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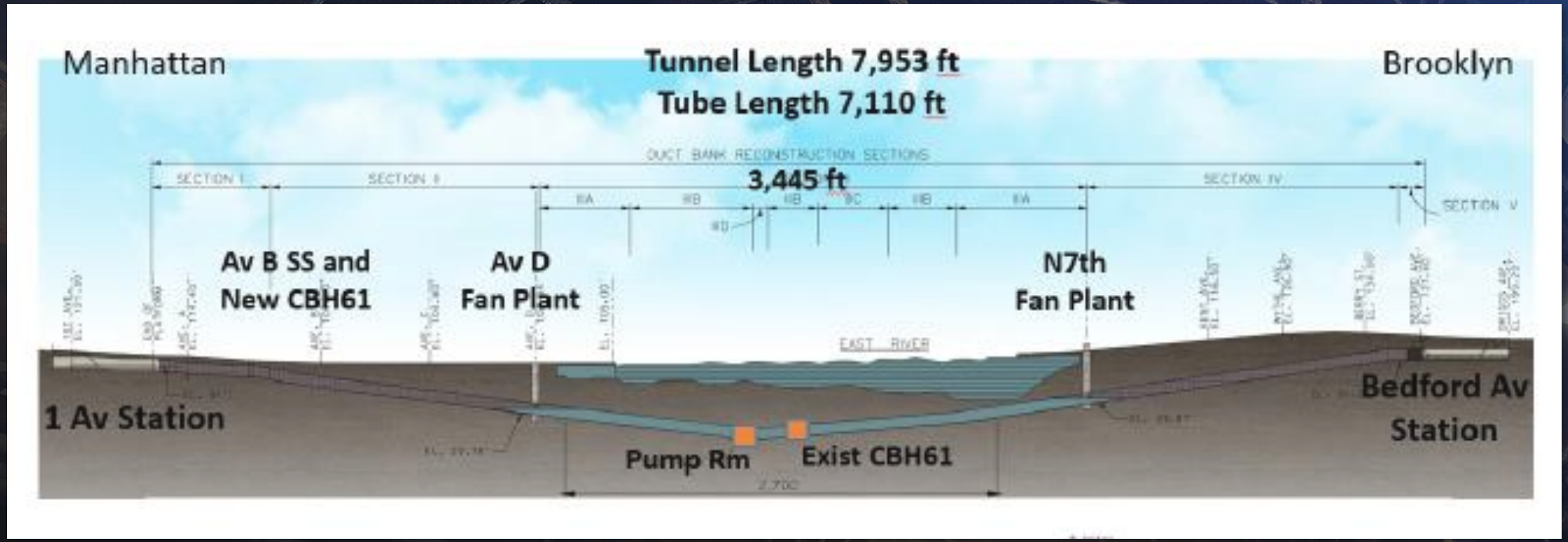
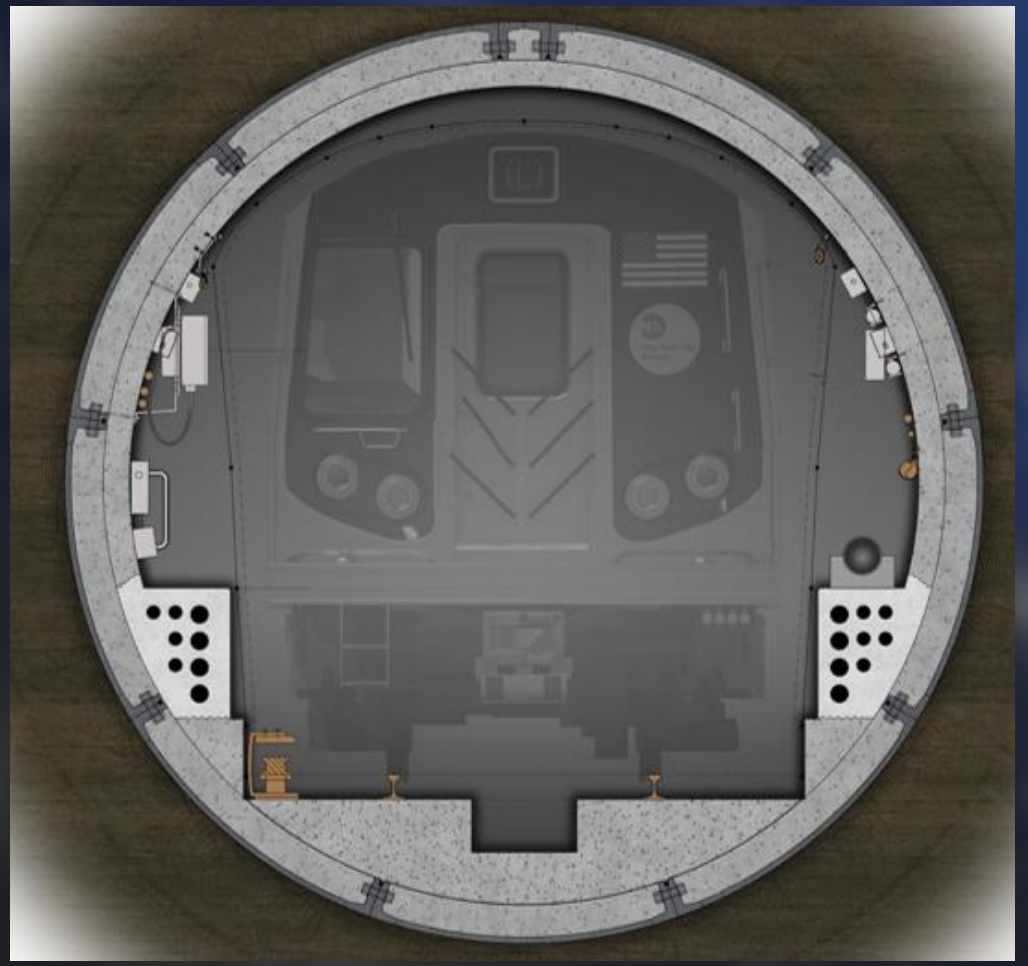
The L Train Tunnel is 1.5 miles long – and over 100 years old – stretching from 1st Ave Station in Manhattan to Bedford Ave Station in Brooklyn...

