Appendix A

Amtrak Gateway Project – Hudson Yards Study Final Report
by Tutor Perini Corporation and Parsons Brinckerhoff (2012)

Amtrak Gateway Project – Hudson Yards Study

FINAL REPORT

November 16, 2012

Prepared for Related Companies and Amtrak

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1.0 EXECUTIVE SUMMARY

The *Northeast Corridor Infrastructure Master Plan*, prepared by Amtrak and representatives of 12 northeastern states and released in spring 2010, projects a significant increase in both passenger ridership and Amtrak and NJ Transit train service across the Hudson River by the year 2030. The existing 100-year-old, two-track North River tunnels are at their current capacity of approximately 25 trains per hour (tph), per direction, and are insufficient to meet projected demand.

Amtrak appointed Parsons Brinckerhoff (PB) to perform a preliminary evaluation related to adding two new tracks under the Hudson River as part of Amtrak's Gateway Project. The new tracks would branch from the Northeast Corridor (NEC) tracks in New Jersey and run in tunnel into Penn Station New York (PSNY) via the 'A' Yard at the western limit of the station complex. The new tunnel tracks would connect to existing yard tracks and to an extension of the 'I' Ladder, providing, in total, access to existing platform Tracks 1–18. This connection would be crucial to fulfill the operational reliability and capacity requirement that would serve as the backbone to Amtrak's Gateway Project.

The two new tracks would transverse under the southeast corner of the MTA-LIRR West Side Yards (Hudson Yards) which is currently under development by the Related Companies ('Related'). Specifically, the new tracks would be located in tunnel(s) constructed under the southeastern section of the Eastern Rail Yard (ERY) Site between Eleventh and Tenth Avenues.

Amtrak is aware that they should take advantage of establishing a right-of-way for the future Gateway Tunnel to make connections to 'A' Yard and the extension of the 'I' Ladder. Preliminary meetings between Related and Amtrak began in June of 2012 in which Related inquired if the proposed track alignment could be shifted farther north to avoid a proposed tower in the terra firma area just east of the Eleventh Avenue viaduct. Parsons Brinckerhoff revised the alignment with no significant operational impacts to the track geometry. This revised alignment provided less impact to the LIRR Maintenance Facility (MOE building).

Amtrak, MTA-LIRR and Related understand that construction of both the Overbuild structures and the Gateway Tunnel should ideally occur during the same construction period in order to mitigate impacts to the railroad operations/facilities and the occupied new buildings in the future. Accordingly, Amtrak, MTA-LIRR and Related agreed to the appointment of Parsons Brinckerhoff and Related's contractor, Tutor Perini Civil (TPC), to jointly undertake the study described in this report to develop and evaluate design and construction concepts for constructing the Gateway Tunnel in the Hudson Yards.

Given that the potentially complex easement arrangements for the future Gateway Tunnel, LIRR facilities and Overbuild structures have yet to be resolved, three conceptual design solutions were developed for the Gateway Tunnel providing different levels of structural separation between the proposed tunnel and the foundations of the

Overbuild structures. Furthermore, cognizant that the level of construction of the Gateway Tunnel will be dependent on the availability of funding, the study also developed construction options, which included constructing the Gateway Tunnel at the same time as the Overbuild Foundations, as well as options to construct the tunnel separately in the future. These included options to construct a deck structure above the elevation of the tunnel to facilitate future tunnel construction, as well as a 'Not to Preclude' option which entails reconfiguring the Overbuild foundations to preserve a pathway to construct the tunnel independently in the future.

From the technical and cost evaluations of the various design and construction options considered, the study determined five 'Pricing Solutions' as providing the optimum cost and schedule comparisons for present day and future construction solutions for the Gateway Tunnel. All five Pricing Solutions require the section of tunnel under the LIRR MOE Building to be constructed during the same construction period as the Overbuild structures owing to the shallow depth of the tunnel in this area. The Pricing Solutions are presented below:

Pricing Solution	**Description**	**Current Construction Costs** (See notes)	**Future Construction Costs** (See Notes)	**Total Costs**	**Complete First 400 Ft**	**Complete Last 400 Ft**
1	Fully Integrated Cut & Cover Tunnel	$120	$0	$120	4/2014	9/2014
2A	Fully Isolated With Deck, Full Depth Secant Piles, No Center Caisson	$118	$93	$211	4/2014	7/2014
2B	Partially Isolated With Deck, Full Depth Secant Piles, Center Caisson	$121	$101	$222	4/2014	7/2014
2C	Fully Isolated With Deck, Partial Depth Secant Piles, No Center Caisson	$114	$94	$208	4/2014	7/2014
3	Fully Isolated, Not to Preclude, No Deck, Transfer Beams On Caissons, No Center Caisson	$97	$133	$229	4/2014	7/2014

Notes:

1. All dollar values in millions
2. Future costs based on 2012 dollars
3. All pricing solutions include fully integrated cut/cover tunnel at Section C (Under MOE Building)

Schedule

1	Submit four (4) week study	11/16/2012
2	NTP Design	12/3/2012
3	Notice to vacate MOE	12/3/2012
4	Vacating of MOE complete	3/1/2013
5	Complete demolition of MOE & utility relocation	6/1/2013
6	Start platform foundations	4/2014
7	Start platform structural steel at Tower A	5/2014

2.0 STUDY APPROACH AND SYNOPSIS

2.1 Study Approach

The following steps were implemented by the study:

1. Evaluation of the Horizontal and Vertical Alignments of the Gateway Tunnel in the Hudson Yards.
2. Evaluation of the Internal Space Requirements for the Gateway Tunnel.
3. Evaluation of the Existing Infrastructure and Utilities in the Hudson Yards, Planned Overbuild Construction and Site Logistics.
4. Subdivision of the Gateway Tunnel Alignment within the Hudson Yards based on the physical constraints determined in Step 3.
5. Development of Conceptual Design Solutions (Alternatives) for the Gateway Tunnel based on different levels of structural separation with the Foundations of the Overbuild Structures.
6. Development of Construction Options for the Conceptual Design Solutions based on constructing the Gateway Tunnel at the same time as the Overbuild Foundations or separately in the future.
7. Technical Evaluation of a Matrix of the various Conceptual Design Solutions and Construction Options viable along the Gateway Tunnel Alignment within the Hudson Yards.
8. Development of Plans and Sections for the Matrix items defined in Step 7.
9. Development of Cost Solutions and Construction Schedules for most viable Construction Solutions for combining the Gateway Tunnel construction with the Overbuild Foundations or undertaking Tunnel construction separately in the future.

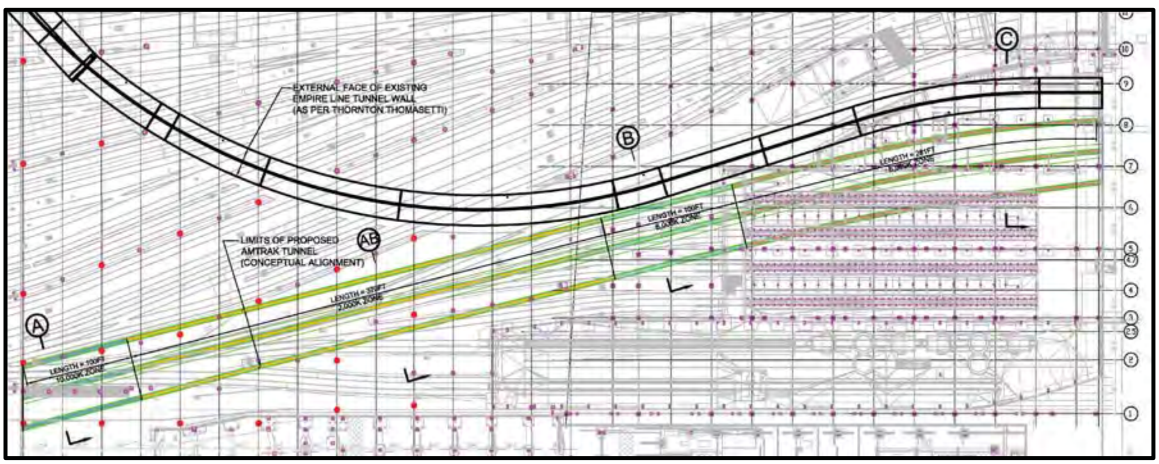
2.2 Study Synopsis

The technical and cost evaluations of the various design solutions and construction options considered by the study are addressed in detail in subsequent sections of this report. Provided below is a synopsis of the study and its findings.

Based on the existing infrastructure within the Hudson Yards and future Overbuild constraints, the Gateway Tunnel alignment was subdivided into four sections as illustrated in drawing SK-RP-1. The main characteristics of each section are summarized below:

- **Section A:** The southwest end of the alignment, adjacent to Eleventh Avenue, is characterized by the high column loads imposed by the Overbuild Tower D (10,000 kip column loads). The tunnel alignment is also at its deepest in this section.
- **Section AB:** This section of the tunnel alignment is occupied by shop tracks serving the MOE Building and is characterized by multiple columns carrying the Overbuild platform only (2,000 kip loads).
- **Section B:** This section of tunnel is in close proximity to the existing Amtrak Empire Line Tunnel. This area is also characterized by multiple columns carrying high loads from Overbuild Structures (6,000 kip column loads).
- **Section C:** The western end of the tunnel is occupied by the LIRR MOE Buildings and is characterized by multiple high column loads from the Overbuild Structures (6,000 kip column loads). The tunnel is also at its shallowest along this section.

Figure 2-1: Section Reference Plan



Since the potentially complex easement arrangements for the future Gateway Tunnel, LIRR facilities and Overbuild structures have yet to be resolved. Three conceptual design solutions were developed for the Gateway Tunnel (Step 5 above). The design solutions, which are illustrated in Figure 2-2, provide different levels of structural separation between the proposed Gateway Tunnel and the foundations of the Overbuild structures. The Gateway track alignments beneath the Hudson Yards are the same for the fully integrated (Alternative 1) and fully isolated (Alternative 2) conceptual design solutions. However, the southern track would need to be shifted south approximately 3 feet to accommodate the center Overbuild caissons shown for the partially isolated (Alternative 3) design solution (i.e., the middle caissons would be embedded in the center wall of the tunnel).

Cognizant that the level of construction of the Gateway Tunnel will be dependent on the availability of funding, the study developed construction options, which included constructing the Gateway Tunnel at the same time as the Overbuild Foundations, as well as options to construct the tunnel separately in the future (Step 6 above). The latter included options to construct a deck structure above the elevation of the tunnel concurrent with construction of the Overbuild foundations in order to facilitate future tunnel construction. In addition, a 'Not to Preclude' option was developed whereby the Overbuild foundations would be configured to preserve a pathway to construct the tunnel independently in the future. No other measures to facilitate future tunnel construction would be included with this option.

Based on the technical and cost evaluations of the various design and construction permutations described above, the five 'Pricing Solutions' listed in Table 2-1 and illustrated in the drawings at the end of this section, were identified as providing the optimum cost and schedule comparisons for present day and future construction solutions for the Gateway Tunnel. However, the construction under the LIRR MOE Building (Section C) in all five Pricing Solutions requires the fully integrated tunnel (Alternative 1) to be constructed at the same time as the Overbuild construction activities. This is due to the shallow tunnel depth, which precludes constructing the sizable transfer beam required to carry the Overbuild column loads to either side of the Tunnel.

Table 2-1: Pricing Solutions

Pricing Solution	Design and Construction Description	Drawing
1	Fully Integrated Cut-&-Cover Tunnel	SK-CS-01
2A	Deck with Full Depth Secant Piles (Where Applicable) – No Center Overbuild Caisson	SK-CS-2A
2B	Deck with Full Depth Secant Piles (Where Applicable) – With Center Overbuild Caisson	SK-CS-2B
2C	Deck with Partial Depth Secant Piles – No Center Overbuild Caisson	SK-CS-2C
3	Not to Preclude Future Tunnel Construction – No Center Overbuild Caisson	SK-CS-03

Cost estimates for the present day and future tunnel construction elements for each Pricing Solution are summarized in Table 2-2.

Table 2-2: Cost Estimates

Pricing Solution	Description	Current Construction Costs (See notes)	Future Construction Costs (See Notes)	Total Costs	Complete First 400 Ft	Complete Last 400 Ft
1	Fully Integrated Cut & Cover Tunnel	$120	$0	$120	4/2014	9/2014
2A	Fully Isolated With Deck, Full Depth Secant Piles, No Center Caisson	$118	$93	$211	4/2014	7/2014
2B	Partially Isolated With Deck, Full Depth Secant Piles, Center Caisson	$121	$101	$222	4/2014	7/2014
2C	Fully Isolated Deck Lid, Partial Depth Secant Piles, No Center Caisson	$114	$94	$208	4/2014	7/2014
3	Fully Isolated, Not to Preclude, No Deck, Transfer Beams On Caissons, No Center Caisson	$97	$133	$229	4/2014	7/2014

Notes:

1. All dollar values in millions
2. Future costs based on 2012 dollars
3. All pricing solutions include fully integrated cut/cover tunnel at Section C (Under MOE Building)

Schedule

1	Submit four (4) week study	11/16/2012
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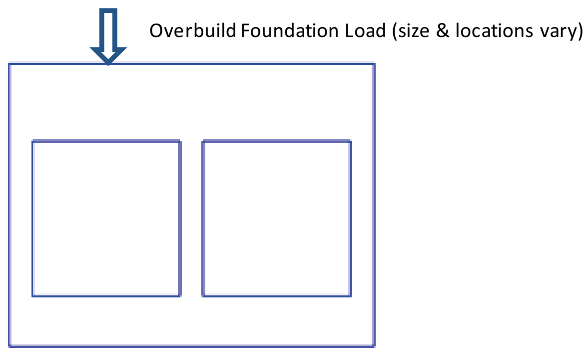
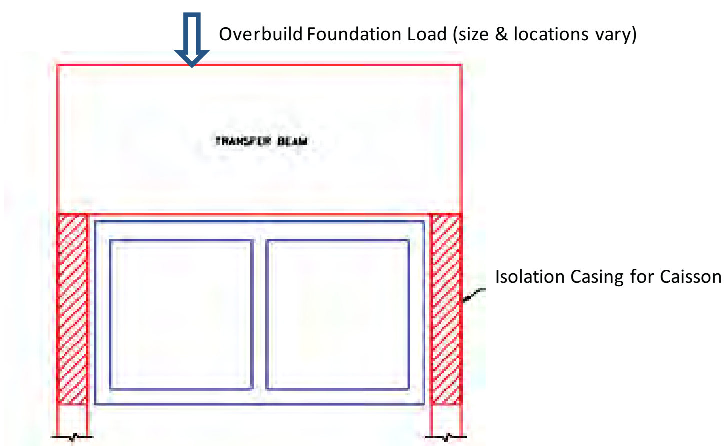
5	Complete demolition of MOE & utility relocation	6/1/2013
6	Start platform foundations	4/2014
7	Start platform structural steel at Tower A	5/2014

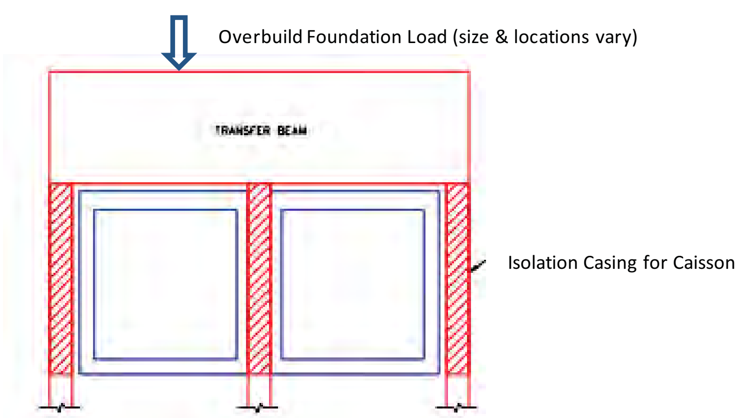
Figure 2-2: Conceptual Design Solutions for the Gateway Tunnel



Alternative 1: Fully Integrated Tunnel and Overbuild Foundation Structures

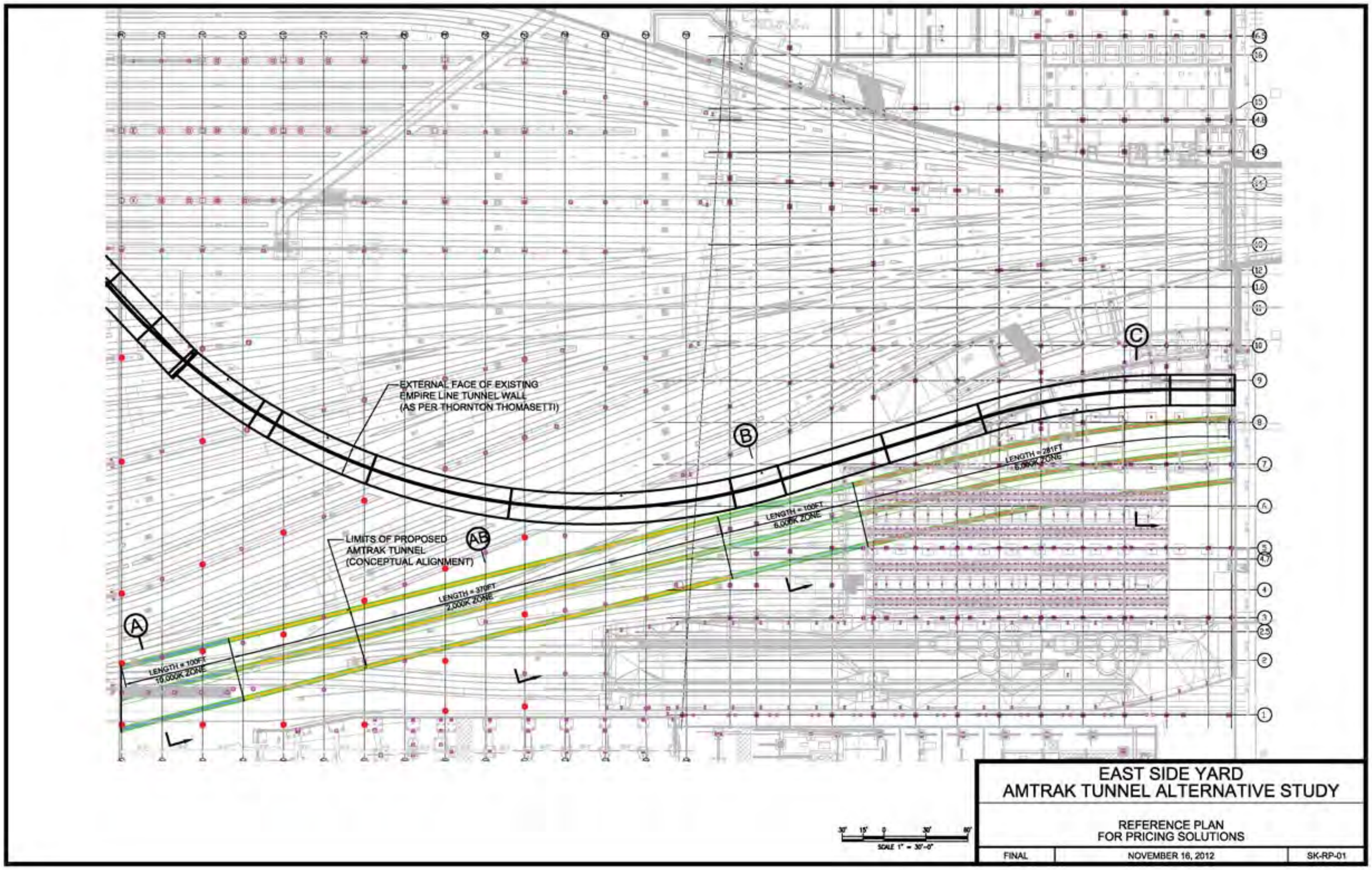


Alternative 2: Fully Isolated Tunnel and Overbuild Foundation Structures

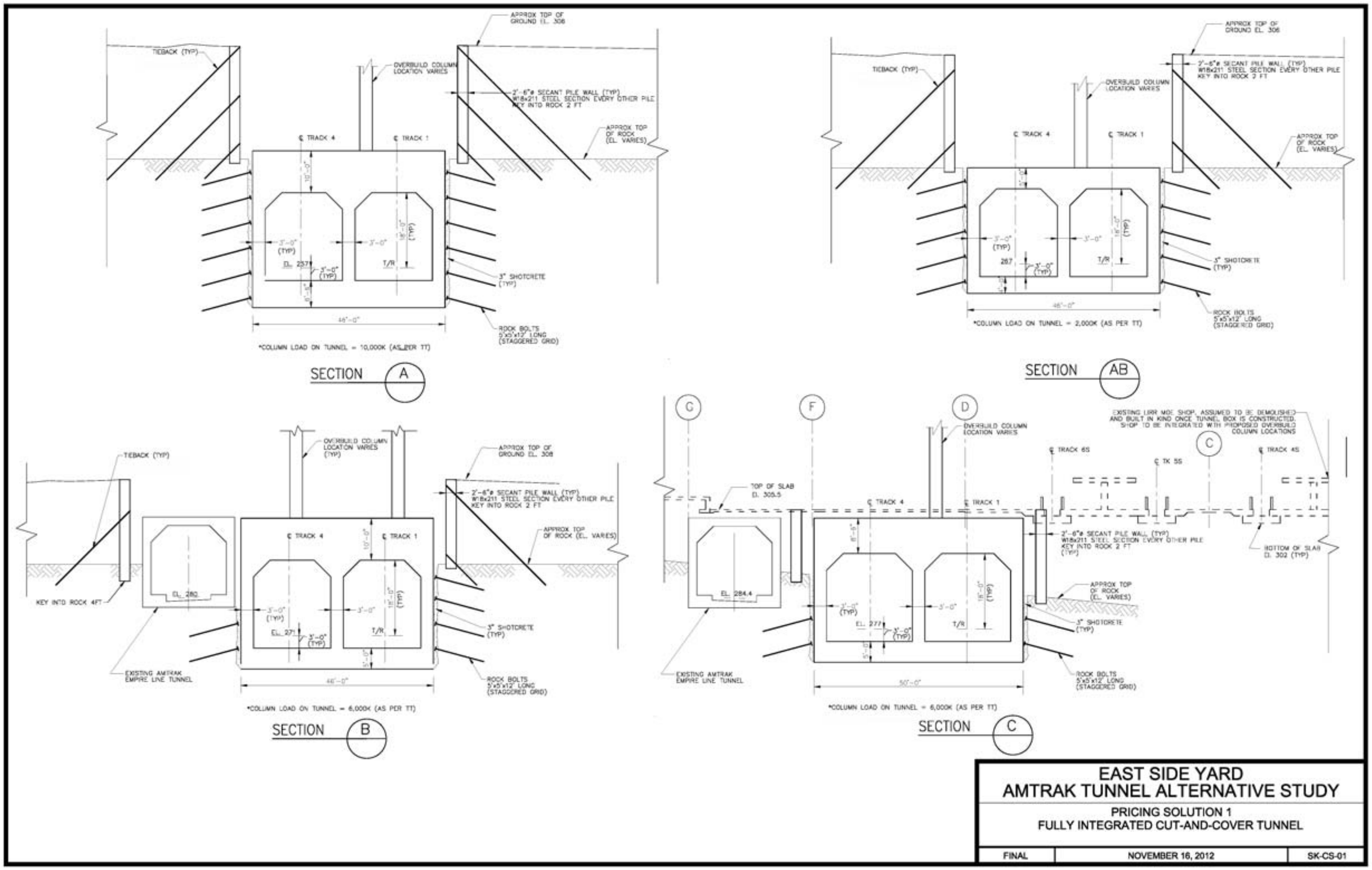


Alternative 3: Partially Isolated Tunnel and Overbuild Foundation Structures

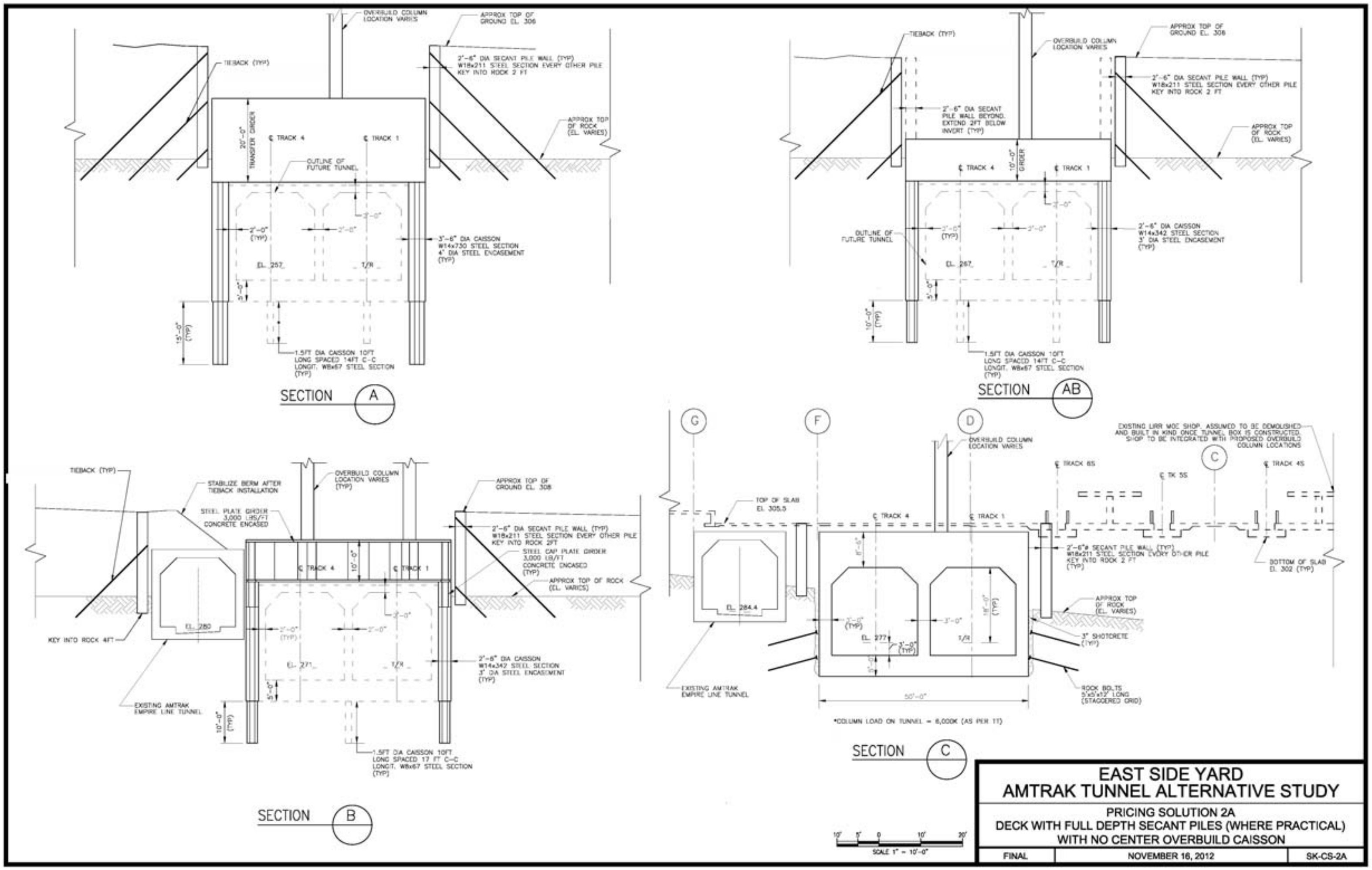
SK-RP-01: Reference Plan for Pricing Solutions



