Houston’s Upper Brays Tunnel Liner Removal
A True Trenchless Project

Presented by
Mary Bac, P.E. – City of Houston
Datta Shirodkar, P.E. – Boyer Inc
Overview

- History & Background
- Investigation & Inspection
- Project Scope of Work
- Anticipated Challenges
- Pre-Planning & Safety
- Construction Overview
Upper Brays Tunnel History

• 108-inch tunnel approximately 60 feet deep installed from 1988 to 1990

• Part of West District Diversion project

• Location: Tunnel runs west from the junction box at W. Sam Houston Parkway S. and Westheimer Road and turns south at West Houston Center Boulevard

• Designed by Pate Engineers and constructed by National Projects, Inc.

• MRC sewer with corrosion protection consisting of concrete with limestone aggregate and 6mm HDPE liner (Schlegal Lining)
Tunnel Contracts - Vicinity Maps

West District Diversion Contract No. 1  West District Diversion Contract No. 2
Tunnel Contracts - Specifications

- RCP or MRC sewer with corrosion protection, consisting of concrete with limestone aggregate and a PVC or HDPE liner

- Liner: PVC liner integrally cast into the concrete (Ameron T-Lock or equal) or an HDPE liner mechanically fastened to the concrete (Schlegel Lining or equal)

- HDPE Liner: 6mm thick white sheet anchored at the bottom edges (5 o’clock and 7 o’clock positions) and crown of the pipe with bolts and HDPE batten strips.

- Stainless Steel Anchoring Rings: Upstream and downstream of each manhole, and every 100 feet along sewer. Three anchoring rings 12-inches apart at upstream and downstream of each structure and beginning and end of each segment.
Tunnel Contracts - Details

**MONOLITHIC REINFORCED CONCRETE (MRC) SEWER IN LINED TUNNEL**

**INTERIOR LINING DETAIL**
Schlegal Lining

- Self-Supporting HDPE Liner
- Anchoring: Steel batten strips and HDPE batten strips
- Fasteners: Stainless Steel Type 304 bolts
- Spacers at bottom of liner for drainage to relieve back water pressure
- Schlegal submittal shows 4mm liner (City objected) with no anchoring rings between manholes (no objection by City noted)
Schlegal Lining (cont’d)

• 26 installations world-wide and 15 installations in U.S., 14 of which were installed in the City of Houston (the other was in Austin)

• Liner was installed by SLT North America (Schlegal) and Environmental Protection Systems

• Most of the City installations were part of the Northside Relief Sewer System.

• 1991 video inspection showed 54% of approximately 64,000 feet of HDPE liner installed in Northside Sewer Relief Tunnel (NSRT) had failed, 4% had major deformations and 42% had minor deformations (Allen & Bishop, 1994)

• 1991 Upper Brays Tunnel showed little deformation, but the system was not in operation at that time (Allen & Bishop, 1994)
Tunnel Liner Investigation

• Tunnel Liner Investigation Reports: Prepared by Turner Collie & Braden (TC&B) in 1992 for NSRT and 1994 for Upper Brays Tunnel, Horspen Gulley and Smith Road Systems

• TC&B report (Allen & Bishop, 1994) indicated primary cause of failure was the method of attachment of the liner to the pipe

• Schlegel Lining submittal indicates lining system is self-supporting, so a design for static water pressure was not needed, since there is a space between the pipe and liner that allows for water to drain through weep holes at the bottom edges.
Tunnel Liner Investigation (cont’d)

• Schlegal calculations did not consider the possibility of flow level being above the bottom edges for a prolonged period

• With flow levels above the bottom edges, static water pressure would not be relieved leading to potential liner failure

• TC&B also reported that imperfections impacting circular shape of sewer could result in non-uniform support of liner

• TC&B recommended that the liner be removed from all tunnels and for the tunnels to be inspected every 10 years.
Sewer Inspection

