Midtown Tunnel
Integrated Site Investigation
STGEC 2012

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Fugro Atlantic
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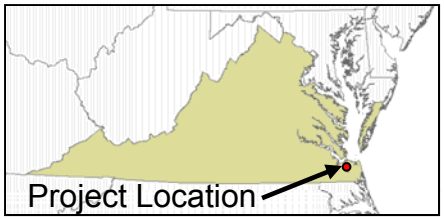
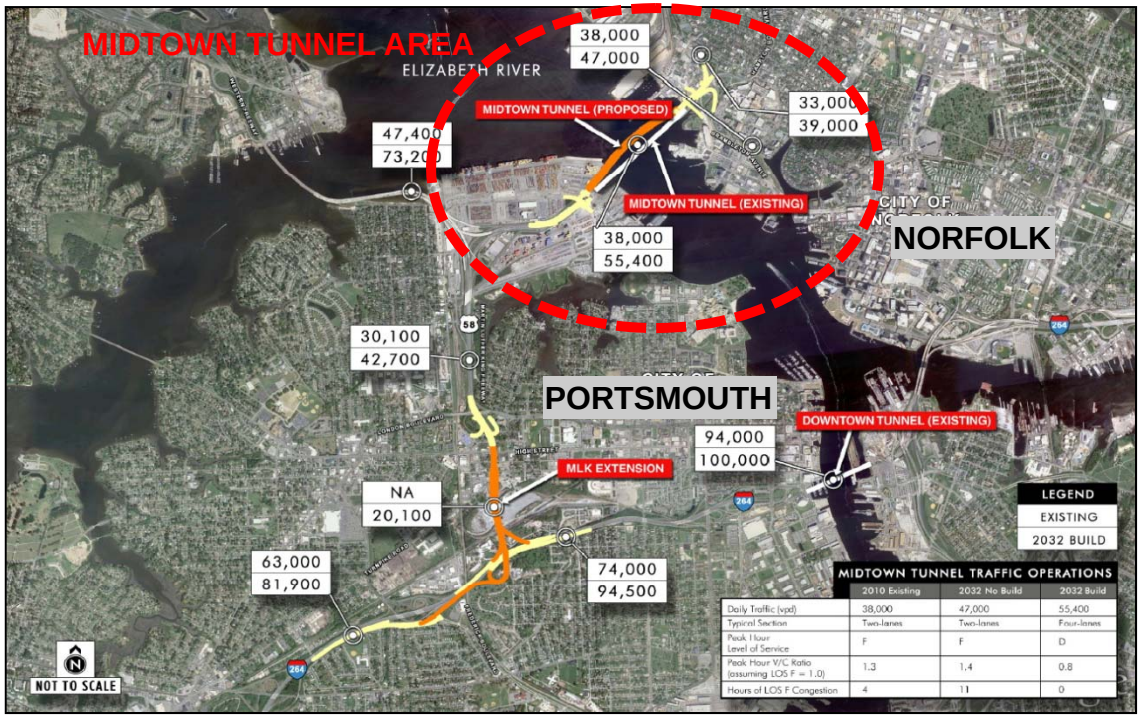
Midtown Tunnel Second Parallel Tunnel

- Part of the Downtown Tunnel, Midtown Tunnel, and MLK Extension Project
- New 2-lane tunnel to connect Portsmouth and Norfolk
- Existing 2-lane tunnel constructed using pre-cast concrete tubes in late 1950s
- Cut-and-cover technique
- Traffic volumes
  - 2010: 38,000 vpd
  - 2032: 55,400 vpd
- Public-private partnership (P3) with Elizabeth River Crossings

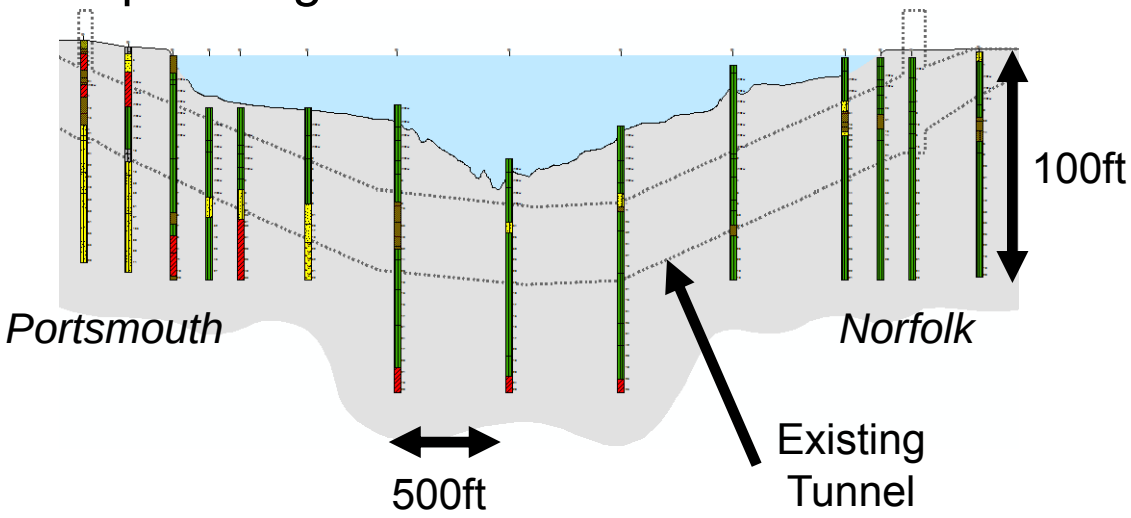




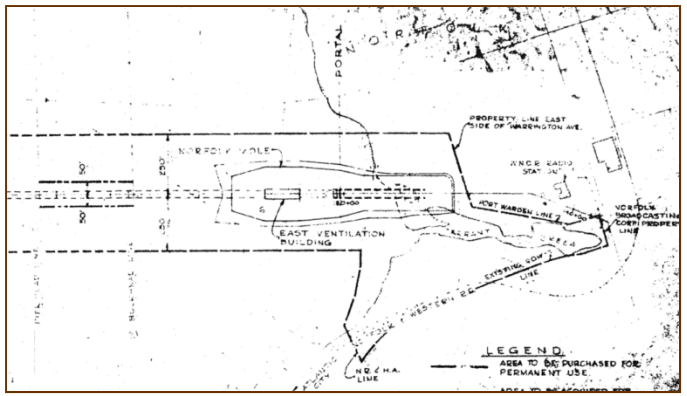
Source: http:/driveert.com

2008 Site Investigation Objectives

- During presolicitation meeting, design-build teams indicated they needed more information than the 1957-1960 borings from original tunnel construction
- Provide geotechnical data to interested design-build team(s)
- Verify 1957-1960 borings
- Document existing site conditions
- Identify potential issues for consideration in design and construction planning

