BWRR
BALTIMORE-WASHINGTON RAPID RAIL

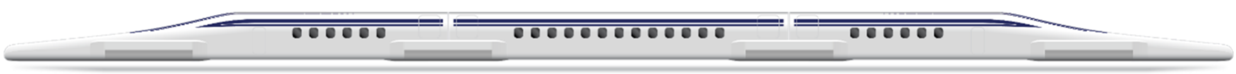

Exhibit K

Construction Plan

BALTIMORE-WASHINGTON SCMAGLEV PROJECT

CONSTRUCTION PLANNING MEMORANDUM

REVISION: 2

DATE: MAY 14, 2020

(Response to data requests #1, 2, and 26)

BWRR

BALTIMORE-WASHINGTON RAPID RAIL

BALTIMORE-WASHINGTON SCMAGLEV PROJECT

CONSTRUCTION PLANNING MEMORANDUM

4.3 PRELIMINARY ENGINEERING

REVISION.: 2

DATE: MAY 14, 2020

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NOTES/REVISIONS FOR VERSION CONTROL

Revision 0: 2018-12-10

Revision 1: 2019-01-09

Revision 2: 2020-05-14

File Name: Construction Plan Rev2 20.05.14

1. INTRODUCTION

The Baltimore-Washington Maglev Project will provide new infrastructure, stations, and facilities for a Superconducting Maglev (SCMAGLEV) train system between Washington, DC, and Baltimore, MD.

The primary elements of the project are:

- SCMAGLEV rolling stock and systems using technology developed by Central Japan Railway Company (JR Central)
- Two guideways, one in each direction, borne by tunnel and viaduct structures
- Three stations:
    - Washington, DC
    - Baltimore-Washington International Thurgood Marshall Airport (BWI)
    - Baltimore, MD

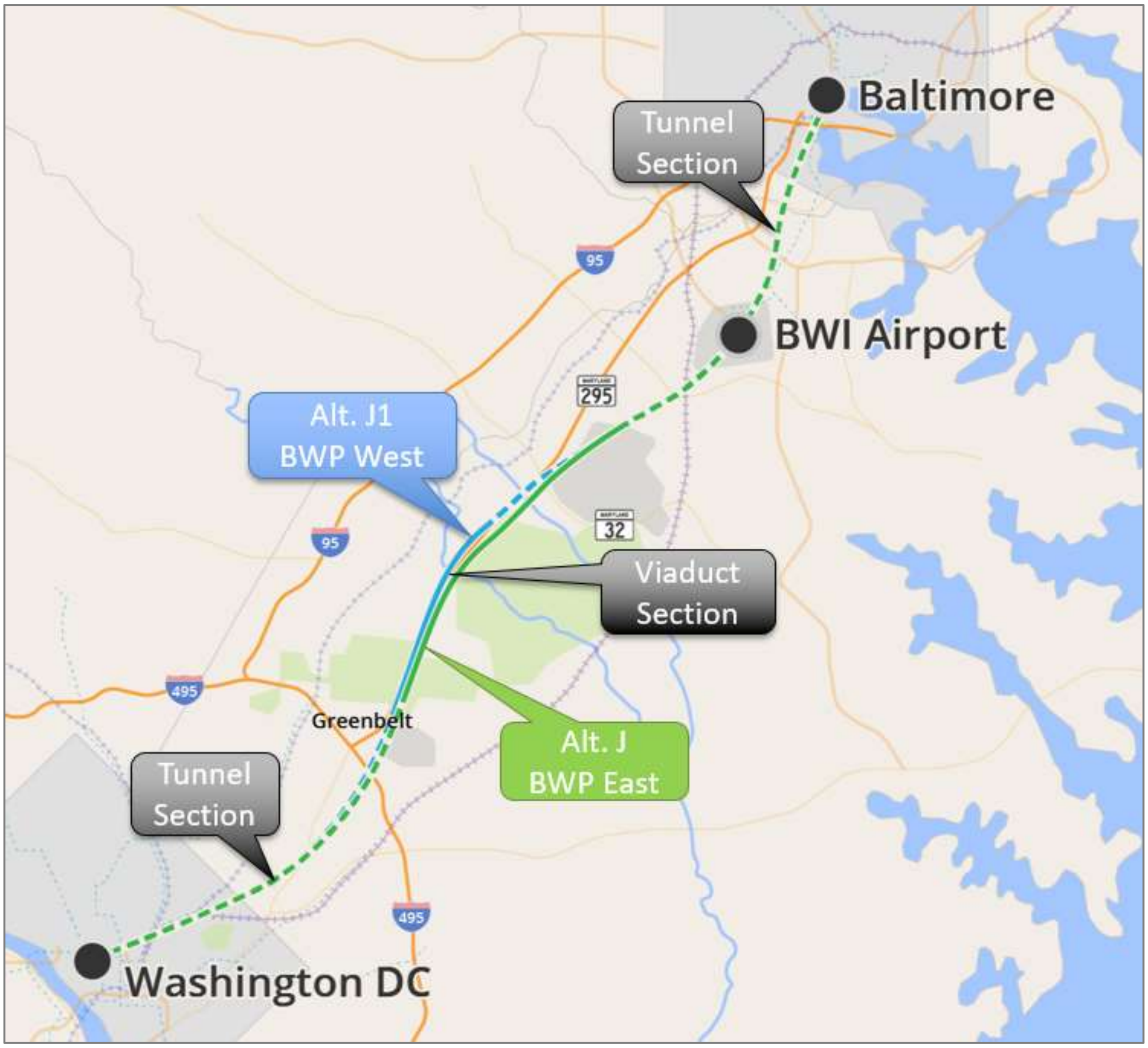
An Environmental Impact Study (EIS) is underway. Two alignment alternatives were retained for further study in the Final Alternatives Report (November 2018). The alignments generally follow the Baltimore-Washington (BW) Parkway corridor as listed in Table 1 and shown in Figure 1.

Table 1. Alignment Alternatives

Alternative	Name
J	BW Parkway Modified–East
J1	BW Parkway Modified–West

This document addresses construction requirements associated with the two BW Parkway alternatives to support the preparation of the Draft EIS (DEIS).

Figure 1. Conceptual Engineering Alignment Alternatives



2. GENERAL

Two alignment alternatives have been identified for further study in the DEIS: Alternatives J (BW Parkway East) and J1 (BW Parkway West). After departing the District of Columbia and Maryland border, alignment generally follows the BW Parkway corridor.

Each alternative is comprised of two main construction configurations: elevated structure and deep bored tunnel. Transition portals provide the connection between the tunnel and viaduct portions of each route. The project will include three passenger stations, one Trainset Maintenance Facility (TMF), two Maintenance of Way (MOW) facilities, substations and associated transmission facilities, ancillary train service/control facilities, Fresh Air / Emergency Egress (FA/EE) locations, tunnel boring machine (TBM) launch/retrieval sites, temporary access roads and permanent parking and related operational space.

3. CONSTRUCTION SCHEDULE APPROACH

A construction schedule was developed as follows:

- Break each alignment alternative into logical contract packages
- Obtain input from general contractors, engineers, architects, and other subject matter experts to determine reasonable durations or production rates for each project element
- Review historic information where available to validate assumptions

The following preconstruction activity efforts will be initiated, and in some cases completed, prior to the start of construction:

Environmental Impact Statement (EIS): The process whereby a project requiring major federal action is evaluated to determine its environmental impacts and the actions that are necessary to mitigate those impacts. An EIS culminates in a Record of Decision (ROD) issued by the lead federal agency.

Preliminary Design: Preliminary engineering for the preferred alternative is prepared to support the EIS. Design will be advanced concurrent with the completion of the EIS to an advanced preliminary phase sufficient to procure construction contracts.

