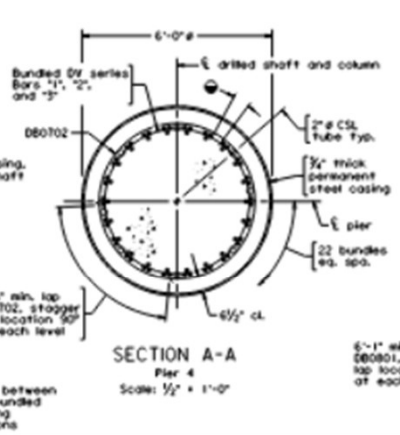


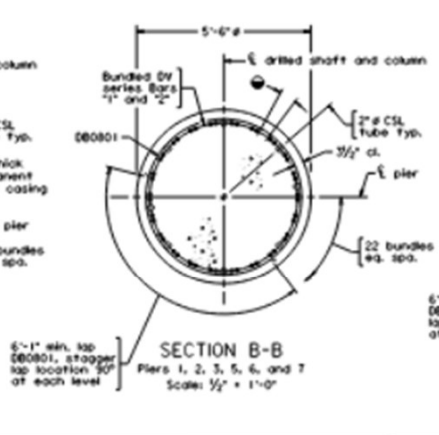

PART PLAN

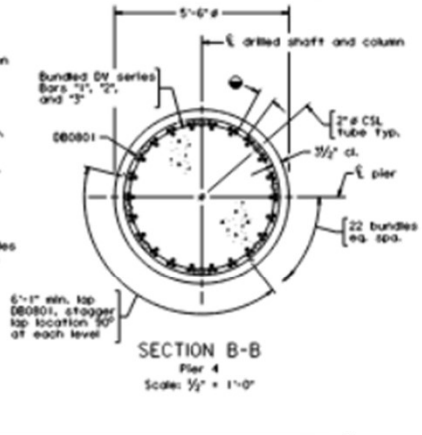
# Drilled Shaft Details - Piers




| DRILLED SHAFT DATA TABLE | | | | | | | | | | | TRANSVERSE REINFORCEMENT DATA TABLE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-structure Unit | Column/ Shaft | Lt. or Rt. of Rte. 92 Const. ℄ | Casing type | Elevations | | | Dimensions | | Nominal Axial Resistance *(Tons/shaft) | Factored Axial Resistance *(Tons/shaft) | DB0801 | | DB0702 | |
| | | | | Elev. GL | Elev. TS | Elev. TR | Dim. "W1" | Dim. "W2" Min. | | | X | Y | J | K |
| Pier 1 | 6 | Left | Temporary | 314.5 | 313.5 | 295.5 | 19.0' | 30.0' | 1504 | 827 | 102 | 29.50' | 53 | 17.50' |
| | 7 | Right | | 314.5 | 313.5 | 295.5 | 19.0' | 30.0' | | | 102 | 29.50' | 53 | 17.50' |
| Pier 2 | 8 | Left | ¾" thick, permanent | 303.2 | 313.3 | 291.0 | 12.2' | 22.0' | 1447 | 796 | 74 | 21.50' | 66 | 21.77' |
| | 9 | Right | | 303.2 | 313.3 | 291.0 | 12.2' | 22.0' | | | 74 | 21.50' | 66 | 21.77' |
| Pier 3 | 10 | Left | ¾" thick, permanent | 299.1 | 313.3 | 288.0 | 11.1' | 22.0' | 1447 | 796 | 74 | 21.50' | 75 | 24.77' |
| | 11 | Right | | 299.1 | 313.3 | 288.0 | 11.1' | 22.0' | | | 74 | 21.50' | 75 | 24.77' |
| Pier 4 | 12 | Left | ¾" thick, permanent | 318.7 | 317.7 | 281.7 | 37.0' | 30.0' | 1504 | 827 | 102 | 29.50' | 107 | 35.50' |
| | 13 | Right | | 318.7 | 317.7 | 281.7 | 37.0' | 30.0' | | | 102 | 29.50' | 107 | 35.50' |
| Pier 5 | 14 | Left | Temporary | 319.4 | 318.4 | 300.4 | 19.0' | 30.0' | 1504 | 827 | 102 | 29.50' | 53 | 17.50' |
| | 15 | Right | | 319.4 | 318.4 | 300.4 | 19.0' | 30.0' | | | 102 | 29.50' | 53 | 17.50' |
| Pier 6 | 16 | Left | Temporary | 318.1 | 317.1 | 299.1 | 19.0' | 30.0' | 1504 | 827 | 102 | 29.50' | 53 | 17.50' |
| | 17 | Right | | 318.1 | 317.1 | 299.1 | 19.0' | 30.0' | | | 102 | 29.50' | 53 | 17.50' |
| Pier 7 | 18 | Left | Temporary | 318.5 | 317.5 | 299.5 | 19.0' | 30.0' | 1504 | 827 | 102 | 29.50' | 53 | 17.50' |
| | 19 | Right | | 318.5 | 317.5 | 299.5 | 19.0' | 30.0' | | | 102 | 29.50' | 53 | 17.50' |

* The Strength Limit State controls the drilled shaft design.

# Drilled Shaft Special Provision (including CSL testing)

**ORDER NO.: L02**
**CONTRACT ID. NO.: C0000111280B07**

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
**DRILLED SHAFTS**

October 3, 2023

0092-019-860, B607, C501

**I. DESCRIPTION**

This work shall consist of all labor, materials, equipment, and services necessary to perform all operations to complete the drilled shaft installation in accordance with the Specifications, this Special Provision, and with the details and dimensions shown on the Plans, and as directed by the Engineer. Drilled shafts are reinforced concrete, deep foundation elements, cast-in-place against insitu material through augered holes. Unless otherwise shown on the Plans, drilled shafts are straight and vertical.

**II. SITE INFORMATION**

If Engineering Geology Sheets are included in the Contract Documents, the data on subsurface conditions are not intended as representations or warranties of continuity of such conditions. The data is made available for the convenience of the Contractor, and it is expressly understood that the Department will not be responsible for interpretations or conclusions drawn there from.

The Contractor or prospective bidders may obtain, prior to bidding, right-of-entry and complete whatever investigations, research, tests, or analyses required for bid purposes.

If a geotechnical report was prepared for this project, this report was prepared to establish design guidelines only and is not considered part of the Contract Documents or a warranty of subsurface conditions. The opinions and engineering analyses expressed in the report are those of the authors, and they represent their interpretation of subsurface conditions, and field and laboratory test data. Therefore, the information in the Geotechnical Report is not intended as a substitute for the Contractor's personal investigation, interpretation, and good judgment.

**III. QUALIFICATIONS OF DRILLED SHAFT CONTRACTOR**

The Drilled Shaft Contractor performing the work described in this Special Provision shall have experience consisting of successful installation of at least ten drilled shaft projects installed within the past 5 years, two of which shall be similar or greater size and in similar geologic conditions. The Drilled Shaft Contractor shall provide documentation of his superintendent's qualifications, record of experience, and prior project references demonstrating that he can handle unusual site conditions and equipment breakdowns. The drilled shaft work shall be performed under the supervision of the Drilled Shaft Contractor's superintendent, who shall have at least 5 years of experience installing drilled shafts within the last 8 years and shall be fully knowledgeable and experienced in construction of drilled shaft foundations of similar size and geologic conditions as those shown on the Plans.

The mentioned documentation shall reference, for each project, the names and phone numbers of owner's representatives who can verify the Drilled Shaft Contractors' participation on those projects, detail the size and number of the shafts, methods used during installation, methods used for wall stabilization, local soil conditions, actual construction time, and contract time.

The Engineer may accept or reject the Drilled Shaft Contractor and/or Superintendent based on his qualifications and previous field performance.

142

**QUALIFICATIONS OF DRILLED SHAFT CONTRACTOR{ TC "QUALIFICATIONS OF DRILLED SHAFT CONTRACTOR 2-9-24 (SPCN)" \f C \l "1" }**

The Contractor is advised that ***Part III Qualifications of Drilled Shaft Contractor*** in the Special Provision for Drilled Shafts dated 10-3-23 are waived by the Department and will not apply to the acceptance or rejection of the Drilled Shaft Contractor, however the Contractor shall take the Drilled Shaft Contractors qualifications into consideration towards the performance of the work.

All other Drilled Shaft Contractor requirements in the Special Provision apart from those noted in ***Part III Qualifications of Drilled Shaft Contractor*** shall be enforced as part of the Contract.

The Contractor shall discuss the Qualifications of the Drilled Shaft Contractor at the General and/or Drilled Shaft Pre-Construction Conferences.

2-9-24 (SPCN)

**2. Crosshole Sonic Logging (CSL) Test**

A. General

Crosshole Sonic Logging (CSL) is a nondestructive testing (NDT) method that measures the time for an ultrasonic pulse to travel from a signal source inside an access tube to a receiver inside another access tube and evaluates the integrity of drilled shafts. In uniform, good quality concrete, the travel time between these equidistant tubes will be relatively constant from the bottom to the top of the drilled shafts and correspond to a reasonable concrete pulse velocity. In uniform, good quality concrete, the CSL test will also produce records with good signal amplitude and energy. Longer travel times and lower amplitude or energy signals indicate the presence of irregularities such as poor-quality concrete, voids, honeycombs, or soil intrusions. The signal will be completely lost by the receiver and system recorder for more severe defects such as voids and soil intrusions.