- RedZone Robotics sewer inspection performed in 2013 by CleanServe
- Liner failure observed in multiple locations
- Some liner completely detached from crown of pipe
- Equipment unable to pass in multiple areas
- Inspection was abandoned 365 feet downstream of manhole UBU01007 due to high water level
- No inspection performed from UBU01007 to the lift station due to high water level
Sewer Inspection (cont’d)

UBU01013 - UBU01012

Cross Section
Sewer Inspection (cont’d)

UBU01011 – UBU01010

UBU01009 – UBU01008
Sewer Inspection (cont’d)

### Gas Summary

<table>
<thead>
<tr>
<th>Upstream MH</th>
<th>Downstream MH</th>
<th>Average Concentration of H₂S (ppm)</th>
<th>Maximum Concentration of H₂S (ppm)</th>
<th>Average Temperature (degrees F)</th>
<th>Maximum Temperature (degrees F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBU01013</td>
<td>UBU01012</td>
<td>7.3</td>
<td>9.0</td>
<td>94</td>
<td>96</td>
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<tr>
<td>UBU01012</td>
<td>UBU01011</td>
<td>6.4</td>
<td>8.0</td>
<td>88</td>
<td>90</td>
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<tr>
<td>UBU01011</td>
<td>UBU01010</td>
<td>7.4</td>
<td>8.0</td>
<td>88</td>
<td>88</td>
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</tbody>
</table>

### Flow Summary

<table>
<thead>
<tr>
<th>Upstream MH</th>
<th>Downstream MH</th>
<th>Flow Height</th>
</tr>
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<tbody>
<tr>
<td>UBU01013</td>
<td>UBU01012</td>
<td>20%</td>
</tr>
<tr>
<td>UBU01012</td>
<td>UBU01011</td>
<td>20%</td>
</tr>
<tr>
<td>UBU01011</td>
<td>UBU01010</td>
<td>30%</td>
</tr>
<tr>
<td>UBU01010</td>
<td>UBU01009</td>
<td>30%</td>
</tr>
<tr>
<td>UBU01009</td>
<td>UBU01008</td>
<td>30%</td>
</tr>
<tr>
<td>UBU01008</td>
<td>UBU01007</td>
<td>30%</td>
</tr>
<tr>
<td>UBU01007</td>
<td>UBU01006</td>
<td>30%</td>
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## Sewer Inspection (cont’d)

<table>
<thead>
<tr>
<th>Upstream MH</th>
<th>Downstream MH</th>
<th>Inspected Length (ft)</th>
<th>Average Sediment Depth (inches)</th>
<th>Sediment Volume (CY)</th>
<th>RedZone Recommendation</th>
<th>Inspected Length (ft)</th>
<th>Sediment Depth (inches)</th>
<th>Sediment Volume (CY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBU01013</td>
<td>UBU01012</td>
<td>616</td>
<td>0.0</td>
<td>0.0</td>
<td>No cleaning</td>
<td>980</td>
<td>0</td>
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<tr>
<td>UBU01012</td>
<td>UBU01011</td>
<td>1759</td>
<td>3.4</td>
<td>38.6</td>
<td>No cleaning</td>
<td>1800</td>
<td>0</td>
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<tr>
<td>UBU01011</td>
<td>UBU01010</td>
<td>432</td>
<td>3.2</td>
<td>8.7</td>
<td>No cleaning</td>
<td>1570</td>
<td>0</td>
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<tr>
<td>UBU01010</td>
<td>UBU01009</td>
<td>1315</td>
<td>1.9</td>
<td>12.3</td>
<td>Light cleaning from 1161.5 ft to 1179.8 ft</td>
<td>1285</td>
<td>0</td>
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<tr>
<td>UBU01009</td>
<td>UBU01008</td>
<td>1760</td>
<td>1.3</td>
<td>9.3</td>
<td>No cleaning</td>
<td>1725</td>
<td>0</td>
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<tr>
<td>UBU01008</td>
<td>UBU01007</td>
<td>1245</td>
<td>4.2</td>
<td>38.0</td>
<td>No cleaning</td>
<td>1215</td>
<td>0</td>
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<tr>
<td>UBU01007</td>
<td>UBU01006</td>
<td>365</td>
<td>14.1</td>
<td>65.8</td>
<td>Light cleaning</td>
<td>990</td>
<td>3”-6” over 215 feet upstream of MH 006</td>
<td>7.4</td>
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<tr>
<td>UBU01006</td>
<td>UBU01005</td>
<td>1285</td>
<td></td>
<td></td>
<td></td>
<td>1285</td>
<td>8-18” sand and mud over most of the segment</td>
<td>133.9</td>
</tr>
<tr>
<td>UBU01005</td>
<td>UBU01004</td>
<td>810</td>
<td></td>
<td></td>
<td></td>
<td>810</td>
<td>0</td>
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<tr>
<td>UBU01004</td>
<td>UBU01003</td>
<td>1090</td>
<td></td>
<td></td>
<td></td>
<td>1090</td>
<td>3”-6” soft mud over 200 feet</td>
<td>3.7</td>
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<tr>
<td>UBU01003</td>
<td>UBU01002</td>
<td>1780</td>
<td></td>
<td></td>
<td></td>
<td>1780</td>
<td>6-26” over entire segment</td>
<td>378.6</td>
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<tr>
<td>UBU01002</td>
<td>UBU01001</td>
<td>1340</td>
<td></td>
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<td></td>
<td>1340</td>
<td>24” soft mud over 70 feet downstream of MH 002</td>
<td>27.3</td>
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Debris Estimate