L TRAIN TUNNEL PROFILE AND SECTIONS

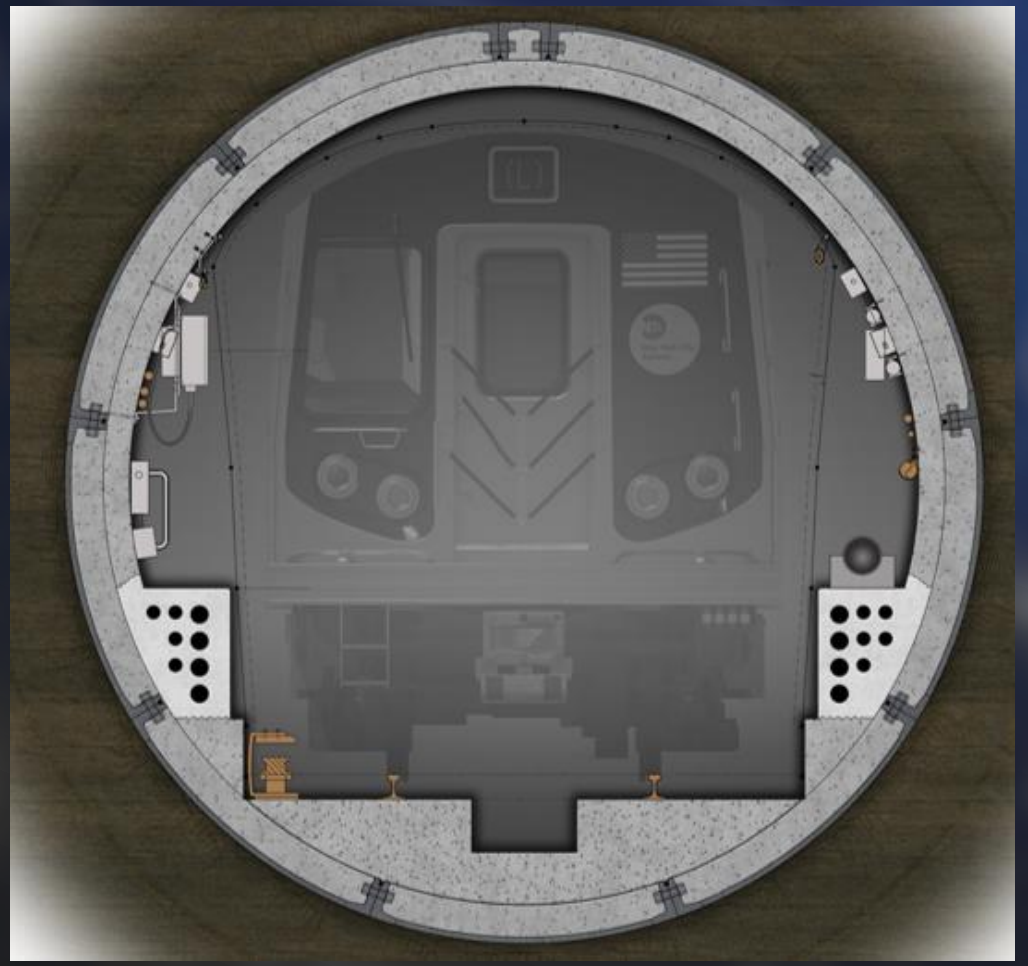


In 2012, Hurricane Sandy filled the tunnel with salt water, from the Avenue D Fan Plant to the North 7th Street Fan Plant...

