Southeastern Transportation Geotechnical Engineering Conference

Charlotte 2023

GEOTECHNICAL EXPLORATION AND DESIGN FOR THE HAMPTON ROADS BRIDGE-TUNNEL MEGAPROJECT

52nd Annual Southeastern Transportation Geotechnical Engineering Conference (STGEC) - 2023
Charlotte, NC

Brian D. Keaney, PE

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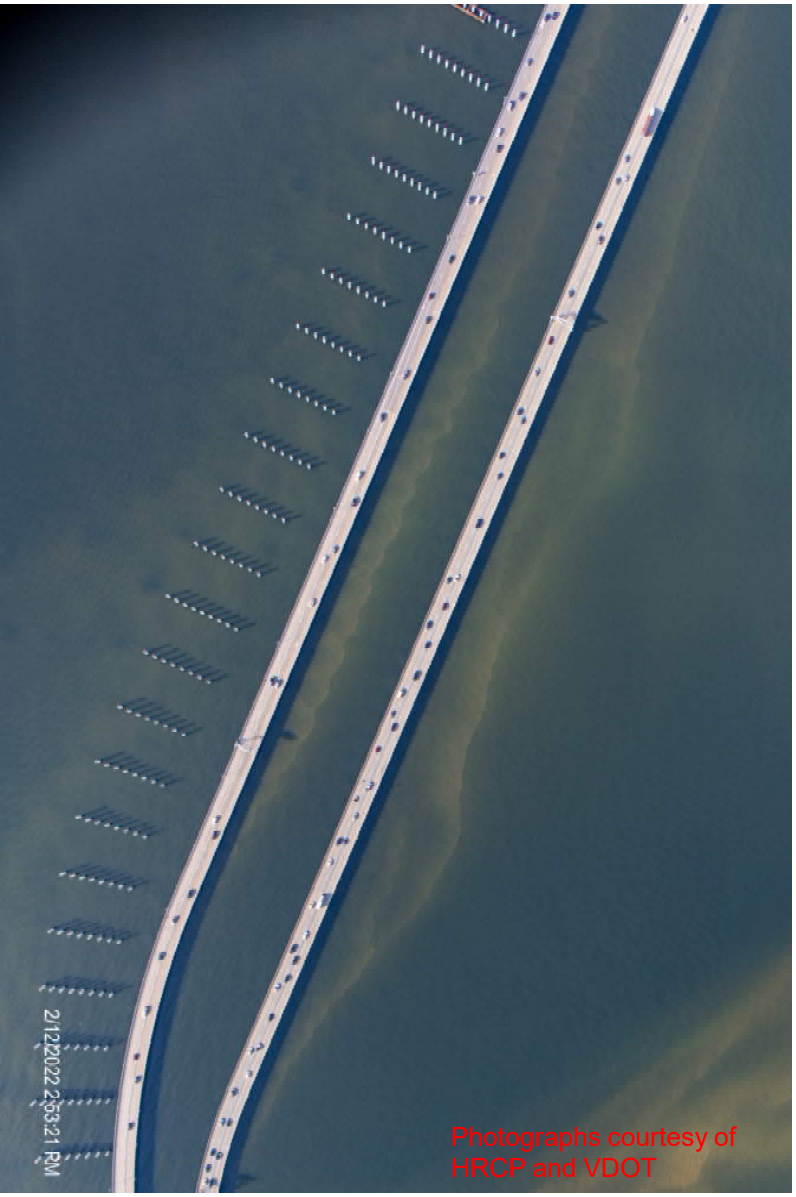

AGENDA

I. Project Information and Scope of Work

II. Geotechnical Explorations

III. Site Characterization

IV. Geotechnical Design

V. Design Services During Construction

VI. Construction Photos

PROJECT LOCATION

- I-64 Corridor from Hampton to Norfolk
  - Vital Link to Coastal Virginia
  - Maintains Unimpeded Access to this Key Maritime Corridor
- Regional Population of 1.7 Million
- First Opened in 1957 – 1st Underwater Tunnel Crossing between Manmade Islands
- Second Bridge-Tunnel Crossing Opened in 1976

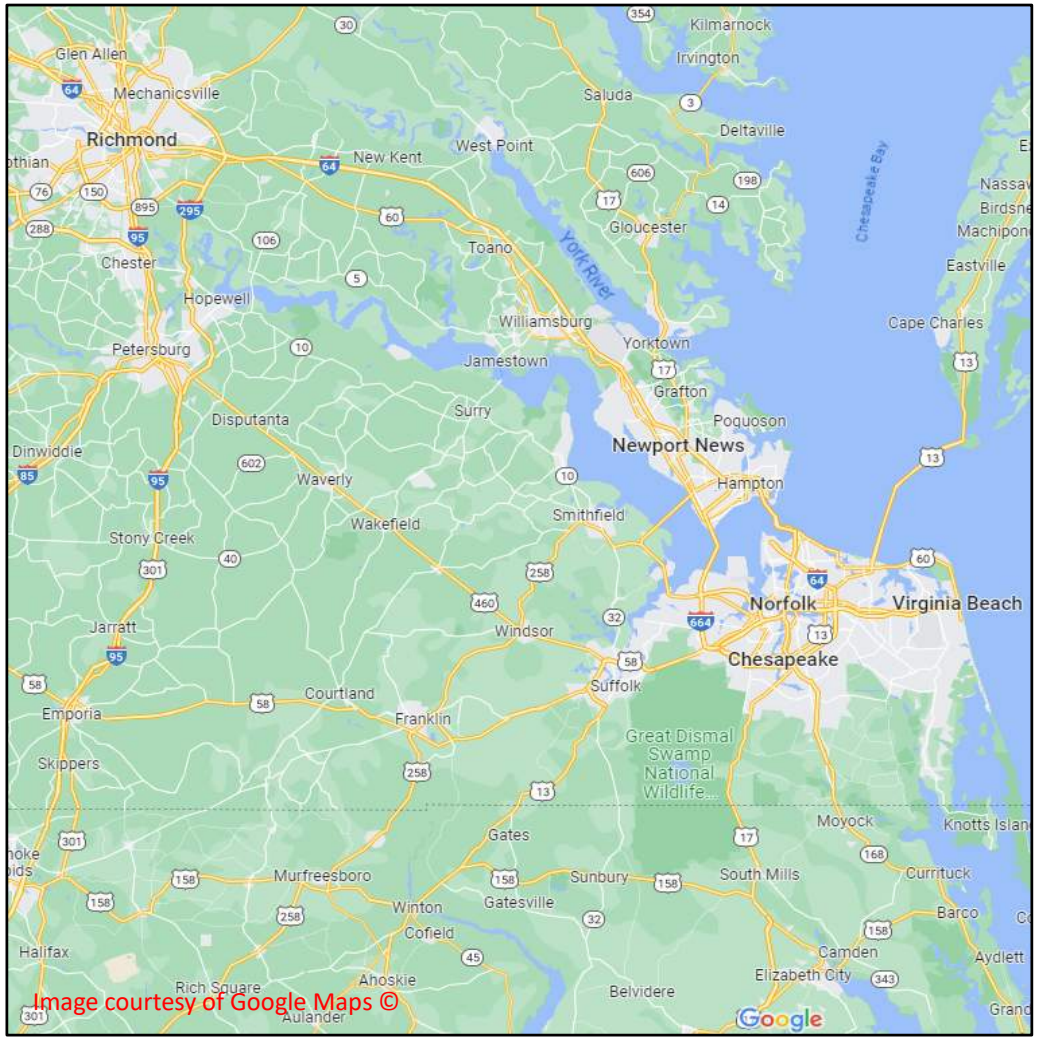

Image courtesy of Google Maps ©

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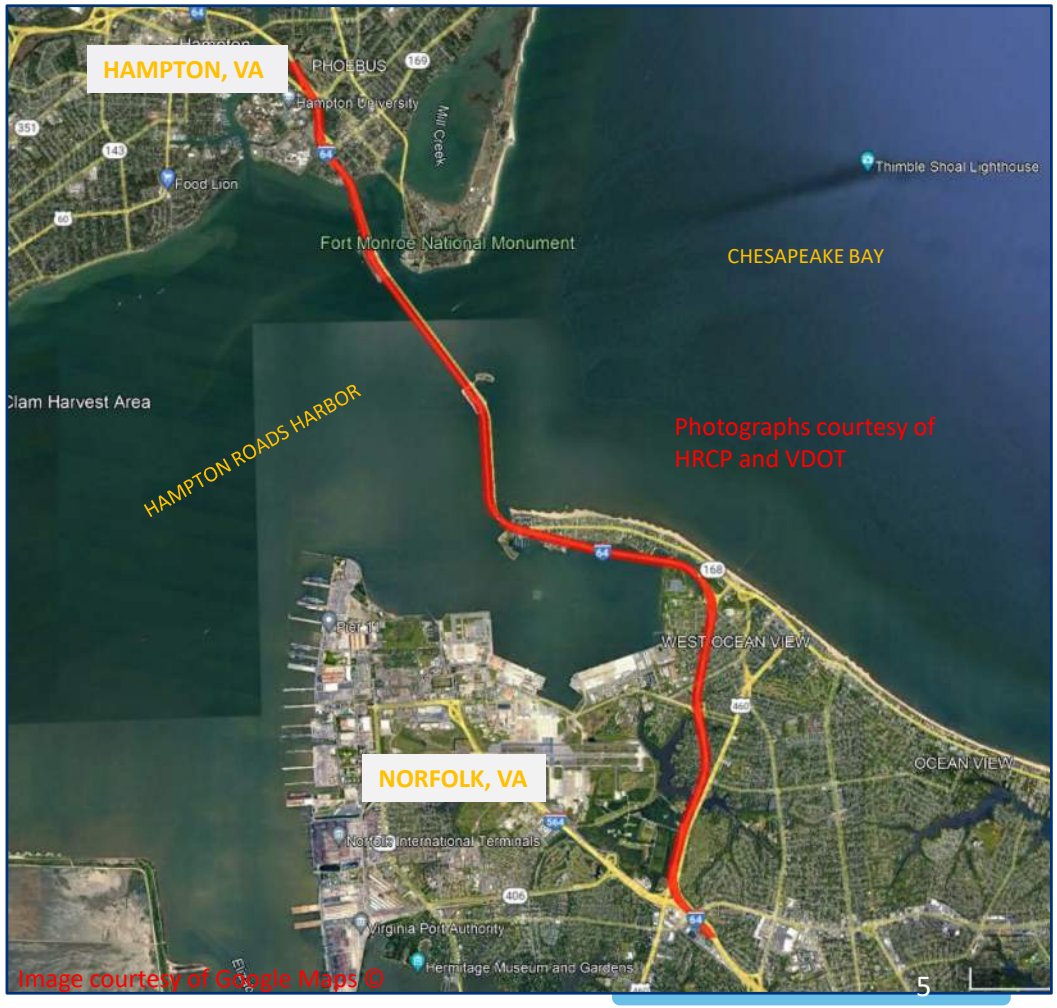
PROJECT SCOPE

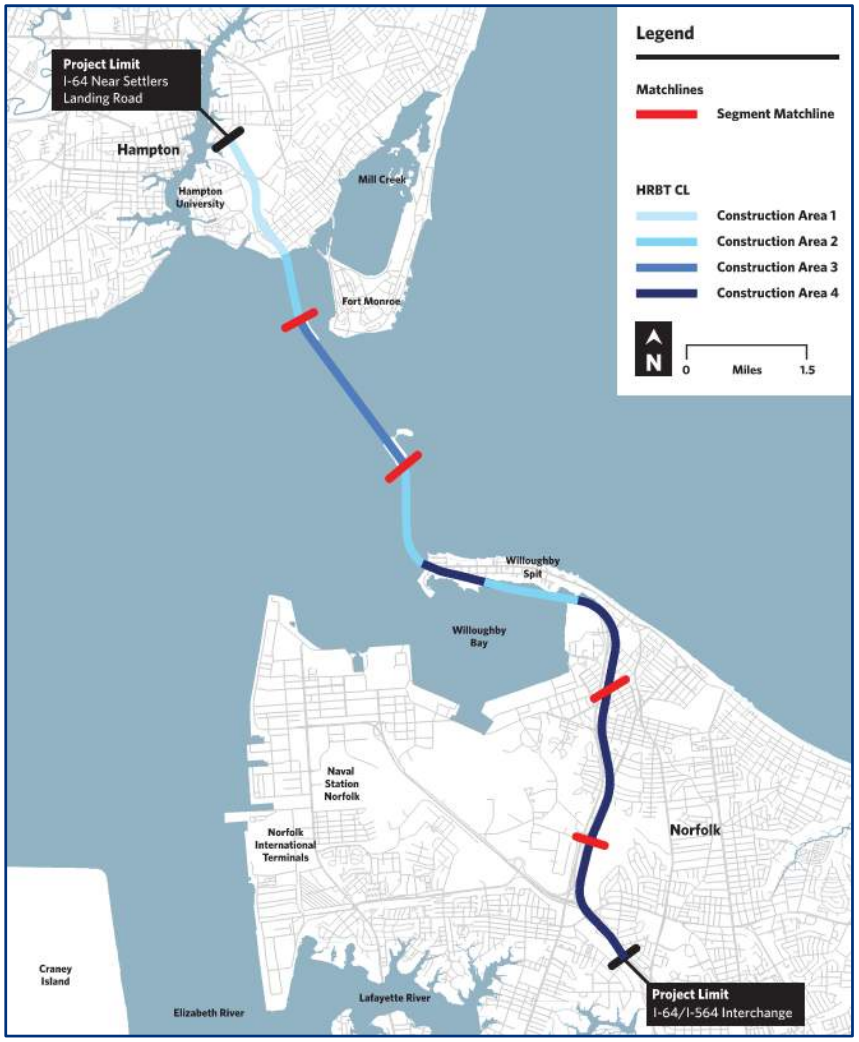
- Almost 10 miles of Interstate Widening
- Roadway Widening
  - Existing: 4 lanes with two tunnels
  - Future: 6 lanes (+ driveable shoulder) on land with 8 lanes over/under water
- 2 New Bored Tunnels, Tunnel Approach Structures, and Island Expansions
- 1 Bridge Overpass Replacement
- 4 Overwater Trestle Replacements
  - 3 Temp MOT Bridges
- 6 Overwater Trestle Widenings
- 17 Overpass Bridge Widenings*
  (All designed but 3 de-scoped)
- Retaining Walls, Sound Barrier Walls, & Miscellaneous Structures



