



Technical Memorandum

Date: Monday, December 10, 2018

Project: GPC6, C2012668-02 Task Order #39 Dallas CBD
Second Light Rail Alignment (D2 Subway)

To: Ernie Martinez, DART D2 Project Manager

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Subject: FIRST DRAFT Technical Memorandum #05 – For Review Only
Existing Conditions – Underpinning Parking Garage

Executive Summary

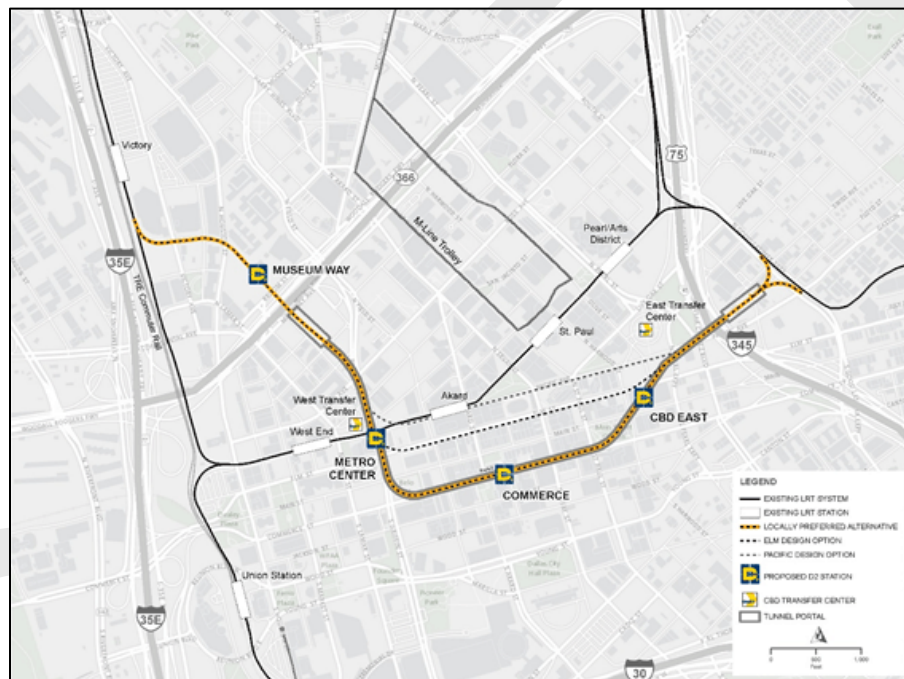
The DART D2 extension project is a planned light rail system within the central business district of Dallas, Texas. Three underground stations have been identified in the Locally Preferred Alignment (LPA) which include Metro Center Station, Commerce Street Station and Central Business District (CBD) East Station. This memorandum describes the challenges and constraints associated with the mined construction of the Central Business District (CBD) East Station directly below the existing Elm St. Parking Garage, with the use of the Sequential Excavation Method (SEM). As per the current profile of the running tunnels and stations of the LPA, the mined excavation of the CBD East Station would interfere with the existing parking garage foundation piers. To avoid the conflict with the existing building foundations and provide competent rock cover for the mined construction of the CBD East Station, it is recommended that the vertical alignment be lowered, and the station relocated in the south-west direction. It is also suggested that further revisions be made to the vertical alignment to avoid interferences of the existing sewer line at Commerce Station with adjacent running tunnels.

It should be noted that at the time this memorandum is prepared, the horizontal alignment and profile of the LPA were under review, and that cut-and-cover construction for the Central Business District (CBD) East Station was also being considered as an alternative method of construction.