Right-of-Way Acquisition: Parcels along the project alignment will need to be acquired to begin construction of the SCMAGLEV civil infrastructure including the use of easements where applicable. Based on projects of a similar length and magnitude, up to three years may be required to secure all the properties needed for the project. Priority will be given to the right-of-way (ROW) parcels required for initial construction contracts, specifically, construction staging sites, mobilization, and launch/retrieval sites for TBMs. ROW acquisitions can proceed with private money prior to the ROD and continue into construction phases.

Permitting: Several permits and approvals will be required prior to or during the early stages of construction. Some permits relate to the protection of specific environmental resources, for example, wetlands and streams. The permit application process will start during preparation of the EIS and use many of the same analyses and studies being conducted for the EIS. Some permits will need to be finalized by the construction contractors depending upon their chosen means and methods of performing the necessary construction.

Geotechnical Investigation Program: A detailed geotechnical investigation program is required to provide bidders with sufficient data for their proposals. The program, comprising up to 300 boreholes, will be completed prior to or during early stages of the construction contracting.

Procurement: The process of prequalifying, selecting, and negotiating design and construction contracts is anticipated to take approximately two years. The procurements can be initiated prior to completion of the EIS so that the contractor teams are prepared to mobilize personnel, equipment, and material immediately upon issuance of a ROD.

Early Works: Prior to the start of major linear infrastructure works (tunnels and viaducts) and stations, various activities to prepare construction sites are required, including utility relocations, building demolition, preparation of staging sites, and excavation for TBM launch sites. The activities can be accomplished as an initial stage of the major infrastructure contracts, or through separate early works contracts concurrent with the procurement of major construction contracts.

SCMAGLEV System Safety: BWRR expects that a Rule of Particular Applicability (RPA) will be required for the operation of the system. The rulemaking process will likely proceed in parallel with the EIS process. Construction can proceed prior to completion of the RPA, but operations cannot commence without it.

A bar chart schedule is presented in Figure 2. The schedule is similar for alignment Alternatives J and J1, for Cherry Hill and Camden Yards stations, and for both BARC TMF sites.

Acceleration strategies, such as pre-ordering the TBMs during the design phase and overlapping guideway construction, can reduce the overall schedule.

3.1 SCHEDULE DEFINITIONS

The tasks (ID #) identified in the schedule in Figure 2 below are defined/expanded upon with identification of relevant sections herein as follows:

ID 1: TBM Manufacturing and Assembly - The type of TBM necessary for respective tunnel segments will be determined and begin procurement and manufacturing as soon as possible. (See Section 6.0)

ID 2: Launching Gantry Manufacturing and Assembly - Gantry manufacturing for Viaduct construction, as applicable depending on construction method selected. (See Section 7.0)

ID 3: Clearing and Grubbing – Removal of trees, brush and other surface obstructions at construction sites along the alignment (viaducts, portals, TMF, substations, FA/EEs, stations, TBM launch sites, etc.), and at construction laydown areas off the alignment.

ID 4: Utility Diversions / Relocation – Prior to the start of construction, where applicable, a utility effort will be required. (See Section 17.0).

ID 5: TBM Launch / Retrieval Sites - Installation of Support of Excavation (SOE) (e.g. slurry, pile, and lagging, etc.) for TBM launch and retrieval shafts along the alignment. Launch shafts and laydown areas will be larger to accommodate the TBM itself and to handle tunnel spoils, segment storage, etc., while retrieval shafts and laydown areas will be smaller and serve as retrieval locations of TBM. (See Sections 5 and 6)

ID 6: Tunnel Construction - Construction of tunnel segments simultaneously along the project alignment. Baseline assumption for tunnel excavation advance rate used herein is 30 ft per day with as many as 8/9 TBMs (J/J1 alignment, Cherry Hill Station Alternative) or 9/10 TBMs (J/J1 alignment, Camden Yards Station Alternative) boring simultaneously. (See Section 6.0)

ID 7: Viaduct/Ramps Construction - Construction of the Viaduct structure and associated ramps along the project alignment. Assumes construction along multiple fronts by one or more contractors with close coordination and staging to minimize construction time. (See Section 7.0)

ID 8: Portal Construction - Construction of transition portals between TBM tunnels and above-ground structures (e.g. Viaduct, or Cherry Hill Station alternative). Assumed duration from prior experience, anticipated size of excavation and staging to minimize traffic impact at Cherry Hill Station portal alternative. (See Section 9.0)

ID 9: Stations Construction - Construction of stations in Washington, D.C. (Mt. Vernon Square East), at BWI Airport, and Baltimore, MD (Cherry Hill Station or Camden Yards Station). Length of time assumes multiple fronts of construction and carefully coordinated construction staging to for underground stations to maximize productivity and minimize traffic impact. (See Section 8.0)

ID 10: TMF Civil Construction - Construction of Trainset Maintenance Facility (TMF), with three alternatives: (1) BARC West, (2) BARC Airstrip and (3) MD-198. (See Section 10.0)

ID 11: FA/EE Civil Construction – Construction of Fresh Air/Emergency Egress facilities

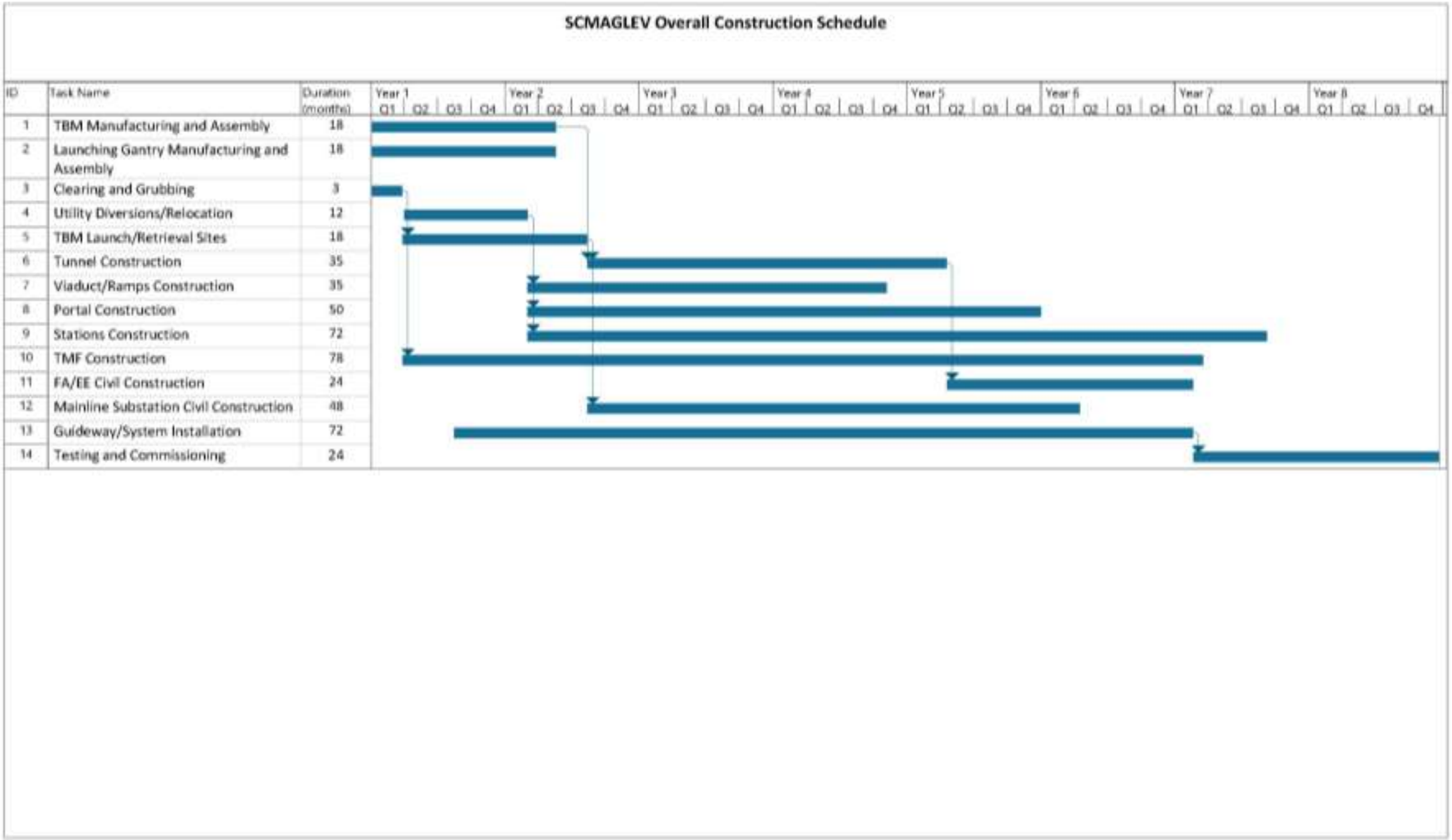
ID 12: Mainline Substation Civil Construction - Construction of substation facilities along the alignment; will also require a study process prior to start of construction. (See Section 11.0)

ID 13: Guideway/System Installation - Installation guideway and systems along the alignment

ID 14: Testing and Commissioning - Testing trainsets and systems leading up to start of service.