PROJECT BACKGROUND

- Owner is Virginia Department of Transportation (VDOT)
- $3.9 Billion Design-Build Contract
- Design-Build Team is Hampton Roads Connector Partners (HRCP)
- Construction Joint Venture (CJV)
  - Dragados USA
  - Flatiron Constructors
  - Vinci Construction
  - Dodin Campenon Bernard
- Design Joint Venture (DJV)
  - HDR, Inc.
  - Mott MacDonald

[Homepage - Hampton Roads Bridge-Tunnel Expansion Project (hrbtexpansion.org)]



HDR SCOPE OF SERVICES

Roadway

ROW & Environmental

Drainage & Utilities

Structural

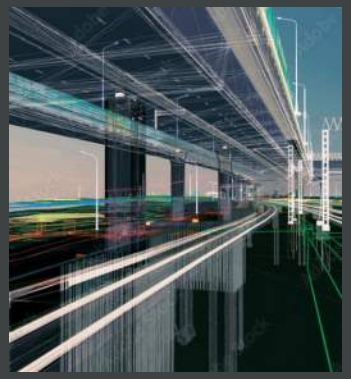
Geotechnical

Traffic & MOT

Lighting & ITS

Signage & Pavement Marking

Landscape & Aesthetics



BIM-3D Modeling

GEOTECHNICAL EXPLORATIONS

Geotechnical Exploration Plan (GEP)

- Supplemental Information
- VDOT MOI, Chapter III – Geotechnical Engineering
- AASHTO Guidelines

Marine Program

- Tunnels & Islands
- Trestles

Landside Program

- Roadway
- Pavements
- Bridges
- Retaining & Sound Barrier Walls
- Utility/Drainage Locations
- Overhead Signs/ITS
- Other Miscellaneous Structures

BORING ID KEY FOR SUPPLEMENTAL PROGRAM

TRESTLE BORINGS

B. Direction · D. Pier Number · E. Identifier

A - B - C - D - E

A. Bridge Segment · C. Exploration Type

Field Descriptions

A. Bridge Segment = Bridge Name
B. Direction = Direction of lane traffic
C. Exploration Type = Exploration Type (CPT or SPT)
D. Pier Number = Unique Pier Number
E. Identifier = Boring identifier for piers with 2 or more borings

Code Definitions

A. Bridge Segment
NA = North Approach
SA = South Approach
WB = Willoughby Bay

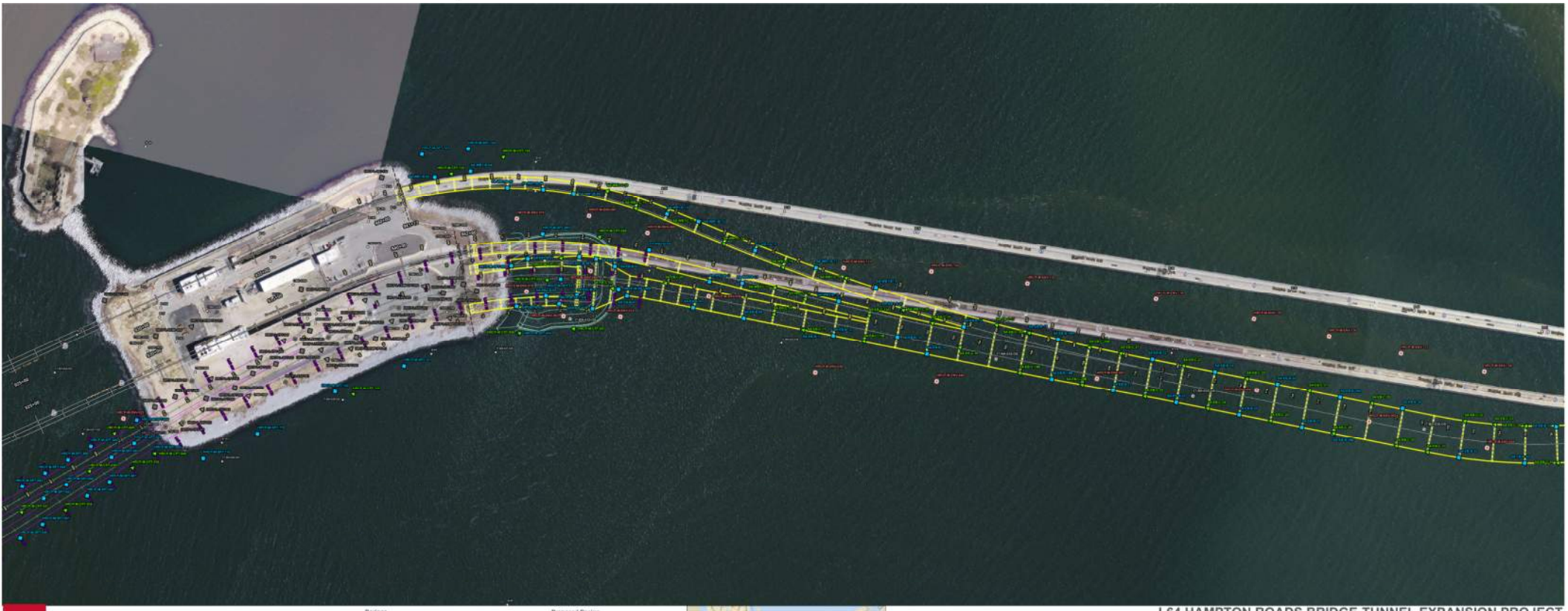
B. Direction
EB = Eastbound
WB = Westbound
NB = Northbound
SB = Southbound

C. Exploration Type
S = SPT
C = CPT
ENV = Environmental

SEGMENT 2A BORINGS

HRCP-M - C - E

Marine · C. Exploration Type · E. Identifier



Borings

- New CPT
- New SPT
- New Environmental Barge Drilling Location
- DJV (BMI) Existing Environmental Bore Drilling
- VDOT Existing CPT
- VDOT Existing SPT
- VDOT Historic
- DJV (MM) Existing CPT
- DJV (MM) Existing SPT

Proposed Design

- Construction Baseline
- Island Expansion
- Proposed Tunnel Design
- South Island TAS
- Bridge Design
- North Island TAS

0 Feet 300

DATA SOURCE:
VGIN Aerial Imagery, NOAA Imagery, ESRI World Imagery, ESRI World Transportation

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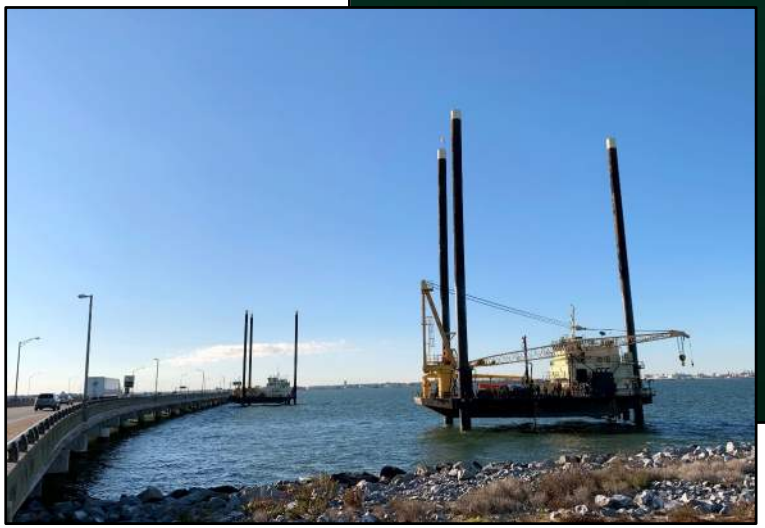
I-64 HAMPTON ROADS BRIDGE-TUNNEL EXPANSION PROJECT
MARINE GEOTECHNICAL EXPLORATION PLAN (REV 2)
SEGMENT 2-3 - SOUTH TRESTLES

SUPPLEMENTAL MARINE PROGRAM

- Marine Investigation
  - Completed between October 2019 and May 2020
  - 477 Exploration Points Completed in this time
  - Over 56,000 feet (includes Island explorations)
  - SPT, CPT, Environmental, Geophysical
    - DMT, Seismic Cone
    - 5 Subcontractors
  - Up to six different drill platforms working daily
  - Day and Night Shifts
  - About 20 different staff worked in field



BORING ID KEY

Land Borings

A B - C D E - F G

*Used for all land borings except for Land Bridges

Land Bridge Borings

A B - C H - F

*For Land Bridges only

Field Descriptions

A. Segment Number = Segment of HRBT Project
B. Exploration Type = Exploration Type (CPT or SPT)
C. Purpose = Design element boring is intended for
D. Direction = Direction of lane traffic
E. Lane Location = Location regarding lane: inside, outside, or ramp
F. Number = Boring number (by Purpose in sequence)
G. Grade = At grade, cut, or fill (Widening only)
H. Bridge Number = Unique land bridge identifier(Land Bridge Only)

Code Definitions

B. Exploration Type
B = SPT
C = CPT

C. Purpose
BR = Bridge
ITS = Signage
RW = Retaining Walls
SW = Sound Walls
SWM = Stormwater Management
W = Lane/Road Widening

D. Direction
EB = Eastbound
WB = Westbound
NB = Northbound
SB = Southbound

E. Lane Location
I = Inside Lanes
O = Outside Lanes
R = Ramp

G. Grade (*Widening Only)
A = At Grade
C = Cut
F = Fill

BORINGS SUMMARY

Segment	SPT	CPT	Existing Borings	Total (New)	Total (All)
1	88	14	4	98	102
3	161	48	9	210	219
4	118	52	8	168	176
5	100	24	3	124	127

BH Purpose	Bridge	ITS	Retaining Walls	Sound Walls	Stormwater Management	Road/Lane Widening	Existing
Segment 1	7	17	22	2	2	48	4
Segment 3	33	23	41	32	4	77	9
Segment 4	66	12	4	28	0	27	8
Segment 5	22	26	33	0	0	41	3

Borings
SPT
CPT Sounding
SPT and CPT
Bridge
Existing
ITS

Road and Bridge Design
Retaining Wall
Roadway
Scourbelt
SWM
Bridges
Piers
Lane Lines
Paved Shoulder
SWM Basin
ITS
Retaining Walls
Sound Walls

Jurisdictional Waters
Delineated WOUS

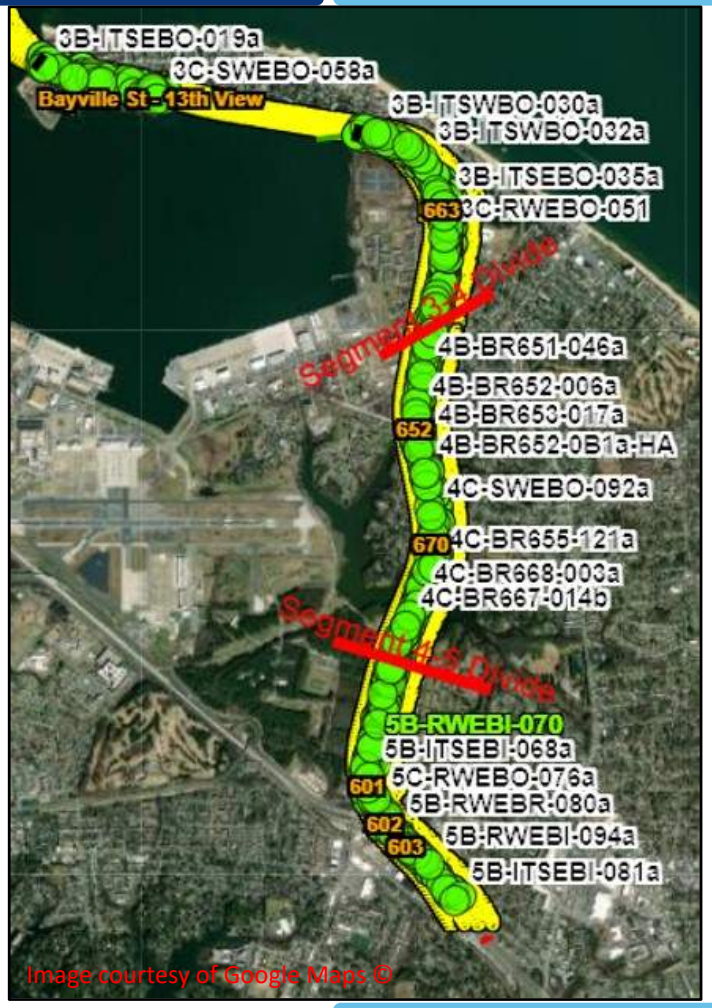
0 Feet 300

DATA SOURCE:
VGIN,
ESRI World Transportation

I-64 HAMPTON ROADS BRIDGE-TUNNEL EXPANSION PROJECT
GEOTECHNICAL EXPLORATION PLAN
SEGMENT 3/4 - NORFOLK - NAVY

SUPPLEMENTAL LANDSIDE PROGRAM

- Landside Investigations
  - Completed between July 2019 and August 2020
  - 821 Exploration Points Completed in this time
  - Over 42,000 feet
  - SPT, CPT, Pavement Coring
    - Environmental sampling
    - DMT, Seismic Cone, DCP
    - 4 Subcontractors
  - Up to 3 Drilling Platforms at once
  - Day and Nighttime Operations with Traffic Control



Barge Work and Night Work

Marsh Work & Difficult Terrain

PLANNING & EXECUTING THE GEP

- Existing Information
- Planning and Permitting
- Mobilization and Access
- Staff Training and Safety
- Coordination and Stakeholders
- Managing Data and Samples
- ArcGIS
  - Field Maps App
  - Survey123 App
- Real-time Access of Information & Online Progress Dashboard

