The Elizabeth River Tunnels Project

The Virginia Concrete Conference
Richmond, VA • March 5, 2015

Elizabeth River Tunnels

Presentation Agenda

- ERT Project Overview & Update

  - Daniel Francis, SKW Constructors

- Concrete Challenges

  - John Gajda, CTL Group

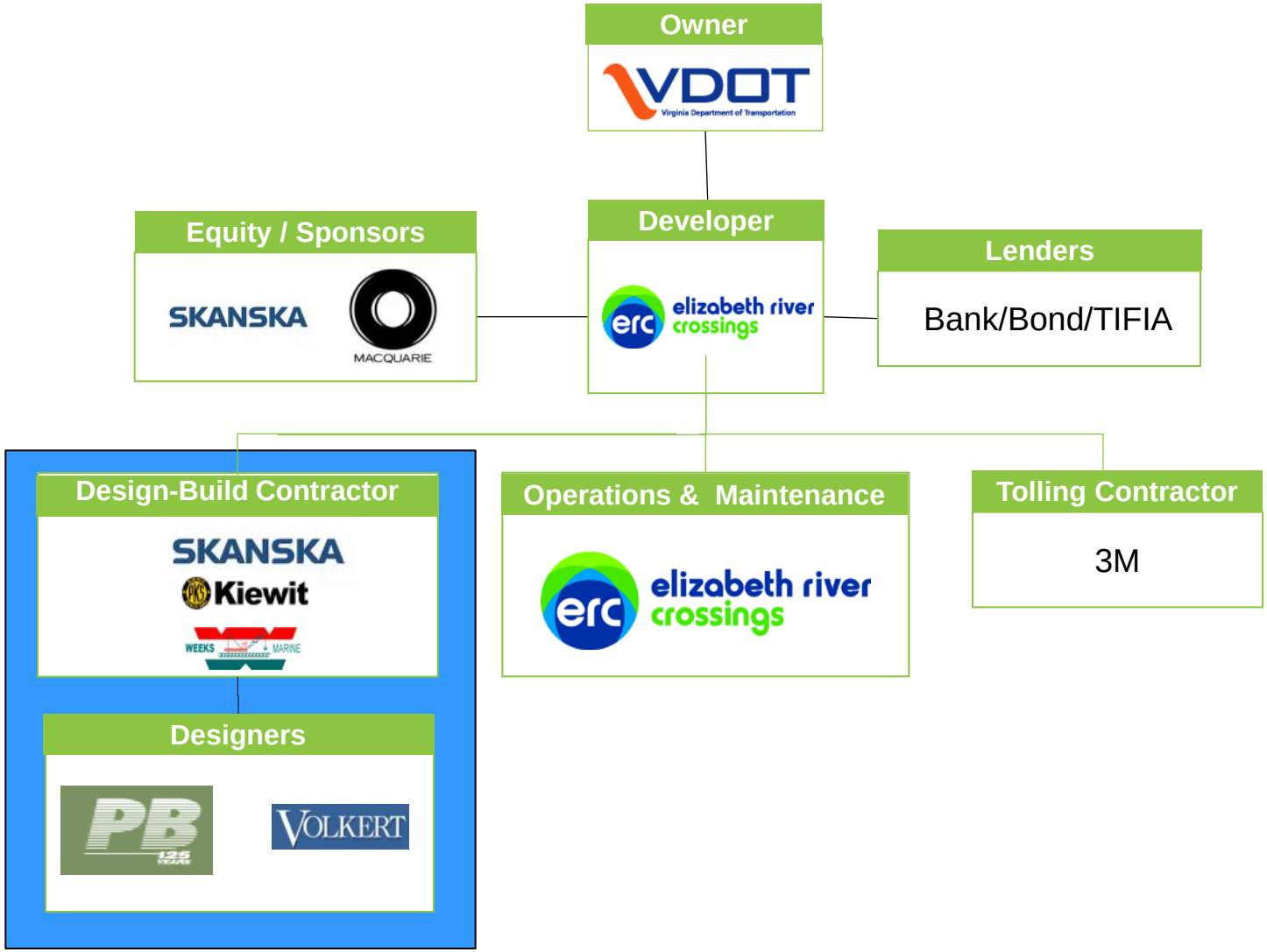
- Questions

Project Overview & Update

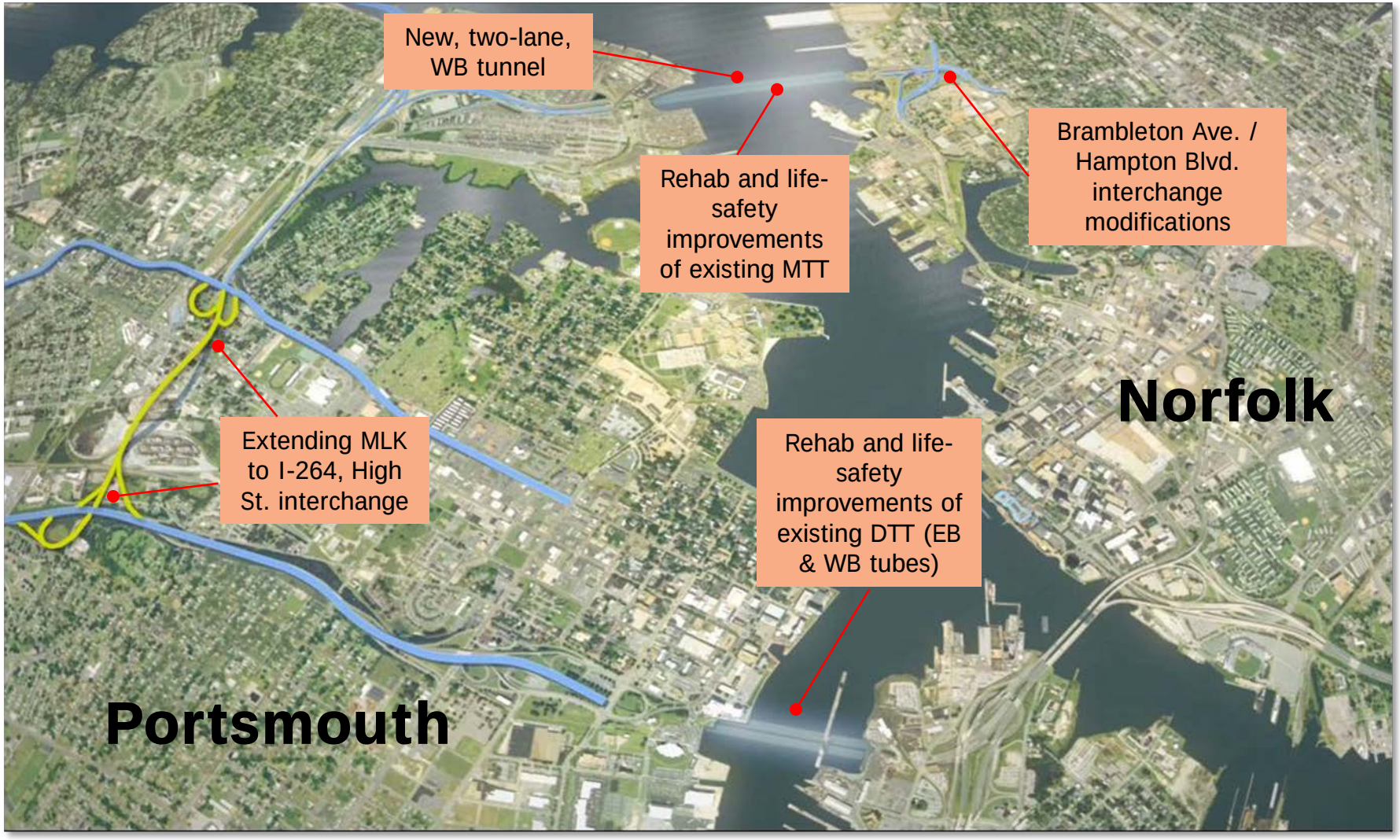
Daniel Francis, SKW Constructors

Elizabeth River Tunnels

ERT Project Team



ERT Project Scope



ERT Project Schedule

Project	Completion Date
Refurbishment of Existing Downtown Tunnels	• August 2016
New MLK Freeway Extension	• December 2016
New Midtown Tunnel	• December 2016
Refurbishment of Existing Midtown Tunnel	• May 2018