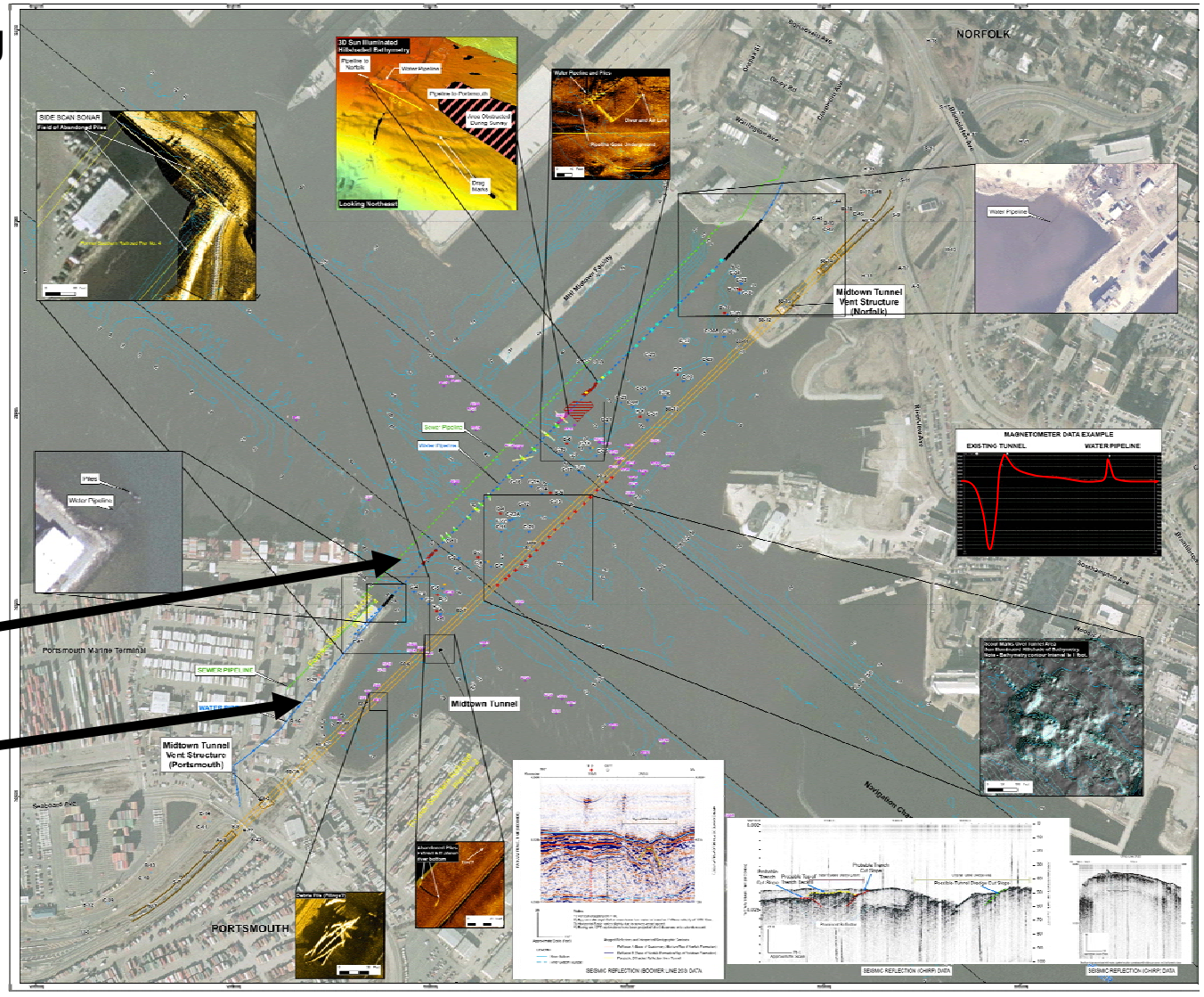


Water Pipeline(?)



2008 Integrated Site Investigation Program

- River Bottom Charting
- Land Survey
- Seismic Reflection
- Geotechnical Investigations
  - Marine (Fugro)
  - Land (VDOT)

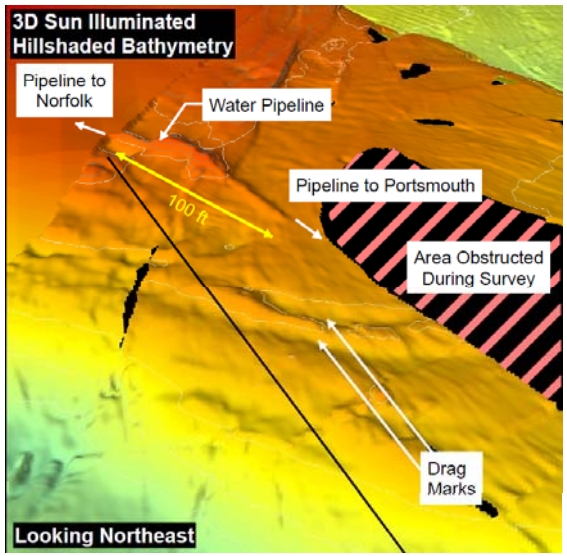


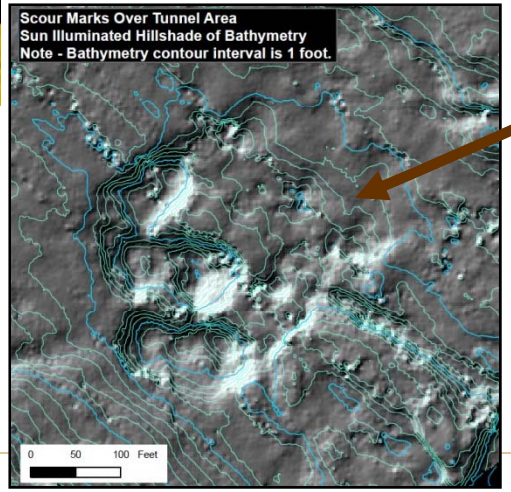
42-in HRSD SEWER LINE

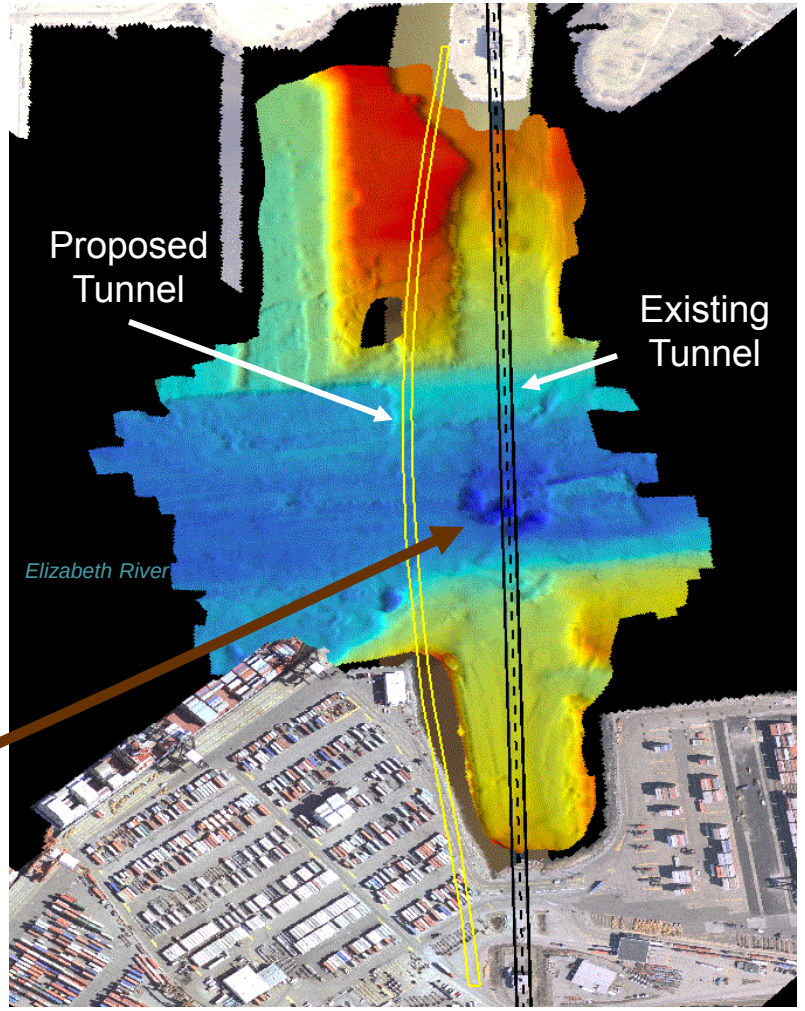
30-in NORFOLK RAW WATER LINE

Multibeam Survey

- Provide accurate river bottom elevation model
- Dredge material volume estimates
- Identify obstructions and features (e.g. scour above tunnel)