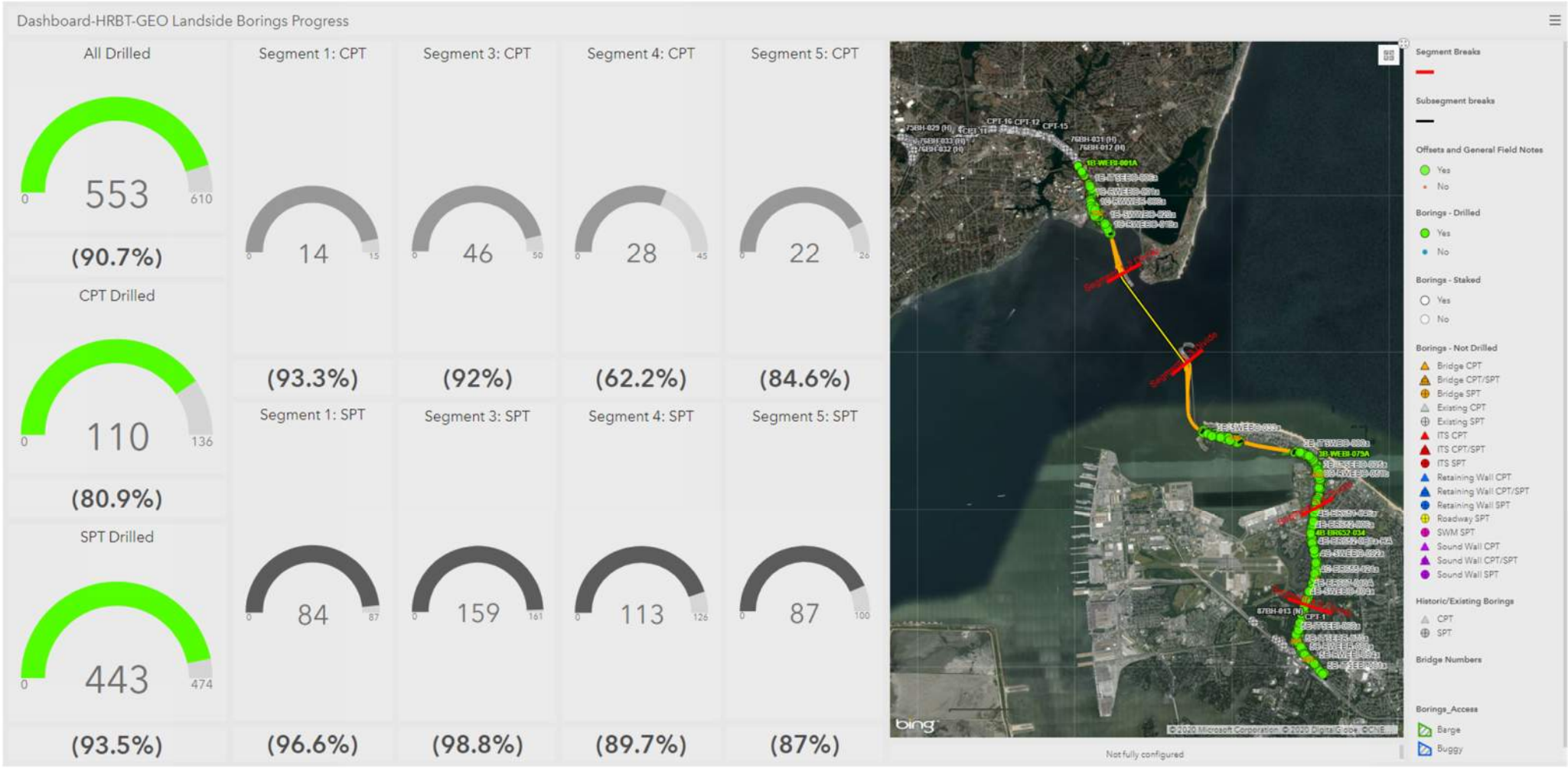
Data Collection and Reporting:

Field Mobility and Survey Solutions

Data Collection Apps

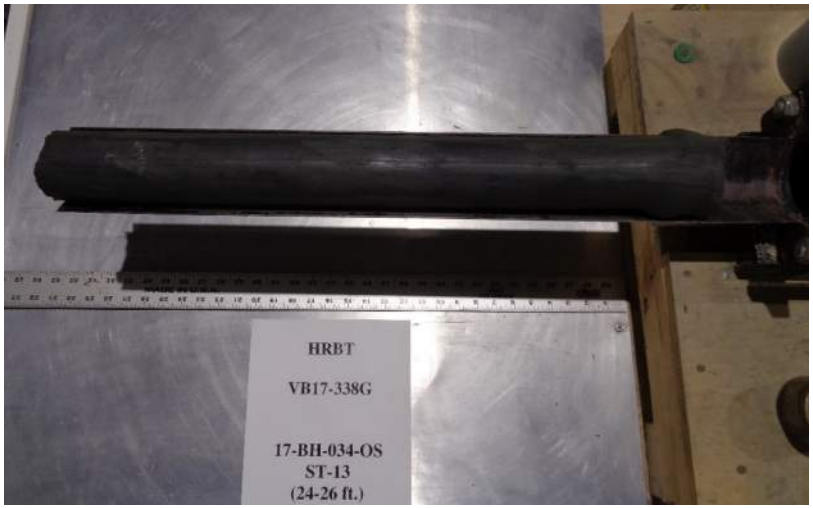
- Field Maps/Collector (Map-centric)
  - Preconfigured maps and collection forms
  - Capture location & condition
  - Appends photos and videos
  - Real-time and off-line collection
- Survey123 (Form-centric)
  - "Smart" forms with skip logic, defaults, and support for multiple languages
  - Collect data via web or mobile devices
  - On-the-fly analysis and reporting

Presentations & Progress Updates



LABORATORY TESTING PROGRAM

- Index Testing (MC, AL, Grain Size, Unit Weight, Specific Gravity)
- Strength Testing (CU, UU, UCS, DS)
- Consolidation Testing
- Earthwork Type Testing (Proctor, CBR, Mr)
- Corrosivity Testing
- Organic Content
- Other Specialty Testing



SITE CHARACTERIZATION

- Coastal Plain Physiographic Province
- Artificial Fill soils (Islands and Embankments)
- Alluvial Soils
- Tabb Formation
  - Lynnhaven & Sedgefield Members
- Yorktown Formation

Geologic Stratum 1978 (Historic)	Geologic Stratum 1989 (Current)	Geologic Age (Period, Epoch)	Geologic Origin for HDR Boring Logs
Fill	Fill	N/A	Fill, Af
Alluvium	Alluvium	Quaternary Holocene	Alluvium Qac = coarse-grained Qaf = fine-grained Qao = organic, fine-grained
Tabb Formation	Tabb Formation Lynnhaven Member	Quaternary Pleistocene	Tabb Formation Qtc = coarse-grained Qtf = fine-grained Qto = organic, fine-grained
Sand Bridge Formation	Tabb Formation Sedgefield Member		
Norfolk Formation			
Yorktown Formation	Yorktown Formation	Tertiary Pliocene	Yorktown Formation Tys = coarse-grained Tyf = fine-grained

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CONTENTS

APPENDICES

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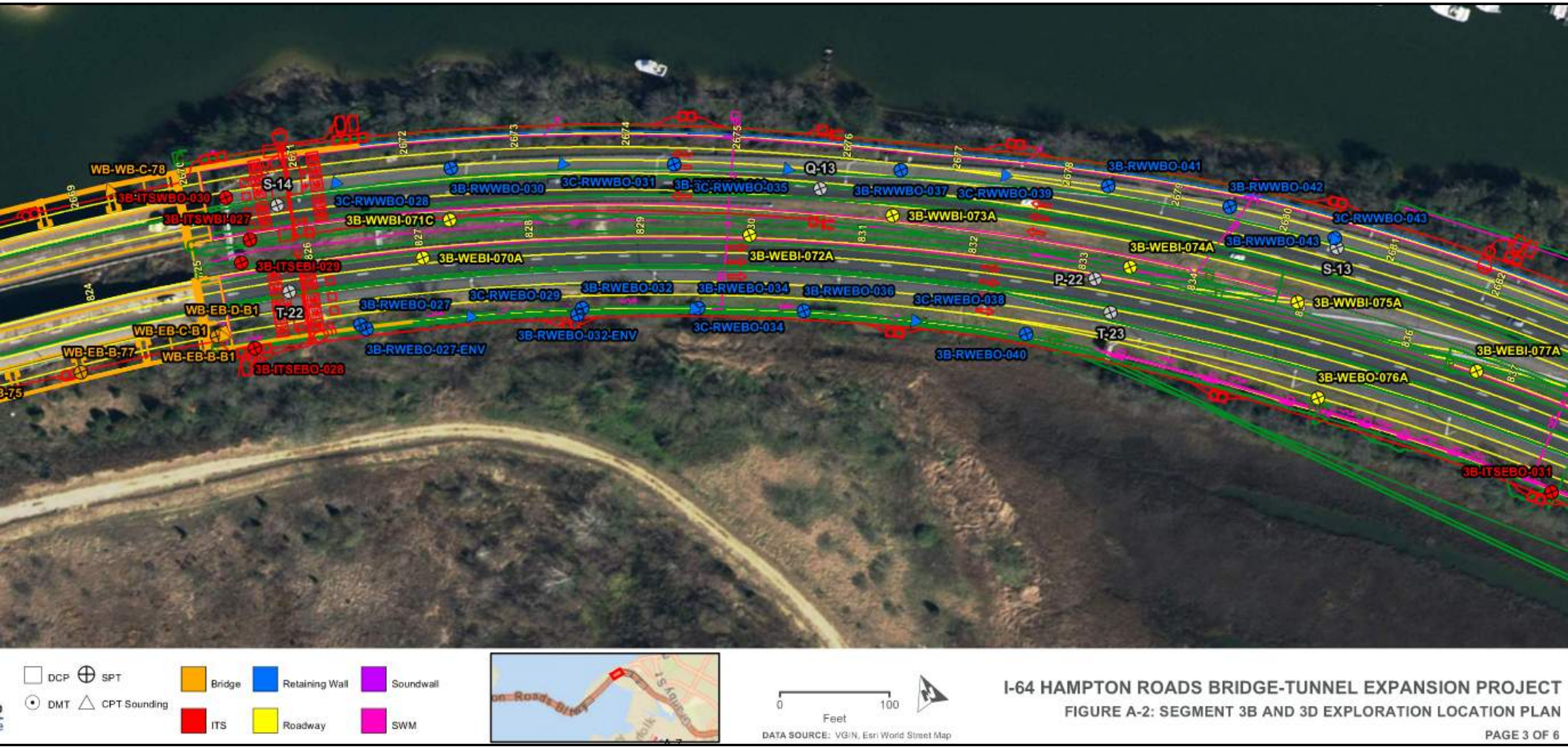
SITE EXPLORATION PLANS

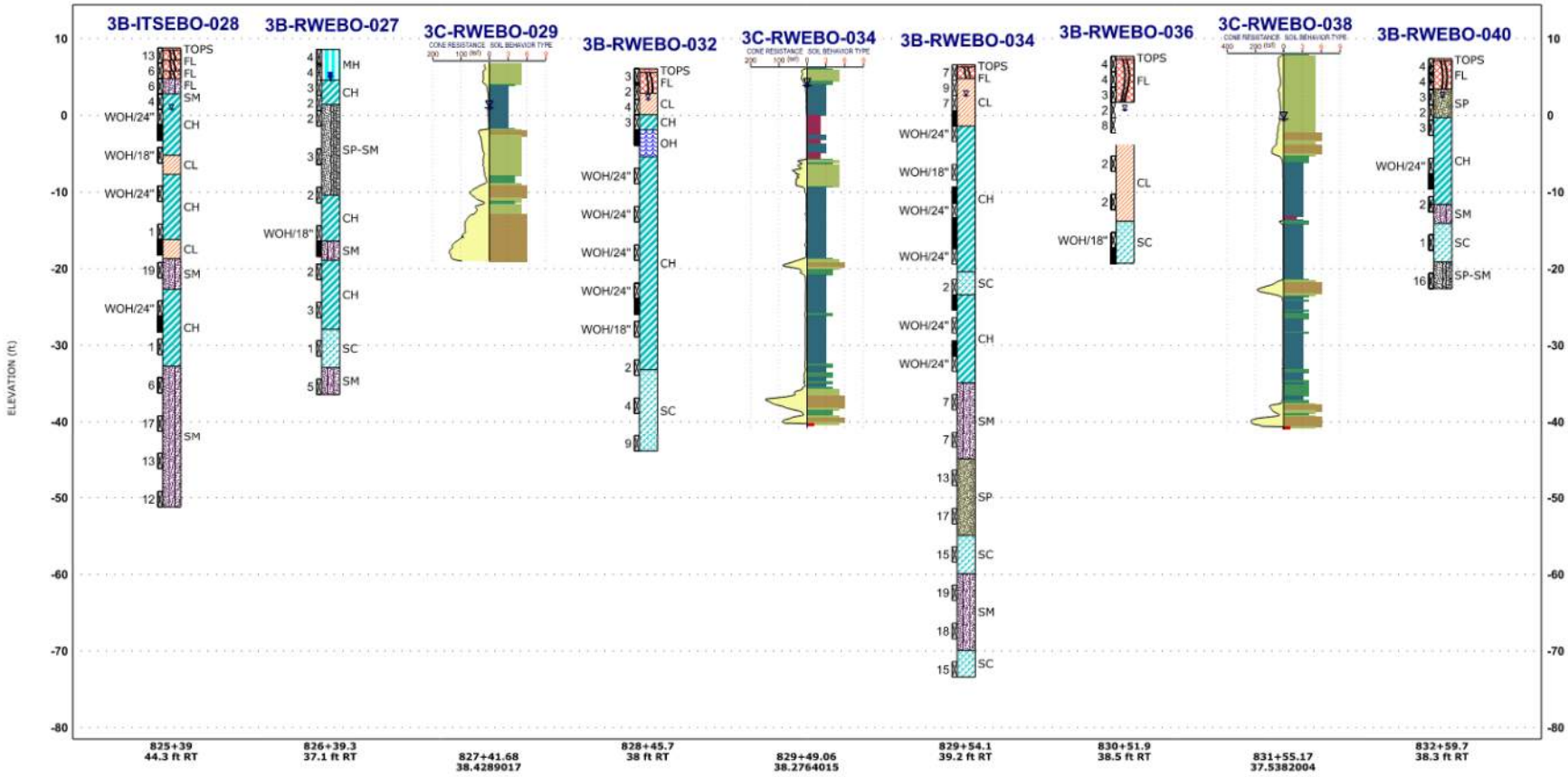


I-64 HAMPTON ROADS BRIDGE-TUNNEL EXPANSION PROJECT

FIGURE A-2: SEGMENT 3B AND 3D EXPLORATION LOCATION PLAN

Figure A-11 - Subsurface Profile at Wall RW 308, DS 3-5

FHWA REGION	STATE	FEDERAL AID ROUTE	FEDERAL AID PROJECT	STATE ROUTE	STATE PROJECT	SHEET NO.
3	VA.					