ERT Project Component 1:

Existing Tunnel Rehabilitation

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Tunnel Rehabilitation Project Scope

Rehabilitation Projects

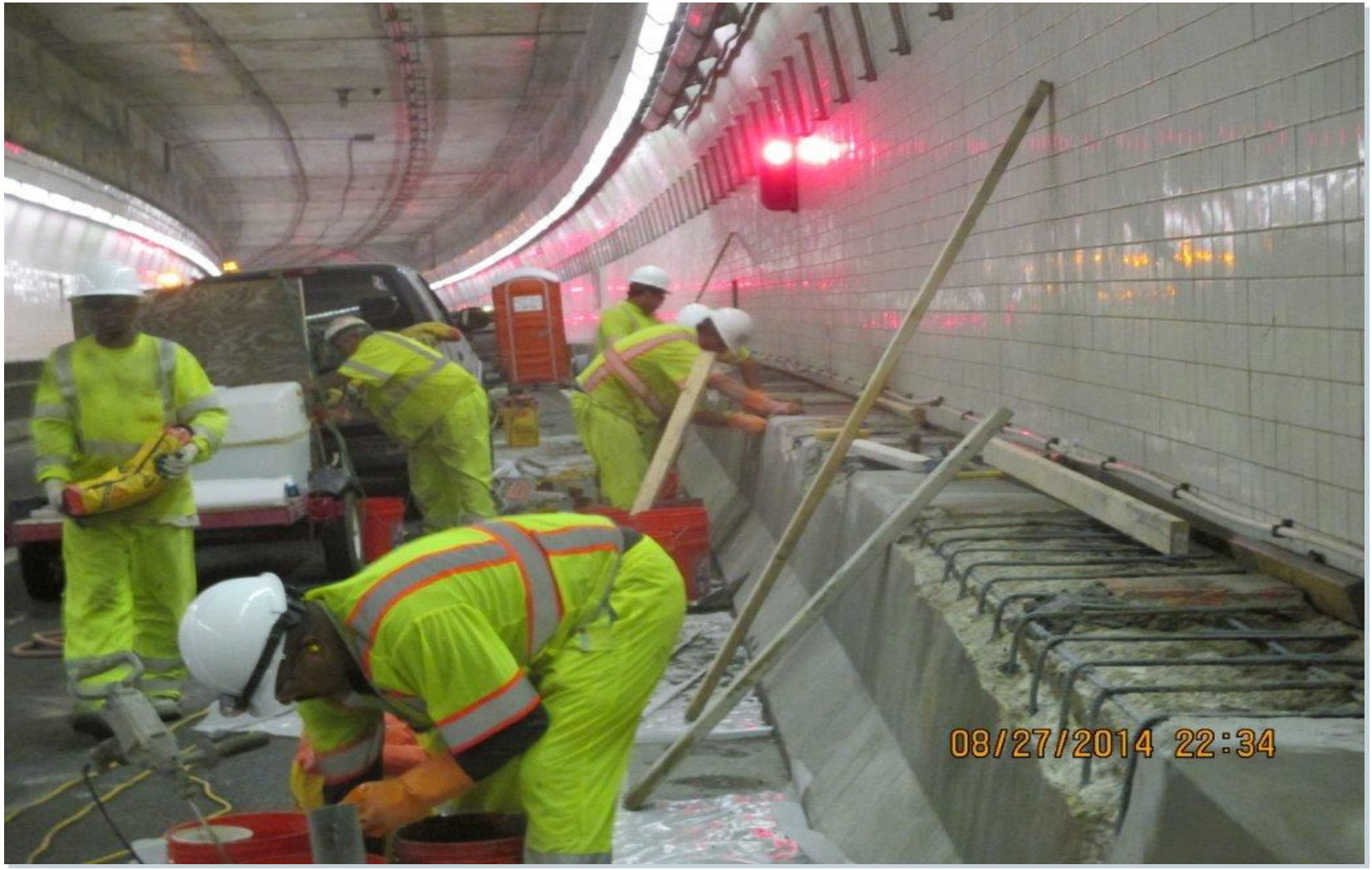
- Existing WB Downtown Tunnel
- Existing EB Downtown Tunnel
- Existing (EB) Midtown Tunnel

Rehabilitation Activities

- Removal of suspended ceilings
- Replace existing transverse with longitudinal ventilation
- Fire-life safety upgrades to 100 mega watt
- Concrete repairs (spalls and cracks)
- Electrical rehabilitation and upgrades
- Misc. signage, painting and repairs

DTT Rehabilitation: Ceiling Removal

DTT Rehabilitation: Barrier Repair



DTT Rehabilitation

Fire Protection & Structural Repairs

DTT-WB Lighting Before

DTT-WB Lighting and After

ERT Project Component 2:

MLK Freeway Extension

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MLK Freeway Extension

elizabeth river crossings
VDOT Virginia Department of Transportation
SKW CONSTRUCTORS A SKANSKA, KIEWIT, WEEKS JV
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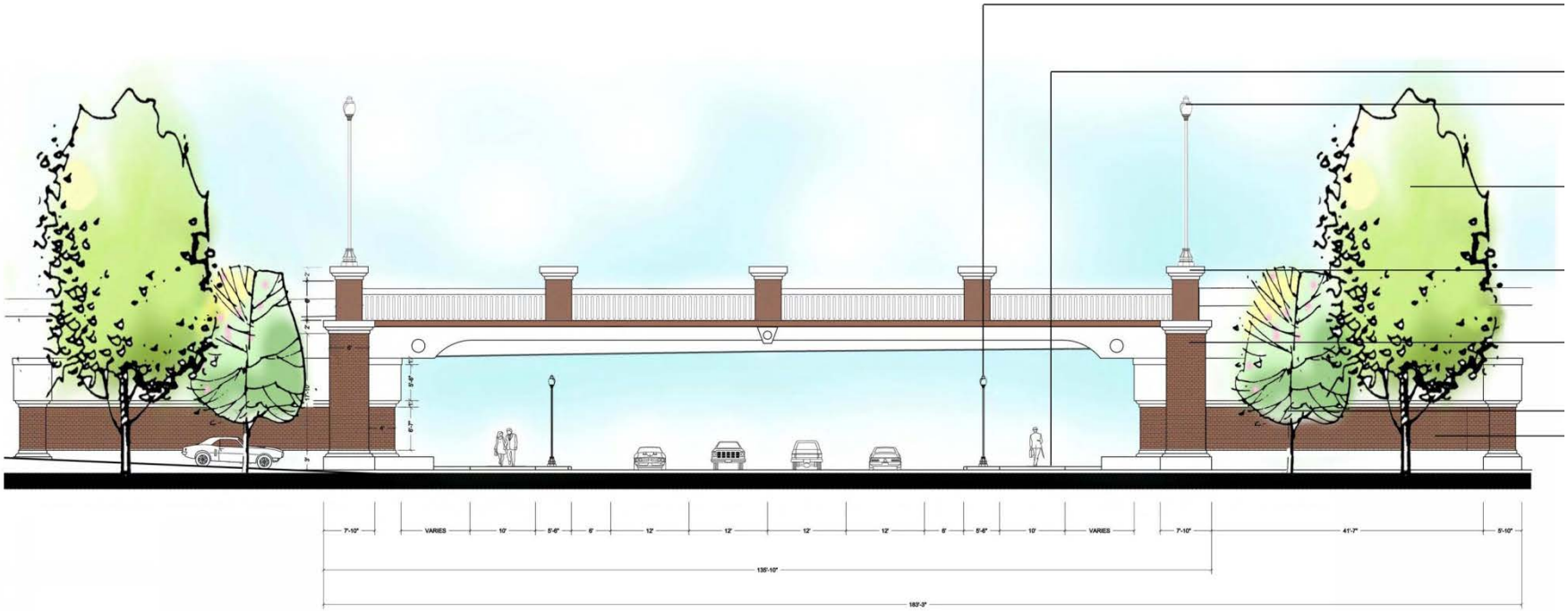
MLK Extension: Pile Driving

MLK Extension: Ped Bridge Cap Pour

MLK Extension: Structural Steel Erection

MLK Extension: Aesthetic Treatments

- MLK over High St.