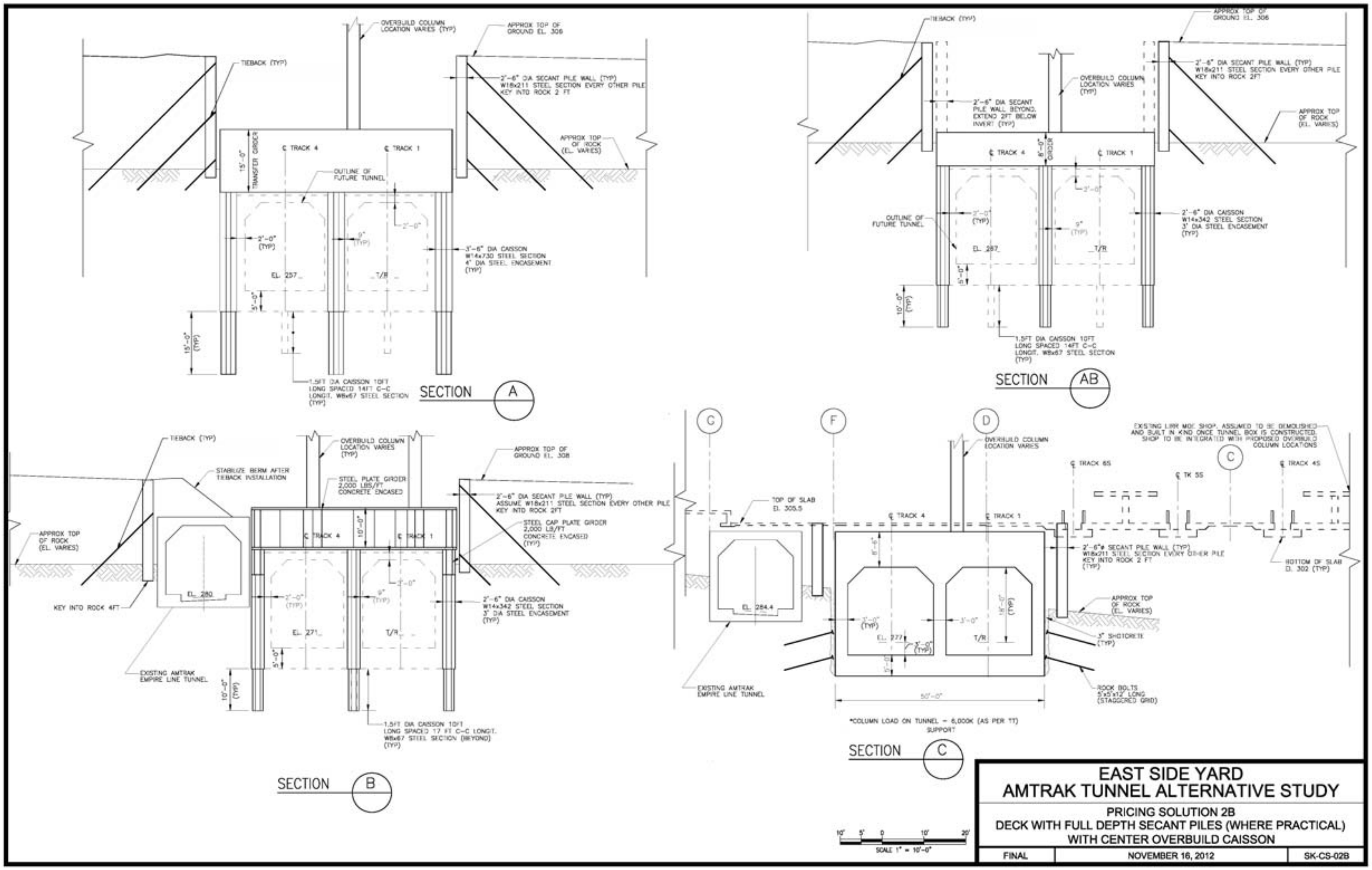
SK-CS-01: Pricing Solution 1 – Fully Integrated Cut-and-Cover Tunnel



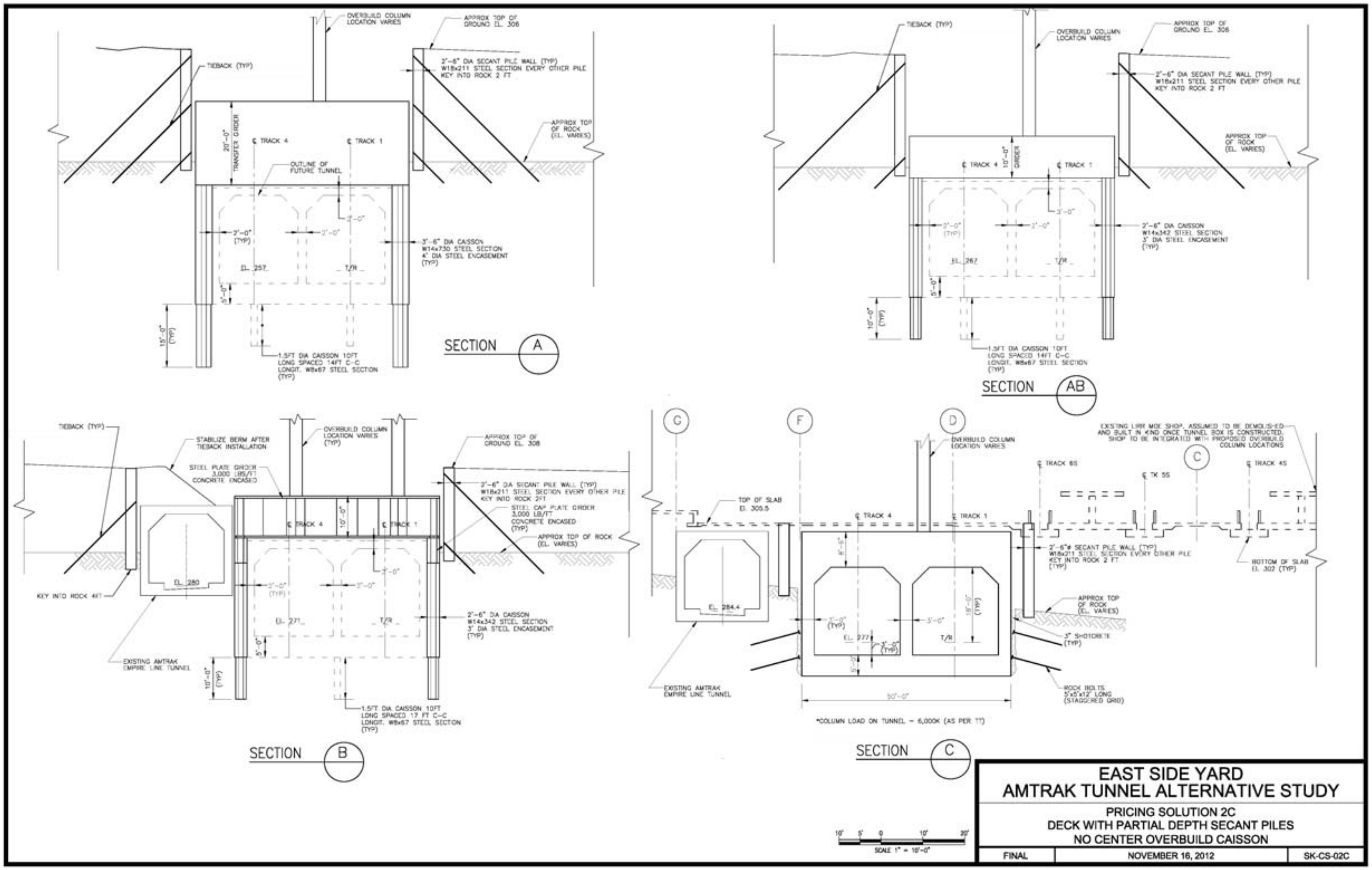
SK-CS-2A: Pricing Solution 2A – Deck with Full Depth Secant Piles (where practical) with No Center Overbuild Caisson



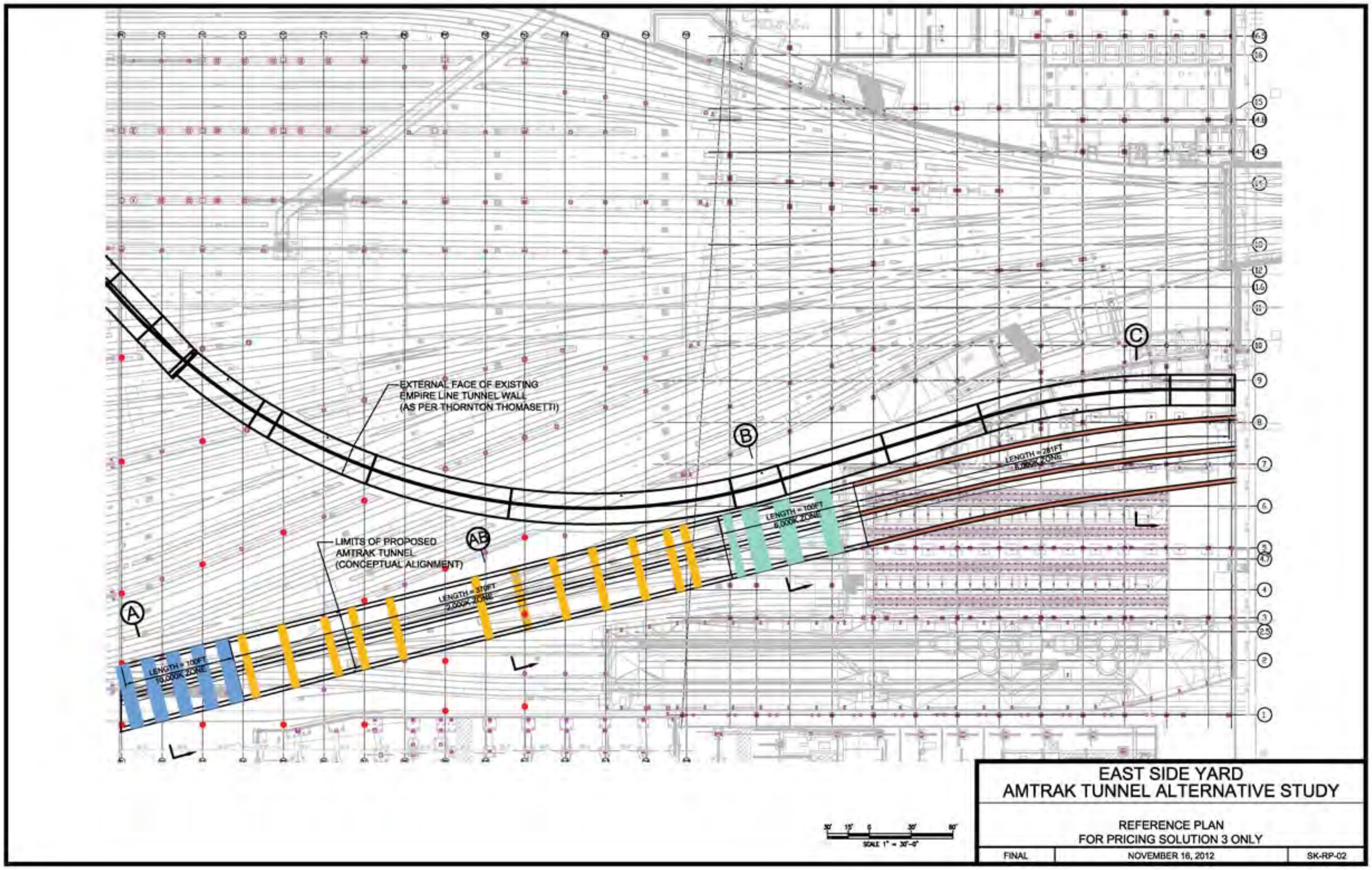
SK-CS-02B: Pricing Solution 2B – Deck with Full Depth Secant Piles (where practical) with Center Overbuild Caisson



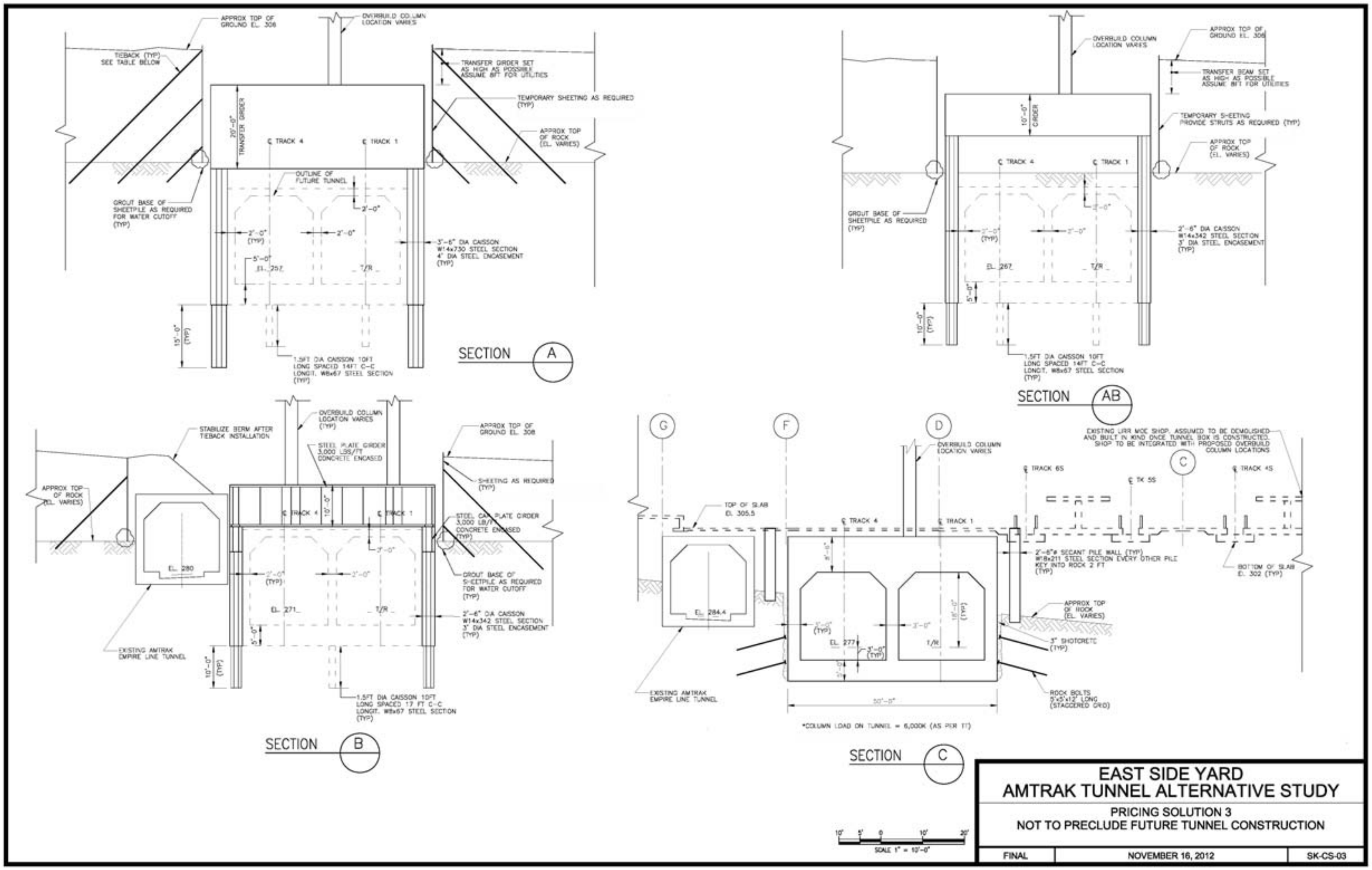
SK-CS-02C: Pricing Solution 2C – Deck with Partial Depth Secant Piles with No Center Overbuild Caisson



SK-RP-02: Reference Plan for Pricing Solution 3 Only



SK-CS-03: Pricing Solution 3 – Not To Preclude Future Tunnel Construction



3.0 AMTRAK'S GATEWAY PROJECT

3.1 Overview of Gateway Project

The *Northeast Corridor Infrastructure Master Plan*, prepared by Amtrak and representatives of 12 northeastern states and released in spring 2010, projects a significant increase in both passenger ridership and Amtrak and NJ Transit train service across the Hudson River by the year 2030. The existing 100-year-old, two-track North River tunnels are at their current capacity of approximately 25 trains per hour (tph), per direction, and are insufficient to meet projected demand.

Amtrak requested Parsons Brinckerhoff (PB) perform a preliminary evaluation related to adding two new tracks under the Hudson River, from tracks along the Northeast Corridor (NEC) in New Jersey into New York's Penn Station via the 'A' Yard at the western limit of the station complex. The new tunnel tracks would connect to existing yard tracks and to an extension of the 'I' Ladder, providing, in total, access to existing platform Tracks 1–18. This connection would be crucial to fulfill the operational reliability and capacity requirement that would serve as the backbone to this project.

The proposed two-track Amtrak tunnel alignment would travel across existing LIRR's East Side Yards (ESY), between Eleventh and Tenth Avenues making the crucial connection into Tracks 1A, 2A, and the extended 'I' Ladder within 'A' Yard on the eastern side of Tenth Avenue.

Preliminary meetings between Related and Amtrak began in June of 2012 in which Related inquired if the proposed track alignment could be shifted farther north to avoid a proposed tower in the terra firma area just east of the Eleventh Avenue viaduct. PB revised the alignment with no significant operational impacts to the track geometry. This revised alignment provided less impact to the LIRR Maintenance Facility (MOE building). This revised alignment serves as the basis for this current study.

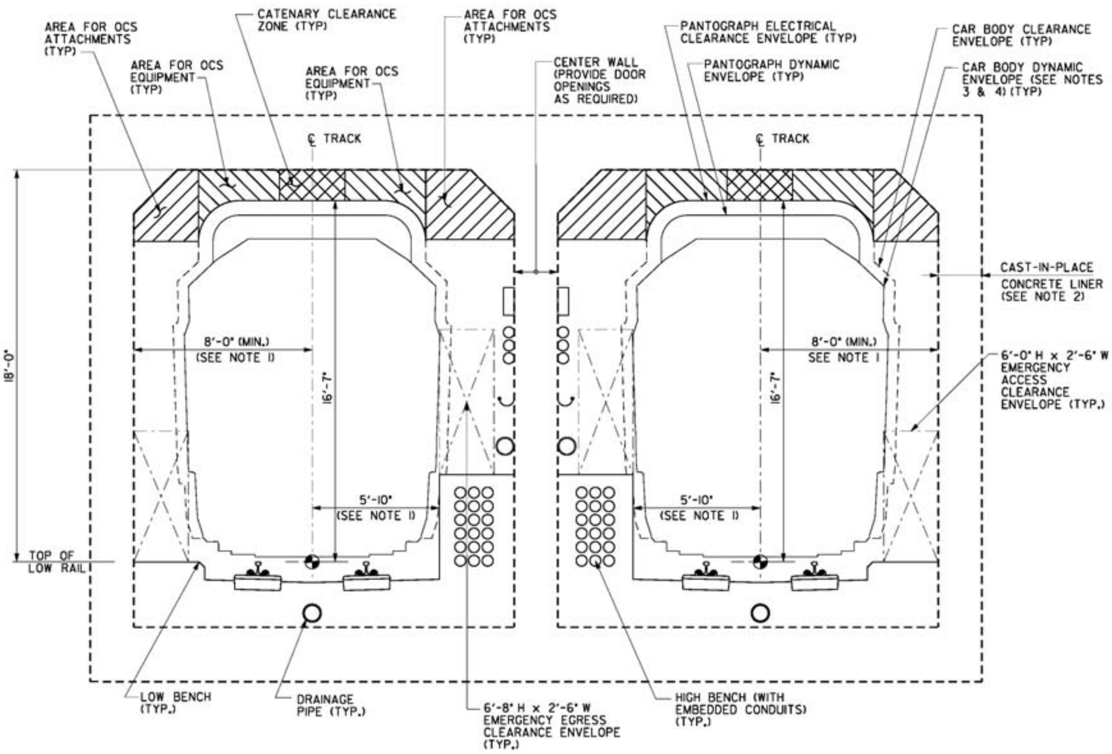
3.2 Review of Internal Space Requirements for Tunnel

As part of the conceptual engineering studies performed by Parsons Brinckerhoff (PB) for Amtrak (Phase 1 – Section 1, Final Report submitted May 27, 2011), PB provided internal tunnel space proofing for cut-and-cover tunnels between Ninth and Twelfth Avenues. Since that report was released, PB was tasked to study the possibility of revising the track alignment to avoid a proposed overbuild structure on the terra firm area south of the East Rail Yards (ESY) adjacent to the Eleventh Avenue Viaduct.

Using this revised track alignment; PB since re-reviewed the internal clearances as described below. Refinement to these dimensions and final verification of these dimensions will be completed during the Final Design stage with Amtrak and NJ Transit. The purpose of the memo submitted to Amtrak was to capture and verify that all overall assumptions for vehicle carbody clearance, catenary clearance, low bench clearance, high bench clearance, fire-life safety, and ventilation issues have been captured and other major elements have not been excluded.

The cross section in Figure 3-1 defines the internal space between the tunnel walls and roof. The structure is shown dashed.

Figure 3-1: Tunnel Internal Space Requirements



CUT-AND-COVER TUNNELS
TANGENT TRACK

NOTES:

1. FOR CURVED TRACK, THESE DIMENSIONS NEED TO BE INCREASED AN ADDITIONAL 1½" PER DEGREE OF CURVATURE. ADDITIONALLY, THESE CLEARANCES SHALL BE FURTHER INCREASED BY 1" FOR EACH INCH OF SUPERELEVATION FOR EACH 5' OF HEIGHT ABOVE TOP OF RAIL.
2. CAST-IN-PLACE CONCRETE LINER THICKNESSES VARY FOR CUT-AND-COVER TUNNELS. OVERALL TUNNEL WIDTH VARIES DEPENDING ON DEGREE OF CURVE.
3. THE CAR BODY CLEARANCE ENVELOPE MAY IMPEDE INTO THE EMERGENCY EGRESS AND EMERGENCY ACCESS ENVELOPES. HOWEVER, THE DYNAMIC ENVELOPE SHALL NOT.
4. THE CAR BODY DYNAMIC ENVELOPE WAS DEVELOPED USING THE FOLLOWING VEHICLES:

AMTRAK:	NJ TRANSIT:	LIRR:
AEM-7	ALP-44	DM-30
ACELA EXPRESS	ALP-46	MI/M3/M7
HHP-8	NEW DUAL MODE	
P32AC-DM	COMET II, III, IV, V	
AMFLEET	ARROW III, IV	
VIEWLINER	MULTILEVEL	
HERITAGE BAGGAGE CAR		
PLASSER MFS-40		

The internal tunnel space was developed for the use of the following vehicles:

Amtrak	NJ Transit	LIRR
AEM-7	ALP-44	DM-30
Acela Express	ALP-45	M1/M3/M7
HHP-8	ALP-46	
P32AC-DM	Comet II, III, IV, V	
AM Fleet	Arrow III, IV	
Viewliner	Multilevel	
Heritage Baggage Car		
Plasser MFS-40		

3.2.1 Static Vehicle Outline

This envelope is provided by the vehicle manufacturer. This envelope is defined as the composite vehicle outline at a motionless position.

3.2.2 Dynamic Vehicle Outline

This envelope is provided by the vehicle manufacturer. Defined as the extreme car body displacement that can occur for any combination or rotational, lateral, and vertical car body movements that can occur when the vehicle is operating on level, tangent track. These car body movements are due to truck suspension movement, spring action, allowable wheel and wear, and permitted tolerances in vehicle construction. In addition to car body movements on level, tangent track, the effects of track curvature and superelevation must also be considered to allow additional room for vehicle overhang on curves and for vehicle lean when curves are superelevated. In addition to superelevated tracks, car body overhang on horizontal curvature also increases lateral displacement of the dynamic outline relative to the track centerline. Maximum center and end excesses are calculated by AREMA formulae using the proposed alignment curve data.

3.2.3 Vehicle Clearance Envelope

Is defined as the space occupied by the vehicle dynamic envelope, plus allowances for rail wear and track safety tolerances, plus a running clearance. The clearance envelope represents the space into which no physical part of the systems (other than the rail vehicle and passenger evacuation envelope) would be placed, constructed, or protrude. This assumes a maximum 6-inch perpendicular offset from the dynamic envelope that would occur near the top of the vehicle. This dimension would be less, lower on the carbody, adjacent to the high bench.

3.2.4 Catenary Clearances

Catenary clearances are determined based on the American Railway Engineering and Maintenance-of-Way Association (AREMA) criteria. This envelope contains provisions for air clearance, catenary uplift, catenary depth, and other tolerances defined within AREMA. The pantograph width is 7 feet (3 feet-6 inches from centerline of track to end horn). The contact wire height is proposed at a vertical dimension of 16 feet-3 inches above top of rail. The air gap requirement of 9 inches (greater than 150-foot support spacing) is assumed above this zone. This dimension could be reduced based on a shorter spacing in a later stage of design.

3.2.5 High Bench

Top of high bench is located 4 feet above top of low rail. The vertical face of the bench is 5 feet-10 inches from centerline of tangent track. The vertical face of the bench is separated from the dynamic vehicle envelope by a radius of 2 inches. On curves, the gap must be increased by a distance of approximately 1.5 inches per degree of curvature, plus 1 inch per inch of superelevation if the bench is on the inside of the curve. This “gap” has been an acceptable tolerance for other railroad projects. Subsequent refinements to this dimension can be addressed at a later stage of design development. A minimum dimension of 2-foot-6 inch by 6-foot-8-inch passageway along the high bench is provided between the dynamic envelope and any continuous obstruction alongside the track and designated as passenger emergency evacuation path and maintenance personnel access.

3.2.6 Low Bench

Located at the opposite side of the track as the high bench, the low bench is a designated as a passageway for the conductor or other Amtrak personnel to access the vehicle at track level to connect brake hoses between vehicles or to accomplish other work to allow a disabled train to be pulled from the tunnel if needed. It is assumed, if needed, one would walk to the front or rear of the train on the high bench, and around to the other side of the train. This minimum envelope dimension of 2 feet-6 inches by 6 feet will be maintained. The top of the low bench would be the same elevation as top of rail.

3.2.7 Ventilation

Conceptual design has not advanced far enough to develop a complete emergency ventilation design. Preliminary conceptual design of the emergency ventilation system will be similar to the ARC tunnel. The Gateway tunnels will be ventilated via "push-pull" to meet NFPA 130 criteria. Fan plants will be located on the New Jersey side of the Hudson River and on 12th Avenue on the New York side of the Hudson River. Ventilation ducts will extend in the tunnels from each fan plant to part-way into the tunnels forming ventilation zones that cannot be occupied by more than one train at any given time. Access to each zone will be controlled by a fixed signal system that would preclude more than one train from entering an occupied ventilation zone. Each ventilation zone will be ventilated in "Push-Pull" mode and smoke and hot gases from the incident train will be contained in the ventilation zone such that trains occupying adjacent ventilation zones will not be contaminated from the incident zone.

While the ARC tunnels were able to have ventilation ducts extend all the way to the proposed station, the Gateway tunnels will be unable to accommodate ventilation ducts east of Eleventh Avenue within the ESY due to spatial constraints imposed by proposed overbuild columns, proximity to the existing Amtrak Empire Line Tunnel, and LIRR MOE facility. Therefore, to provide a ventilation zone from the proposed Twelfth Avenue Fan Plant to existing 'A' Yard that will meet NFPA 130 criteria, a fan plant is proposed to be built at the portal of the Gateway tunnels at the existing 'A' yard underneath the existing Lerner building. Providing a fan plant at the tunnel portal at Tenth Avenue will allow the stretch of tunnel across Hudson Yards to be as compact as possible eliminating a ventilation duct.

4.0 SITE LOGISTICS WITHIN THE HUDSON YARDS

In order to maintain the platform schedule for the ERY, regardless of the construction option selected, the tunnel alignment will be constructed from Tenth Avenue heading west towards Eleventh Avenue. As the first portion of the tunnel alignment (approximately 400 feet) is completed, platform construction will commence working over the completed tunnel alignment.