NORMALIZED SOIL BEHAVIOR TYPE
(Robertson, 2009)

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clays - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff, fine grained

Notes: See borehole logs for complete data.
See Material and Sample Symbols List.

The subsurface information shown on the boring logs (SPT) and cone penetrometer tests (CPT) in these plans was obtained with reasonable care and recorded in good faith solely for use by the Department in establishing design controls for the project. The Department has no reason to suspect that such information is not reasonably accurate as an approximate indication of the subsurface conditions at the sites where the borings were taken. The Department does not in any way warrant or guarantee that such data can be projected as indicative of conditions beyond the limits of the borings shown; and any such projections by bidders are purely interpretive and altogether speculative. Further, the Department does not in any way guarantee, either expressly or by implication, the sufficiency of the information for bid purposes.

The SPT and CPT logs are made available to bidders in order that they may have access to subsurface data identical to that which is possessed by the Department, and are not intended as a substitute for personal investigation, interpretation and judgment by the bidders.

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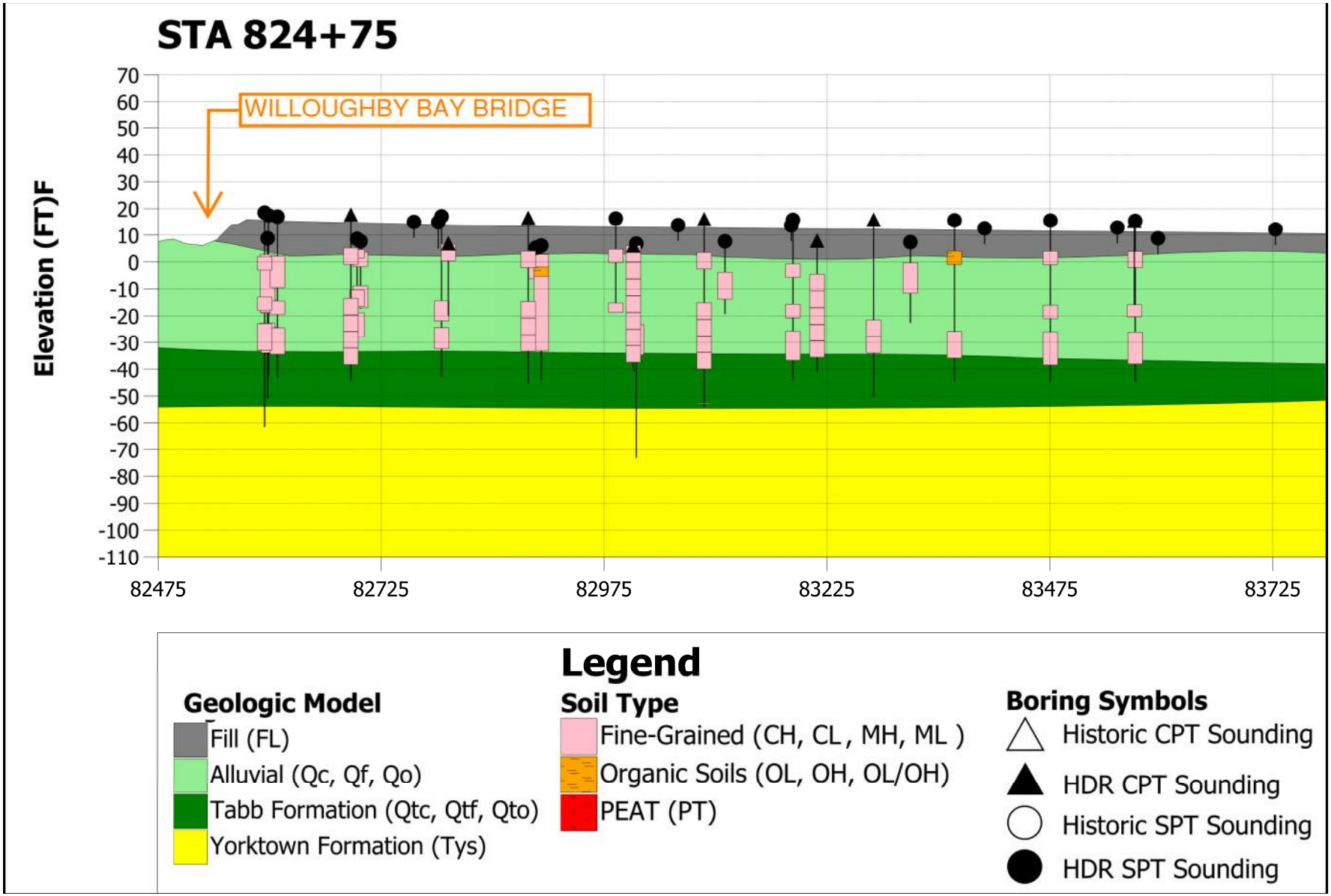
COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

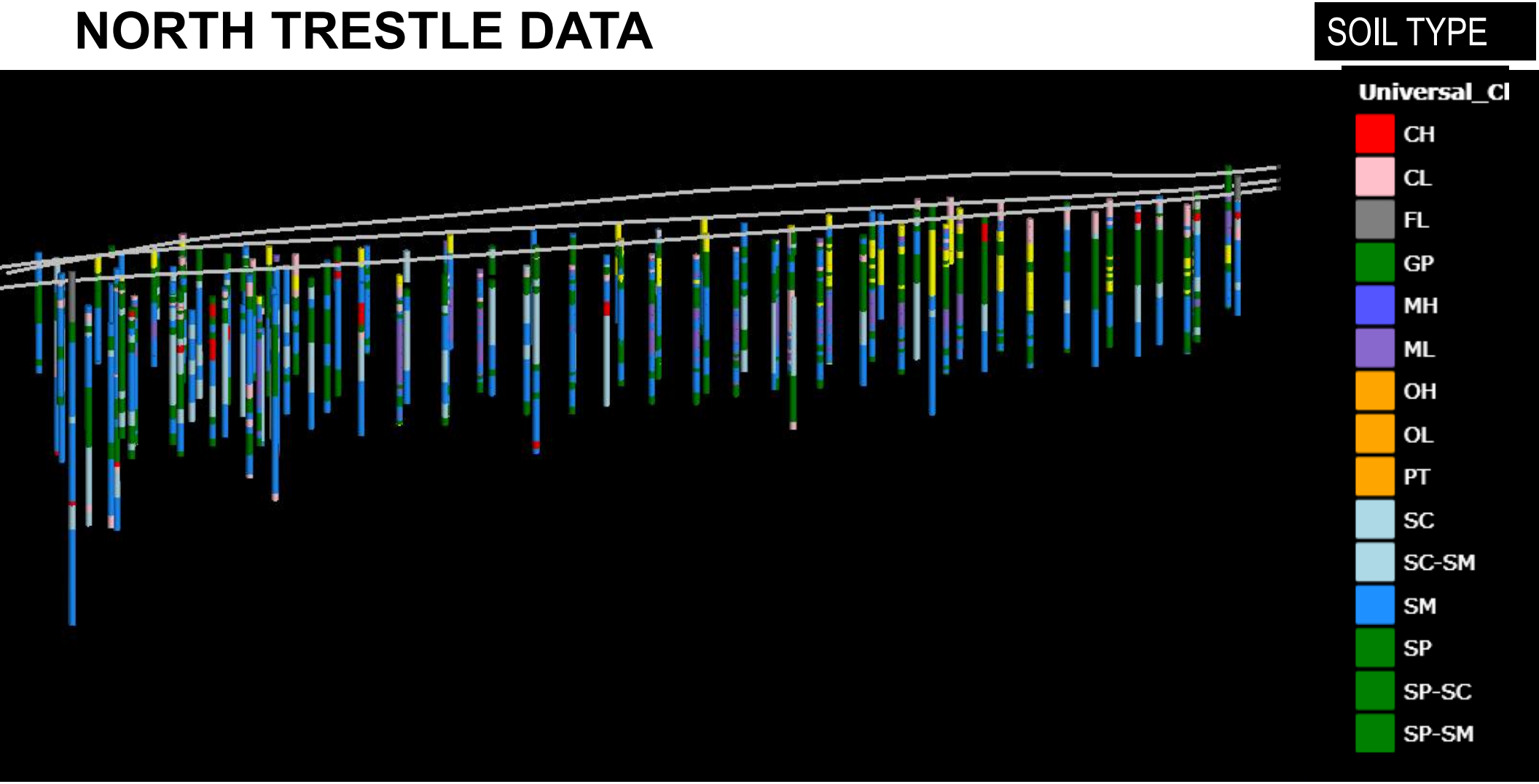
MATERIALS DIVISION

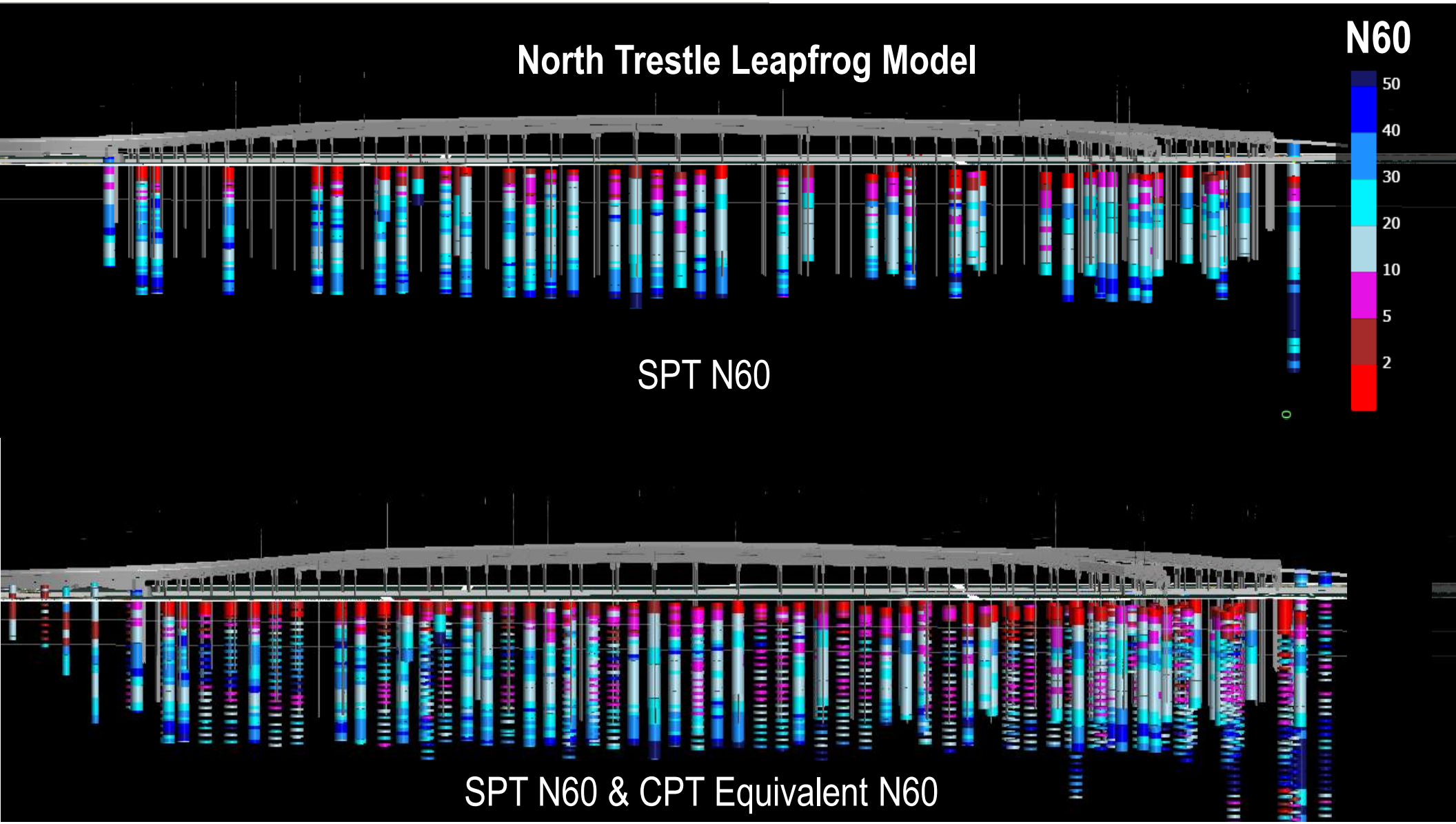
0064-M06-0032
ENGINEERING GEOLOGY

No.	Description	Date	Drilled:	Date	Plan No.	Sheet No.
	Revisions		Logged:			
			Checked:			