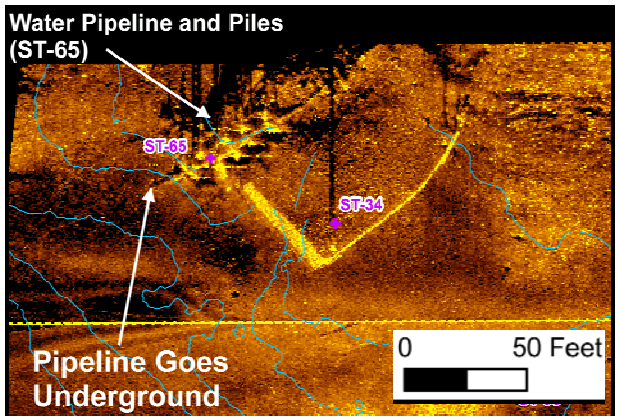


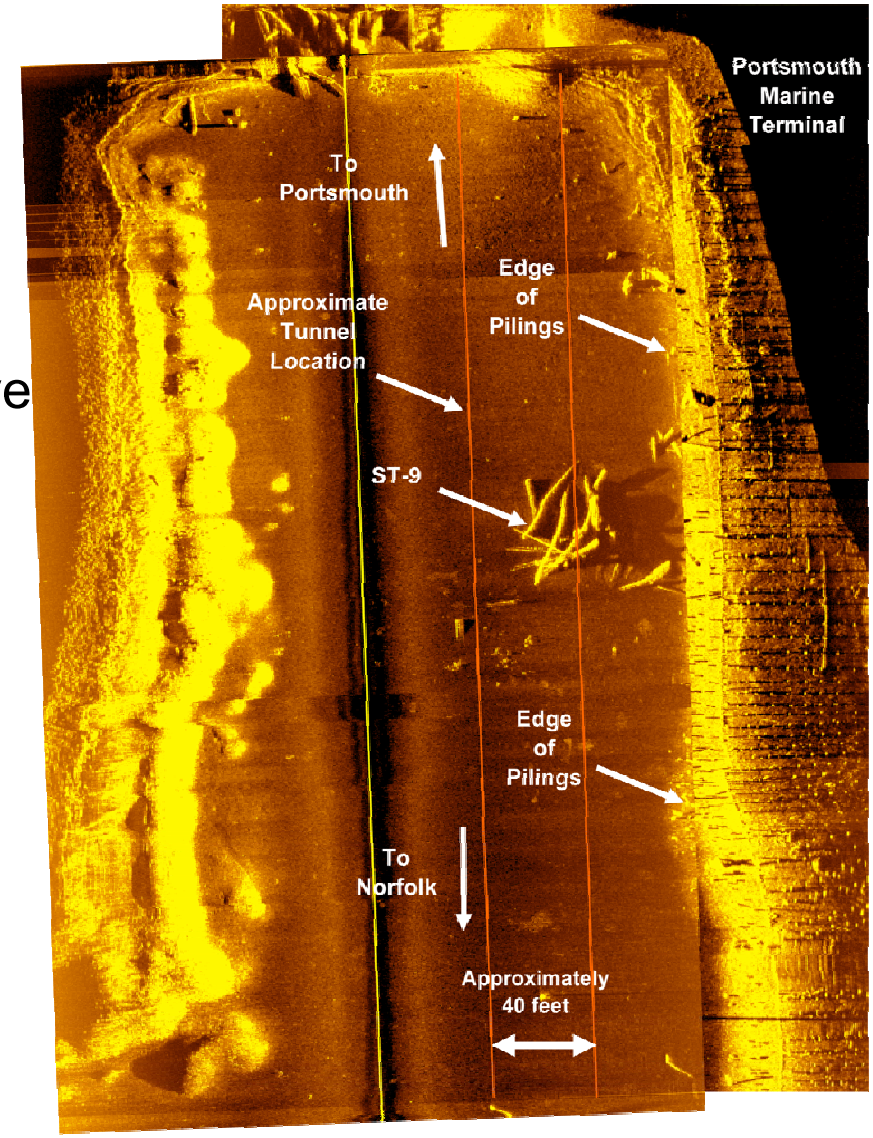


Scour up to 8ft deep over tunnel

Side Scan Sonar Survey

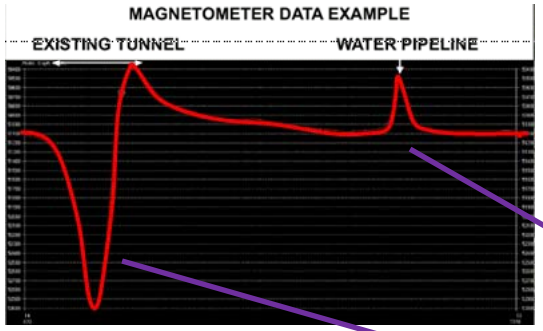
- Abandoned pier (field of piles) to right of existing tunnel alignment are within proposed tunnel alignment
- Isolated piles
  - Some extended 6ft above river bottom
- Pile of piles (ST-9)
- Tires and misc debris
- Water pipeline

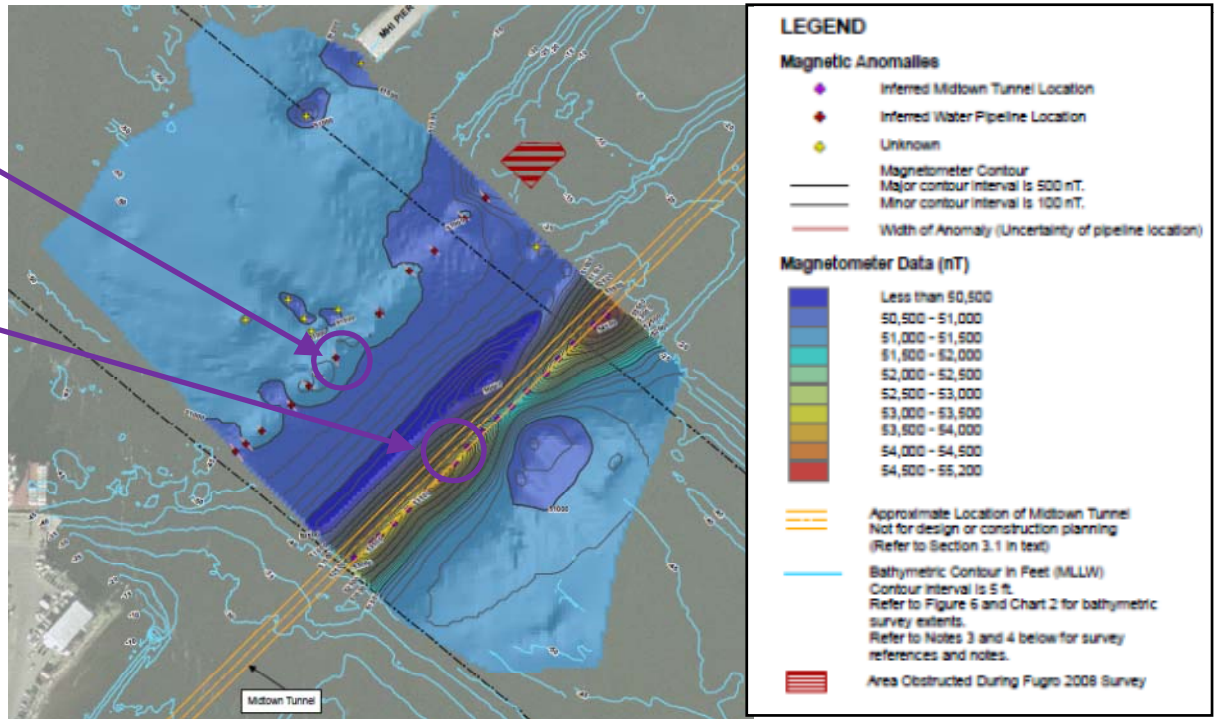




Magnetometer Survey

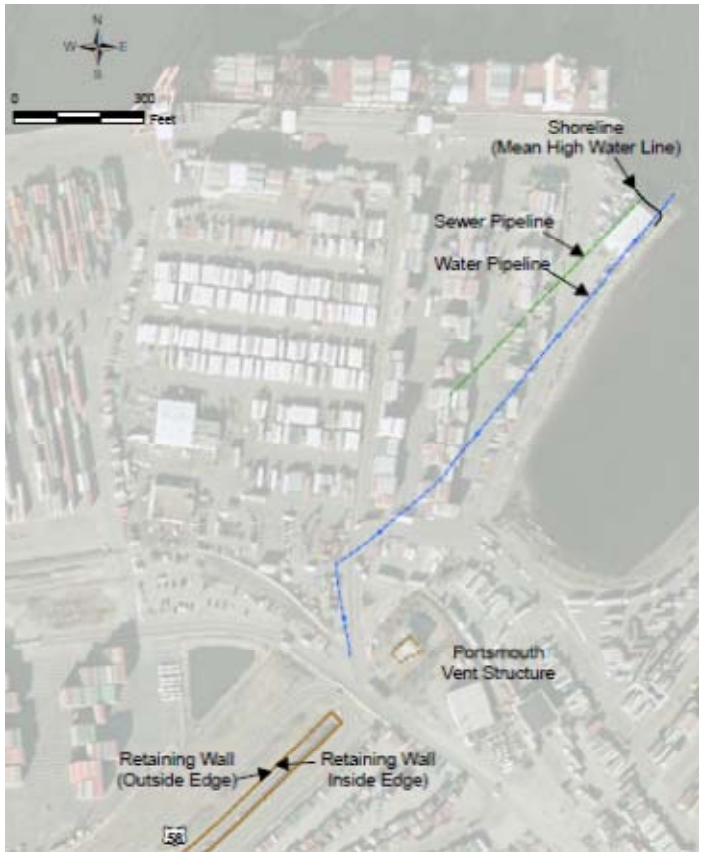
- Locate magnetic anomalies related to ferromagnetic objects at river bottom or shallowly buried
- Mapped horizontal location of water pipeline





Land Survey

PORTSMOUTH



- Shoreline Land Surveys
  - Located existing Midtown Tunnel structures
  - Water and Sewer pipeline shore crossings
  - Used to correlate to offshore structures and help identify safe drilling locations during geotechnical investigations

