



**Massachusetts Water Resources Authority**

# Metropolitan Water Tunnel Program Working Group

## Tunneling 101

August 4, 2021

Please visit the project website  
[www.mwra.com/mwtp.html](http://www.mwra.com/mwtp.html)



# Metropolitan Water Tunnel Program







## Agenda

- Metropolitan Water Tunnel Program Update
- History of Tunneling
- Details of the Technology
- What You'll See on the Surface
- Environmental Considerations (Construction Impacts)
- Upcoming Meetings
- Questions and Comments



# Metropolitan Water Tunnel Update

- Geotechnical Investigation Update:
  - Rock Outcrop Mapping – 2 MassDOT sites remaining
  - Surface Geophysical Surveys – Complete
  - Rock Drilling to Full Depth at:
    - Wellesley - Hegarty PS (416 ft)
    - Needham - St Mary St PS (513 ft)
    - Newton - Newton South High School (470 ft)
    - Waltham - Cedarwood PS (437 ft)
  - Rock Drilling Ongoing at:
    - Waltham - Chapel Road
    - Brookline - Newton Street PS
  - Rock Drilling Upcoming:
    - Waltham, Weston, Needham, Boston
  - Borehole testing and instrumentation installation where drilled to full depth – Ongoing
- Shaft site concept designs and tunnel alignment alternatives development – Ongoing
- DEIR – analysis of shaft sites and tunnel alignments – Beginning this fall





# History of Tunneling



## Background of Tunneling

During the Presentation, think about:

- What do you know about tunnels?
- What do you think your community wants to know?

Keep in Mind:

- There are lots of different kinds of tunnel, we are focused on deep rock water tunnels







# Many Different Types of Tunnels



Sewers



Trains



Automobiles



CSO



Utility Corridors



Subway



## Many Different Types of Tunnels

### ... and Water

- Convey water at required quantity and pressure
- When larger diameters than pipelines are needed
- Built underground – less disruption at the surface
- Provides ability to perform maintenance on existing tunnel year-round