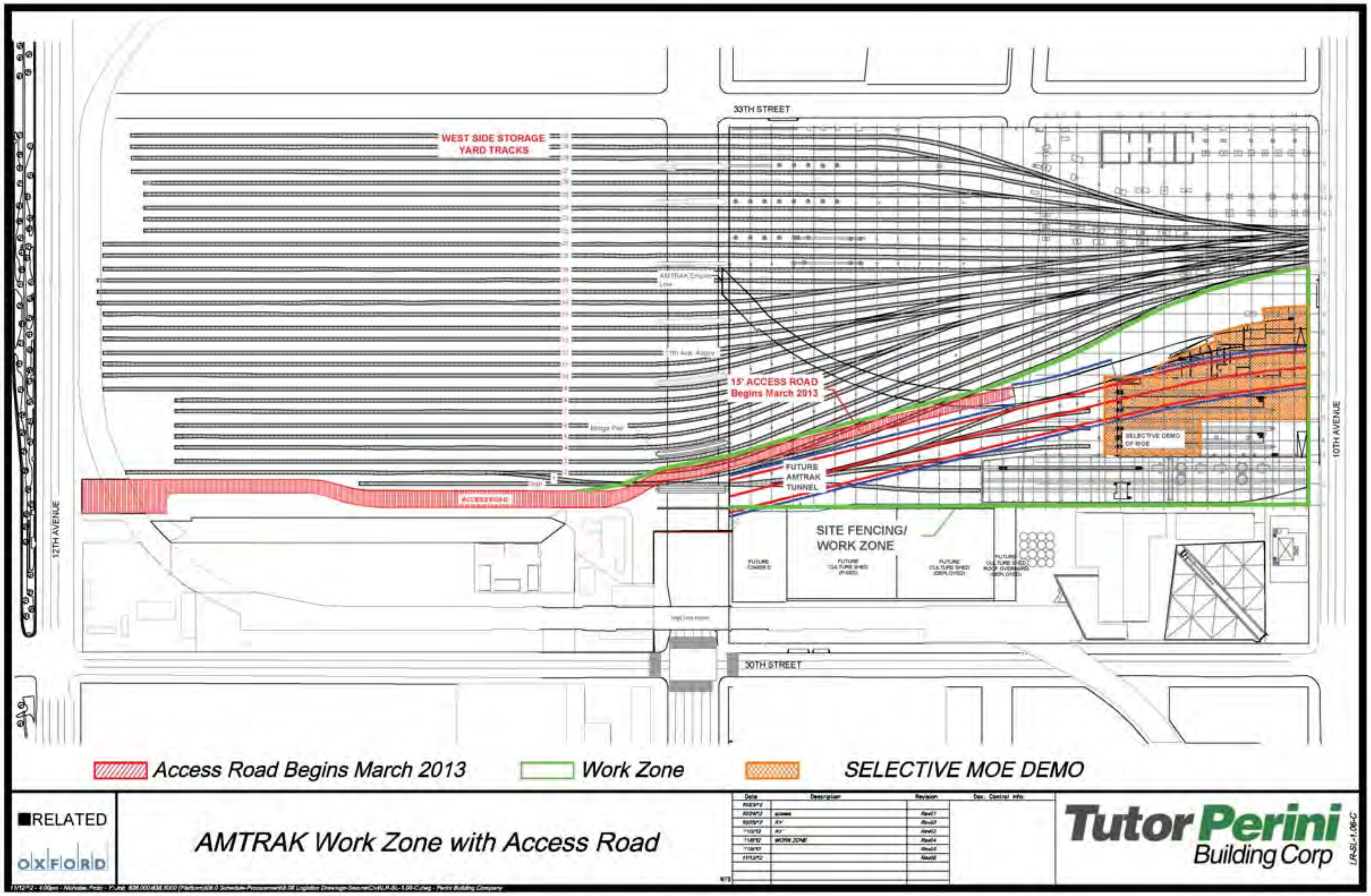
During tunnel construction, it is anticipated that the primary access to the alignment will be from Twelfth Avenue. See the attached plan showing the anticipated work zone and access route. It is not anticipated at this time that the existing ramp from Tenth Avenue will be viable access point. We anticipate having to remove this ramp early in the tunnel construction sequencing.

During the construction phase, it is also anticipated that the tunnel access and work zone will likely impede access to yard tracks 0, 1, & 2. The actual phasing and duration of the yard track impedance will be further developed during the detailed design phase of the tunnel alignment. The TPC construction team will work closely with the LIRR to minimize the actual duration of any impacts to the yard tracks. The detailed logistics plans will be co-authored with the LIRR during the design phase of this project.

In general, the anticipated construction sequence is as follows:

1. Fence off construction zone
2. Utility relocations, MOE building demolition, yard track removal
3. Secant piling and Caisson construction
4. Excavation/bracing
5. Tunnel construction
6. Backfill
7. Platform foundation construction and Crane pad development (after the first 400 feet are constructed). MOE reconstruction and utility restoration is part of this work
8. Yard track reconstruction

Figure 4-1: Anticipated Work Zone and Access Route



5.0 UTILITIES

5.1 General

The construction of the proposed Amtrak tunnel within the Eastside Yard, will directly impact a portion of the existing utility infrastructure of the yard, including but not limited to storm sewer, sanitary sewer, electrical AC & DC power, communication, signals, gas and water (potable and fire protection). A conceptual utility investigation, following the usual practice and methods of a quality "D" subsurface utility investigation (ASCE 38-02), was performed to identify potential utility impacts of construction.

The investigation has been performed using available existing utility information and has been compiled on drawing numbers SK-UTL-01 thru SK-UTL-05. The subsurface utility information was obtained from drawings provided by Tutor-Perini and utility drawings from the original LIRR yard design drawings (1982). LIRR has not been specifically consulted regarding the potential utility impacts, and it should be assumed that LIRR will have concern over the construction operation and will require strict measures to maintain and protect their facilities as well as a review/approval period. It is also recommended that additional subsurface utility investigation be performed to supplement the developed information; including field investigations and test pits to increase the ASCE level of quality from the current "D" to "C", "B" or "A" depending on the criticality of specific locations and utilities.

We have assumed that the entire LIRR maintenance facility will be completely shut down so that no utility services will be required during the shutdown period. All existing utilities serving the maintenance facility will be restored in kind as they exist at this time.

5.2 Storm & Sanitary Sewer

5.2.1 Storm Sewer

The proposed tunnel will require a portion of the system to be removed, relocated, and restored. The East Side Yard storm sewer system consists of a network of catch basins that collect surface run off, and elliptical reinforced concrete pipes (E.R.C.P.) that acts as the yard's trunk line to convey storm water off site. The surface run off north of the empire line tunnel is collected and is pumped via a 24" force main into the yard's elliptical trunk line. The surface run off south of the empire line is also collected thru a network of catch basins, but is connected to the trunk line via gravity connections throughout the yard.

<u>Option 1: Temporary Gravity Sewer Replacement</u>

The storm sewer system is required to be maintained throughout construction activities, and one option is to build a temporary gravity sewer to relocate the drainage system outside of the excavation zone to the extent possible.

- **E.R.C.P. Storm Sewers:** The existing (E.R.C.P.) and associated manholes that will be impacted from the open cut of the proposed tunnel will be required to be removed and temporarily replaced. Crossing of the excavation will be required to connect to the existing sewer outside of the construction zone. In locations where excavation crossings are required, the temporary sewer replacement shall be an equivalent size ductile iron or fiberglass (CCFRMP) circular pipe that shall be hung, supported and protected. After tunnel construction has concluded, the trunk line sewer shall be replaced in kind in its original location.
- **Surface run off collection network:** The existing catch basins and intermediate storm sewer pipes that will be impacted from the open cut of the proposed tunnel construction will require removal and temporary replacement. Within the construction zone, temporary replacement of catch basins and sewers may be reduced based on staging, site set up and temporary grading. However, to maintain service for the existing catch basins located outside of the construction zone, excavation crossings will be required. In locations where excavation crossings are required, the temporary sewer replacement shall be an equivalent size ductile iron circular pipe that shall be hung, supported and protected. After tunnel construction has concluded, the sewers and catch basins shall be replaced in kind in its original location.

Option 2: Temporary Pumping of Storm Sewer

A feasibility study will be initiated to determine the possibility of extending the existing force main through a system of temporary force main piping to a point west of Eleventh Avenue. This would eliminate the need for a temporary gravity trunk line within the excavation zone. This concept would require the modification of the existing storm water pumping system. If this is not feasible, an auxiliary temporary pumping system can be provided within the work zone to convey storm water from the end of the existing force main to a point beyond the work zone. After tunnel construction has concluded, the sewers and catch basins shall be replaced in kind in their original locations.

5.2.2 Sanitary Sewer

The proposed tunnel construction activities will impact the existing sanitary sewer servicing the LIRR maintenance facility. The existing sewer shall be removed and replaced in kind after construction of the tunnel roof.

5.3 Electrical – AC & DC Power

5.3.1 AC Power

The proposed tunnel construction activities will impact the existing AC Power system that currently provides lighting for the South Access Road and exterior of the Maintenance Building and provides facility power to the interior of the building. Therefore, it is assumed that during construction activities, the impacted portion of the AC system serving lighting and the Maintenance Building will be temporarily taken out of service and temporary construction lighting be provided.

AC Power MH's and conduits also serve to connect the LIRR Emergency Facilities building just west of Eleventh Avenue to portions of the yard that are to remain in operation during the tunnel construction. To keep this portion of the impacted AC system operable during construction, MH's and conduits will be maintained as is or in a temporary condition. If construction activities are facilitated by removing this essential system a temporary emergency generator will be provided for the use of the LIRR. Any portion of the AC system removed will be restored in kind upon completion of the proposed tunnel roof.

5.3.2 DC Negatives

The proposed tunnel construction activities will impact the existing DC Negative system for the portion of the LIRR yard serving the maintenance facility. Therefore, it is assumed that during construction activities, the impacted portion of the DC Negative system will be temporarily taken out of service. If construction activities are facilitated by removing the deactivated system it will be restored in kind upon completion of the proposed tunnel roof.

5.3.3 DC Positives

The proposed tunnel construction activities will impact the existing DC Positive system. One segment of the impacted DC Positive serves the portion of the LIRR yard serving the maintenance facility. It has been assumed that the LIRR maintenance facility will be shutdown and the tracks entering it deactivated. Therefore, during construction activities, the impacted portion of the DC Positive system will be temporarily taken out of service. If construction activities are facilitated by removing the deactivated system it will be restored in kind upon completion of the proposed tunnel roof.

Another segment of the impacted DC Positive system serves tracks north of the proposed construction area that are to remain in operation. Specifically DC MH P8 is within the proposed tunnel excavation and must be temporarily relocated or maintained in place in a temporary condition (such as a wooden box). In addition if it is determined that DC MH P8 conflicts with the proposed tunnel roof a rerouting of the system from MHs P9 and P6 to P8 will be required. Temporary and/or final rerouting of the DC MH P8 system will have to be staged to provide service to all active tracks with minimal disruptions (off peak only). Final restoration of the DC power system must be coordinated to accommodate the possible conflict between bottom of DC MH P8 and the proposed tunnel roof by providing an alternative MH location or modified MH and tunnel roof.

5.4 Signal and Communication

5.4.1 Signals

The proposed tunnel construction activities will impact the existing signal system for the portion of the LIRR yard serving the maintenance facility. The impacted portion of the signal system will be temporarily taken out of service. If construction activities are facilitated by removing the deactivated system it will be restored in kind upon completion of the proposed tunnel roof. It remains to be confirmed that there is no existing signal equipment within the LIRR Maintenance Building that is required for operation of the portion of the yard that must remain in operation during tunnel construction.

5.4.2 Communications

The proposed tunnel construction activities will impact the existing communications system for the portion of the LIRR yard serving the maintenance facility. The impacted portion of the communications system will be temporarily taken out of service. If construction activities are facilitated by removing the deactivated system it will be restored in kind upon completion of the proposed tunnel roof.

5.5 Water (Fire & Potable) and Gas

5.5.1 Water (Fire & Potable)

The 10” fire protection and 6” potable water lines are impacted by the proposed open cut construction. Upon initial review, it appears that the fire protection and potable water mains service areas outside of the construction zone. Therefore, the water mains will be temporarily relocated outside of construction zone. Any exposed water mains will be protected from freezing by insulation and/or heat trace.

5.5.2 Gas

Upon initial review it appears that the 5-inch gas line services only the LIRR maintenance facility. It has been assumed that the gas line can be deactivated and capped outside of the construction influence area. If the existing gas line is removed during construction it will be replaced as required by LIRR.

6.0 DESIGN SOLUTIONS & CONSTRUCTION OPTIONS

6.1 Subdivision of Site

For the purpose of the study the proposed tunnel alignment has been divided into four distinct sections as delineated in drawing SK-ALT1-01. The sections reflect the significantly different physical constraints and characteristics imposed along the tunnel alignment by the layout and loads of the planned overbuild structures, as well as from the existing Amtrak Empire Line Tunnel and the LIRR railroad infrastructure and MOE Buildings. The main characteristics of each section are summarized below:

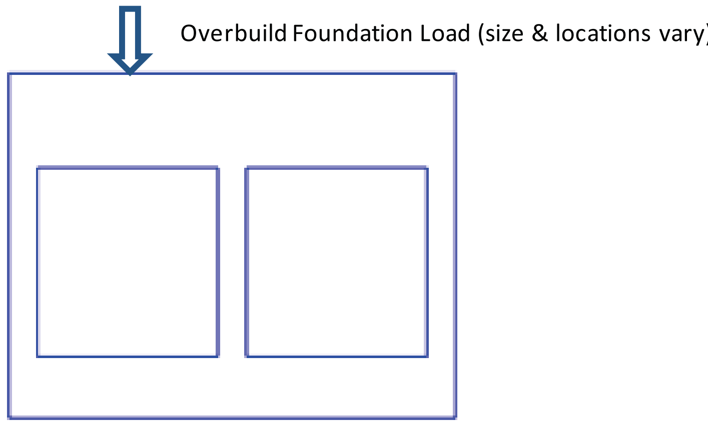
- **Section A:** The southwest end of the alignment, adjacent to Eleventh Avenue, is characterized by the high column loads imposed by the Overbuild Tower D (10,000 kip column loads). The tunnel alignment is also at its deepest in this section.
- **Section AB:** This section of the tunnel alignment is occupied by shop tracks serving the MOE Building and is characterized by multiple columns carrying the Overbuild platform only (2,000 kip loads).
- **Section B:** This section of tunnel is in close proximity to the existing Amtrak Empire Line Tunnel. This area is also characterized by multiple columns carrying high loads from Overbuild Structures (6,000 kip column loads).
- **Section C:** The western end of the tunnel is occupied by the LIRR MOE Buildings and is characterized by multiple high column loads from the Overbuild Structures (6,000 kip column loads). The tunnel is also at its shallowest along this section.

6.2 Conceptual Design Alternates

Cognizant that the potentially complex easement arrangements for the future Gateway Tunnel, LIRR facilities and Overbuild structures have yet to be resolved, three conceptual design solutions have been developed for the permanent structures. The design solutions, designated Alternates 1, 2 and 3, provide different levels of structural separation between the proposed Gateway Tunnel and the foundations of the Overbuild structures as described below:

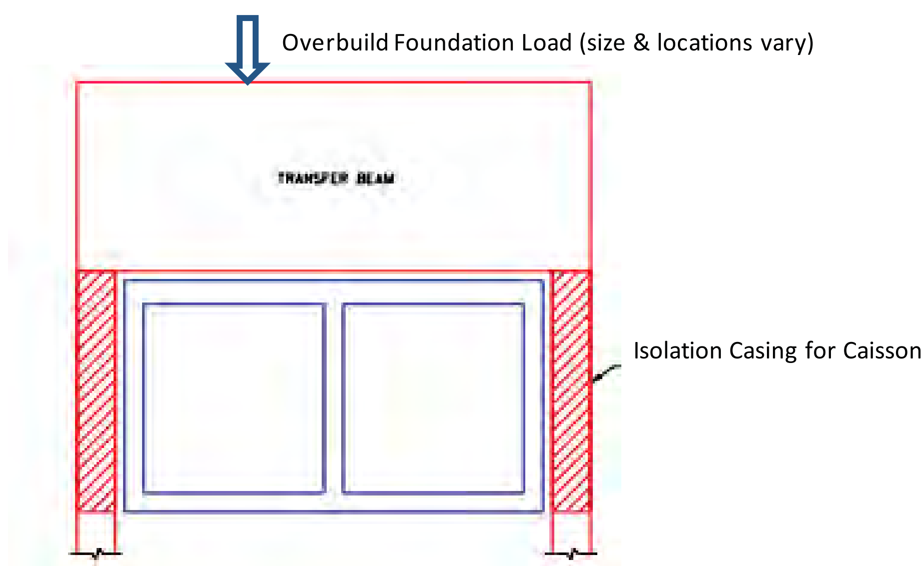
The tunnel structure, which is founded on rock, is designed to carry the column loads of the overbuild structures. This is the simplest construction solution which utilizes the proposed tunnel as a pad or pseudo-strip foundation for the overbuild structures. However, integrating the tunnel and overbuild structures complicates interface issues between the structures such as railroad easement arrangements, isolation of railroad vibrations from the overbuild structures, fire & life safety and terrorist threat mitigation measures, and demarcation of maintenance responsibilities for the structures. These interface issues, including vibration isolation, will be addressed during detail design.

Figure 6-1: Alternative 1: Fully Integrated Tunnel and Overbuild Foundation Structures



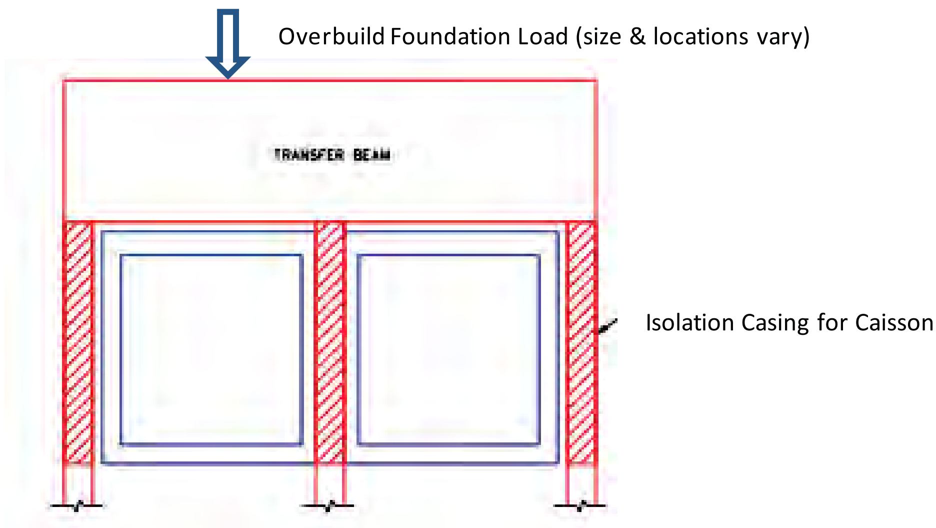
The Alternative 2 design solution transfers the overbuild column loads onto caisson foundations located on either side of the tunnel. Isolation casing is utilized at tunnel elevation to isolate the caisson foundations from the tunnel box and transfer the overbuild column loads below the invert of the tunnel. This design solution eliminates the majority of interface issues between the tunnel and overbuild structures.

Figure 6-2: Alternative 2: Fully Isolated Tunnel and Overbuild Foundation Structures



The Alternative 3 design solution transfers the overbuild column loads onto caisson foundations located either side of the tunnel and along the dividing wall between the tracks, thereby reducing the span and size of the overbuild transfer structures. Isolation casing is again utilized at tunnel elevation to isolate the caisson foundations from the tunnel box and transfer the overbuild loads below the invert of the tunnel. While this design solution will isolate the overbuild loads from the tunnel, it nevertheless also introduces more complicated structural joint and waterproofing details between the structures and many of the interface issues associated with the fully integrated design solution will remain pertinent in this case.

Figure 6-3: Alternative 3: Partially Isolated Tunnel and Overbuild Foundation Structures



6.3 Construction Options

Each of the above conceptual design solutions was developed along the alignment to evaluate their technical feasibility and to determine costs and schedule implications for constructing the tunnel's structural box. Recognizing that construction of the tunnel will be dependent on the availability of funding, the construction options listed in Table 6-1 and described below were considered.

Table 6-1: Tunnel Construction Options

Alternative	Design Concept	Construction Options	Tunnel Construction
Alt. 1	Fully Integrated	Option 1	Full Build
Alt. 2	Fully Isolated	Option 1	Full Build
		Option 2A	Deck Supported on Full Depth Secant Pile Walls to facilitate Future Build
		Option 2B	Deck Supported on Independent Caissons to facilitate Future Build
		Option 3	Easement Corridor Only
Alt. 3	Partially Isolated	Option 1	Full Build
		Option 2A	Deck Supported on Full Depth Secant Pile Walls to facilitate Future Build
		Option 2B	Deck Supported on Independent Caissons to facilitate Future Build
		Option 3	Easement Corridor Only

- **Option 1:** Full construction of the tunnel's structural box concurrent with the overbuild construction activities
- **Option 2:** Configuration of the overbuild foundations and construction of a deck structure at or above the roof elevation of the tunnel to support the Hudson Yard's railroad infrastructure/operations in order to preserve an easement and facilitate independent construction of the tunnel's structural box at some future date. This option has been further subdivided as follows:
  - **Option 2A:** Secant pile walls drilled full depth through rock and toed below the invert level of the future tunnel are utilized to support the deck structure. The secant pile walls also serve as the temporary excavation support during construction of the deck and overbuild foundations and will provide temporary sidewall support during subsequent mining of the tunnel.
  - **Option 2B:** The temporary deck structure is supported on pre- installed caissons spaced along the tunnel alignment. Secant pile walls, drilled into the top of rock, are used to support the temporary excavations for construction of the deck and overbuild foundations along the tunnel alignment. Rockbolts will be utilized to support rock faces exposed at locations where the excavations extend into rock.
- **Option 3:** This 'Not to Preclude' option entails configuring and constructing the overbuild foundations to preserve an easement corridor for constructing of the tunnel box separately in the future. While this option will preserve a pathway to construct the tunnel independently, no other measures are incorporated during construction of the overbuild structures to facilitate tunnel construction.

6.4 Alternative 1: Fully Integrated Tunnel and Overbuild Foundation Structures

6.4.1 Design Concept

The tunnel is designed to directly support the columns of the Overbuild structures. The tunnel invert is founded in rock and serves as the foundation for the Overbuild structures. This design concept is technically viable along the entire tunnel alignment within the Hudson Yards. As the column loads vary along the tunnel alignment the dimensions of the tunnel box will also vary as illustrated in drawing SK-ALT1-02.

6.4.2 Construction Option 1

Full Construction of Integrated Tunnel and Overbuild Foundations

Fully integrating the tunnel and overbuild foundations requires the tunnel box to be constructed concurrently with the overbuild structures. Accordingly, Option 1 is the only means of construction if this design solution is selected.

The initial stage of construction will entail relocations of railroad infrastructure and utilities to accommodate open cut excavation of the deep trench in which the tunnel will be constructed. It also requires demolition of sections of the existing LIRR MOE structures within Section C. At the same time the support of excavation (SOE) walls will be installed to facilitate excavation down through the overburden soils to rock. Due to the relatively high groundwater elevation and likelihood of contamination, the study anticipates secant pile walls toed into rock will be utilized for the SOE. Alternative methods could be explored during detailed design. As much as possible tie back anchors will be utilized in lieu of struts to support the SOE walls. At Section B, there is insufficient space to accommodate the SOE between the Empire Line Tunnel and the trench for the Gateway tunnel. Therefore the secant pile wall in this vicinity is anticipated to cross over and run on the north side of the Empire Line Tunnel. Alternatively, bracing at the roof level of the Empire Line Tunnel could be considered.

Mass excavation of the overburden soils will follow installation of SOE walls. The excavation will be extended through rock to the tunnel invert level utilizing controlled blasting techniques. Channel drilling and rock splitting techniques will also be necessary in close proximity to the Empire Line. Pattern rock bolting will be used to temporarily support the rock faces in the trench.

Shotcrete will be applied to the rock faces in the trench and lower sections of the secant pile walls to provide an adequately smooth surface to attach the waterproofing fleece and membrane used to waterproof the new tunnel. A mud mat will also be placed in the invert. The permanent cast-in-place reinforced concrete tunnel invert, walls and roof will be placed following installation of the waterproof membrane.

The final stages of construction will entail completing the overbuild column connections to the tunnel box, cutting off the top of the secant pile walls, backfilling the tunnel trench and reinstating the railroad infrastructure and utilities.

6.5 Alternative 2: Fully Isolated Tunnel and Overbuild Foundation Structures

6.5.1 Design Concept

In this design concept the columns of the overbuild structures are supported on transfer beams to transfer the building loads onto caisson foundations located on either side of the tunnel. Isolation casing is utilized at tunnel elevation to isolate the caisson foundations from the tunnel box and carry the overbuild column loads below the invert of the tunnel.

The tunnel's structural box is only designed for the ground and groundwater pressures and the railroad infrastructure and operating surcharge loads within the Yard. While the structural dimensions of the tunnel roof, invert and walls will be reduced compared to those of the fully integrated structure (Alternative 1), buoyancy measures are required to counter hydraulic uplift pressures. For the purpose of this study, friction piles have been allowed for in the tunnel invert. Other options such as double corrosion protection anchors or rock keys can be explored during detailed design.

Transferring the largest column loads onto the caissons either side of the tunnel will require substantial transfer structures. Significantly, due to the relatively shallow cover above the proposed tunnel at Section C, under the LIRR MOE structures, there will be insufficient room to accommodate the required transfer beam for the overbuild column loads if the transfer structure is located immediately above the tunnel roof.

Since the tunnel and overbuild foundation structures are entirely independent of each other, the structures can be constructed concurrently or separately. Therefore, construction Options 1, 2 and 3 are available as described below.

6.5.2 Construction Option 1

Full Construction of Tunnel and Overbuild Foundations

Construction will begin with railroad infrastructure and utility relocations and demolition of sections of the existing LIRR MOE structures to accommodate open cut excavation of the deep trench to construct the tunnel. The overbuild caisson foundations and tunnel friction piles will also be drilled at this stage in conjunction with the SOE secant pile walls described earlier for the fully integrated tunnel and overbuild design solution.

Mass excavation of the overburden soils within the tunnel trench will be followed by excavation of the rock to formation level utilizing the same controlled blasting/rock splitting techniques and rock support measures described earlier. A smoothing layer of shotcrete will again be applied to the rock faces and lower sections of the secant pile walls for the tunnels waterproofing fleece and membrane. A mud mat will also be placed in the invert, accommodating the counter buoyancy friction piles that will be integrated into the tunnel invert. The permanent cast-in-place reinforced concrete invert, walls and roof will be placed following installation of the waterproof membrane.

The final stages of construction will entail constructing the overbuild transfer beam and caisson connections above the tunnel roof elevation. Styrofoam or similar compressible material will be used to infill the annulus between the tunnel roof and transfer structures. The structural connections between the transfer beams and column footings will then be completed and where applicable the tops of the secant pile walls cut. Tunnel construction is completed by backfilling the tunnel trench and reinstating the railroad infrastructure and utilities.

6.5.3 Construction Options 2A and 2B

Construction of Tunnel Decking and Overbuild Foundations

In lieu of fully constructing the tunnel box in conjunction with the overbuild structures, construction Options 2A and 2B entail constructing a deck structure over the tunnel alignment as described in section 6.2. Since the overbuild foundation transfer structures will already bridge over the tunnel alignment, the deck structure is only required between the transfer structures.

Option 2A, incorporating full depth secant pile walls, is only considered viable within Section AB of the alignment where the spacing between the overbuild foundations permits construction of the walls (see drawing SK-ALT2-01). In Sections A and B the close spacing between the overbuild columns renders this option impractical.

Option 2B is viable at Sections, A AB and B (see drawings SK-ALT2-02, SK-ALT2-03 and SK-ALT-04.

Future Tunnel Construction Stages

Future tunnel construction will entail mining the rock under the deck (and between the secant pile walls where applicable) by controlled blasting in conjunction with channel and line drilling and rock splitting techniques to minimize impacts to the deck and overbuild caisson foundations. The steel isolation casing used to isolate the overbuild caissons from the final tunnel will afford some protection to the overbuild caissons during mining. Nevertheless, noise and vibrations associated with blasting and other construction activities may cause nuisance to occupants in the overbuild buildings.

The friction piles required to counter hydraulic uplift pressures in the final tunnel structure will be drilled following completion of tunnel excavation. The headroom within the tunnel will be approximately 25 feet at this stage of the construction. Shotcrete will be applied to the exposed secant pile sidewalls and/or rock faces as applicable in order to provide an adequately smooth surface to attach the waterproofing fleece and membrane used to waterproof the new tunnel. At the locations of the overbuild foundation transfer structures styrofoam or similar compressible material will be used to infill the annulus to the tunnel roof prior to installing the waterproofing fleece and membrane. In the invert the mud mat will be placed allowing the counter buoyancy friction piles to be integrated into the tunnel invert. The permanent cast-in-place reinforced concrete tunnel invert, walls and roof will then be placed following installation of the waterproof membrane.

6.5.4 Construction Option 3

Overbuild Foundations Construction

Since these structures will be completely independent of the future tunnel construction they can be located at relatively shallow depth. Open cut excavation will only be required to construct the overbuild transfer structures. Steel sheeting can be installed instead of secant pile walls to support the smaller individual excavations required to construct each overbuild transfer structure (see drawings SK-ALT2-05, SK-ALT2-06 and SK-ALT2-07.

Future Tunnel Construction Options

Future tunnel construction methods are discussed separately in Section 6.7.