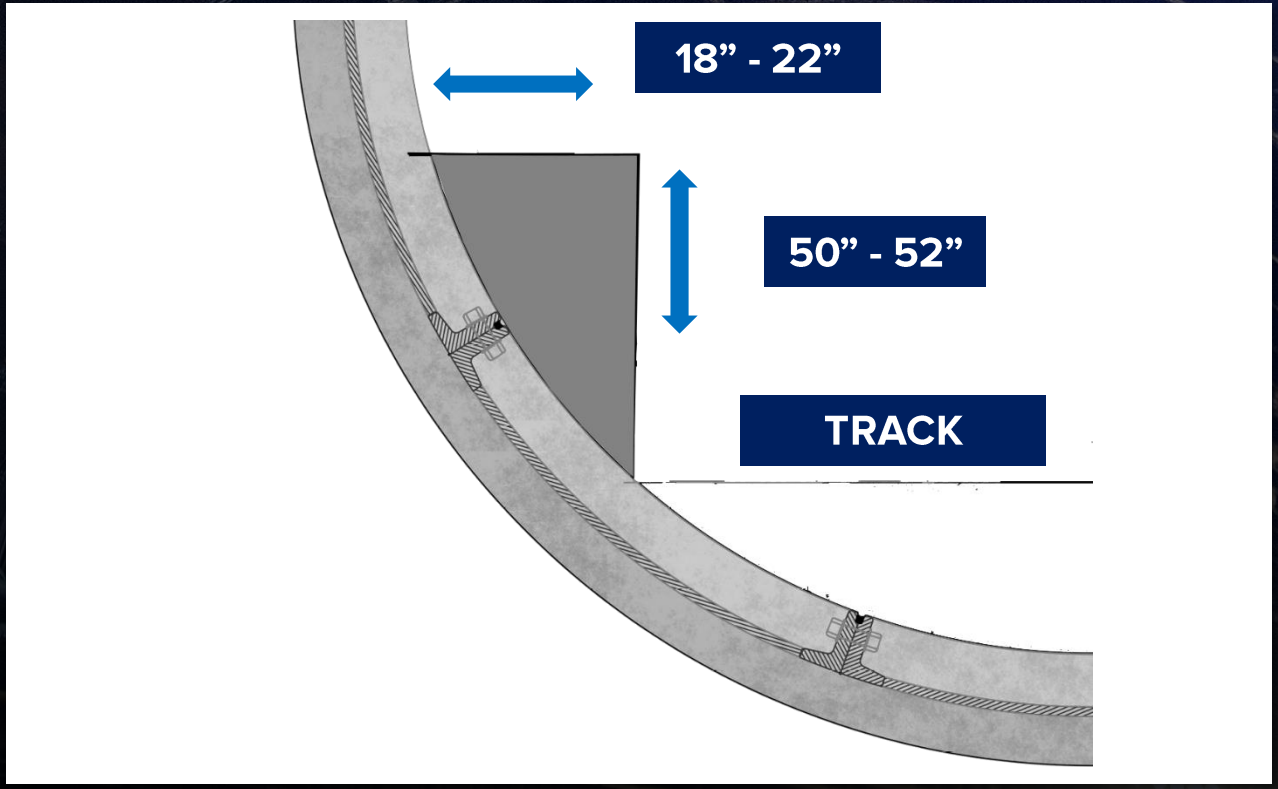
Major structural elements of the tunnel are **not compromised.**



Internal components are problematic — the circuit breaker house and power cables were exposed to a corrosive accelerant: salt water.



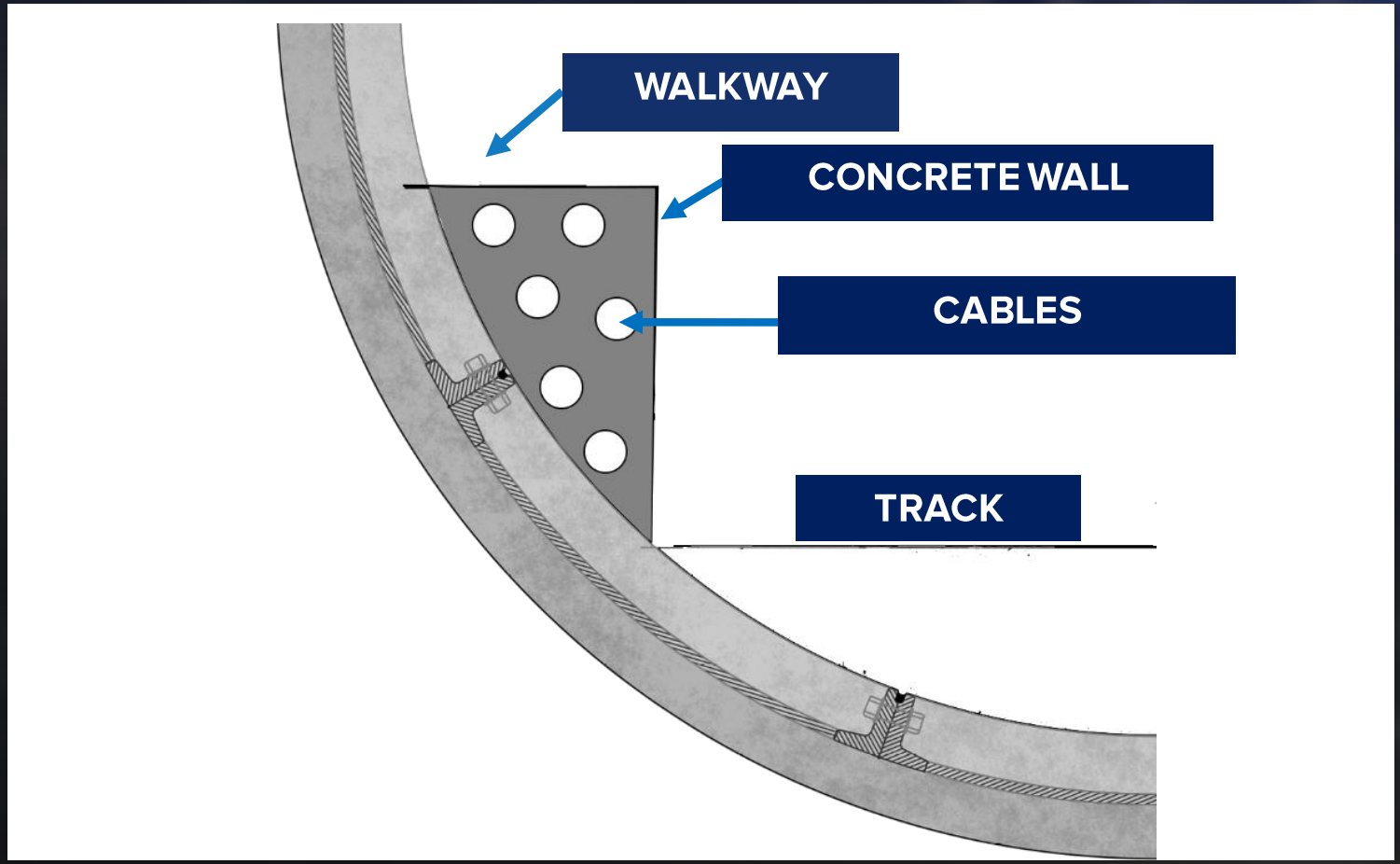
INTERNAL ELEMENT OF CONCERN:
"BENCHWALLS"
WHAT IS A BENCHWALL?



