THE PROJECT THAT WORE MANY HATS

Successful underground construction lead by an experienced and versatile project team.

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ARCADIS Design & Consultancy for natural and built assets

HOUSTON PUBLIC WORKS

Project Team

- City of Houston Public Works and Engineering - Client
- IDS – Construction Management
- CYMI – Contractor
- Bortunco – Subcontractor
- R+B Group - Subcontractor

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Agenda

1 Project Overview	2 Project Construction Methods	3 Conclusions
• Client Introduction • Project Objective • Project Scope and Design	• History and Overview of Technology • Project Specifics • Construction Applicability	• Construction Methods Recap • Reasons for Success • Questions

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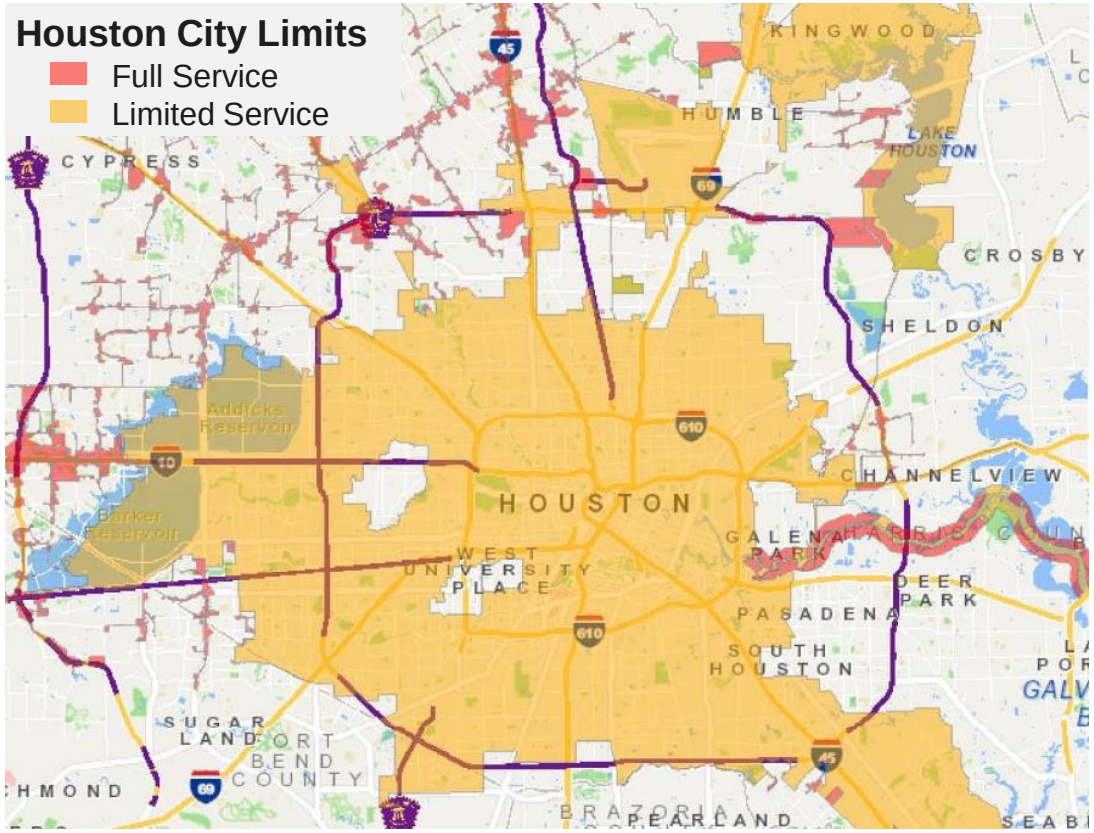
Project Overview

Client: The City of Houston



Source: Houston GIMS

- Serves over 2.1 million residents
- 640 square miles
- 250 MGD
- 6,100 miles of sanitary sewer
- 383 lift stations
- 39 wastewater treatment plants
- Capital Improvement Plan (CIP) covers rehabilitation, elimination and/or replacement of lift stations

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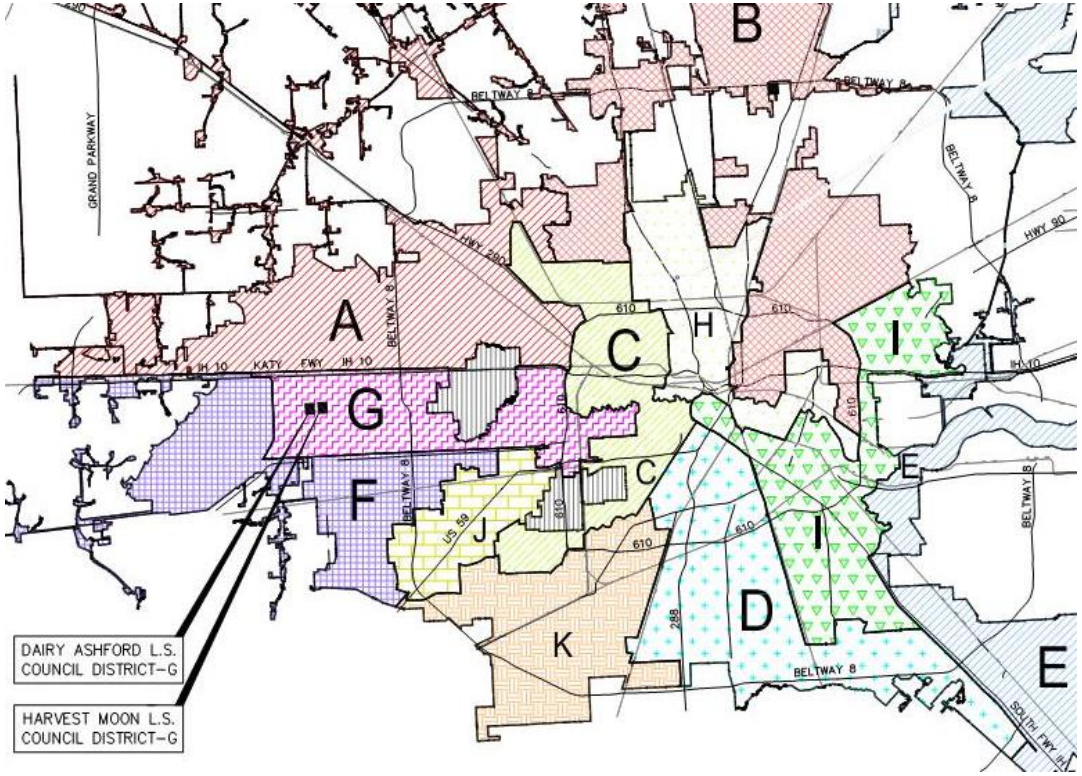
Project: Lift Station Renewal/Replacement