6.6 Design Alternative 3: Partially Isolated Tunnel and Overbuild Foundations

6.6.1 Design Concept

This design solution is similar to the fully isolated design concept in that it transfers the overbuild column loads onto caisson foundations which carry the loads below the tunnel invert level. However, in this case caissons are also installed along the tunnel center wall which divides the tracks in order to reduce the span and size of the overbuild transfer structures. Isolation casing is again utilized at tunnel elevation to isolate the caisson foundations from the tunnel box and transfer the overbuild loads below the invert of the tunnel. Nevertheless, incorporating the center column through the middle of the tunnel means the structures will not be entirely isolated from one another. Structural joint details and waterproofing to accommodate the center columns will be significantly more complex. Furthermore, the dimension of the center wall will increase because of the inclusion of the center column. Since the overbuild loads are not transferred to the tunnel, the tunnel's structural box will be designed only for the ground and groundwater pressures and the railroad infrastructure and operating surcharge loads, thereby maintaining thinner tunnel invert, walls and roof relative to those of the fully integrated structure (Alternative 1). For the purpose of the study, friction piles have again been allowed for in the tunnel invert in order to counter hydraulic uplift pressures.

While the center column will enable the transfer structure to be reduced in size relative the fully isolated configuration, there is still insufficient cover under the LIRR MOE structures at Section C to accommodate the beam.

With the loads of the overbuild structures being isolated from the tunnel, the structures can be constructed concurrently or separately. Therefore, construction Options 1, 2 and 3 are again available although complicated by the structural and waterproofing details to accommodate the center columns.

6.6.2 Construction Option 1

Tunnel construction will be similar to that described in section 6.5.2 for Alternative 2.

6.6.3 Construction Options 2A and 2B

Decking and Overbuild Foundations Construction

Construction will be similar to that described in Section 6.5.3 for Alternative 2. Option 2A is only viable in Section AB. Option 2B is viable in Sections A, AB and B. See drawings SK-ALT3-01, SK-ALT3-02, SK-ALT3-03 and SK-ALT3-04.

Future Tunnel Construction Stages

Tunnel construction will be similar to that described in section 6.5.3 for Alternative 2.

6.6.4 Construction Option 3

Overbuild Foundations Construction

Overbuild foundation construction will be similar to that described in section 6.5.4 for Alternative 2 with the exception of drilling the additional center caissons. See drawings SK-ALT3-05, SK-ALT3-06 and SK-ALT3-07.

Future Tunnel Construction

Future tunnel construction methods are discussed separately in section 6.7.

6.7 Option 3 (Not to Preclude): Future Tunnel Construction Methods

Future tunnel construction for the 'Not to Preclude' case could utilize cut-and-cover excavation methods or underground mining techniques. Cut-&-cover excavation methods would be most disruptive to future railroad operations within the Hudson Yards. Underground mining methods would likely also cause some disruption to the railroad but not to the physical extent of cut-and-cover methods. However, mining methods will be slower and carry potentially higher risk. Possible tunnel construction methods are described below.

6.7.1 Cut-and-Cover Tunnel Construction

Stage 1 of future tunnel construction by cut-and-cover methods would entail railroad infrastructure and utility relocations. Combinations of secant pile wall construction, steel sheeting and soldier pile and lagging could then be utilized to negotiate the existing overbuild foundations and provide excavation support down to rock.

Stage 2 would entail mass excavation of the overburden soils along the tunnel alignment between the overbuild foundations to the top of rock. Excavation would continue vertically in rock to the tunnel invert level utilizing controlled blasting techniques. Channel drilling and rock splitting techniques would also be necessary in closest proximity to the Empire Line Tunnel and the already constructed overbuild caisson foundations. Pattern rock bolting would be used to temporarily support the rock faces in the trench. Sequential mining techniques would be used undercut the soil and rock under the overbuild transfer beams between the isolated caissons. The undersides of the transfer beams can be exposed since the beams are supported by the caissons. If the transfer beams are shallow relative to the tunnel elevation, pre-support methods such as spiles or grouted canopy tubes could be used to retain the ground between the tunnel roof the underside of the overbuild transfer structures.

Stage 3 of tunnel construction requires drilling the friction piles in the floor of the tunnel excavation. The piles will be incorporated in the invert of the final tunnel structure to counter hydraulic uplift pressures. The headroom within the tunnel will be approximately 25 feet at this stage of the construction. Other options, such as blasting keys into the rock sidewalls at invert level could also be investigated.

Stage 4 involves shotcreting the exposed rock sidewalls and covering the rock bolt hardware that extend from the rock face in preparation for the waterproofing fleece and membrane. In the invert the mud mat will be placed accommodating the overbuild center column caissons (where present) and allowing the counter buoyancy friction piles to be integrated into the tunnel invert. The permanent cast-in-place reinforced concrete invert, walls and roof will be placed following installation of the waterproof membrane.

Stage 5 will entail backfilling the tunnel trenches and reinstating the railroad infrastructure and utilities.

6.7.2 Mined Tunnel Construction – Utilizing Jet Grouting or Ground Freezing

In order to facilitate underground tunnel construction the groundwater and overburden soils will first need to be treated. Possible ground treatment methods include jet grouting and ground freezing. The following ground treatment options have been considered:

- Jet Grouting
- Ground Freezing

Stage 1 of construction would entail implementation of the selected ground treatment method. Jet grouting from the surface would be most disruptive to the LIRR infrastructure and operations. However, implementing ground freezing from the surface would also entail significant disruption in order to drill the freeze pipes and install/operate the freezing infrastructure. Horizontal freezing operations from within the tunnel would minimize surface disruption to the rail yard but would be a very slow process because the freeze could only be advanced in nominal 100-foot segments ahead of the tunnel face due to the limitations of horizontal drilling. The freezing process will take several months following installation of the freeze pipes. Freezing can potentially induce significant heave and expansion forces during the freeze process and subsequent settlement once the freeze is turned off.

Stage 2 of the construction would entail mining through the treated ground in one or both directions depending on site access. Mining would progress utilizing pre-support spiles installed in front of the mining face to prevent raveling or collapse of any overburden soils in the roof area of the tunnel. The pre-support is installed in front of each advance of the tunnel face. Controlled blasting methods would be utilized in combination with channel/line drilling and rock splitting techniques where necessary. Initial rock support in the tunnel would comprise pattern rock bolting and shotcrete, together with steel ribs or lattice girders where required.

Stage 3 will entail drilling the friction piles in the floor of the tunnel excavation. The piles will be incorporated in the invert of the final tunnel structure to counter hydraulic uplift pressures. The headroom within the tunnel will be approximately 25 feet at this stage of the construction. Other options, such as blasting keys into the rock sidewalls at invert level could also be investigated.

Stage 4 involves spraying smoothing shotcrete if not already incorporated in the initial support system in stage 2. In the invert the mud mat will be placed accommodating the overbuild center column caissons (where present) and allowing the counter buoyancy friction piles to be integrated into the tunnel invert. The permanent cast-in-place reinforced concrete invert, walls and roof will be placed following installation of the waterproof membrane.

6.8 Summary of Construction Solutions for Pricing

Table 6.2 defines five viable construction options, or Pricing Solutions, that have been developed from the technical evaluations described in this section. In all cases the Pricing Solutions require construction of the fully integrated tunnel (Alternative 1) under the LIRR MOE Building (Section C) due to the limited space above the tunnel. Pricing Solution 2B reflects incorporating a middle caisson for the partially isolated design concept (Alternative 3).

Table 6-2: Pricing Solutions

Pricing Solution	Design Alternative/Construction Option at Site Locations			
	A	AB	B	C
1	Alt.1/Opt.1	Alt.1/Opt.1	Alt.1/Opt.1	Alt.1/Opt.1
2A	Alt.2/Opt. 2B	Alt.2/Opt.2A	Alt.2/Opt.2B	Alt.1/Opt.1
2B	Alt.3/Opt.2B	Alt.3/Opt.2A	Alt.3/Opt.2B	Alt.1/Opt.1
2C	Alt.2/Opt.2B	Alt.2/Opt.2B	Alt.2/Opt.2B	Alt.1/Opt.1
3	Alt.2/Opt.3	Alt.2/Opt.3	Alt.2/Opt.3	Alt.1/Opt.1

Cost estimates and construction schedule implications for these construction Pricing Solutions are presented separately in this report.

7.0 COST ESTIMATES AND CONSTRUCTION SCHEDULES

7.1 Cost Estimates

Cost estimates for the present day and future tunnel construction elements for each of the Pricing Solutions identified in the previous section are presented in Table 7-1.

7.2 Construction Schedules

Construction schedules for Pricing Solutions 1, 2A/2B/2C and 3 are shown in Tables 7-2, 7-3, and 7-4, respectively.

Table 7-1: Pricing Solutions

Hudson Yards ERY Platform and Tower A
AMTRAK Tunnel Construction Options
Tutor Perini Civil Group Design Study Estimated Costs

11/15/12

	Description	Solution 1 Fully Integrated Cut & Cover Tunnel Full Length				Solution 2A Fully Isolated Cut & Cover Tunnel under MOE Shop Protective Deck over Remainder Full Depth Secant Piles (where practical) No Center Caisson			
		Quantity	Unit	Unit Price	Extension	Quantity	Unit	Unit Price	Extension
Site Preparation, Demolition, and Restoration Costs	Remove / Reinstall Yard Tracks (MTA FA)	1	LS	$ 2,500,000	$ 2,500,000	1	LS	$ 2,500,000	$ 2,500,000
	Demolish / Replace MOE Building	28,000	SF	$ 500	$ 14,000,000	28,000	SF	$ 500	$ 14,000,000
	Remove / Reinstall Shop Tracks (MTA FA)	1	LS	$ 500,000	$ 500,000	1	LS	$ 500,000	$ 500,000
	Bypass Pump Elliptical Sewer	1	LS	$ 2,800,000	$ 2,800,000	1	LS	$ 2,800,000	$ 2,800,000
	Replace 38x60 Elliptical Sewer	600	LF	$ 1,275	$ 765,000	600	LF	$ 1,275	$ 765,000
	Remove / Replace AC/DC Pwr & Sig (MTA FA)	1	ALOW	$ 3,000,000	$ 3,000,000	1	ALOW	$ 3,000,000	$ 3,000,000
	Remove / Replace Other Utilities	1	ALOW	$ 2,000,000	$ 2,000,000	1	ALOW	$ 2,000,000	$ 2,000,000
	Shop Electrical / HVAC Facilities	1	ALOW	$ 3,000,000	$ 3,000,000	1	ALOW	$ 3,000,000	$ 3,000,000
	Subtotal Site Prep Costs				$ 28,565,000				$ 28,565,000
Specific Construction Costs	Site Section A - Tower D Area	100	LF	$ 117,000	$ 11,700,000	100	LF	$ 109,000	$ 10,900,000
	Site Section AB - Shop Track Area	370	LF	$ 83,000	$ 30,710,000	370	LF	$ 75,650	$ 27,990,500
	Site Section B - Empire Line Tunnel Area	100	LF	$ 100,000	$ 10,000,000	100	LF	$ 115,000	$ 11,500,000
	Site Section C - MOE Shop Area	280	LF	$ 102,000	$ 28,560,000	280	LF	$ 102,000	$ 28,560,000
	Dewatering	1	LS	$ 2,000,000	$ 2,000,000	1	LS	$ 2,000,000	$ 2,000,000
	Subtotal Tunnel Costs				$ 82,970,000				$ 80,950,500
	Subtotal Site Prep and Tunnel Costs				$ 111,535,000				$ 109,515,500
Design Fees	4 Week Concept Design Fees				$ 240,000				$ 240,000
	Design Fees	7.5	%		$ 8,365,125	7.5	%		$ 8,213,663
	Subtotal Design Fees				$ 8,605,125				$ 8,453,663
	Total Current Construction Costs				$ 120,140,125				$ 117,969,163
Future Costs Prepared by Parsons Brinckerhoff	Total Future Construction Costs				$ -				$ 93,381,000
	Grand Total Costs				$ 120,140,125				$ 211,350,163

	Description	Solution 2B Partially Isolated Cut & Cover Tunnel under MOE Shop Protective Deck over Remainder Full Depth Secant Piles (where practical) Includes Center Caisson				Solution 2C Fully Isolated Cut & Cover Tunnel under MOE Shop Protective Deck over Remainder Secant Piles Toed into Rock No Center Caisson				Solution 3 Fully Isolated - Not to Preclude Cut & Cover Tunnel under MOE Shop No Protective Deck Transfer Beams on Caissons No Center Caisson			
		Quantity	Unit	Unit Price	Extension	Quantity	Unit	Unit Price	Extension	Quantity	Unit	Unit Price	Extension
Site Preparation, Demolition, and Restoration Costs	Remove / Reinstall Yard Tracks (MTA FA)	1	LS	$ 2,500,000	$ 2,500,000	1	LS	$ 2,500,000	$ 2,500,000	1	LS	$ 2,500,000	$ 2,500,000
	Demolish / Replace MOE Building	28,000	SF	$ 500	$ 14,000,000	28,000	SF	$ 500	$ 14,000,000	28,000	SF	$ 500	$ 14,000,000
	Remove / Reinstall Shop Tracks (MTA FA)	1	LS	$ 500,000	$ 500,000	1	LS	$ 500,000	$ 500,000	1	LS	$ 500,000	$ 500,000
	Bypass Pump Elliptical Sewer	1	LS	$ 2,800,000	$ 2,800,000	1	LS	$ 2,800,000	$ 2,800,000	1	LS	$ 2,800,000	$ 2,800,000
	Replace 38x60 Elliptical Sewer	600	LF	$ 1,275	$ 765,000	600	LF	$ 1,275	$ 765,000	600	LF	$ 1,275	$ 765,000
	Remove / Replace AC/DC Pwr & Sig (MTA FA)	1	ALOW	$ 3,000,000	$ 3,000,000	1	ALOW	$ 3,000,000	$ 3,000,000	1	ALOW	$ 3,000,000	$ 3,000,000
	Remove / Replace Other Utilities	1	ALOW	$ 2,000,000	$ 2,000,000	1	ALOW	$ 2,000,000	$ 2,000,000	1	ALOW	$ 2,000,000	$ 2,000,000
	Shop Electrical / HVAC Facilities	1	ALOW	$ 3,000,000	$ 3,000,000	1	ALOW	$ 3,000,000	$ 3,000,000	1	ALOW	$ 3,000,000	$ 3,000,000
	Subtotal Site Prep Costs				$ 28,565,000				$ 28,565,000				$ 28,565,000
Specific Construction Costs	Site Section A - Tower D Area	100	LF	$ 117,600	$ 11,760,000	100	LF	$ 109,000	$ 10,900,000	100	LF	$ 78,000	$ 7,800,000
	Site Section AB - Shop Track Area	370	LF	$ 81,500	$ 30,155,000	370	LF	$ 65,400	$ 24,198,000	370	LF	$ 36,000	$ 13,320,000
	Site Section B - Empire Line Tunnel Area	100	LF	$ 109,000	$ 10,900,000	100	LF	$ 115,000	$ 11,500,000	100	LF	$ 96,000	$ 9,600,000
	Site Section C - MOE Shop Area	280	LF	$ 102,000	$ 28,560,000	280	LF	$ 102,000	$ 28,560,000	280	LF	$ 102,000	$ 28,560,000
	Dewatering	1	LS	$ 2,000,000	$ 2,000,000	1	LS	$ 2,000,000	$ 2,000,000	1	LS	$ 2,000,000	$ 2,000,000
	Subtotal Tunnel Costs				$ 83,375,000				$ 77,158,000				$ 61,280,000
	Subtotal Site Prep and Tunnel Costs				$ 111,940,000				$ 105,723,000				$ 89,845,000
Design Fees	4 Week Concept Design Fees				$ 240,000				$ 240,000				$ 240,000
	Design Fees	7.5	%		$ 8,395,500	7.5	%		$ 7,929,225	7.5	%		$ 6,738,375
	Subtotal Design Fees				$ 8,635,500				$ 8,169,225				$ 6,978,375
	Total Current Construction Costs				$ 120,575,500				$ 113,892,225				$ 96,823,375
Future Costs Prepared by Parsons Brinckerhoff	Total Future Construction Costs				$ 100,905,000				$ 93,880,000			Cut & Cover Tunnel	$ 132,600,000
	Grand Total Costs				$ 221,480,500				$ 207,772,225				$ 229,423,375

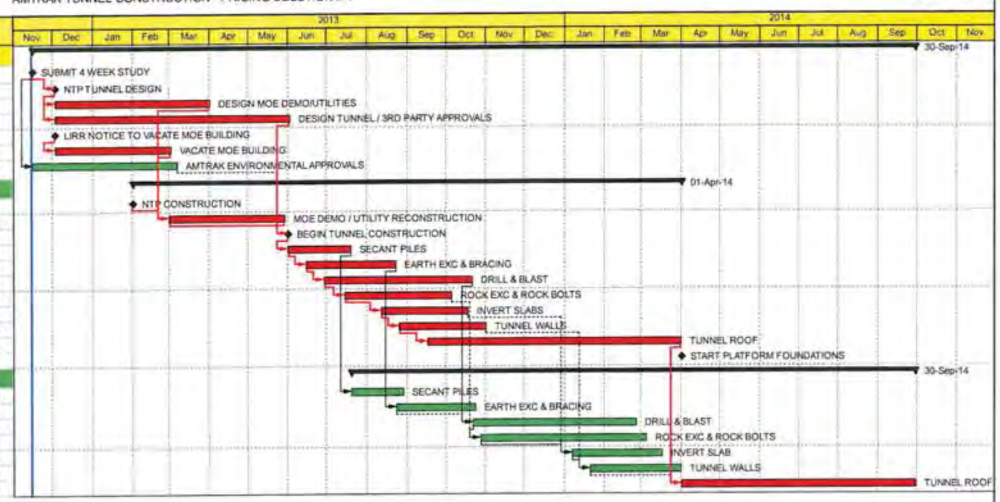
Future Costs	Mined Tunnel (vertical jet grouting)	$ 145,771,000
		$ 145,771,000
		$ 242,594,375
Future Costs	Mined Tunnel (vertical ground freeze)	$ 170,268,000
		$ 170,268,000
		$ 267,091,375

Exclusions:
1. AMTRAK Costs
2. MTA /LIRR Costs
3. Related overhead costs
4. Structural interface cost potentials (TBD)

Table 7-2: Amtrak Tunnel Construction – Pricing Solution 1

AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 1 16-Nov-12 11:13

Activity ID	Activity Name	Original Duration	Start	Finish
	AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 1	684	16-Nov-12	30-Sep-14
A1000	SUBMIT 4 WEEK STUDY	0	16-Nov-12*	
A1100	NTP TUNNEL DESIGN	0	03-Dec-12*	
A1200	DESIGN MOE DEMO/UTILITIES	120	03-Dec-12	01-Apr-13
A1300	DESIGN TUNNEL / 3RD PARTY APPROVALS	182	03-Dec-12	02-Jun-13
A1400	LIRR NOTICE TO VACATE MOE BUILDING	0	03-Dec-12*	
A1500	VACATE MOE BUILDING	90	03-Dec-12	02-Mar-13
A1900	AMTRAK ENVIRONMENTAL APPROVALS	112	16-Nov-12	07-Mar-13
	SECTION C & B (381 FEET)	[illegible]	01-Feb-13	01-Apr-14
A1600	NTP CONSTRUCTION	0	01-Feb-13*	
A1700	MOE DEMO / UTILITY RECONSTRUCTION	90	01-Mar-13*	29-May-13
A1800	BEGIN TUNNEL CONSTRUCTION	0	01-Jun-13*	
A2000	SECANT PILES	41	01-Jun-13	19-Jul-13
A2100	EARTH EXC & BRACING	59	15-Jun-13	23-Aug-13
A2200	DRILL & BLAST	96	29-Jun-13	21-Oct-13
A2300	ROCK EXC & ROCK BOLTS	71	15-Jul-13	05-Oct-13
A2400	INVERT SLABS	58	12-Aug-13	18-Oct-13
A2500	TUNNEL WALLS	58	26-Aug-13	01-Nov-13
A2600	TUNNEL ROOF	166	17-Sep-13	31-Mar-14
A2700	START PLATFORM FOUNDATIONS	0	01-Apr-14*	
	SECTION AB, & A (470 FEET)	[illegible]	20-Jul-13	30-Sep-14
A2800	SECANT PILES	35	20-Jul-13	29-Aug-13
A2900	EARTH EXC & BRACING	52	24-Aug-13	24-Oct-13
A3000	DRILL & BLAST	107	22-Oct-13	25-Feb-14
A3100	ROCK EXC & ROCK BOLTS	90	28-Oct-13	05-Mar-14
A3200	INVERT SLAB	60	07-Jan-14	17-Mar-14
A3300	TUNNEL WALLS	60	21-Jan-14	31-Mar-14
A3400	TUNNEL ROOF	157	01-Apr-14	30-Sep-14



AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 1

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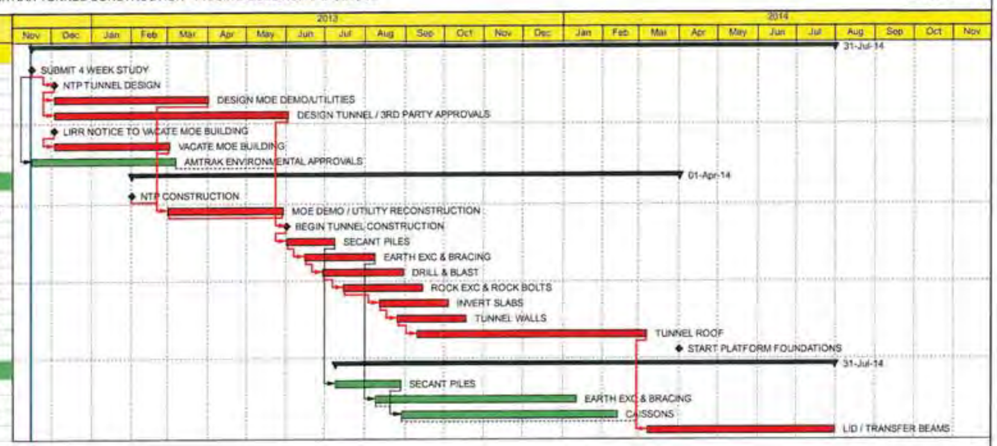
Table 7-3: Amtrak Tunnel Construction – Pricing Solution #2A, 2B, and 2C

AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 2A, 2B, 2C

16-Nov-12 11:13

Activity ID	Activity Name	Original Duration	Start	Finish
	AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 2A, 2B, & 2C	623	16-Nov-12	31-Jul-14
A1000	SUBMIT 4 WEEK STUDY	0	16-Nov-12*	
A1100	NTP TUNNEL DESIGN	0	03-Dec-12*	
A1200	DESIGN MOE DEMO/UTILITIES	120	03-Dec-12	01-Apr-13
A1300	DESIGN TUNNEL / 3RD PARTY APPROVALS	182	03-Dec-12	02-Jun-13
A1400	LIRR NOTICE TO VACATE MOE BUILDING	0	03-Dec-12*	
A1500	VACATE MOE BUILDING	90	03-Dec-12	02-Mar-13
A1900	AMTRAK ENVIRONMENTAL APPROVALS	112	16-Nov-12	07-Mar-13
	SECTION C (281 FEET)	[illegible]	[illegible]	[illegible]
A1600	NTP CONSTRUCTION	0	01-Feb-13*	
A1700	MOE DEMO / UTILITY RECONSTRUCTION	90	01-Mar-13*	29-May-13
A1800	BEGIN TUNNEL CONSTRUCTION	0	01-Jun-13*	
A2000	SECANT PILES	31	01-Jun-13	08-Jul-13
A2100	EARTH EXC & BRACING	46	15-Jun-13	08-Aug-13
A2200	DRILL & BLAST	53	29-Jun-13	30-Aug-13
A2300	ROCK EXC & ROCK BOLTS	53	15-Jul-13	14-Sep-13
A2400	INVERT SLABS	46	12-Aug-13	04-Oct-13
A2500	TUNNEL WALLS	46	26-Aug-13	18-Oct-13
A2600	TUNNEL ROOF	152	10-Sep-13	07-Mar-14
A2700	START PLATFORM FOUNDATIONS	0	01-Apr-14*	
	SECTION B, AB, & A (570 FEET)	[illegible]	[illegible]	[illegible]
A2800	SECANT PILES	44	09-Jul-13	26-Aug-13
A2900	EARTH EXC & BRACING	131	09-Aug-13	11-Jan-14
A3000	CAISSONS	141	29-Aug-13	12-Feb-14
A3100	LID / TRANSFER BEAMS	125	08-Mar-14	31-Jul-14



AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 2A, 2B, 2C

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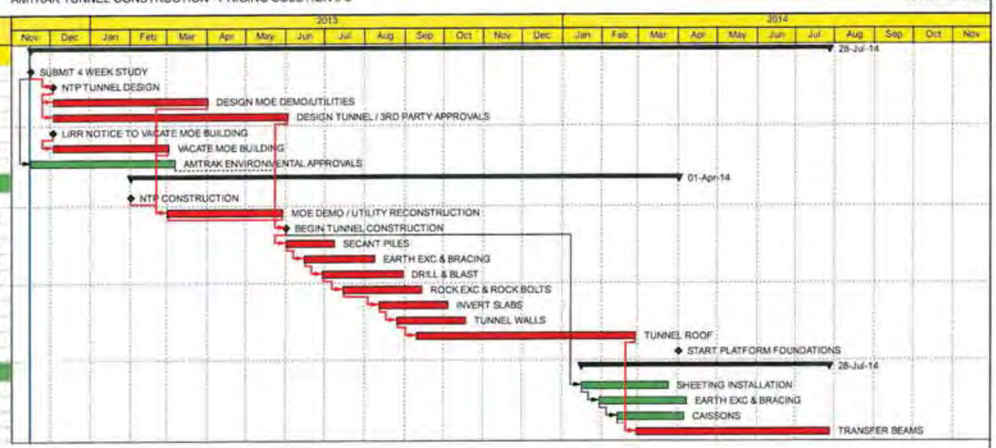
Table 7-4: Amtrak Tunnel Construction – Pricing Solution #3

AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 3 16-Nov-12 11:13

Activity ID	Activity Name	Original Duration	Start	Finish
	AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 3	620	16-Nov-12	28-Jul-14
A1000	SUBMIT 4 WEEK STUDY	0	16-Nov-12*	
A1100	NTP TUNNEL DESIGN	0	03-Dec-12*	
A1200	DESIGN MOE DEMO/UTILITIES	120	03-Dec-12	01-Apr-13
A1300	DESIGN TUNNEL / 3RD PARTY APPROVALS	182	03-Dec-12	02-Jun-13
A1400	LIRR NOTICE TO VACATE MOE BUILDING	0	03-Dec-12*	
A1500	VACATE MOE BUILDING	90	03-Dec-12	02-Mar-13
A1900	AMTRAK ENVIRONMENTAL APPROVALS	112	16-Nov-12	07-Mar-13
	SECTION C (281 FEET)	324	01-Feb-13	01-Apr-14
A1600	NTP CONSTRUCTION	0	01-Feb-13*	
A1700	MOE DEMO / UTILITY RECONSTRUCTION	90	01-Mar-13*	29-May-13
A1800	BEGIN TUNNEL CONSTRUCTION	0	01-Jun-13*	
A2000	SECANT PILES	31	01-Jun-13	08-Jul-13
A2100	EARTH EXC & BRACING	46	15-Jun-13	08-Aug-13
A2200	DRILL & BLAST	53	29-Jun-13	30-Aug-13
A2300	ROCK EXC & ROCK BOLTS	53	15-Jul-13	14-Sep-13
A2400	INVERT SLABS	46	12-Aug-13	04-Oct-13
A2500	TUNNEL WALLS	46	26-Aug-13	18-Oct-13
A2600	TUNNEL ROOF	145	10-Sep-13	27-Feb-14
A2700	START PLATFORM FOUNDATIONS	0	01-Apr-14*	
	SECTION B, AB, & A (570 FEET)	194	16-Jan-14	28-Jul-14
A2800	SHEETING INSTALLATION	58	16-Jan-14	24-Mar-14
A2900	EARTH EXC & BRACING	58	30-Jan-14	07-Apr-14
A3000	CAISSONS	45	13-Feb-14	05-Apr-14
A3100	TRANSFER BEAMS	129	28-Feb-14	28-Jul-14



AMTRAK TUNNEL CONSTRUCTION - PRICING SOLUTION # 3

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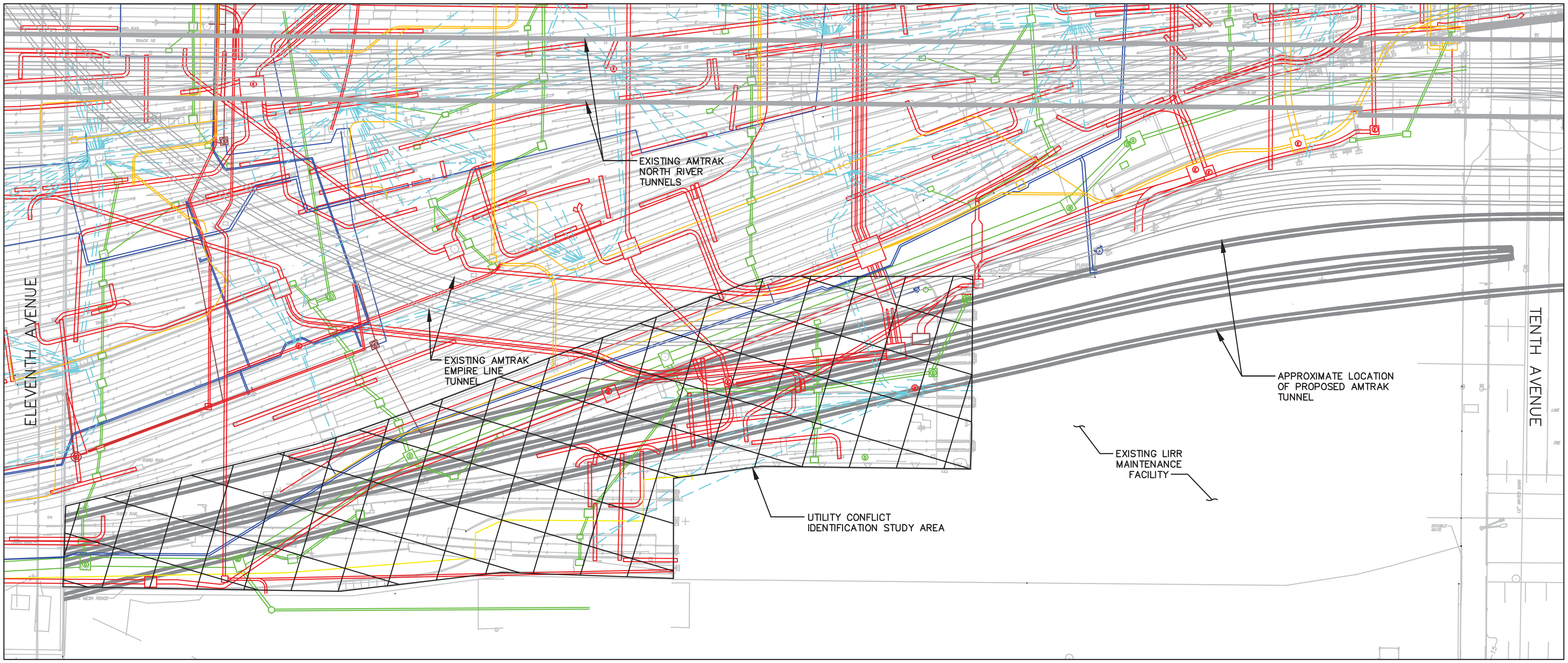
8.0 CONCLUSIONS & RECOMMENDATIONS

The fully integrated cut-and-cover tunnel segment (Pricing Solution 1) appears to be the most efficient and practical solution available. Although it was anticipated at the onset of this study that the solutions with a full deck isolating the overbuild structures from the tunnel (Pricing Solutions 2A, 2B, 2C) were going to be monetarily less to construct during the construction of the overbuild structures, the cost analysis did not support it. At the onset of the study, it was expected that Pricing Solution 1 would have the greatest initial cost and that Pricing Solutions 2 (2A, 2B, 2C) and 3 would each be lower cost options. However, the analysis shows minor difference in initial construction cost between options. This can be explained as follows:

- The execution of all five pricing solutions would require essentially the same site preparation costs, including removal and replacement of the LIRR MOE shop building, shop tracks, and utilities. All of the solutions would require the construction of a fully integrated cut-and-cover tunnel for approximately one-third of the tunnel length.
- For the deck options (Pricing Solutions 2A, 2B, 2C), it was determined that the protective deck and transfer beams would not be supported solely on the secant pile support of excavation system. Instead, it would be necessary to install caissons to carry the high loads.
- Pricing Solutions 2A and 2B would require a large quantity of secant pile walls in rock to advance the piles below the elevation of future tunnel invert.
- The partially isolated Pricing Solution 2C (with an embedded center caisson) would allow the reduction in depth and cost of transfer girders but would not offset the additional cost of the center caissons.

