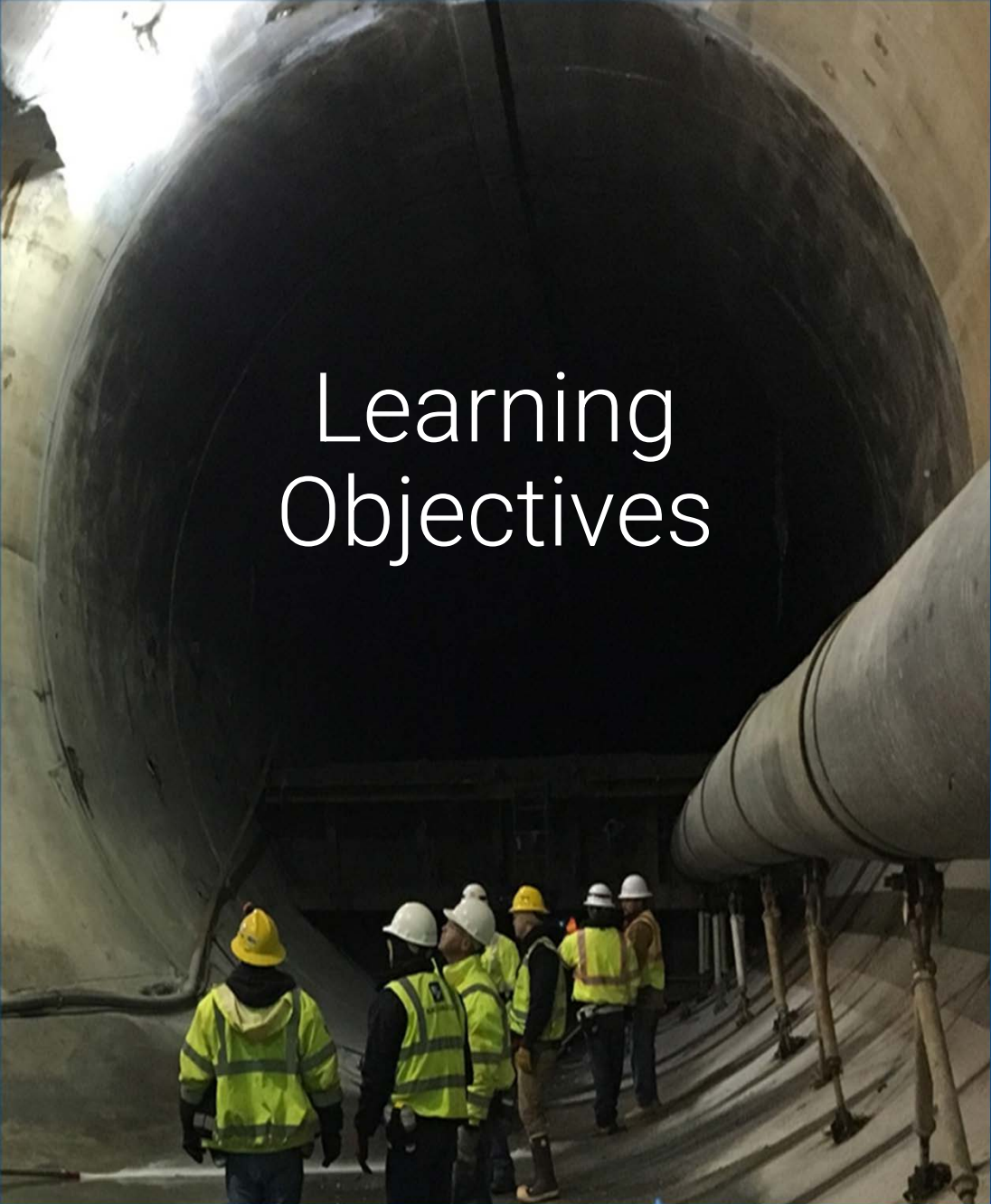


Tunnels: A Resilient Solution to Flood Control

Stephen O'Connell, P.G.



A photograph of a large tunnel under construction. In the foreground, several workers wearing yellow safety vests and hard hats are standing on a metal walkway, looking into the dark tunnel. The tunnel walls are made of large, curved concrete segments. The text "Learning Objectives" is overlaid in white on the left side of the image.

Learning Objectives

1. Learn how tunnels can be incorporated into other flood control solutions in an urban area.
2. Learn to avoid common problems and pitfalls with tunneling.
3. Gain valuable insight into coastal flood protection using tunneling.
4. Learn how to gain public support for tunneling due to decreased environmental and social impacts during construction and operation.



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Tunnels as a Flood Control Solution



Why Tunnels?

- Minimizes social and environmental impacts during construction and operation
- Avoids obstacles
- Minimizes existing utility and structure conflicts
- Multiple approaches to address the specific needs of the project
- Proven technologies across all ground types and service applications

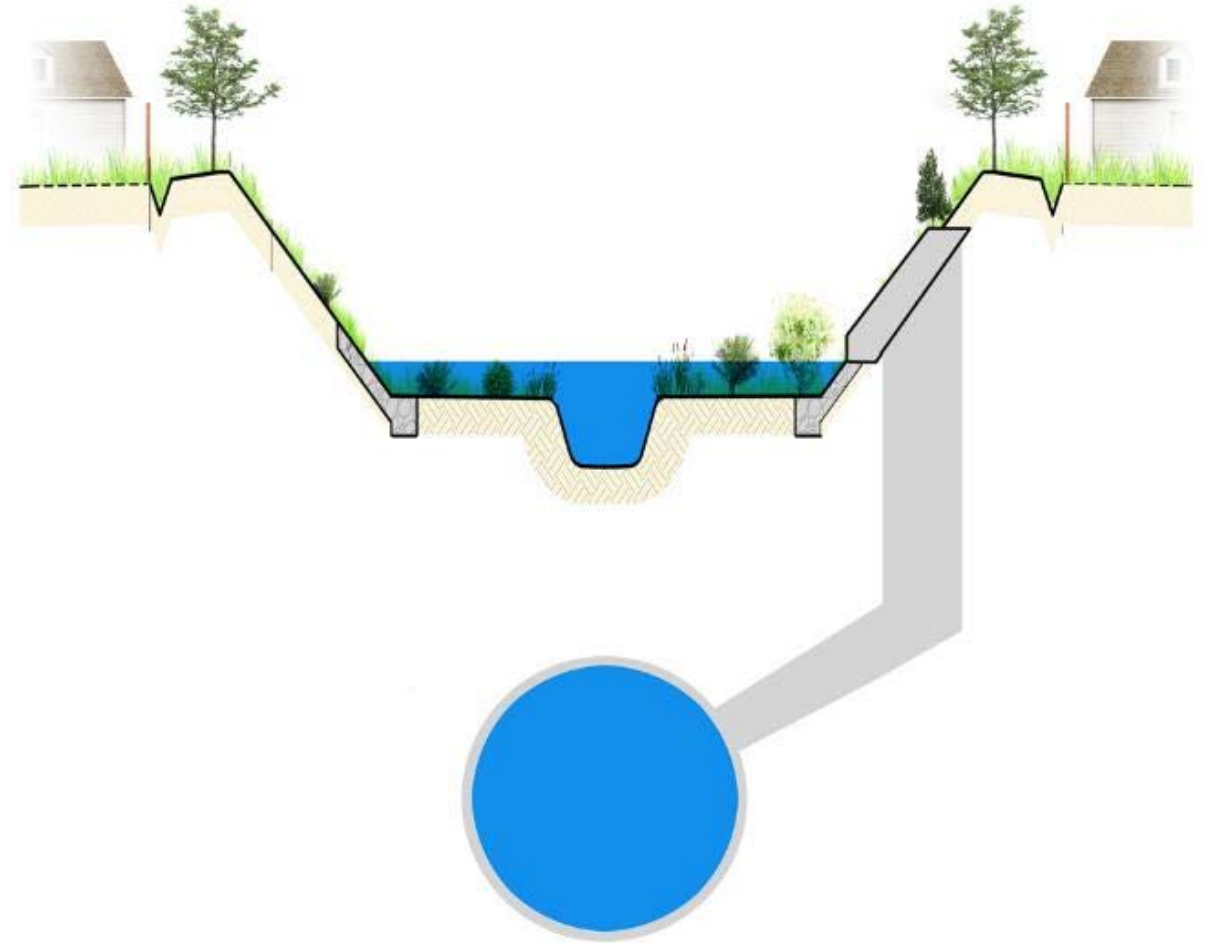
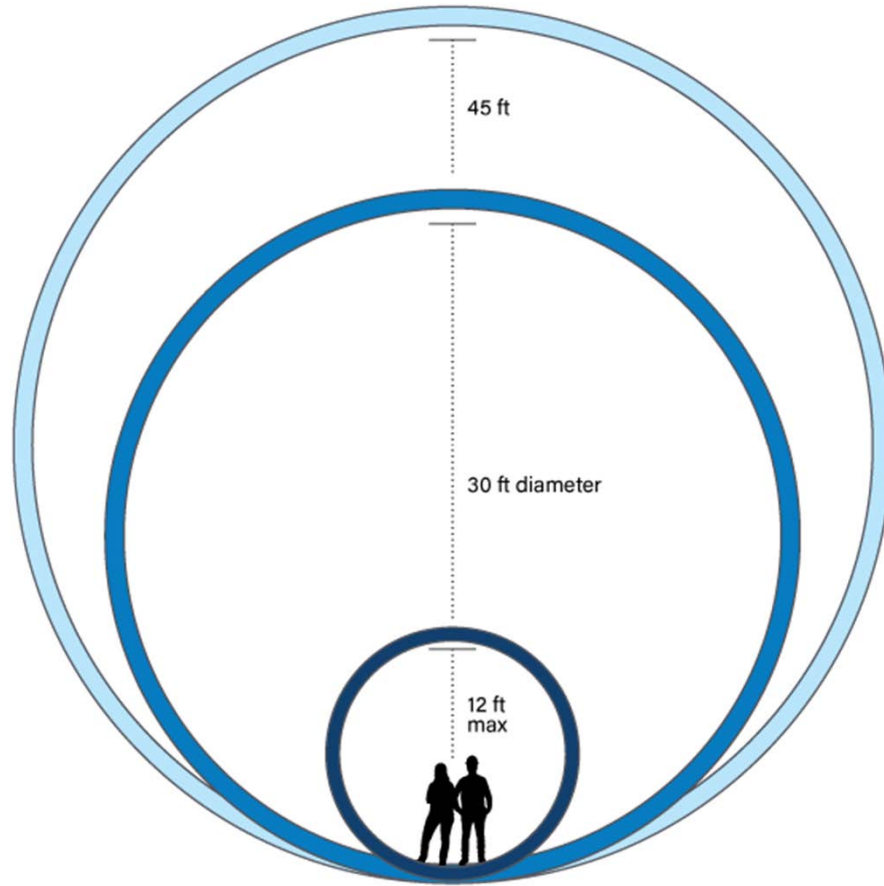