WHAT IS THE BENCHWALL?

- Holds and protects cables, which decades ago were less stable and did not have state-of-the-art fireproofing materials.
- Provides access/egress walkway for workers or, in the event of an emergency, for train passengers and first responders.

CUTAWAY OF BENCHWALL



BENCHWALL CONDITIONS

Example of cement benchwall in good condition.

BENCHWALL CONDITIONS

SOME PORTIONS CRUMBLING, SOME WEATHERED, OTHER PORTIONS STABLE

Example of cement benchwall eroded by saltwater, holding power cables.

CURRENT L TRAIN TUNNEL DESIGN PLAN:

- Remove and replace all 32,000 feet (both tunnels) of benchwall.
- Install 126,000 feet of power cable and 176,000 feet of communications cable inside new benchwall.

Much of the benchwall was planned to be removed by hand — a laborious, time-consuming process — to avoid damage to the century-old tunnel's concrete lining...

We empaneled an expert review team from Cornell and Columbia engineering schools to do a final review of the plan ahead of the L Train shutdown.

The review team was charged with examining the current plan and recommending new designs, new systems, or technology that would improve the project and/or expedite the timetable, or confirm the current plan as the best way forward.

REVIEW TEAM

Mary Boyce,
Dean of Engineering,
Morris C. And Alma
Schapiro Professor,
Columbia University

Lance Collins,
Joseph Silbert Dean of
Engineering,
Cornell University

George Deodatis,
Santiago and
Robertina Calatrava
Family Professor of
Civil Engineering,
Columbia University

Peter Kinget,
Bernard J. Lechner
Professor of
Electrical
Engineering,
Columbia University

Andrew Smyth,
Professor of Civil
Engineering,
Columbia University

Tom O'Rourke, Thomas
R. Briggs Professor of
Engineering,
Cornell University

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THE L TRAIN TUNNEL PROJECT REPORT

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Cornell Engineering

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R. Briggs Professor of
Engineering,
Cornell University

THE L TRAIN TUNNEL

The Review Team has:

- ✓ Toured the L Train Tunnel
- ✓ Toured the Hudson River Tunnel and consulted with Amtrak
- ✓ Consulted with WSP, Jacobs (CM) and Contractors
- ✓ Consulted with L Train Team
- ✓ Been briefed by MTA/NYCT on current plan
- ✓ Conducted an in-depth review and performed hundreds of hours of work

THE L TRAIN TUNNEL

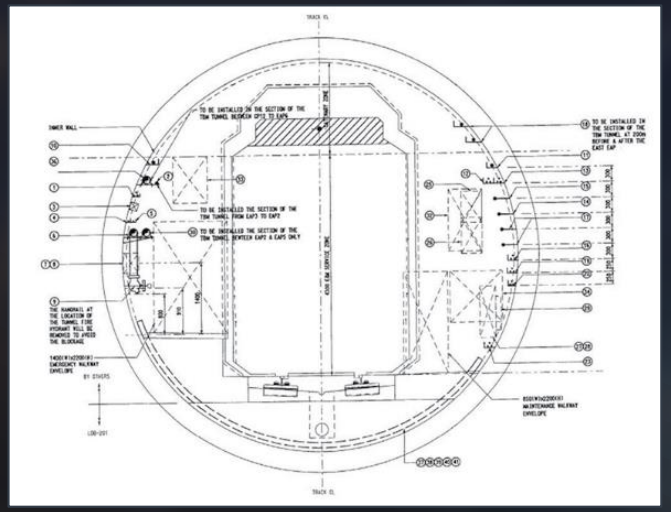
The expert review team also considered state-of-the-art rail tunnels in cities around the world to implement the most efficient design here at home…