<table>
<thead>
<tr>
<th>Engineer’s Debris Estimate</th>
<th>Debris (CY)</th>
<th>Debris (Wet Ton) 1.5 Tons/CY</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBU01013 to UBU01006</td>
<td>173</td>
<td>260</td>
<td>Redzone Inspection</td>
</tr>
<tr>
<td>UBU01006 to UBU01001</td>
<td>544</td>
<td>816</td>
<td>1996 Man Entry Inspection</td>
</tr>
<tr>
<td>Total Estimated Debris</td>
<td></td>
<td>1076</td>
<td></td>
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<tr>
<td>(Wet Tons)</td>
<td></td>
<td></td>
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</table>
## Flow Data

<table>
<thead>
<tr>
<th>Remarks</th>
<th>Node 1</th>
<th>Node 2</th>
<th>Node 3</th>
<th>Node 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Weather 2hr Peak Flow, MGD</td>
<td>97.92</td>
<td>84.25</td>
<td>56.65</td>
<td>30.62</td>
</tr>
<tr>
<td>Design Rain (2Y6H) Event has been used to calculate Wet Weather Peak; 10.5 MGD Flow has been diverted from West District to Upper Brays during this period.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Peak Hour Dry Weather Flow, MGD</td>
<td>11.26</td>
<td>7.88</td>
<td>3.92</td>
<td>3.96</td>
</tr>
<tr>
<td>No flow has been diverted from West District to Upper Brays during Dry Weather Model Run.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Average Daily Flow, MGD</td>
<td>7.68</td>
<td>5.77</td>
<td>2.33</td>
<td>3.44</td>
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<tr>
<td>No flow has been diverted from West District to Upper Brays during Dry Weather Model Run.</td>
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<tr>
<td>Minimum Flow, MGD</td>
<td>3.26</td>
<td>3.00</td>
<td>0.95</td>
<td>2.05</td>
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<tr>
<td>No flow has been diverted from West District to Upper Brays during Dry Weather Model Run.</td>
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<td></td>
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</tr>
</tbody>
</table>
Upper Brays Tunnel Liner Removal Project

- Timeline
  - Bidset preparation: January 2016 to February 2016
  - Advertisement: 02/19/16 & 02/26/16
  - Pre-bid Meeting: 03/02/16
  - Bid Opening: 03/24/16
  - Notice to Proceed: 07/13/16

- Estimated Construction Cost: $12 million
- Contract Duration: 730 days
Scope of Work

• Removal of approximately 16,000 linear feet of liner from the 108” Upper Brays tunnel starting at the Westheimer West Belt junction box and ending at the bypass shaft at the Upper Brays Lift Station