Introduction

The DART D2 extension project is a planned light rail system in the center of Dallas, Texas. With planning beginning in 2007, recent developments have resulted in the approval of the 'DART D2 Subway Locally Preferred Alignment (LPA)' in September 2017. The LPA alignment (**Figure 1**) runs from Victory Park to Deep Ellum via Commerce Street and downtown Dallas. At the time of this memorandum, the alignment includes at-grade, open cut, cut-and-cover, and mined tunnel sections. The mined tunnel section through downtown Dallas includes at least one underground mined station and twin running tunnels between open cut sections. It is noted that the configuration of underground openings and the method of their construction may be revised in the future as the alignment profile is being finalized.

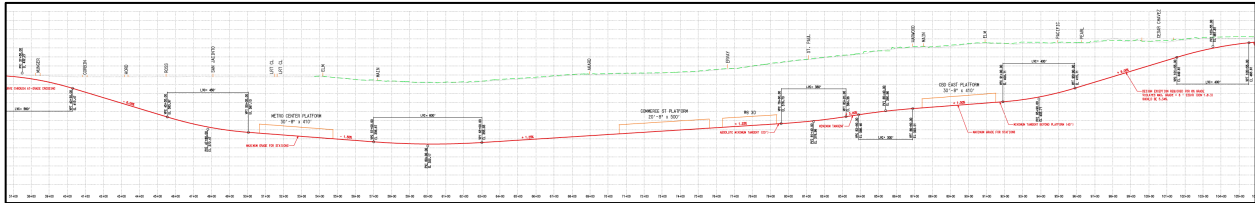
FIGURE 1: DART D2 SUBWAY LPA ROUTE



Tunnel Alignment

A series of alignments have been studied since planning started in 2007 and evolved into the LPA with much of its underground section situated beneath Commerce Street. Presently the LPA underground section, shown in **Figure 2**, extends from Pacific Avenue (approximate Station 94+94) to San Jacinto Avenue (approximate Station 48+08). Three underground stations are identified as Metro Center Station, Commerce Street Station and Central Business District (CBD) East Station. The average depth from the surface to track level is 59-ft, with a high of 68-ft and a low of 53-ft.

FIGURE 2: LPA TRACK VERTICAL ALIGNMENT FOR UNDERGROUND SECTION



Central Business District (CBD) East Station and Existing Elm St. Parking Garage

This memorandum describes the challenges and constraints associated with mined construction of the Central Business District (CBD) East Station directly below the existing parking garage as it is currently planned per the LPA (see **Figure 3**). Tunneling considerations and recommendations for the construction of the station are also provided based on the use of the Sequential Excavation Method (SEM).