ERT Project Component 3:

New MTT Approaches

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New MTT: Portsmouth Approach

New MTT: Portsmouth Approach

New MTT: Norfolk Approach

New MTT: Norfolk Approach

Concrete Challenges

John Gajda, CTL Group

elizabeth river crossings

VDOT Virginia Department of Transportation

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Concrete Challenges

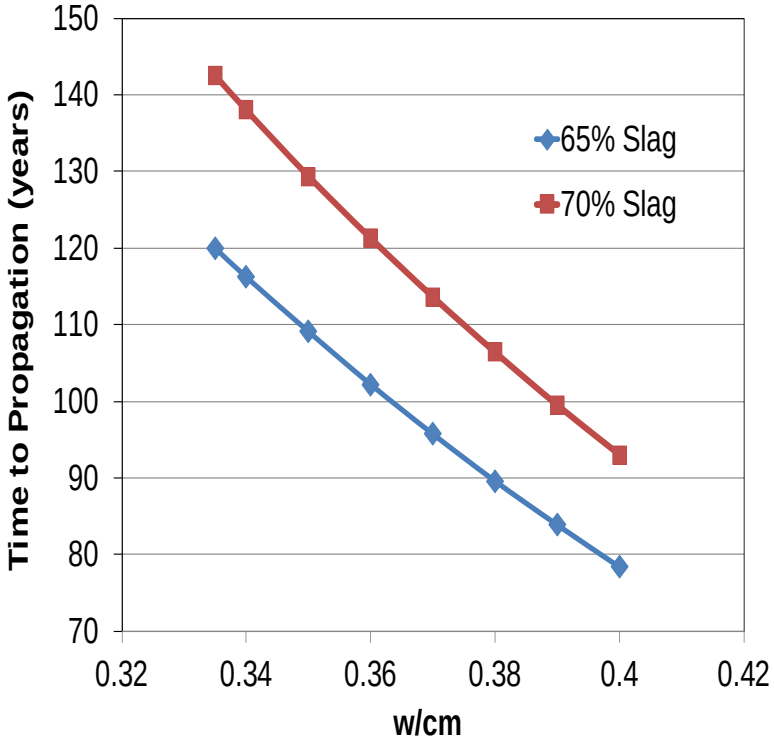
- 120 Year Service Life
- Available Materials
- Flowable Concrete
- 6000 psi at 28 Days
- Unit Weight Limit

120 Year Service Life Requirement

- **Environment**
  - Corrosive
  - Brackish Water, Airborne Chlorides, and Deicer Salts
- **Coatings/Protection**
  - Exterior and Interior
  - Not Allowed to Consider in Service Life Analyses
- **Future Cathodic Protection**
  - Couldn’t use Corrosion Inhibitors
- **Design Constraints**
  - Black Rebar and Cover
- **Concrete**

120 Year Service Life (cont.)

- **Models Drive Concrete Towards**
  - Corrosion Inhibitor
  - Silica Fume
  - Low w/cm
  - High SCMs
- **Also Important**
  - Low Paste Content
  - Cracking



Available Materials

- **Cementitious Materials**
  - Fly Ash Shortage?!?
  - Slag Cement Produced Onsite
- **Natural Sand**
- **Limestone Coarse Aggregate**
  - Dolomitic Marble
  - High Thermal Expansion
  - Dirty (High Fines Content)

Concrete Mix Development

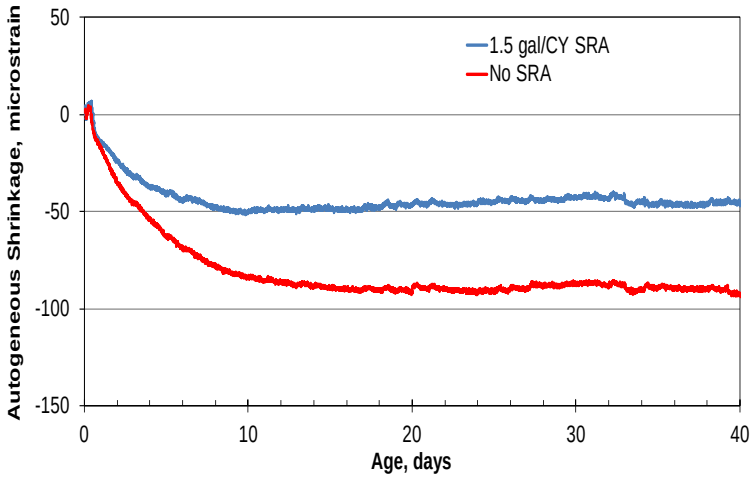
- **>100 Trial Batches by Lafarge for Final Mix**
- **Optimized Aggregate Blend**
- **Cementitious**
  - 65% Grade 120+ Slag Cement
  - 35% Type I/II Portland Cement
- **Low Water Content**
- **Shrinkage Reducing Admixture**

Concrete Testing

- **Mechanical**
  - Compressive Strength
  - Tensile Strength
  - Elastic Modulus
- **Durability**
  - STADIUM
  - Rapid Chloride (C1202)
  - Air Content
- **Thermal**
  - Adiabatic Temperature Rise
  - Thermal Expansion
- **Shrinkage**
  - Restrained Ring (C1581)
  - Autogenous
  - Drying (C157)
- **Other**
  - Unit Weight
  - Segregation Potential

Concrete Properties

- **Excellent Permeability**
  (~200 Coulombs after Accelerated Curing)
- **Good Compressive Strength**
  (2000 psi at 2 days, 9000 psi at 28 days)
- **Reasonably Low ATR**
  (~80°F at 7 days)

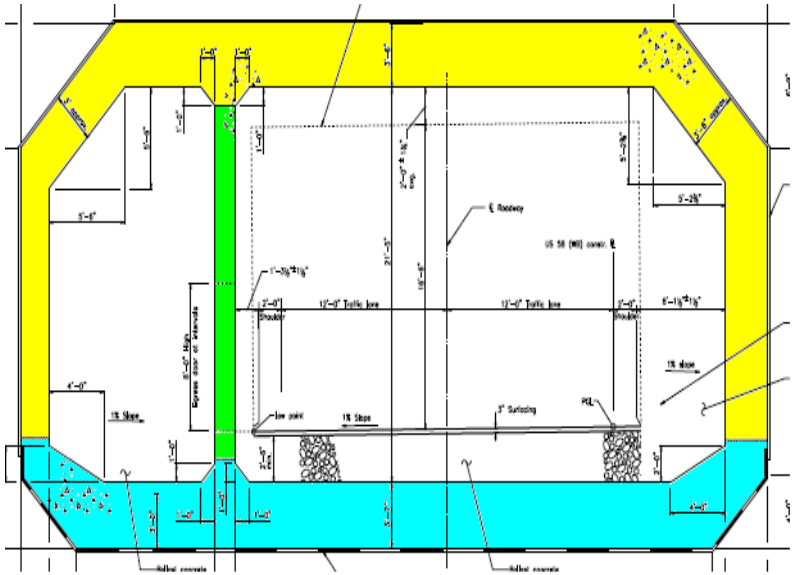


but ...