It will be necessary to resolve technical and non-technical construction-related issues during the design phase of the project. These include the interface between building owners and LIRR, the remediation of railroad vibrations from the overbuild structures, and the demarcation of maintenance responsibilities of the tunnel structures.

Appendix –
Engineering Drawings



COMBINED EXISTING UTILITY MAP

GENERAL UTILITY NOTES

1. THE EXISTING MAPPING SHOWN SHALL BE CONSIDERED SCHEMATIC AND DOES NOT REPRESENT THE EXACT LOCATION OR A COMPLETE SURVEY OF EXISTING UTILITIES AND YARD SURFACE FEATURES.
2. THE UTILITY INVESTIGATION IS CONSISTENT WITH A QUALITY "D" SUBSURFACE UTILITY INVESTIGATION (ASCE 38-02), AND UTILITIES ARE SHOWN FROM AVAILABLE INFORMATION AT THE TIME OF INVESTIGATION.
3. ASSUME CUT-AND-COVER METHOD OF CONSTRUCTION FOR PROPOSED TUNNEL.
4. IT HAS BEEN ASSUMED THAT THE L.I.R.R. MAINTENANCE FACILITY WILL BE PARTIALLY OR COMPLETELY SHUTDOWN AND PARTIALLY REMOVED PRIOR TO UTILITY RELOCATION OR REMOVAL.
5. IT HAS BEEN ASSUMED THAT TRACKS SERVICING THE L.I.R.R. MAINTENANCE FACILITY WILL BE OUT OF SERVICE AND REMOVED PRIOR TO UTILITY RELOCATION OR REMOVAL.
6. ALL UTILITIES SHALL BE KEPT IN SERVICE DURING CONSTRUCTION AT ALL TIMES, UNLESS OTHERWISE APPROVED BY OWNER.
7. UTILITY IMPACTS INCLUDE (BUT NOT LIMITED TO):
   - STORM SEWER (SK-UTL-02)
   - SANITARY SEWER (SK-UTL-02)
   - ELECTRICAL – AC & DC POWER (SK-UTL-03)
   - COMMUNICATION (SK-UTL-04)
   - SIGNALS (SK-UTL-04)
   - GAS (SK-UTL-05)
   - WATER – POTABLE & FIRE (SK-UTL-05)

LEGEND

- UTILITY CONFLICT IDENTIFICATION STUDY AREA
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING ELECTRICAL – AC & DC POWER
- EXISTING COMMUNICATION
- EXISTING SIGNALS
- EXISTING GAS
- EXISTING WATER – POTABLE & FIRE

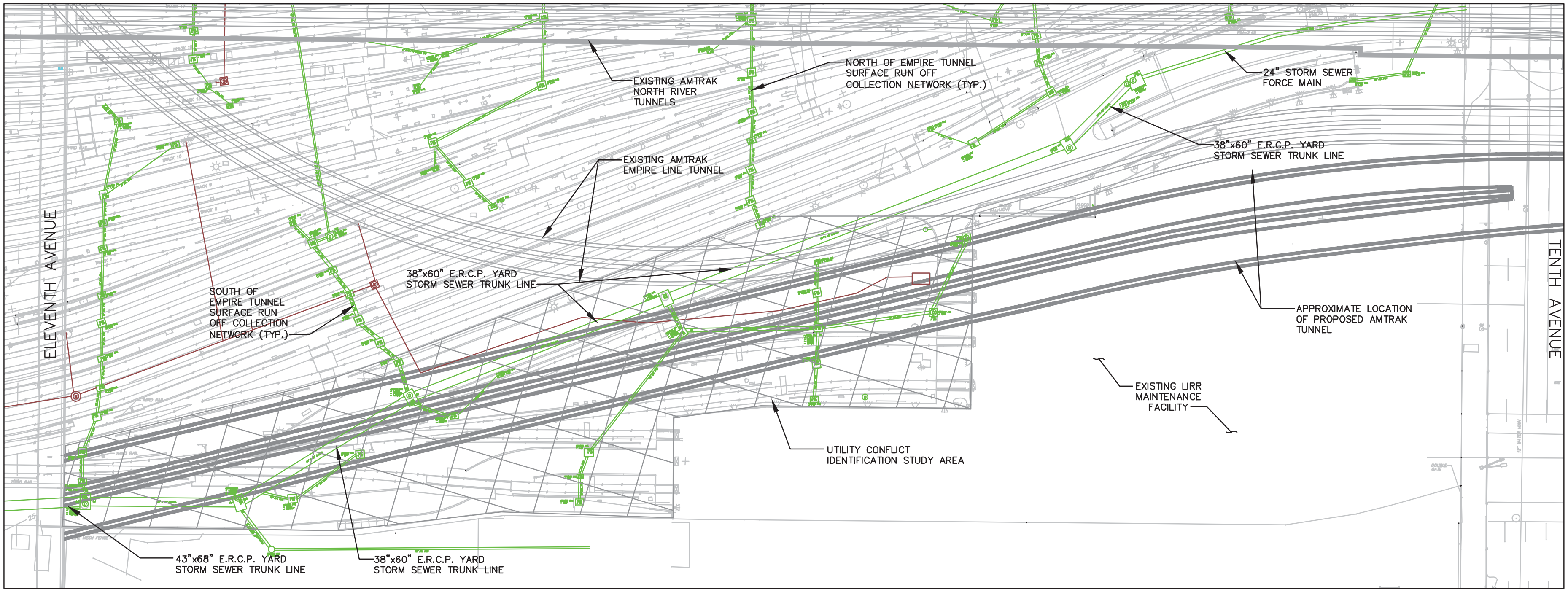
SCALE

30' 15' 0 30' 60'

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

EXISTING COMBINED UTILITY CONFLICT IDENTIFICATION

DRAFT	NOVEMBER 9, 2012	SK-UTL-01



EXISTING STORM & SANITARY SEWER

TYPE	SIZE	UTILITY WORK DURING TUNNEL CONSTRUCTION	POST TUNNEL CONSTRUCTION
STORM SEWER CONCEPTUAL UTILITY PLAN BREAKDOWN			
YARD STORM SEWER TRUNK LINE	38"x60" E.R.C.P. TO 43"x68" E.R.C.P.; AND ASSOCIATED MANHOLES	• MAINTAIN SERVICE AND BUILD TEMPORARY REPLACEMENT TRUNK LINE • REMOVE EXISTING IMPACTED TRUNK LINE • HANG, SUPPORT AND PROTECT TEMPORARY SYSTEM AS NEEDED OVER EXCAVATION AREA	RESTORE INKIND
SURFACE RUN OFF COLLECTION NETWORK	12" TO 21" PVC; AND ASSOCIATED CATCH BASINS	• MAINTAIN SERVICE AND BUILD TEMPORARY REPLACEMENT STORM SEWERS • REMOVE EXISTING IMPACTED STORM SEWERS/CATCH BASINS • HANG, SUPPORT AND PROTECT TEMPORARY SYSTEM AS NEEDED OVER EXCAVATION	RESTORE INKIND
SANITARY SEWER CONCEPTUAL UTILITY PLAN BREAKDOWN			
SANITARY SEWER FOR L.I.R.R. FACILITY	8" PVC WITH LIFT STATION	• LIFT STATION TO BE DEMOLISHED • DEMOLISH SANITARY PIPE WITHIN CONSTRUCTION ZONE AND CAP PIPE FOR FUTURE CONNECTION	RESTORE INKIND

STORM SEWER CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL HAVE A DIRECT EFFECT ON THE EXISTING STORM SEWER SYSTEM, WHICH WILL REQUIRE A PORTION OF THE SYSTEM TO BE REMOVED, RELOCATED, AND RESTORED. THE EAST SIDE YARD STORM SEWER SYSTEM CONSISTS OF A NETWORK OF CATCH BASINS THAT COLLECT SURFACE RUN OFF, AND ELLIPTICAL REINFORCED CONCRETE PIPES (E.R.C.P.) THAT ACTS AS THE YARD'S TRUNK LINE TO CONVEY STORMWATER OFF SITE. THE SURFACE RUN OFF NORTH OF THE EMPIRE LINE TUNNEL IS COLLECTED AND IS PUMPED VIA A 24" FORCE MAIN INTO THE YARD'S ELLIPTICAL TRUNK LINE. THE SURFACE RUN OFF SOUTH OF THE EMPIRE LINE IS ALSO COLLECTED THRU A NETWORK OF CATCH BASINS, BUT IS CONNECTED TO THE TRUNK LINE VIA GRAVITY CONNECTIONS THOUGH OUT THE YARD.

OPTION 1: TEMPORARY GRAVITY SEWER REPLACEMENT

THE STORM SEWER SYSTEM IS REQUIRED TO BE MAINTAINED THROUGHOUT CONSTRUCTION ACTIVITIES, AND ONE OPTION IS TO BUILD A TEMPORARY GRAVITY SEWER TO RELOCATE THE DRAINAGE SYSTEM OUTSIDE OF THE CONSTRUCTION ZONE TO THE EXTENT POSSIBLE.

- E.R.C.P. STORM SEWERS: THE EXISTING (E.R.C.P.) AND ASSOCIATED MANHOLES WHICH WILL BE IMPACTED FROM THE OPEN CUT OF THE PROPOSED TUNNEL WILL BE REQUIRED TO BE REMOVED AND TEMPORARILY REPLACED. CROSSING OF THE EXCAVATION WILL BE REQUIRED TO CONNECT TO THE EXISTING SEWER OUTSIDE OF THE CONSTRUCTION ZONE. IN LOCATIONS WHERE EXCAVATION CROSSINGS ARE REQUIRED, THE TEMPORARY SEWER REPLACEMENT SHALL BE AN EQUIVALENT SIZE DUCTILE IRON CIRCULAR PIPE WHICH SHALL BE HUNG, SUPPORTED AND PROTECTED. AFTER TUNNEL CONSTRUCTION HAS CONCLUDED, THE TRUNK LINE SEWER SHALL BE REPLACED INKIND IN ITS ORIGINAL LOCATION.

- SURFACE RUN OFF COLLECTION NETWORK: THE EXISTING CATCH BASINS AND INTERMEDIATE STORM SEWER PIPES WHICH WILL BE IMPACTED FROM THE OPEN CUT OF THE PROPOSED TUNNEL CONSTRUCTION WILL REQUIRE REMOVAL AND TEMPORARY REPLACEMENT. WITHIN THE CONSTRUCTION ZONE, TEMPORARY REPLACEMENT OF CATCH BASINS AND SEWERS MAY BE REDUCED BASED ON STAGING, SITE SET UP AND TEMPORARY GRADING. BUT TO MAINTAIN SERVICE FOR THE EXISTING CATCH BASINS LOCATED OUTSIDE OF THE CONSTRUCTION ZONE, EXCAVATION CROSSINGS WILL BE REQUIRED. IN LOCATIONS WHERE EXCAVATION CROSSINGS ARE REQUIRED, THE TEMPORARY SEWER REPLACEMENT SHALL BE AN EQUIVALENT SIZE DUCTILE IRON CIRCULAR PIPE WHICH SHALL BE HUNG, SUPPORTED AND PROTECTED. AFTER TUNNEL CONSTRUCTION HAS CONCLUDED, THE SEWERS AND CATCH BASINS SHALL BE REPLACED INKIND IN ITS ORIGINAL LOCATION.

OPTION 2: TEMPORARY PUMPING OF STORM SEWER

A FEASIBILITY STUDY WILL BE INITIATED TO DETERMINE THE POSSIBILITY OF EXTENDING THE EXISTING FORCE MAIN WEST PAST ELEVENTH AVENUE SO THAT A GRAVITY TRUNK LINE IS TEMPORARILY NOT REQUIRED WITHIN THE EXCAVATION ZONE. THE PREFERRED CONCEPT WOULD BE TO USE OR SLIGHTLY MODIFY THE CURRENT STORM WATER PUMPING OPERATION. IF THIS IS UNACCEPTABLE TO L.I.R.R. A FOLLOW UP STUDY WILL DETERMINE THE FEASIBILITY OF PROVIDING AN AUXILIARY TEMPORARY PUMPING OPERATION WITHIN THE WORK ZONE ALSO ELIMINATING THE NEED FOR A GRAVITY TRUNK LINE IN THE VICINITY OF EXCAVATION.

SANITARY SEWER CONCEPTUAL UTILITY PLAN

1. THE PROPOSED TUNNEL ALIGNMENT AND CONSTRUCTION ACTIVITIES WILL TEMPORARILY IMPACT THE EXISTING SANITARY SEWER SERVICING THE L.I.R.R. MAINTENANCE FACILITY.
2. AS STATED ON SHEET SK–UTL–01, IT HAS BEEN ASSUMED THAT THE L.I.R.R. MAINTENANCE FACILITY WILL BE PARTIALLY OR COMPLETELY SHUTDOWN. THEREFORE, IT SHALL BE ASSUMED THAT DURING CONSTRUCTION ACTIVITIES THE SANITARY SEWER SERVICE CAN BE SHUTDOWN, BUT ONLY ON THE CONDITION THAT THE ENTIRE FACILITY WILL NOT BE IN OPERATION.
3. IF ENTIRE FACILITY IS NOT SHUTDOWN, A TEMPORARY SANITARY SEWER LINE SHALL BE FURNISHED AND INSTALLED, WHICH WILL CONNECT TO THE EXISTING SYSTEM WITHIN THE YARD. A TEMPORARY LIFT STATION MAY BE REQUIRED TO MAINTAIN SERVICE TO THE L.I.R.R. FACILITY.
4. THE EXISTING SEWER SHALL BE REMOVED AND RESTORED TO ITS ORIGINAL LOCATION AFTER CONSTRUCTION ACTIVITIES HAVE CONCLUDED.

LEGEND

- UTILITY CONFLICT IDENTIFICATION STUDY AREA
- STORM SEWER
- SANITARY SEWER
- ELECTRICAL – AC & DC POWER
- COMMUNICATION
- SIGNALS
- GAS
- WATER – POTABLE & FIRE

SCALE

30' 15' 0 30' 60'

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

EXISTING STORM & SANITARY SEWER CONFLICT IDENTIFICATION

DRAFT | NOVEMBER 9, 2012 | SK–UTL–02

TYPE	UTILITY WORK DURING TUNNEL CONSTRUCTION	POST TUNNEL CONSTRUCTION
AC ELECTRICAL CONCEPTUAL UTILITY PLAN BREAKDOWN		
MH-A6	• MAINTAIN MANHOLE AND CONDUITS IN PLACE OR TEMPORARILY RELOCATE	RESTORE INKIND
YARD LIGHTING	• REMOVE AND PROVIDE TEMPORARY LIGHTING	RESTORE INKIND
MH-A5	• MAINTAIN MANHOLE AND CONDUITS IN PLACE OR TEMPORARILY RELOCATE	RESTORE INKIND
BUILDING LIFT STATION	• SEE SANITARY SEWER UTILITY PLAN ON SK-UTL-02 FOR REQUIREMENTS	RESTORE INKIND
BUILDING ELECTRICAL ROOM	• REMOVE AND DEACTIVATE • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
MH-A4	• MANHOLE TO REMAIN • CONDUITS TO BE MAINTAINED THRU CONSTRUCTION ZONE	RESTORE INKIND
MH-A3	• MANHOLE TO REMAIN • CONDUITS TO BE MAINTAINED THRU CONSTRUCTION ZONE	RESTORE INKIND
DC NEGATIVE ELECTRICAL CONCEPTUAL UTILITY PLAN BREAKDOWN		
MH-N4	• MANHOLE TO REMAIN • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
MH-N6	• MANHOLE TO BE DEMOLISHED • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
DC POSITIVE ELECTRICAL CONCEPTUAL UTILITY PLAN BREAKDOWN		
MH-P9	• MANHOLE TO REMAIN • CONDUITS TO BE MAINTAINED THRU CONSTRUCTION ZONE	RESTORE INKIND
MH-P8	• MAINTAIN MANHOLE AND CONDUITS IN PLACE OR TEMPORARILY RELOCATE	SEE DC POSITIVE NOTES
MH-P6	• MANHOLE TO REMAIN • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
MH-P11	• MANHOLE TO BE DEMOLISHED • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND

*ALL ELECTRICAL DUCT BANKS ARE REINFORCED CONCRETE

EXISTING AC & DC ELECTRICAL POWER

AC ELECTRICAL CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE AC ELECTRICAL SYSTEM TO BE REMOVED, RELOCATED, AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE AC ELECTRICAL MANHOLES AND CONDUITS SHALL BE REPLACED INKIND IN THE ORIGINAL LOCATIONS.

1. MANHOLES AND CONDUITS WHICH ARE IMPACTED FROM THE PROPOSED CONSTRUCTION;

1.1. THAT POWER SITE LIGHTING CAN BE DE-ENERGIZED DURING CONSTRUCTION, ON CONDITION THAT TEMPORARY LIGHTING IS PROVIDED.

1.2. THAT POWER THE L.I.R.R. MAINTENANCE FACILITY CAN BE DE-ENERGIZED, ON THE CONDITION THAT THE ENTIRE FACILITY WILL NOT BE IN OPERATION.

1.3. THAT CONNECT TO THE L.I.R.R. EMERGENCY FACILITY SHALL BE REQUIRED TO BE MAINTAINED DURING CONSTRUCTION ACTIVITIES OR ALTERNATIVELY PROVIDE A TEMPORARY REPLACEMENT GENERATOR.

2. IN LOCATIONS WHERE EXCAVATION CROSSINGS ARE REQUIRED, THE TEMPORARY MANHOLES AND DUCT BANKS SHALL BE MAINTAINED IN PLACE IN A TEMPORARY CONDITION (SUCH AS WOODEN BOX AND SPLIT DUCT PVC) OR TEMPORARILY RELOCATED.

DC NEGATIVE ELECTRICAL CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE DC NEGATIVE ELECTRICAL SYSTEM TO BE REMOVED AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE DC NEGATIVE ELECTRICAL MANHOLES AND CONDUITS SHALL BE REPLACED INKIND IN THE ORIGINAL LOCATIONS.

1. UPON INITIAL REVIEW IT APPEARS THAT THE IMPACTED DC NEGATIVE MANHOLES AND CONDUITS ONLY SERVE THE TRACKS DEDICATED FOR THE L.I.R.R. MAINTENANCE FACILITY AND CAN BE TAKEN OUT AND TEMPORARILY DEACTIVATED.

DC POSITIVE ELECTRICAL CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE DC POSITIVE ELECTRICAL SYSTEM TO BE REMOVED, RELOCATED AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE DC POSITIVE ELECTRICAL MANHOLES AND CONDUITS SHALL BE REPLACED INKIND.

1. UPON INITIAL REVIEW IT APPEARS THAT THE IMPACTED DC POSITIVE ARE ESSENTIAL TO PROVIDING POWER FOR PORTIONS OF THE YARD OUTSIDE OF THE CONSTRUCTION ZONE AND MUST REMAIN ACTIVE.

1.1. SPECIFICALLY 'DC MH-P8' WHICH IS WITHIN THE PROPOSED TUNNEL EXCAVATION AND MUST BE EITHER MAINTAIN IN PLACE AS IS, OR IN A TEMPORARY CONDITION (SUCH AS WOODEN BOX) OR TEMPORARILY RELOCATED.

1.2. IF ADDITIONAL EXISTING INFORMATION DETERMINES THAT 'DC MH-P8' CONFLICTS WITH THE PROPOSED TUNNEL ROOF, A RE-ROUTING OF THE ELECTRICAL SYSTEM FROM MANHOLE 'DC MH-P9' AND 'DC MH-P6' TO A RELOCATED 'DC MH-P8' WILL BE REQUIRED.

1.3. TEMPORARY AND/OR FINAL REROUTING OF THE 'DC MH-P8' SYSTEM WILL HAVE TO BE STAGED TO PROVIDE SERVICE TO ALL ACTIVE TRACKS WITH MINIMAL DISRUPTIONS (OFF PEAK ONLY).

LEGEND

- UTILITY CONFLICT IDENTIFICATION STUDY AREA
- STORM SEWER
- SANITARY SEWER
- ELECTRICAL – AC & DC POWER
- COMMUNICATION
- SIGNALS
- GAS
- WATER – POTABLE & FIRE

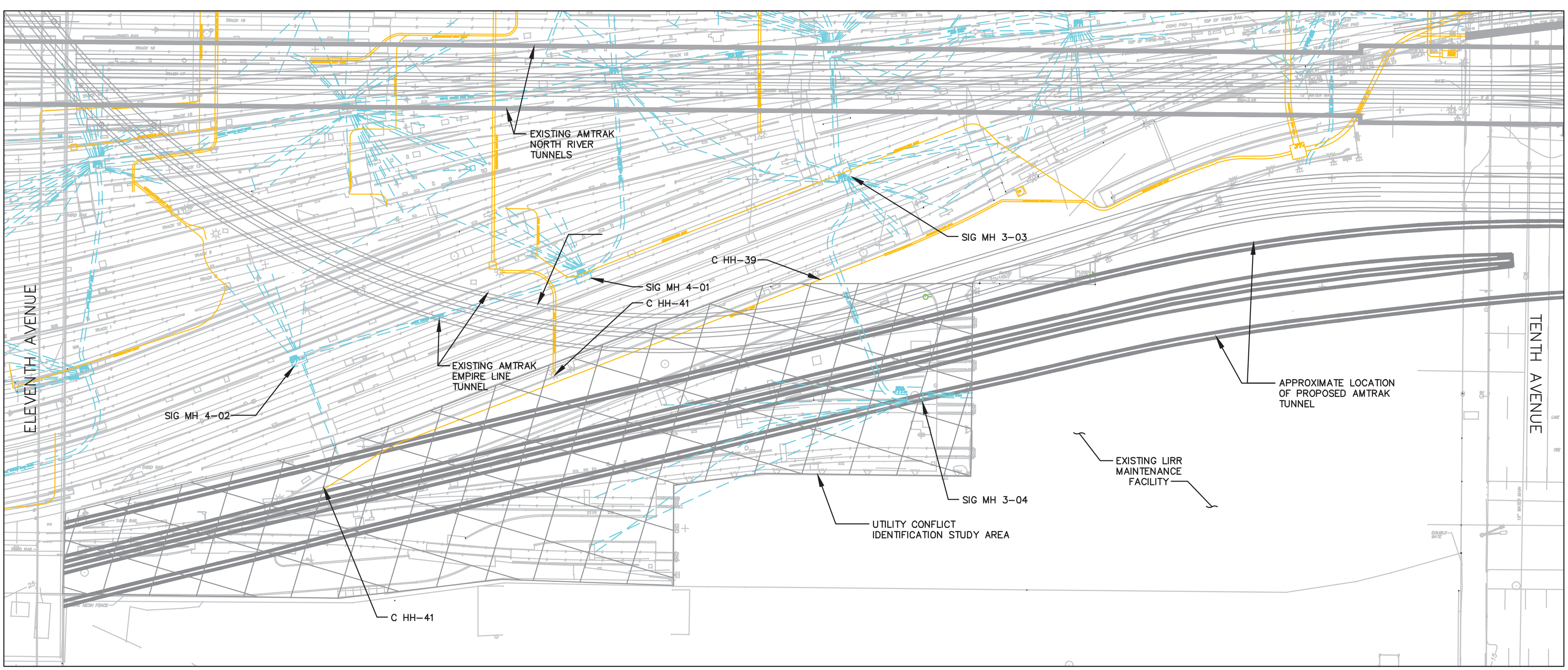
SCALE

30' 15' 0 30' 60'

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

EXISTING AC & DC ELECTRICAL POWER CONFLICT IDENTIFICATION

DRAFT | NOVEMBER 9, 2012 | SK-UTL-03



EXISTING SIGNAL AND COMMUNICATION

TYPE	UTILITY WORK DURING TUNNEL CONSTRUCTION	POST TUNNEL CONSTRUCTION
COMMUNICATIONS CONCEPTUAL UTILITY PLAN BREAKDOWN		
C HH-41	• REMOVE HANDHOLE • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
C HH-40	• HANDHOLE TO REMAIN • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
SIGNAL CONCEPTUAL UTILITY PLAN BREAKDOWN		
MH 4-02	• MANHOLE TO REMAIN • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
MH 4-01	• MANHOLE TO REMAIN • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
MH 3-03	• MANHOLE TO REMAIN • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP CONDUITS FOR FUTURE CONNECTION	RESTORE INKIND
MH 3-04	• MANHOLE TO BE DEMOLISHED • DEMOLISH CONDUITS WITHIN CONSTRUCTION ZONE AND CAP FOR CONDUITS FUTURE CONNECTION	RESTORE INKIND

COMMUNICATIONS CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE COMMUNICATION SYSTEM TO BE REMOVED AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE COMMUNICATION HANDHOLES AND CONDUITS SHALL BE REPLACED INKIND IN THE ORIGINAL LOCATIONS.