# History of Tunneling – a Boring History



Hand Excavation  
Drilling & Blasting



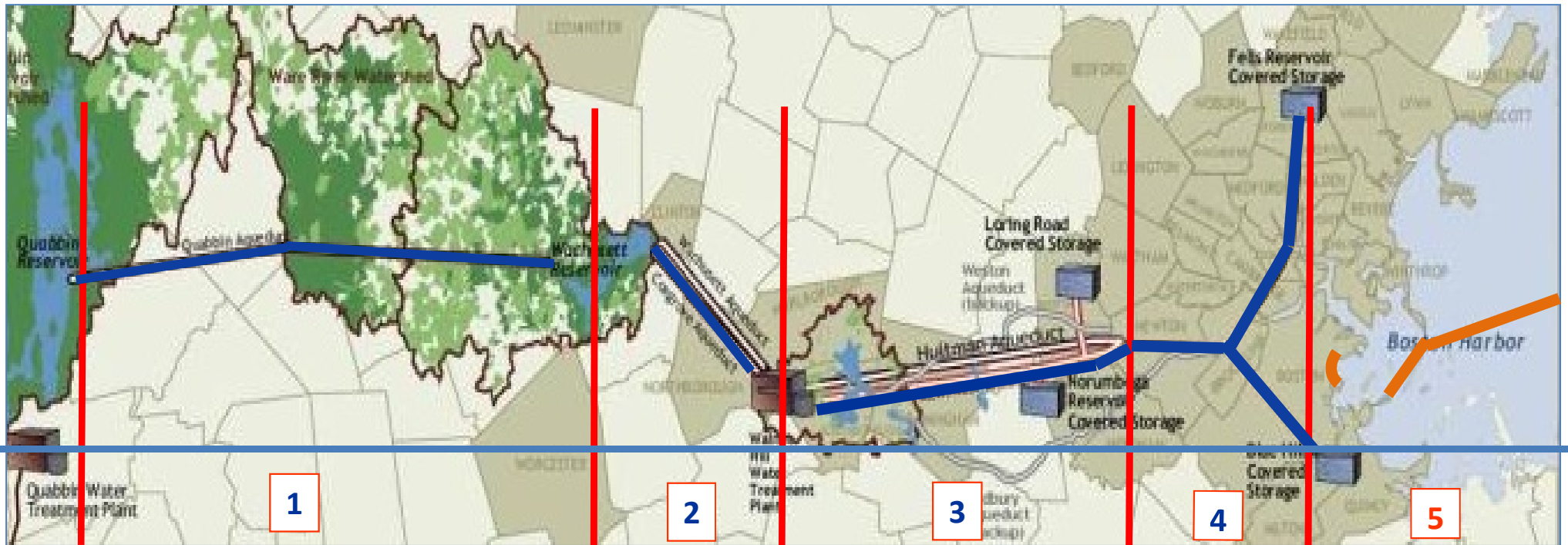
Mechanization



Tunnel Boring Machine  
(TBM)



# MWRA Water Tunnels – Quabbin to Boston



**1**  
Quabbin Aqueduct  
Circa 1939

**2**  
Southborough Tunnel  
Circa 1940  
Cosgrove Tunnel  
Circa 1967

**3**  
MetroWest Water Supply  
Tunnel  
Circa 2003

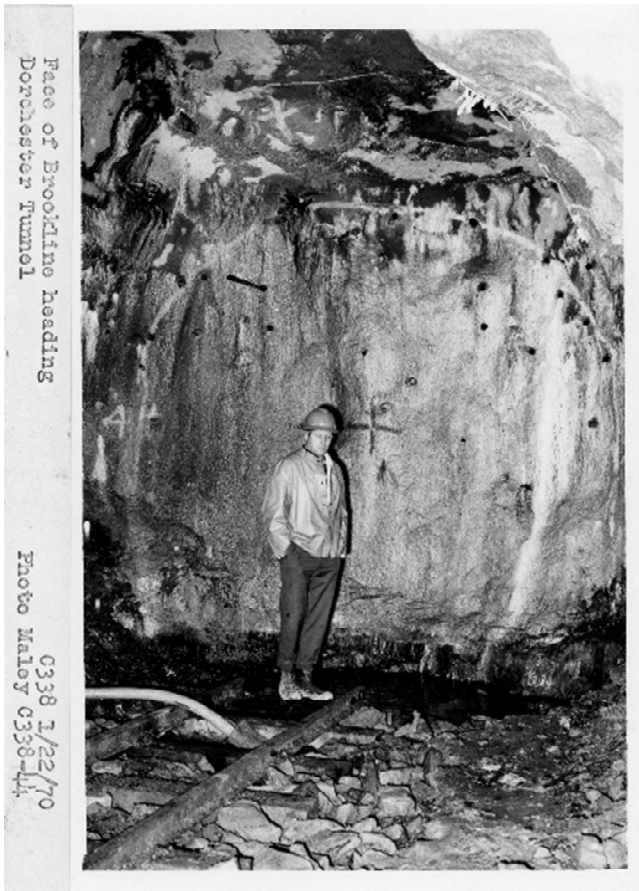
**4**  
City Tunnel  
Circa 1950  
City Tunnel Ext  
Circa 1963  
Dorchester Tunnel  
Circa 1976