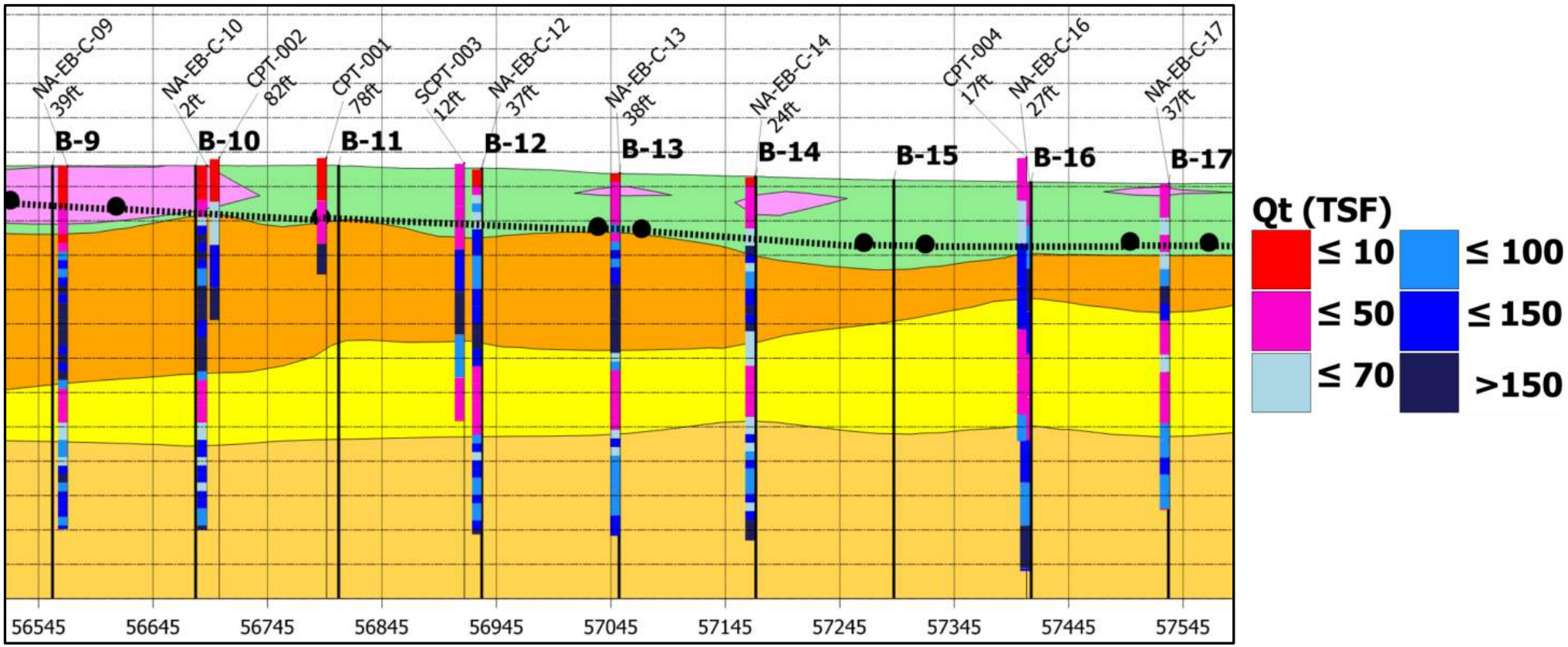

STA 824+75
WILLOUGHBY BAY BRIDGE
Elevation (FT)F
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
82475
82725
82975
83225
83475
83725
Legend
Geologic Model
Fill (FL)
Alluvial (Qc, Qf, Qo)
Tabb Formation (Qtc, Qtf, Qto)
Yorktown Formation (Tys)
Soil Type
Fine-Grained (CH, CL, MH, ML)
Organic Soils (OL, OH, OL/OH)
PEAT (PT)
Boring Symbols
Historic CPT Sounding
HDR CPT Sounding
Historic SPT Sounding
HDR SPT Sounding

NORTH TRESTLE DATA

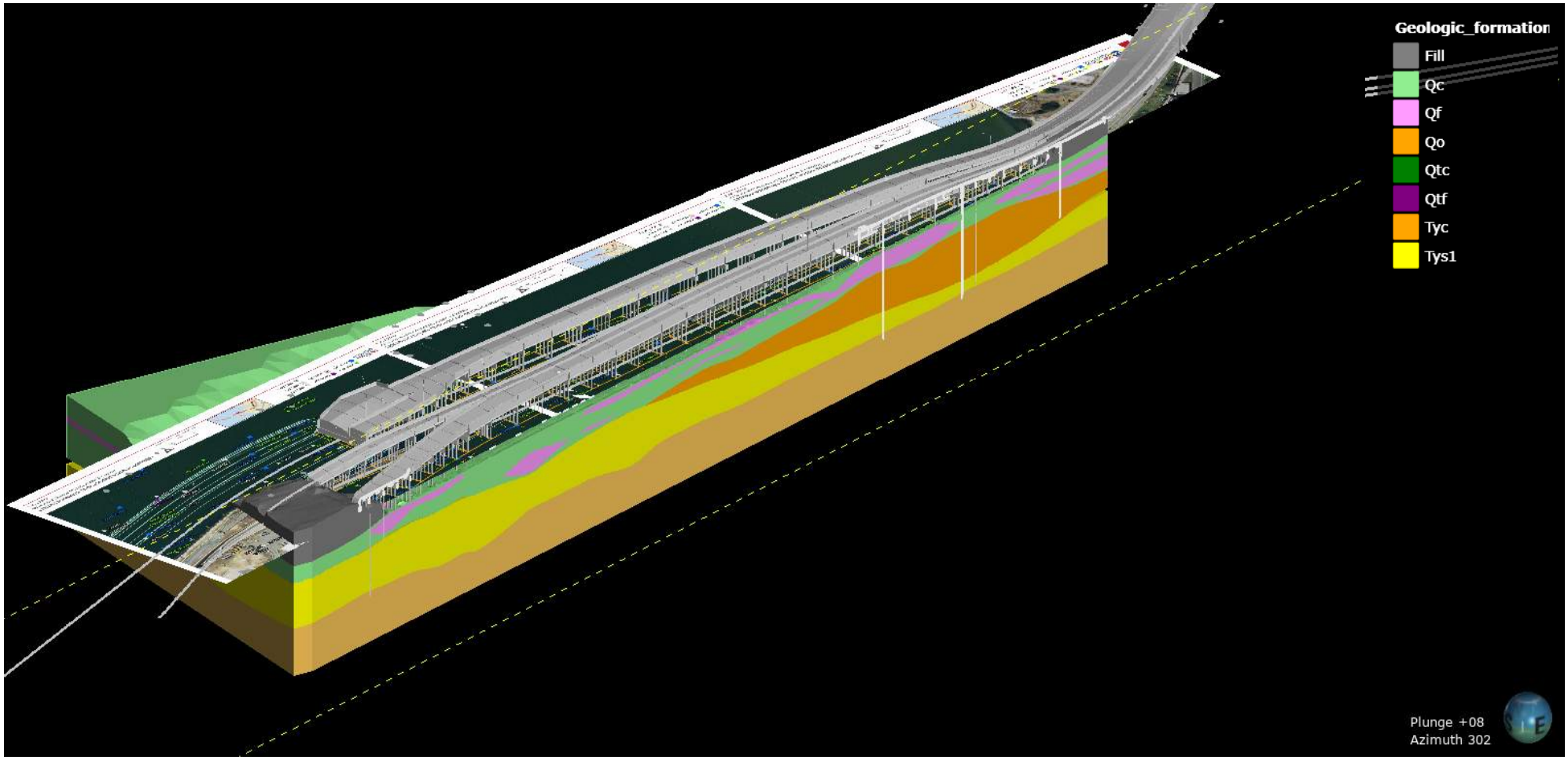



North Trestle Leapfrog Model
N60
50
40
30
20
10
5
2
SPT N60
SPT N60 & CPT Equivalent N60

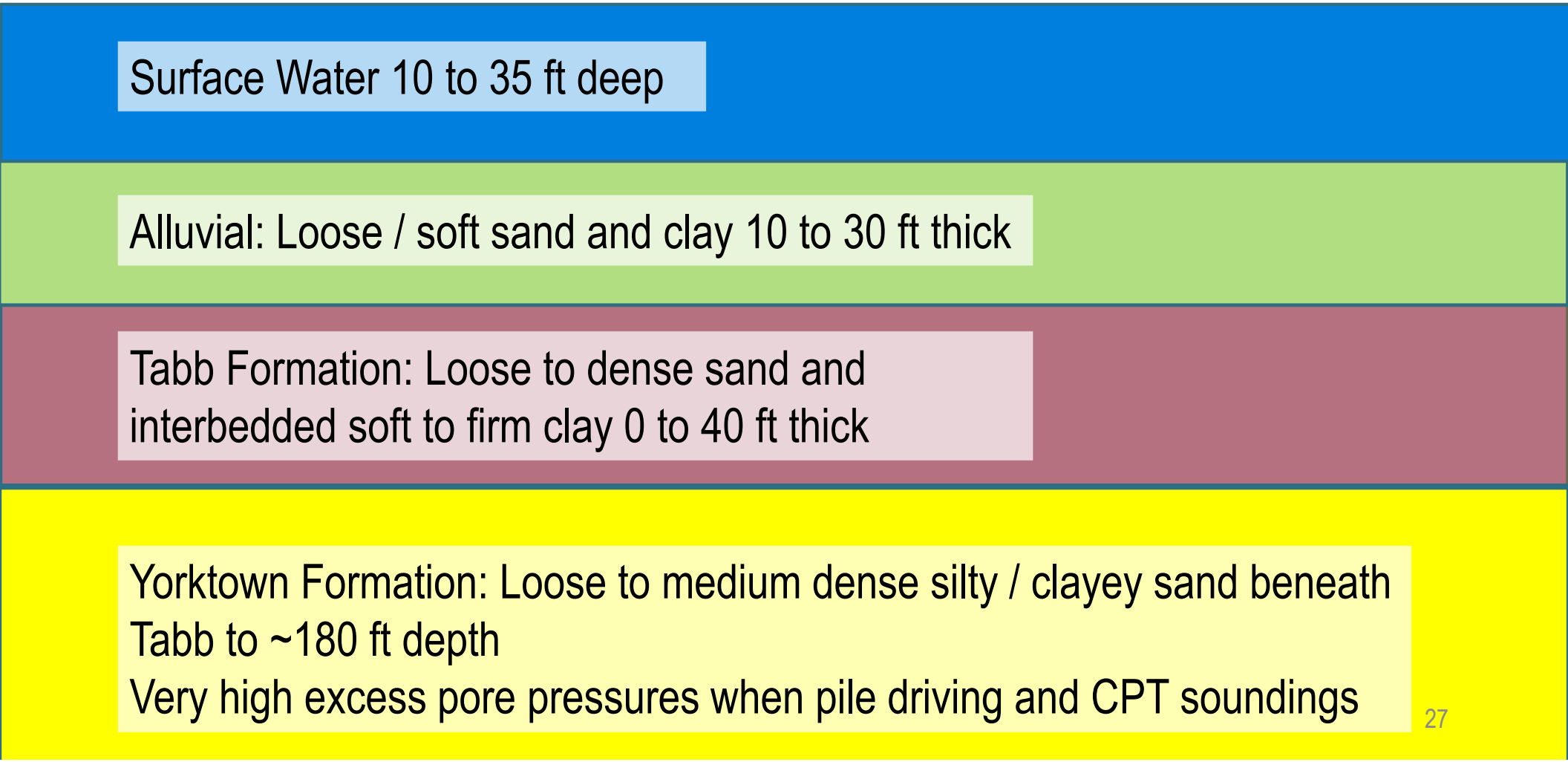
COMMUNICATE VARIABILITY THROUGH VISUALIZATIONS



NORTH TRESTLE MODEL



GENERALIZED GEOLOGY – TRESTLES AREAS



GEOTECHNICAL DESIGN AND REPORTING

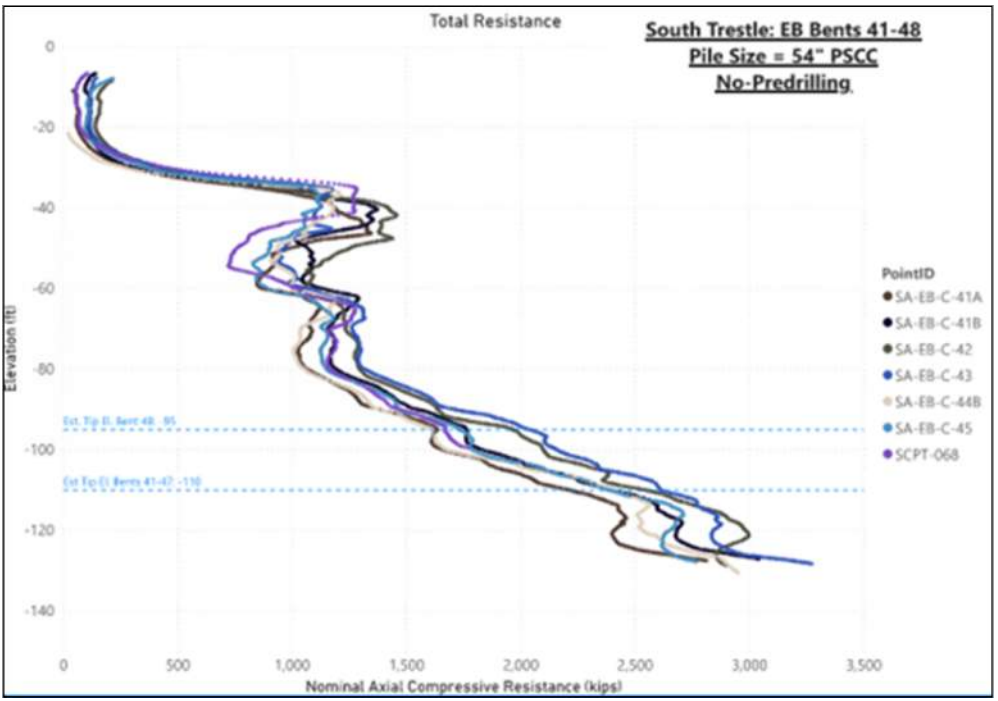
- Stage 1 – Preliminary
- Stage 2 – Final/RFC
- Design Soil Parameters
- Geotechnical Engineering Reporting (GER)
  - Roadways
    - Seismic
    - Pavements
    - Earthwork & Slopes - Embankments/Cuts
    - **Settlement and Stability**
    - Retaining Walls – Global/External
    - Stormwater Management Ponds
    - Drainage Pipes/Utilities
  - Miscellaneous Structures
    - Sound Barrier Walls
    - OHSS/Poles/ITS
    - Retaining Walls
  - Reliability
  - **Ground Improvement**
  - Ground Movement/Damage Risk Assessments
  - Instrumentation & Monitoring
  - Construction Considerations

- Foundation Design Reports (FDR)
  - Embankment Settlement and Slope Stability
  - Downdrag
  - Lateral Resistance of Piles
  - **Axial Resistance of Piles**
  - Pile Group Settlement
  - Pile Hammer Evaluations and Driveability
  - Construction Considerations and Notes on Plans
  - Instrumentation & Monitoring