1. UPON INITIAL REVIEW IT APPEARS THAT THE CONSTRUCTION WILL HAVE A MINIMAL IMPACT ON COMMUNICATION HANDHOLES AND CONDUITS. THEREFORE, IMPACTED COMMUNICATIONS CAN BE TAKEN OUT AND TEMPORARILY DEACTIVATED.

SIGNAL CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE SIGNAL SYSTEM TO BE REMOVED AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE SIGNAL MANHOLES AND CONDUITS SHALL BE REPLACED INKIND IN THE ORIGINAL LOCATIONS.

1. UPON INITIAL REVIEW IT APPEARS THAT THE IMPACTED SIGNAL MANHOLES AND CONDUITS ONLY SERVE THE TRACKS DEDICATED FOR THE L.I.R.R. MAINTENANCE FACILITY AND CAN BE TAKEN OUT AND TEMPORARILY DEACTIVATED.

LEGEND

UTILITY CONFLICT IDENTIFICATION STUDY AREA
STORM SEWER
SANITARY SEWER
ELECTRICAL – AC & DC POWER
COMMUNICATION
SIGNALS
GAS
WATER – POTABLE & FIRE

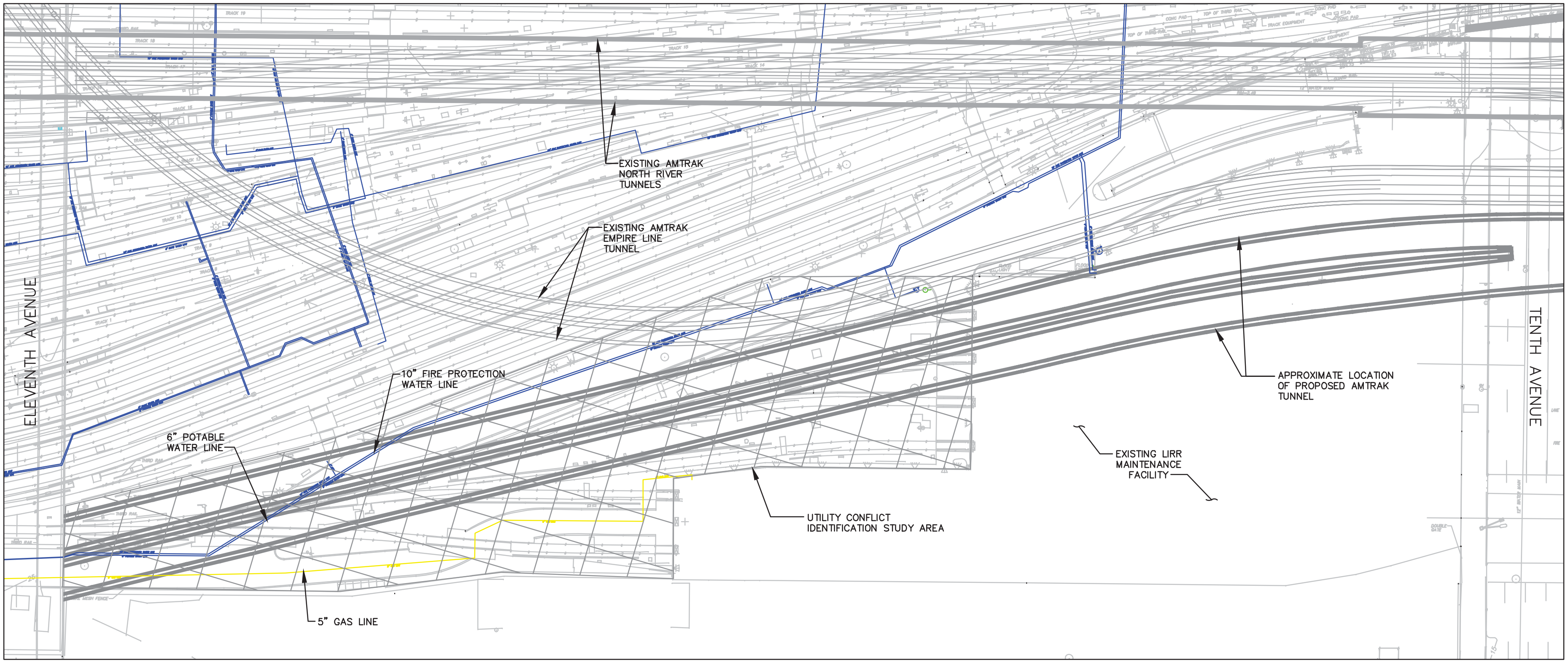
SCALE

30' 15' 0 30' 60'

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

EXISTING COMMUNICATION & SIGNAL CONFLICT IDENTIFICATION

DRAFT | NOVEMBER 9, 2012 | SK-UTL-04



EXISTING WATER (POTABLE & FIRE) AND GAS

TYPE	SIZE	UTILITY WORK DURING TUNNEL CONSTRUCTION	POST TUNNEL CONSTRUCTION
WATER CONCEPTUAL UTILITY PLAN BREAKDOWN			
FIRE PROTECTION WATER LINE	10"	• MAINTAIN SERVICE AND INSTALL TEMPORARY REPLACEMENT • HANG, SUPPORT AND PROTECT TEMPORARY SYSTEM AS NEEDED OVER EXCAVATION AREA	RESTORE INKIND
POTABLE WATER LINE	6"	• MAINTAIN SERVICE AND INSTALL TEMPORARY REPLACEMENT • HANG, SUPPORT AND PROTECT TEMPORARY SYSTEM AS NEEDED OVER EXCAVATION AREA	RESTORE INKIND
GAS SEWER CONCEPTUAL UTILITY PLAN BREAKDOWN			
BUILDING GAS SERVICE	5"	• MAINTAIN SERVICE AND INSTALL TEMPORARY REPLACEMENT • HANG, SUPPORT AND PROTECT TEMPORARY SYSTEM AS NEEDED OVER EXCAVATION AREA	RESTORE INKIND

WATER CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE WATERMAIN SYSTEM TO BE REMOVED, RELOCATED AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE WATERMAINS FOR BOTH FIRE AND POTABLE WATER SHALL BE REPLACED INKIND IN THE ORIGINAL LOCATIONS.

1. 10" FIRE PROTECTION WATER LINE: SHALL BE MAINTAINED EITHER BY RELOCATING THE LINE OUTSIDE OF THE CONSTRUCTION AREA OR MAINTAINING THRU THE CONSTRUCTION ZONE BY CROSSING THE EXCAVATION. ALL EXCAVATION CROSSINGS SHALL REQUIRE THE WATERMAIN TO BE HUNG, SUPPORTED AND PROTECTED.
2. 6" POTABLE WATER LINE: SHALL BE MAINTAINED EITHER BY RELOCATING THE LINE OUTSIDE OF THE CONSTRUCTION AREA OR MAINTAINING THRU THE CONSTRUCTION ZONE BY CROSSING THE EXCAVATION. ALL EXCAVATION CROSSINGS SHALL REQUIRE THE WATERMAIN TO BE HUNG, SUPPORTED AND PROTECTED.

GAS CONCEPTUAL UTILITY PLAN

THE PROPOSED TUNNEL WILL REQUIRE A PORTION OF THE GAS LINE TO THE L.I.R.R. MAINTENANCE FACILITY TO BE REMOVED AND RESTORED AFTER TUNNEL CONSTRUCTION HAS CONCLUDED. THE GAS LINE SHALL BE REPLACED INKIND IN THE ORIGINAL LOCATIONS.

1. 5" GAS LINE: UPON INITIAL REVIEW IT APPEARS THAT THE IMPACTED GAS LINE ONLY SERVES THE L.I.R.R. MAINTENANCE FACILITY AND CAN BE DEACTIVATED, ONLY ON THE CONDITION THAT THE ENTIRE FACILITY WILL NOT BE IN OPERATION DURING CONSTRUCTION ACTIVITIES.

LEGEND

- UTILITY CONFLICT IDENTIFICATION STUDY AREA
- STORM SEWER
- SANITARY SEWER
- ELECTRICAL – AC & DC POWER
- COMMUNICATION
- SIGNALS
- GAS
- WATER – POTABLE & FIRE

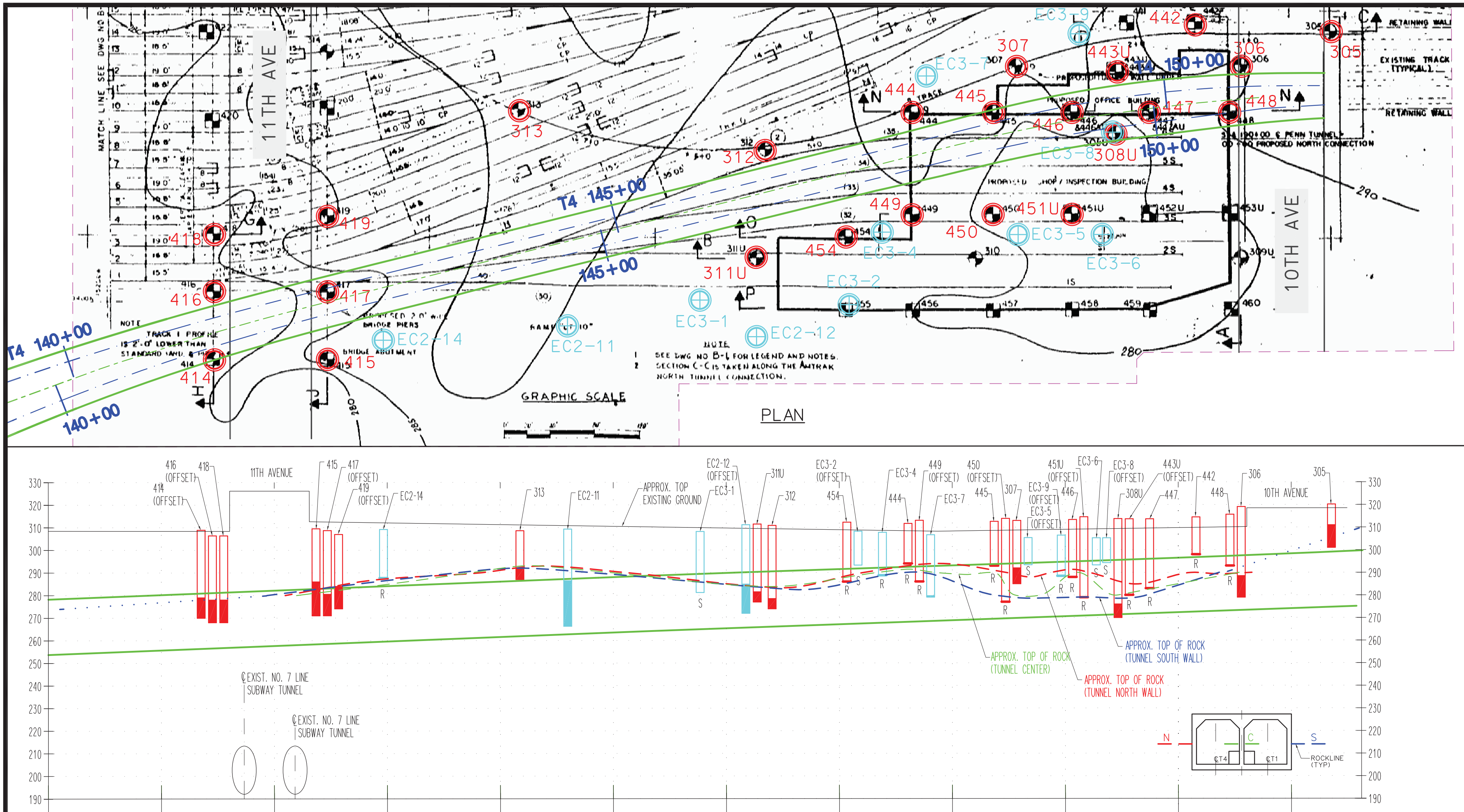
SCALE

30' 15' 0 30' 60'

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

EXISTING WATER AND GAS CONFLICT IDENTIFICATION

DRAFT | NOVEMBER 9, 2012 | SK–UTL–05



VERTICAL SCALE IN FEET: 30′ 0 30′ 60′

HORIZONTAL SCALE IN FEET: 60′ 0 60′ 120′

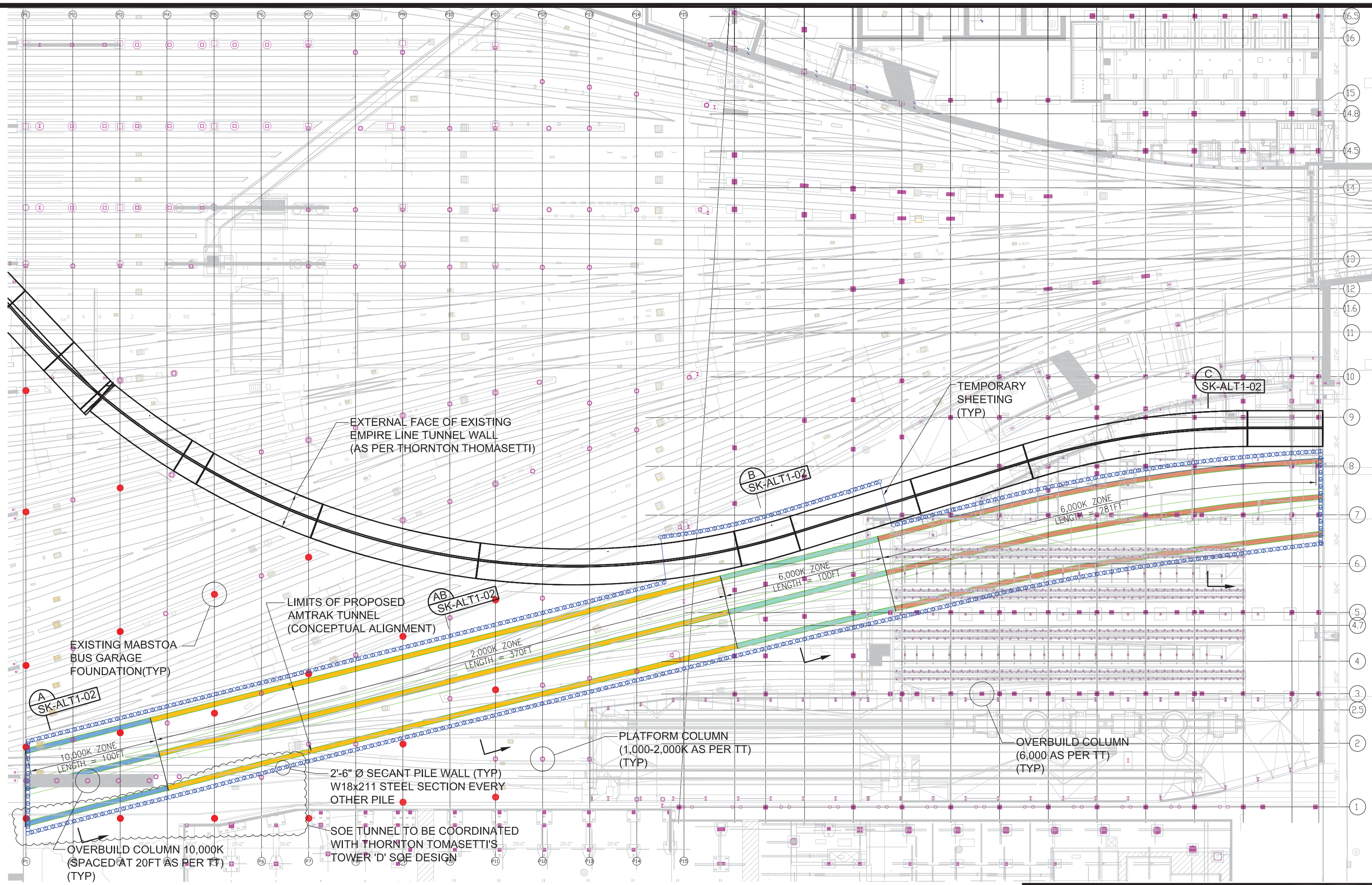
LEGEND:

R	END OF BORING – SPLIT SPOON REFUSAL
S	END OF BORING – SOIL
(red circle)	WEST SIDE STORAGE YARD COMPLEX BORINGS (LIRR/MTA)
(blue circle)	LANGAN BORINGS
(red) OR (blue)	ROCK CORING

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

GEOTECHNICAL
BORING PLAN AND PROFILE
(BORINGS BY OTHERS)

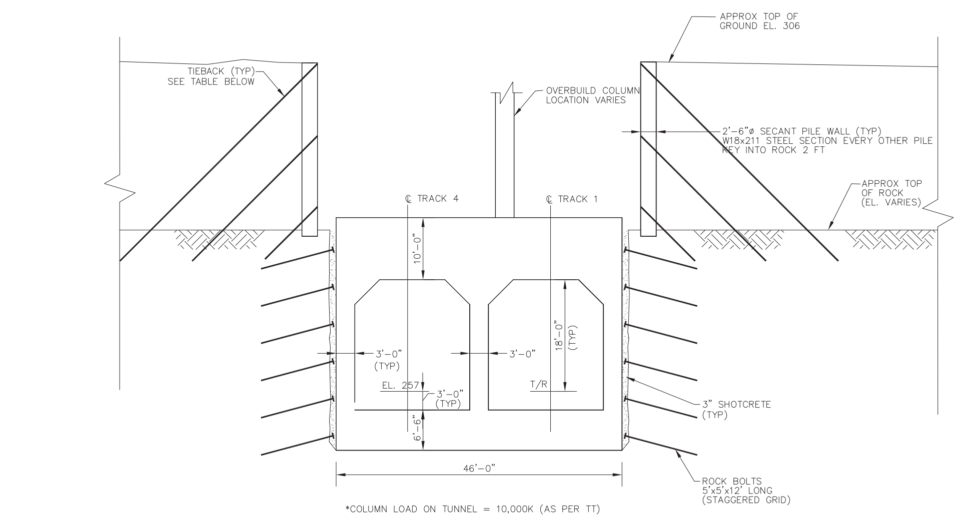
FINAL | NOVEMBER 16, 2012 | SK-GEO-01



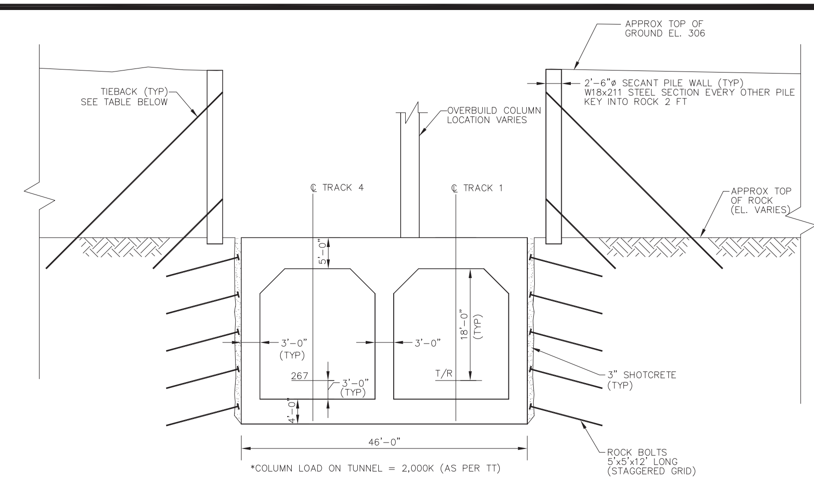
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

FULLY INTEGRATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 1
OPTION 1

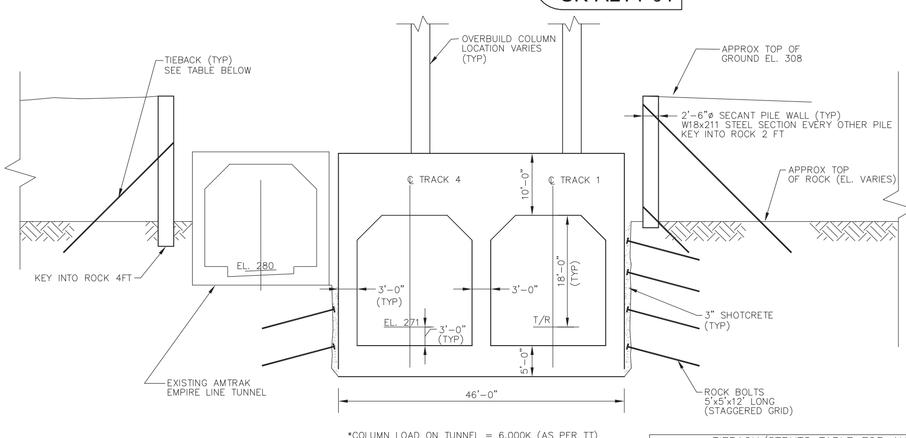
FINAL	NOVEMBER 16, 2012	SK-ALT1-01



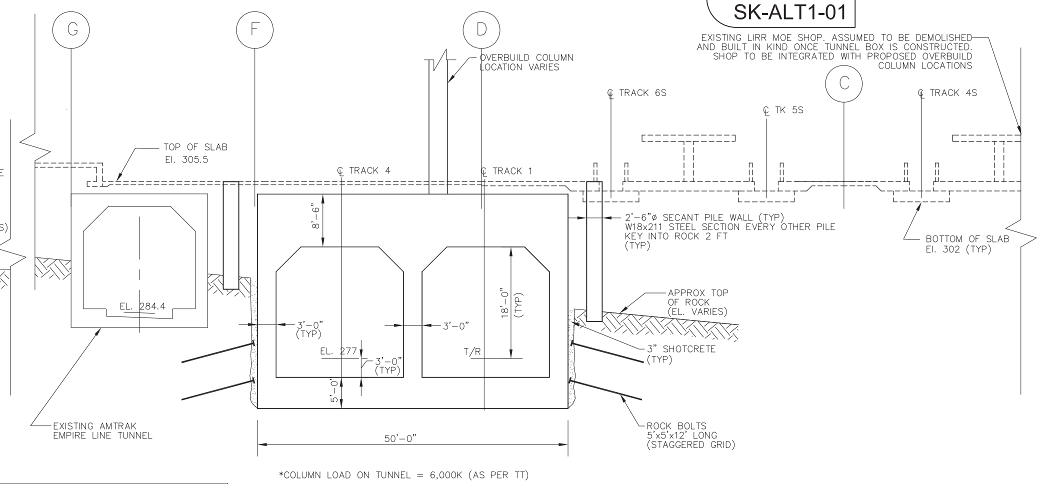
SECTION A SK-ALT1-01



SECTION AB SK-ALT1-01



SECTION B SK-ALT1-01



SECTION C SK-ALT1-01

TIEBACK/STRUTS TABLE FOR ALTERNATIVES 1, 2 AND 3 (OPTIONS 1, 2A AND 2B)

SECTION	LEVEL	UNBONDED LENGTH (FT)	MIN BONDED LENGTH (FT)	BAR SIZE (IN)
SECTION A	1	33	10	1-1/4
	2	17	13	1-3/4
	3	5	10	1-3/8
SECTION AB	1	18	10	1-1/4
	2	5	10	1-1/4
SECTION AB-1**	1	SUPPORTED BY 36" DIA. STRUTS 1/2" THICK AT 20FT C-C SPACING WITH W14x193 WALERS		
	2	5	10	1-1/4
SECTION B SOUTH	1	23	11	1-3/4
	2	5	10	1-3/8
SECTION B NORTH	1	16	14	1-3/4
SECTION C	1	SUPPORTED BY 36" DIA. STRUTS 1/2" THICK AT 20FT C-C SPACING WITH W14x193 WALERS		
	2			

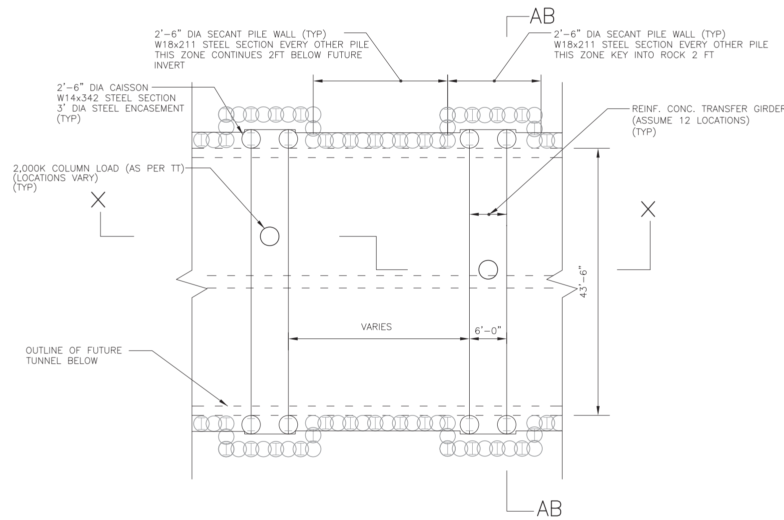
* FOR ALL TIEBACK LOCATIONS USE (2) C12x20.7 WALERS
** AB-1 IS ASSUMED AS 100LF WHERE STRUTS ARE TO BE UTILIZED BECAUSE OF PROXIMITY TO THE EMPIRE LINE TUNNEL

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

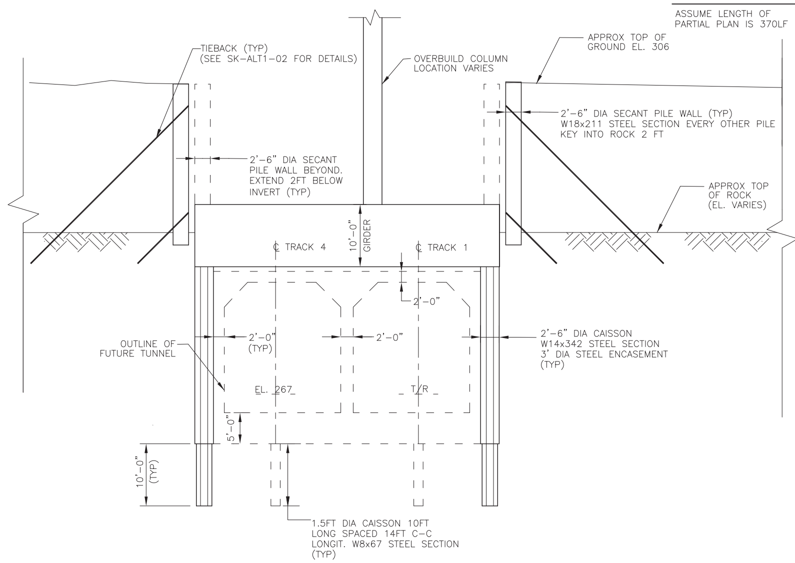
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

FULLY INTEGRATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 1
OPTION 1

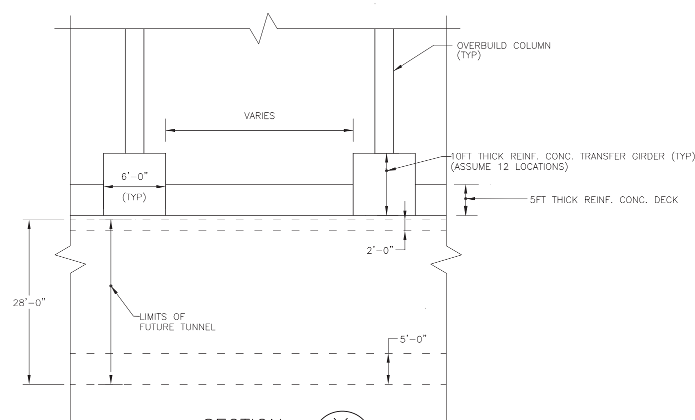
FINAL	NOVEMBER 16, 2012	SK-ALT1-02



PARTIAL PLAN
ASSUME LENGTH OF PARTIAL PLAN IS 370LF



SECTION AB



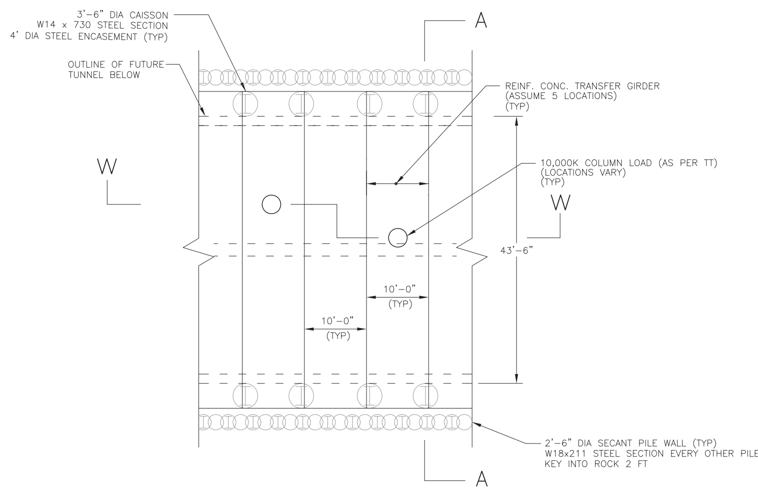
SECTION X

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

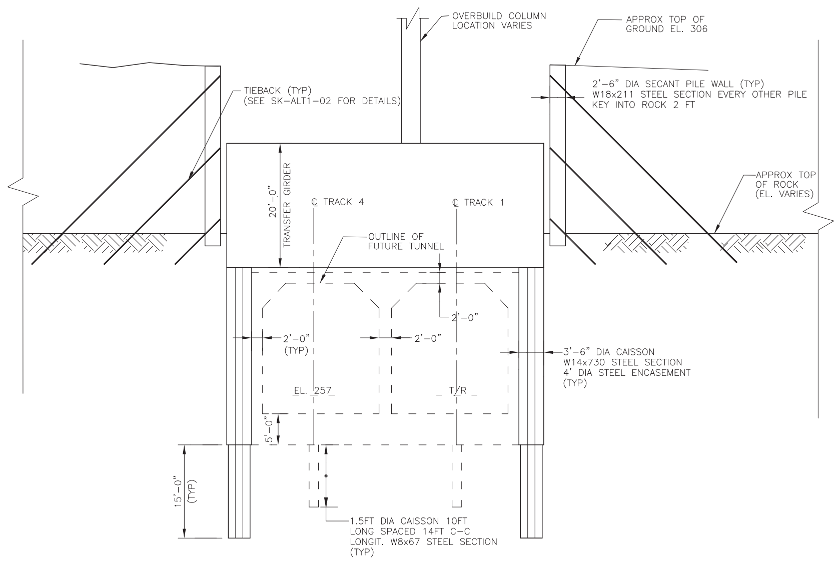
FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 2A