Goal: Eliminate Dairy Ashford Lift Station and Harvest Moon Lift Station

Harvest Moon LS Site



City Council and Lift Station Vicinity Map

Dairy Ashford Lift Station Site

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Project: Lift Station Renewal/Replacement

- **Scope**:
  - Install 4,200 LF of parallel 24” sanitary sewer and 30” force main
  - Replace Harvest Moon Lift Station
    - Higher Capacity (21 MGD)
    - Updated Instrumentation

Parallel Sanitary Sewer and Force Main Alignment

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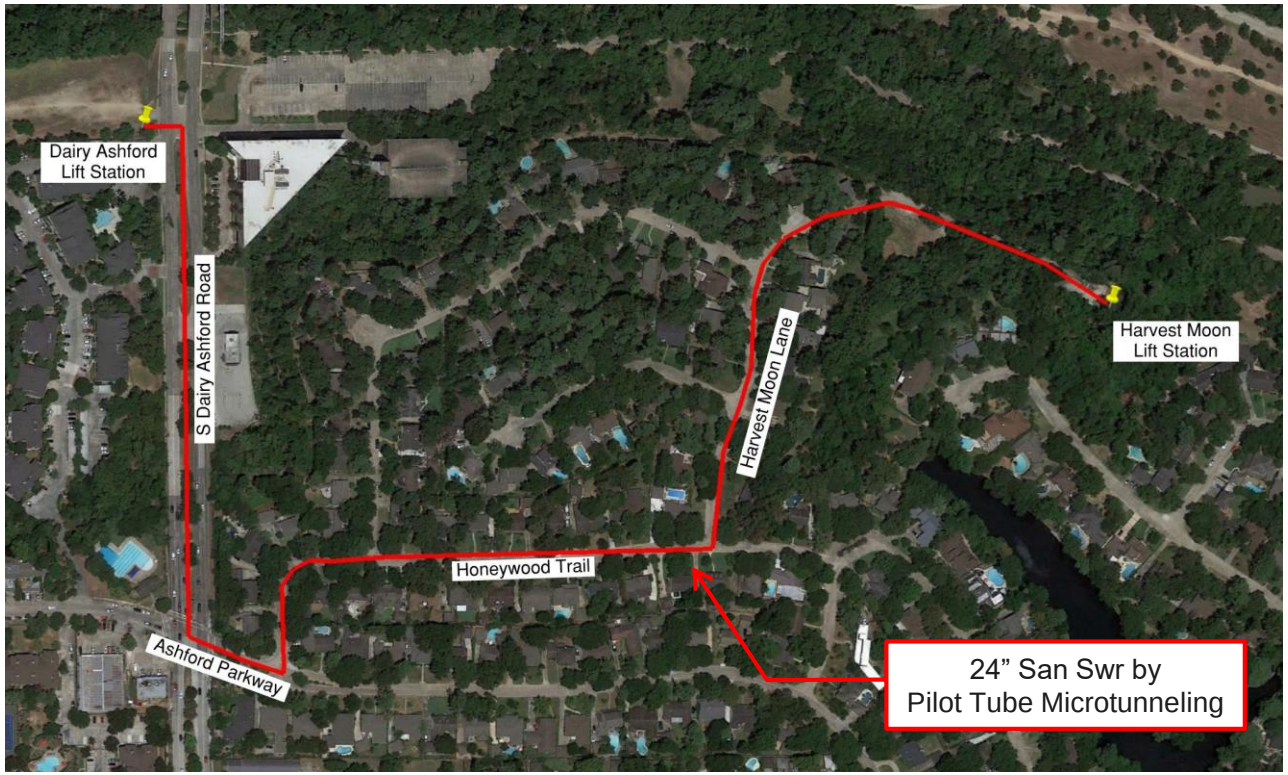
Project Construction Methods:
24-Inch Sanitary Sewer

Construction of 24-Inch Sewer

4,200 LF of 24” sanitary sewer constructed by **Pilot Tube Microtunneling**



Proposed Sanitary Sewer Alignment

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Pilot Tube Microtunneling

History & Overview: Pilot Tube Microtunneling

- Introduced in the United Stated in 1995
- Began as a method for installing small diameter household connections
- Successful installation for pipes from 4” to 48” in diameter
- Three Pass System
  - Precise Installation of pilot tubes
  - Advancing augers along pilot tube path
  - Installation of final product pipe

