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Novel Solutions for Successful Large Diameter Boring Projects.

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Abstract: Population growth in metropolitan cities such as Phoenix and Las Vegas is generating an ever-increasing demand for utility pipeline installation and renewal. Replacement of aging and undersized pipelines can present costly challenges for municipalities when poor project design and unforeseen disruptions are added to the cost.

This paper discusses two successful trenchless installation projects. It explains how and why each trenchless method was selected and how costly conflicts can be avoided with the utilization of Subsurface Utility Engineering.

Installation challenges are discussed in two case studies where innovative solutions were employed to increase the probability of success. The first case study involves a 72” reclaimed water main placed inside a 96” O.D. steel casing. The major challenge in this case was the presence of a poorly designed, gravity fed sewer line situated 2-ft about the proposed casing line.

The second case study involves the installation of a 30” diameter RGRCP pipe which required a 502-ft BMTA to install a 60” O.D. steel casing. An unexpected conflict with a 56-ft pile of concrete debris presented a major challenge for the crew.

1. INTRODUCTION:

Urban sprawl in populous cities both above and below ground, will no longer tolerate traditional construction methods such as trenching or open-cut, in most cases. Advancements in technology, design methods, and engineering have made trenchless more cost-effective than ever before. Trenchless methods include all methods of pipeline installation or renewal with minimal or no surface disturbance.

Even with the best of technology however, not all projects are as successful as we anticipate. In order to minimize the possibility delays and overruns it is necessary to have a clear understanding of the scope of the project, a good design plan, employ proven pre-construction practices such as S.U.E., and have the wisdom and experience to "**expect the unexpected."**

This paper describes two trenchless methods: Hand Tunneling and Boring Machine Tunnel Attachment (BMTA). Depending on design, soil conditions, pipe diameter, length of bore and existing utility and environmental constraints, each is a viable solution for a variety of trenchless pipeline installations.

The term "trenchless" or "no-dig" is slightly deceiving because many trenchless methods such as Hand Tunneling and BMTA require an excavated pit or shaft to operate.

2. TRENCHLESS METHOD - Hand Tunneling

Hand Tunneling *is cost effective method of installing a large diameter steel casing for short distances. It is a practical alternative that allows you to monitor the face of a tunnel while excavating, and easily control line and grade. It requires minimum work space and can be used to install casings as small as 30-inches in diameter.*

The term hand tunneling is used to describe the type of man-entry tunneling in which a person excavates the face of the tunneling with a hand tool. Pipe Sizes: 36" – 144" / Lengths: 0' – 600' / Box Sizes: 36" x 36" - 144" x 144" / Soil: Dry Clay, Wet Clay, Dry Sand, Dry Silt.

Step 1 - Hand tunneling requires a tunnel shaft.
Step 2 - This process is begun by a person excavating the face of the tunnel in the contour of the primary liner. The spoil is then loaded into buckets and the excavated material is transported to the shaft.

Step 3 - The pipe is jacked into place, or the tunnel liner is installed. This process is repeated until the tunnel is complete.

Step 4 - At periodic intervals the line and grade of the tunnel is checked using a construction laser.

A. HAND TUNNEL CASE STUDY

PROJECT: CM@Risk Town of Gilbert, AZ. Contractor – Pulice Construction, AZ. Sub-contractor – Specialized Services Company, AZ

OVERVIEW: The purpose of this project was to install a 96-inch OD X 1-inch wall steel casing and subsequent installation of a 72-inch reclaimed water line.

SOIL CONDITIONS: Good

LENGTH OF BORE: 100-ft, 90-ft

CONSTRAINTS (EXPECTED): 36-inch sewer line, telephone duct bank, right-of-way, short distance of run, diameter of tunnel.

DESIGN: With all of the above constraints in mind, the Town of Gilbert explored various design approaches to determine the most cost effective method of installing the water line. Due to the size and length of bore required, hand tunnelling was selected because of its economical benefits.

Method	Advantages	Disadvantages
Auger Boring	none	No auger this diameter
HDD	none	Unsafe and impractical
Pipe Ramming	prevent cave-ins	Too costly, cannot control line and grade.

CONSTRUCTION:

(Skid Steer pumping into spoils bucket)

- Setup jacking machine in bore pit excavated by contractor.
- Hand tunneled 96-inch casing through the earth, contend with the chip cave-in around the 36-inch sewer line.
- Attached 74.25 x 96-inch carbon steel casing spaces to waterline.
- Placed monitors inside 96-inch casing in front of 72-inch line for monitoring it as it is jacked through the casing.