• Disposal of approximately 0.5 million pounds of HDPE Liner

• Flow Control: Total and/or partial diversion/bypass pumping of existing wastewater flows (dependent on the Contractor’s means and methods)

• Traffic Control (TxDOT right of way on Westheimer)

• Removal & Disposal of debris

• Post liner removal laser inspection, sonar inspection and condition assessment via robotics
Scope of Work - Continued

• Modification/Removal/Installation of drops inside existing Manholes

• Removal of existing Grating & Ladders

• Installation of Safety nets in lieu of existing ladders & grating

• Construction of a Permanent Diversion Structure in place of an existing Manhole
Vicinity Map
Anticipated Challenges

• Safety
• Traffic Control
• Flow Control
• Limited Access
  • Diversion Structure at Treatment Plant
  • Junction Box at Beltway/Westheimer
  • 11 manholes (2 offset, 1 buried, 5 in or near street) over 1,000 feet apart
• Complaints
## Bid Results

<table>
<thead>
<tr>
<th>Bidder</th>
<th>Bid Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boyer, Inc.</td>
<td>$8,876,300.00</td>
</tr>
<tr>
<td>PM Construction &amp; Rehab, LLC</td>
<td>$11,811,326.60</td>
</tr>
<tr>
<td>Oscar Renda Contracting, Inc.</td>
<td>$12,178,000.00</td>
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<tr>
<td>Kenny Construction Company</td>
<td>$13,141,465.00</td>
</tr>
<tr>
<td>S.J. Louis Construction of Texas, Ltd.</td>
<td>$22,368,100.00</td>
</tr>
</tbody>
</table>
PRE-PLANNING & SAFETY

• Tunnel Layout & Location

• Safety
  • Ingress/Egress
  • Transportation inside the tunnel
  • Ventilation
  • Communication

• Custom Fabrication

• Avoid/reduce/eliminate citizens complaints

• Cause minimum disruption
CONSTRUCTION OVERVIEW

• Flow Control
• Cleaning, Debris Removal & Disposal
• Liner Removal & Disposal
• Laser Scanning & CCTV
• Construction of Permanent Diversion Structure
TUNNEL LAYOUT & LOCATION
INGRESS & EGRESS

- 20’ dia. Access shaft at Upper Brays LS
- Crane & Man Basket
- Landing at the bottom of access shaft
- Ladder to get to the invert of the tunnel
LOWERING CREW INSIDE THE ACCESS SHAFT
TRANSPORTATION INSIDE THE TUNNEL

• Bob Cat Skid Steer
• Custom Fabricated Cart
  • Budgeted Cost – Kia Reo
  • Actual Cost – BMW 328i (Fully Loaded)
VENTILATION

• Most Important aspect of Safety
• Move 1,000,000 Cubic feet of air
• Minimum 200 CFM Per Person
• Minimum air velocity – 30 ft./min
• Combination of 2-5HP, 1-50HP, 1-40-HP, 2-20 HP Blowers
• Blowers Operating in Blow & Suction mode
• Ventilated Tunnel 3 miles long, 108” in diameter, 65 ft. below ground
• Air Velocities up to 400 ft./min
VENTILATION PLAN – PROFILE VIEW
20 HP BLOWER IN BLOW MODE
40 HP BLOWER IN EXHAUST MODE
40 HP BLOWER IN EXHAUST MODE
COMMUNICATION

- Main Repeater Station
- 4 Mobile Repeater stations
- Digital Radios
- Seamless Communication inside the 3 mile tunnel & above ground
COMMUNICATION - MAIN REPEATER
COMMUNICATION SCHEMATIC
CUSTOM EQUIPMENT & FABRICATION

• Tower Crane
• Bob-Cat Skid Steer
• Debris Screen/Catch bar
• Debris cleaning bucket
• Debris Disposal Bucket
• Transportation Cart
• Batten Strip Removal attachment
FLOW CONTROL/DIVERSION
FLOW CONTROL/DIVERSION