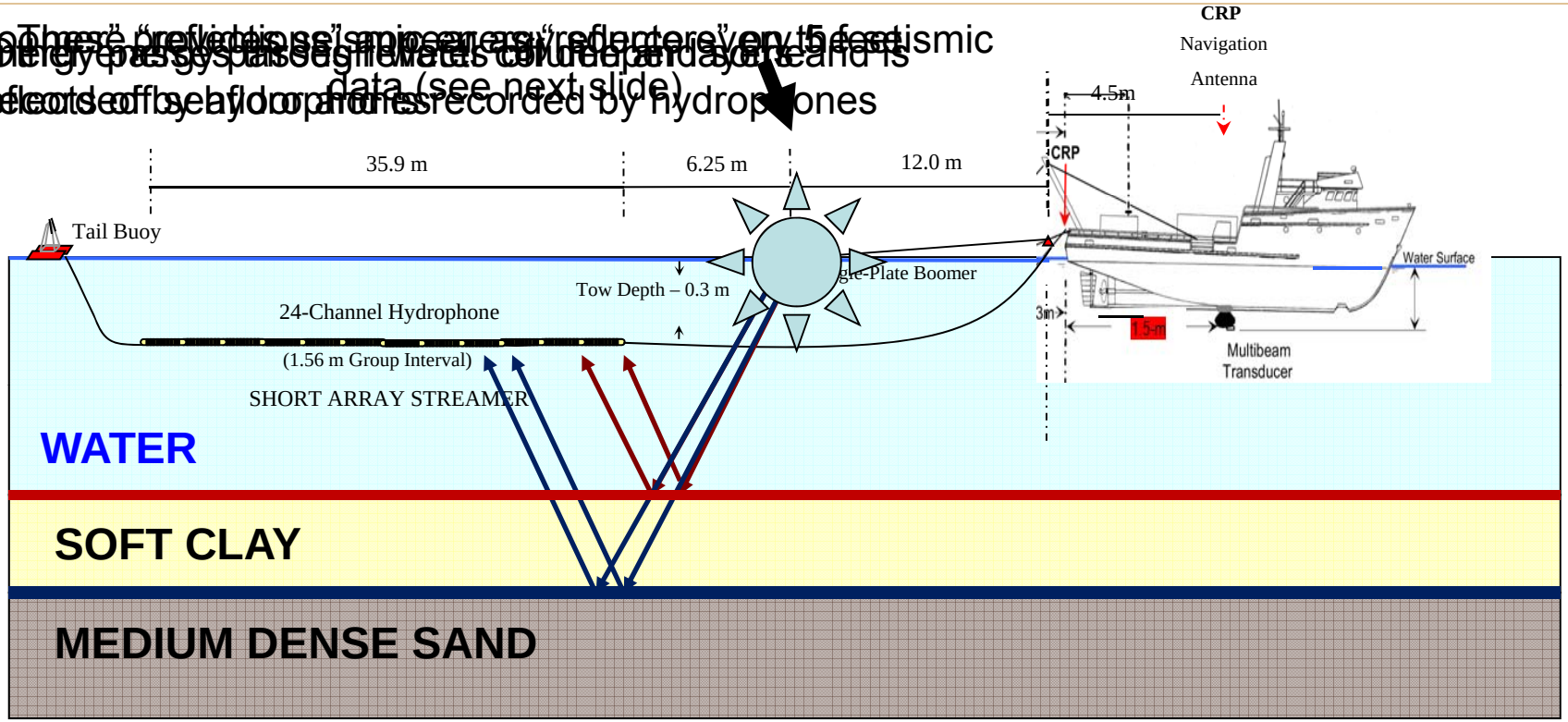
PHOTO 10: View looking toward Norfolk (northeast) across Elizabeth River

PHOTO 7: 30-inch diameter water pipeline landfall on Portsmouth shore. View is looking downstream (northwest).

Multichannel Seismic Reflection

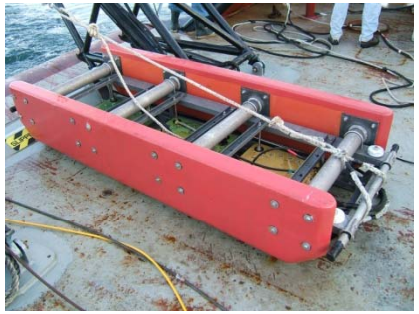
"Boomer" provides seismic energy every 5 feet

Energy passes through water and soft clay and is reflected off hard sand layer and recorded by hydrophones