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

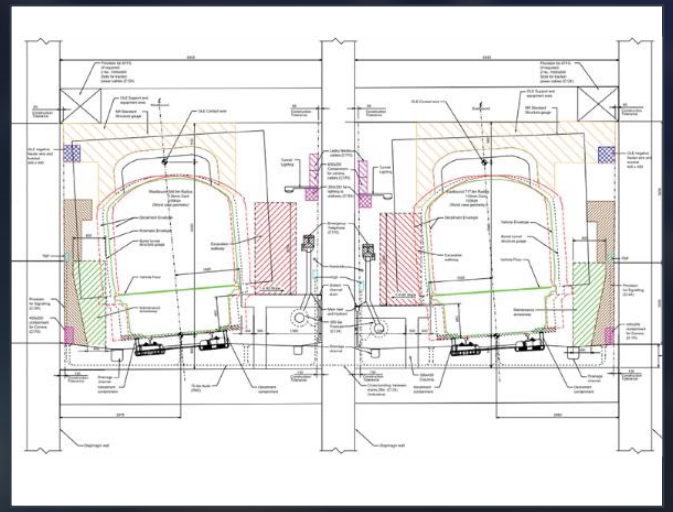
THE L TRAIN TUNNEL

Cornell Engineering

HONG KONG



LONDON



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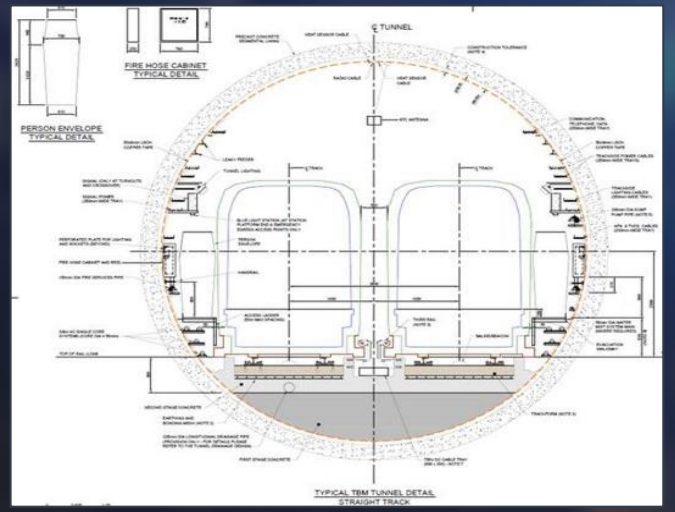
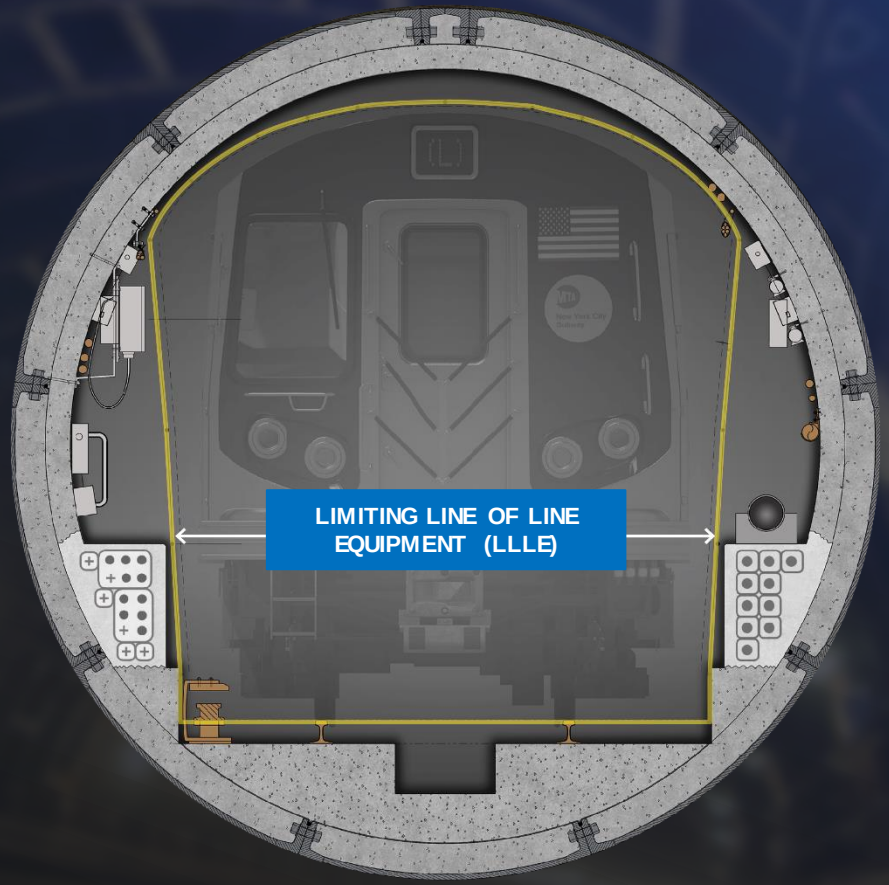


The team found that some other modern tunnel designs under construction do not use benchwalls to protect cables.