The schedule shown in Figure 2 assumes that multiple contracts are awarded and executed concurrently. Constraints on procurement activities, financing, or other factors could prolong the overall schedule beyond what is shown.

Figure 2. SCMAGLEV Overall Construction Schedule



4. START OF SERVICE

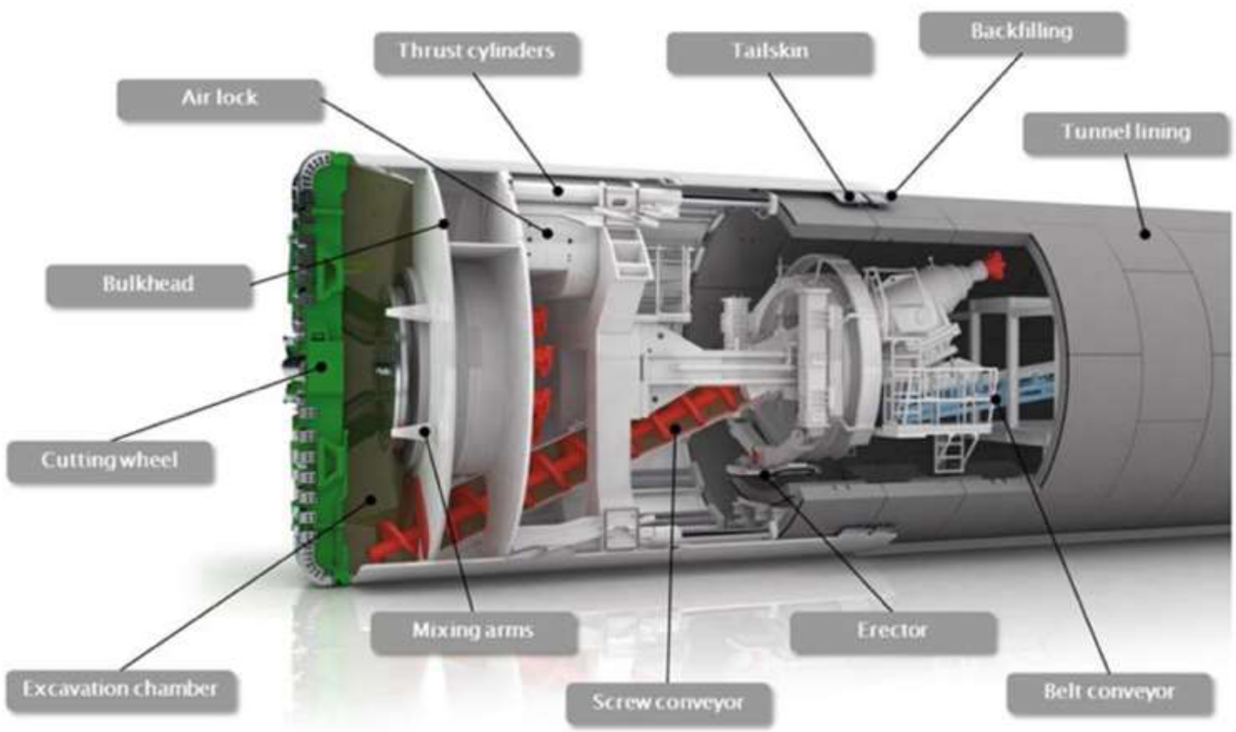
Assuming construction starts in 2022 with a construction duration of just under eight years, Start of Service will be at the end of 2029.

5. UNDERGROUND CONSTRUCTION METHODS

5.1 EARTH PRESSURE BALANCE (EPB) TBMS

In North America, EPB TBMs are the most common and have been used successfully in the project area. They rely on balancing the thrust pressure of the machine against the soil and water pressures from the ground being excavated. EPB TBMs are well suited for boring in soft ground, as expected with most drives on this project. They can also mine through variable soils and groundwater. The excavation method for an EPB TBM is based on tunnel face support provided by the excavated soil itself (Figure 3).

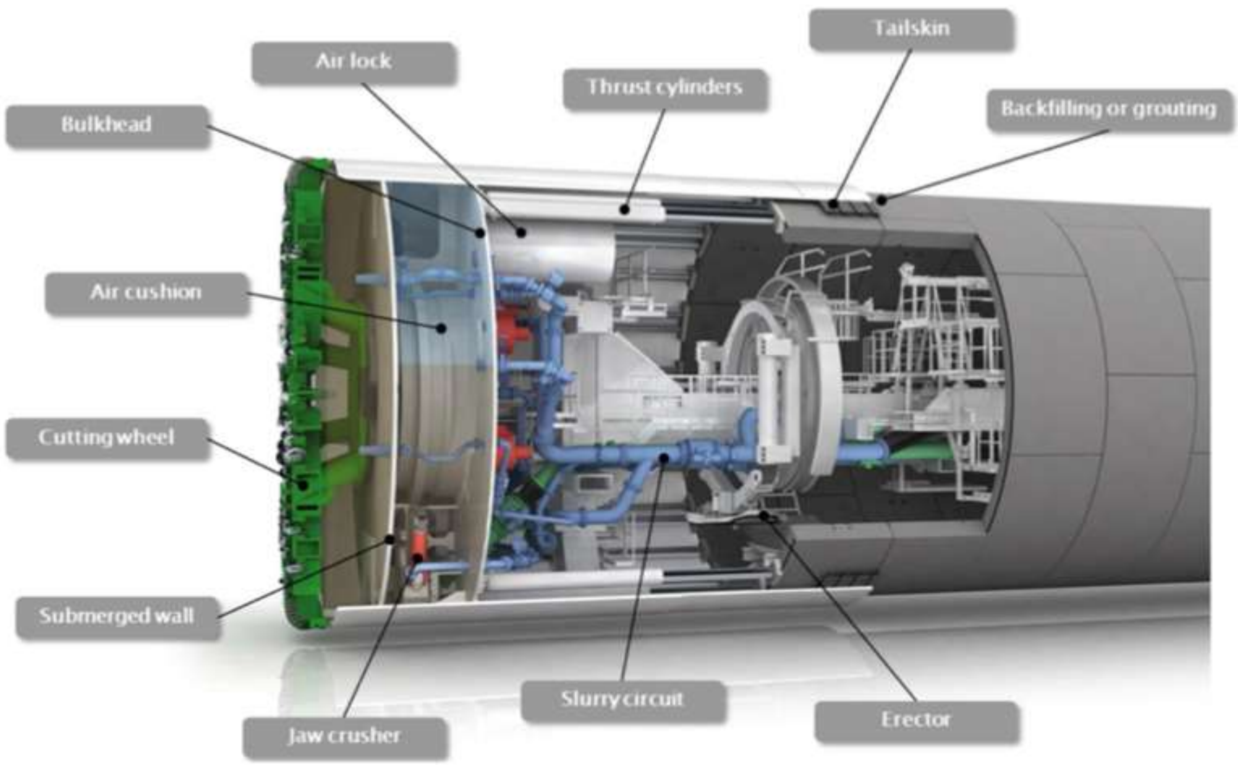
Figure 3. Schematic of EPB TBM (Courtesy of Herrenknecht)



5.2 SLURRY-FACE TBMS

Slurry-face TBMS are typically used for tunneling in heterogeneous geologies and high-water pressure zones, where the addition of the slurry and the closed spoil removal system provides more precise pressure control (Figure 4). A detailed understanding of the local geology and potential high water-pressure zones will be identified during the next phase of the ground investigation program. Slurry-face TBMs add bentonite (clay) slurry in a pressurized environment at the tunnel excavation face. This combination of pressure and slurry stabilizes and supports the soils during excavation. Depending on the ground encountered, conditioners may be added to the slurry. Excavated soil is mixed with the slurry fluid, pumped out of the tunnel to an above-ground separation plant through an ~18-inch diameter pipeline with in-line booster pumps, and separated from the slurry mixture.