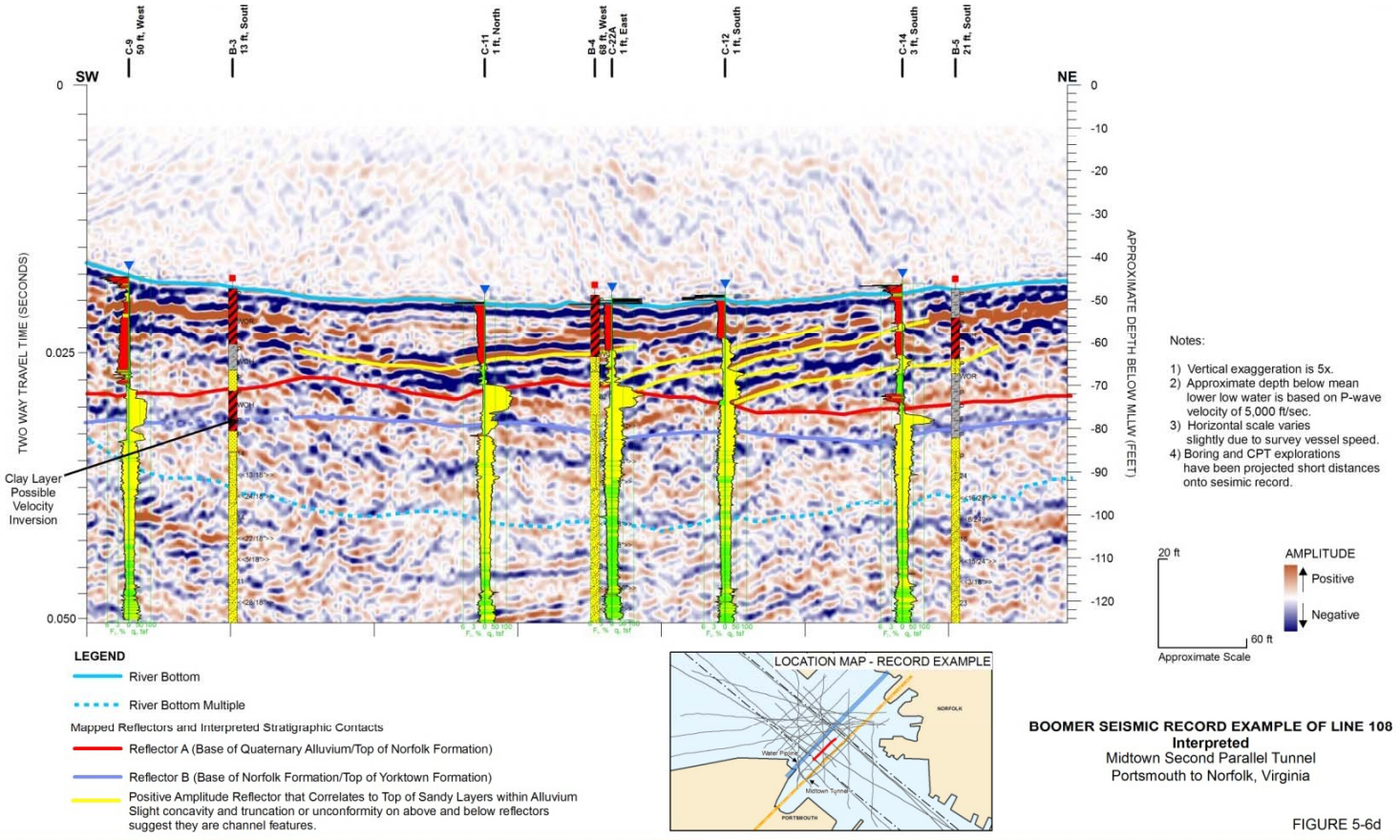
Hydrophone Streamer

Boomer Source



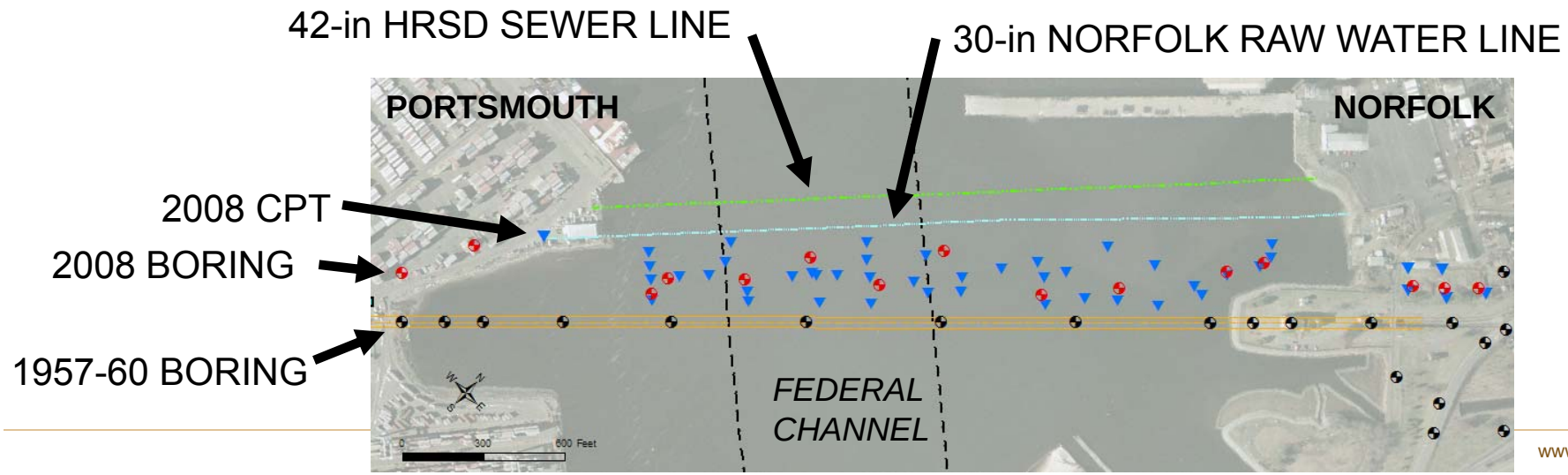
Multichannel Seismic Reflection

- Correlate stratigraphy between explorations
- Dredge cut slopes from original construction: ~3H:1V
- Chirp seismic reflection for upper 20ft



Geotech: Sample Borings and Lab Testing

- Marine drilling and sampling from jack-up platform
  - 10 borings
  - 79 to 127 feet below river bottom
- Marine wireline sampling and SPTs
- Environmental sampling
- Laboratory testing onboard and onshore

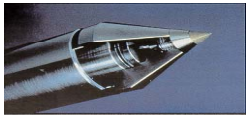


Geotech: In Situ Testing

- 40 CPT soundings
- 4 full-flow penetrometer T-bars
- 4 vane shear testing profiles
- All conducted using a seabed frame system

Seabed In Situ Testing

CPT



10 cm^2

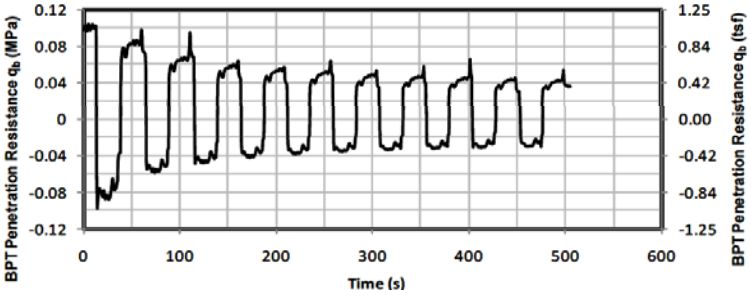
T-bar

40mm diameter by 250mm length

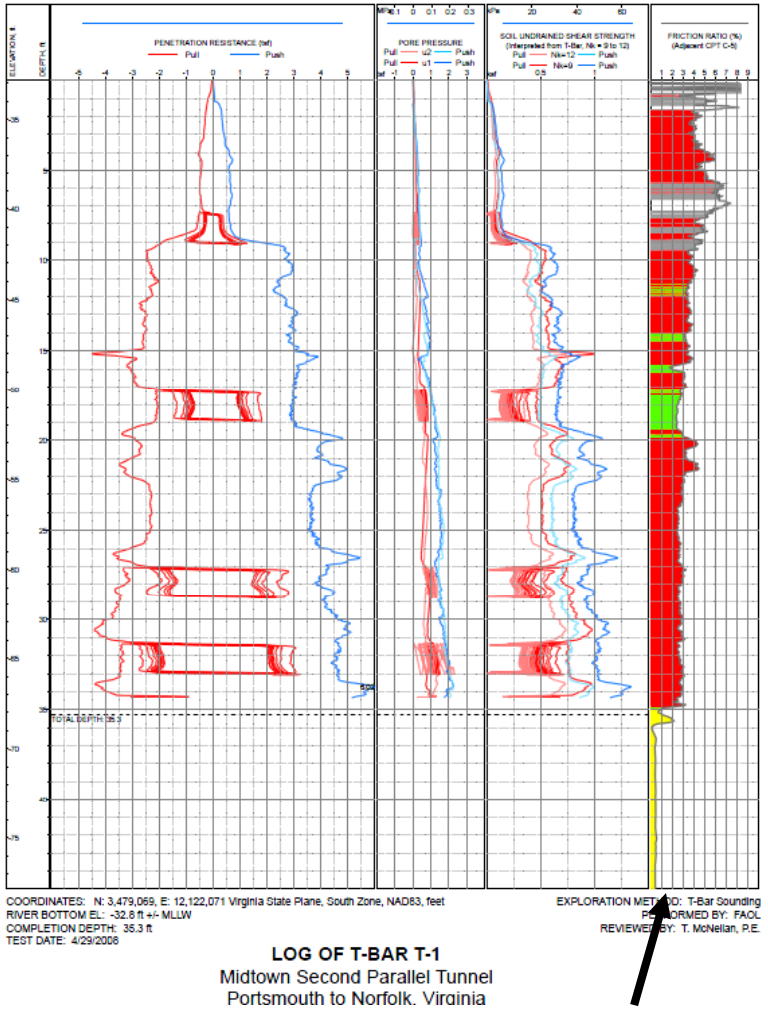
Vane

Full-flow Penetrometer T-bar Soundings

- Measures push and pull resistance and pore pressure
- Can conduct cyclic tests for remolded strength
- Ideal for soft soils



Cyclic Test



SBT from Adjacent CPT

Undrained Shear Strength

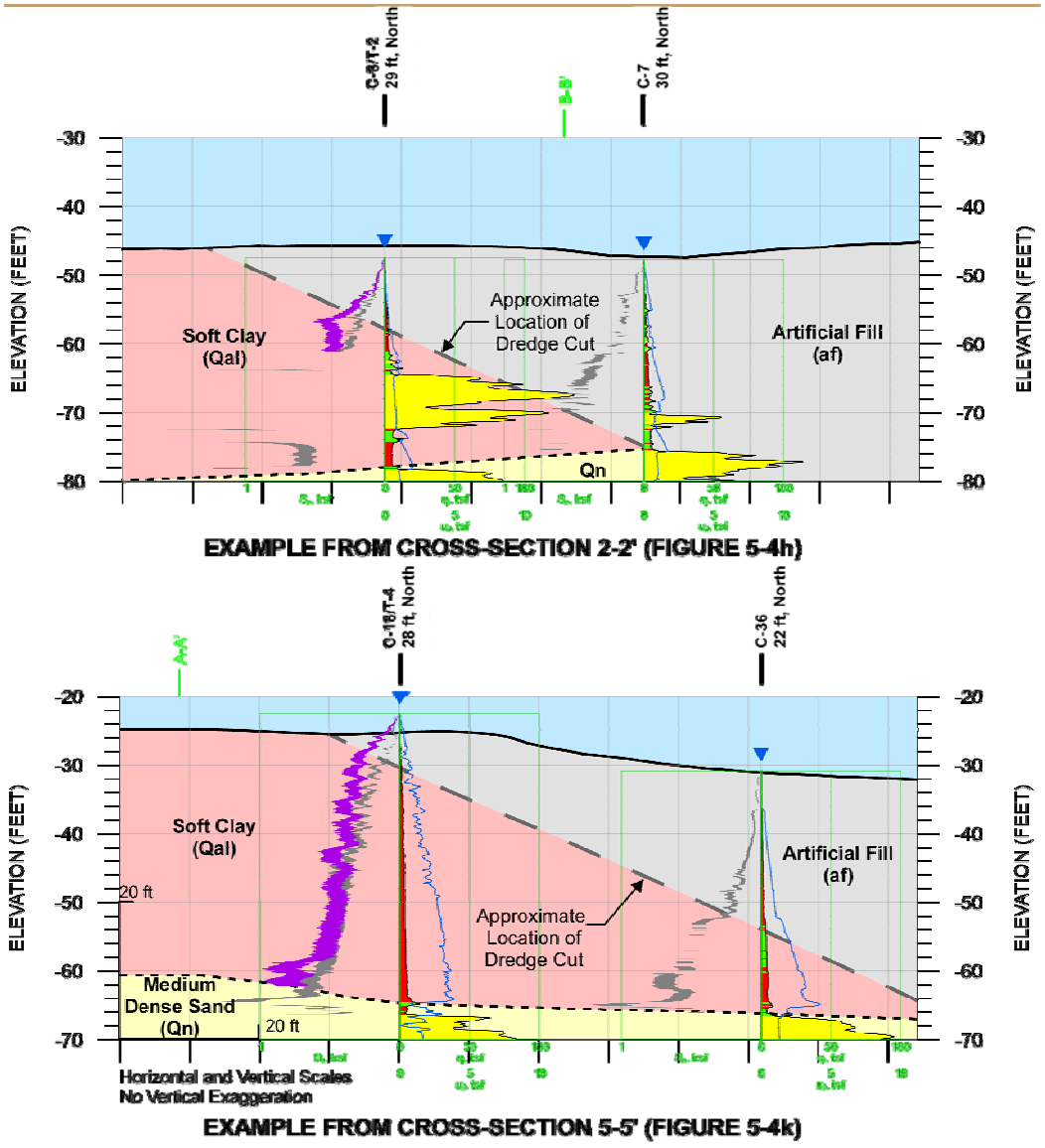
- CPT, T-bar and Ball penetrometers require a bearing factor (Nk)