The Contractor shall install access tubes intended for CSL testing and perform the tests as indicated in the Plans and described herein. When the Contractor is required to perform CSL tests in the Contract, he must only employ experienced personnel and engage the services of approved independent testing firm with previous experience in CSL testing. The Contractor shall submit to the Engineer for his approval the list of personnel and testing firms he intends to use during the CSL testing program along with their competence and field experience to perform evaluate and report the results of CSL tests. The Contractor shall perform the CSL tests in the number and locations specified or as requested by the Engineer, and he shall execute the test at least 48 hours after the completion of concrete placement of a given drilled shaft. The Engineer may specify a longer waiting period when retarders are used in the mix design, or other factors that may result in a slower rate of concrete setting. All CSL testing must be completed within 45 calendar days of concrete placement of a given drilled shaft.

Prior to beginning the CSL test, the Contractor shall assure that the test probes can pass through and down the tubes to the bottom of every installed tube. If a tube is obstructed, the Contractor shall core a hole large enough to accommodate the probe through its full length in the drilled shaft and near the obstructed tube to the depth indicated in the Plans for that CSL tube. If required, coring to accommodate CSL testing shall be at no additional cost to the Department. Core equipment, procedure, and location of the hole shall be approved by the Engineer prior to beginning coring. Logged results of the core drilling shall be submitted to the Engineer along with the cores. The CSL test may commence after the core hole is inspected and the probes can pass through.

The Contractor is responsible for submission of the CSL test report to the Engineer within 5 work days of its performance for a specific drilled shaft. The Engineer will evaluate and analyze the CSL test results within 3 working days of their receipt and provide the Contractor with a response regarding the acceptability of the drilled shaft tested.

# Criteria for Top of Rock Socket Determination

## Defined in VDOT Special Provision by penetration rate:

**3. Rock Socket**

Rock Socket is defined as excavation that is accomplished using the same drilling equipment described in "Special Excavation," operating at full torque and crowd, where the penetration is equal to or less than 1/2-inch in 5 continuous minutes of operation. The drill rig shall be in good condition and shall be capable of applying a minimum crowd of 35,000 pounds while turning the auger for diameters equal to or less than 48 inches, and at least 50,000 pounds of crowd for augers greater than 48 inches in diameter. The Contractor shall provide the Engineer with access to the instrument gauges in order to confirm that full torque and crowd are being applied.

When Rock Socket is specified as a pay item and detailed on the Plans, the Contractor shall provide the minimum penetration into rock as shown on the Bridge Plans, unless field modified by the Engineer.

# TIP testing Special Provisions

**ORDER NO.: L02**
**CONTRACT ID. NO.: C0000111280B07**

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
**THERMAL INTEGRITY PROFILING (TIP) OF DRILLED SHAFTS**

July 30, 2023

0092-019-860, B607

**I. DESCRIPTION**

Thermal Integrity Profiling (TIP) uses the heat generated by curing cement (hydration energy) to assess the quality of drilled shafts. The expected temperature at any location is dependent on the shaft diameter, mix design, time of measurement and distance to the center of the shaft. TIP measurements may be used to estimate the actual shape of the shaft as well. These estimates may be compared with concreting logs to assess the overall quality of the shaft. Good communication between the Contractor, the Drilled Shaft Contractor and TIP Consultant is essential.

TIP measurements that are colder than normal indicate necks, inclusions, or poor quality concrete, while warmer than normal measurements are indicative of bulges. Variations of temperatures between wires reveal cage eccentricity.

**II. QUALIFICATIONS FOR TIP CONSULTANT**

The TIP consultant shall have a licensed professional engineer holding a valid license to practice engineering in the Commonwealth of Virginia who is experienced in supervising the testing and interpreting the results. The TIP Consultant shall be an independent testing agency with documented and approved experience in TIP testing on at least five projects of similar or greater scope within the last 2 years. The Consultant qualifications and a description of the equipment used shall be submitted to the Engineer for approval at least 21 calendar days prior to beginning drilled shaft installation. For each project cited, the names and phone numbers of owner's representatives who can verify the TIP Consultant's participation on those projects shall be provided. Within 14 days after receipt of the installation plan, the Engineer will notify the Contractor of any additional information required or changes necessary to meet the Contract requirements.

**III. ASSISTANCE BY THE DRILLED SHAFT CONTRACTOR TO THE TIP TESTING CONSULTANT**

The Drilled Shaft Contractor shall provide cooperative assistance, suitable access to the site and the drilled shafts to be tested, and labor as required to assist the TIP Consultant in performing the required tests. Prior to testing, provide the drilled shaft lengths and dates of construction of drilled shaft to the TIP Consultant and coordinate with TIP Consultant to install the necessary TIP instrumentation prior to concreting the shaft.

**IV. EQUIPMENT REQUIREMENTS FOR TIP**

The equipment shall have the following minimum requirements:

(1) A computer-based TIP data acquisition system to monitor temperature versus time after casting.

(2) Ability to collect data at user defined time intervals (typically 15 to 60 minutes).



*TIP photos courtesy of PDI*

# Bid Phase

- **Language in contract required bidders to visually inspect the rock core boxes at the Lynchburg District office prior to bidding.**

**MANDATORY PRE-BID GEOLOGY BORING ROCK CORE SAMPLE REVIEW** – Bidders are advised there will be a **mandatory** Pre-Bid Geology Boring Rock Core Sample Review held at the District Office. Admission to the mandatory Pre-Bid Geology Boring Rock Core Sample Review will be conditioned upon the following:

- Date and Time: Review to be scheduled and completed by Bidder no later than **5:00 PM on June 5th, 2024**
- Location: Lynchburg District Office
- Point of Contact for scheduling review: James "Rusty" Hall, P.E. (District Geologist)
- Phone: 434-841-7376
- Email: James.Hall@VDOT.Virginia.gov
- A photo-ID will be required (example: a valid Driver's License or a valid passport).

Bids will only be accepted from those bidders who are represented at this mandatory Pre-Bid Geology Boring Rock Core Sample Review. Bidders should anticipate a week duration between notifying James "Rusty" Hall of scheduling a time and the actual meeting date. Attendance at this mandatory showing will be evidenced by the representative's signature on the Department's attendance roster.

Bidders are invited to bring a copy of the solicitation proposal with them. Any changes resulting from this mandatory Pre-Bid Geology Boring Rock Core Sample Review will be issued in a written addendum to the solicitation proposal.

# Construction - Installation Plan

1.4. Tooling

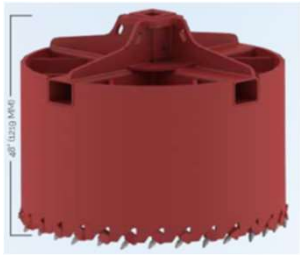
- 1.4.1. 66" and 72" Nominal Diameter Drilling Tools
- 1.4.2. Dirt augers
- 1.4.3. Rock augers
- 1.4.4. Core barrels, roller barrels, air barrels
- 1.4.5. Slurry augers
- 1.4.6. Drilling Buckets
- 1.4.7. Cleanout buckets
- 1.4.8. Excavation grab tools

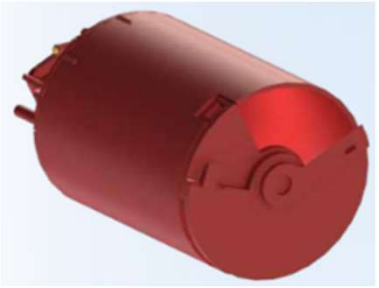
1.9. Construction

- 1.9.1. Temporary Casings – Smooth wall, rolled and welded pipe. 74" Nominal ID, 0.500" wall, will be used as temporary casings. *The pipe meets ASTM A252 specifications.*
- 1.9.2. Permanent Casings – Casings will conform to ASTM A242, 46 ksi. Casings will be shipped and installed at full length.
- 1.9.3. Permanent Casings - 72" OD x 0.75" wall, ordered lengths 30' to 46'

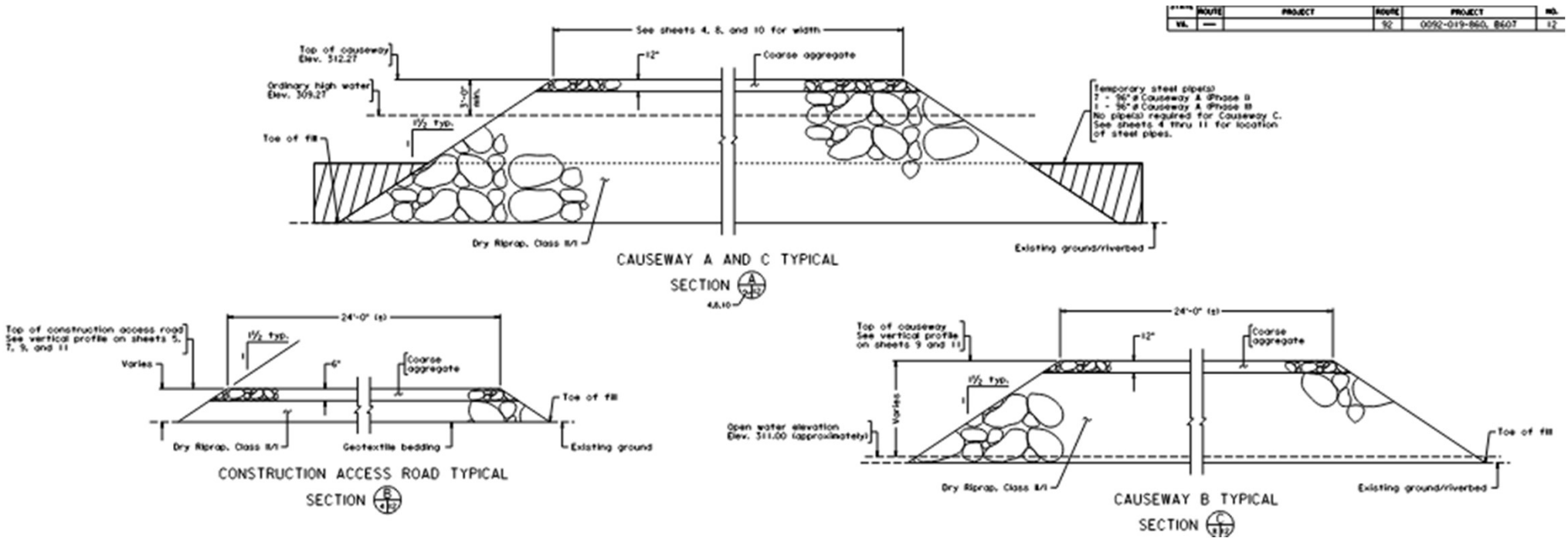
*Polymer Slurry Specifications, SP X.2.*