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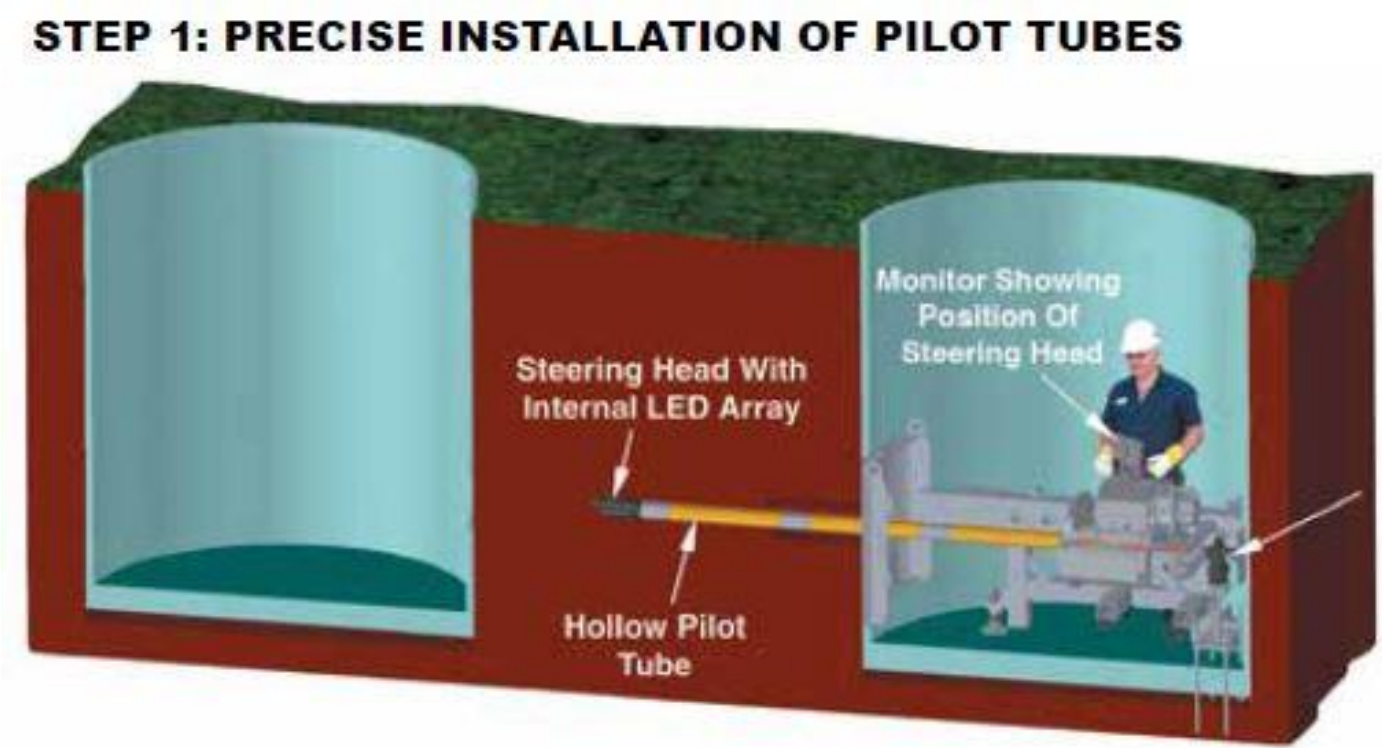
History & Overview: Pilot Tube Microtunneling



Source: Akkerman

The first step in the Guided Boring Method is the installation of the pilot tubes on line and grade.

The pilot tubes are inserted through the ground from the launch shaft to the reception shaft.

Theodolite/Camera, Sighted Down Center of Pilot Tubes

On the leading end of the pilot tube is the steering head with an angled tip.

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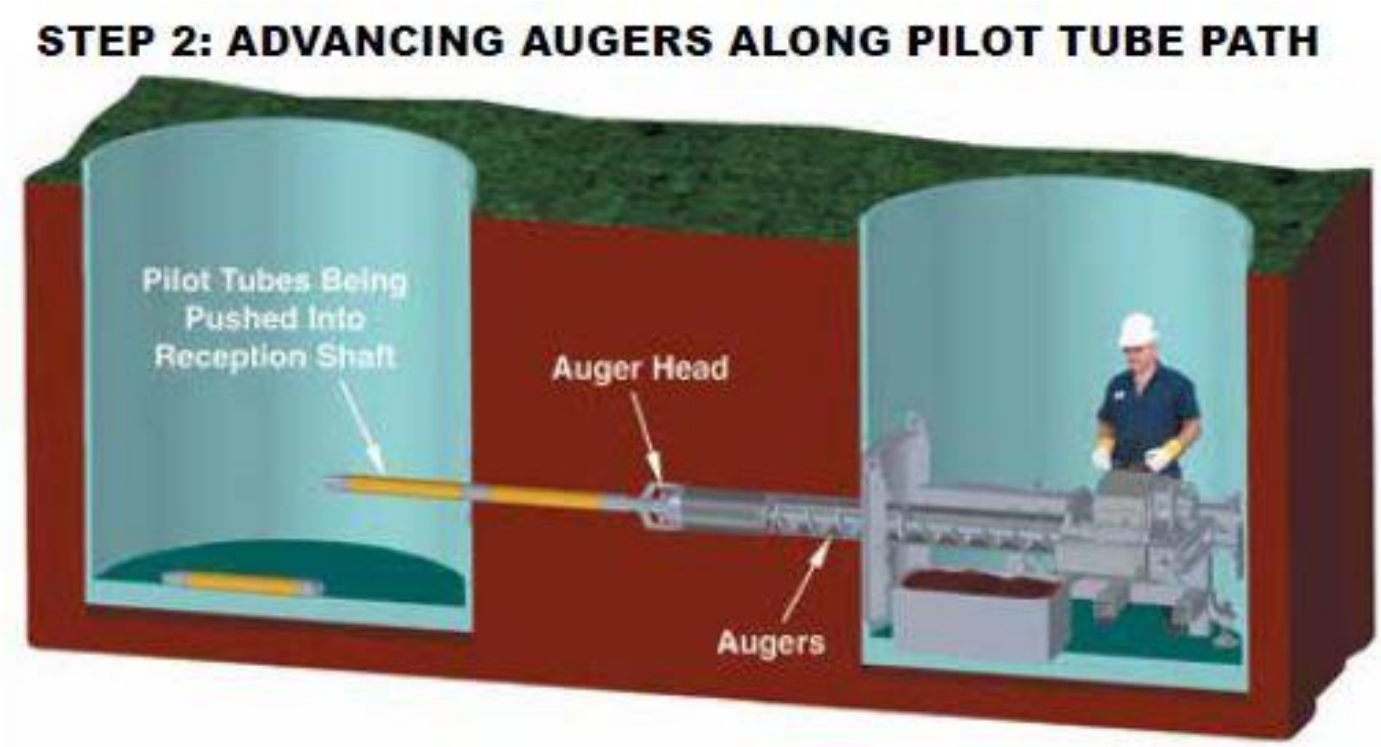
History & Overview: Pilot Tube Microtunneling