**5**  
Boston Harbor  
Sewer/CSO Tunnels  
Circa 1990-2000's





# Metropolitan Tunnels – State of the Art Technologies of the Day



Tunnel Face Drilling and Blasting



Dorchester Tunnel  
Raise Bore Shaft



Muck Conveyor



pilot cutters  
hester Tunnel

0338 2/4  
Photo Maloy 0338



## Details of the Technology



# Tunneling Terminology

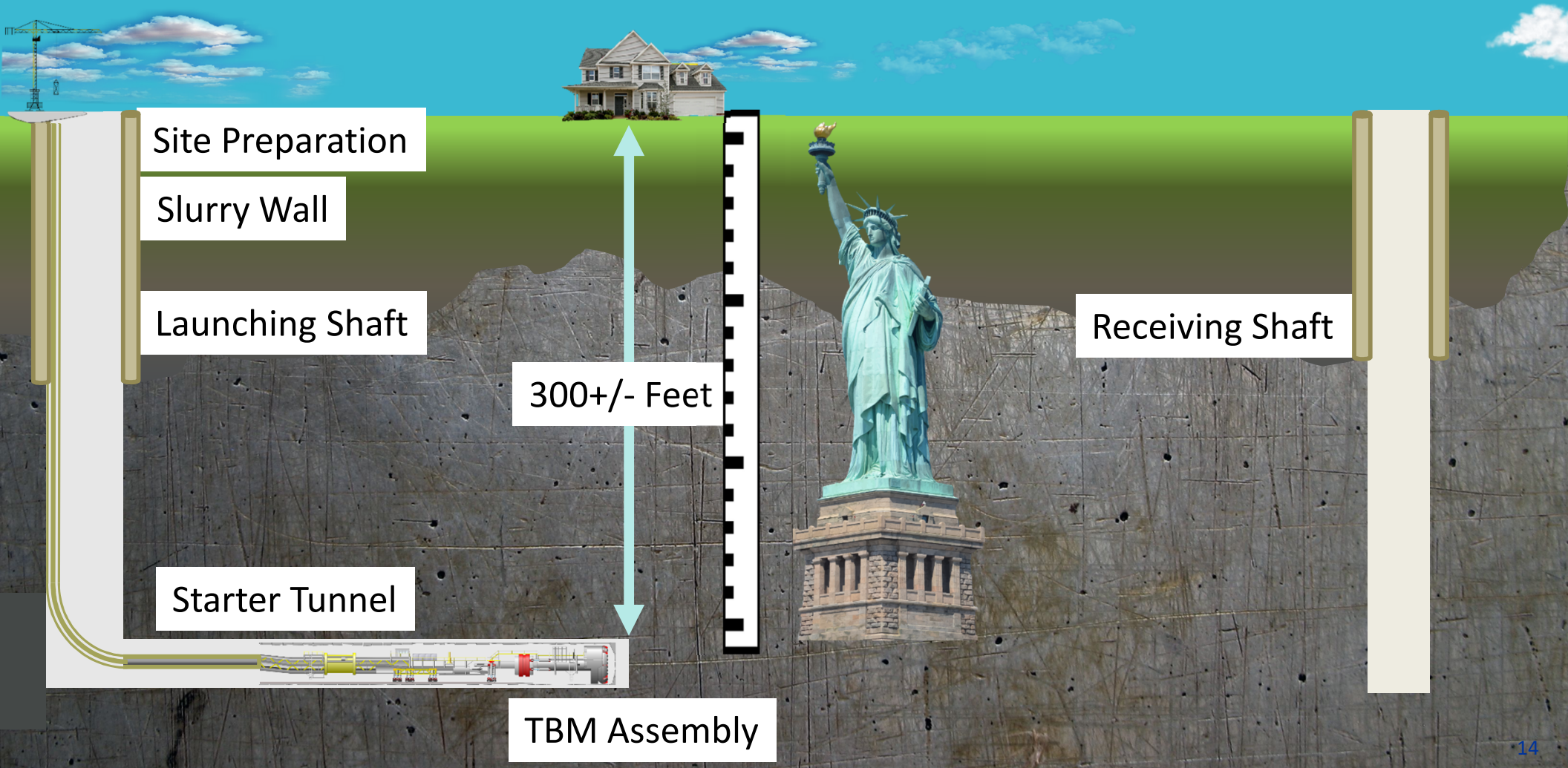
- Site Preparation
- Launching Shaft
- Receiving Shaft
- Connection Shaft
- Support of Excavation
- Starter Tunnel
- TBM Assembly
- TBM Drive
- Extract TBM
- Tunnel Muck
- Site Restoration