Benefits of Water Conveyance Tunnels

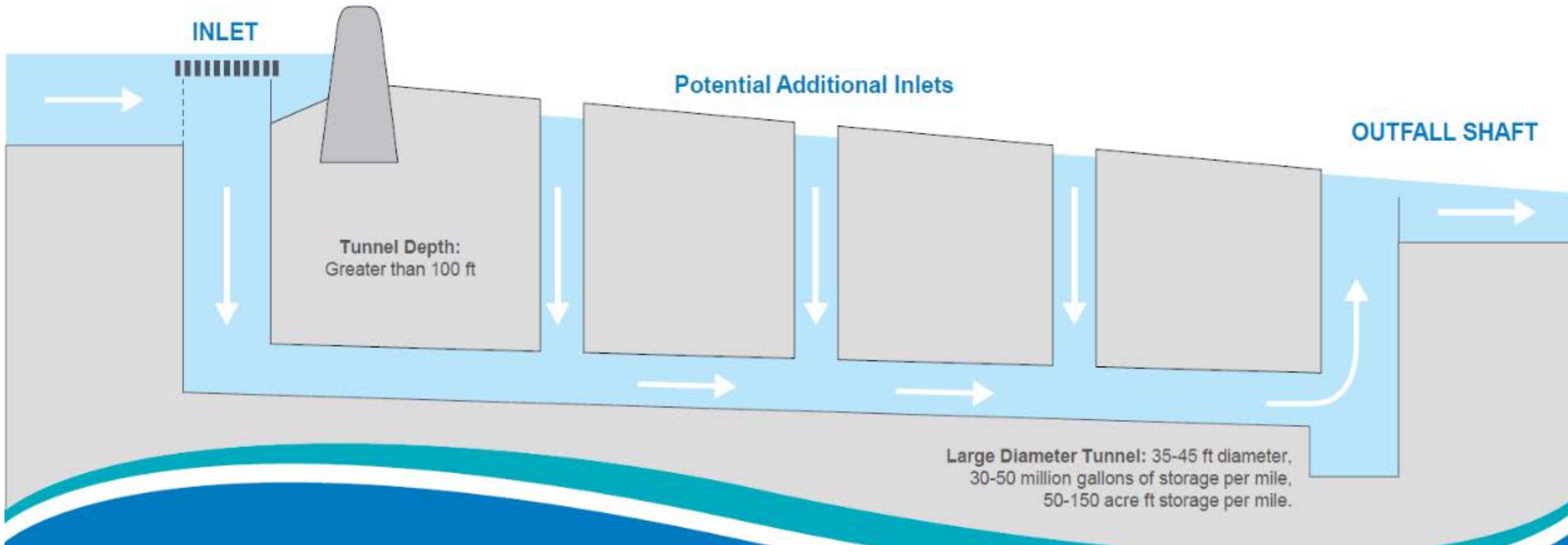
- Urban Constraints
- Mitigates Environmental Impacts
- Infrastructure Security
- Manage Challenging Stratigraphy
- Avoids Community Disruption
- Road/RR/Mass Transit Crossings
- Waterway and Major Utility Crossings



General Stormwater Tunnel Arrangement

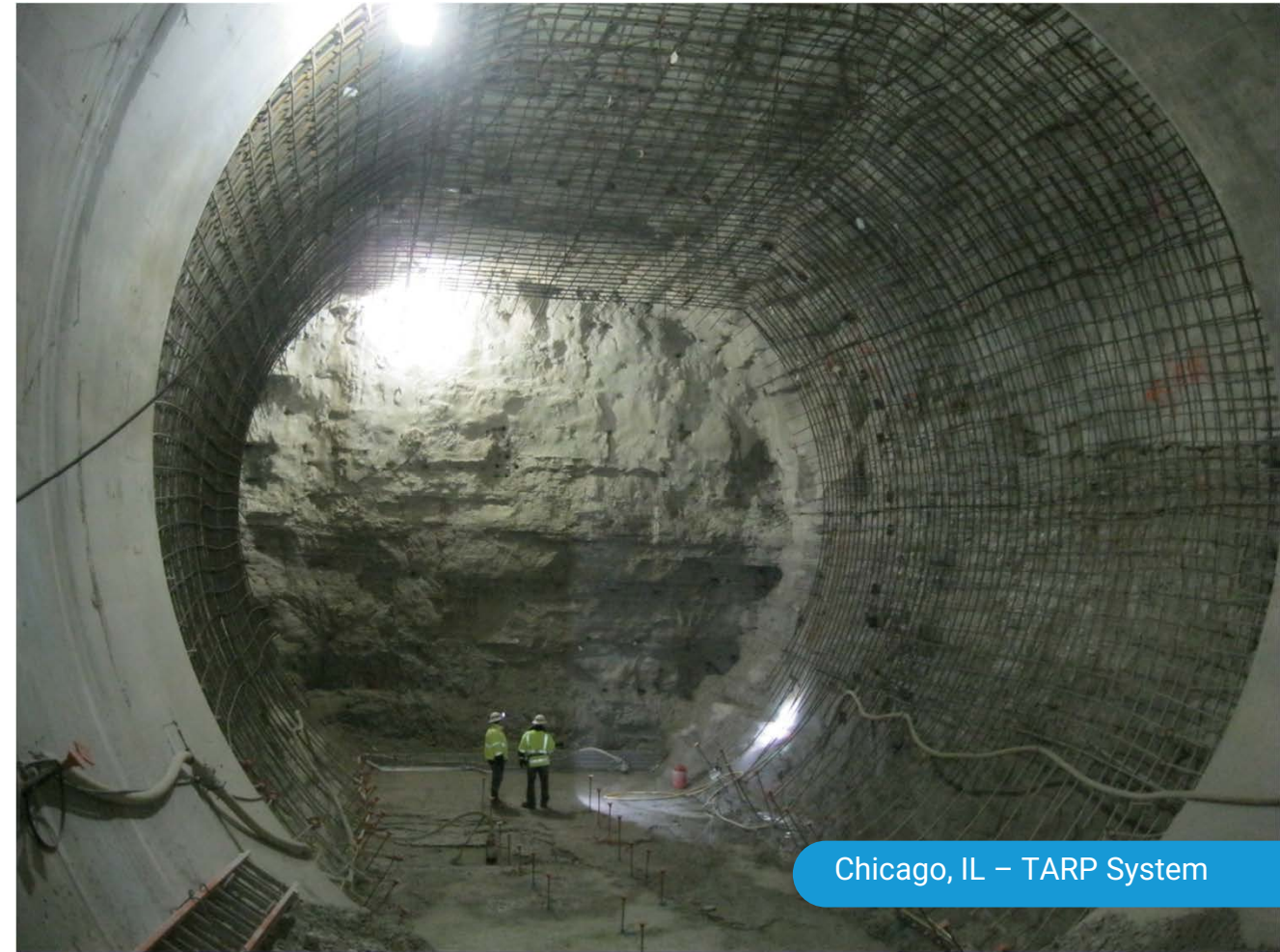


Introduction to Flood Tunnels



Typical System Components

- Diversion Structures
- Drop Shaft
- Screening Structures
- Vortex/De-aeration Chambers
- Access/Maintenance Structures
- Pump Stations
- Starter Tunnel
- Adits
- Near Surface Sewer Connections