(View of bore pit face)

(Bentonite hose & valves)

(Landing used for skid steer & pushing casings)

(View looking into tunnel with vent line and lighting

CHALLENGES (UNEXPECTED): The project experienced a conflict with an existing 36-inch gravity feed sewer line 2-ft above the steel casing trench line. The existing 36-inch sewer pipeline was previously backfilled with chip, which proved unstable when the 96-inch casing crossed beneath it. The 96-inch tunnel was poorly designed as it only considered the invert, not the OD or the excavation/bedding required for installation of the 36-inch sewer line.

SOLUTION: The boring sub-contractor vacuum excavated two holes on the sewer line and filled it with chip to prevent cave-in and further delays and complete the project on time and within budget.

(Tunnel shelf used to control sluffing / cave-in)

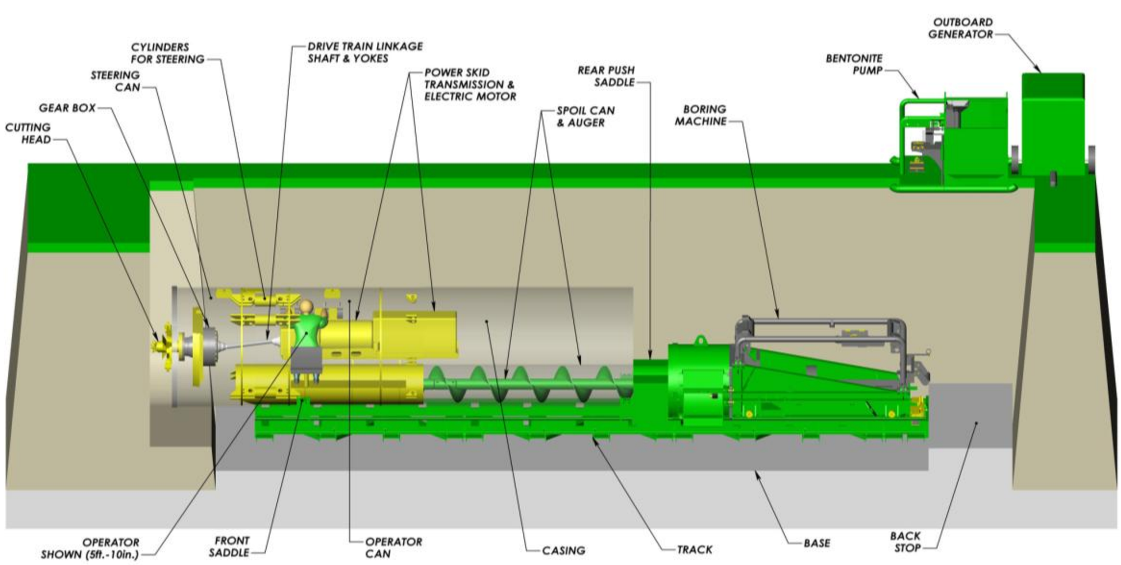
3. TRENCHLESS METHOD – Bore Machine Tunnel Attachment

(BMTA 60” & Bore Machine.)

BMTA - *For applications where line and grade are critical and tunnel diameter is greater than 48-inches. Cutting head is individually powered, separate from the power supply of the boring machine itself.*

Electric over hydraulic controls provide maximum controllability of line and grade. The boring machine provides the BMTA with thrust and auger spoil removal

BORING MACHINE TUNNELING ATTACHMENT



B. BMTA CASE STUDY

PROJECT: Owner – Arizona Department of Transportation, Contractor – Haydon Building Corp., AZ, Sub-contractor – Specialized Services Company, AZ.

(Water retention basin)

OVERVIEW: The purpose of this project was to install a 60-inch OD x .500-inch wall steel casing and subsequent installation of a 30-inch RGRCP diversion line to divert irrigation water from a retention basin to a pump station.

SOIL CONDITIONS: Hard caliche

LENGTH OF BORE: 500-ft

CONSTRAINTS (EXPECTED): This was a very long bore in hard soil conditions under a busy freeway, with only 4-ft of cover between the freeway and the casing. Existing 48-inch storm drain.

DESIGN: With all of the above constraints in mind, ADOT explored various design approaches to determine the most cost effective method of installing the diversion line. Because this project required such a lengthy bore (500-ft) the BMTA was selected because of its ability to control line and grade for such distances.

Method	Advantages	Disadvantages
Auger Bore	Auger Available	Long bore, issues with turning auger, have to pull auger to control grade.
BMTA	Monitor Grade at The Moment of Cutting, Cost Efficient	Once started with a certain head difficult to change
Hand Tunnel	Control line and grade	Cost and time
Open Cut	Not an option	Freeway Crossing

CONSTRUCTION:

- Setup shoring in bore pit excavated by GC.
- Setup BMTA in bore pit.
- Install 500-ft OD 60-inch steel casing.
- Attach casing spacers to the 30-inch RGRCP.
- Push through the 30-inch RGRCP.
- Fill the annular space with chip.
- Brick and mortar the ends of the casings.