RECOMMENDATIONS

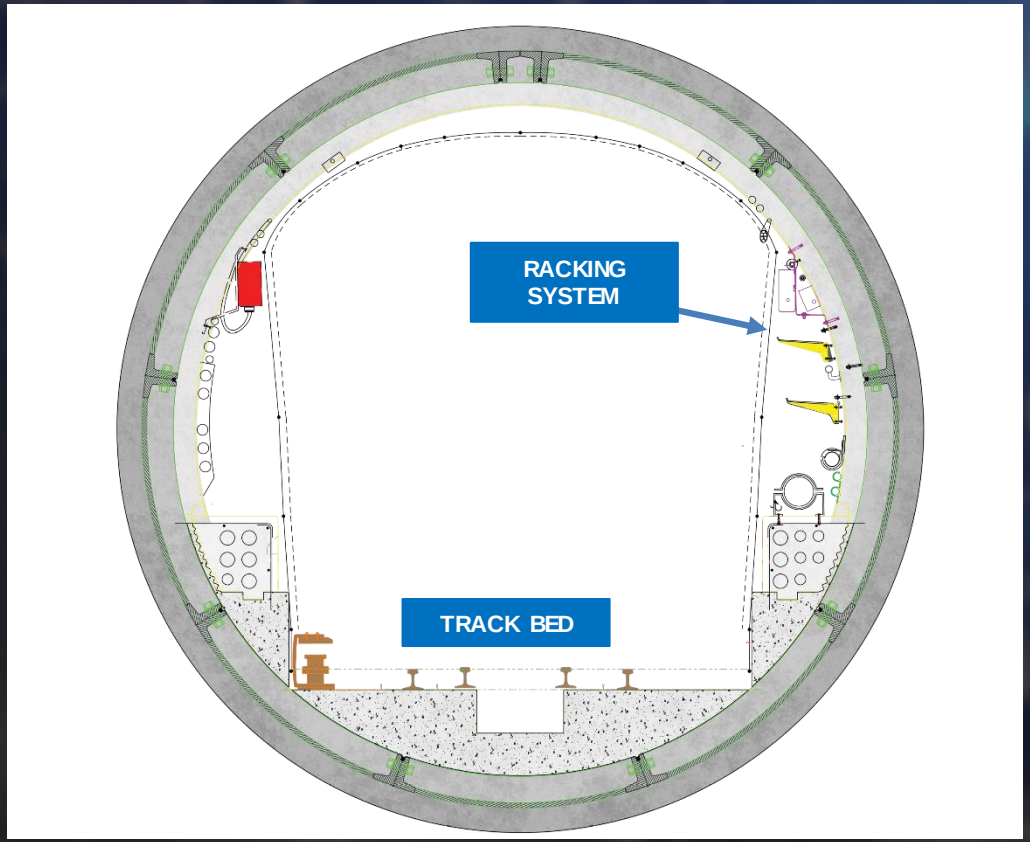
1. Implement a new power and control system design.



RECOMMENDATIONS

Cables

2. Implement new “racking” system design to suspend cables on the side of the tunnel. Place negative returns on the track bed.



RECOMMENDATIONS

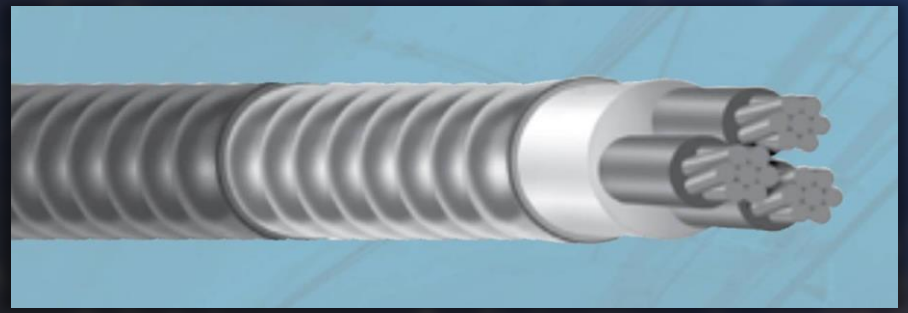
Cables

3. Decouple cable system housing from benchwall. New cable system design does NOT use benchwall structures for housing power, control and signal cables.

RECOMMENDATIONS

Cables

4. Jacket cables with low smoke, zero halogen fireproof material, which has proven successful in airline and transportation industries and satisfies NFPA 130 fire code requirements.



RECOMMENDATIONS

Cables

5. Abandon all old cables in benchwall, reducing demolition and construction work, as well as cost.

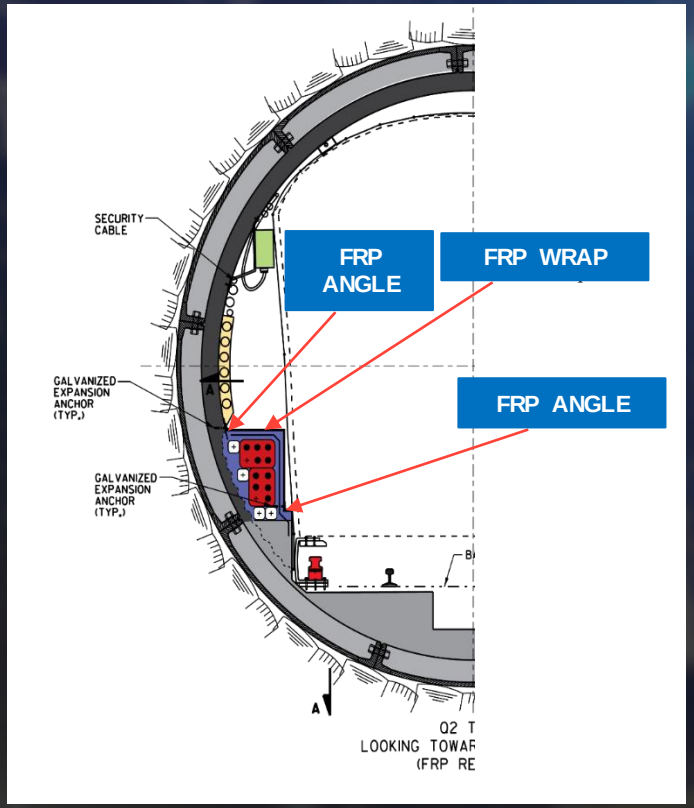
RECOMMENDATIONS

Benchwall

6. a. Leave benchwall where structurally stable.