Figure 4. Schematic of SLURRY TBM (Courtesy of Herrenknecht)



Slurry-face TBM tunneling, uses bentonite slurry to apply fluid (hydraulic) pressure to the tunnel face and transport soil cuttings from the tunneling machine's pressure chamber to the surface. The slurry mixed with soil cuttings is processed to separate the soil from the slurry. Separated soil is disposed of at approved locations selected by the tunnel contractor(s) (See Section 14), and the cleaned bentonite slurry is returned to the machine's cutting chamber. The slurry mixed at a surface plant is pumped in and out of the tunnel and the TBM pressure chamber through a series of pipes. As a result, excavated material is kept enclosed and in a fluid state until it reaches the slurry separation plant (Figure 5).

Figure 5. Typical Slurry Treatment Plant (Courtesy of Schauenburg)

This method involves the setup of one or more temporary slurry treatment plants. The slurry treatment plant provides two basic functions: (1) prepares the bentonite slurry by mixing the slurry and (2) treats the used slurry (slurry discharge). The removal process involves settling, use of sieves for separation of large particles, and centrifuges for small particles. Water for the plant is typically stored on-site in storage tanks. The slurry plant is anticipated to require an approximately 1-acre site for the equipment and enclosure. Water removed from the discharge slurry is recycled for use in preparing the bentonite slurry.

5.3 TUNNEL LINING CONSTRUCTION

Precast concrete segments (Figure 6) with gaskets provide initial and final support of the tunnel. Single-pass, double- gasketed, precast concrete segments are the lining system of choice to limit infiltration of water and gas through the final lining. These provide a high-quality lining close behind the TBM.

Precast concrete segments will be fabricated off-site by the contractor and delivered by truck. Several days or weeks of segments may be stored at the work site to ensure uninterrupted supply. A typical precast segment storage area is shown in Figure 7 and will vary in size depending upon the number of segments the contractor prefers to maintain on-site; however, typically 1 to 2 acres will be dedicated to segment storage.

Figure 6. Typical Precast Concrete Segmental Lining (Courtesy of Herrenknecht)

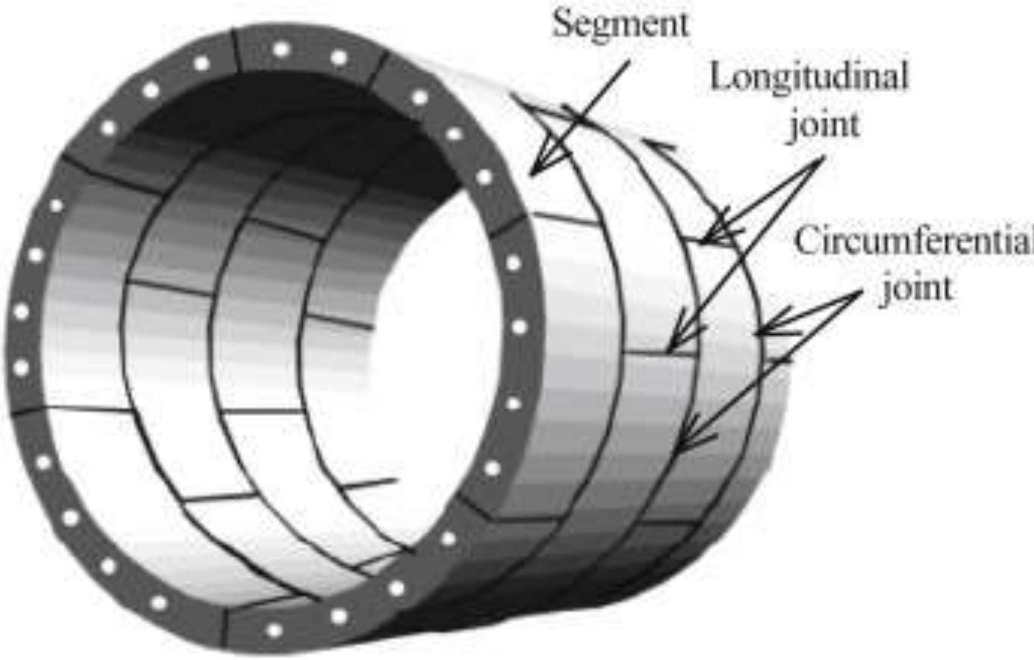
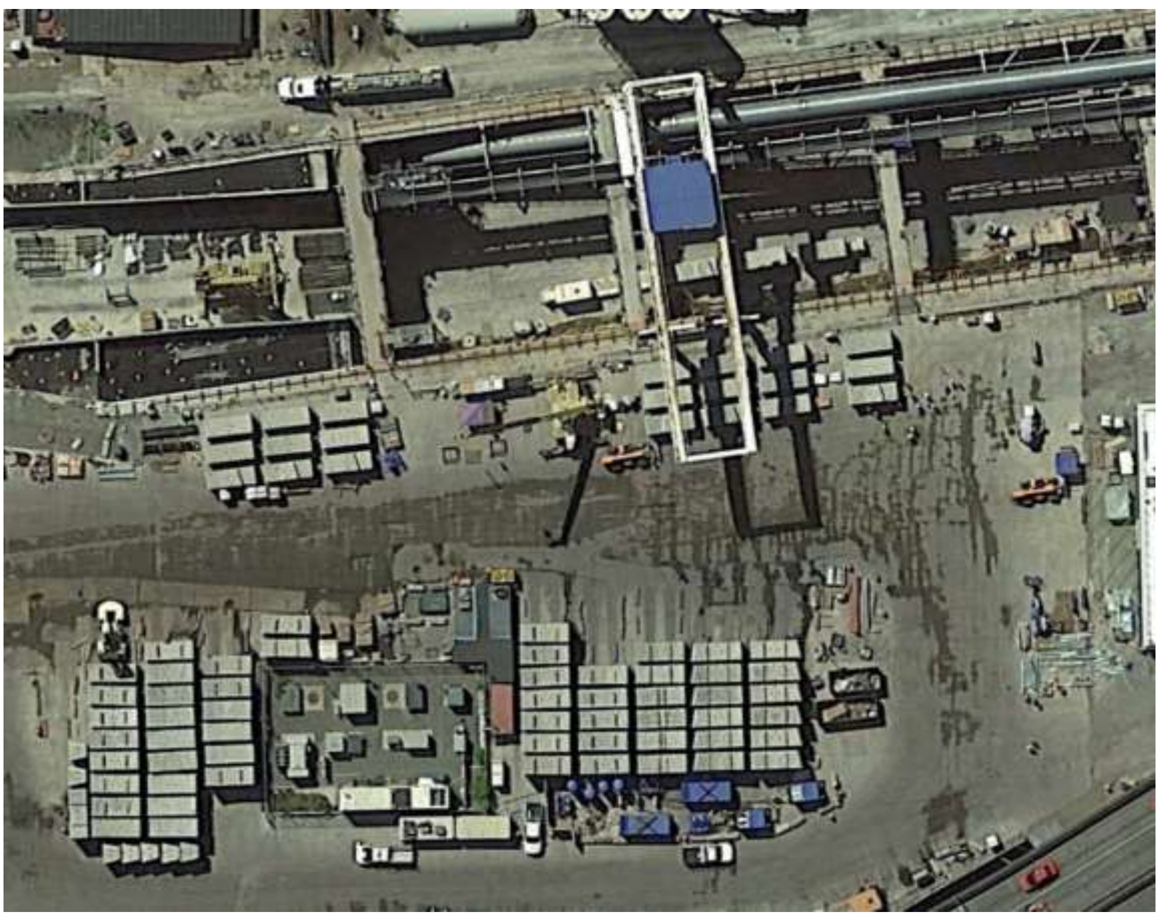