| Property at 70°F (Units) | At the Time of Slurry Introduction in the Drilled Shaft, During Drilling and Before Concrete Placement in the Drilled Shaft | Test Method |
|---|---|---|
| Density in Fresh Water[a] (lb/ft$^3$) | 64 maximum | Mud Weight (Density) API 13B- 1, Section 1 |
| Viscosity (sec per quart) | 32 to 135 | Marsh Funnel and Cup API 13B- 1, Section 2.2 |
| pH | 8 to 11.5 | Glass Electrode, pH meter or pH paper Strips |
| Sand Content[b] (%) | 1.0 maximum | Sand API13B-1, Section 5 |



# Construction - Access causeway



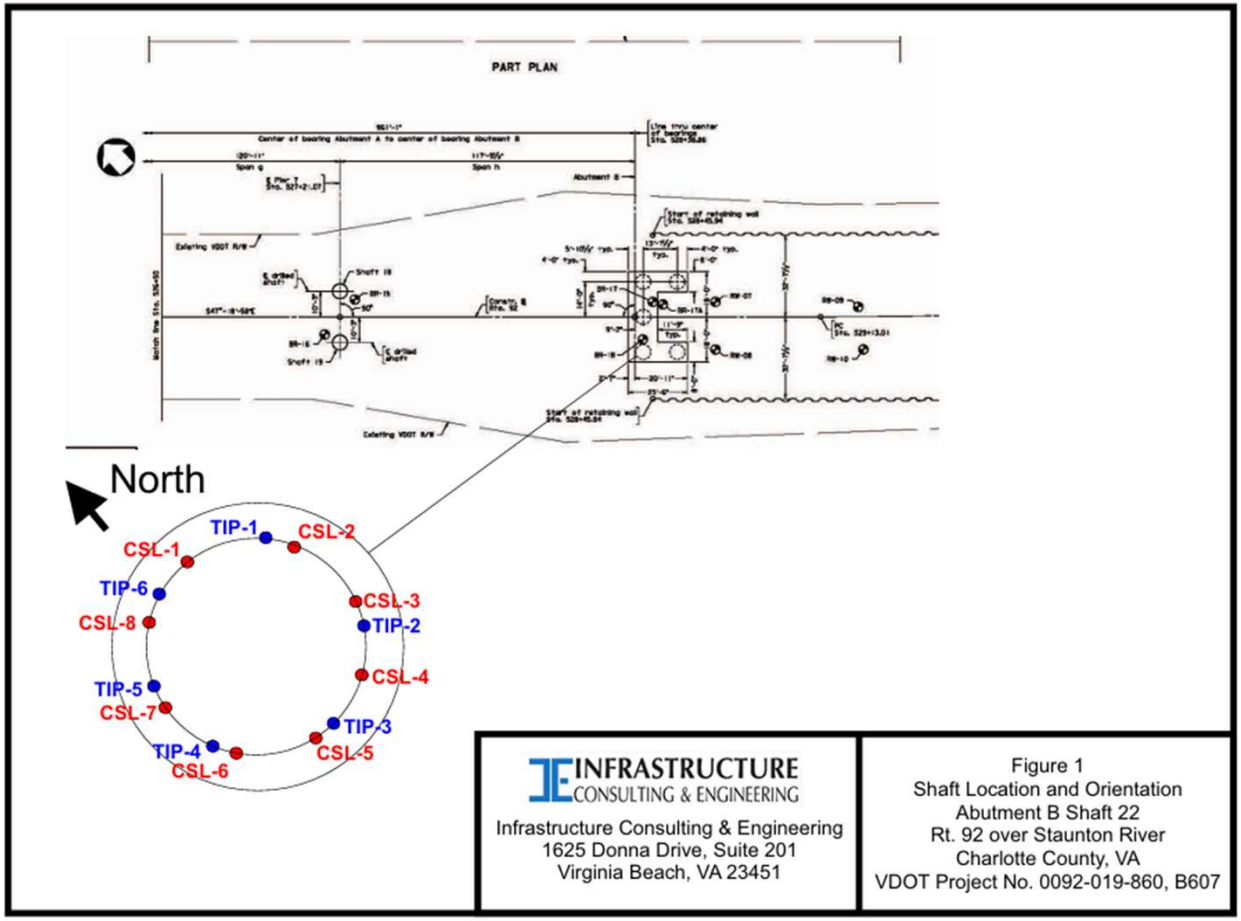
# Construction - Access Causeway

# Construction - Trial Shaft

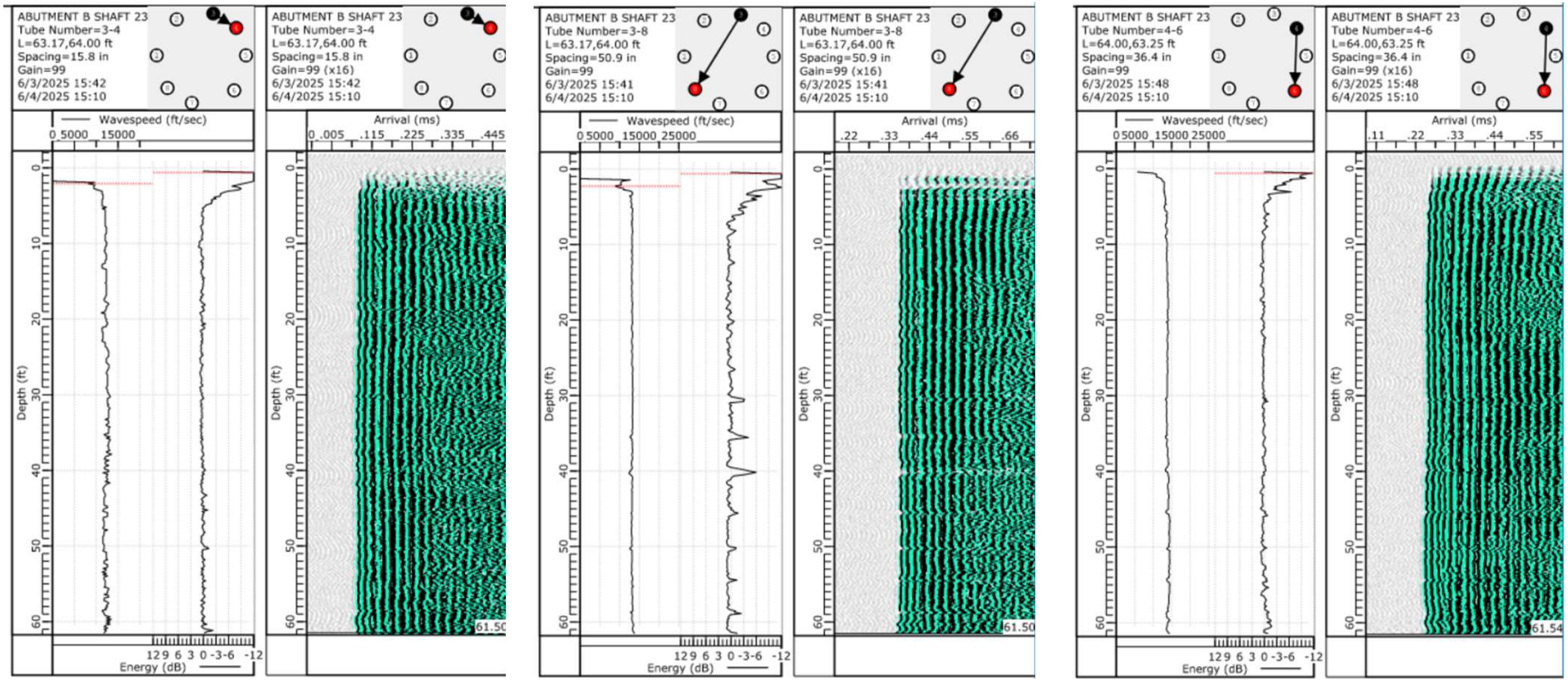
- Contractor requested to make trial shaft the first production shaft at an abutment. This was agreed to at the contractor's risk.
- Trial shaft was at Abut B, did not have permanent casing.
- Initial pour issues with concrete mix design and admixtures. First 5 trucks were not accepted due to being out of spec for slump flow and air content.
- Second attempt to pour was successful with only a minor issue at the very top of the trial shaft starting to set.
- Contractor performed PIT to evaluate top 1-2 feet of trial shaft.