FINAL	NOVEMBER 16, 2012	SK-ALT2-01

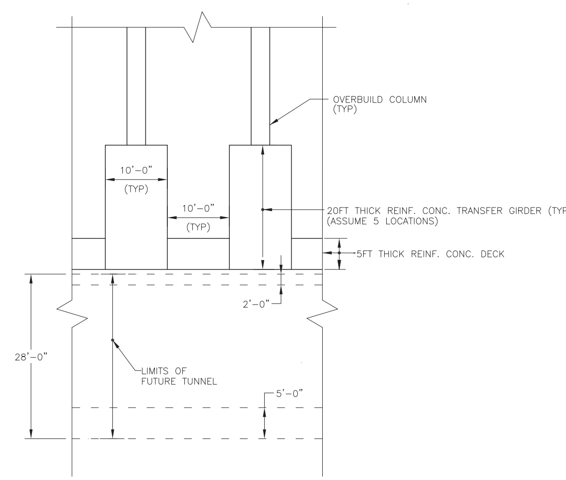


PARTIAL PLAN

ASSUME LENGTH OF PARTIAL PLAN IS 100LF



SECTION A



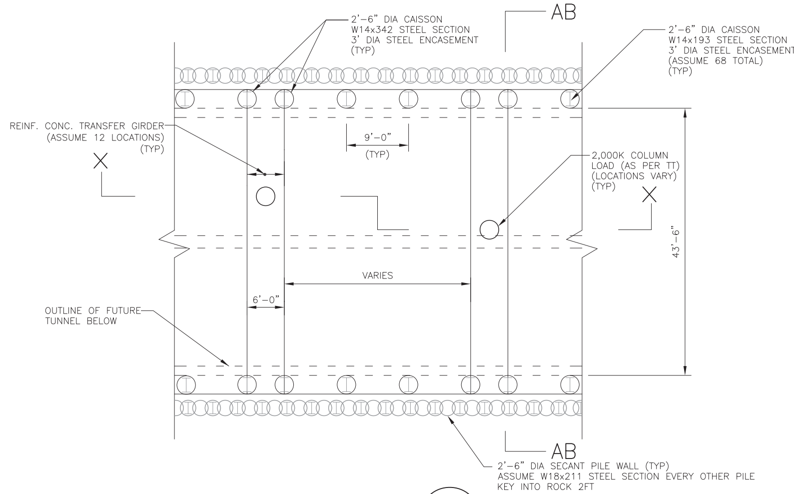
SECTION W

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

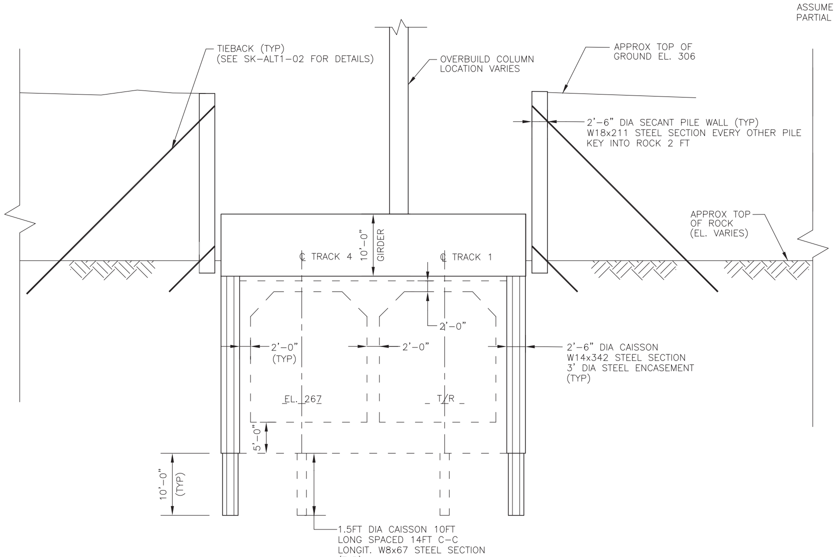
FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 2B

FINAL	NOVEMBER 16, 2012	SK-ALT2-02

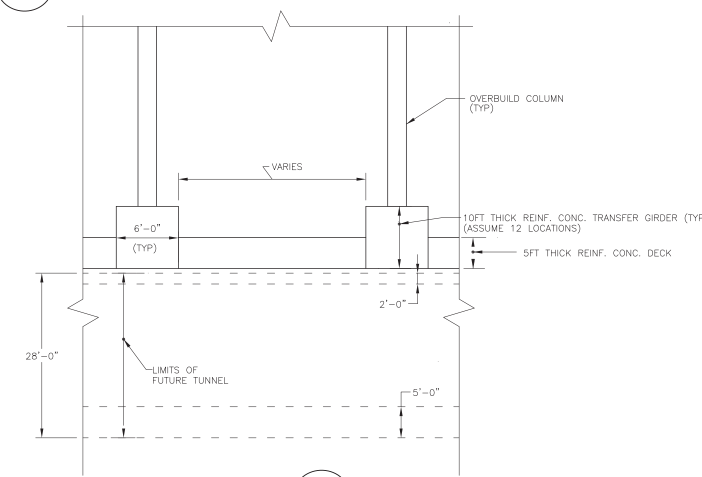


PARTIAL PLAN

ASSUME LENGTH OF
PARTIAL PLAN IS 370LF



SECTION AB



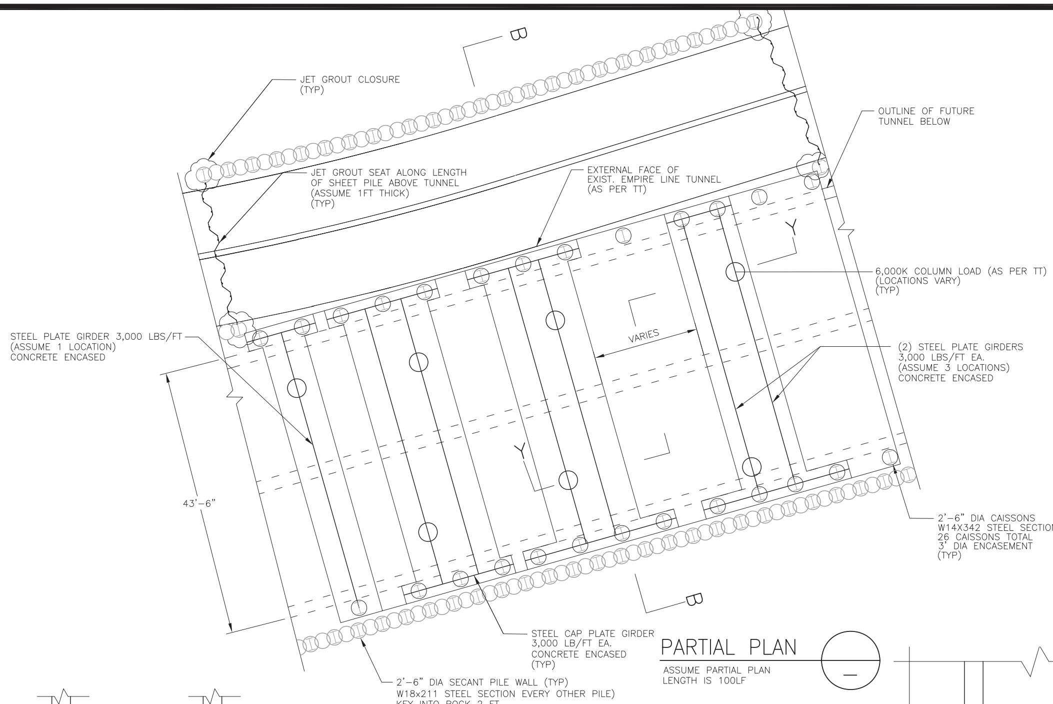
SECTION X

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

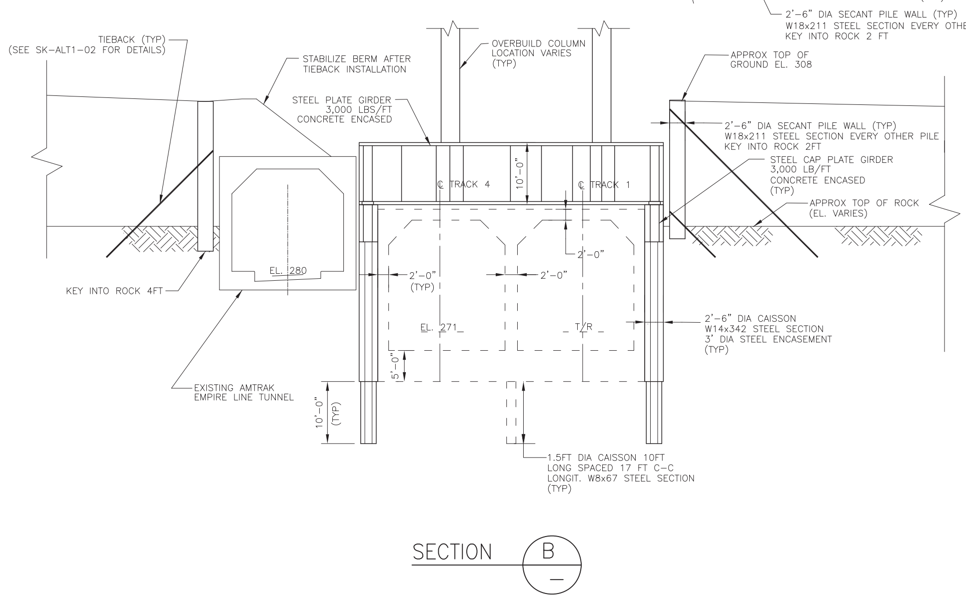
FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 2B

FINAL	NOVEMBER 16, 2012	SK-ALT2-03

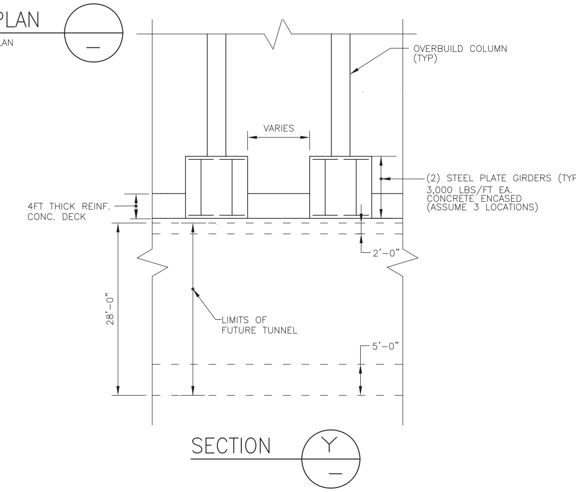


PARTIAL PLAN

ASSUME PARTIAL PLAN LENGTH IS 100LF



SECTION B



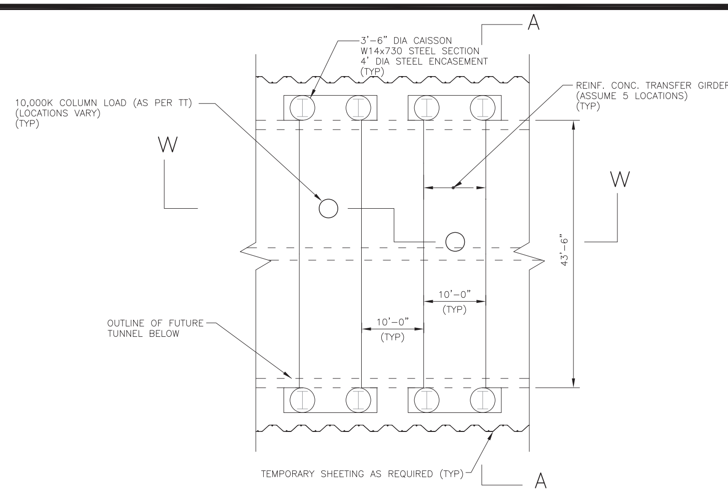
SECTION Y

SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 2B

FINAL	NOVEMBER 16, 2012	SK-ALT2-04

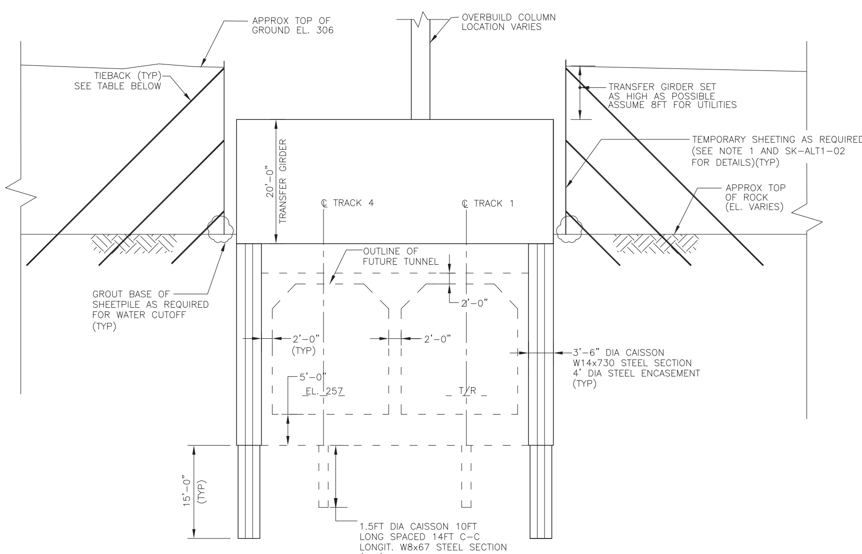


PARTIAL PLAN

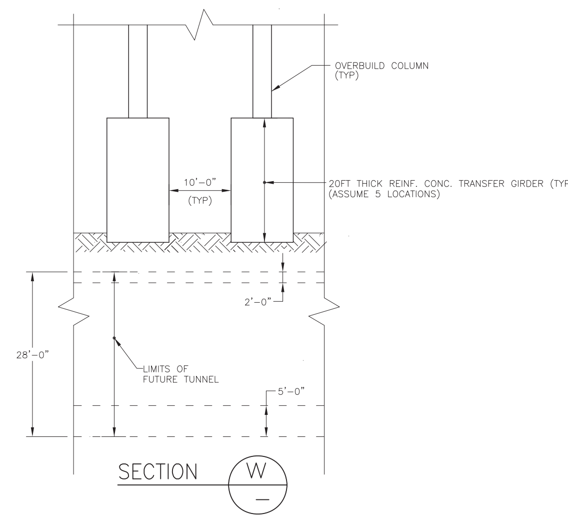
ASSUME LENGTH OF
PARTIAL PLAN IS 100LF

NOTES:

1. FOR COST ESTIMATE PURPOSES ONLY ASSUME SHEET PILE TYPE PZ35 WITH (3) TIERS OF 1-3/4" TIE-BACKS FOR SUPPORT OF EXCAVATIONS UP TO 26FT DEEP. FOR SUPPORT OF EXCAVATIONS LESS THAN 20FT DEEP ASSUME (2) TIERS OF TIE-BACKS ARE USED. STRUTS MAY BE USED IN LIEU OF TIE-BACKS AT CONTRACTOR'S OPTION.



SECTION A



SECTION W

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

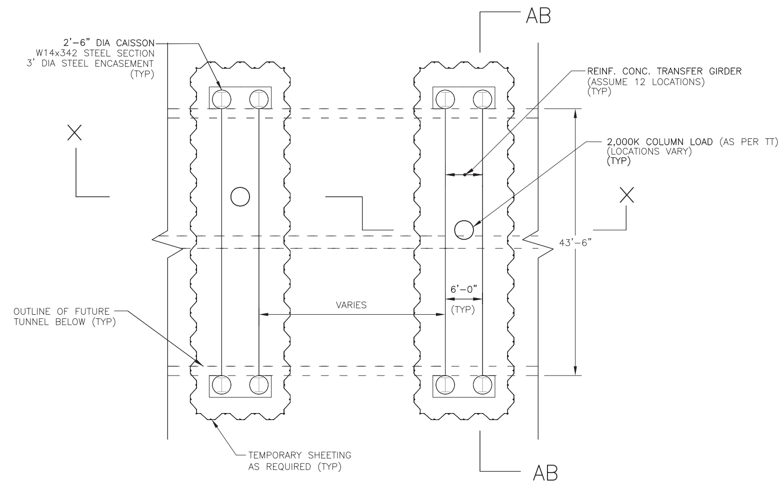
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 3

FINAL	NOVEMBER 16, 2012	SK-ALT2-05

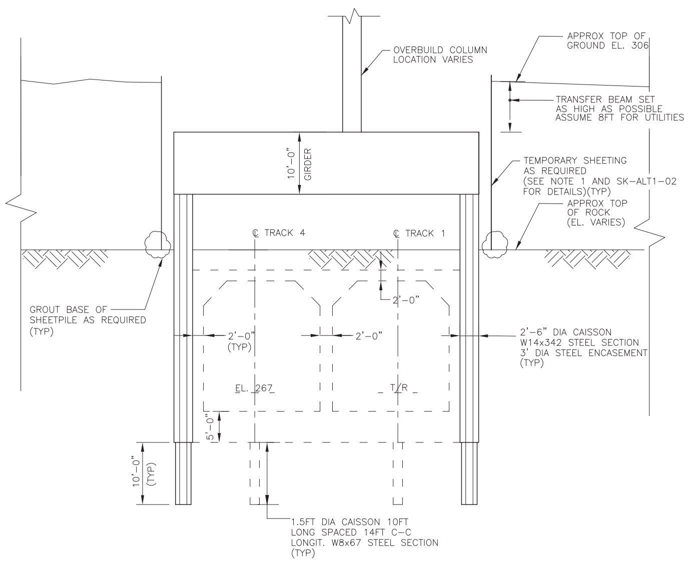
NOTES:

1. FOR COST ESTIMATE PURPOSES ONLY, ASSUME SHEET PILE TYPE PZ35 WITH (3) TIERS OF STRUTS.

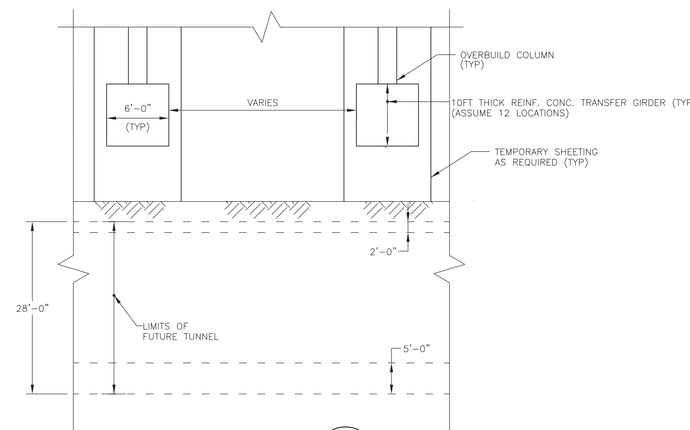


PARTIAL PLAN

ASSUME LENGTH OF PARTIAL PLAN IS 370LF



SECTION AB



SECTION X

SCALE 1" = 10'-0"

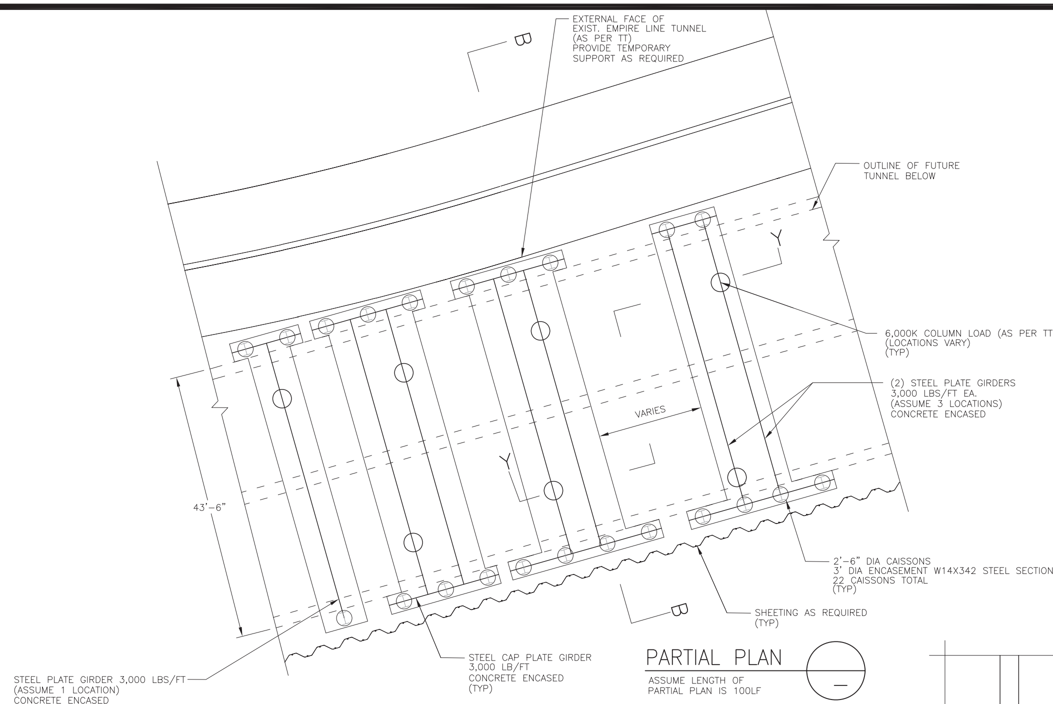
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 3

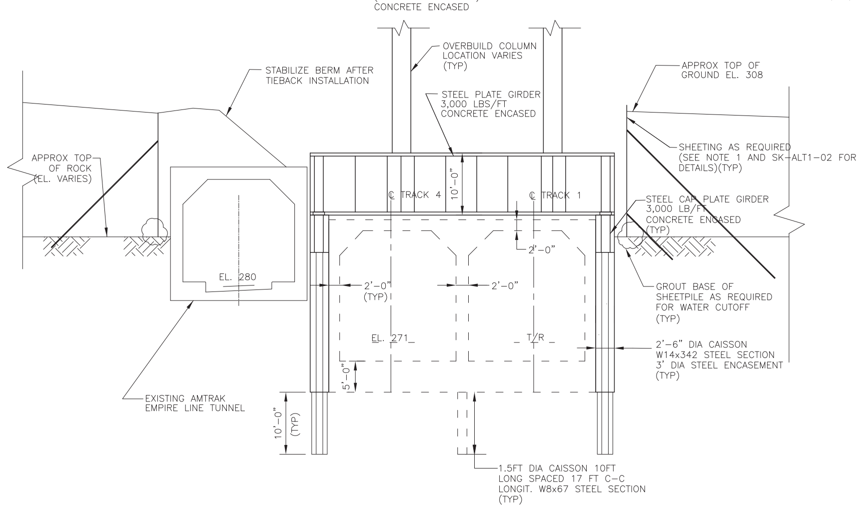
FINAL	NOVEMBER 16, 2012	SK-ALT2-06

NOTES:

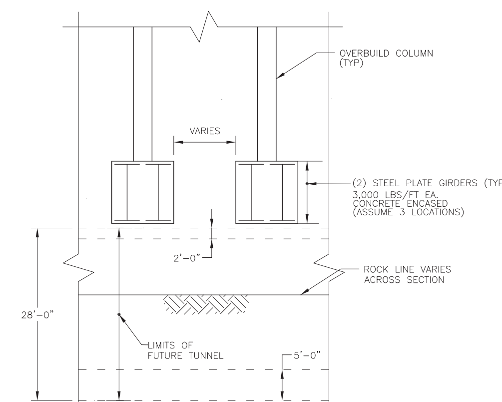
1. FOR COST ESTIMATE PURPOSES ONLY ASSUME SHEET PILE TYPE PZ35 WITH (3) TIERS OF 1-3/4" TIE-BACKS FOR SUPPORT OF EXCAVATIONS UP TO 26FT DEEP. FOR SUPPORT OF EXCAVATIONS LESS THAN 20FT DEEP ASSUME (2) TIERS OF TIE-BACKS ARE USED. STRUTS MAY BE USED IN LIEU OF TIE-BACKS AT CONTRACTOR'S OPTION.