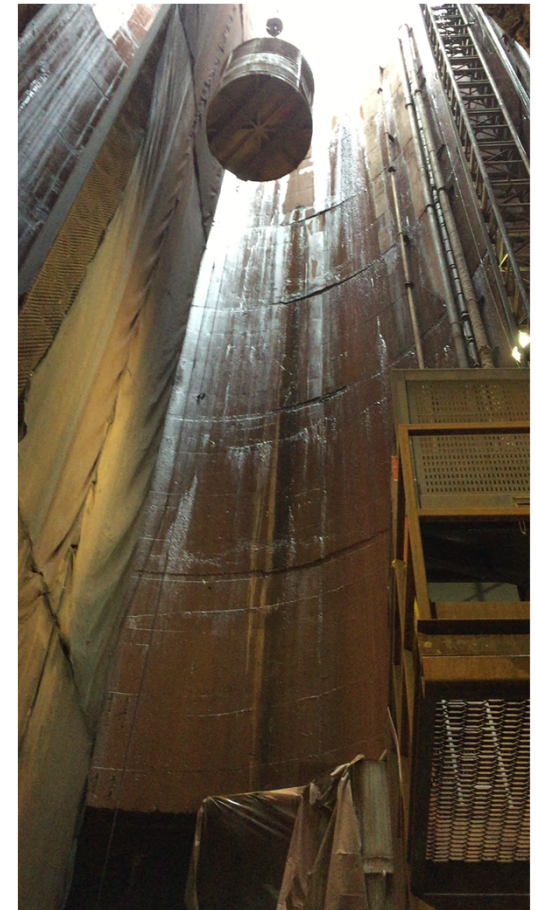
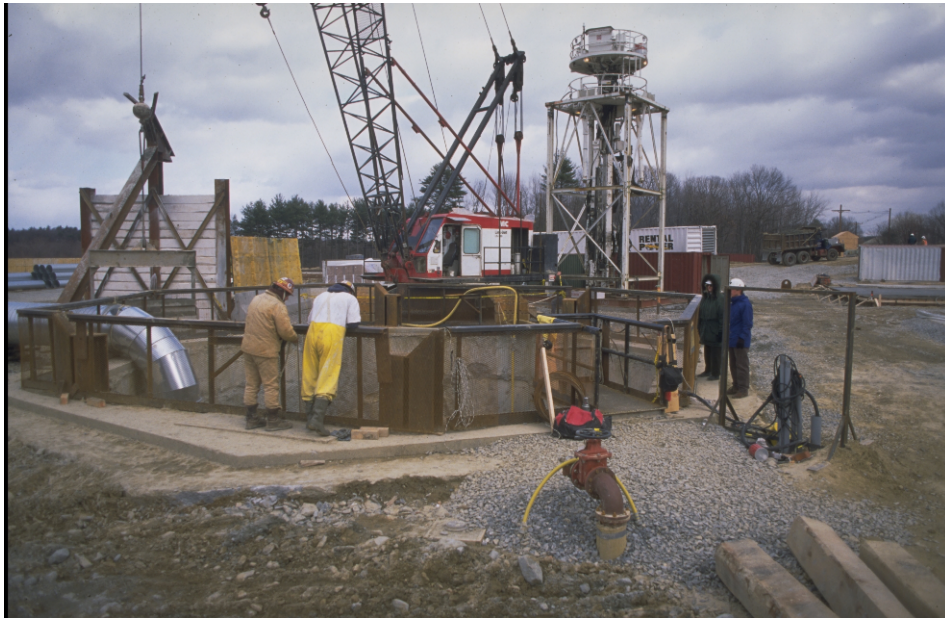
# Tunnel Sequence







# Shafts



- Why do we need them?
- How large are they?
- How are they “generally” constructed?



# Shafts – Top Down Method

## Sequence

- Overburden (Soil)
  - Install support of excavation to top of rock (Secant piles, slurry walls, ground freezing)
  - Excavate soil using conventional excavation equipment (excavators) and muck bins
  - Hoist excavated soil from shaft bottom to surface
- Rock
  - Use controlled blasting to break up rock (5 to 10 feet at a time)
  - Remove broken up rock with conventional excavation equipment
  - Install initial support, typically rock bolts with wire mesh or shotcrete (sprayed concrete)