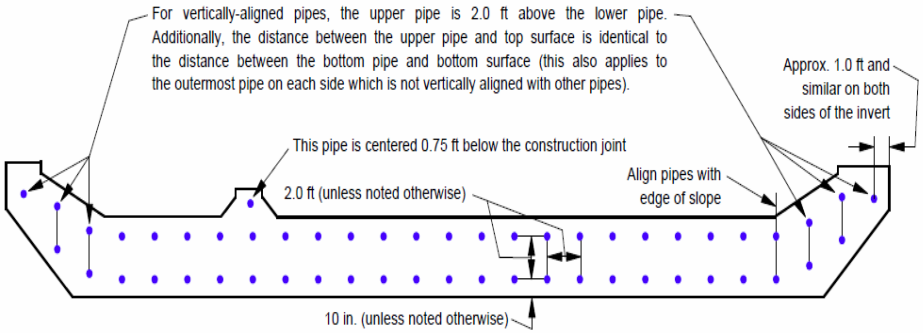
- **Increased Expansion Tendency**
  - High Elastic Modulus
  - Lower Tensile Strength (~9% of the comp. str.)
  - High CTE (6.1 microstrain per °F)
  - Autogenous Shrinkage (~90 microstrain w/o SRA)

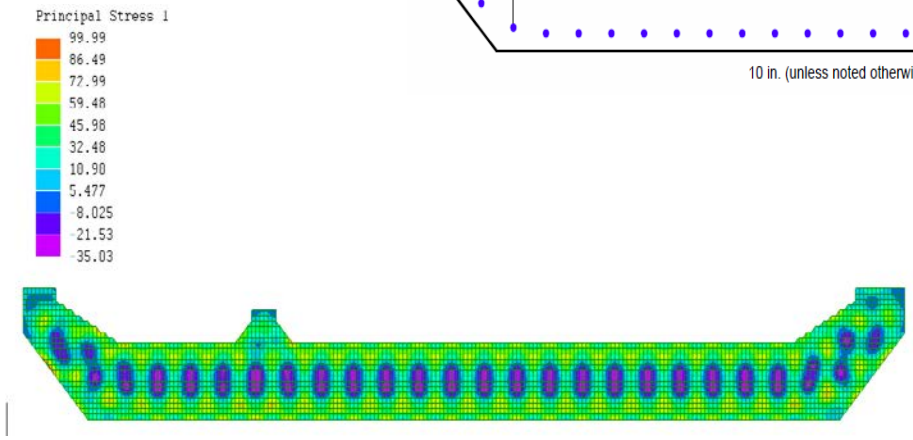
Thermal Control at First Glance …

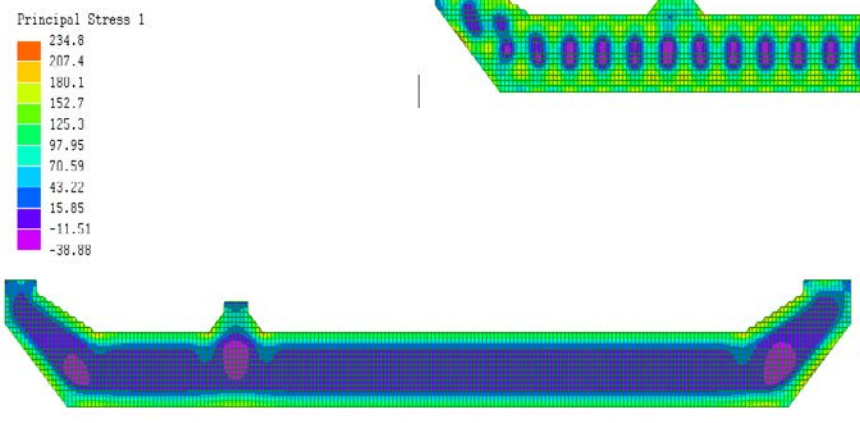
- **Address Cracking Concerns**
  - Keep the Temperature Difference from Exceeding 35°F
  - Ensure Similar Temperatures throughout the Entire Placement
  - Insulate
- **Address DEF Concerns**
  - Keep Concrete from Exceeding 160°F
  - ~80°F ATR means max. 80°F concrete temperature at placement



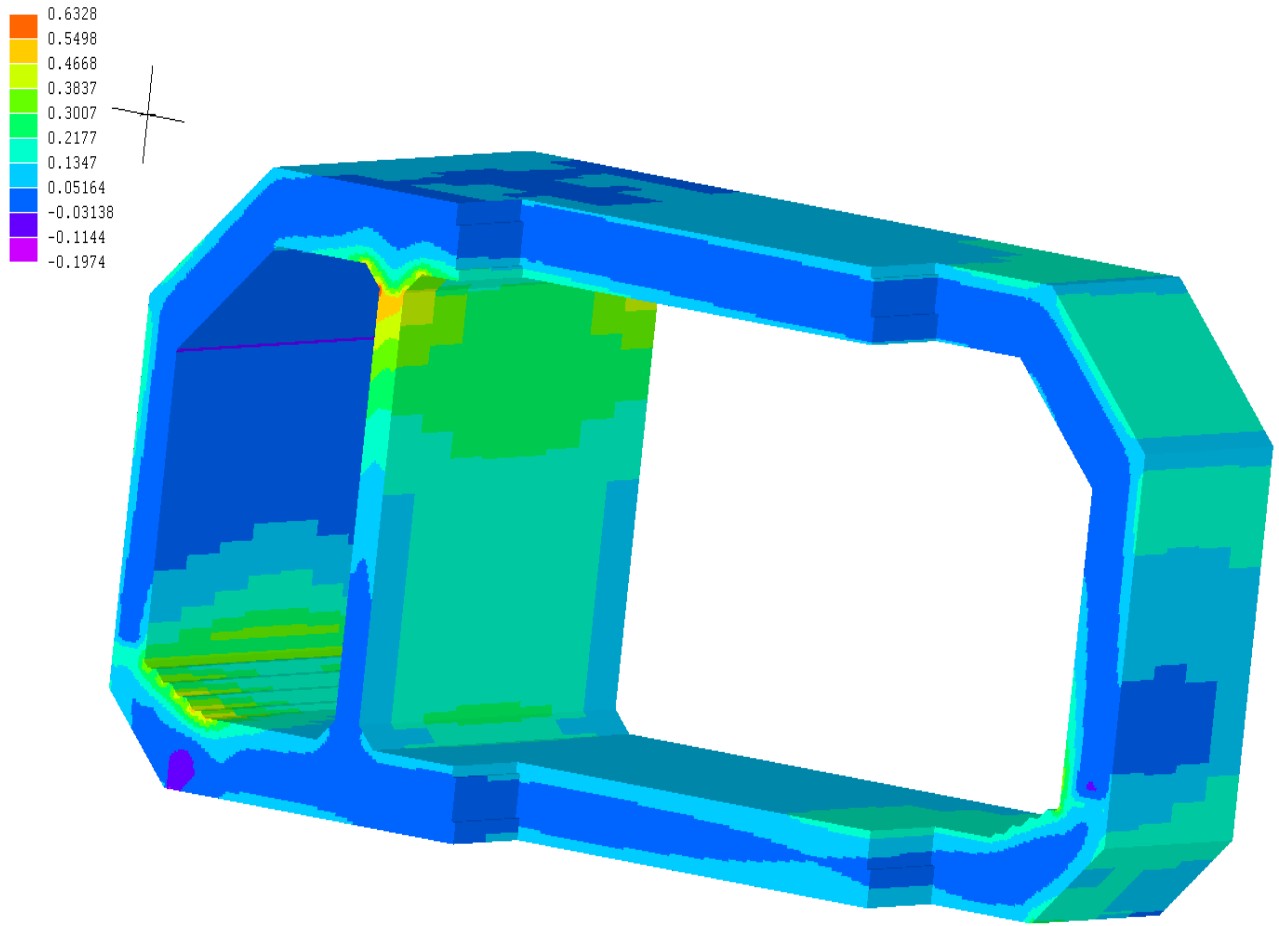
Thermal Modeling of Temperature and Stress

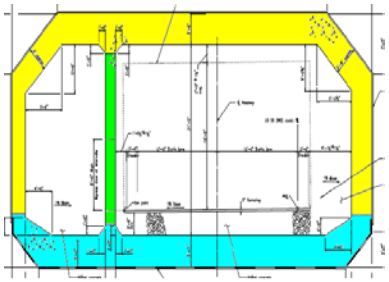






Differential Thermal Movement





Address Differential Thermal Movement

- **Concrete Mix**
  - SRA to Reduce Autogenous Shrinkage
  - Other changes Reduce the Service Life and/or Placeability
- **Concrete**
  - Precool to Reduce Max. Temperature
  - Curing Compound to Reduce Drying Shrinkage
- **Cooling Pipes**
  - Reduce Temperature Rise of Concrete
- **Heat Existing Concrete**
  - Pre-Expand to Reduce Stresses
  - New and Existing Cool at same Rate

Addressing Restraint and Differential Thermal Movement was a Major Challenge!