Chicago, IL – TARP System

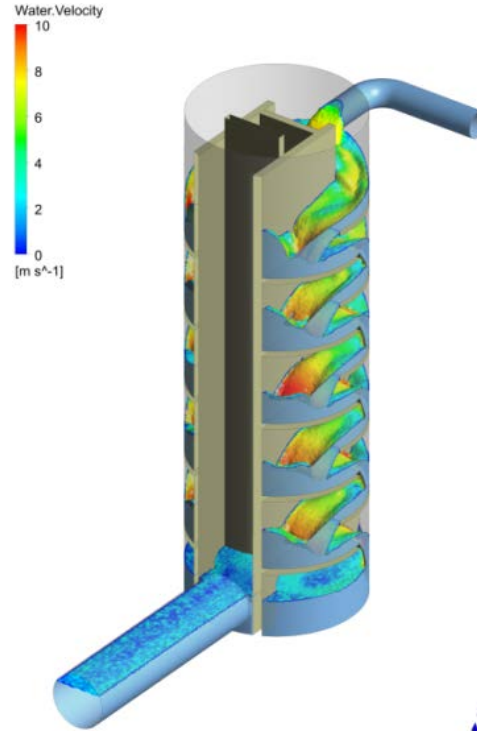
Vortex Drop

- Small diameter shaft
- Widely used design



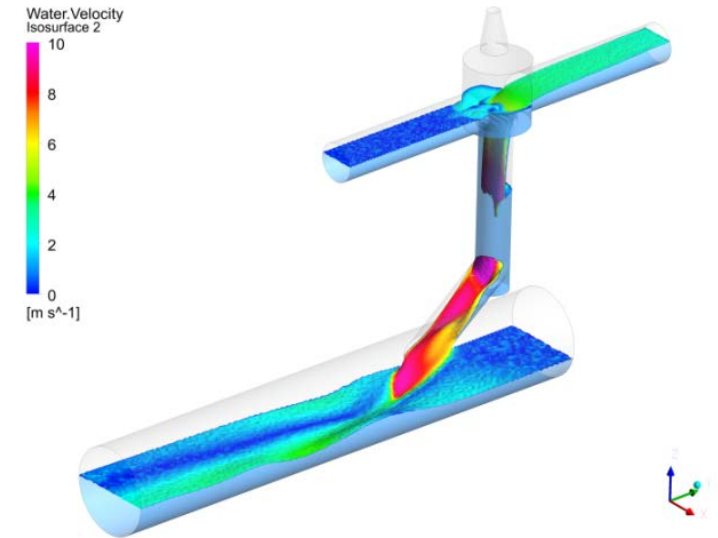
Baffle Drop

- Large diameter shaft
- No dedicated deaeration

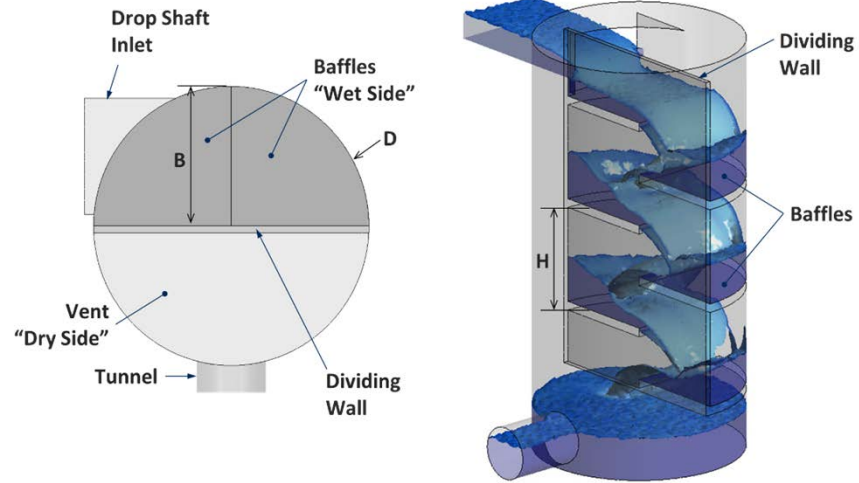


Plunge Drop

- Common for large flow
- Larger the drop, the increased potential for entrained air



Drop Shafts



Why Does Air Entrapment Matter?