Figure 7. Segment storage for the Alaskan Way Viaduct Tunnel Project, Seattle, WA



5.4 TUNNEL VIBRATION AND SETTLEMENT MONITORING

Baseline noise and vibration, representing the current conditions, will be documented prior to the start of construction, and tunneling. Vibration limits are set to eliminate the possibility of physical damage to buildings and to eliminate or minimize exposure to the public

A Noise and Vibration Control Plan will be prepared by the contractor prior to the start of work. Monitoring points will be established along the alignment during construction and tunneling operations with daily monitoring. Work will not continue where noise and vibration levels have been exceeded until acceptable mitigation measures are deployed.

A surface settlement monitoring program will be implemented during construction and tunneling operations. A pre-construction survey of sensitive structures for existing cracks and damages will be conducted. Tolerance levels are established based on thresholds for buildings, roads, and other sensitive structures to ensure no damage. This includes an Alert Notification System that notifies the responsible personnel when tolerances are exceeded. Instrumentation will likely include Borehole Extensometers, Inclinometers, Tunneling Diameter Measure Device, Structure Monitoring Points, Ground Monitoring points, Utility Monitoring Points, Grid Crack Gauges, Tiltmeters, and Survey Instruments.

5.5 EXCAVATION SUPPORT SYSTEMS

Earth support is an important factor in the construction of deep excavations and is commonly referred to as Support of Excavation (SOE). There are many suitable methods to achieve the needed support. Initial support provides vertical stability while soil is removed from the excavation. This support remains in place for the duration of subsurface work. Support for the station excavation is considered “temporary” over the period of construction. However, most of the materials remain in the ground after the structure is completed.

The final support is provided by the permanent concrete station box structure and includes concrete slabs, walls, and walkways for the station entrances.

Some lateral movement of the excavation walls will occur during soil removal and again during station concreting. The extent of movement depends on the excavation and shoring methods, wall design, and wall height. Project specifications require walls and adjacent ground to be monitored for lateral movement and surface settlement with threshold limits for each.

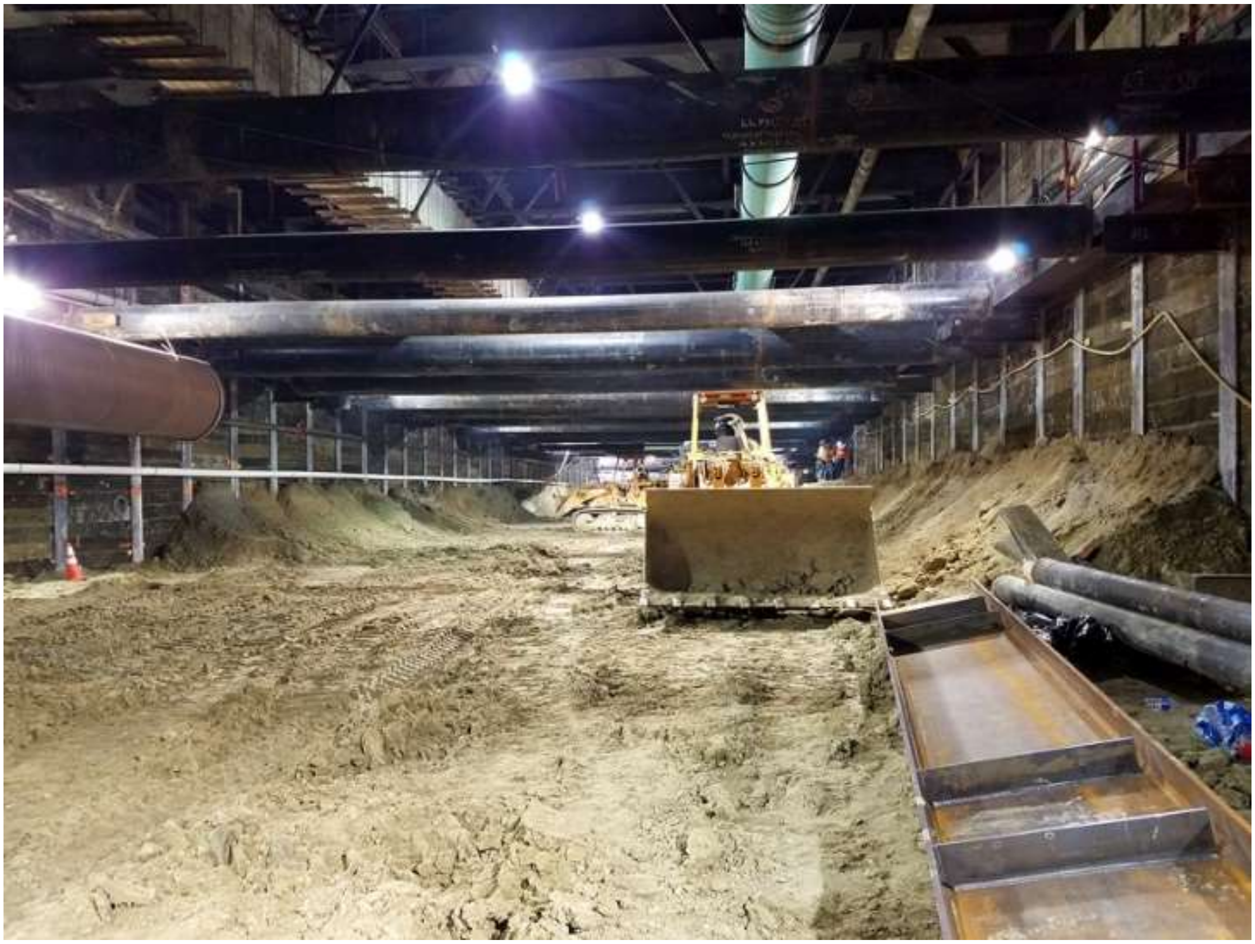
5.6 SOLDIER PILE AND LAGGING

Soldier pile and lagging walls are a type of shoring system typically used along the perimeter of excavation areas to hold back the soil around the excavation. This support system is common for shallower foundations and may be suitable for the top portion of station box construction to allow better flexibility for utility relocations.

Soldier pile and lagging consists of installing vertical steel beams (soldier piles) at regular intervals and lagging, which spans and retains the soil between the piles. Lagging is typically timber or sprayed-on concrete (shotcrete) and is installed progressively as the station is excavated. Soldier piles are installed in pre-augured holes and the annular space between the soldier pile and the holes is then filled with concrete. Pre-auguring allows for more accurate installation of the soldier piles and avoids the noise and vibration associated with pile driving. A soldier pile and lagging excavation and support system is shown in Figure 8.

A soldier pile and lagging system is used where groundwater inflow is not a concern, or where grouting or lowering of the groundwater level (dewatering) can be used to mitigate water seepage between piles. Such locations will be identified after the main project ground investigation program. It is anticipated that soldier piles and lagging may be used where conditions are suitable for underground utility relocations, at tunnel portals, and at TBM launch/retrieval shafts.