# Construction – Trial Shaft Installation

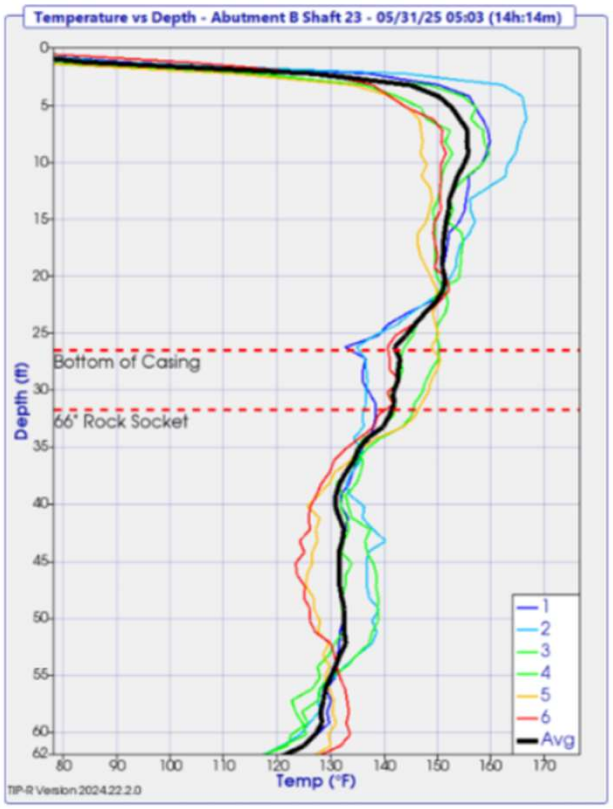
# Construction - CSL and TIP testing – typical layout

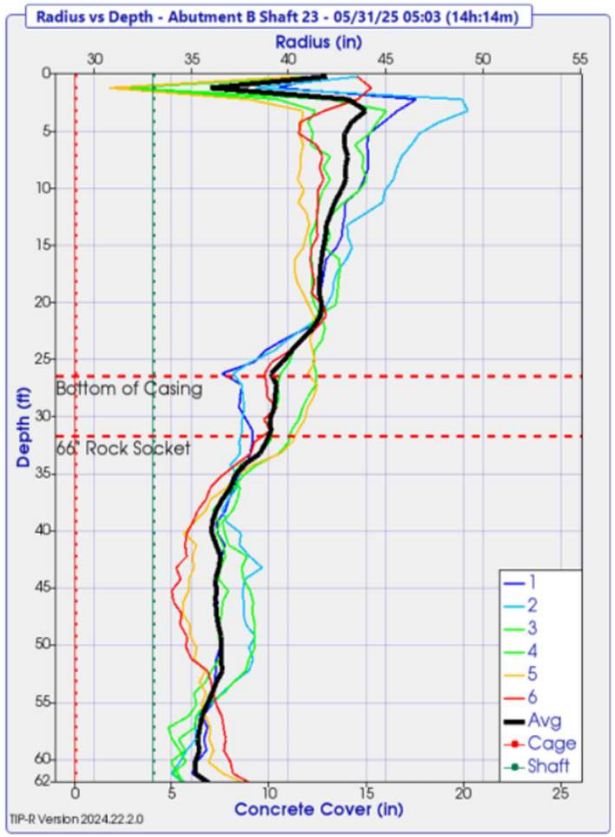


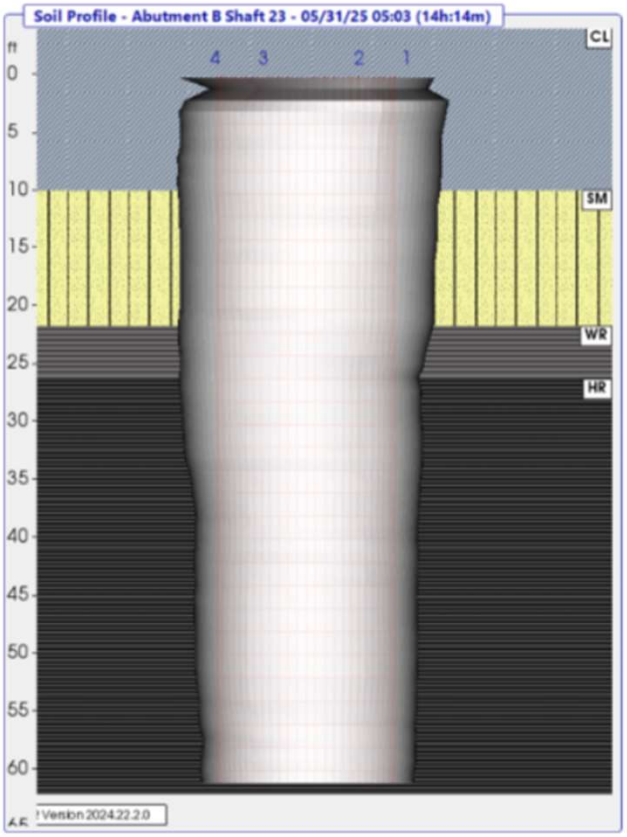
# Construction - CSL test results - trial shaft



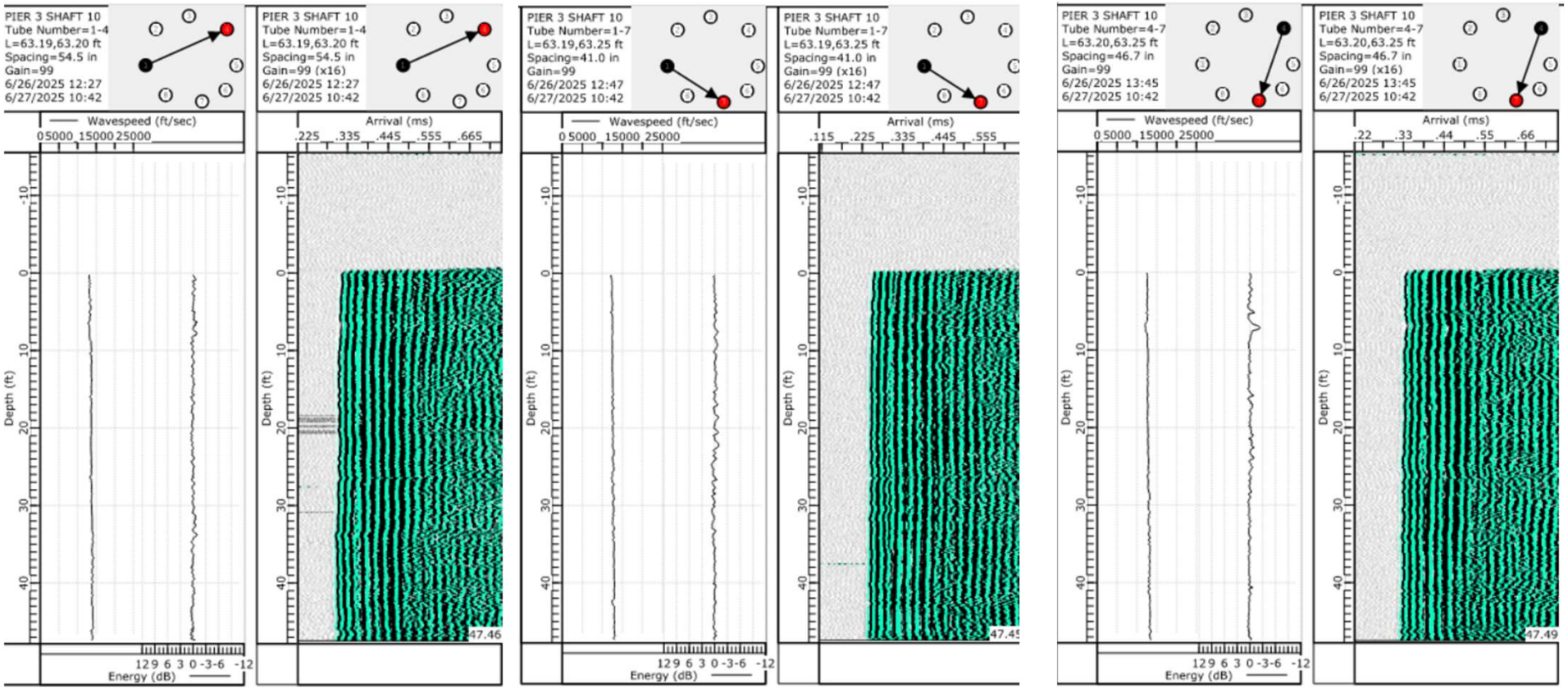
# Construction – TIP testing results - trial shaft