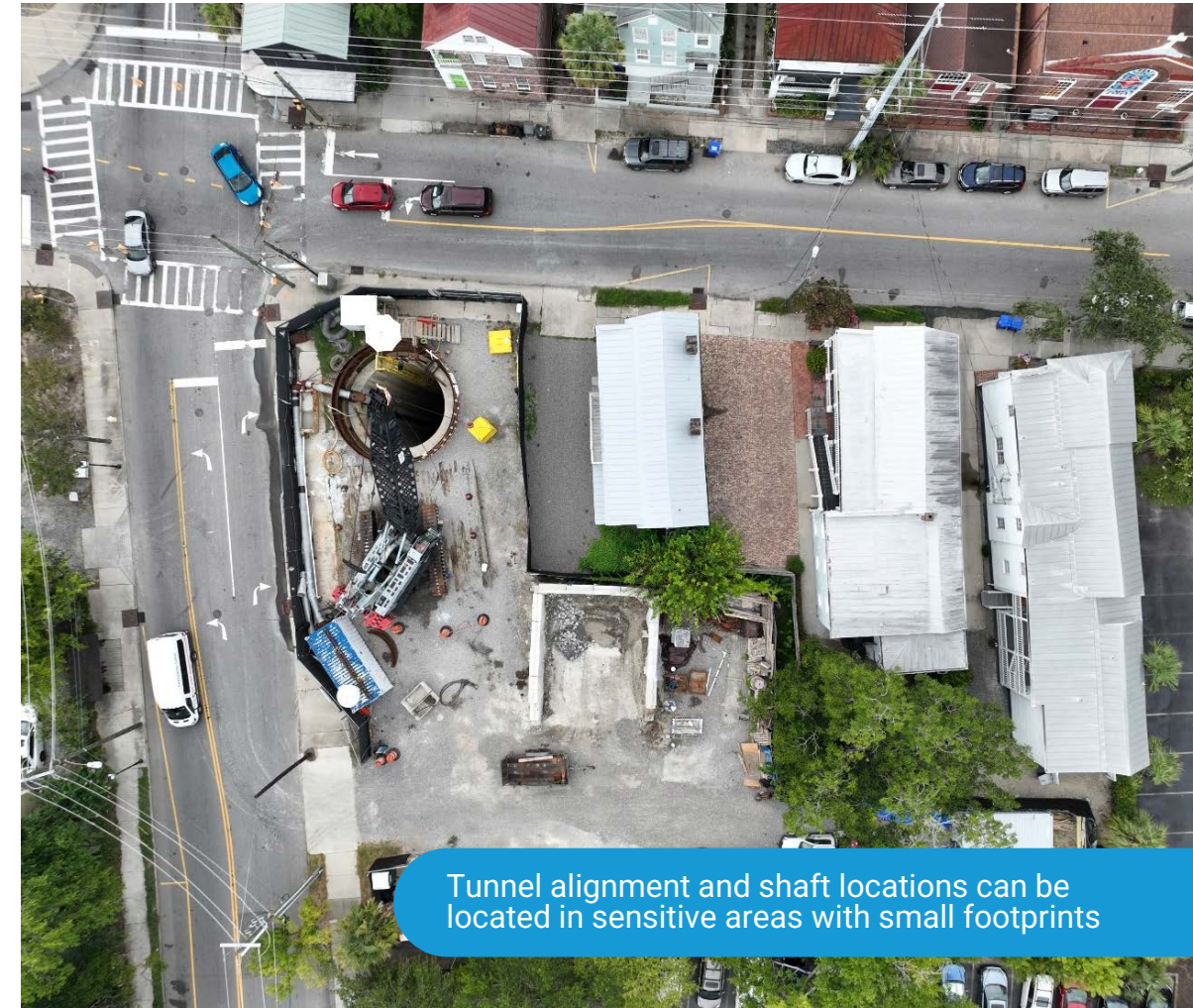


<http://www.youtube.com/watch?v=OYuplf0WmmM>

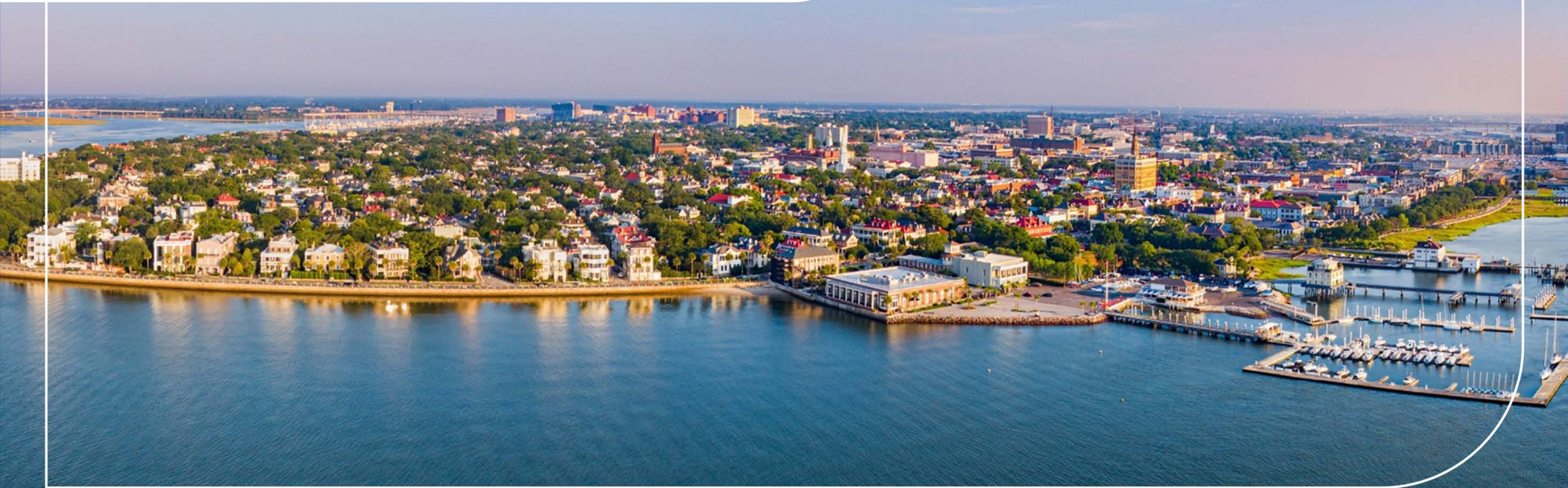
Tunnel Sizing and Alignment Selection

System Hydraulics & Operational Flexibility Horizontal/Vertical Alignment Evaluation

- Risks (technical, third party, other)
- Shaft locations
- Easements
- Capital and operating costs
- Geotechnical considerations
- Community impacts
- Proximity to sensitive structures
- Permits
- Constructability issues