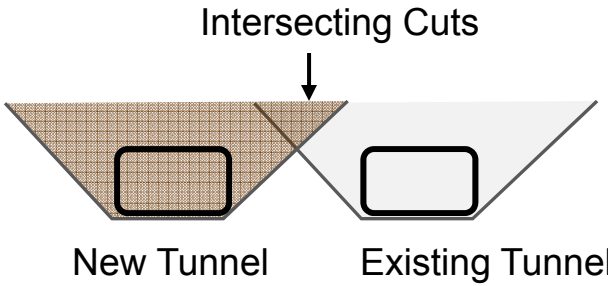
CPT	T-bar or Ball	Vane
$S_u=q_{cNet}/N_k$	$S_u=q_m/N_k$	$S_u=T/K$
$10<N_k<20$	$9<N_k<14$	
$q_{cNet} = q_t - \sigma_{v0}$	q_m = measured penetration resistance	T = Torque K = constant based on vane geometry
$qt = q_c + (1-\alpha)u_2$		

- Full flow penetrometers more straightforward to derive Su
  - Don't correct for pore pressure and overburden pressures
  - Smaller range of bearing factors (Nk)
- Laboratory tests or in situ vane shear tests required to develop site specific Nk factors

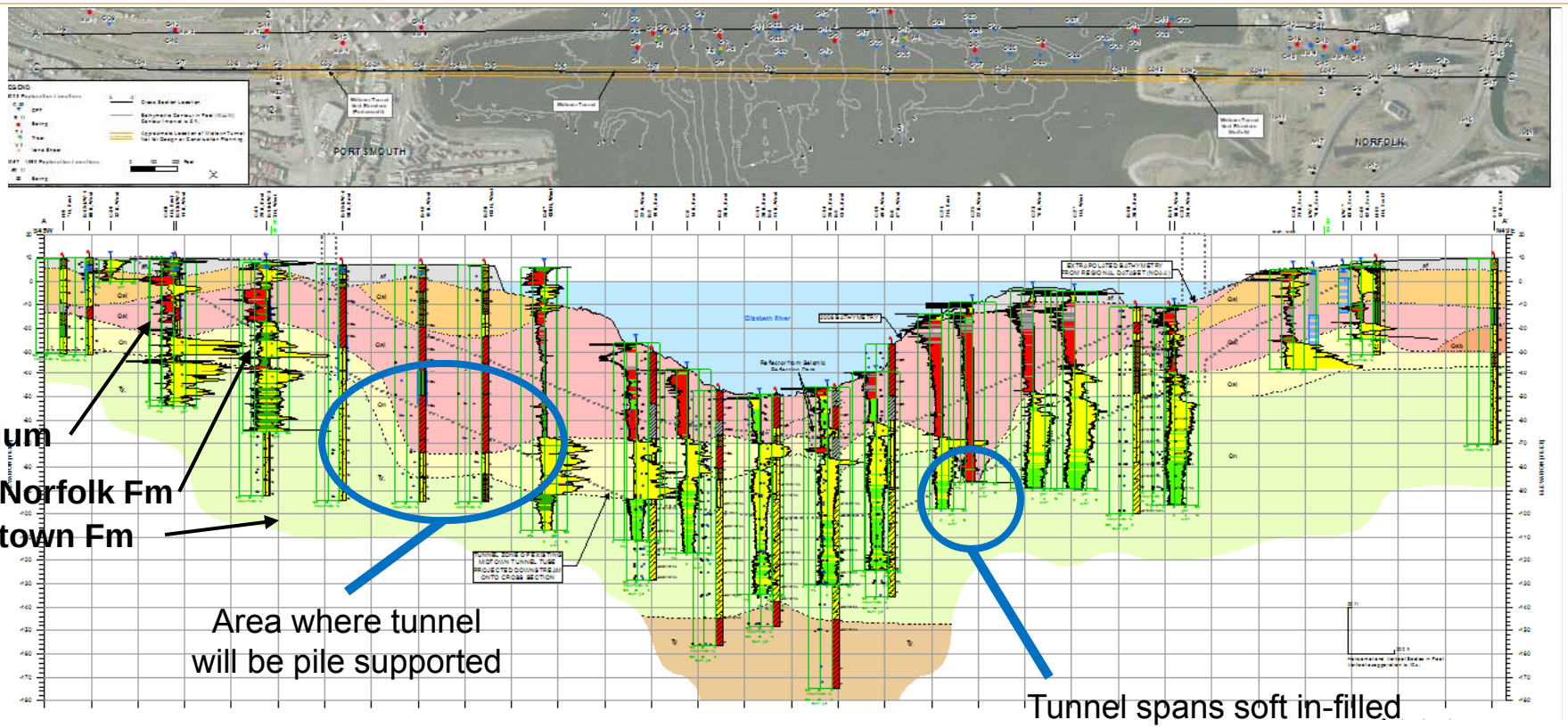
In Situ Tests

- In situ tests provide good S_u profile data
  - Distinct interface between fill and native materials
  - Especially T-bar data
  - T-bar data highest quality S_u tool in soft soils
- Confirm dredge cut slope