FIGURE 3: LPA TRACK ALIGNMENT AND STATION BELOW ELM STREET PARKING GARAGE

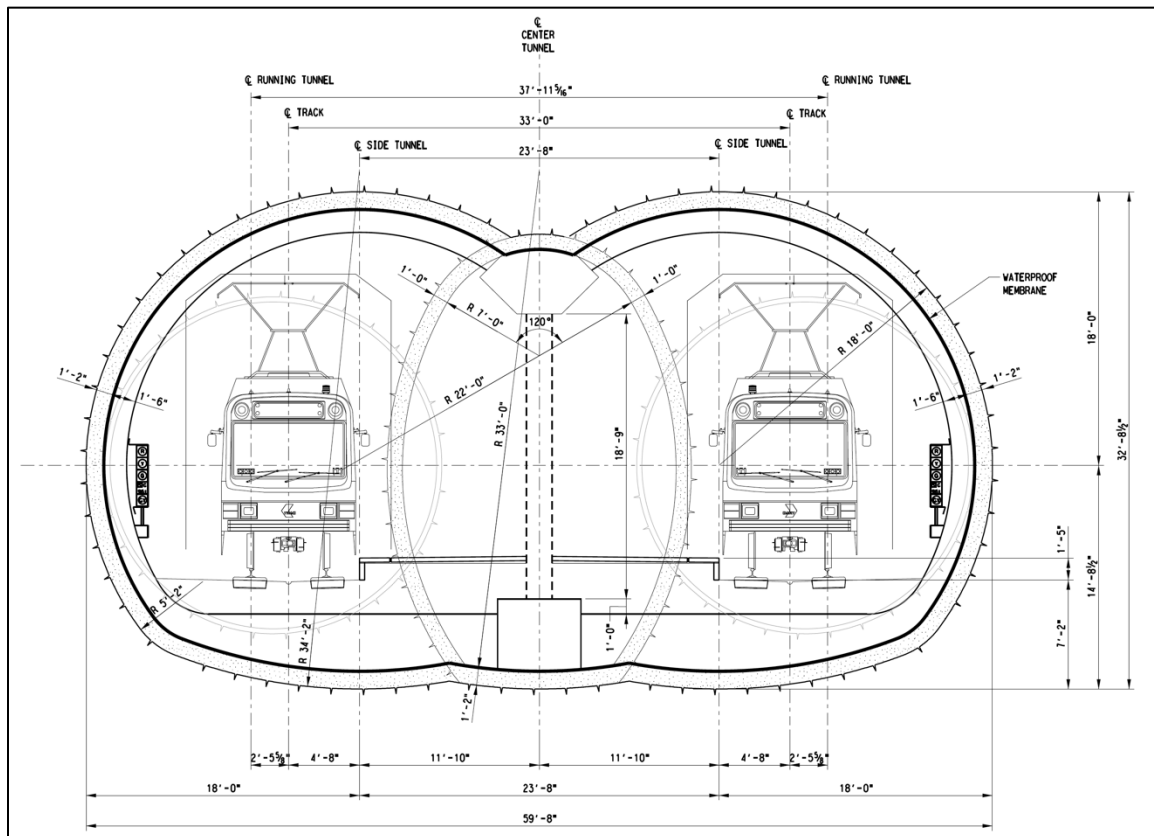


Station Cross Section

The mined Commerce Station cross section has been developed considering the preference for a center platform configuration and requirements for minimum platform width, architectural finishes, and passenger flow through the station. If CBD East Station is executed as a mined station, the configuration will follow the triple vault geometry shown in **Figure 4**. The triple vault arch allows for economy in the

overall cross sectional size in comparison to a single arch cavern, while maintaining station operational requirements. This is particularly important when defining the vertical height of the tunnel and distance from the existing structure's foundation.

FIGURE 4: TRIPLE VAULT GEOMETRY FOR CBD EAST STATION



Elm Street Parking Garage

The Elm Street parking garage is composed of a 10 story and a 7 story adjacent structures, built at different periods. At this time, record drawings are only available for the 7 story structure, which is supported on reinforced concrete pier foundations with a typical center-to-center spacing of 22 ft in the transverse direction and 49 ft in the longitudinal direction and with diameters ranging from 18 to 46 inches (see **Figure 5** and **Figure 6**). The piers were required to be drilled up to 6 feet into the bearing stratum (indicated in the record drawings to be at ~29-ft below grade), which resulted in the bottom of the piers at approximately 35 feet below grade. Based on the record drawings and on the assumed bearing capacity of the ground, the 46-in diameter piers, which constitute the main support of the entire structure, can carry a load of ~1,000 kips in bearing, plus an additional ~2,100 kips in friction. No record drawings are available for the 10 stories structure as of the date of this memorandum. For the purpose of this memorandum, it has been assumed that the 10 story structure support system is similar to the as-builts shown for the 7 story structure, however, it is important that as-built record drawings are acquired for the entire structure of the Elm Street Parking Garage as these may differ from the available information.