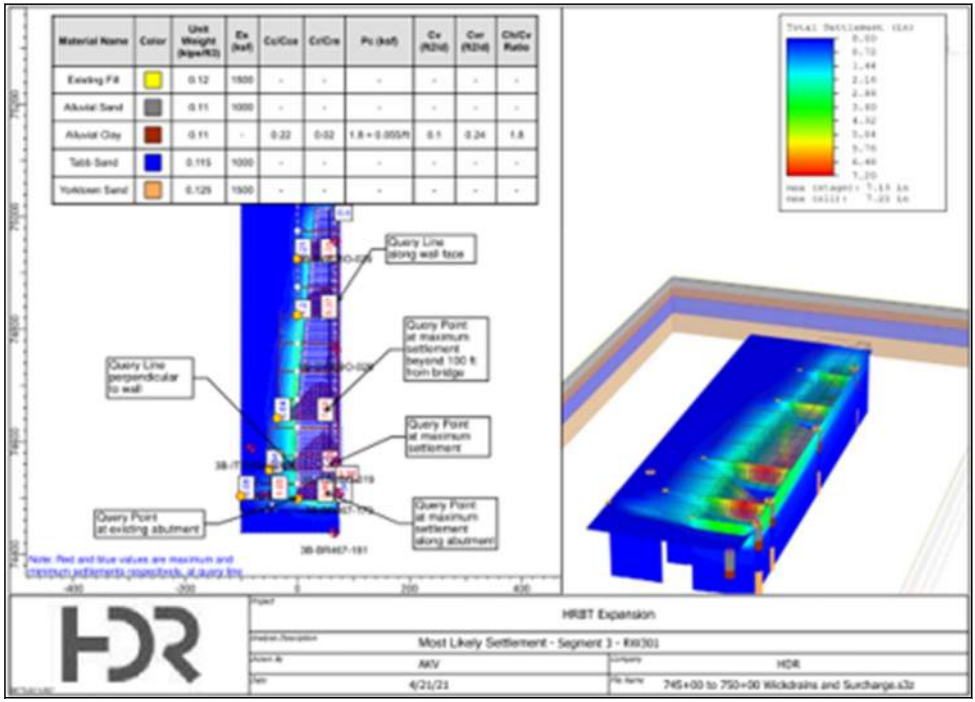
- Other Report Submissions
  - Design Parameters for Supplier/Vendor Designs
  - Substation Sites
  - Pile Load Test Plan and Protocol
  - Pile Load Test Report – Trestle Designs

GEOTECHNICAL DESIGN CHALLENGES

Foundation Design
- CPT based direct method - Eslami & Fellenius (1997)
- Calibrated to Pile Load Test Results
- PowerBI for data visualizations with large amounts of data



Settlement Analysis
- Settle3 to model existing and proposed
- Soil Parameter Selections
- Reliability



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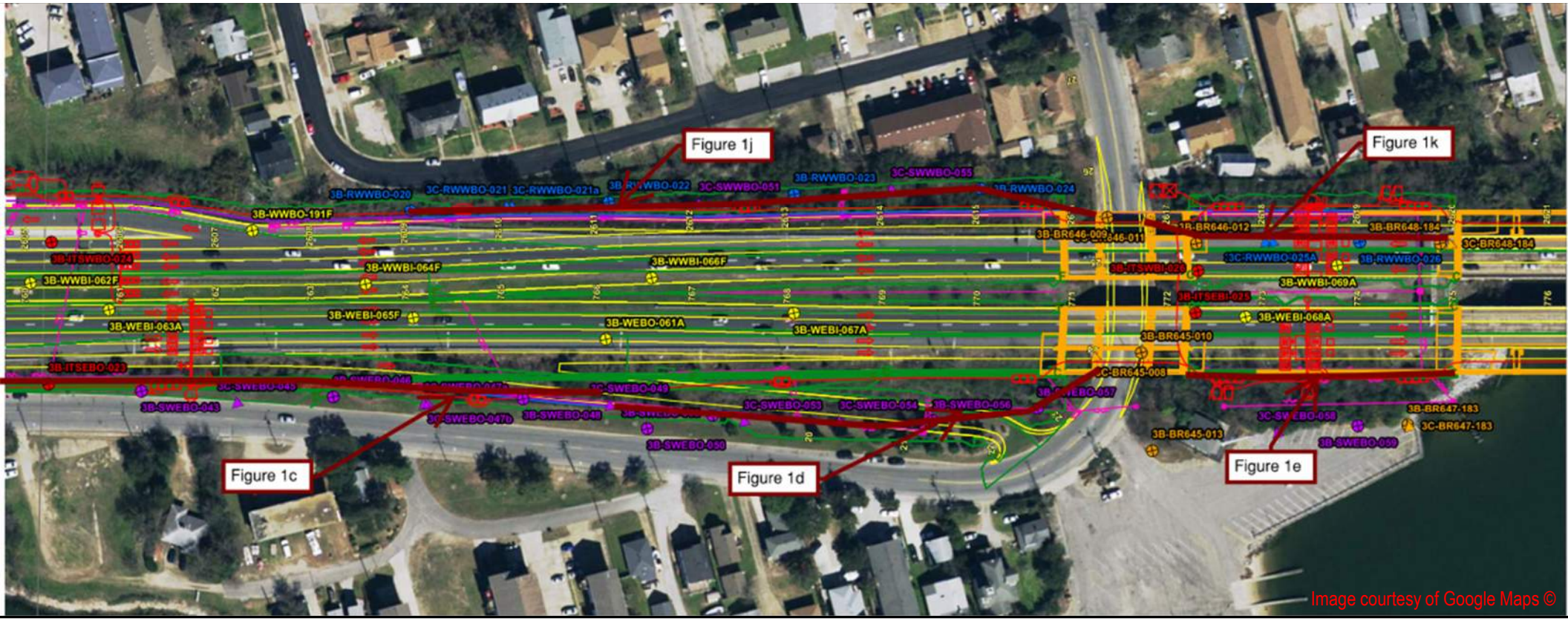
PILE LOAD TEST PROGRAM OVERVIEW

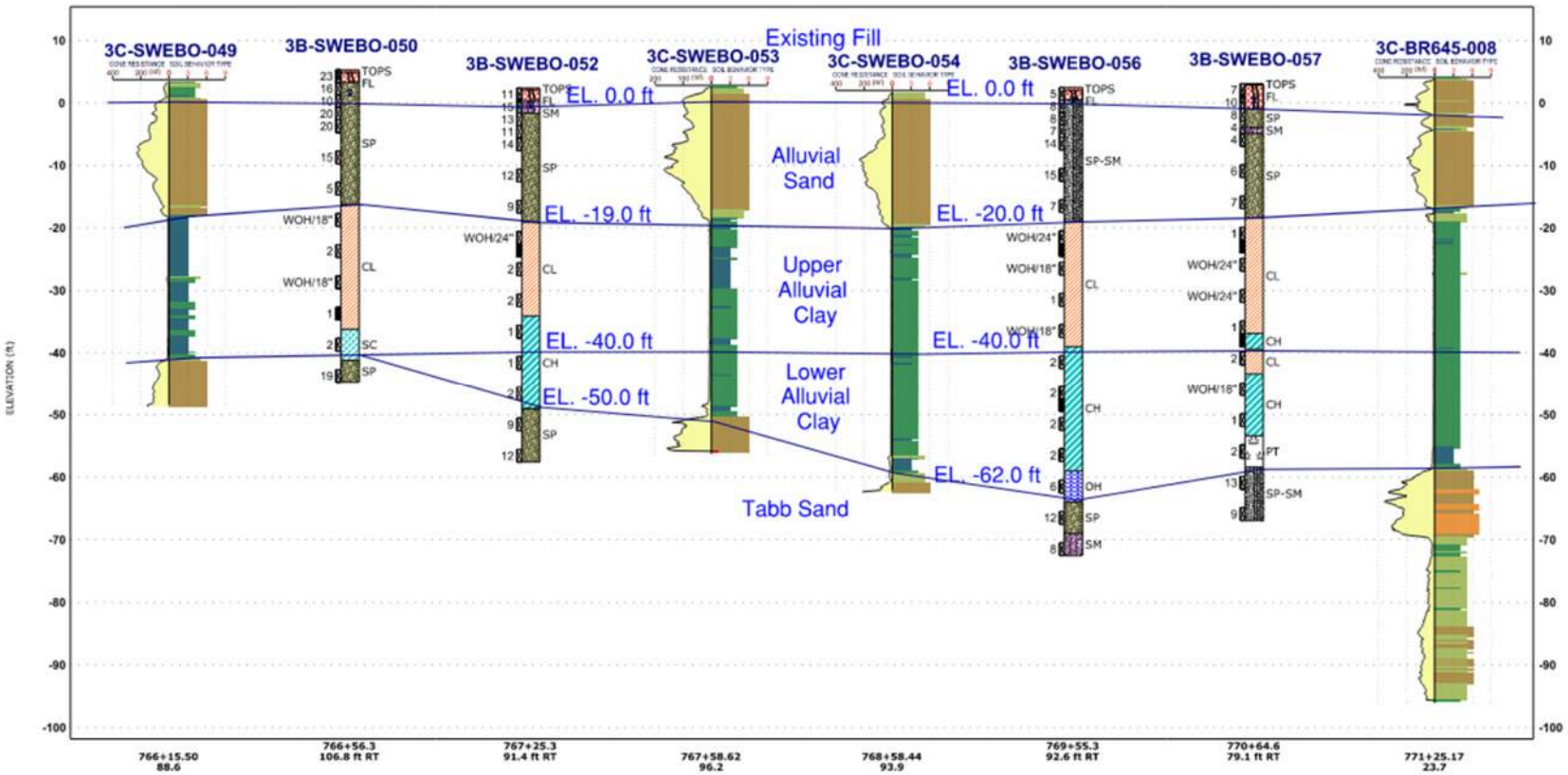
- North Trestle
  - 2 Dynamic Load Test Piles
  - 1 Static Load Test Piles
- South Trestle
  - 2 Dynamic Load Test Piles
  - 2 Static Load Test Piles
- Willoughby Bay Bridge
  - 2 Dynamic Load Test Piles
  - 1 Static Load Test Pile
- RF = 0.8 (used 0.65 in all other areas of the project)

BRIDGE PILE TYPES

- North & South Trestles:
  - 54-inch Precast Prestressed Concrete Cylinder Piles w/ 6.75-inch wall thickness
- Willoughby Bay Trestle:
  - 24-inch Square Prestressed Concrete (PSC)
- Landside Overpass Bridges:
  - 12-inch Square PSC (Overpass locations)
  - 24-inch Square PSC (Wetland/Creek Areas)
  - 30-inch Square PSC (Wetland/Creek Areas)
  - HP 14 x 102 Steel H-Piles (2 locations only)
- Trestle MOT Bridges
  - 36-inch diameter Steel Pipe Piles (Open-End)
  - HP 12 x 74 Steel H-Piles (Abutments)