   b. Fortify weakened structure with fiber reinforced polymer (FRP) wrap and strapping, reducing the need for continual fixes.

   c. Remove unstable benchwall.

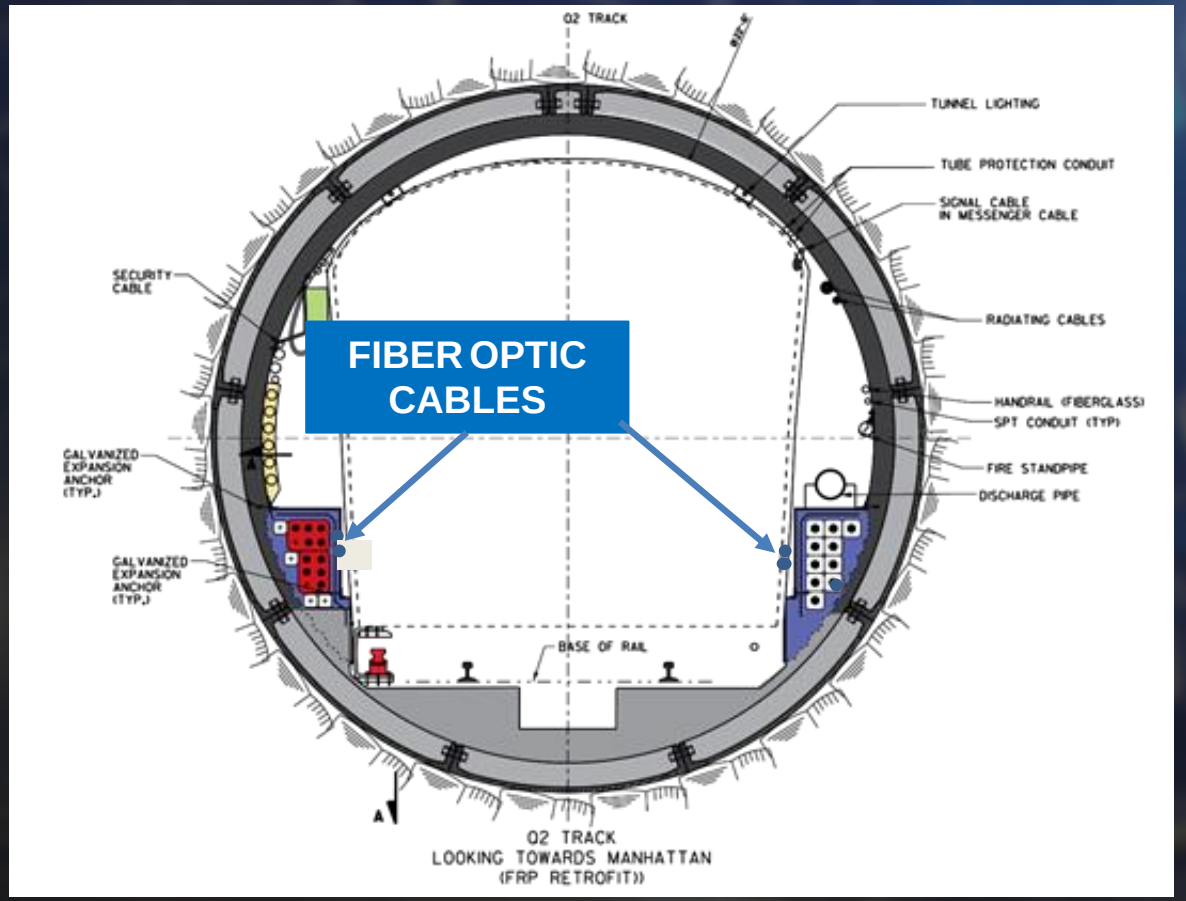


RECOMMENDATIONS

Benchwall

7. a. Install “smart” fiber optic sensor cables along remaining benchwall to detect shifts or cracks in benchwall.