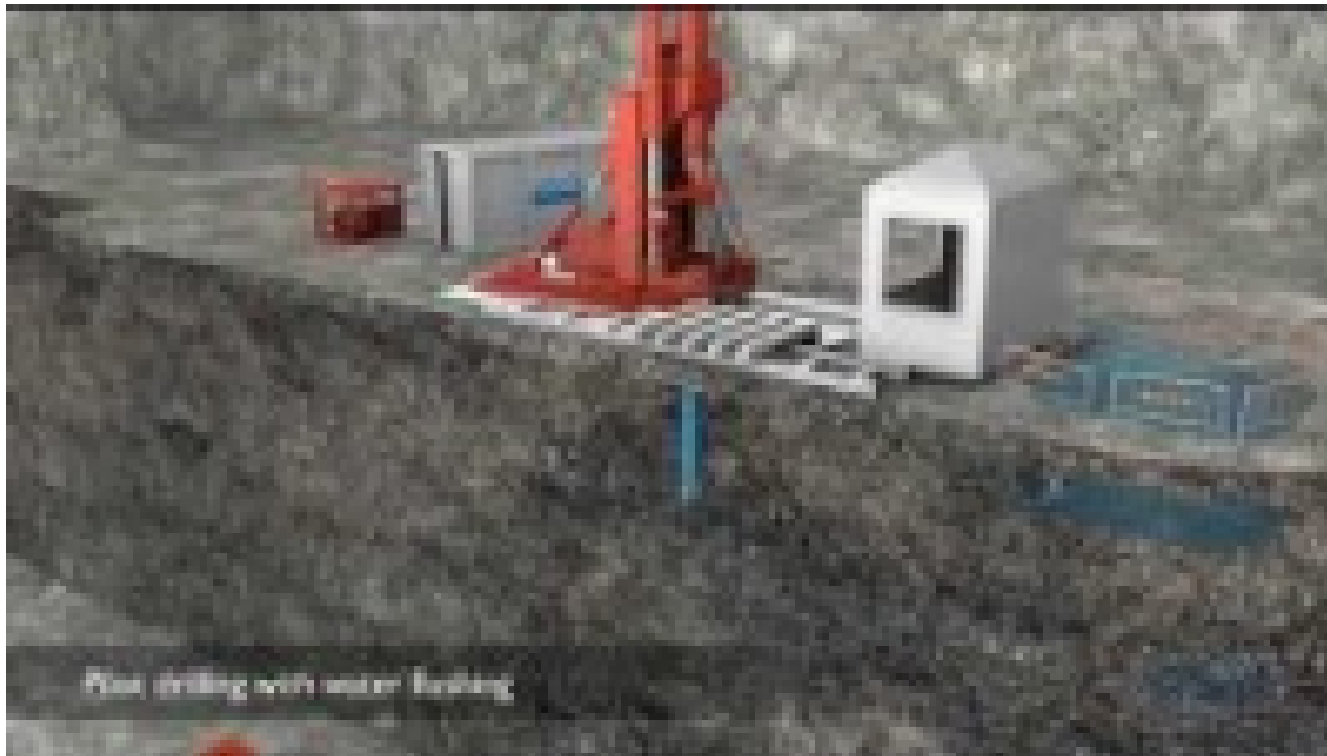


## Shafts – What you'll see from the bottom (Launching Shaft)





## Shafts – Bottom Up Method (Raise Bore)



Source: <https://my.sandvik.com>

### Sequence\*:

- Pilot Hole
- Pilot bit removal
- Reamer bit installation
- Reaming / Excavation
- Muck Removal

\* Requires tunnel to be completed first





## Shafts – Bottom Up Method (Raise Bore)



LEFT TOP: Truck-mounted Drill Rig installs pilot hole through top of tunnel.