ERT Project Component 4:

New Midtown Tunnel

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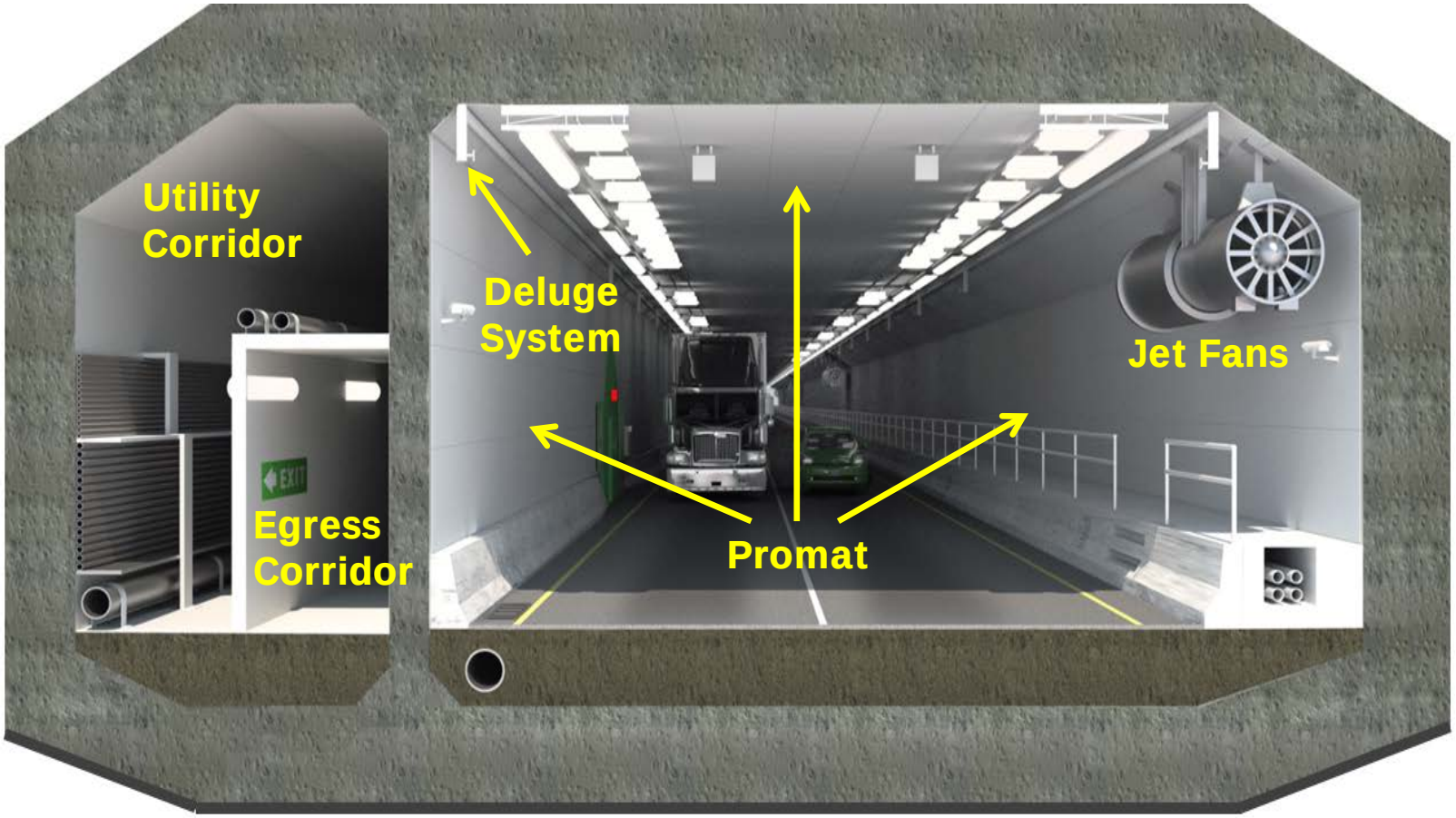
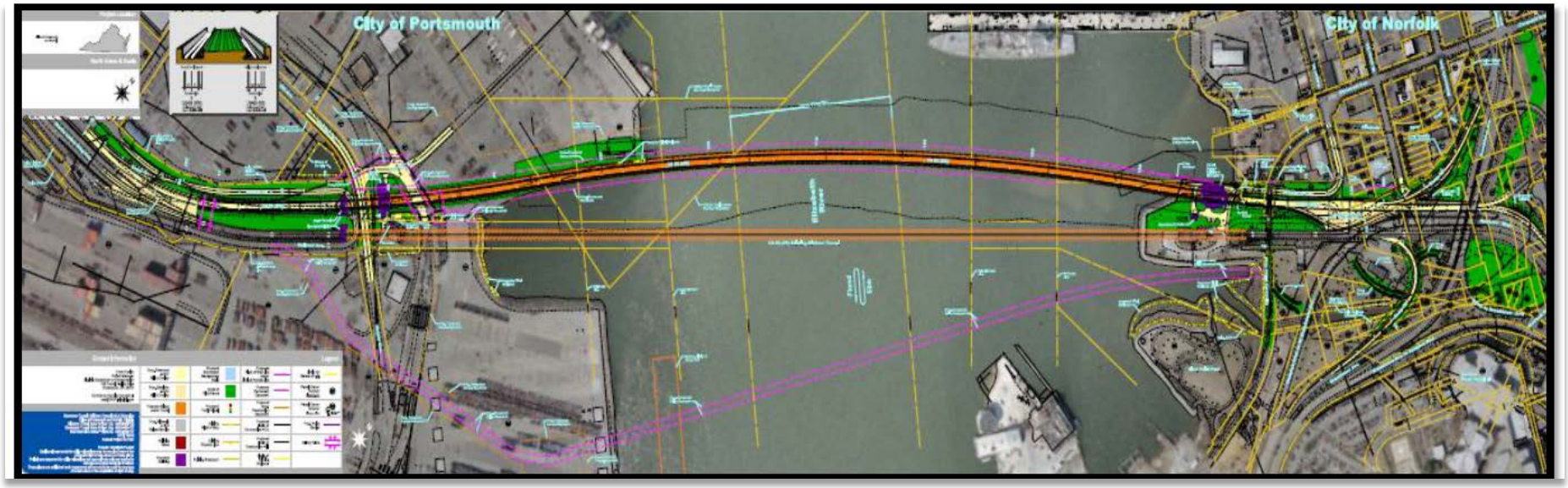
New MTT: Final Concept