Install Diversion weir

- Excavate 30’Lx30’Wx50’D Shaft
- Saw Cut 28”T reinforced concrete slab
- Laser Scan Inside of the existing JB
- Design, Fabricate & Install a diversion weir with 36” Pneumatic Knife Gate Valve
DIVERSION WEIR OPERATION

- Open Knife Gate Valve everyday at 6.30 am and Close at 5.00 pm
- Store flow in 72” & 78” Pipes Upstream
- Coordinate with WWOP’s to shut off Lift Stations everyday
- Divert Flow inside the 108” Tunnel
CLEANING, DEBRIS REMOVAL & DISPOSAL

- Total 600 TN of Sewer Debris
- Granular Sand
- Skid Steer with Custom Fabricated cleaning Bucket
- Custom Fabricated Disposal Bucket
CUSTOM DISPOSAL BUCKET
CUSTOM DISPOSAL BUCKET
READY FOR A WALK ??
LINER REMOVAL & DISPOSAL

• HDPE Liner – 0.25’ thick
• Cut into strips – 3ft. Wx10-12ft. L using pneumatic bucket chain saws
• Floated & drug inside the Tunnel using Skid steer
• Washed using bleach & muriatic acid
• Bundled together after cutting using 3ftx3ft panels
• 0.5 Million pounds recycled – Environmentally friendly
• Batten Strips removed using Skid Steer & Custom attachment
LINER REMOVAL & DISPOSAL
LOWERING CREW USING REMOTE CONTROLLED TOWER CRANE
CUTTING LINER USING PNEUMATIC CHAIN SAWS
CUTTING LINER USING PNEUMATIC CHAIN SAWS
CUTTING LINER USING PNEUMATIC CHAIN SAWs
LINER CUT IN PANELS
TUNNEL AFTER REMOVING LINER
TUNNEL AFTER REMOVING LINER
SCHLAGEL LINER SCARPYARD?
CLEANER THAN YOUR KITCHEN TABLE!!
READY TO MAKE SOME CHAIRS
LASER SCANNING & CCTV

• Specified – Red-zone Robotics
• Proposed – Laser Scanning & CCTV
• True As-Built showing the horizontal & vertical deflections in the tunnel & elevation of the tunnel invert at any point
• Information can be used on a future Rehabilitation Project
PERMANENT DIVERSION STRUCTURE

- Change Order within the allocated budget
- Upgrade to the Upper Brays system
- Future access & flow Diversion during rehab & inspection
- Built on top of existing 12’Wx15’L Junction box
- 12’Wx15’Lx50’D with 2’T reinforced walls
- Lined with Corrosion Protection Danby PVC Liner
- 316 SS Guide Rails in the corner for future diversion weir
- Removable Pre-Cast Lids with in-built 48” MH Ring & Cover
PERMANENT DIVERSION STRUCTURE
STRUCTURAL SLAB INSTALLATION
INSTALLATION OF DANBY PVC LINER
FIRST 10 FT POUR
LAST 10 FT POUR
FINISHED STRUCTURE
SETTING REMOVABLE PRECAST LID
HIGHLIGHTS

- Project located on Major Thoroughfare
- Very minimal to no complaints
- True Trenchless project
- Ventilated entire Tunnel: 3 Miles, 108” Dia, 65 ft. Below Ground
- Communication throughout entire Tunnel
- Project Completed 9 months ahead of schedule
- Project Completed within budget with upgrades to the UB System
- Re-Cycled 0.5 M lbs. of HDPE Liner
KEY PLAYERS

• JASON IKEN – Sr. Assistant Director (ex), COH
• SHANNON DUNE – Sr. Assistant Director, COH
• MARY BAC – Engineer of Record, COH
• DAVID TAJADOD – Construction Manager, COH
• BRAD WINKLER – Construction Manager, Weston Solutions
• BRIAN CAMPBELL – Senior Project Manager, COH
• SIDNEY BOMER – Operations Manager, COH
• SHEMAN IRISH – Site Inspector
• MARK BOYER – President, Boyer Inc.
• KEVIN TREADWELL – Superintendent, Boyer Inc.
Any questions?