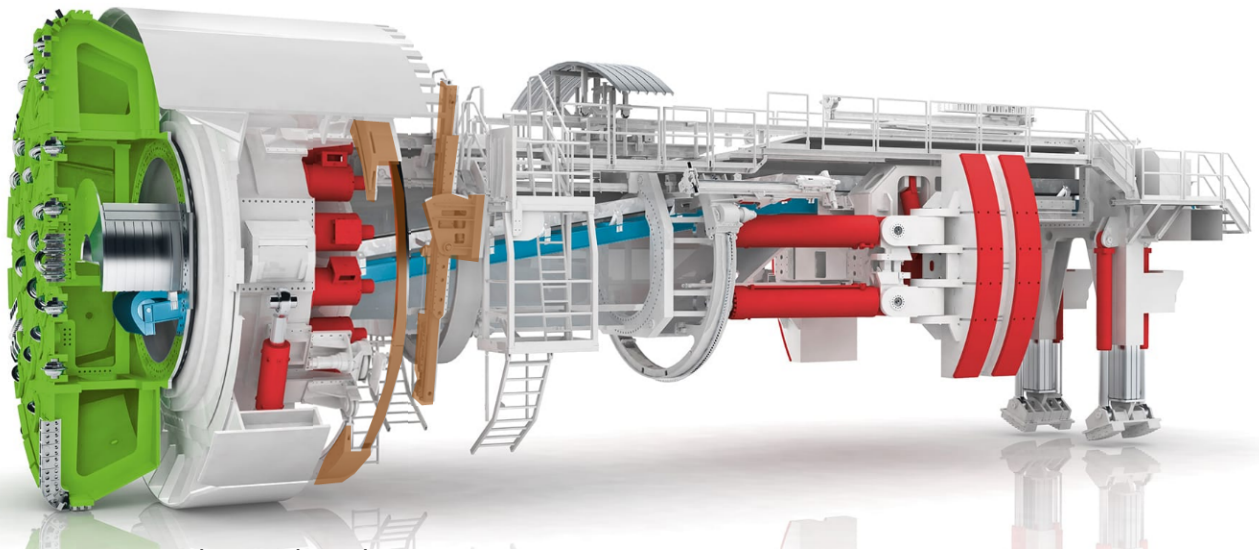
LEFT BOTTOM: Raise bore drill used to rotate and extract raise bore cutterhead to the surface (reaming the pilot hole).



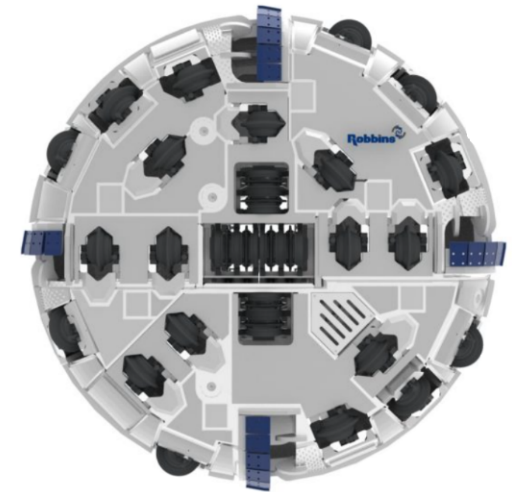
RIGHT: Worker, in tunnel, attaches raise bore cutterhead to pilot hole drill steel.



# TBM Current Technology



Source: [www.herrenknecht.com](http://www.herrenknecht.com)



Source: [www.robblins.com](http://www.robblins.com)

- **Cutterhead** grinds the bedrock into small pieces
- **Conveyors** move the broken rock to the back of the TBM
- **Self propelled** grippers push to side of tunnel, jacks propel forward
- Bedrock is self supporting or supported with rib (**rib erector**), rock bolts (**rock drill**), and shotcrete





# TBM Disc Cutters

Concentric kerfs on rock face



TBM Cutterhead and  
Disc Cutters



# Some TBM Facts



**Crew size:** 10-15 people below ground, more above ground, work around the clock, periodic breaks for maintenance



**Height of the TBM:** 12 foot diameter – roughly height of a room



**Speed:** Time sensitive, relatively slow! Approximately 50 feet per day - over 1000 years to reach the center of the earth at this rate



**Length of the TBM and Trailing Gear:** 300 feet long – a football field or about 10 school buses end to end



**Rock Cutters:** Called disc cutters - hardened steel, narrow edge rolls under high thrust to fracture the rock



**Manufacturers:** Herrenknecht AG, Akkerman, Lovat, and Robbins, are a few of the major ones





## How is a TBM Launched?

Before launching the TBM – prepare the bottom of the launching shaft



Starter and Tail Tunnels constructed from base of Launching Shaft



Develop base of Launching Shaft (vertical conveyor, water pumps, ventilation, TBM power)