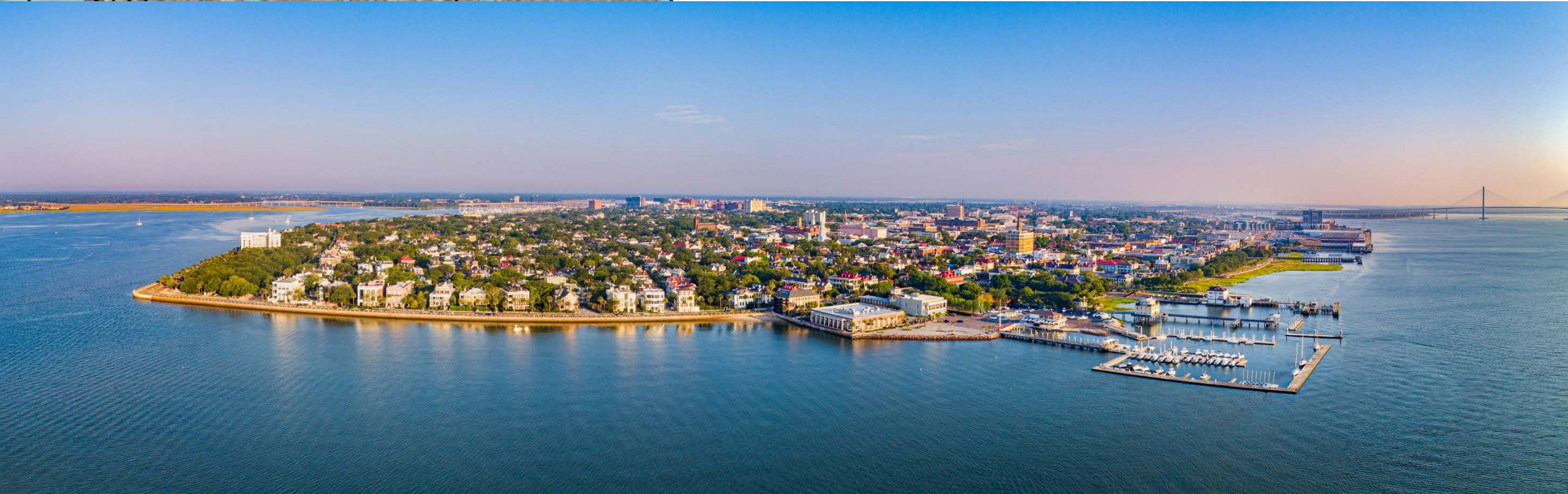


Charleston, SC | Case Study





Charleston Peninsula The Low Country



Charleston Peninsula

Historic Infill and Current Flooding

Medical District

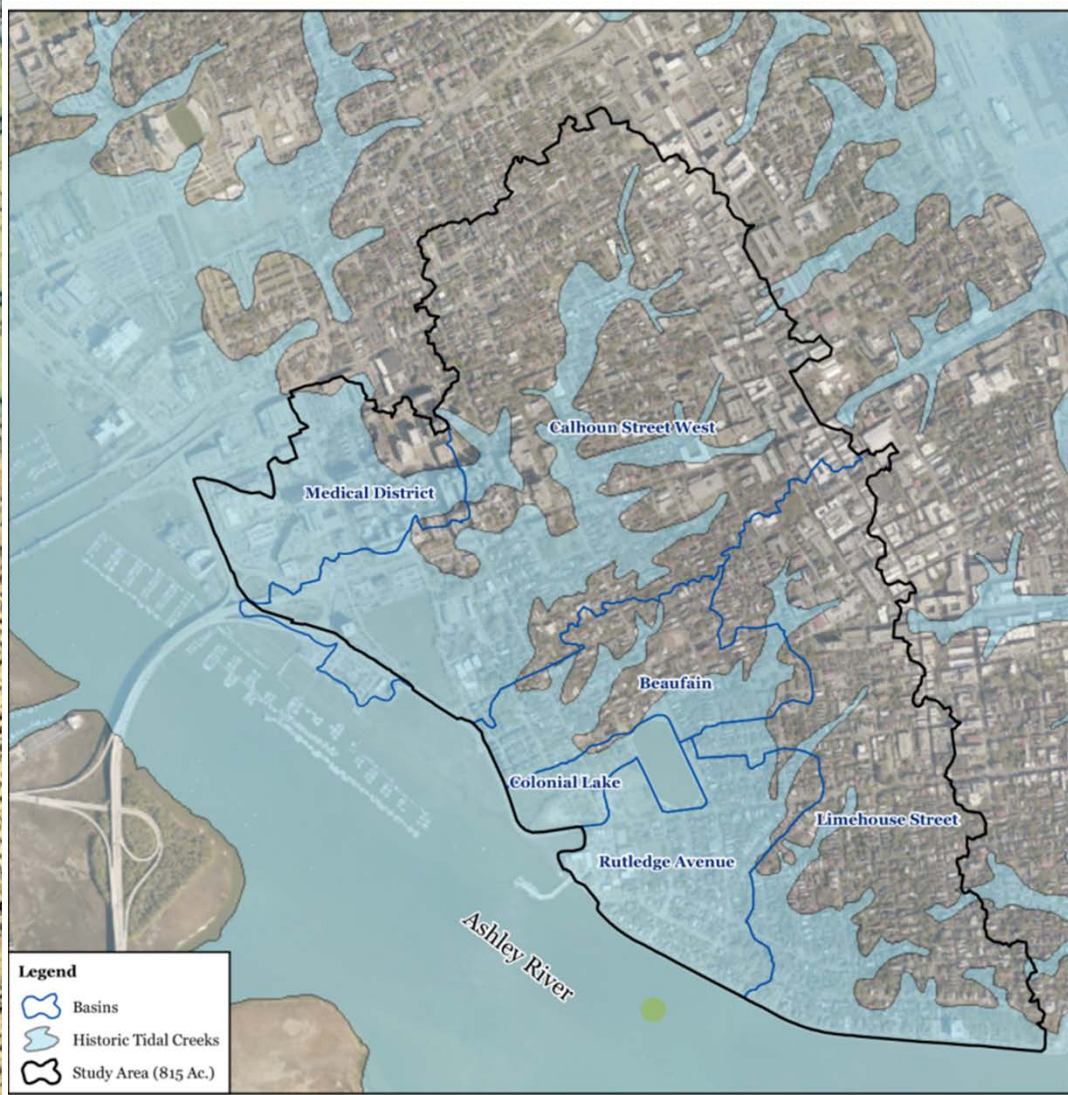