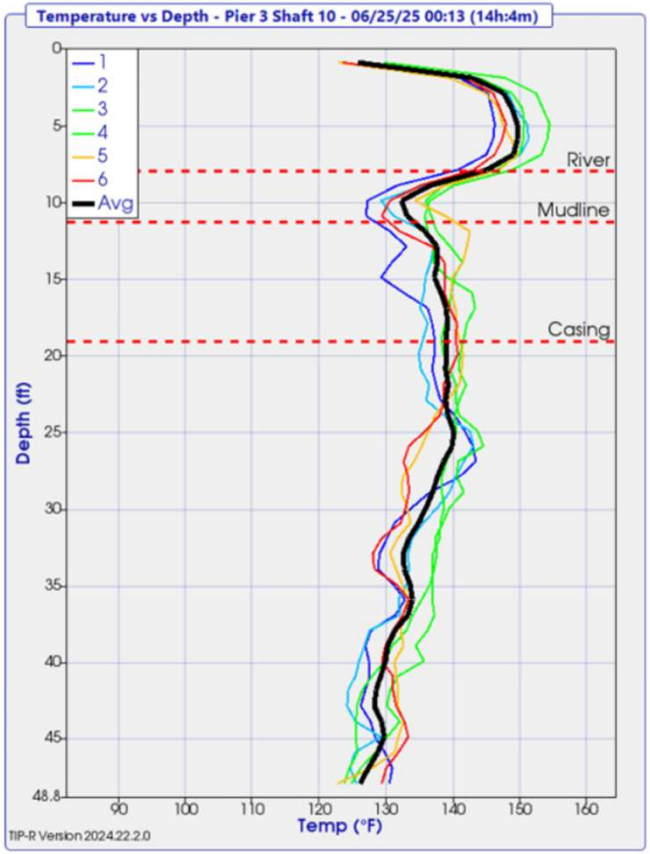



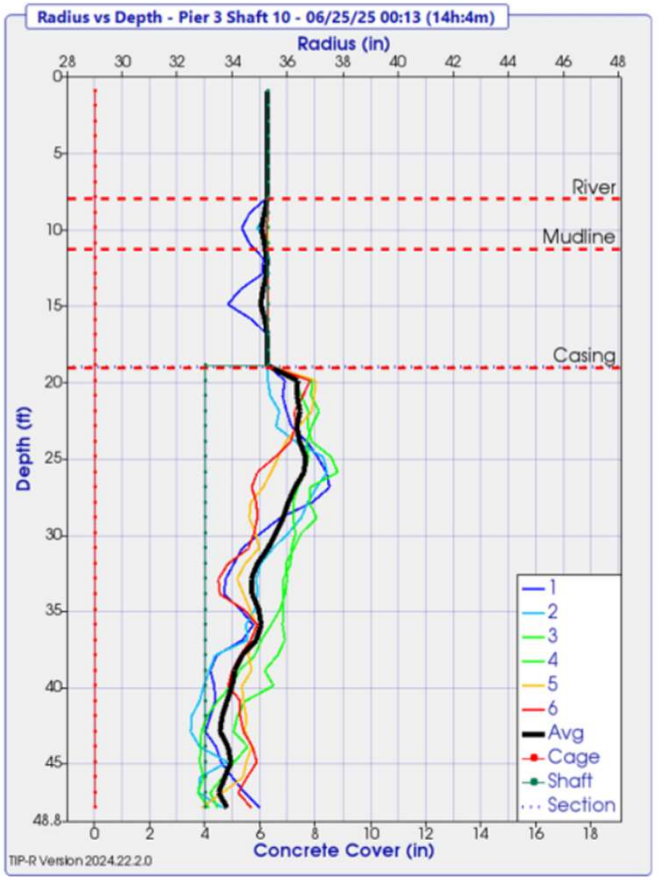
# Construction - CSL test results - production shafts

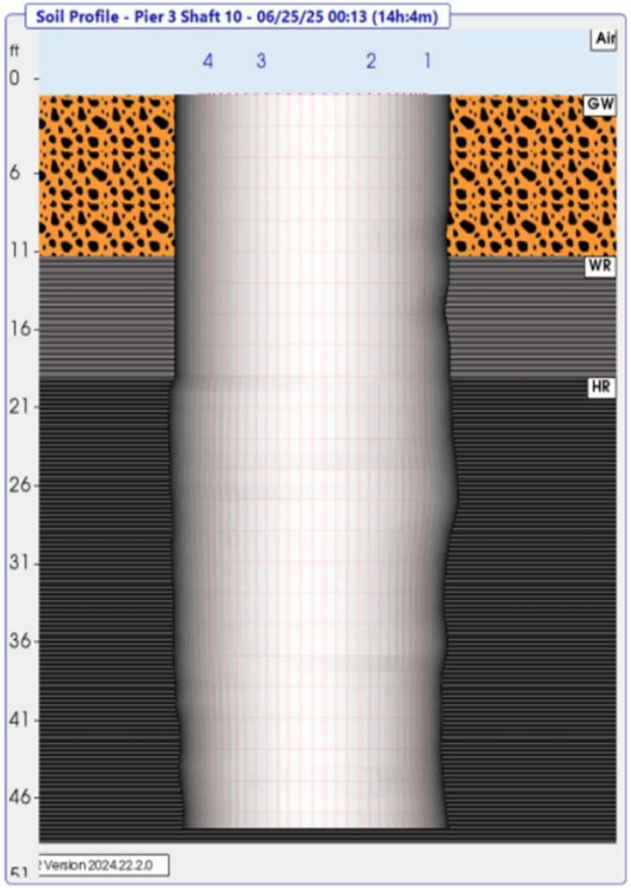


RV0

# Construction - TIP testing results – production shafts



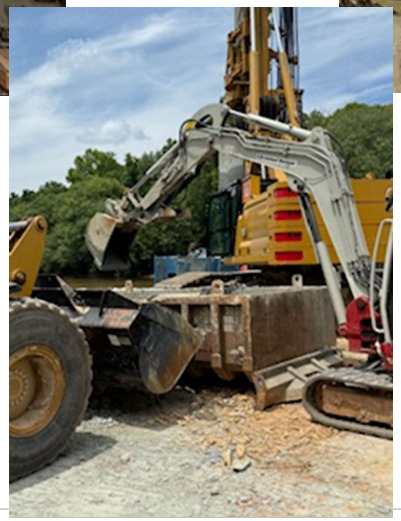



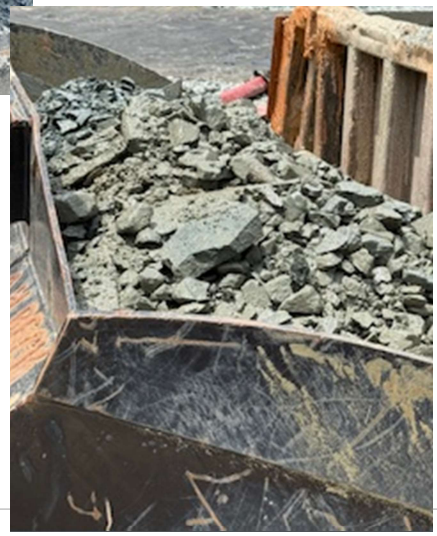
**Slide 38**

**RV0** Note that this drilled shaft shows evidence of bulging below the casing. Rock socket is designed to be narrower by 6 inches but we lose concrete into the fractured rock.

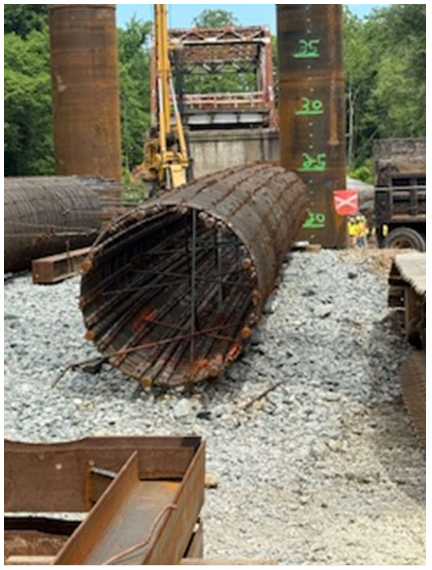
Vester, Robert (VDOT), 2025-09-10T19:52:44.362

# Construction - Production Shafts





# Construction - Production Shafts

# Lessons learned

- Require contractors to view rock cores in person pre-bid
- Rock penetration rate in SP is key. Highly fractured hard rock behaves similar to unfractured rock
- Highly fractured rock characterization/investigation - in-situ testing - rock borehole shear test (RBST)??
- Consider MWD and/or sonic drilling
- Specify load test (bi-directional load cell or similar) in contract??

# Construction - Collaboration

- Close coordination/collaboration was key between:
- Lynchburg District (S&B, Materials, CN, Environmental)
- CO S&B Geotechnical
- Contractor
- Drilled shaft Subcontractor
- Mother Earth

# Questions???

**"In theory there is no difference between theory and practice. In practice there is."** *Yogi Berra*


VDOT
Virginia Department of Transportation

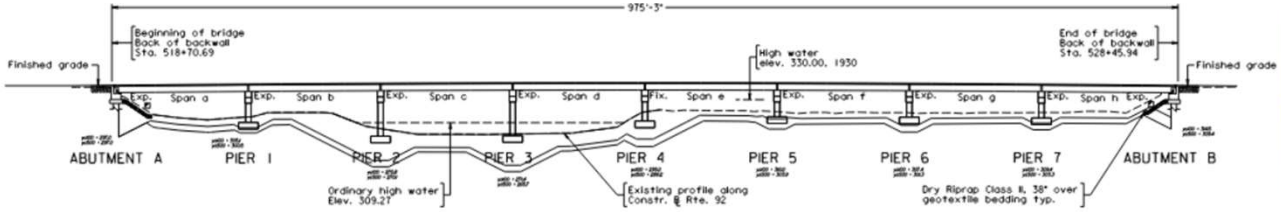
# Geology

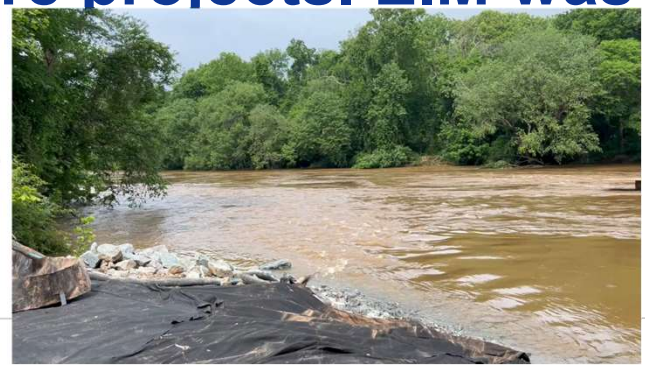
**From GER:**

- ***We have differentiated IGM and rock using core recovery and RQD rather than auger/sampler refusal.***
- ***We have characterized the materials below refusal but above interpreted TOR as non-friable IGM.***
- ***Non-friable IGM descriptions should be used with caution as they only represent the more competent, recovered core and do not represent the strata washed out during coring.***