FIGURE 5: LEVEL 1 PLAN

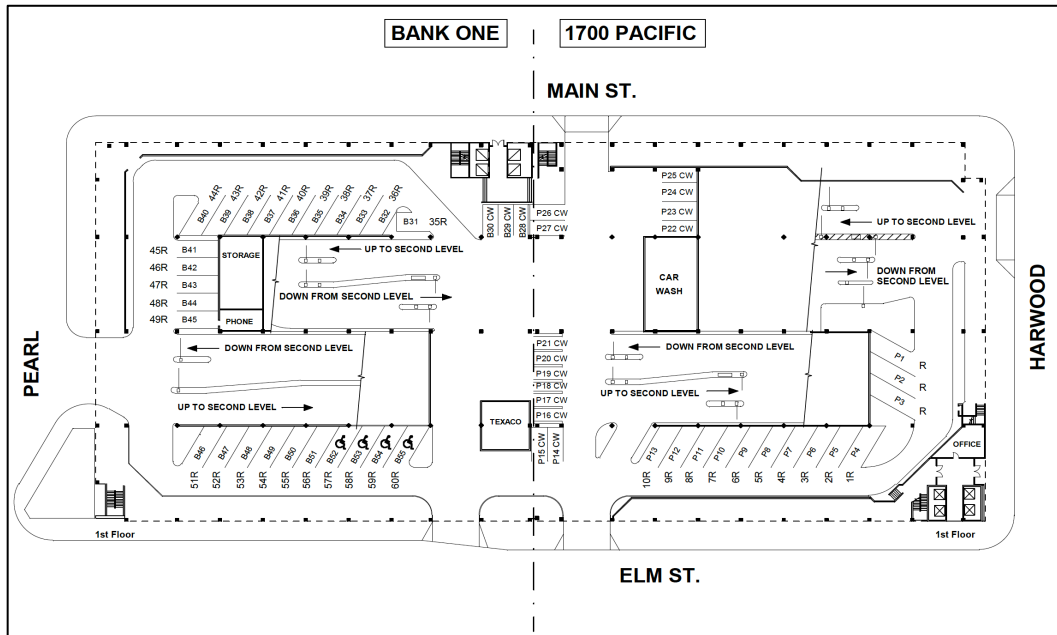
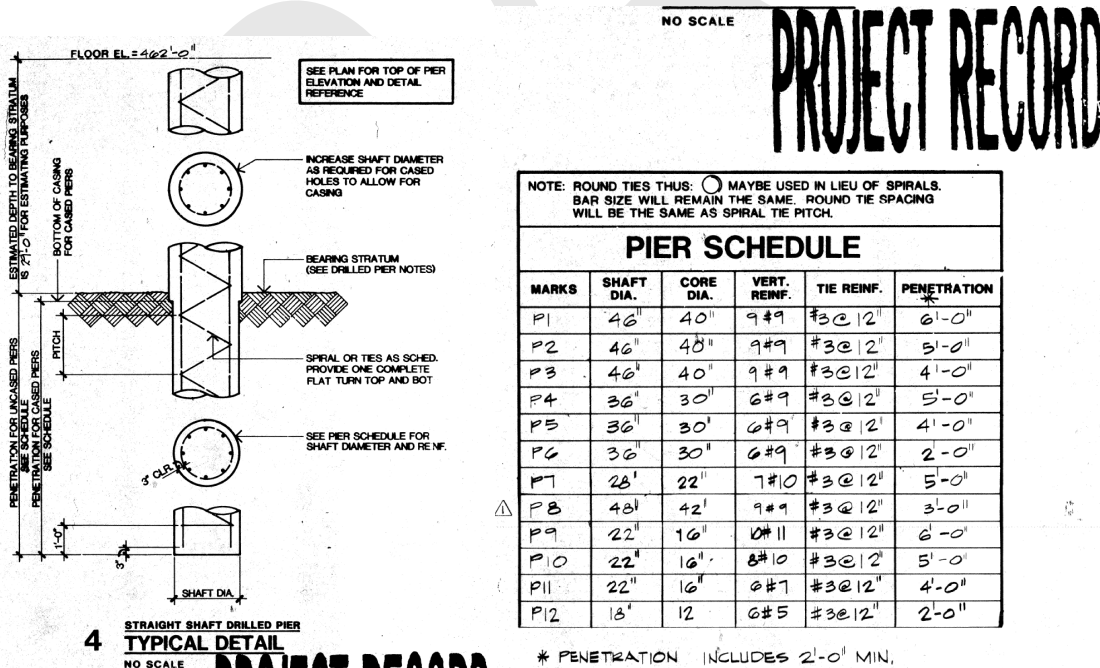