Beaufain

Colonial Lake

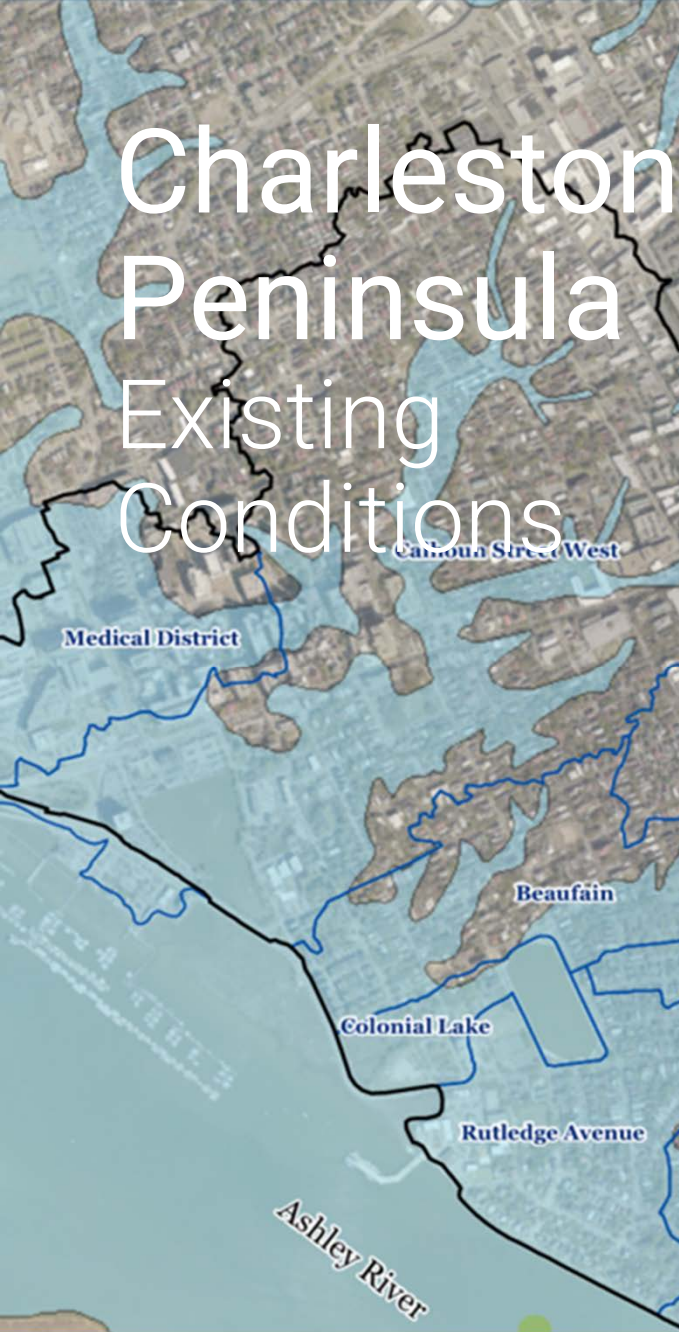
Rutledge Avenue

Limehouse Street

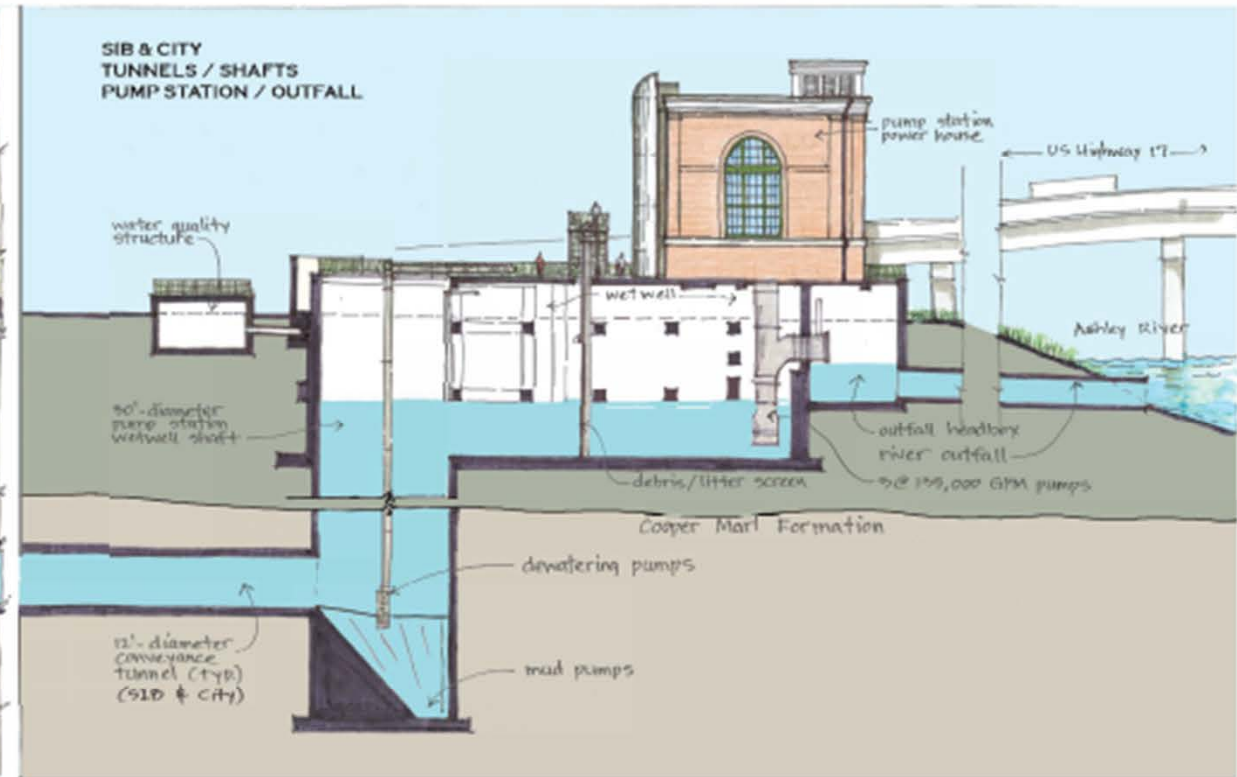
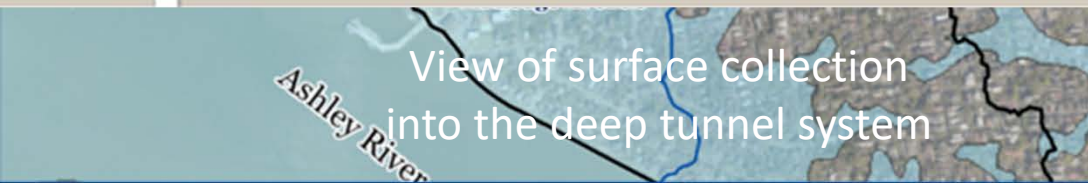
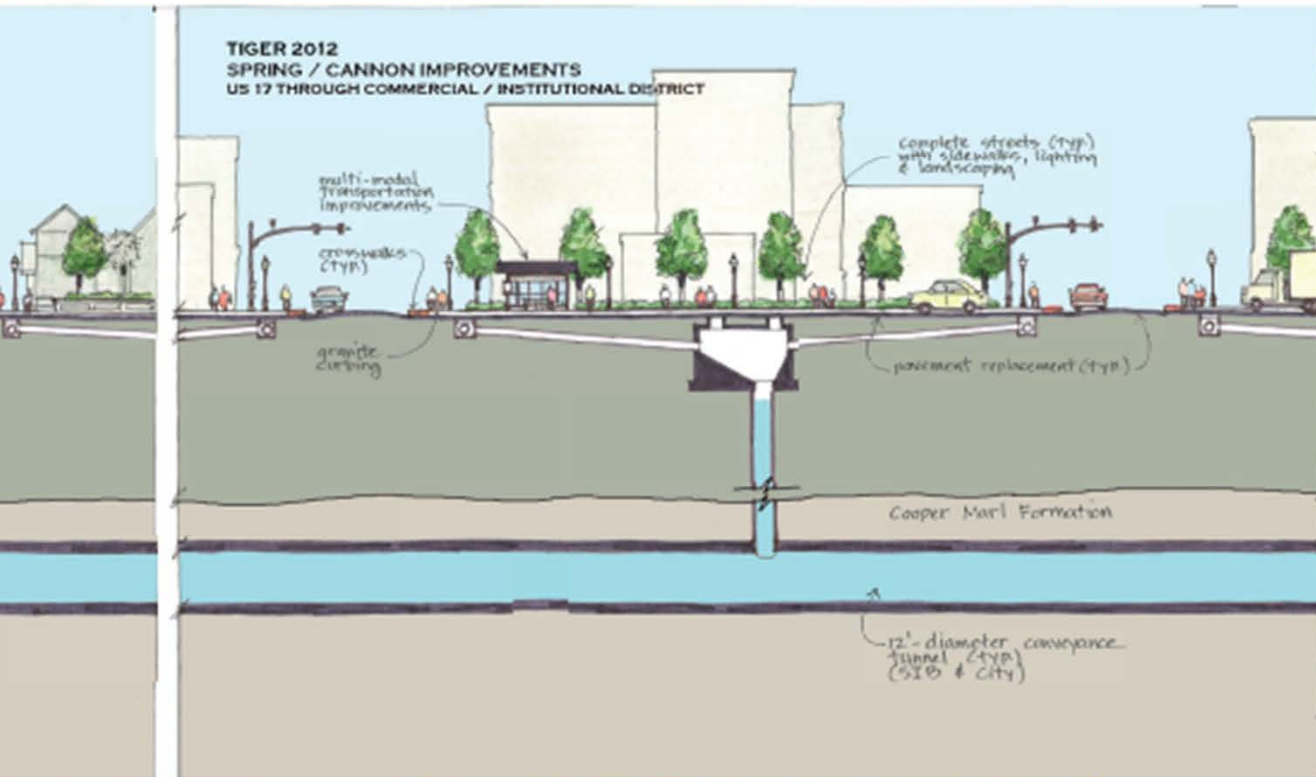
Ashley River