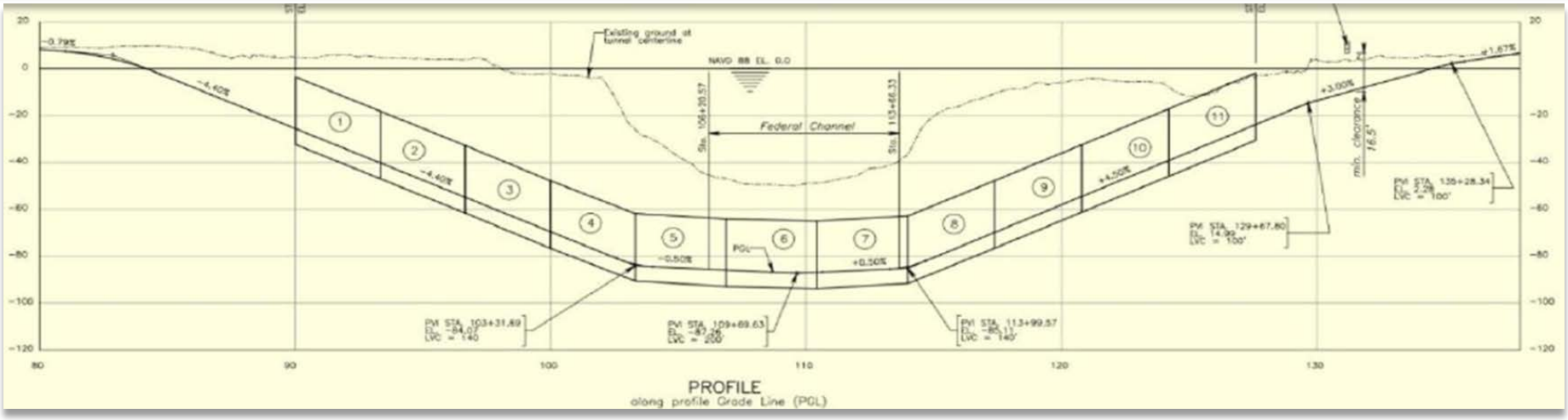
- Concrete shell, Immerse Tube Tunnel (ITT)
- Westbound tube connecting Norfolk to Portsmouth
- Two vehicular lanes and an egress corridor



New MTT: Offset Alignment

New MTT: Plan & Profile





New MTT: Tunnel Element Fabrication

(1 min. time lapse video)

New MTT: Tunnel Element Fabrication

New MTT: Floating Tubes

New MTT: Float Out of Litter 1

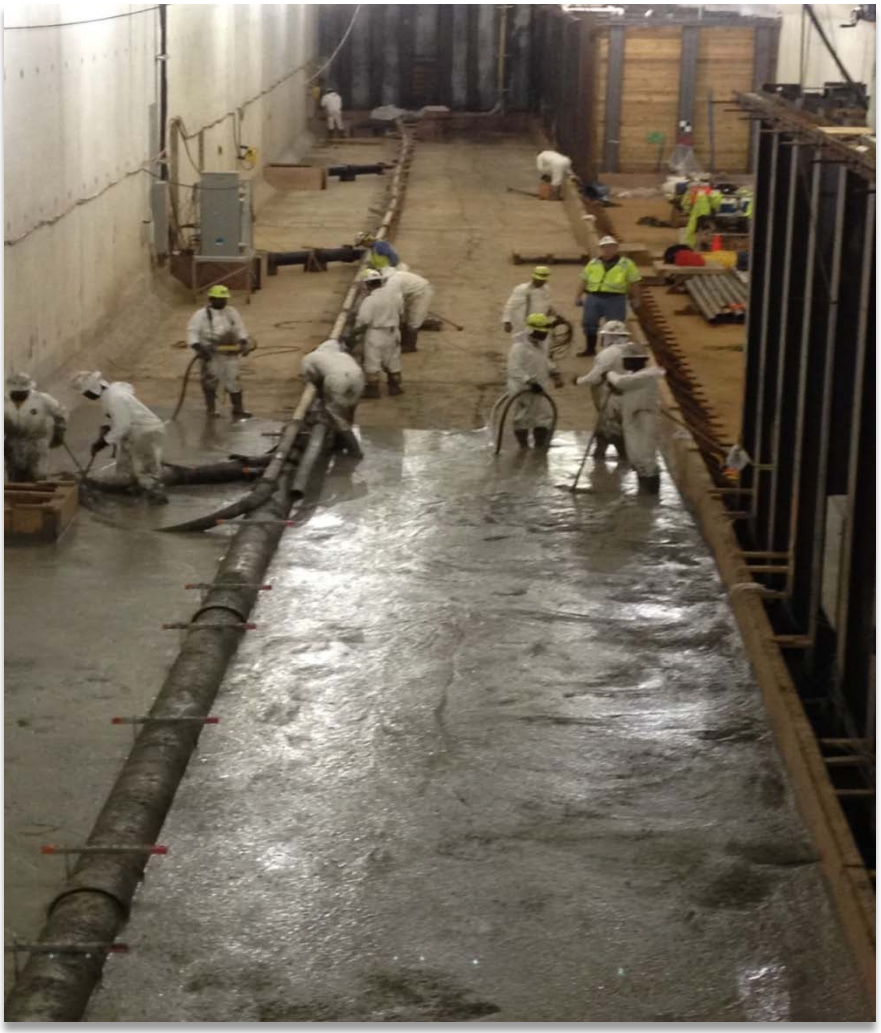
(1 min. time lapse video)