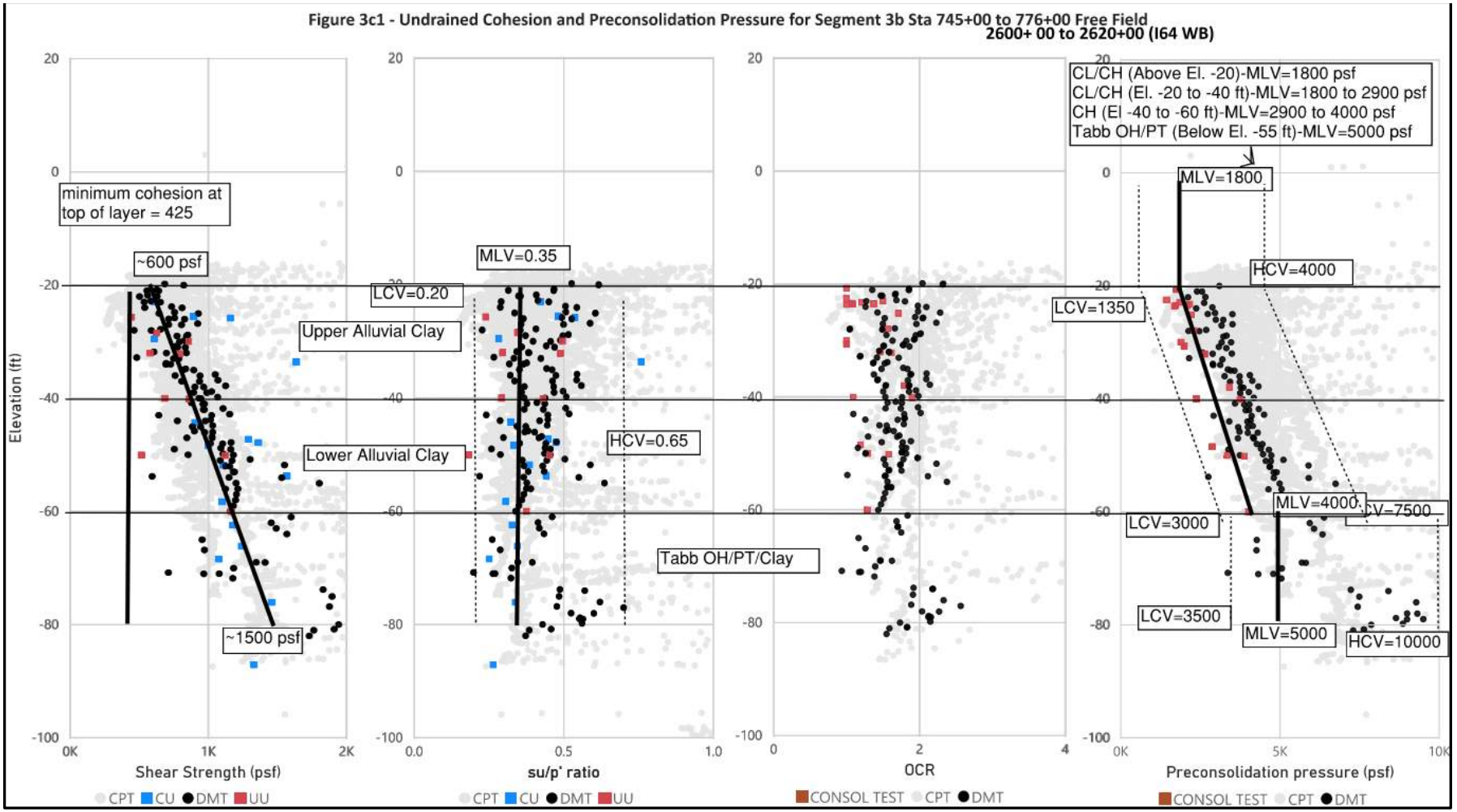


GROUND IMPROVEMENT RECOMMENDATIONS

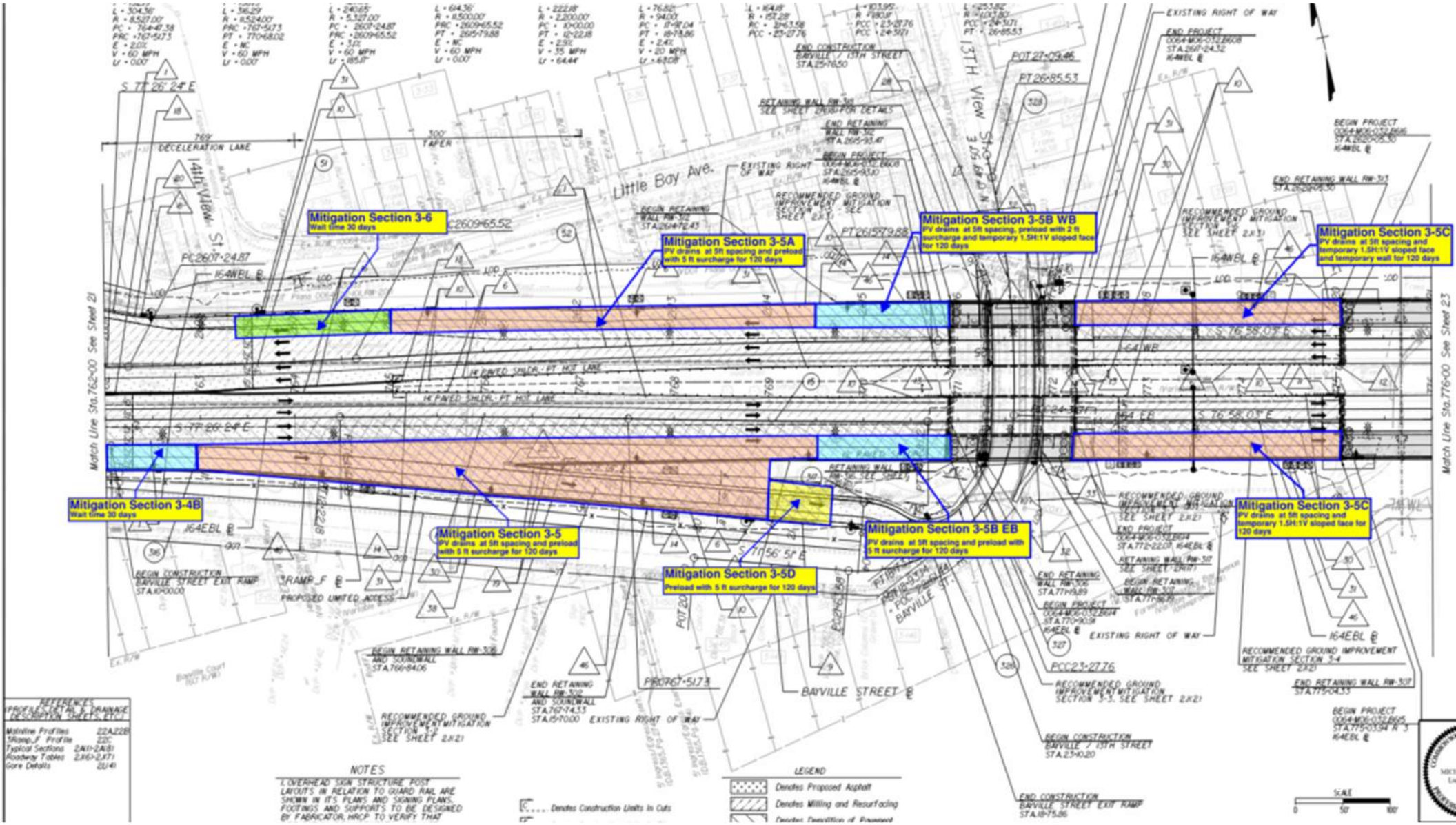


GROUND IMPROVEMENT

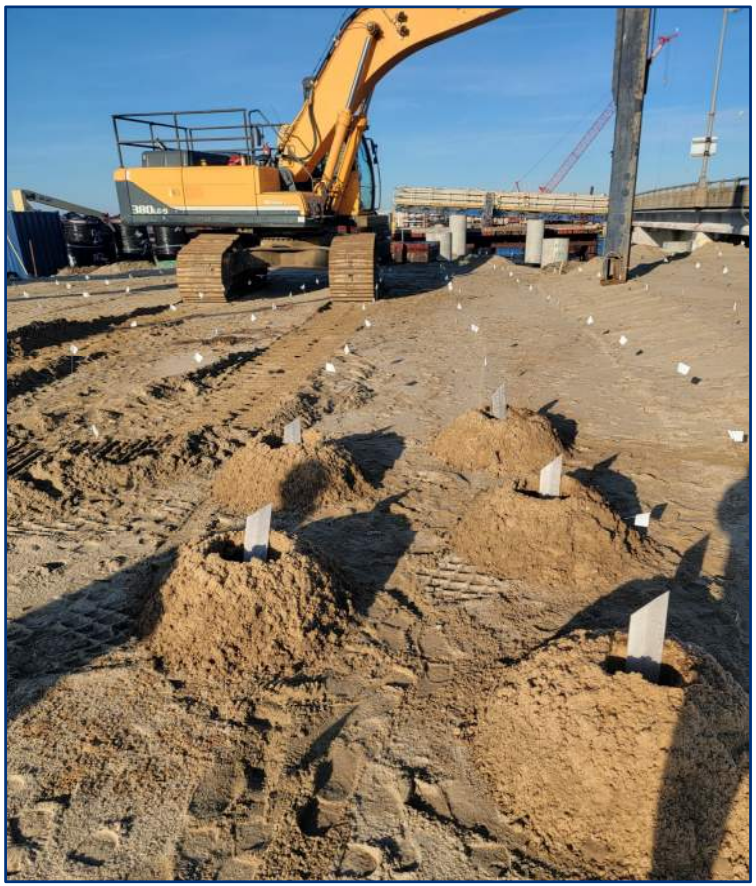
Soft Plastic Clays



Soft Plastic Clays


Mitigation Section 3-6
Wait time 30 days
Mitigation Section 3-5A
PV drains at 5ft spacing and preload with 5 ft surcharge for 120 days
Mitigation Section 3-5B WB
PV drains at 5ft spacing, preload with 2 ft surcharge and temporary 1.5H:1V sloped face for 120 days
Mitigation Section 3-5C
PV drains at 5ft spacing and temporary 1.5H:1V sloped face and temporary wall for 120 days
Mitigation Section 3-4B
Wait time 30 days
Mitigation Section 3-5
PV drains at 5ft spacing and preload with 5 ft surcharge for 120 days
Mitigation Section 3-5D
Preload with 5 ft surcharge for 120 days
Mitigation Section 3-5B EB
PV drains at 5ft specing and preload with 5 ft surcharge for 120 days
Mitigation Section 3-5C
PV drains at 5ft spacing and temporary 1.5H:1V sloped face for 120 days
Little Bay Ave.
13TH View St
BAYVILLE STREET
Match Line Sta.762+00 See Sheet 21
Match Line Sta.776+00 See Sheet 23
NOTES
LEGEND
Denotes Proposed Asphalt
Denotes Milling and Resurfacing

GROUND IMPROVEMENT



GROUND IMPROVEMENT

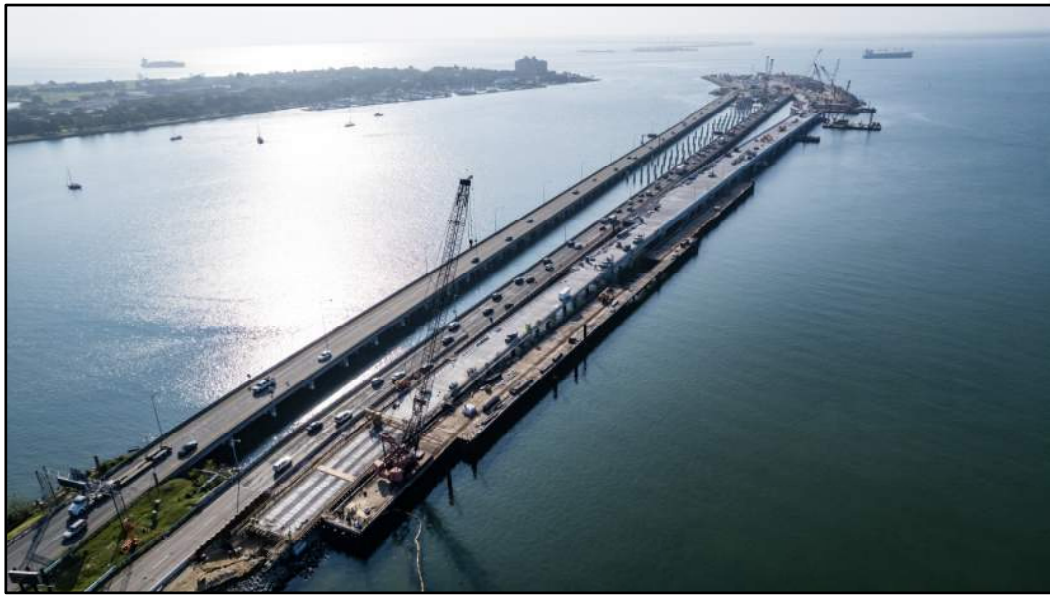
Photographs courtesy of
HRCP and VDOT

DESIGN SERVICES DURING CONSTRUCTION

- Shop Submittals, Field Changes, Work Plans
- Review Dynamic Load Test Reports and Driving Criteria
- Instrumentation Reviews
- Weekly Status Meetings