# Current VDOT Scour Policy

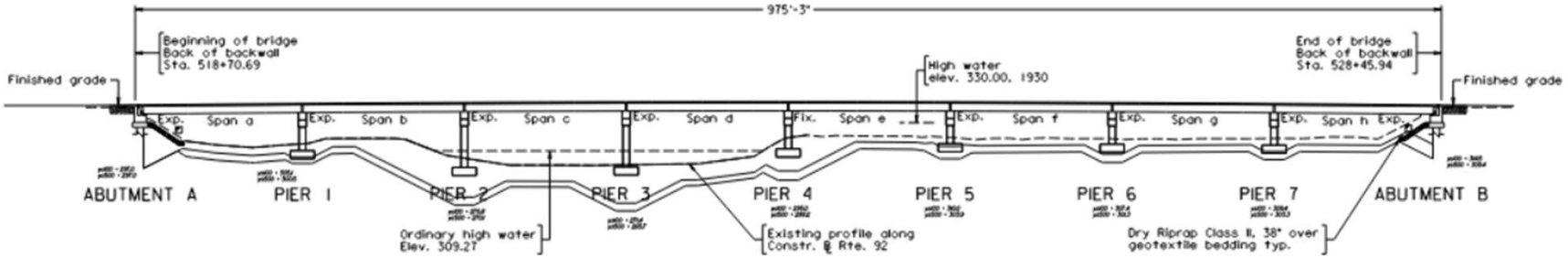
- Current VDOT scour policy is to assume rock with RQD<50% is scourable (very conservative).
- Scour design is per HEC-18.
- Consideration is being given to allowing the use of the Erodibility Index Method (Annandale method) for scour in fractured rock (at piers only) on future projects. EIM was not used for this project.



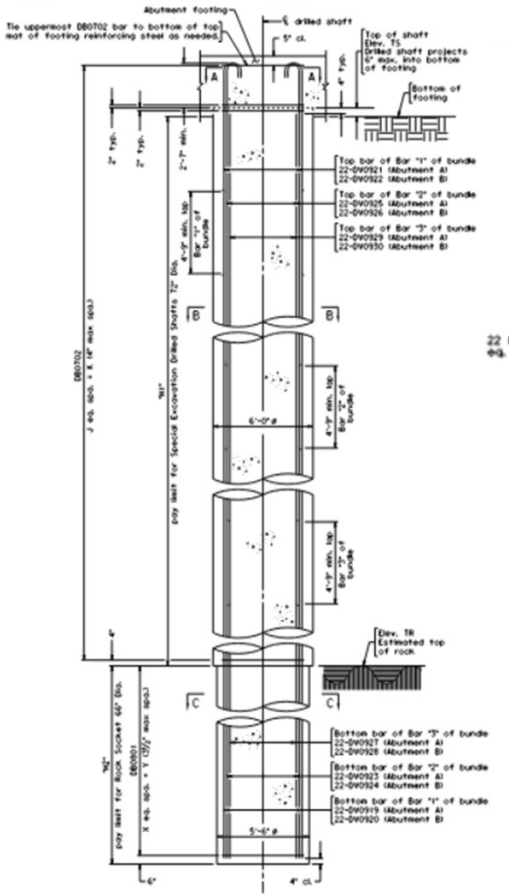



# Design - scour considerations

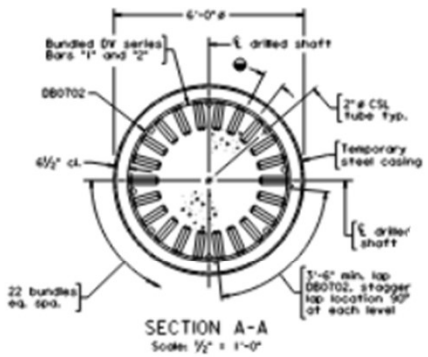
- **Current VDOT scour policy is per HEC-18 and assumes rock with RQD<50% is scourable.**
- **Total design scour depths (100 yr flood): 29 ft in Abut A, 23 to 42 ft in Piers 2 to 4 and 8 to 12 ft in all other substructures.** ***(Depths referenced from bottom of pile cap for abutments and top of drilled shaft for piers)***



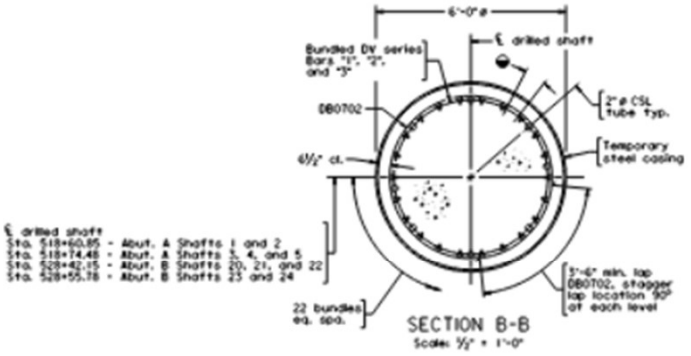
# Drilled Shaft Details - Abutments



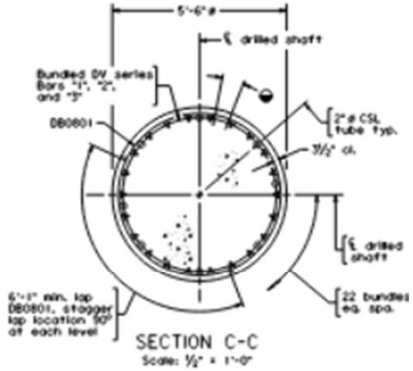
DRILLED SHAFT ELEVATION



SECTION A-A
Scale: ½" = 1'-0"



SECTION B-B
Scale: ½" = 1'-0"



SECTION C-C
Scale: ½" = 1'-0"

| DRILLED SHAFT DATA TABLE | | | | | | | | | TRANSVERSE REINFORCEMENT DATA TABLE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Elevations | | Dimensions | | Required Nominal Axial Resistance ** (Tons/shaft) | Required Factored Axial Resistance ** (Tons/shaft) | DB0801 | | DB0702 | |
| Substructure Unit | Shaft | *Location | Elev. TS | Elev. TR | Dim. "H" | Dim. "HC" minimum | | | X | Y | J | K |
| Abutment A | 1 | Left wingwall | 326.9 | 296.0 | 30.4' | 30.0' | 1504 | 827 | 102 | 29.50' | 100 | 33.12' |
| | 2 | Right wingwall | 326.9 | 296.0 | 30.4' | 30.0' | | | 102 | 29.50' | 100 | 33.12' |
| | 3 | Left, main ftg. | 326.9 | 296.0 | 30.4' | 30.0' | | | 102 | 29.50' | 100 | 33.12' |
| | 4 | Center, main ftg. | 326.9 | 296.0 | 30.4' | 30.0' | | | 102 | 29.50' | 100 | 33.12' |
| | 5 | Right, main ftg. | 326.9 | 296.0 | 30.4' | 30.0' | | | 102 | 29.50' | 100 | 33.12' |
| Abutment B | 20 | Left, main ftg. | 326.9 | 266.0 | 60.4' | 30.0' | 1504 | 827 | 102 | 29.50' | 190 | 63.10' |
| | 21 | Center, main ftg. | 326.9 | 266.0 | 60.4' | 30.0' | | | 102 | 29.50' | 190 | 63.10' |
| | 22 | Right, main ftg. | 326.9 | 266.0 | 60.4' | 30.0' | | | 102 | 29.50' | 190 | 63.10' |
| | 23 | Left wingwall | 326.9 | 266.0 | 60.4' | 30.0' | | | 102 | 29.50' | 190 | 63.10' |
| | 24 | Right wingwall | 326.9 | 266.0 | 60.4' | 30.0' | | | 102 | 29.50' | 190 | 63.10' |

* Location is relative to Constr. ℄ Rte. 92. See sheets 20 and 28 for drilled shaft identification.

** The Strength Limit State controls the drilled shaft design.

# TIP testing Special Provisions

ORDER NO.: L02
CONTRACT ID. NO.: C0000111280B07

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
**THERMAL INTEGRITY PROFILING (TIP) OF DRILLED SHAFTS**

July 30, 2023

0092-019-860, B607

**I. DESCRIPTION**

Thermal Integrity Profiling (TIP) uses the heat generated by curing cement (hydration energy) to assess the quality of drilled shafts. The expected temperature at any location is dependent on the shaft diameter, mix design, time of measurement and distance to the center of the shaft. TIP measurements may be used to estimate the actual shape of the shaft as well. These estimates may be compared with concreting logs to assess the overall quality of the shaft. Good communication between the Contractor, the Drilled Shaft Contractor and TIP Consultant is essential.