Source: Akkerman

The second step is to follow the pilot tube with a reaming head and or a bearing swivel joint to match the diameter of the product pipe. The GBM installs pipe from 4 inch to 48 inch OD. Different types of tooling are available to work in various ground conditions.

The reaming head and auger casings are attached to the pilot tubes and the jacking frame advances the reaming head and casings into the ground.

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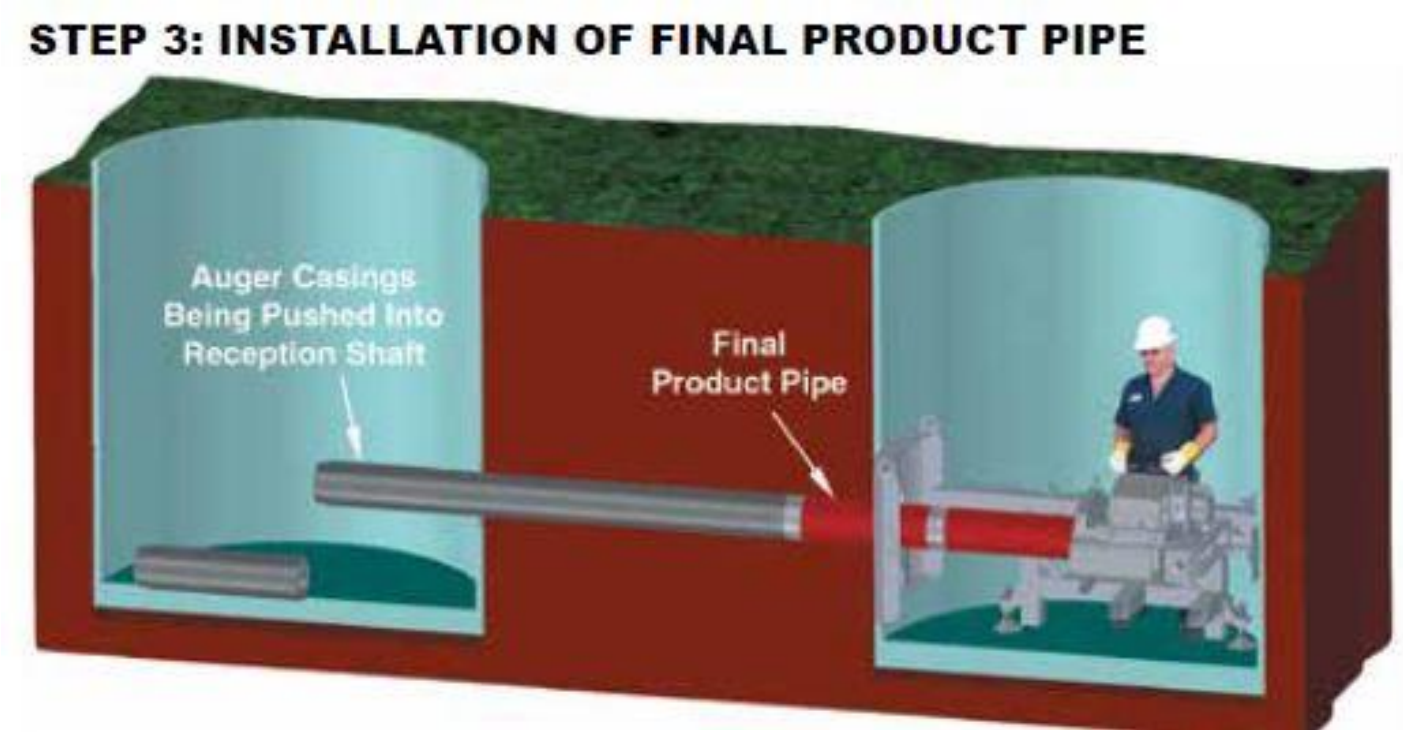
History & Overview: Pilot Tube Microtunneling



Source: Akkerman

The third step is installation of the product pipe. A pipe adapter is installed on the last section of auger casing to match the product pipe.

As the pipe is thrust into place, the auger casings are removed from the reception shaft. This process continues until the product pipe reaches the reception shaft.

With the installation of the product pipe, the job is complete with minimal impact and disruption to activities in the immediate area.