Figure 8. Typical soldier pile and lagging system (Wilshire/La Brea Station, Los Angeles, CA)



5.7 TANGENT PILE OR SECANT PILE WALLS

Tangent pile walls consist of contiguous drilled piles that touch each other. These walls provide a better groundwater seal than the soldier pile and lagging system, but some grouting or dewatering is sometimes needed to control leakage between piles. The contractor occupies one side of the street and drill the piles sequentially to form the retaining wall.

A secant pile wall is similar to the tangent pile wall, but the piles have some overlap, resulting in better water tightness and rigidity. This method consists of boring and concreting the primary piles at centers slightly less than twice the pile diameter. Secondary piles are then bored between the primary piles before the concrete can completely set (Figure 9). Because of the close spacing of tangent piles, utilities crossing the wall often require relocation. Construction of tangent or secant pile walls requires lane closures. Tangent pile or secant pile walls may be used as SOE for tunnel portals or launch/retrieval shafts.

Figure 9. Typical Secant Pile Wall (Courtesy of Swiss Boring)

5.8 DIAPHRAGM/SLURRY WALLS

Diaphragm walls (also known as slurry walls) are structural elements used for retention systems and permanent foundation walls. Slurry walls are constructed using deep trenches or panels that are kept open by filling them with a thick bentonite slurry mixture. Bentonite is a natural clay mineral that, when mixed with water, increases its density. The bentonite forms a layer on the trench wall (called a filtercake) that both inhibits slurry loss into surrounding soils and forms a vertical plane for the slurry to exert hydraulic force on the trench walls, stabilizing the soils and trench. After the slurry-filled trench is excavated to the required depth, structural elements (typically a steel reinforcing cage, shown in Figure 10) are lowered into the trench, and concrete is pumped through a tremie pipe from the bottom, displacing the slurry. Tremie concrete is then placed in one continuous operation through one or more pipes that extend to the bottom of the trench. As the concrete fills the trench, the concrete placement pipes are extracted. Once all the concrete is placed and has cured, the result is a structural concrete panel.

Grout pipes can be placed within slurry wall panels to be used later, if groundwater leakage through finished wall sections is observed. The slurry that is displaced by the concrete is collected and stored in tanks on site and reused for subsequent panel excavations. Slurry wall construction advances in discontinuous sections such that no two adjacent panels are constructed simultaneously. Panels are usually 2.5 to 6 meters (8 to 20 feet) wide, with thickness varying from 0.5 to 1.5 meters (2 to 5 feet). Slurry-wall construction occurs in stages, working on one side of the street at a time.

Diaphragm/Slurry walls have been constructed in virtually all soil types and provide a watertight support system with good wall stiffness to control ground movement. Diaphragm/slurry walls will likely be used for construction of the Mount Vernon Square East and BWI Airport Station boxes and potentially at tunnel portals and launch/retrieval shafts where a robust and watertight support system is required due to proximity to existing structures.

Figure 10. Installation of Rebar Cage Segments for Typical Slurry Wall Panel

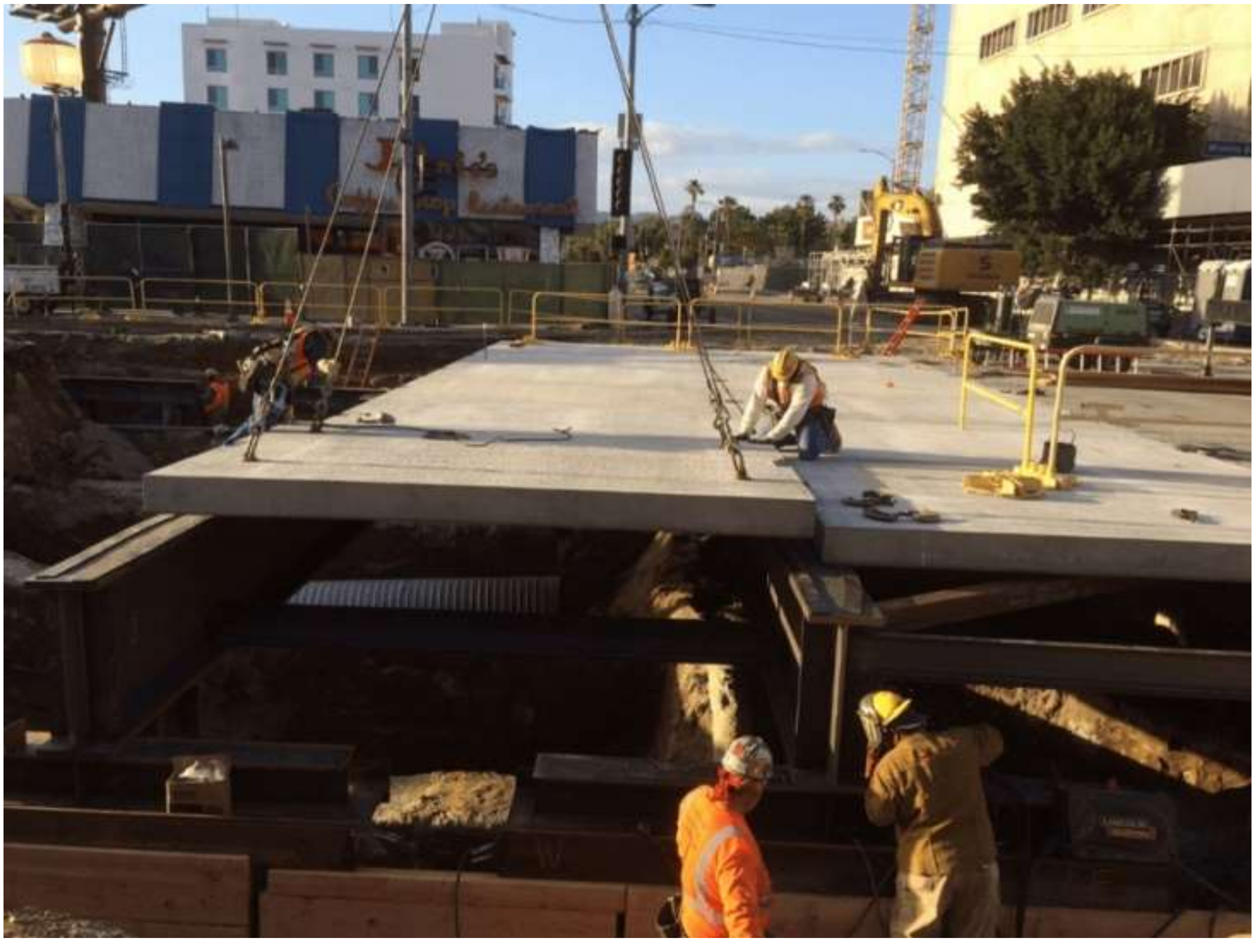
5.9 DECKING AND CROSS-BRACING

After installation of the temporary shoring (support) system and initial excavation, deck beams can be installed, followed by multiple sequences of excavation and installation of cross-bracing. The deck beams and cross-bracing provide lateral support for the support of excavation walls as the soil is excavated. Deck beams are sized and installed to support utilities (either existing or reconstructed) over the excavation.

In special situations where deck beams and cross-bracing cannot be installed, for example to allow access from above, tieback systems may be used. Tiebacks are strong cable strands or steel bars that are installed and grouted into pre-drilled holes that extend outward and downward from the excavation support wall. After the grout sets and the cables or bars are firmly anchored into the ground, the tiebacks are tensioned to provide lateral support to the wall. The use of tiebacks may require temporary underground easements if they extend into private property.

Decking (Figure 11) is placed on the deck beams to allow traffic and pedestrian circulation to resume after the initial excavation. This decking is typically constructed of precast reinforced concrete and is installed flush with the existing street and sidewalk. The decking and support are designed to withstand anticipated loading and exposure. Decking installation requires temporary street closures and is installed in progressive stages. Decking may be used during construction of the Mount Vernon Square East Station, the BWI Airport Station, and the Cherry Hill tunnel portal crossing at W. Patapsco Avenue.