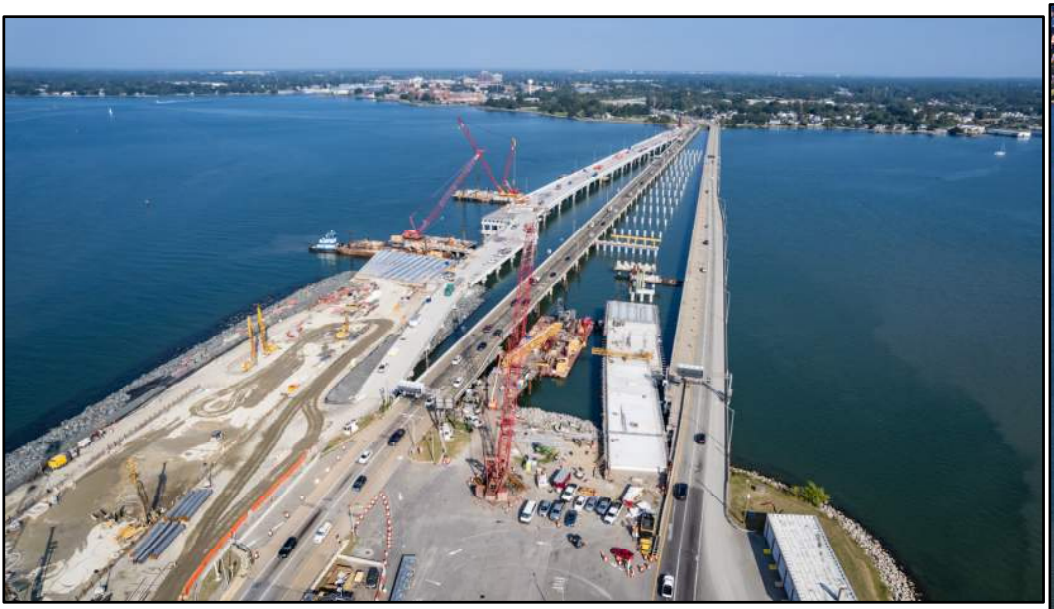
Photographs courtesy of HRCP and VDOT

HAMPTON AND NORTH TRESTLE



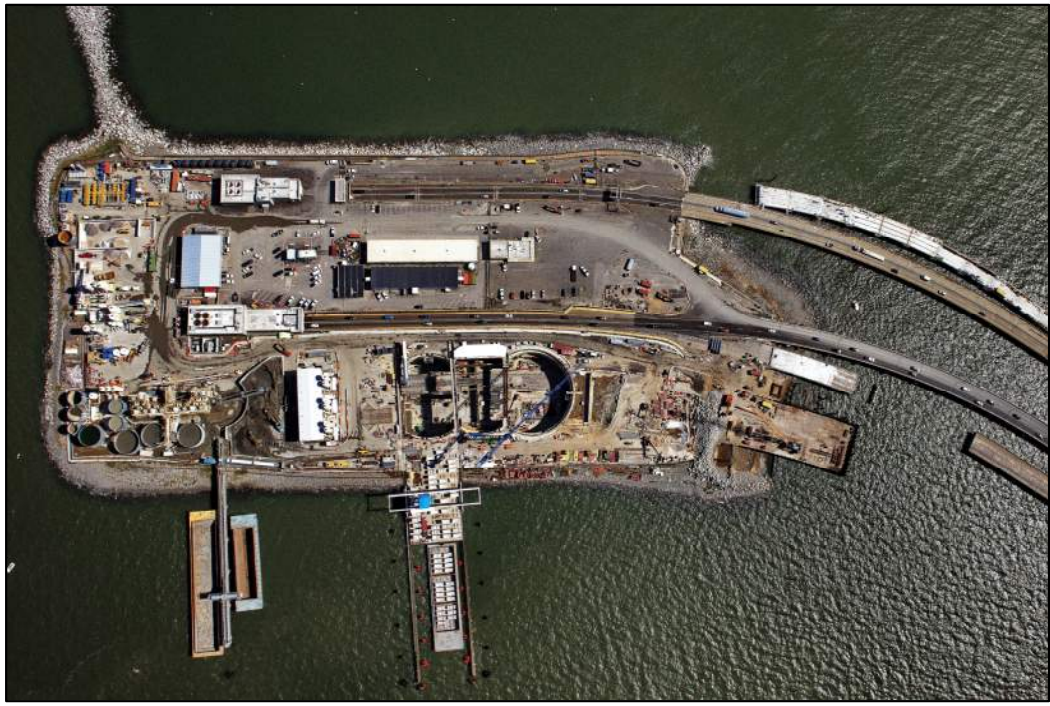
Photographs courtesy of
HRCP and VDOT

NORTH TRESTLE AND CROSSING



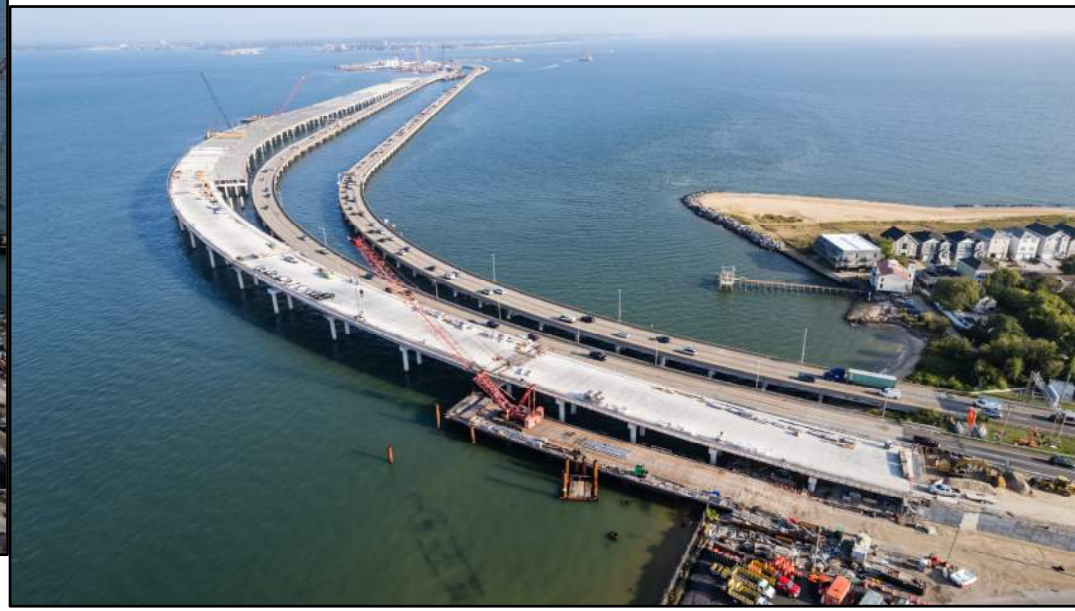
Photographs courtesy of
HRCP and VDOT

SOUTH ISLAND AND TRI-CELL PORTAL



Photographs courtesy of
HRCP and VDOT

SOUTH TRESTLE

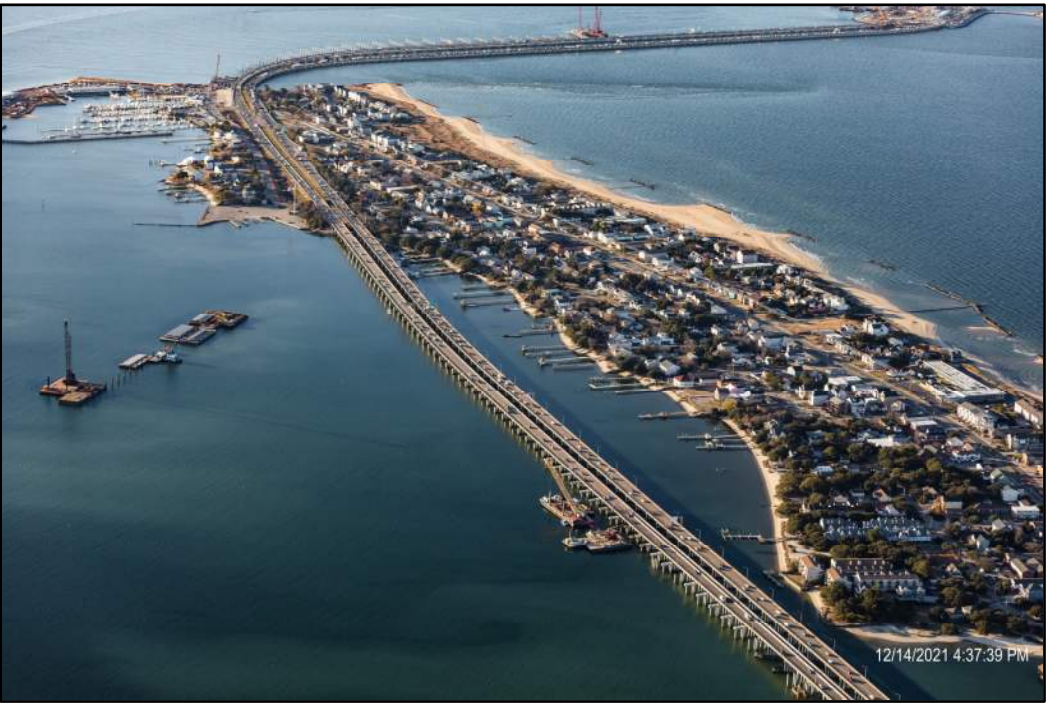


Photographs courtesy of
HRCP and VDOT

WILLOUGHBY SPIT

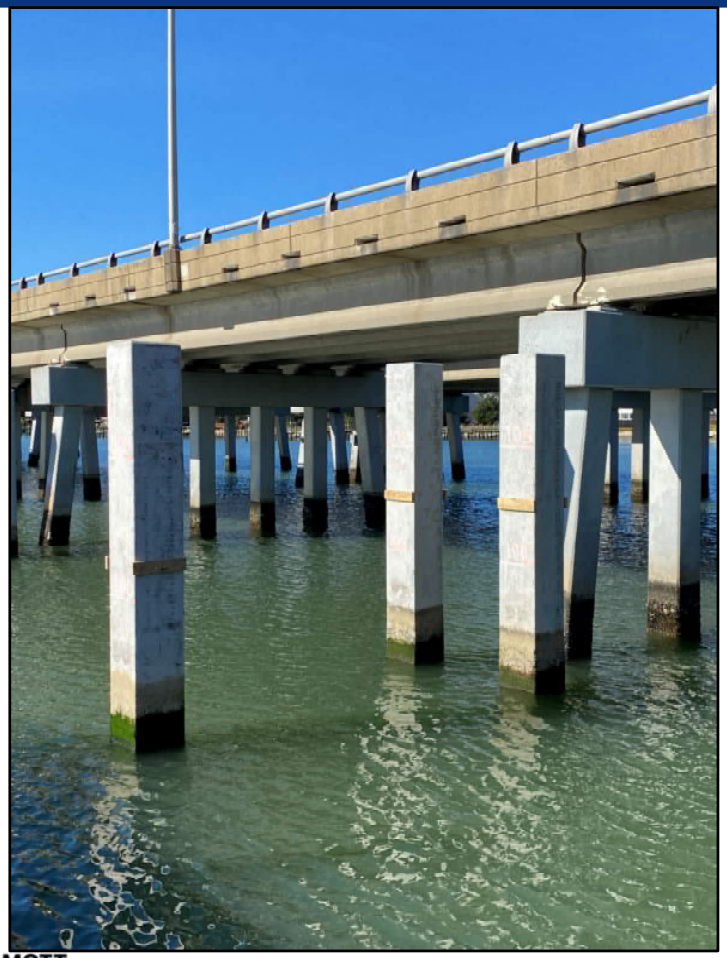
Photographs courtesy of
HRCP and VDOT

WILLOUGHBY BAY TRESTLE

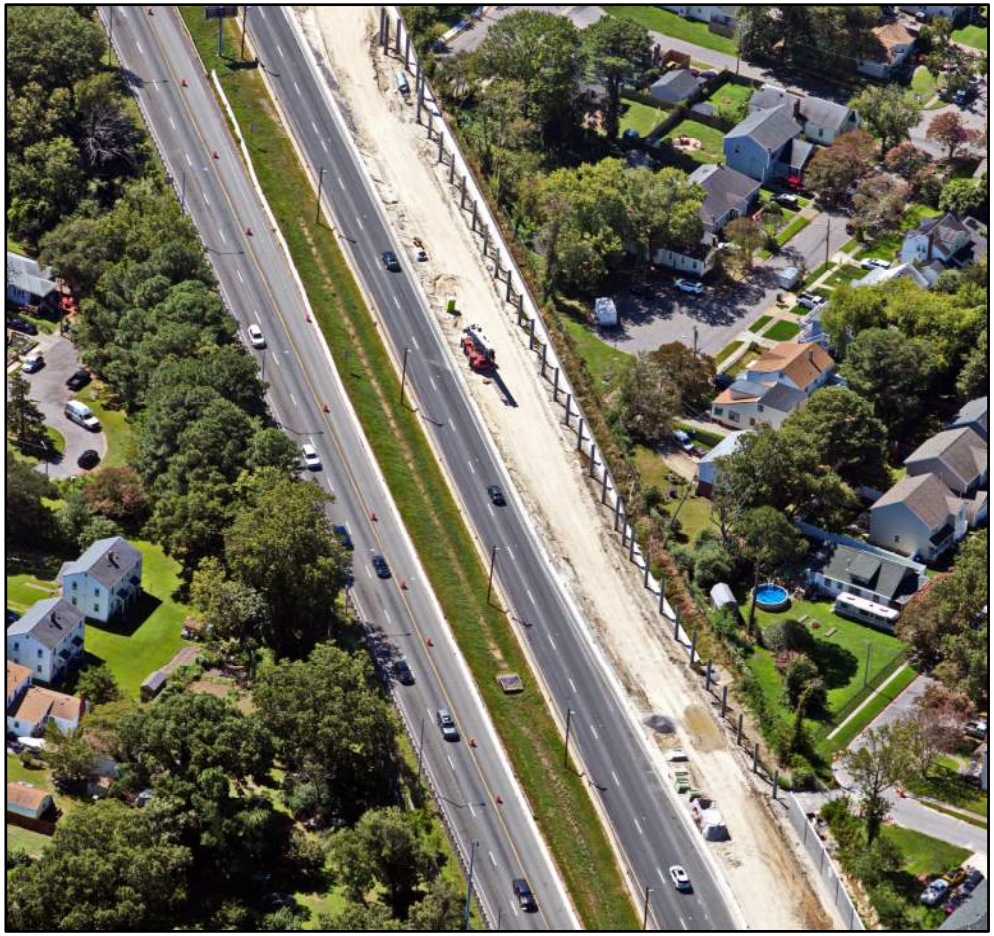


Photographs courtesy of
HRCP and VDOT

24-inch SQUARE PILE PROXIMITY - WBB

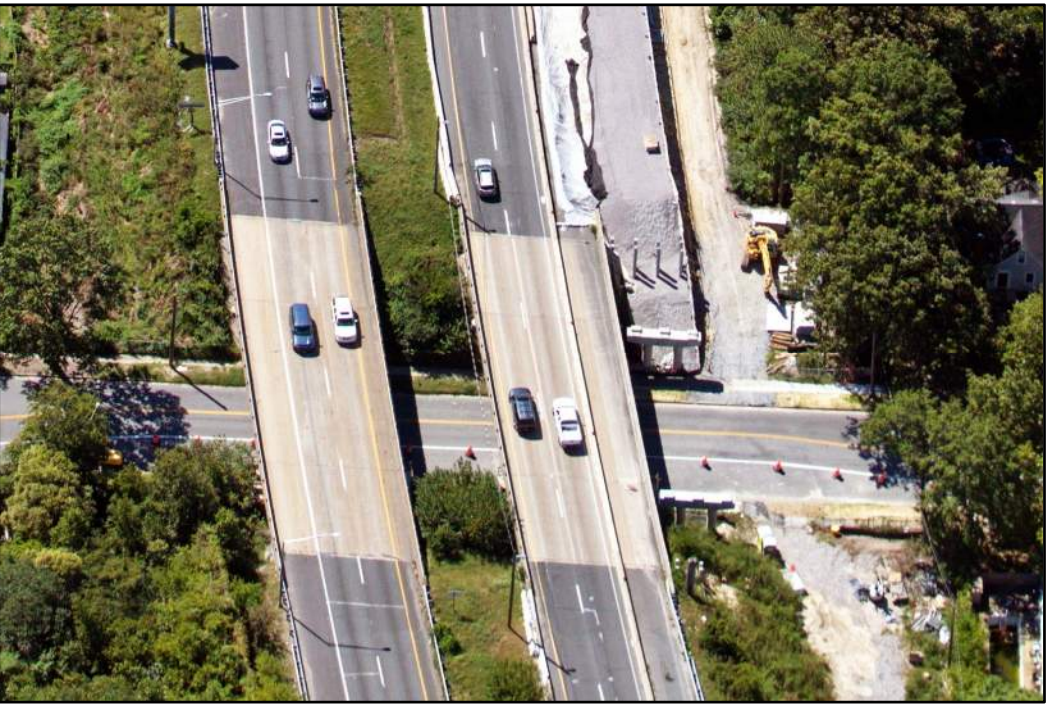


4TH VIEW STREET AND I-64EB WIDENING



Photographs courtesy of
HRCP and VDOT

LANDSIDE BRIDGE WIDENINGS



Photographs courtesy of
HRCP and VDOT

BAY AVENUE AND WETLAND BRIDGES

Photographs courtesy of
HRCP and VDOT

OASTES-MASON AREA

Photographs courtesy of
HRCP and VDOT

PATROL ROAD AND I-564 TERMINUS

Photographs courtesy of
HRCP and VDOT

THANK YOU!

VDOT

Hampton Roads Connector Partners (HRCP)

Mott MacDonald

HDR Geotechnical Team

NCDOT GEU

11/1/2023

Photographs courtesy of HRBT Expansion Website

QUESTIONS