New MTT: Element Tow Down

New MTT: Element Tow Down

New MTT: Elements Moored in Portsmouth

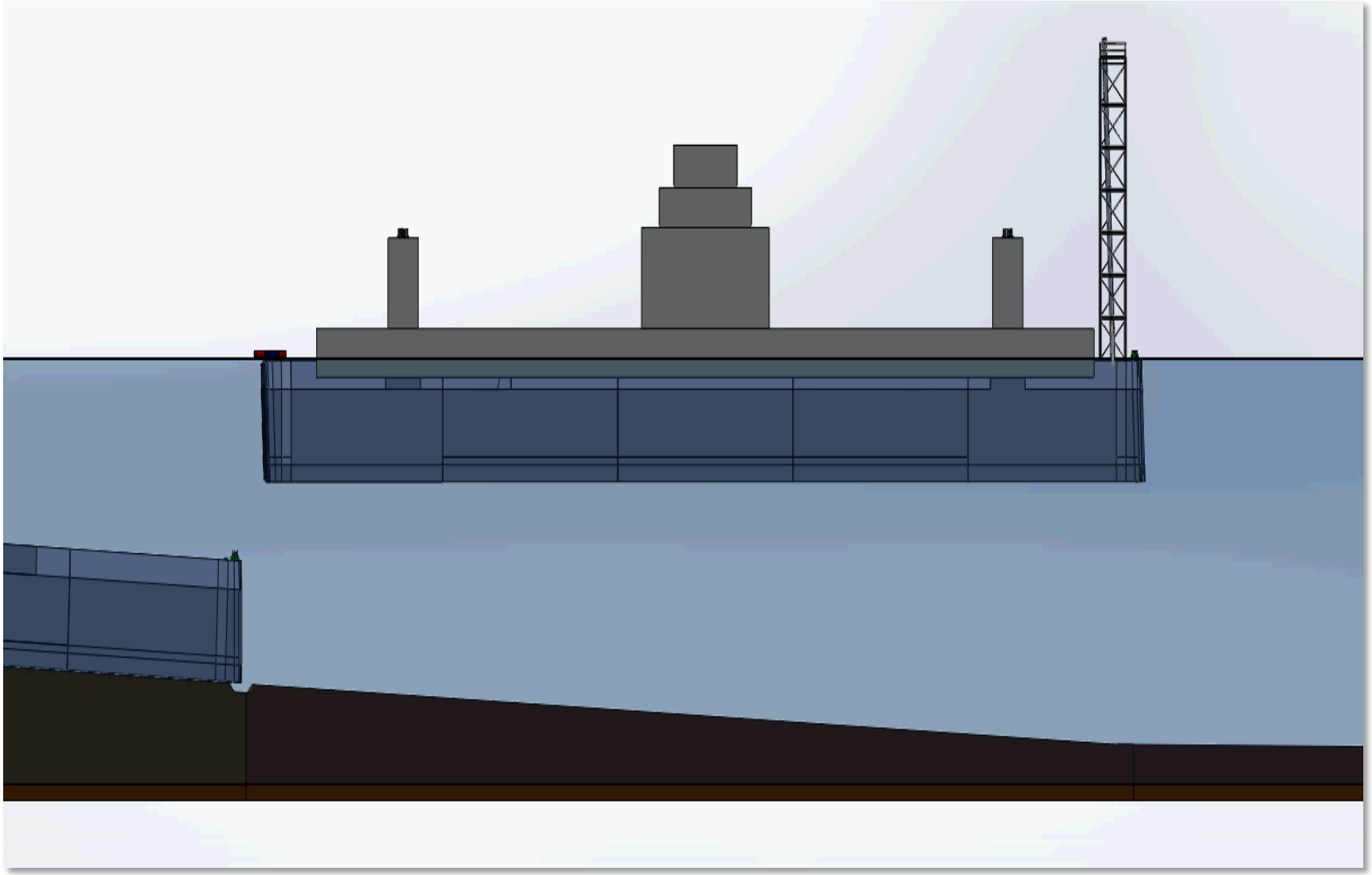
New MTT: Ballast Concrete Placement



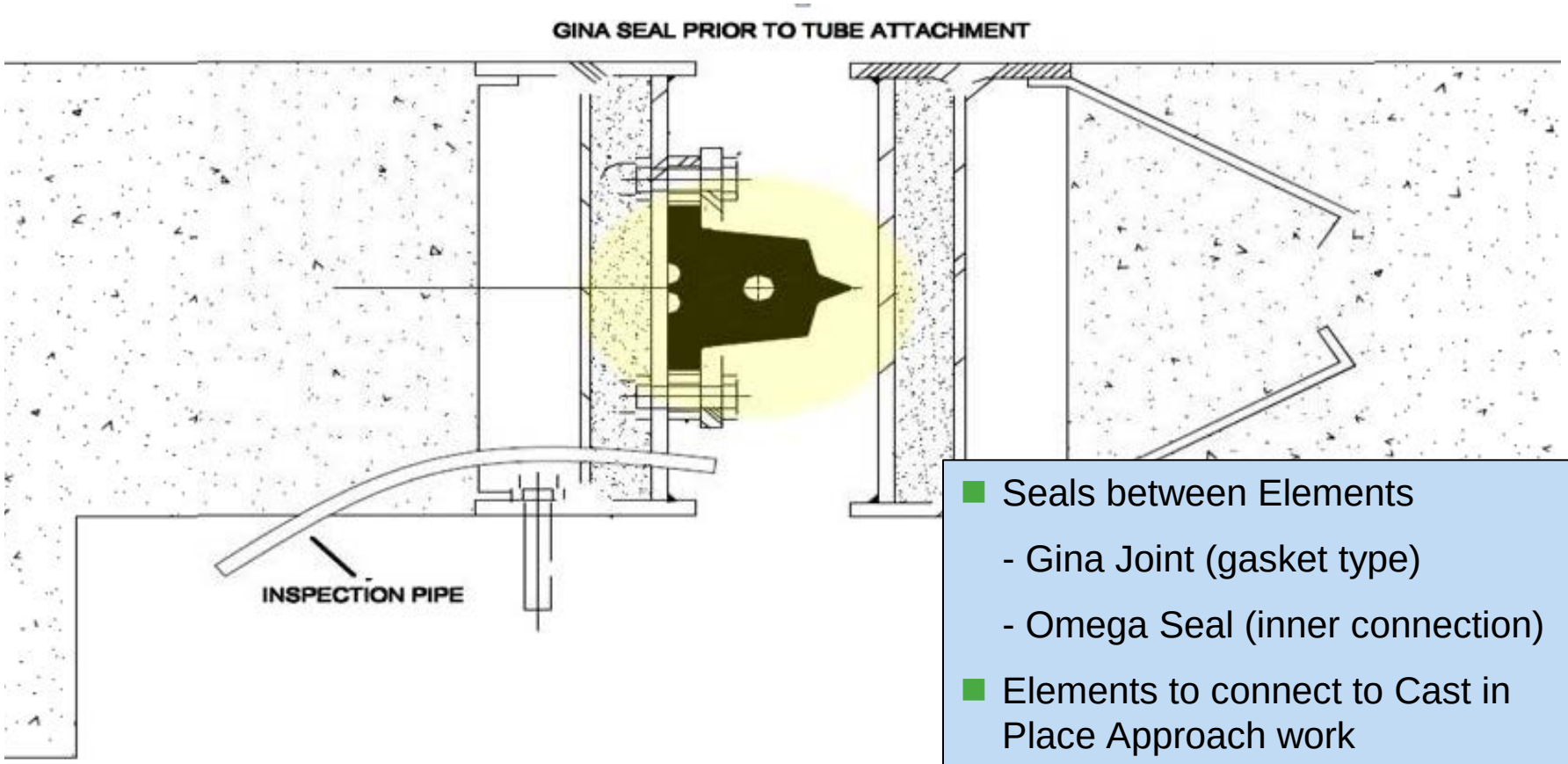
New MTT: Screed Barge

New MTT: Lay Barge

New MTT: Element Immersion

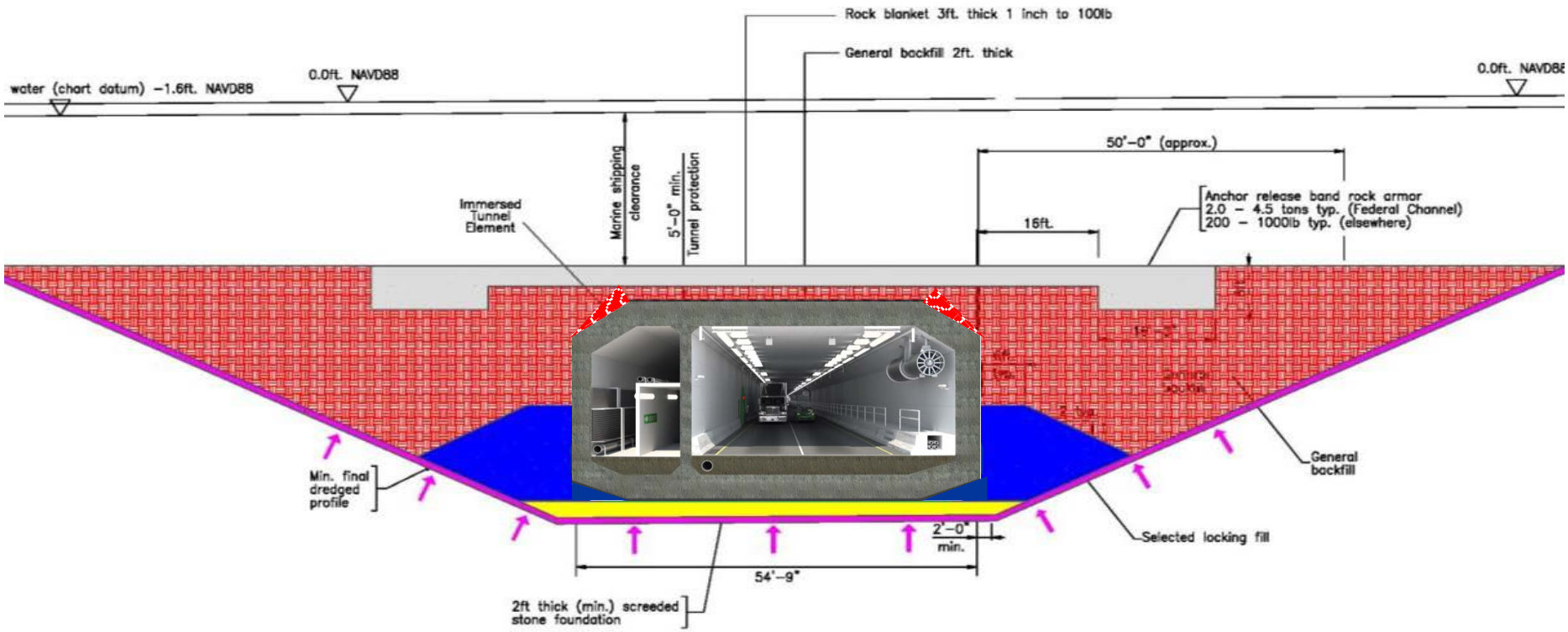


New MTT: Element Seals



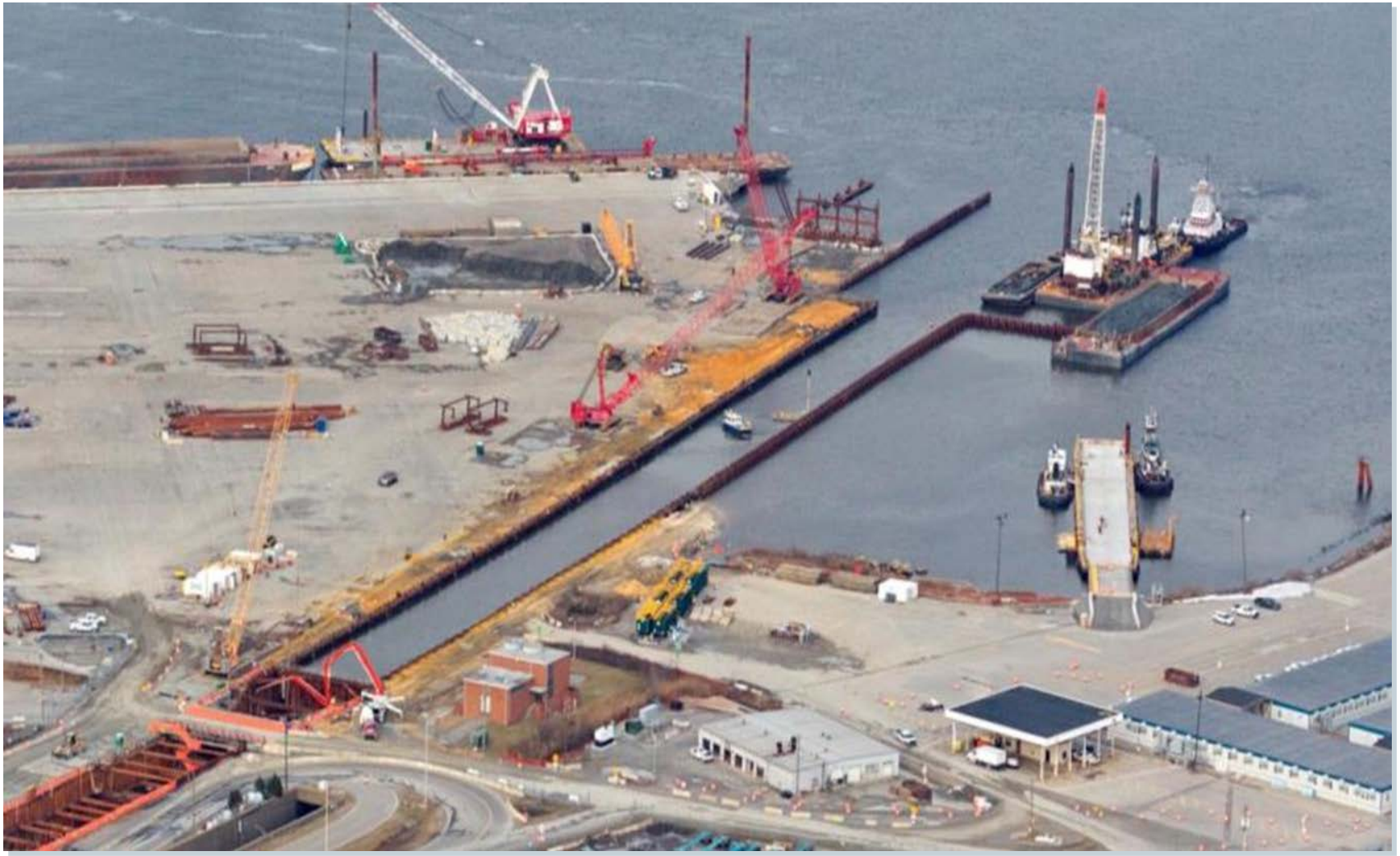
- Seals between Elements
  - Gina Joint (gasket type)