Charleston Peninsula Existing Conditions



Charleston Stormwater Tunnels



View of the stormwater
pump station and river outfall

Charleston

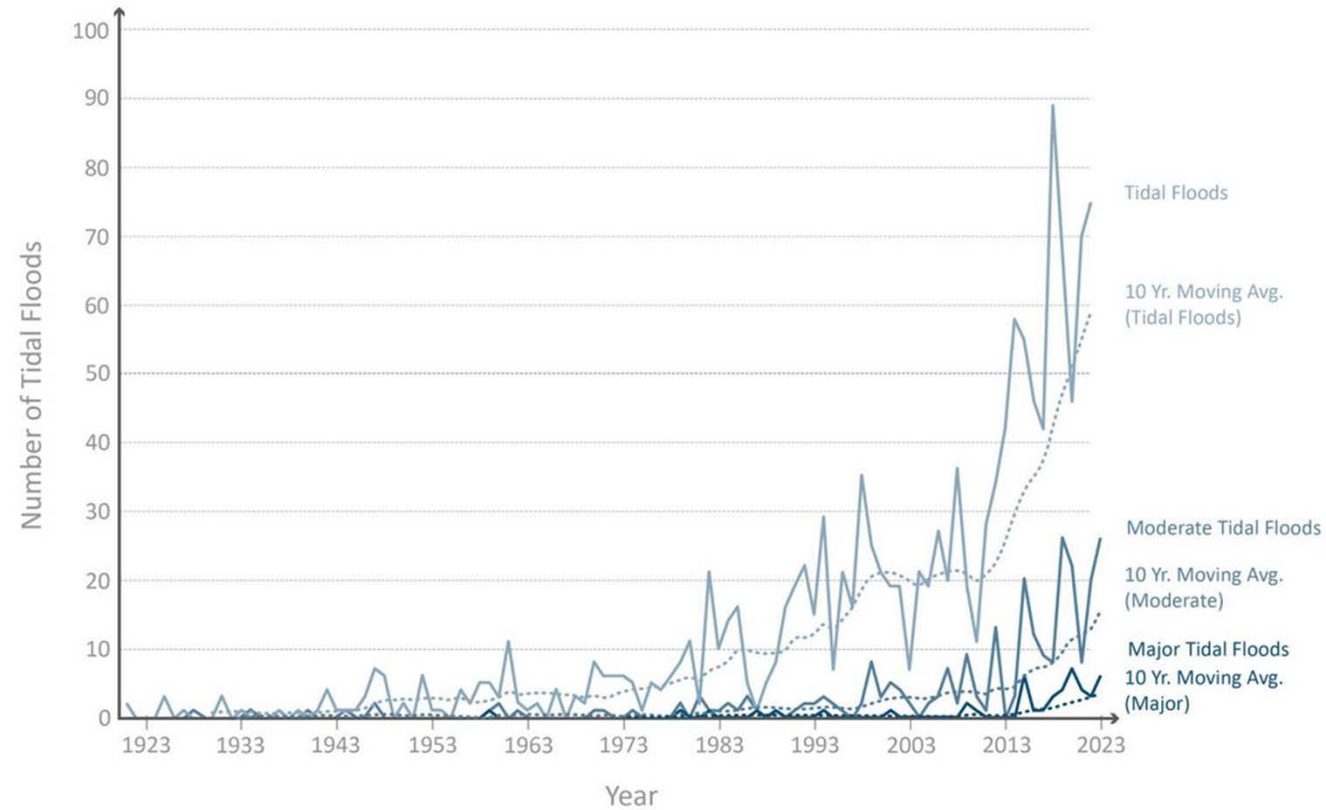
Shafts and Tunnels



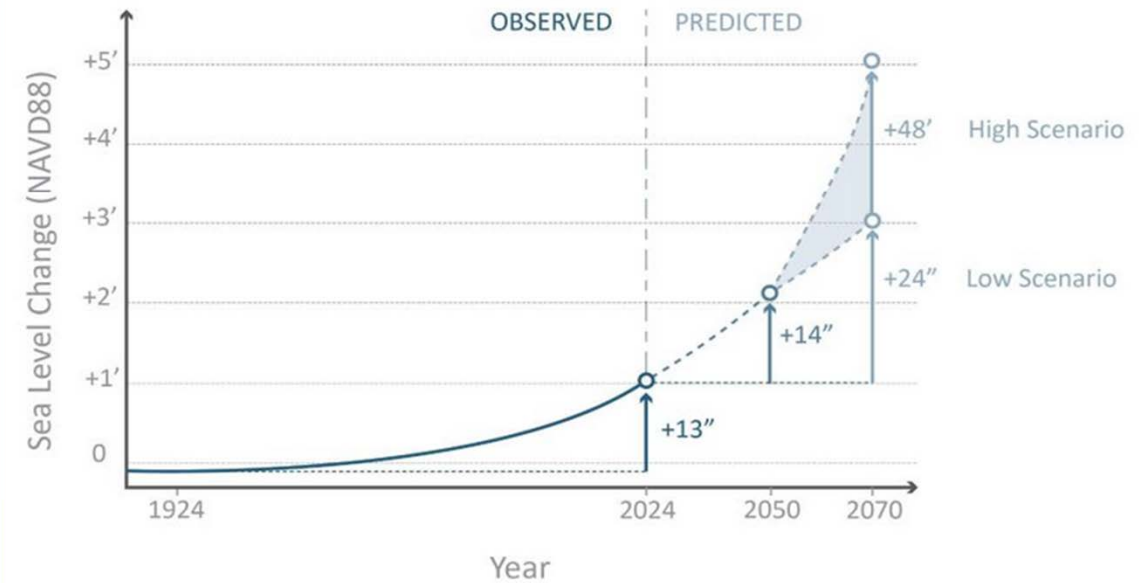


Tidal Flooding & Sea Level Rise

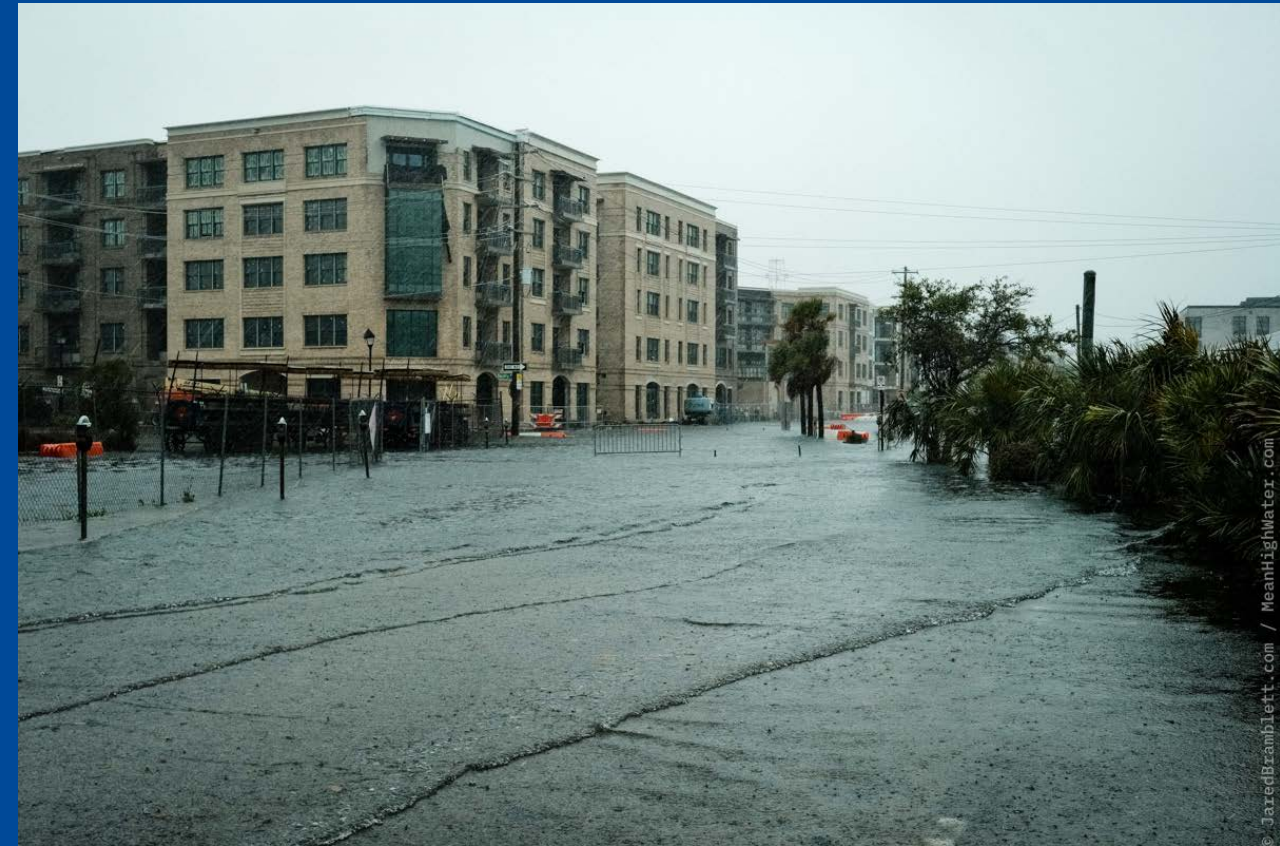
Tidal Floods over Time



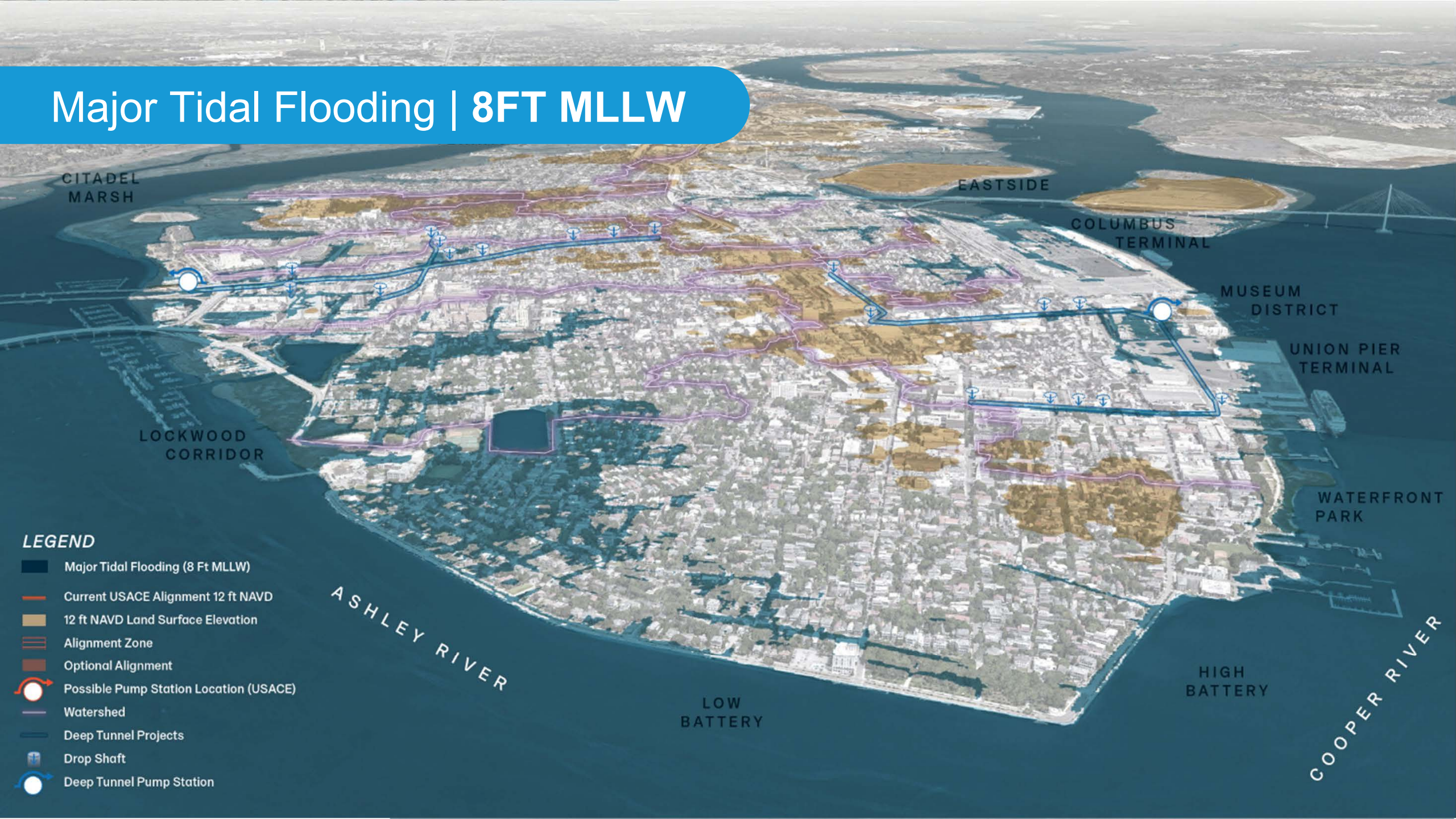
Sea Level Rise
Charleston Harbor Gage



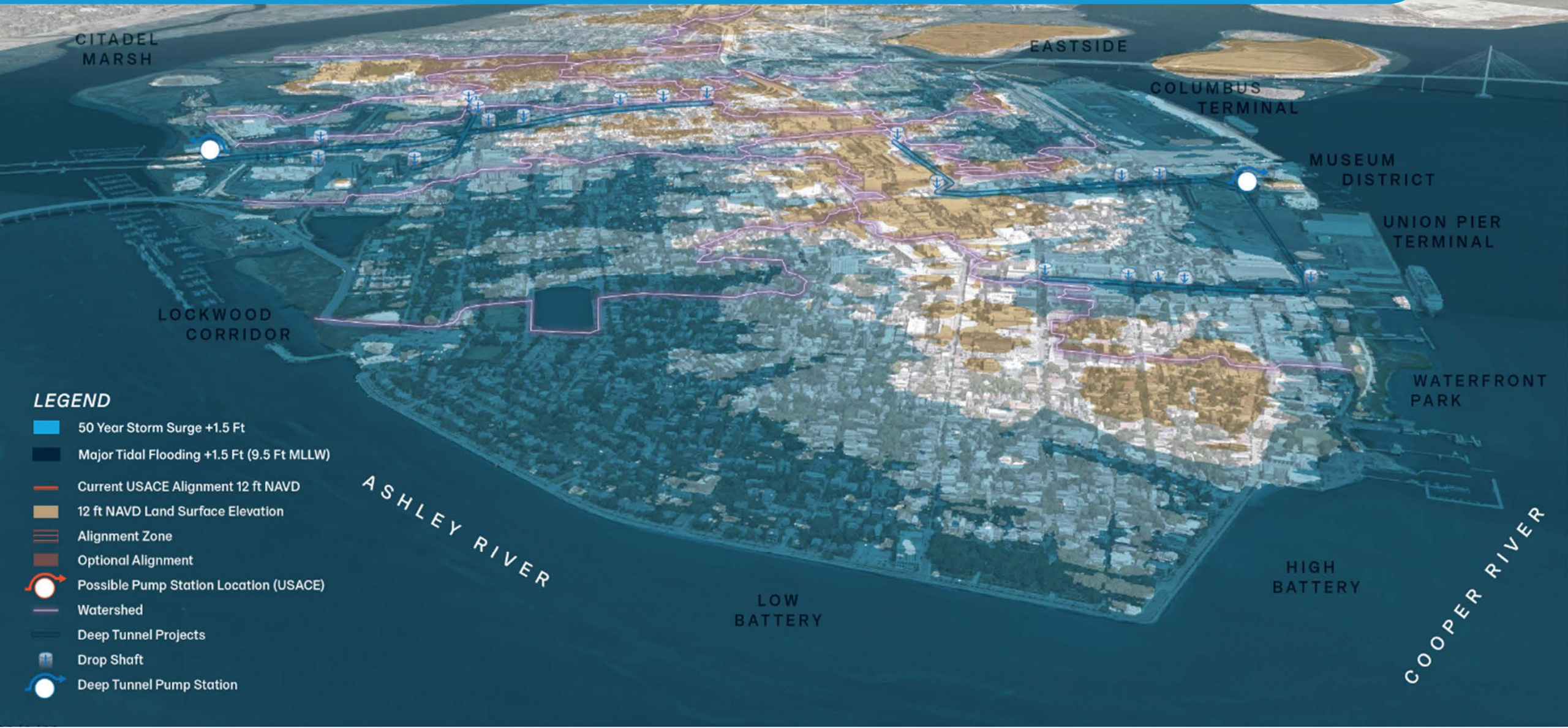
Tidal Flooding



Major Tidal Flooding | 8FT MLLW



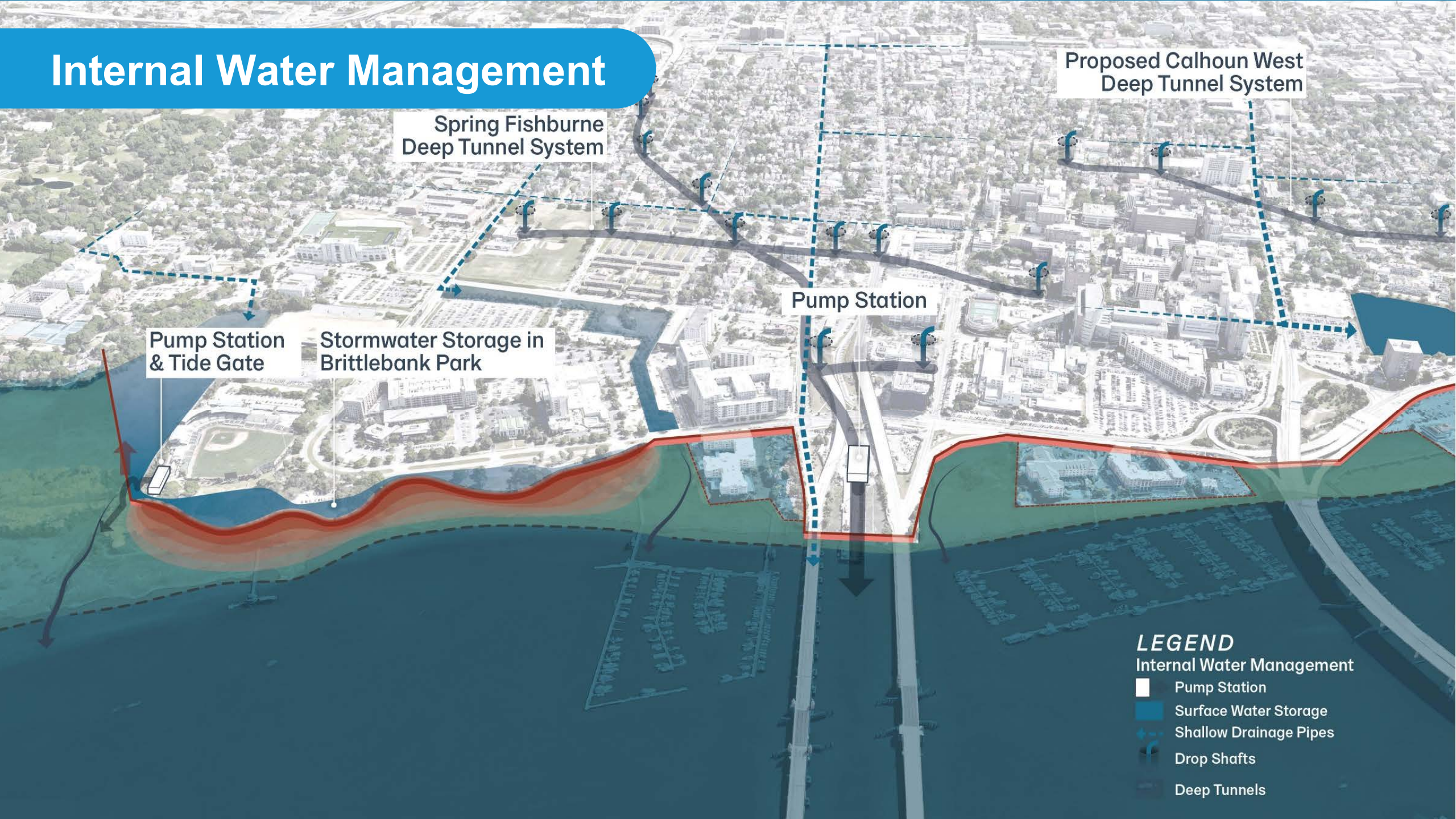
Major Tidal Flooding | 1.5FT SEA LEVEL RISE + STORM SURGE



Major Tidal Flooding + **STORM SURGE** with Perimeter Protection



Internal Water Management



Compound Flood Infrastructure