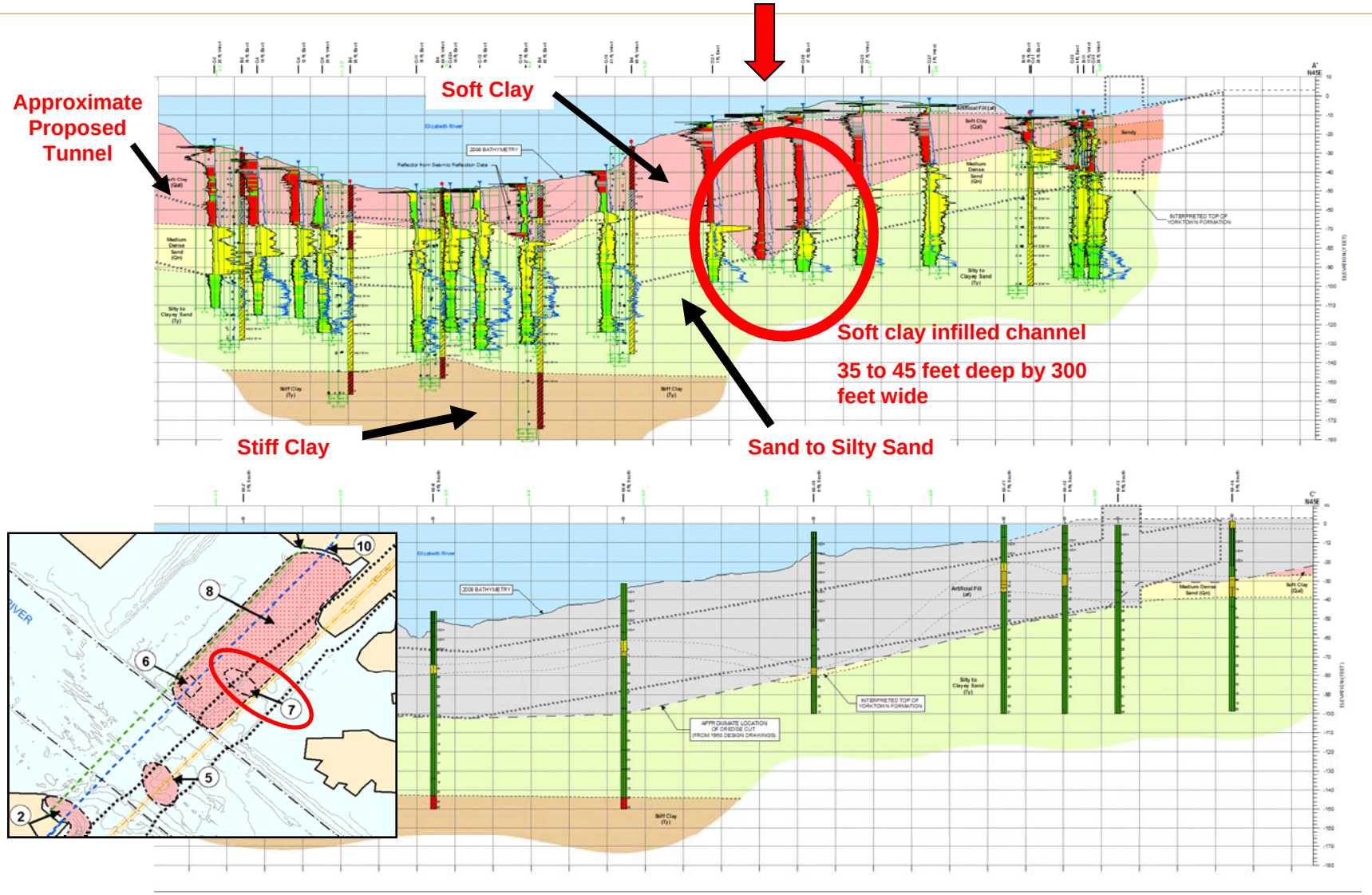
Subsurface Conditions



- Fugro and VDOT reviewed data and cross sections during operations and planned exploration locations based on site features identified during review
  - Contingency CPTs were targeted at the paleochannel on right in section above to better define it

Infilled Channel

Added CPT to Verify Channel Thalweg



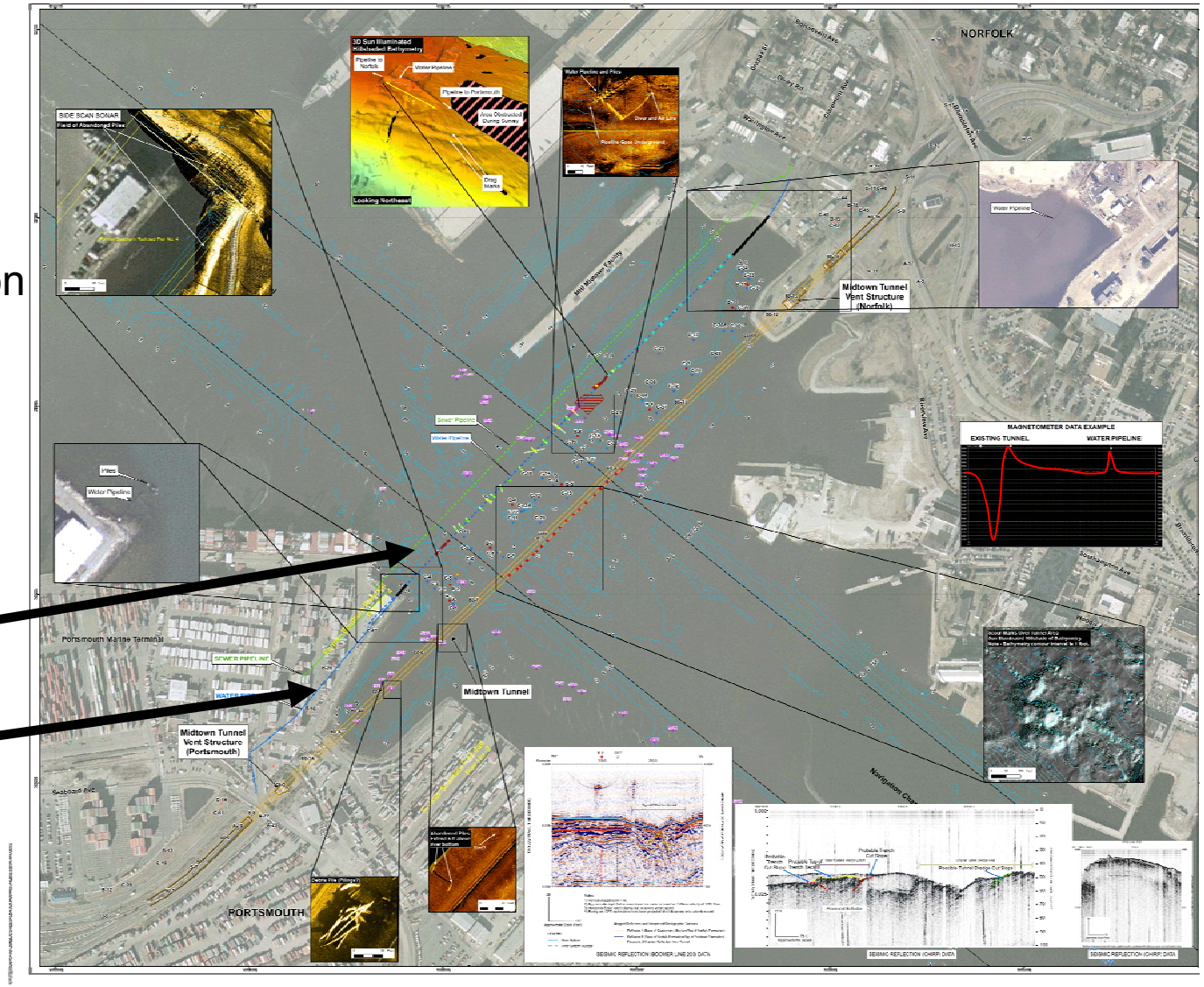
2008 Geotech Data

1960 Geotech Data

- **Channel incised by fluvial processes**

Summary (Water Pipeline Location)

- Located using
  - Side scan sonar
  - Magnetometer
  - Multibeam
  - Seismic reflection
  - Conventional surveying



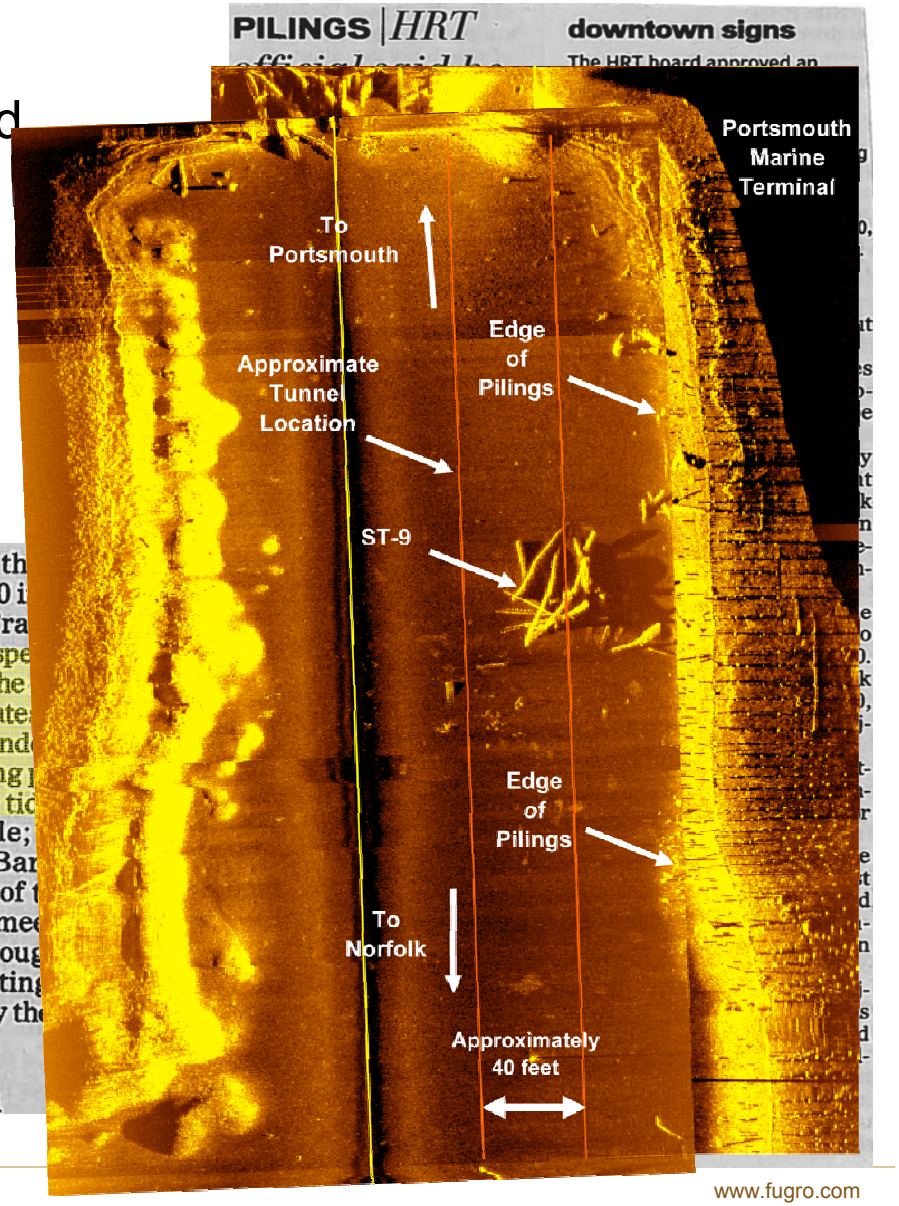
Summary

- Thorough, comprehensive investigation was effective in documenting surface and subsurface conditions
- Integrated approaches provide more value as integrated package than individual parts
- Phasing the work is preferred
- Near real-time evaluation of data used to target features while equipment mobilized in field and optimize data collection

Uncertainty and Risk

Beyond the Historical Routine

- Local "Surprises" resulting from limited or incomplete survey data
- Norfolk Light Rail – Broad Creek
  - December 2008



Light-rail costs pile up as more pilings appear

more money

HRT's board approved spending $369,200 to remove an extra 240 rail pilings from Broad Creek, more than the 20 contracted.