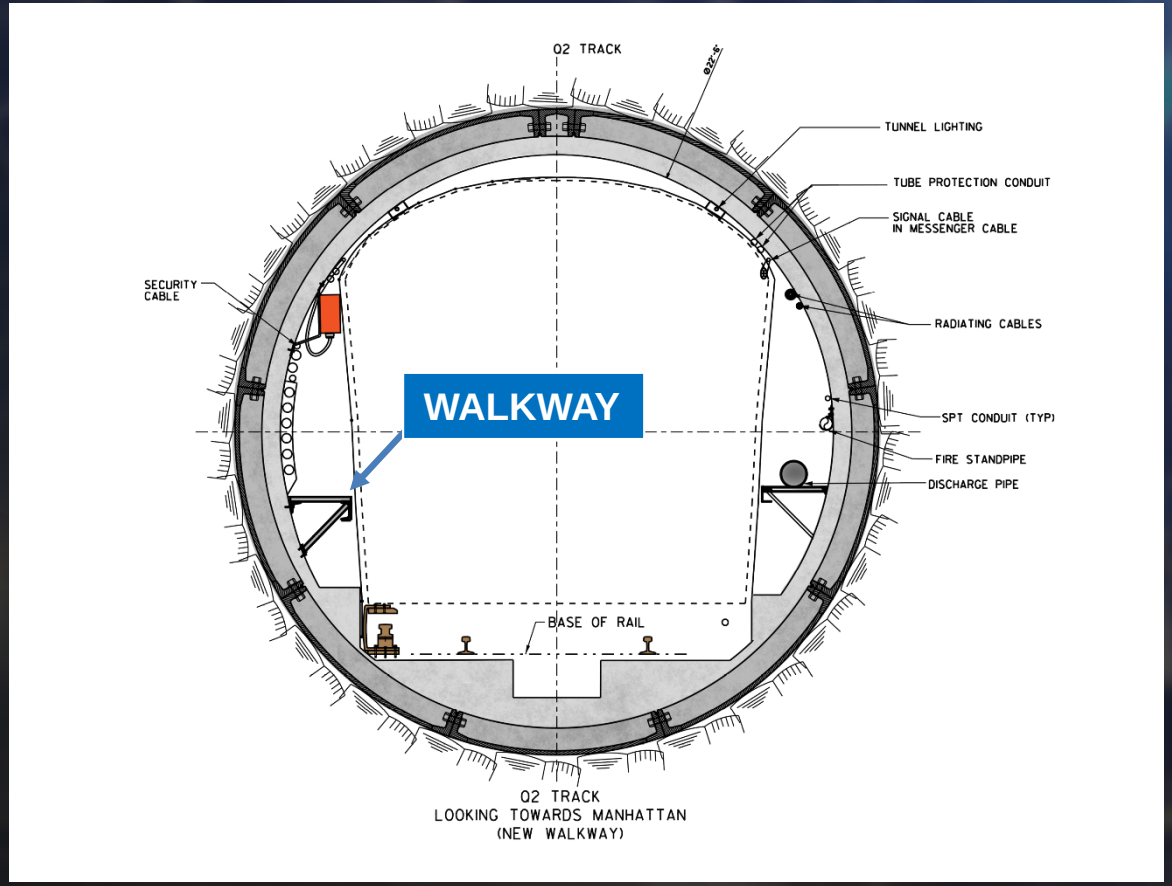
   b. Use high resolution LiDAR to monitor for benchwall deformation.



RECOMMENDATIONS

Benchwall

8. Install walkway to provide access/egress where benchwall has been removed.



RECOMMENDATIONS

Resilience

9. Increase tunnel resilience against flooding:
   a. Increase pump capacity as currently planned.
   b. Install a permanent generator to power pumps, providing redundancy to power sources from both Manhattan and Brooklyn. Explore natural gas vs. diesel fuels.
   c. Consider watertight submarine-type gates (similar to QMT and BBT).
   d. Consider sealing capability for all openings on the L-line from 1st Ave station to Bedford Ave station, depending on critical elevation.

Watertight gate closure at the Queens Midtown Tunnel

RECOMMENDATIONS

Safety

10. Enhance public safety:
    a. Detailed evaluation of control options for dust and airborne silica with an assessment of their impact on construction schedule.
    b. Enlisting an independent environmental firm to monitor air quality and report directly to NYC Transit.
    c. Ongoing structural condition monitoring with smart tunnel technology.

RECOMMENDATION SUMMARY

1. Implement a new power and control system design.
2. Implement “racking” system design for cables.
3. Decouple cable system housing from benchwall.
4. Jacket cables with low smoke, zero halogen fireproof material.
5. Abandon all old cables in benchwall.
6. Leave benchwall unless structurally compromised and fortify using fiber reinforced polymer. Remove unstable benchwall.
7. Install “smart” sensor systems to monitor benchwall integrity.
8. Install walkway where benchwall removed.
9. Increase flood resilience measures.
10. Enhance public safety.

BENEFITS

- New system design achieves all functional outcomes, while reducing work and allowing simultaneous, not sequential execution of critical tasks.
- Racking system will allow greater access to cables for inspection or future upgrades.
- Installation of smart sensor system will allow for monitoring on a continuous basis rather than a periodic basis.
- Upgrades to the pump system and rail will occur in tandem with the cable and benchwall work.
- Dramatic reduction in non value added project scope (i.e. avoiding complete removal and reconstruction of the benchwall).
- Enhanced safety and functionality of the project.
- Enhanced flood resilience.

BENEFITS

- This new system design approach can be potentially applied to other projects, such as the Second Ave. Phase 2 and Hudson River Train Tunnels.

THIS MEANS…

- No closure of service is necessary with this new design.
- Work can be completed with weekend and nighttime closures of ONLY ONE TUBE at a time, leaving the other to run trains in both directions.

This plan has been presented to and reviewed by the MTA, and we hope it will help them implement the best possible solution for New Yorkers.

Thank you to the MTA, the consultants, and everyone who helped us create this plan.

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