# How is a TBM Launched?



Lower TBM to base of Launching Shaft



TBM Assembled on Rails moved to end of starter tunnel, and Launched



## How is a TBM Removed?



- The TBM keeps tunneling forward until it reaches the extraction or receiving shaft at the end of the tunnel
- The TBM “breaks in” through the receiving shaft wall
- The TBM is disassembled much like it was assembled and removed





# What Happens to the Excavated Rock?



Conveyor



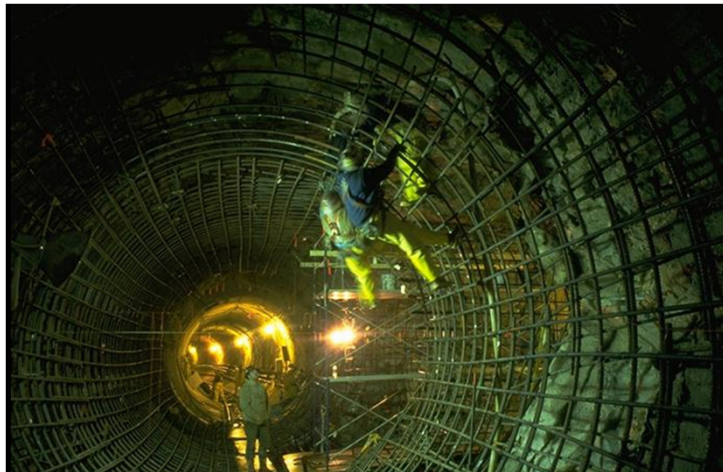
Muck Cars







# Tunnel Liner





**What You'll See  
on the Surface**





## Construction Site – Before and After Aerial Metrowest Water Supply Tunnel – Shaft 5A



- 5 acres +/- (typical)
- Close to transportation
- Close to body of water for discharge
- Near our existing infrastructure
- Away from sensitive receptors





# Construction Site – Before and After Aerial Metrowest Water Supply Tunnel – Shaft L



APPROXIMATE  
CONSTRUCTION  
AREA



APPROXIMATE  
CONSTRUCTION  
AREA

APPROXIMATE  
PERMANENT  
AREA

TBM launch site

- Permanent: 1.5 acres (typical)



## What You'll See



- What's at the site during construction?
  - Is it loud, is it disruptive?
  - How long does construction last?







## **Environmental Considerations (Construction Impacts)**



# Environmental Considerations (Construction Impacts)

## Some 24/7 operation – e.g. TBM Work:

- Locate construction shafts away from homes/businesses
- Install noise barriers to mitigate construction nuisances
- Connection shaft, valve chamber & piping construction have more normal schedules

## Controlled Blasting @ TBM Construction Shaft Site:

- Rock removal is done via controlled blasting
- Specialist assessment of vibration potential
- Set vibration limits & monitoring - protect nearby homes/businesses
- Close coordination with local Fire, Emergency Response, and Rescue

## Construction Traffic:

- Most impact at TBM launching shaft site
- Less at TBM receiving shaft site
- Still less at connection shaft sites
- Dedicated haul routes





## Upcoming Meetings

- September
  - Preliminary Alternatives and Evaluation Criteria
- October
  - Conceptual Designs
- Future topics
  - Shaft Sites, Community Engagement, Costs & Financing, Environmental Mitigation, Site Visits
  - Tell us what you want to hear about/discuss
- MWRA Program Team can provide individual briefings/presentations to your community/organization at any time. Just ask!





## Metropolitan Water Tunnel Program

- Contact Us
  - Carmine DeMaria, Community Relations Coordinator
  - 617-305-5725
  - [Carmine.DeMaria@mwra.com](mailto:Carmine.DeMaria@mwra.com)
  - [Tunnels.info@mwra.com](mailto:Tunnels.info@mwra.com)
- <https://www.mwra.com/mwtp.html>
  - Meeting notices, agendas, presentations, minutes



## Questions/Comments?



Thank you for your  
continued partnership!