By Debbie Messina
The Virginian-Pilot

NORFOLK

The tides tricked The Tide.

Transit officials contracted to remove 20 old wooden railroad pilings from Broad Creek to build a new concrete bridge for Norfolk's light rail.

Apparently, though, a consultant who surveyed the crossing was not there at low tide.

When the water receded, dozens more pilings poked th face. There were 260 i

Hampton Roads Tra Thursday approved spe $369,200 to remove the cy's change order state ber of pilings was "und 20, due to pre-existing visible except at low tid

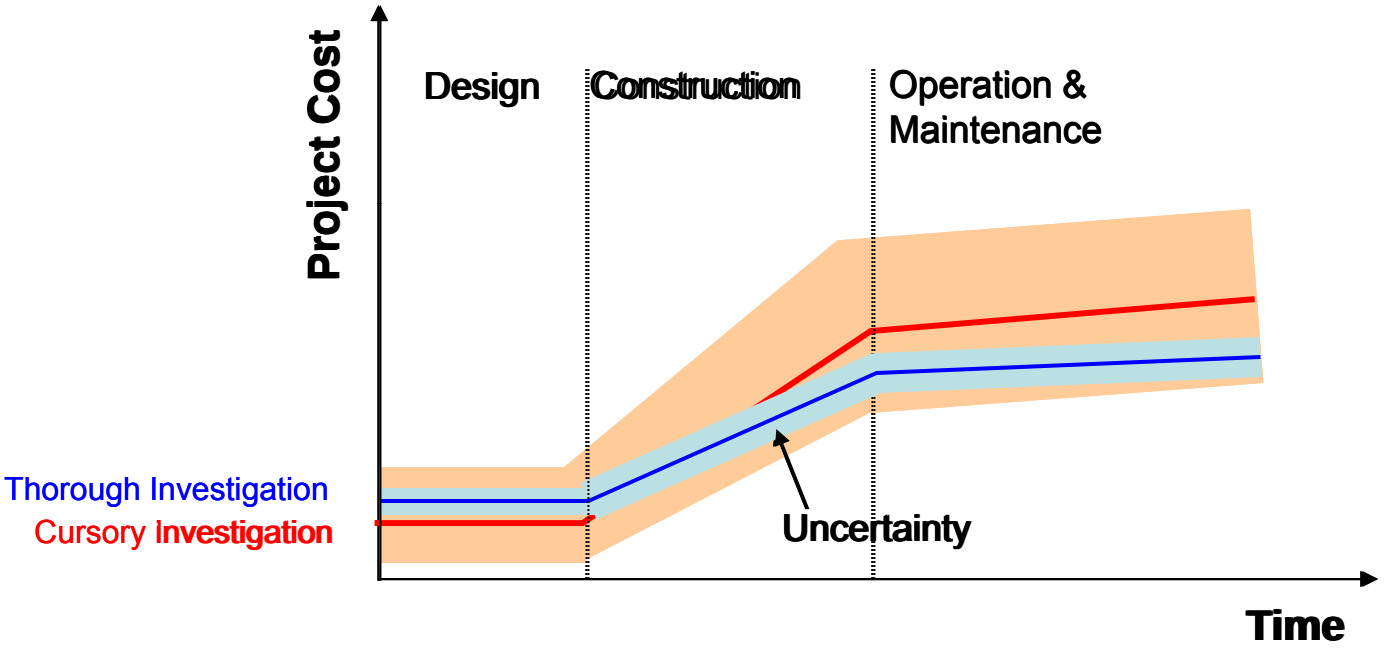
"It's unacceptable; able," Councilman Bar said when informed of a reporter after the mee

"The consultants oug that. ... We keep getting beat up and beat up by th he added.

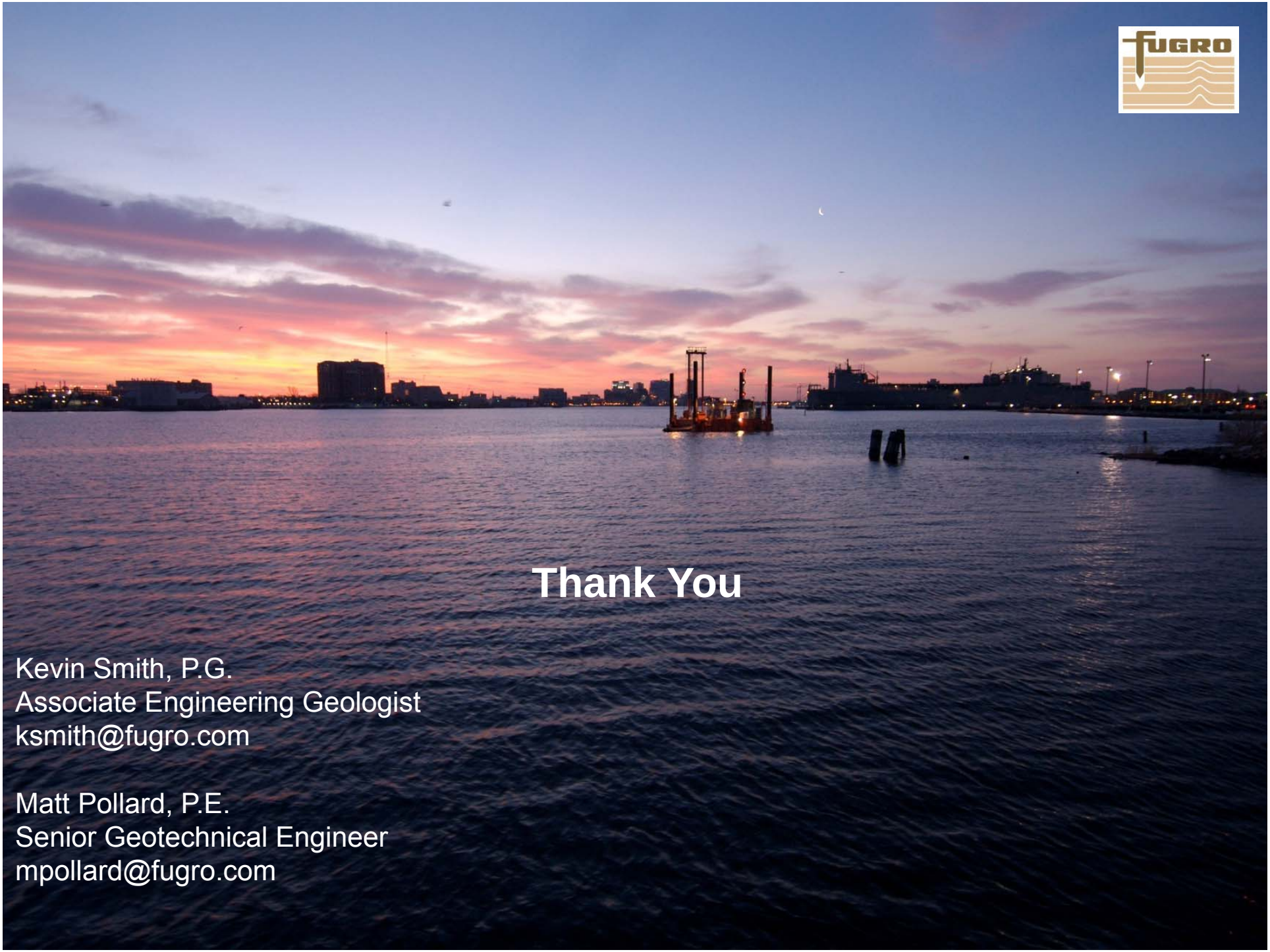
See PILINGS, PAGE 11

What is the Value of Site Investigation?

- When to perform site investigation?
- How much investigation required?



Early Detailed Site Investigation → Reduce Uncertainty → Reduce Risk → Reduce Cost Overrun



Thank You

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