  - Omega Seal (inner connection)
- Elements to connect to Cast in Place Approach work

New MTT: Element Placement



TYPICAL SECTION

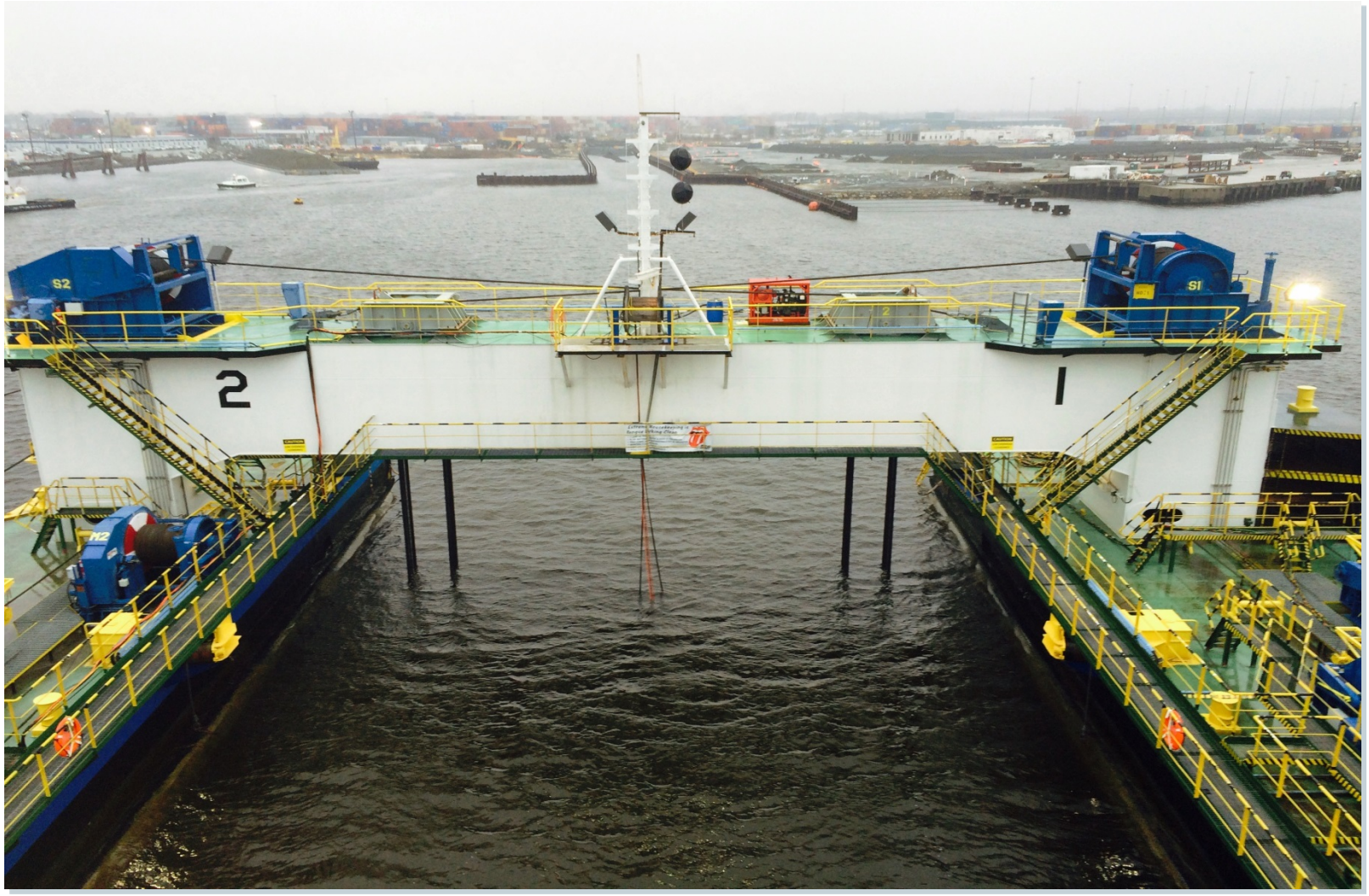
New MTT: Portsmouth Slot



New MTT: Movement of Element into Slot

New MTT: Immersion of Element in Slot

New MTT: Immersion of Element in River



New MTT: Removal of Temporary Bulkheads

Questions?

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