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Project Specifics: Pilot Tube Microtunneling

Akkerman Model 4800 installed in a jacking pit

- Akkerman Model 4800 Series Jacking Frame
  - Jacking Force: 265 Tons
  - Designed Accuracy: ¼” at 400 feet
- Pilot Tube Diameter: 3 ½” - 4”
- Reaming Head Outside Diameter: 11”
- Pipe Lubricant: Bentonite
- Shafts: 19 Total
  - 9 x 12 ft Diameter Receiving Pits
  - 10 x 18 ft Diameter Jacking Pits

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Applicability: Pilot Tube Microtunneling

- Pipe Diameters: 4” – 48”
- Preferred method for gravity sewers due to on-line and on-grade accuracy
- Crowded Utility Corridors
- Higher Cost
- Requires an experienced operator and construction crew
  - Interpret data
  - Ability to right the wrongs

Auger casings advancing along pilot tube path

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Project Construction Methods:
30-Inch Force Main

Construction of 30-Inch Force Main

30” sanitary force main constructed by **Pipe Augering**

Proposed Force Main Alignment

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Pipe Augering

History & Overview: Pipe Augering

- Two pass system
- Sequence of operations:
  - Jacking frame is installed in the work shaft
  - Steel casing advanced by hydraulic jack
  - Excavated spoil transported back to shaft and disposed
  - Section of product pipe are pushed through the open tunnel

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Project Specifics: Pipe Augering

- Auger Pilot Tube was used to ensure on-line and on-grade accuracy
  - Auger Pilot Tube Diameter: 1 ½ - 2 inches
  - Auger Pipe Tube Lubricant: Water
- Length of steel casing section: 10 ft
- Spoil transported by muck cars mounted on Akkerman Model 524 battery powered haul system
- 30-inch force main installed in 8-16 ft sections
- Auger pits sized 8ft x 25 ft

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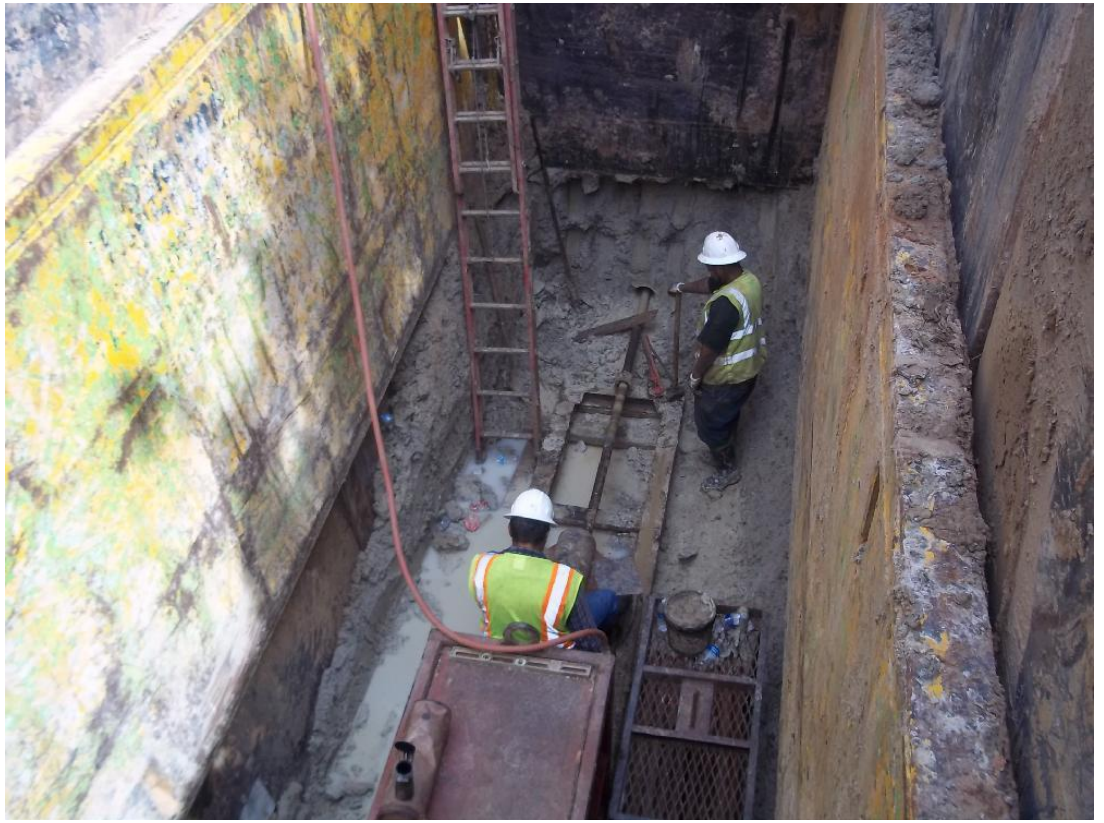
Applicability: Pipe Augering

- Cost effective
- Preferred for force main construction
  - Lower accuracy than pilot tube microtunneling
  - Line and grade accuracy can be improved with an auger pilot tube
- Less time-consuming