TIP measurements that are colder than normal indicate necks, inclusions, or poor quality concrete, while warmer than normal measurements are indicative of bulges. Variations of temperatures between wires reveal cage eccentricity.

**II. QUALIFICATIONS FOR TIP CONSULTANT**

The TIP consultant shall have a licensed professional engineer holding a valid license to practice engineering in the Commonwealth of Virginia who is experienced in supervising the testing and interpreting the results. The TIP Consultant shall be an independent testing agency with documented and approved experience in TIP testing on at least five projects of similar or greater scope within the last 2 years. The Consultant qualifications and a description of the equipment used shall be submitted to the Engineer for approval at least 21 calendar days prior to beginning drilled shaft installation. For each project cited, the names and phone numbers of owner's representatives who can verify the TIP Consultant's participation on those projects shall be provided. Within 14 days after receipt of the installation plan, the Engineer will notify the Contractor of any additional information required or changes necessary to meet the Contract requirements.

**III. ASSISTANCE BY THE DRILLED SHAFT CONTRACTOR TO THE TIP TESTING CONSULTANT**

The Drilled Shaft Contractor shall provide cooperative assistance, suitable access to the site and the drilled shafts to be tested, and labor as required to assist the TIP Consultant in performing the required tests. Prior to testing, provide the drilled shaft lengths and dates of construction of drilled shaft to the TIP Consultant and coordinate with TIP Consultant to install the necessary TIP instrumentation prior to concreting the shaft.

**IV. EQUIPMENT REQUIREMENTS FOR TIP**

The equipment shall have the following minimum requirements:

(1) A computer-based TIP data acquisition system to monitor temperature versus time after casting.

(2) Ability to collect data at user defined time intervals (typically 15 to 60 minutes).

ORDER NO.: L02
CONTRACT ID. NO.: C0000111280B07

**V. SHAFT PREPARATION FOR THERMAL WIRES**

All shafts shall be equipped with a minimum of one thermal wire for every 1 foot of drilled shaft diamete The number of thermal wires shall be rounded up in the case of shafts not of whole foot diameters an a minimum of four wires shall be used for shafts with diameters of 3 feet. The wires shall be even spaced.

Thermal wires shall be aligned with the longitudinal reinforcement of the shaft and stretched to minimiz the wire slack. The wires shall be tied at intervals not exceeding 3 feet to the reinforcement at a locatio on the reinforcement that is 90 degrees to the line connecting the reinforcement to the center of th shaft.

**VI. TIP PROCEDURE**

Thermal wires shall be connected to a Thermal Access Port (TAP) prior to casting concrete to assess that the thermal wires were not damaged during placement of the reinforcing steel cage. Damaged thermal wires prior to casting concrete shall be replaced immediately. Data shall be collected by the TAP every 15 minutes for 24 hours, or as recommended by the TIP Consultant. After completion of the data collection period, the TAP shall be connected to the main TIP data acquisition unit and the data files shall be downloaded for inspection of temperatures versus depth.

Potential local defects indicated by locally low temperatures relative to the average temperature at that depth, or average temperatures significantly lower than the average temperatures at other depths, shall be reported immediately to the Engineer.

**VII. TIP RESULTS**

Results of the TIP shall be stamped by a Professional Engineer licensed in the Commonwealth of Virginia and presented in a written report within 5 working days of completion of testing. The report shall present results of TIP tests including:

1. Graphical displays of all temperature measurements versus depth.
2. Indication of unusual temperatures, particularly significantly cooler local deviations of the average at any depth from the overall average over the entire length.
3. The overall average temperature shall be reported. This temperature is proportional to the average radius computed from the actual total concrete volume installed (assuming a consistent concrete mix throughout). The radius at any point can then be determined from the temperature at that point compared to the overall average temperature.
4. Report variations in temperature between wire (at each depth) which in turn correspond to variations in cage alignment. Where concrete volume is known, the cage alignment or offset from center should be noted.
5. Where shaft specific construction information is available (e.g. elevations of the top of shaft, bottom of casing, bottom of shaft, etc.), these values should be noted on all pertinent graphical displays.

ORDER NO.: L02
CONTRACT ID. NO.: C0000111280B07

**VIII. MEASUREMENT AND PAYMENT**

**Thermal integrity profiling (TIP)** will be measured in units of each per drilled shaft tested and will be paid for at the contract unit price per each. This price shall include full compensation for all costs incurred and related to the TIP testing including, but not limited to, procurement, preparation and installation, conducting the tests, and subsequent reporting of results.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Thermal integrity profiling (TIP) | Each |

# TIP testing Special Provisions

**ORDER NO.: L02**
**CONTRACT ID. NO.: C0000111280B07**

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
**THERMAL INTEGRITY PROFILING (TIP) OF DRILLED SHAFTS**

July 30, 2023

0092-019-860, B607

**I. DESCRIPTION**

Thermal Integrity Profiling (TIP) uses the heat generated by curing cement (hydration energy) to assess the quality of drilled shafts. The expected temperature at any location is dependent on the shaft diameter, mix design, time of measurement and distance to the center of the shaft. TIP measurements may be used to estimate the actual shape of the shaft as well. These estimates may be compared with concreting logs to assess the overall quality of the shaft. Good communication between the Contractor, the Drilled Shaft Contractor and TIP Consultant is essential.

TIP measurements that are colder than normal indicate necks, inclusions, or poor quality concrete, while warmer than normal measurements are indicative of bulges. Variations of temperatures between wires reveal cage eccentricity.

**II. QUALIFICATIONS FOR TIP CONSULTANT**

The TIP consultant shall have a licensed professional engineer holding a valid license to practice engineering in the Commonwealth of Virginia who is experienced in supervising the testing and interpreting the results. The TIP Consultant shall be an independent testing agency with documented and approved experience in TIP testing on at least five projects of similar or greater scope within the last 2 years. The Consultant qualifications and a description of the equipment used shall be submitted to the Engineer for approval at least 21 calendar days prior to beginning drilled shaft installation. For each project cited, the names and phone numbers of owner's representatives who can verify the TIP Consultant's participation on those projects shall be provided. Within 14 days after receipt of the installation plan, the Engineer will notify the Contractor of any additional information required or changes necessary to meet the Contract requirements.

**III. ASSISTANCE BY THE DRILLED SHAFT CONTRACTOR TO THE TIP TESTING CONSULTANT**

The Drilled Shaft Contractor shall provide cooperative assistance, suitable access to the site and the drilled shafts to be tested, and labor as required to assist the TIP Consultant in performing the required tests. Prior to testing, provide the drilled shaft lengths and dates of construction of drilled shaft to the TIP Consultant and coordinate with TIP Consultant to install the necessary TIP instrumentation prior to concreting the shaft.

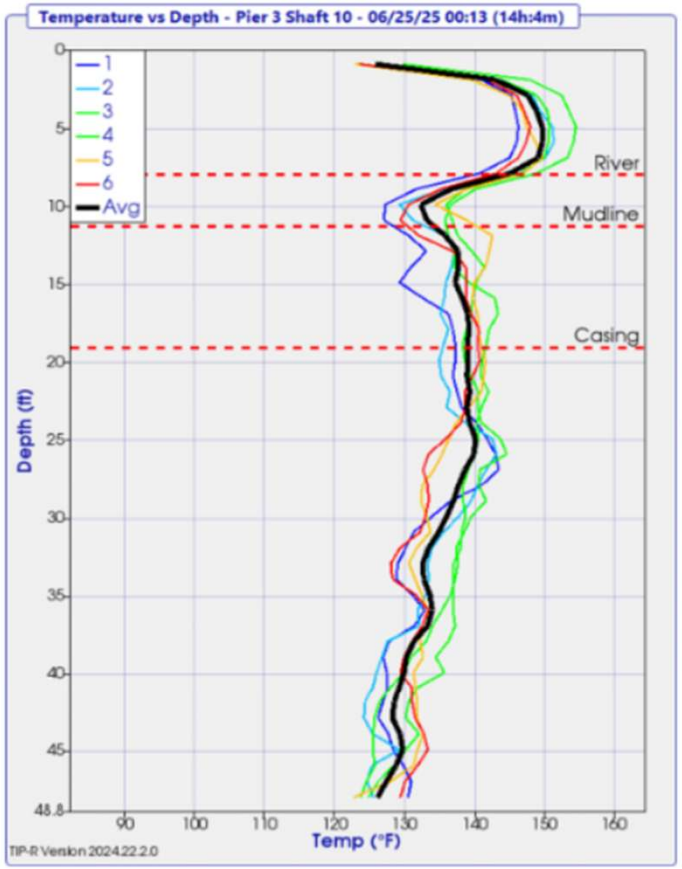
**IV. EQUIPMENT REQUIREMENTS FOR TIP**

The equipment shall have the following minimum requirements:

(1) A computer-based TIP data acquisition system to monitor temperature versus time after casting.

(2) Ability to collect data at user defined time intervals (typically 15 to 60 minutes).