Figure 11. Street Decking (Purple Line Extension, Los Angeles, CA)



5.10 EXISTING FOUNDATIONS

Underground station excavations will be near existing building foundations that may have to be protected depending on specific foundation details. A typical protection is use of a more rigid excavation support system that can resist the additional loads imposed by the adjacent foundations. In such cases, a stiffer tangent pile, secant pile, or slurry-wall shoring system may be used. Pre-loading of excavation support bracing may also be implemented.

For buildings adjacent to cut-and-cover construction the shoring system in conjunction with internal bracing, will provide rigid temporary support of excavation. Underpinning (added foundation systems) may be used to support the adjacent structures; however, such determination will be made during detailed design when foundations for existing structures are investigated in greater detail.

5.11 TRAFFIC

Traffic flow will be affected during the entire period of construction. Mechanisms available to control and maintain traffic at constricted intersections range from use of temporary street decking, to temporarily replacing pavement and sidewalks or traffic rerouting altogether. Decking typically contains hatches or removable panels to facilitate lowering equipment or materials down into the excavation with minimal traffic disruption.

Cross streets are typically carried through intersections on similar decked structures. Pedestrian access will typically remain open, although portions or sections of sidewalks may be closed temporarily. Where sidewalks are temporarily removed, pedestrian access will be maintained by bridges, temporary walkways, and other means. Some streets will also be temporarily closed under special circumstances, such as for deck beam and street decking installation.

6. TUNNEL CONSTRUCTION

6.1 TBM DRIVES WITH LAUNCH/RETRIEVAL SITES

Construction will be accomplished through the award of one or more major construction contracts. The work is largely linear, approximately 60 kilometers (40 miles) in length and will be divided into multiple work fronts, with 8 machines for J, 9 machines for J1, and as many as 10 for Camden Yards Station Alternative, operating simultaneously (Figure 12, Table 2, 3).

Figure 12. Proposed TBM Drives with Launch/Retrieval Sites

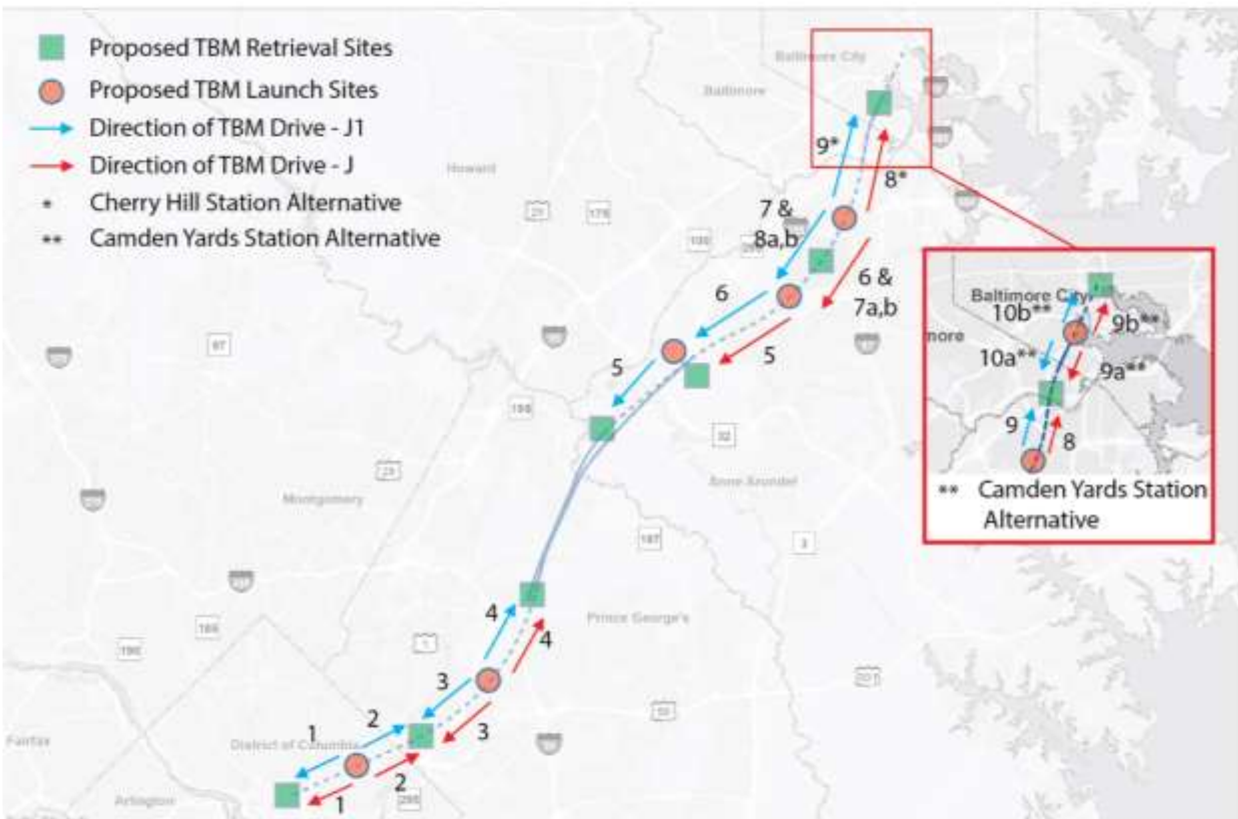


Table 2. Proposed TBM Drives for Underground Portions of Alignment Alternative J

TBM Drive Number	From		To		TBM Drive Length (km)
	Station[4]	Surface Access	Station[4]	Surface Access	
1	104+179	Shaft	101+100	MVE Station	3.079
2	104+329	Shaft	108+142	Shaft	3.813
3	113+012	Shaft	108+177	Shaft	4.835
4	113+162	Shaft	118+348	S. Portal	5.186
5	141+517	Shaft	135+175	N. Portal	6.342
6	146+395	N. Switch Box	141+667	Shaft	4.335[1]
7a	143+603	S. Switch Box	146+395	N. Switch Box	2.633[2]
7b	143+603	S. Switch Box	146+395	N. Switch Box	2.633[2]
8	146+626	N. Switch Box	152+820	Cherry Hill Portal	6.194[3]
Camden Yards Station Alternative					
8-Alt	196+538	N. Switch Box	200+990	Shaft	4.452
9a	204+970	MOW Switch Box	201+025	Shaft	3.945
9b	205+199	MOW Switch Box	206+958	Camden Yards Station	1.759[3]

[1] TBM run using a 15 m diameter TBM for the center express tunnel at BWI and from the South Switch Box to the FA/EE at 141+667

[2] TBM runs using a 16.5 m diameter TBM for two outer Platform tunnels for local BWI trains. Two runs (7a, 7b), each from S. Switch Box to the N. Switch Box, or vice versa, with walk-through of station. Distance shown excludes anticipated length of station box.

[3] For total length of tunneling see Table 12.

[4] Stations represent ends of the shafts where tunnel breakthrough would occur.

Table 3. Proposed TBM Drives for Underground Portions of Alignment Alternative J1

TBM Drive Number	From		To		TBM Drive Length (km)
	Station[4]	Surface Access	Station[4]	Surface Access	
1	104+175	Shaft	101+100	MVE Station	3.075
2	104+325	Shaft	108+137	Shaft	3.812
3	113+037	Shaft	108+172	Shaft	4.865
4	113+187	Shaft	118+061	S. Portal	4.874
5	134+452	Shaft	128+696	N. Portal	5.756
6	141+553	Shaft	134+602	Shaft	6.951
7	146+431	N. Switch Box	141+703	Shaft	4.335[1]
8a	143+639	S. Switch Box	146+431	N. Switch Box	2.633[2]
8b	143+639	S. Switch Box	146+431	N. Switch Box	2.633[2]
9	146+662	N. Switch Box	152+856	Cherry Hill Portal	6.194[3]
Camden Yards Station Alternative					
9-Alt	196+538	N. Switch Box	200+990	Shaft	4.452
10a	204+970	MOW Switch Box	201+025	Shaft	3.945
10b	205+199	MOW Switch Box	206+958	Camden Yards Station	1.759[3]

[1] TBM run using a 15 m diameter TBM for the center express tunnel at BWI and from the South Switch Box to the FA/EE at 141+667

[2] TBM runs using a 16.5 m diameter TBM for two outer Platform tunnels for local BWI trains. Two runs (8a, 8b), each from S. Switch Box to the N. Switch Box, or vice versa, with walk-through of station. Distance shown excludes anticipated length of station box.