Pipe Auger Pilot Tube

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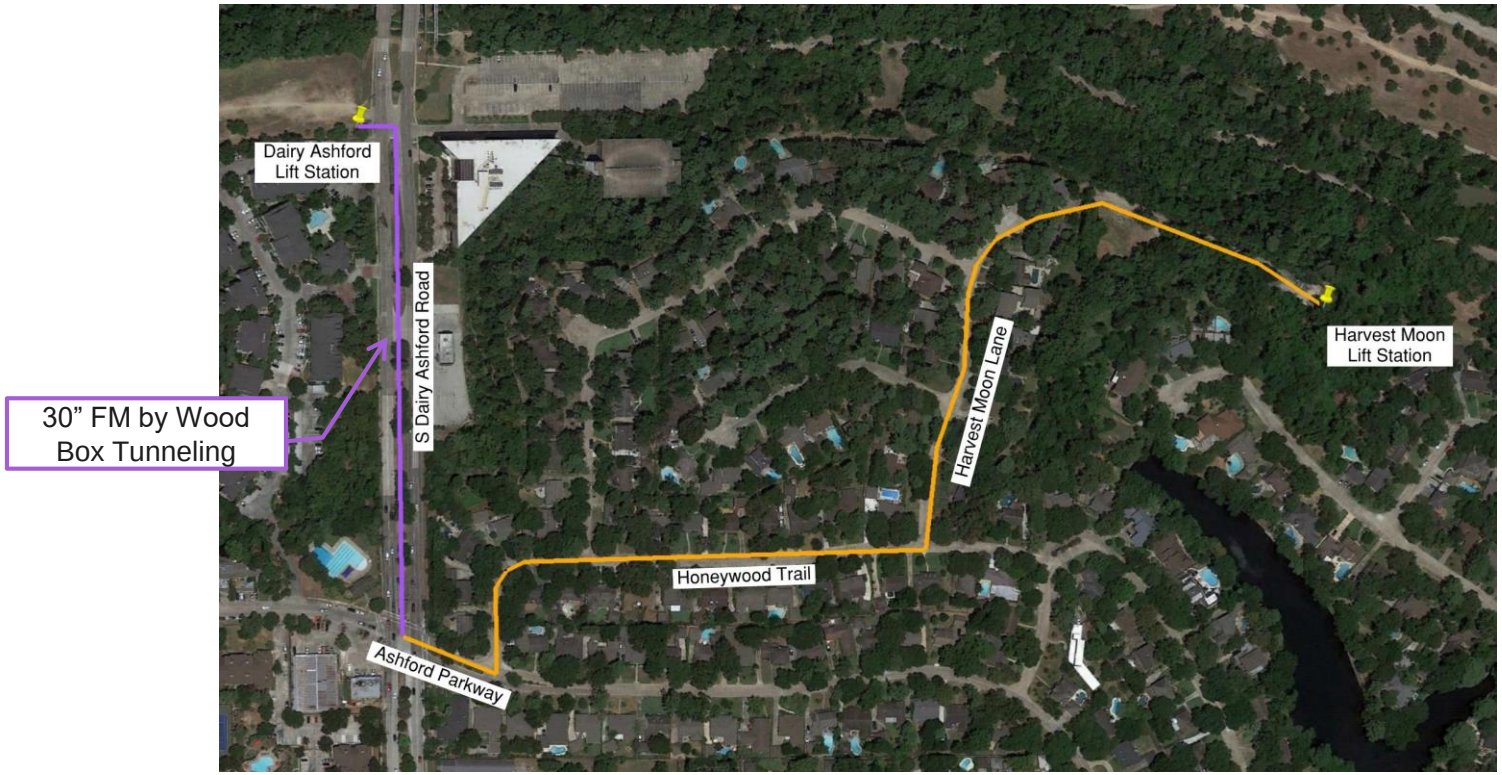
Construction of 30-Inch Force Main

30” sanitary force main constructed by **Wood Box Tunneling**



Proposed Force Main Alignment

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Wood Box Tunneling

History & Overview: Wood Box Tunneling

- Two pass system
- Sequence of operations:
  - Establish alignment for proposed tunnel operations.
  - Excavation by handheld pneumatic clay spades
    - Begin excavation at the bottom and move diagonally upward
  - Install wood braces on the bottom, sides and top of the tunnel.
  - Install product pipe, flush with bottom of tunnel
  - Grout fill tunnel to stabilize pipe

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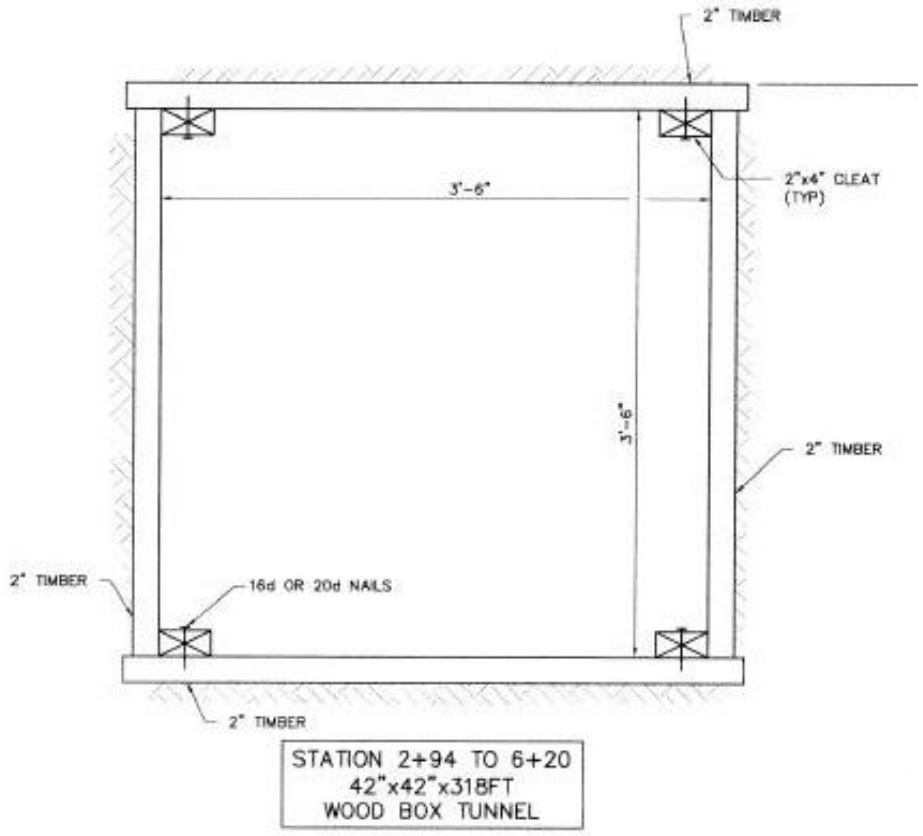
Project Specifics: Wood Box Tunneling

- Tunnel size: 42” x 42”
- Tunnel Lining: Oak Timber
- Shaft sizes:
  - 18 ft Diameter
  - 10 ft x 24 ft
  - 10 ft x 32 ft
- Tunnel ventilation provided by 12-inch industrial blower
  - 200 cubic ft fresh air per minute per person