*TIP photos courtesy of PDI*



# Subsurface Exploration – Sample Boring Logs

VDOT Virginia Department of Transportation

PROJECT #: 0092-019-860, UPC 111280
LOCATION: CHARLOTTE / HALIFAX COS.
STRUCTURE: PIER 3

BR-07
PAGE 1 OF 2

STATION: 522+44 OFFSET: 16 ft LT
LATITUDE: 36.838101° N LONGITUDE: 78.667701° W
SURFACE ELEVATION: 308.0 ft COORD. DATUM: NAD 83

FIELD DATA

Date(s) Drilled: 05/05/2021 - 05/06/2021
Drilling Method(s): NW CA / NQ DBL
SPT Method: Auto Hammer (140 lb)
Other Test(s): Not Applicable
Driller: Connelly & Associates, Inc.
Logger: C. Lewis, Schnabel Engineering

GROUND WATER
FIRST ENCOUNTERED AT 1.8 ft DEPTH (Elev. 306.2)
NO LONG TERM MEASUREMENTS TAKEN

LAB DATA

FIELD DESCRIPTION OF STRATA

0.0 / 308.0
AIR, barge reference elevation 22 inches above water

1.8 / 306.2
WATER, Staunton River

9.0 / 299.0
*Alluvium*, Brown, fine to coarse, POORLY GRADED SAND, very loose, wet (SP)

9.8 / 298.2
*Residuum*, Blue-gray, fine to coarse, SILTY GRAVEL, few sand, very dense, wet, gravel includes flat and elongated rock fragments (GM)

10.5 / 297.5
*IGM*, Blue-gray, fine to coarse, SILTY GRAVEL WITH SAND, trace gravel, very dense, wet (GM)

**Casing Advancer Refusal at 19.5 ft.**

19.5 / 288.5
*IGM*, Recovered core characterized as slightly weathered, moderately hard to hard, gray, METASANDSTONE

(19.5 to 27 ft., median core size cannot be reliably evaluated due to limited recovery)

27.0 / 281.0
Slightly weathered to unweathered, moderately hard to hard, gray, METASANDSTONE, moderately fractured, slightly foliated, fine grained, two joint sets dipping at about 40 to 50 and 70 to 80 deg., joints and fractures are healed with quartz, joints are generally planar and smooth to slightly rough, few second joint sets appeared rough, slickensides were noted on several joint faces, most core breaks appear mechanical from drilling, although fracture and joint infilling appears mostly spotty/weak including some spotty clay/ash coating.

(27 to 36 ft., median core size of recovered material 1.5 in.)
SAME, highly fractured to moderately fractured below 34.8 ft
SAME, moderately fractured

(36 ft. to total depth, RQD > 50)
SAME, spotty calcite filled joints from about 37.5 to 38.5 ft.

REMARKS: Rig Type: Diedrich D-50 (Barge).

PAGE 1 OF 2
BR-07



VDOT Virginia Department of Transportation

PROJECT #: 0092-019-860, UPC 111280
LOCATION: CHARLOTTE / HALIFAX COS.
STRUCTURE: PIER 4

BR-10
PAGE 2 OF 3

STATION: 523+65 OFFSET: 7 ft RT
LATITUDE: 36.837831° N LONGITUDE: 78.667447° W
SURFACE ELEVATION: 320.7 ft COORD. DATUM: NAD 83

FIELD DATA

Date(s) Drilled: 05/19/2021 - 05/21/2021
Drilling Method(s): 3.25" HSA / NQ DBL
SPT Method: Auto Hammer (140 lb)
Other Test(s): Not Applicable
Driller: Connelly & Associates, Inc.
Logger: C. Lewis, Schnabel Engineering

GROUND WATER
FIRST ENCOUNTERED AT 16.5 ft DEPTH (Elev. 304.2)
STABILIZED AT 7.5 ft (Elev. 313.2) AFTER 88 HOURS

LAB DATA

FIELD DESCRIPTION OF STRATA

42.5 / 278.2
*IGM*, Recovered core characterized as slightly weathered to unweathered, hard to very hard, gray, METASANDSTONE, slightly to moderately foliated, f-m grained, some silty lenses and slightly phyllitic, clasts are generally subrounded to angular, cont. undulating white and pink quartz and/or feldspar veins, and minor/spotty calcite, some of the recovered core is pitted/vuggy.

51.1 / 269.6
Slightly weathered to unweathered, hard to very hard, gray, METASANDSTONE, highly to moderately fractured, slightly to moderately foliated, f-m grained, two joint sets dipping at about 30 to 45 and 60 to 70 deg., joints are planar and smooth to slightly rough, weakly healed with spotty quartz, calcite and/or feldspar, some silty lenses/layers, slickensides on numerous joint faces.

(51.1 to 57.1 ft., median core size cannot be reliably evaluted due to limited recovery)
(57.1 ft. to total depth, RQD > 50% for alternating core runs)

SAME, brecciated, pink feldspar/quartz vein noted at about 63 ft., dips about 60 deg. and is slightly phyllitic around the margins

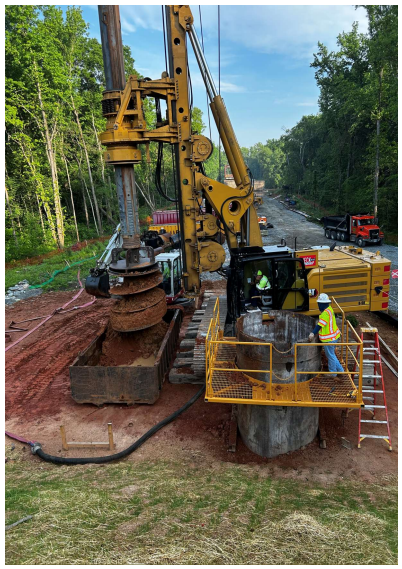
SAME, 0.25 in. offset along healed joint at about 77 ft.

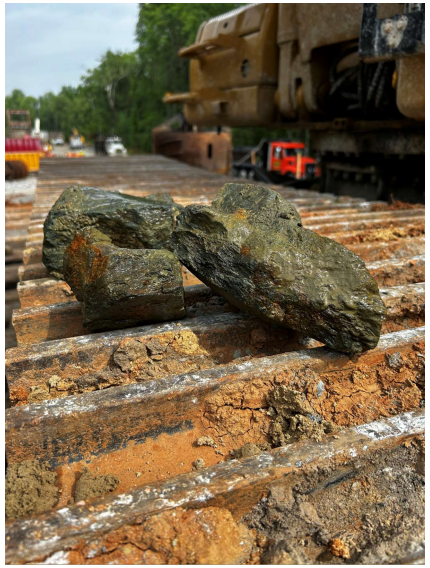
REMARKS: Rig Type: CME-55LC (Track).

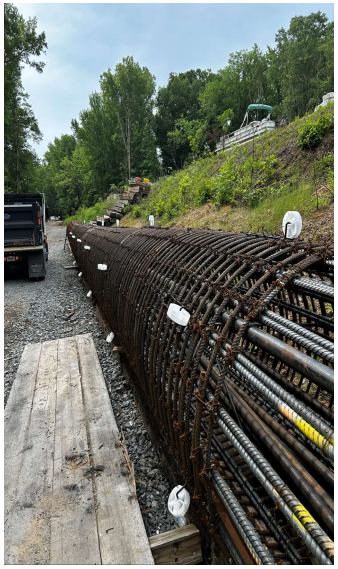
PAGE 2 OF 3
BR-10

# Construction - Access Causeway

# Construction - Trial Shaft Installation

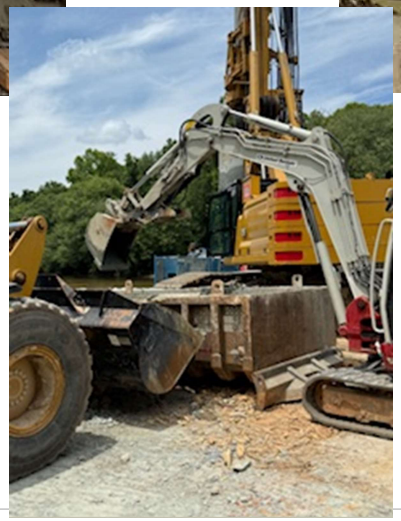


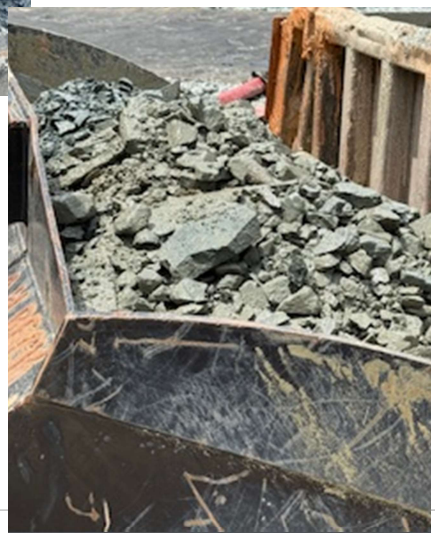




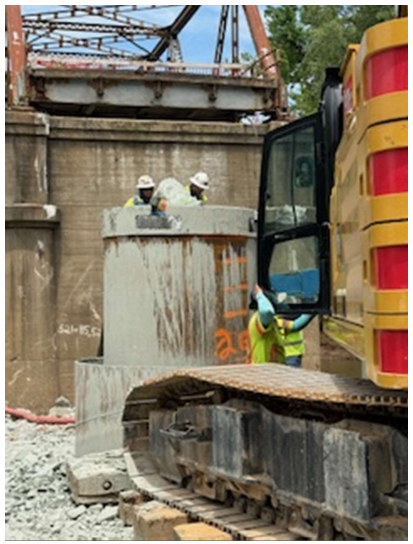
# Construction - Production Shafts

# Construction - Production Shafts





# Construction - Production Shafts



# Construction