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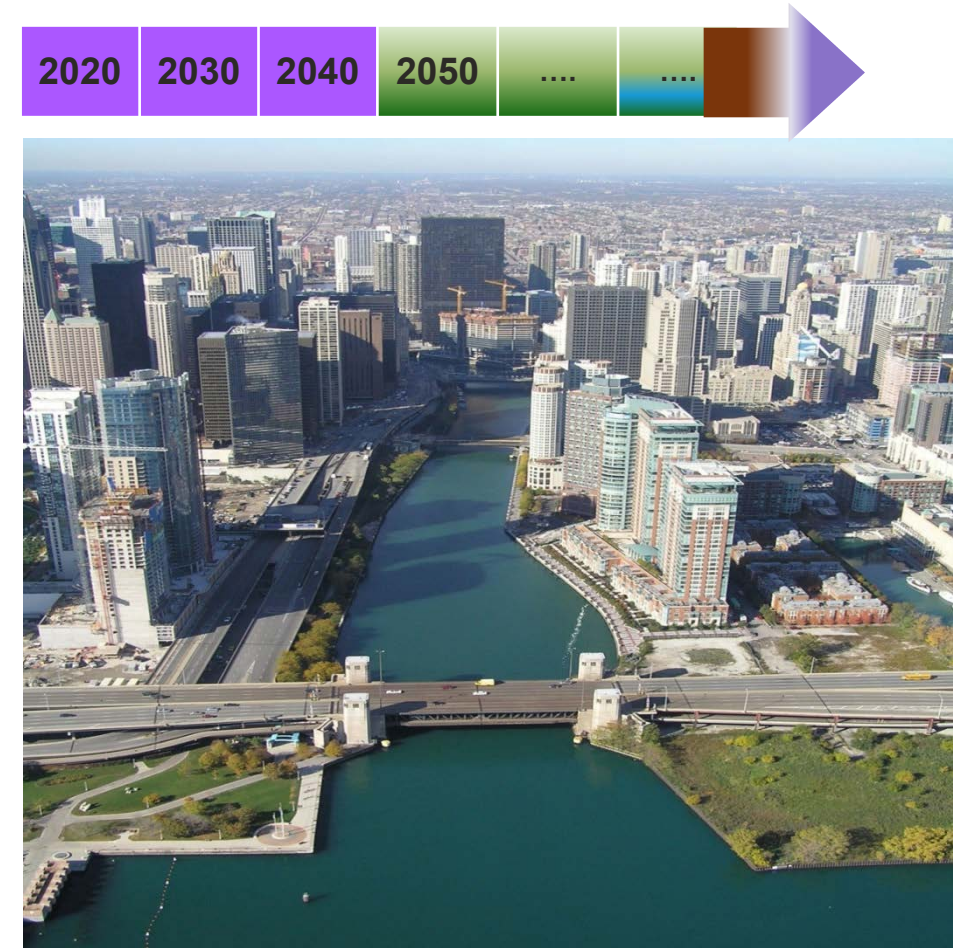
In Closing



Tunnels are Long Term and Sustainable Assets

- Tunnels are designed (and operated) with 100 years + service life expectancy
- Most optimum means to convey/consolidate flows without interfering with surface land features, rivers, roadways, railways and utilities
- Gravity conveyance benefits are maximized - no pumping or energy needed except at terminus
- Tunnels are a significant reliable and sustainable fabric of urban living today...and into the future

Tunnels are integral part of storm/flood management



Large wet weather tunnels have been used for over 50 years to make a substantial contribution in improving quality of life in and around major cities.

Questions?

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