Source: Stiver Engineering

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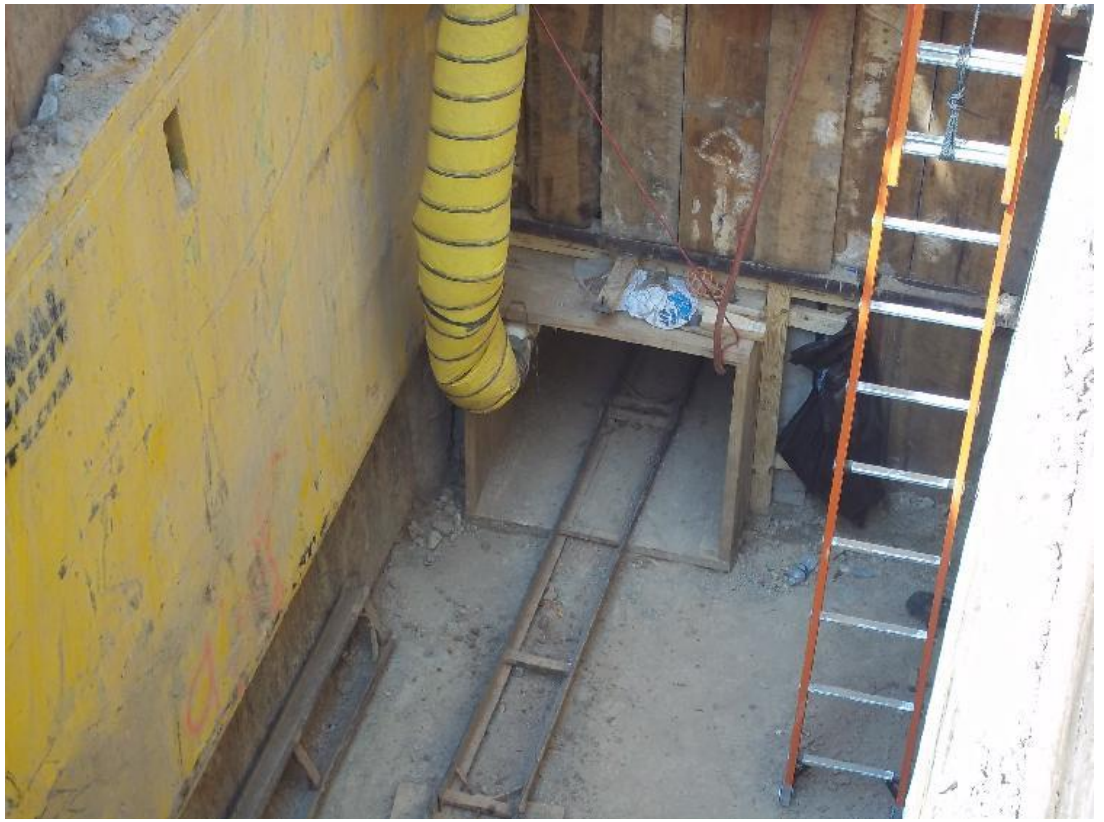
Applicability: Wood Box Tunneling

- Crowded utility corridors
- More forgiving than machine boring
- Provides ability to make slight adjustments
- Requires an experienced and safe crew



Oak timber lining in place

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Project Construction Methods: Existing 24-Inch Sanitary Sewer Repair

Existing 24-Inch Sanitary Sewer Repair

- Existing 24-Inch Sanitary Sewer was in poor condition
- Grout from wood box tunneling tripped the pump breaker at the Dairy Ashford Lift Station
- Approx. 1,000 linear ft required immediate rehabilitation

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Cured In Place Pipe (CIPP)

History & Overview: CIPP

- One pass system
- Sequence of operations:
  - Set up bypass
  - Clean & CCTV pipe
  - Set up inversion structure above manhole
  - Invert resin saturated liner into pipe
  - Heat to cure liner in place
  - Release water and cut and finish liner at ends

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Project Specifics: CIPP

- CIPP Liner:
  - 24-inch diameter
  - 16.5 mm thick polyester felt liner
- Isophthalic based resin

Vipel Isophthalic Based Resin for Underground Sewer Pipe Liners

TYPICAL FILLED LIQUID RESIN PROPERTIES* (1) see back page

	Nominal
Viscosity @ 77°F/25°C, RVF Brookfield Spindle #4 @ 20 RPM, cps.	6,200
Thix Index 2/20	2.7+
Color	Opaque
Specific Gravity @ 77°F/25°C	1.255
Styrene, %	32
Gel Time @ 140°F with (1.0% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and 0.5% Trigonox® KSM), minutes	14
Pot Life @ 77°F/25°C (1% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and + 0.5% Trigonox® KSM), hours	40

Trigonox is a trademark of Akzo Nobel Chemicals

TYPICAL FILLED CAST MECHANICAL PROPERTIES* (2) See back page

		Test Method
Tensile Strength, psi/MPa	7,220/50	ASTM D 638
Tensile Modulus, psi/GPa	690,000/4.8	ASTM D 638
Tensile Elongation, %	1.8	ASTM D 638
Flexural Strength, psi/MPa	12,300/85	ASTM D 790
Flexural Modulus, psi/GPa	700,000/4.8	ASTM D 790
Heat Distortion Temperature, °F/°C @ 264 psi	237/114	ASTM D 648
Barcol Hardness	42	ASTM D 2583

Source: AOC L.L.C.

