Super Storm Sandy:
Under River Tube Recovery and Resiliency

June 5 2013
Sandy damaged 9 under-river tubes
Sandy damage to under river tubes was historic

- Flooded track and equipment
- Destroyed pump control
- Shorted electrical equipment
- Damaged fan control
- Failed signals
- Broken communication gear
Temporary solutions that facilitated prompt service restoration requires permanent fixes and upgrades

Examples

Temporary configurations

- Temporary power lines for pumps
- Temporary pumps
- Temporary wiring for signals, fans, comms

Reduced redundancy

- Fan plants
- Circuit Breaker Houses
- Power feeds
- Reduced pumping capacity
Failures affecting customers have dramatically increased in some areas post-Sandy

Number of customers delayed per month due to signal failures in Montague Tube

In the 6 months before Sandy (customers delayed due to signal problems in Montague tube per month)

300

In the 6 months after Sandy (customers delayed due to signal problems in Montague tube per month)

38,300

120 x increase in customers delayed
Failures affecting customers have dramatically increased in some areas post-Sandy

Number of customers delayed due to signal failures in Montague Tube
In addition corrosion is now becoming apparent that will lead to further failures and customer delays if left unchecked.

Greenpoint Tube rail plates

Greenpoint Tube pump cable

Externally cable appears undamaged but corrosion occurring within jacket
Montague and Greenpoint sustained heavy flooding and were the last tubes to re-enter service post-Sandy

- Opened 1920
- Flooded to ceiling
- Longest tube in system (5000’)
- Re-entered service Dec 21
- Extensive damage to all systems

- Opened 1933
- Flooded to ceiling
- Re-entered service November 10
- Extensive damage to all systems
Montague and Greenpoint tubes flooded to ceiling

Flood line extends to ceiling (Montague)
Montague cable replacement work is complicated by damaged concrete and terracotta ‘duct banks’ that must be demolished and rebuilt.
Montague and Greenpoint tube damage – damage makes pulling cable without rebuilding of the 28,000 linear feet of the duct bank infeasible
Montague and Greenpoint tube damage – duct bank damage
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Montague and Greenpoint tube damage – signal problems
(impedance bond)
Montague and Greenpoint tube damage – circuit breaker house damage that could reduce power reliability
Montague and Greenpoint tube damage – temporary configuration of Whitehall pump plant
Montague and Greenpoint tube damage – corroded rail and fasteners
Montague and Greenpoint tube damage – corroded rail and fasteners
Damaged systems are safe but will lead to increasing delays if unaddressed - we will not compromise on safety

- Power cables
- Communication and control cables
- Signals
- Tunnel lighting
- Track
- Circuit Breaker Houses
- Third Rail
- Fans
- Pumps
To maximize speed and stay ahead of failures an intense work program is planned for Montague and Greenpoint tubes.

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<tr>
<th>Tube</th>
<th>2013</th>
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<td>Jun</td>
<td>Jul</td>
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<td>Montague – 24/7 shut down</td>
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<td>Greenpoint - 12 weekend outages 2013 and 5 week 24/7 shutdown in summer 2014</td>
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Outages on weekends commencing at 12:01 AM on Saturday on these dates:
- July 6
- July 13
- July 20
- August 3
- August 10
- August 17
- August 24
- September 7
- September 28
- October 5
- December 7
- December 14
24/7 shutdown in Montague means other tubes don’t need to wait multiple years for restoration work

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<th>Tube</th>
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<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tr>
<td>Conventional approach for Montague <strong>R</strong> (weekend outages)</td>
<td>Work can start on an adjacent tube</td>
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<td>24/7 shutdown for Montague <strong>R</strong></td>
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Accelerated approach helps reduce unexpected customer delays and further deterioration

- Directly addresses root causes of increased delay causing failures already observed
- Gets ahead of slower onset causes of delay (e.g., corrosion)
- Reduces dramatically the number of post weekend ‘mid-job’ returns to service with associated possibilities for delay causing troubles
Weekday Service During Montague Tunnel Closure

R Service will be split
• Northern R – Forest Hills-71 Av to/from Whitehall St-South Ferry
• Southern R – Bay Ridge-95 St to/from Court St

Service Frequency
• Peak hour service will be slightly reduced due to track capacity limitations (8 TPH vs 10 TPH)
• Off-peak service frequencies will be unchanged

Subway Crowding
• Loads on the R and adjacent lines will increase but are projected to be within our maximum loading guidelines
• Station crowding at transfer locations will be monitored and additional staffing added as needed

Enhanced customer communications regarding transfers and alternative travel routes
Weekday Service During Montague R Tunnel Closure – service alternatives

Riders can transfer to the following lines 2 3 4 5 A C B D F N Q all of which are accessible from the final four R stations in Brooklyn
Weekend/Late Night Service During Montague Tunnel Closure

Weekend Service
- Operates between Forest Hills-71 Av and Bay Ridge-95 St over the Manhattan Bridge

Six stations bypassed
- City Hall
- Cortlandt St
- Rector St

- Enables targeted work at bypassed stations
- Provides a faster ride for some riders traveling between Manhattan and Brooklyn

Late Night Service (Daily)
- Normal shuttle between Bay Ridge-95 St and 36 St would operate

- Service would be rerouted over the Manhattan Bridge (6 stations bypassed)

Enhanced customer communications regarding transfers and alternative travel routes
Service During Weekend closures

Service
- Operates between Nassau Av and Church Av during weekend closures

Bus Shuttle Service
- Operates between Nassau Av and Court Sq, making subway stops during weekend closures
- 3-5 min headway

Stations not served by the G during weekend closures
- Greenpoint Av
- 21 St
- Court Sq

Targeted enhancements in stations out of service on weekends