FIGURE 6: PIER DIMENSIONS AND SCHEDULE



SEM Tunneling Considerations for CBD East Station Construction

Based on boring information available to date, within the station limits the ground surface varies approximately 5 feet and the general geology of the ground can be summarized as indicated in the **Table 1** below.

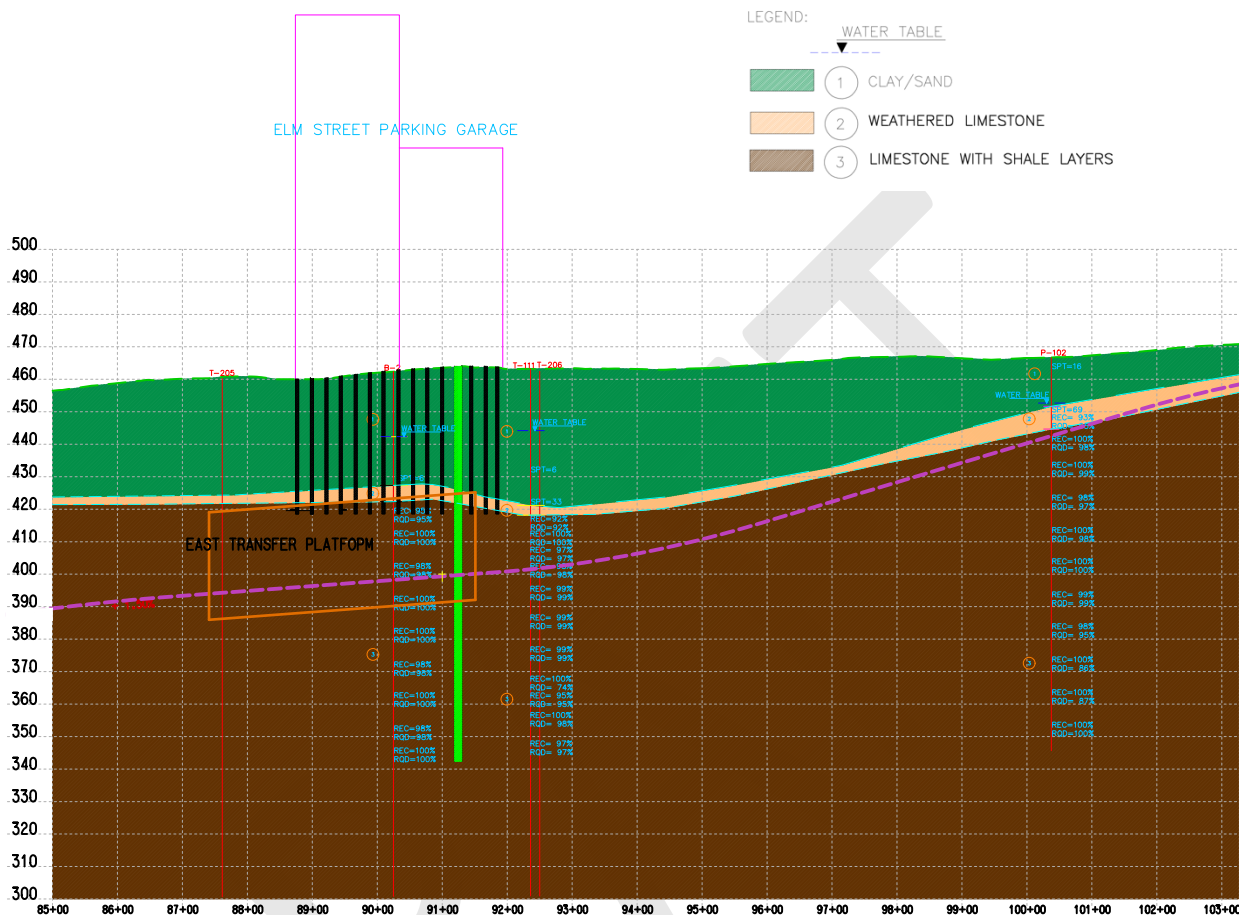
TABLE 1: SUMMARY OF SUBSURFACE CONDITIONS