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Applicability: CIPP

- Little to no excavation required
  - Less impact on community and traffic
  - Faster repair time
- Adaptable and versatile
  - Can navigate bends and various pipe sizes
  - Seamless and jointless

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Project Construction Methods: New Harvest Moon Lift Station

Caisson Method

History & Overview: Caisson Method

- Used for underwater construction
- Soil probing required
- Open cylindrical caisson
  - Open top and bottom
  - Concrete structure poured in layers
  - Inside of structure excavated to promote sinking
  - Dry bottom of structure with well point and pour bottom slab

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Project Specifics: Caisson Method

- Lift station depth: 58 ft
- 5,000 psi concrete
- Excavation by:
  - Hand digging
  - Mini-excavator
  - Clam shell bucket
- Construction took approximately 1 month

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Applicability: Caisson Method

- Alternative for traditional deep excavation
  - Less surface interruption
  - Safer
  - Faster
- Science and Art
  - Requires an experienced crew

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Conclusion

Conclusion

Pilot Tube Microtunneling:

- Best for on-line and on-grade accuracy
- Good for gravity sewer construction in busy utility corridors
- Interpret and react to data and machine

Pipe Augering:

- Less sophisticated
- Lower cost
- Use pipe auger pilot tube to increase accuracy
- Good for force main construction

Wood Box Tunneling:

- Full control over line and grade
- Ability to make slight adjustments to avoid conflict
- Hold safety paramount

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Conclusion

CIPP:

- Little to no excavation required
- Quick turnaround
- Good immediate rehabilitation and emergency repairs

Caisson Method:

- Good for deep excavation
- Can be safer and faster than traditional excavation
- Half science, half art

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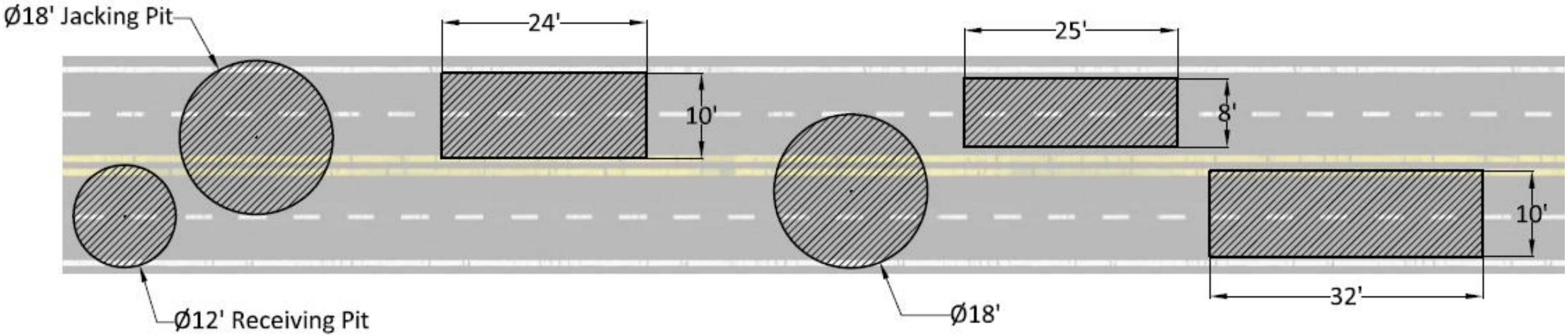
Shaft Size Comparison

Pilot Tube Microtunneling: **Pipe Augering:** **Wood Box Tunneling:**



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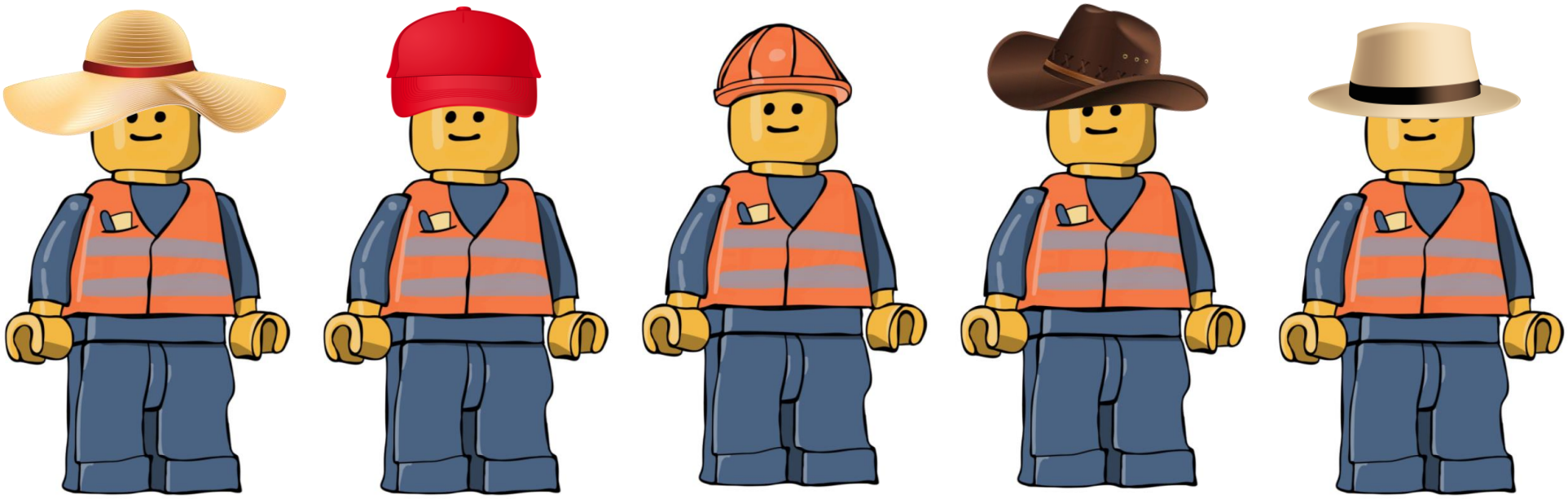
Reasons for success:



Underground construction is not a “one size fits all” scenario. Project success is achieved by an experienced team of engineers and contractors, who can fashion the many hats of underground construction

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Questions/Discussion

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Thank you!

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