PARTIAL PLAN
ASSUME LENGTH OF PARTIAL PLAN IS 100LF



SECTION B



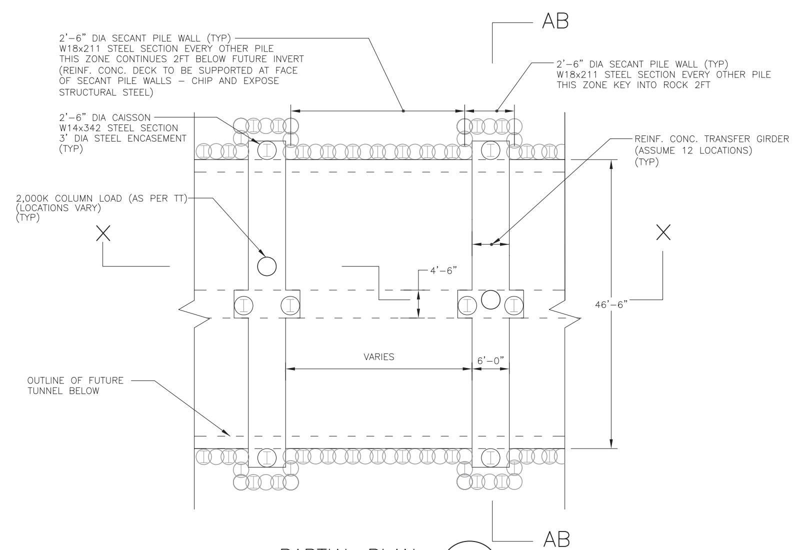
SECTION Y

SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

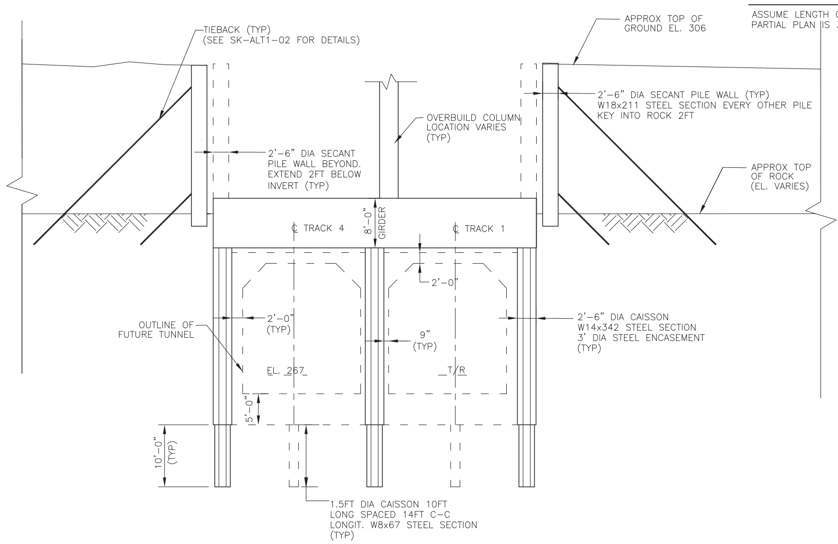
FULLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 2
OPTION 3

FINAL	NOVEMBER 16, 2012	SK-ALT2-07

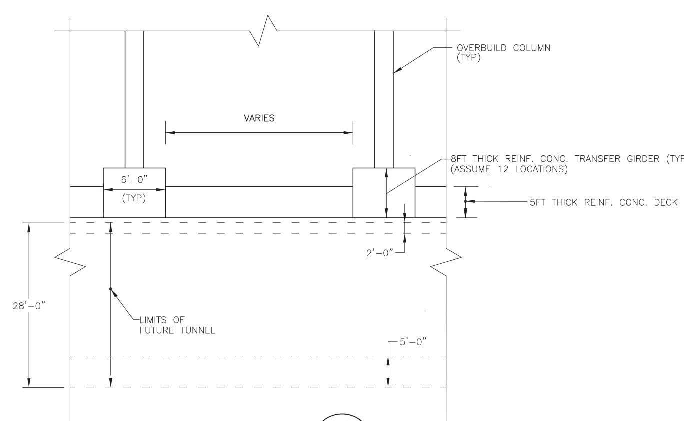


PARTIAL PLAN

ASSUME LENGTH OF PARTIAL PLAN IS 370LF



SECTION AB



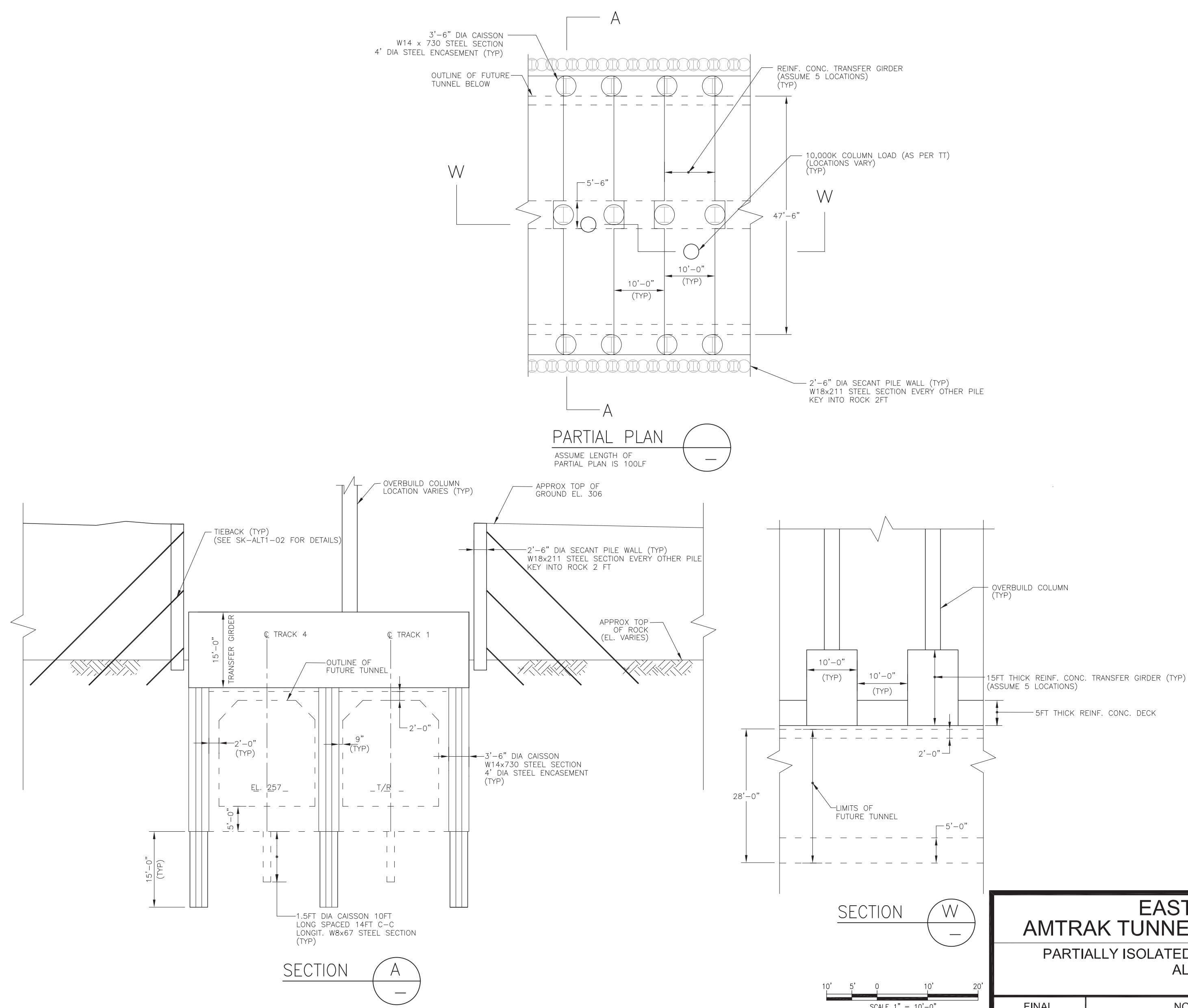
SECTION X

SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3
OPTION 2A

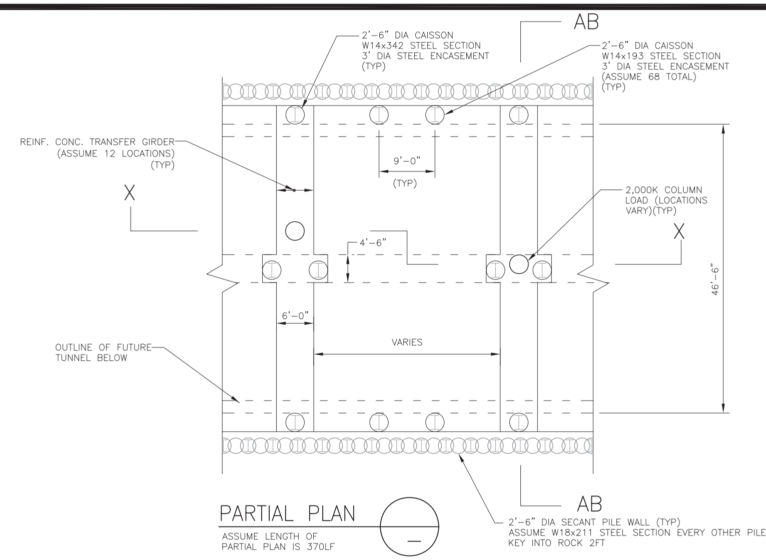
FINAL	NOVEMBER 16, 2012	SK-ALT3-01



EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

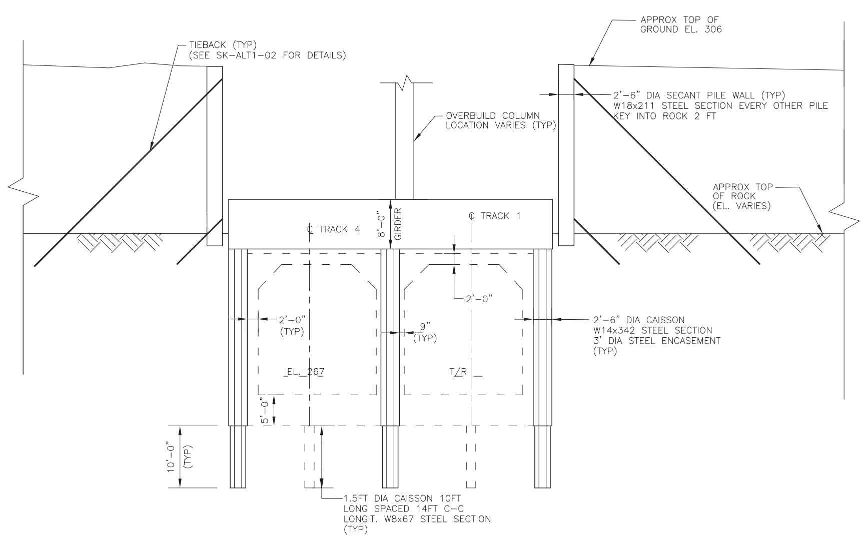
PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3
OPTION 2B

FINAL	NOVEMBER 16, 2012	SK-ALT3-02

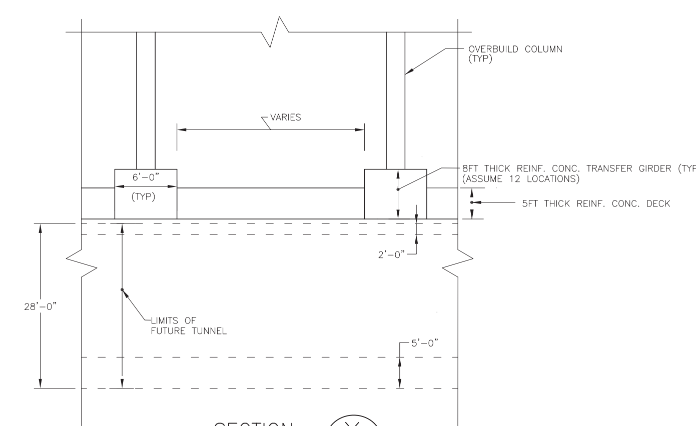


PARTIAL PLAN

ASSUME LENGTH OF
PARTIAL PLAN IS 370LF



SECTION AB



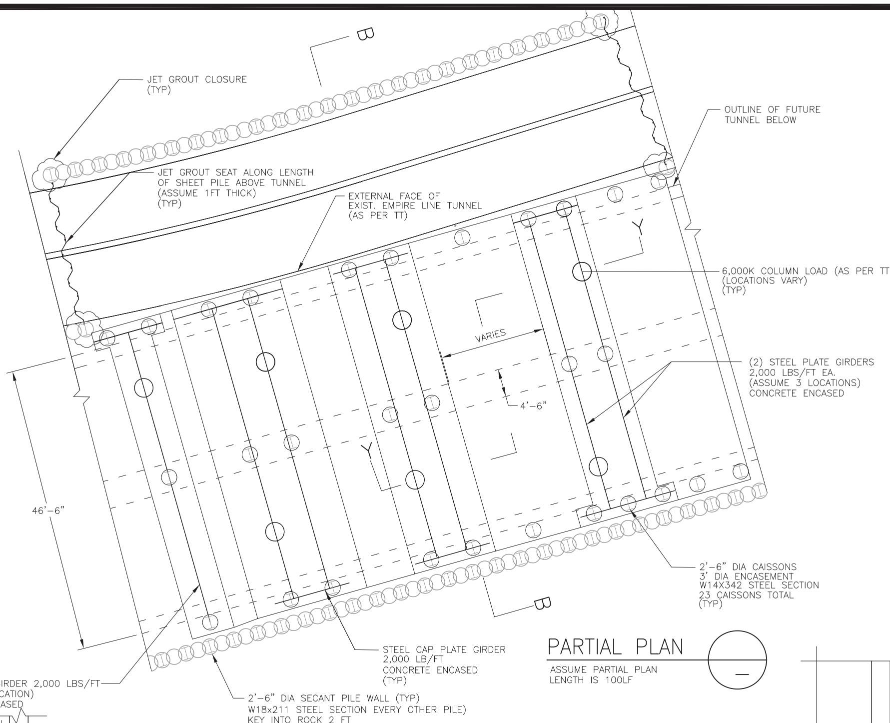
SECTION X

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

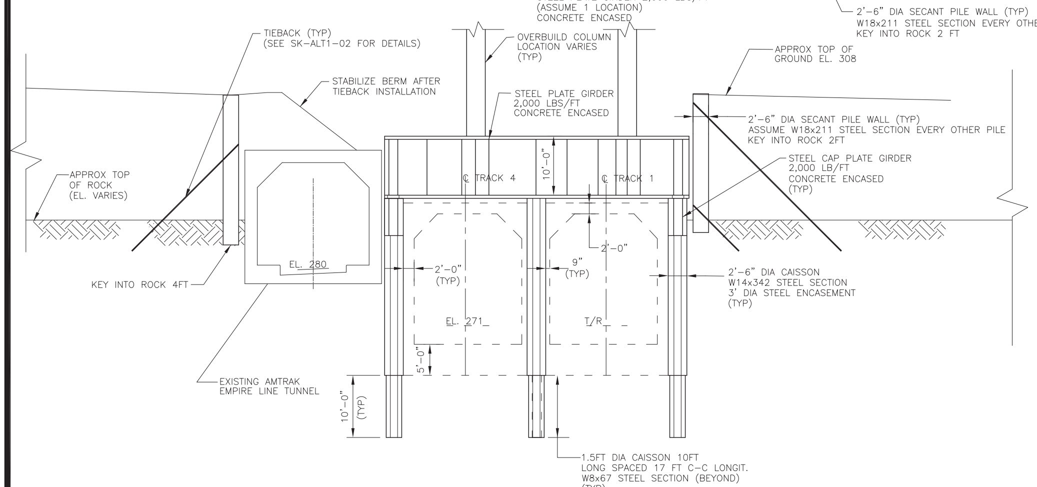
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3
OPTION 2B

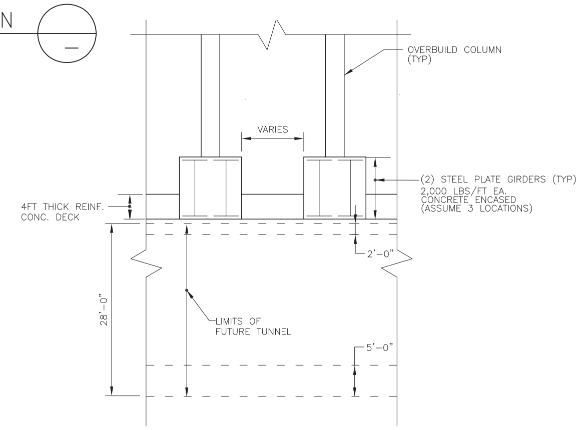
FINAL	NOVEMBER 16, 2012	SK-ALT3-03



PARTIAL PLAN
ASSUME PARTIAL PLAN LENGTH IS 100LF



SECTION B



SECTION Y

10' 5' 0 10' 20'
SCALE 1" = 10'-0"

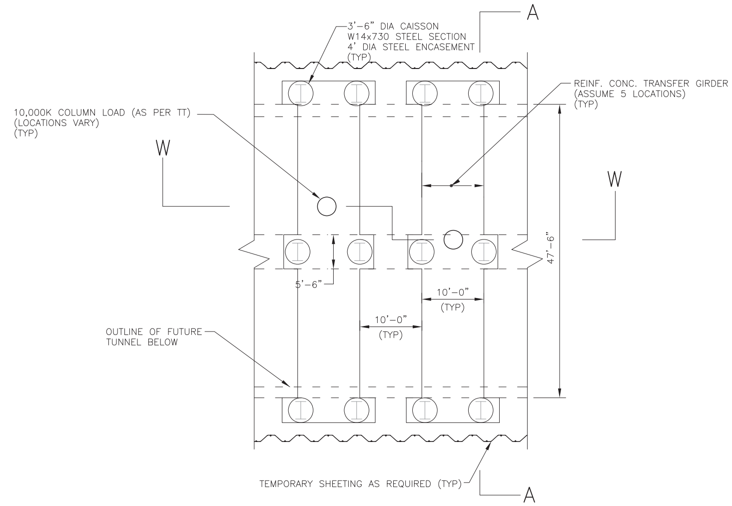
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3
OPTION 2B

FINAL	NOVEMBER 16, 2012	SK-ALT3-04

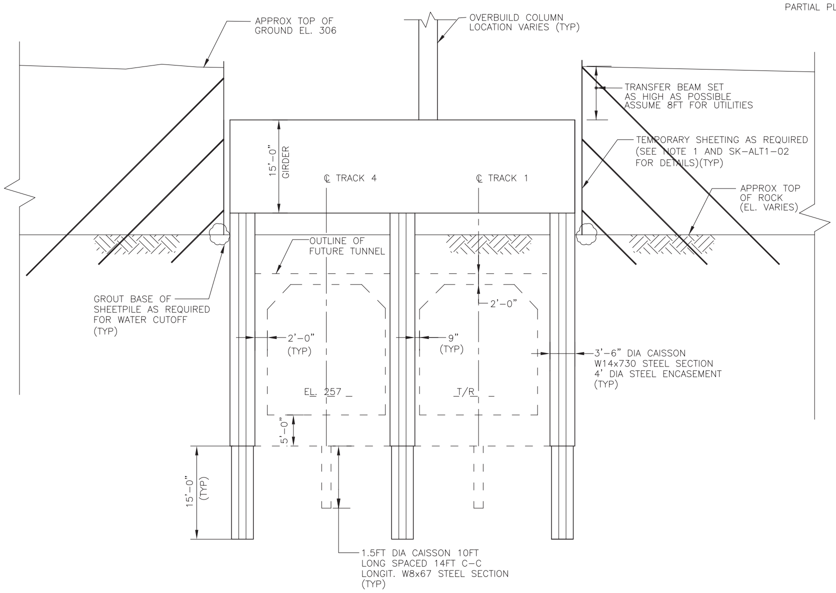
NOTES:

1. FOR COST ESTIMATE PURPOSES ONLY ASSUME SHEET PILE TYPE PZ35 WITH (3) TIERS OF 1–3/4" TIE–BACKS FOR SUPPORT OF EXCAVATIONS UP TO 26FT DEEP. FOR SUPPORT OF EXCAVATIONS LESS THAN 20FT DEEP ASSUME (2) TIERS OF TIE–BACKS ARE USED. STRUTS MAY BE USED IN LIEU OF TIE–BACKS AT CONTRACTOR'S OPTION.

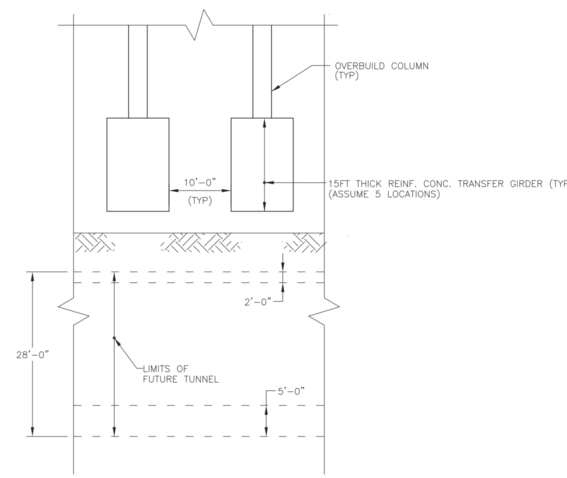


PARTIAL PLAN

ASSUME LENGTH OF PARTIAL PLAN IS 100LF



SECTION A



SECTION W

10' 5' 0 10' 20'
SCALE 1" = 10'–0"

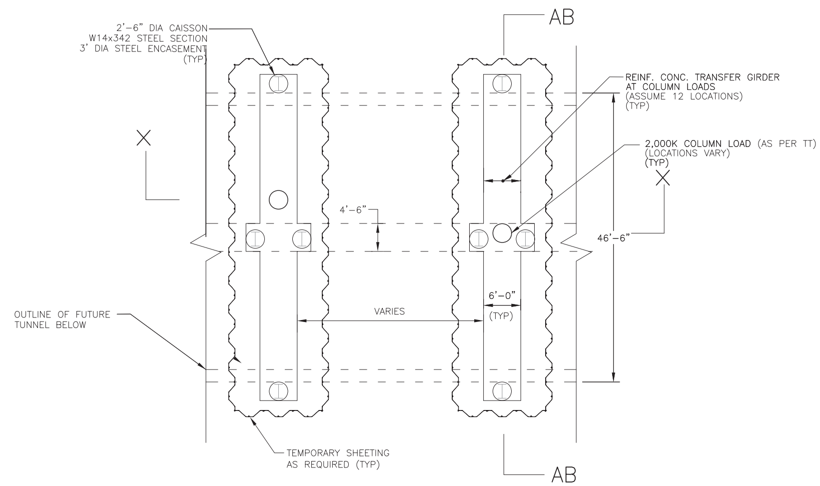
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3
OPTION 3

FINAL	NOVEMBER 16, 2012	SK-ALT3-05

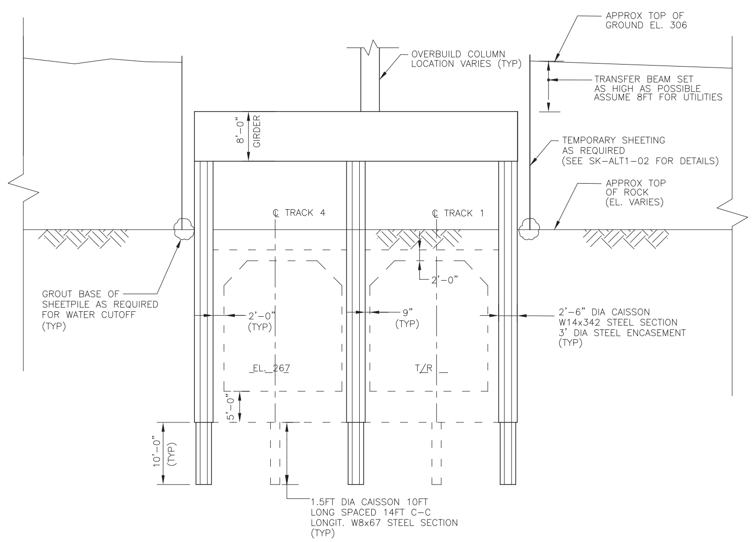
NOTES:

1. FOR COST ESTIMATE PURPOSES ONLY, ASSUME SHEET PILE TYPE PZ35 WITH (3) TIERS OF STRUTS.

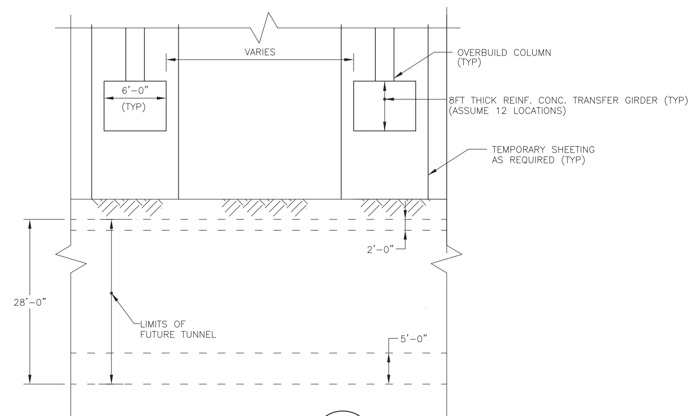


PARTIAL PLAN

ASSUME LENGTH OF PARTIAL PLAN IS 370LF



SECTION AB



SECTION X

SCALE 1" = 10'-0"

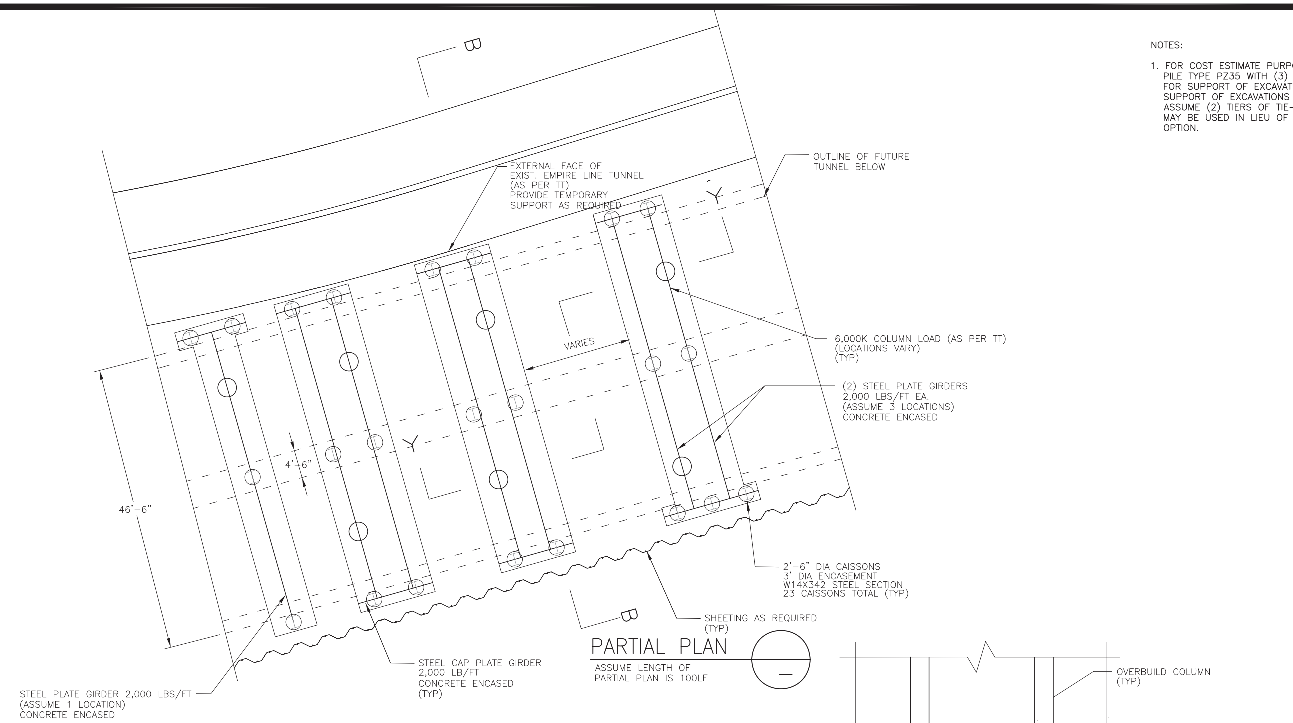
EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3
OPTION 3

FINAL	NOVEMBER 16, 2012	SK-ALT3-06

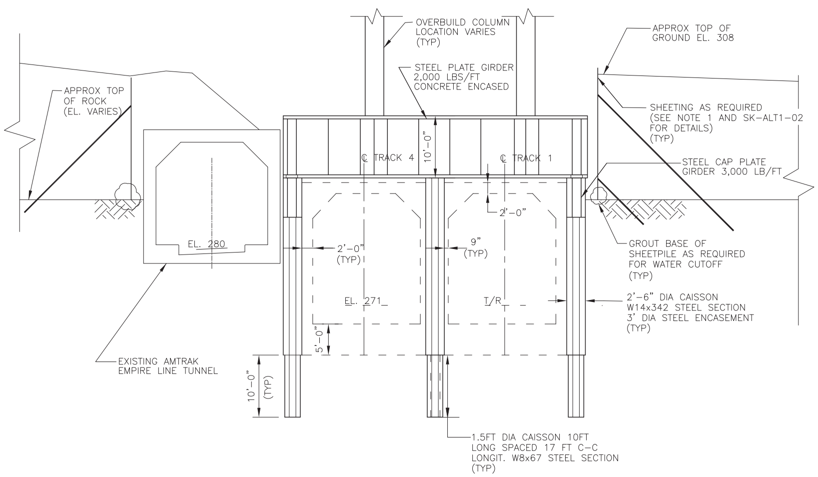
NOTES:

1. FOR COST ESTIMATE PURPOSES ONLY ASSUME SHEET PILE TYPE PZ35 WITH (3) TIERS OF 1-3/4" TIE-BACKS FOR SUPPORT OF EXCAVATIONS UP TO 26FT DEEP. FOR SUPPORT OF EXCAVATIONS LESS THAN 20FT DEEP ASSUME (2) TIERS OF TIE-BACKS ARE USED. STRUTS MAY BE USED IN LIEU OF TIE-BACKS AT CONTRACTOR'S OPTION.

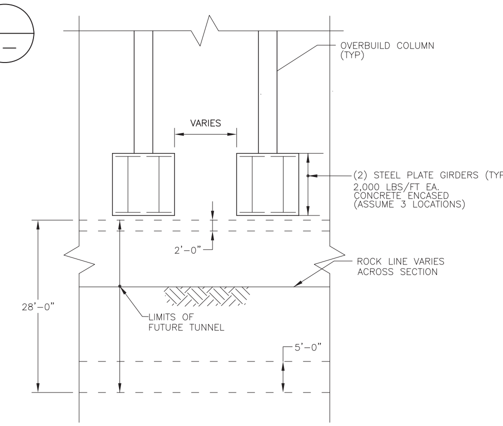


PARTIAL PLAN

ASSUME LENGTH OF PARTIAL PLAN IS 100LF



SECTION B



SECTION Y

SCALE 1" = 10'-0"

EAST SIDE YARD
AMTRAK TUNNEL ALTERNATIVE STUDY

PARTIALLY ISOLATED CUT-AND-COVER TUNNEL BOX
ALTERNATIVE 3

OPTION 3

FINAL	NOVEMBER 16, 2012	SK-ALT3-07