Stratum	Thickness*	Description
Stratum F (Fill)	xx-xx ft	Consists of manmade mixture of sandy and/or clayey fill material with traces of silt and sand, and containing organic matter, brick asphalt glass or concrete pieces with density ranging from loose to dense
Stratum 2 (Alluvial Soils)	xx-xx ft	Predominantly granular alluvial deposits with consistency ranging from medium dense to dense.
Stratum 3 (Clay/Silt)	xx-xx ft	Medium dense clay/silt typically consisting of gray or tan sand with smaller amounts of clay, silt and gravel.
Austin Chalk Formation	xx-xx ft	An upper highly-weathered layer of soft decomposed and highly-fractured bedrock (10-ft or less in thickness). Below the highly-weathered layer, typically consists of light to dark gray limestone and shaley limestone, sound to slightly fractured, medium hard to hard, fine-grained, thin to massive.
	or xx-xx ft	
Eagle Ford Shale	>xx ft	Moderately to extremely fractured, soft to medium hard, slightly weathered to weathered, dark gray, fine-grained. A very weak rock which is prone to swelling upon exposure to wetting.

***To be provided upon completion of geotechnical investigation**

As shown in above station cross section (see Figure 4), the distance between top of rail and the upper excavation limit (excluding the rock support) is approximately 25-ft, which corresponds to elevation ~425-ft at its lowest point along the station. As per the current longitudinal profile of the running tunnels and stations of the LPA, the excavation of the CBD East Station would interfere (conflict) with the existing parking garage foundation piers (see **Figure 7**).

FIGURE 7: CONCEPTUAL GEOLOGICAL PROFILE AT CBD EAST SECTION



Below are three alternatives that can be considered to address the conflict of the existing building foundations and mined construction of the CBD East Station:

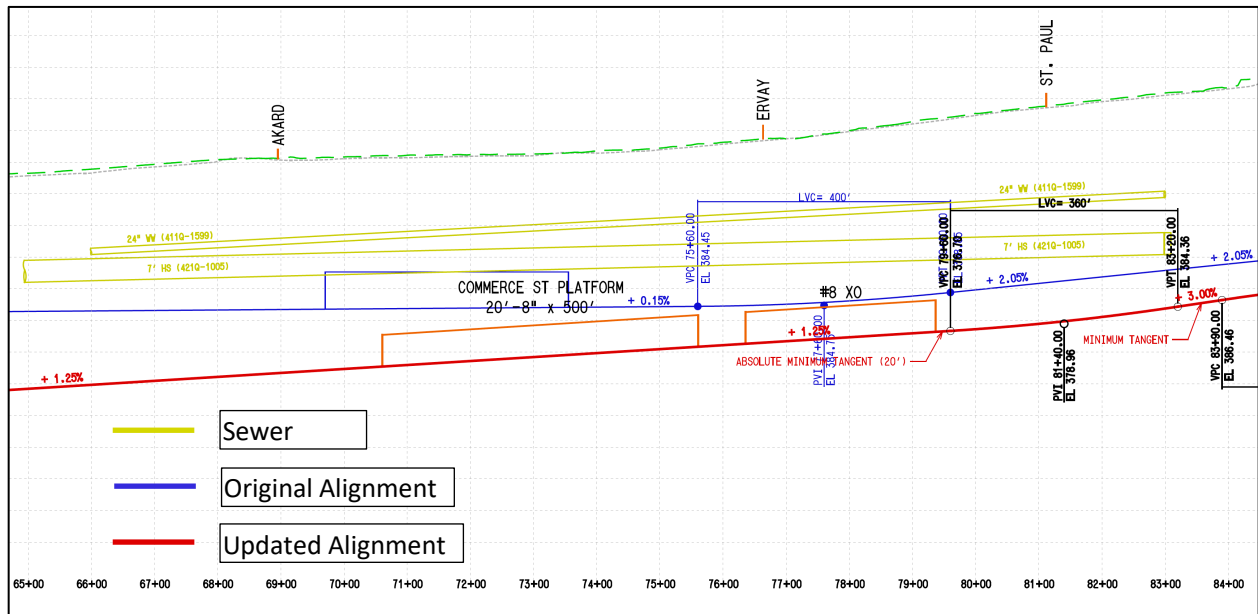
- a. *Temporary underpinning and building foundation load transfer to station's final lining:* Temporarily underpin the existing structure (Parking Garage) with jacking frames supported on piles that extend below the invert of the proposed station, excavate and construct the station, and finally transfer the building's foundation loads to the station's final lining. This approach is not recommended due to the extensive underpinning that will be required and the magnitude of the loads that will need to be supported by the station's final lining.
- b. *Permanent underpinning of existing foundations outside the station limits:* This method is similar to the temporary underpinning, however, it requires the use of a permanent framing system and foundations outside the station's limits. This approach is also not recommended since it is considered not practical and of high risk to the existing structure.

For alternatives a & b above, in addition to the large number of columns and magnitude of loads that will need to be supported, the following items need to be also considered, which further make these alternatives undesirable:

- Total number of columns that need reframing (approximately 20+ columns are impacted when overlaying the assumed column layout over the station cavern).
 - Potential damages to the existing structure due to extensive structural reframing, jacking and load transfer operations.
 - Maintaining minimum headroom for operation of the parking garage after reframing.
 - Time restrictions and parking garage closures to perform the works.
 - Potential restriction on the type of construction equipment needed due to existing overhead clearance and access constraints.
 - Protection and relocation of existing services.
 - Environmental considerations if lead based paint and/or asbestos cement materials are encountered on site.
 - Additional structural instrumentation and monitoring due to underpinning works.
 - Special inspections, approval and coordination with the Buildings Department and other agencies.
- c. *Revising the vertical alignment and relocation of the station:* Lowering the vertical alignment and relocating the station in the south-west direction will result in avoiding the underpinning of the existing garage structure and permit the excavation of the station with competent rock cover. Shifting the station and lowering the vertical profile avoids interference with the heavily loaded foundation piers above the station, where the rock cover is less; however, the foundations piers would now be situated above the running tunnel and their impact on the running tunnel will need to be also evaluated. To permit mined excavation and design of temporary and permanent supports, the minimum distance between the base of the piers and the station crown should be between 15 and 20-ft.

It should be noted that after a review of the alignment, it became apparent that further refinement of the down-station vertical alignment is also required to avoid interferences of the running tunnels and the Commerce Station with the existing sewer line (see **Figure 8**). This will provide additional rock cover for the tunnels and stations and increase the separation with the existing sewer.

FIGURE 8: EXISTING SEWER BENEATH COMMERCE STREET



Recommendations

After a review of the vertical and horizontal alignments, geology, size and geometry envisioned for the mined station, potential cover of competent rock, proximity and interference with the existing garage foundations and an assessment of the possible loading conditions for the CBD East Station at its planned location, it is apparent that the consideration of modifications to the vertical alignment and a relocation of the station would be necessary. It is also recommended that further refinements be made to the vertical alignment to avoid interferences with the existing sewer at Commerce Station and adjacent running tunnels.

References

- [1] Elm Street Parking Garage As-Built Drawing Package.