(BMTA & Bore Machine in bore pit)

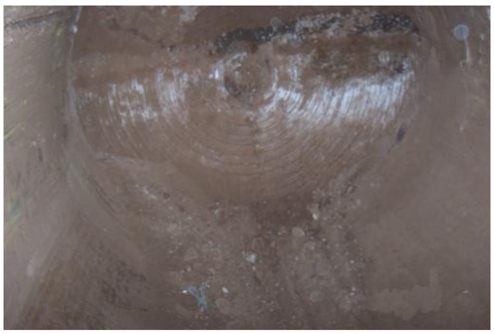
(16" auger/casing used to extract spoils)

(View inside 500' tunnel)

(View of bore pit, track, and bore machine)

(60"BMTA control area and target)

CHALLENGES (UNEXPECTED): Undisclosed median backfilled with 24-inch long chunks of concrete.



(View of concrete debris left behind by road crews)

(60" cutting head)

SOLUTION: Hand excavated in front of the 60-inch cutting head until the limits of the median were met. Then open cut the median and pushed the casing through and resumed boring.

4. PROVEN TRENCHLESS DESIGN PRACTICE: Subsurface Utility Engineering

a. Branch of engineering that reduces risk of conflict due to unreliable data and unforeseen challenges. Subsurface Utility Engineering is not confined to highways. It can be used with good results on airport, railroad, transit, building construction, military, sanitation, nuclear, and any other public works project where underground utilities may be encountered. It can also be used for environmental purposes, such as detecting and mapping underground storage tanks, septic fields, and even contaminants. S.U.E. adds value, quality, and accountability to any project.

b.

c. **Major S.U.E. Activities:** (United States Department of Transportation - Federal Highway Administration)

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Scope of Work - The process of developing a written project-specific work plan package that consists of scope of work, levels of service vs. risk allocation, project schedule and desired project delivery method. This S.U.E. work plan package is agreed upon by the S.U.E. provider and the client, describing the S.U.E. work to be performed.

Designating - The process of using a surface geophysical method or methods to interpret the presence of a subsurface utility and mark its horizontal position on the ground surface or on above-ground surface markers.

(Field survey by vacuum crew)

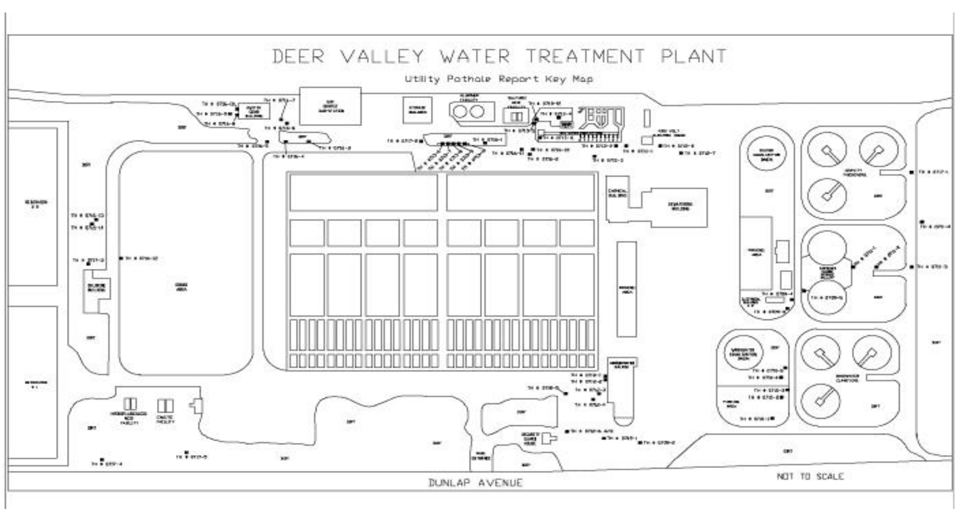
(Vacuum crew exposing utility)

Locating - The process of exposing and recording the precise vertical and horizontal location and providing utility size and configuration of a utility.

(Exposed utility)

Data Management - The process of surveying, designating, and locating information to project control and transferring it into the client's CADD system, GIS files, or project plans.

Conflict Analysis - The engineering process of using a conflict matrix to evaluate and compare depicted designating information with proposed plans (highway, bridge, drainage, and other) in order to inform all stakeholders of potential conflicts, potential resolutions and costs.



d. For each $1.00 spent on the use of subsurface utility engineering services on street and highway projects the overall project experienced a savings of $4.62. *(According to Purdue University Study for FHA)*