[3] For total length of tunneling see Table 12.

[4] Stations represent ends of the shafts where tunnel breakthrough would occur.

6.2 TBM LAUNCH/RETRIEVAL SITES STAGING AREA

Construction staging areas will be necessary for tunnel construction, similar to what is required for stations and ancillary facilities. Space will be needed for assembly, launch, operation, and retrieval of TBMs. Work zones to support tunnel excavation operations will include areas for processing and removing tunnel spoils, handling precast concrete tunnel-lining segments, and housing tunnel utilities (such as ventilation, water supply, wastewater removal, power supply, etc.).

The launch points of TBMs require a sizeable staging area with a launch shaft excavated to below the depth of the tunnel invert. The TBM will be partially assembled on the surface and lowered into the hole for complete assembly prior to launch. In addition to the cutter head, substantial trailing equipment is necessary to support the operation of the machine, including building of the tunnel lining with precast segments and conveyance of the spoils, or muck, out of the tunnel.

Excluding the launch shaft itself, the laydown area will require a minimum of 1.6 to 2 hectares (4 to 5 acres) to allow for segment storage, TBM laydown and staging, generators, machine shops/workshops, construction personnel parking, construction offices, equipment storage, and tunnel muck storage. Where two TBMs are planned to be launched at one site, a laydown area on the order of 2.8 to 3.2 hectare (7 to 8 acres) minimum is preferable. Retrieval shafts and associated laydown areas will be significantly smaller, with shaft dimensions on the order of 35 meters (115 feet) length, by 35 meters (115 feet) width, and associated laydown area of 0.8 to 1.2 hectare (2 to 3 acres). Laydown areas for retrieval shafts require sufficient space to allow for installation of Support of Excavation (SOE) which in the case of slurry wall construction includes assembly of large rebar reinforcement cages. Estimated shaft dimensions with total anticipated laydown area size are summarized in Tables 4 and 5 below (including dimensions for station boxes, portals, and switch caverns). Note, any space demarcated for future construction (i.e. substations, etc.) will be used as laydown for tunneling operations prior to the need for construction of said structures/facilities. Such additional construction areas are included in the estimated laydown areas noted in Tables 4 and 5 below.

Table 4. Alignment Alternative J Launch/Retrieval Laydown Areas

TBM Launch/Retrieval Sites[4]	Shaft/Box Dimensions (L x W x H) (ft)	Estimated Laydown Area Size (Acres)
Station 101+100 - Retrieve	Washington, D.C. MVE Station[2]	-
Station 104+267 - Launch	500 x 100 x 205[1]	17
Station 108+160 - Retrieve	115 x 115 x 150	3
Station 113+102 - Launch	500 x 100 x 302[1]	16
Station 118+348 - Retrieve	South Portal[2]	-
Station 135+175 - Retrieve	North Portal[2]	-
Station 140+281 – FA/EE Location Alt.	115 x 115 x 186	3.5
Station 141+601 – Launch/Retrieve	500 x 100 x 201[1]	12
Station 143+576 – Launch/Retrieve	S. BWI Switch Box[2]	15.5

TBM Launch/Retrieval Sites[4]	Shaft/Box Dimensions (L x W x H) (ft)	Estimated Laydown Area Size (Acres)
Station 146+481 – Launch/Retrieve	N. BWI Switch Box[2]	10
Station 151+097 – FA/EE Location	115 x 115 x 181	6
Station 152+820 – Retrieve	Cherry Hill Portal[2]	-
Camden Yards Station Alternative		
Station 205+034 – Launch	MOW Switch Box[3]	15
Station 206+958 - Retrieve	Camden Yards Station[2,3]	-

[1] Section of box width must be 35 m wide across a 35 m length to allow for FA/EE construction and required dimensions
[2] Please see respective sections for discussions of Portals and Station Boxes. Retrieval will use viaduct and portal construction laydown.
[3] Camden Yards Station Alternative. Camden Yards Station alignment alternative has separate alignment stationing
[4] Stationing indicates approximate center point of FA/EE facilities, not the launch/retrieval shaft

Table 5. Alignment Alternative J1 Launch/Retrieval Laydown Areas

TBM Launch/Retrieval Sites[4]	Shaft/Box Dimensions (L x W x H) (ft)	Estimated Laydown Area Size (Acres)
Station 101+100 - Retrieve	Washington, D.C. MVE Station[2]	-
Station 104+263 - Launch	500 x 100 x 165[1]	17
Station 108+154 - Retrieve	115 x 115 x 146	3
Station 113+100 - Launch	500 x 100 x 265[1]	18.25
Station 118+061 - Retrieve	South Portal[2]	-
Station 128+696 – Retrieve	North Portal[2]	-
Station 134+482 – Launch	500 x 100 x 140	6.8
Station 140+318 – FA/EE Location Alt.	115 x 115 x 150	3.5
Station 141+638 – Launch/Retrieve	500 x 100 x 175[1]	12
Station 143+612 – Launch/Retrieve	S. BWI Switch Box[2]	15.5
Station 146+517 – Launch/Retrieve	N. BWI Switch Box[2]	10
Station 151+133 – FA/EE Location	115 x 115 x 175	6.3
Station 152+856 – Retrieve	Cherry Hill Portal[2]	-

TBM Launch/Retrieval Sites[4]	Shaft/Box Dimensions (L x W x H) (ft)	Estimated Laydown Area Size (Acres)
Camden Yards Station Alternative		
Station 205+034 – Launch	MOW Switch Box[3]	15
Station 206+958 - Retrieve	Camden Yards Station[2,3]	-

[1]Section of box width must be 35 m wide across a 35 m length to allow for FA/EE construction and required dimensions
[2] Please see respective sections for discussions of Portals and Station Boxes.
[3]Camden Yards Station Alternative; Camden alignment alternative has separate alignment stationing
[4] Stationing indicates approximate center point of FA/EE facilities, not the launch/retrieval shaft

FA/EE sites are generally required at approximately every 5km (though a maximum spacing of 6 km is possible) and will serve as TBM launch/retrieval sites to minimize disruption and streamline construction. The launch sites will be used for stockpiling the spoils excavated from the tunnel by the TBM. The site spacing allows for efficient storage and transport of the spoils to the areas designated for disposal.

The equipment anticipated to construct the launch site will include gantry or boom crane(s), excavator(s), bulldozer(s), pile driver(s), dump trucks, pay loaders, rock drills, sheet pile vibrators/hammers, and/or slurry wall excavator, slurry plant/grouting plant, generators, and concrete trucks. Additional equipment will be necessary to construct the FA/EE when the TBMs are removed. Tables 6 and 7 show the locations of launch/retrieval shafts with estimated duration of shaft construction (Slurry wall construction and shaft excavation and support), hours of operation, and trip generation for trucks and workers for alternatives J and J1, respectively.

TBM components will be delivered to the tunnel staging sites by truck. Several oversize deliveries will be required, some during nights and weekends. However, these large component deliveries are limited to the initial setup and removal period for the TBM, and the TBM parts are designed to limit weight as well as space limitations that may be imposed on deliveries. TBM manufacturers coordinate with the contractors for such restrictions and needs. New access roads to the laydown areas will maintain a grade less than approximately 14% with a crushed stone base, if not currently paved, to permit construction truck traffic to and from the sites including TBM deliveries, spoils removal, and general material/concrete deliveries.

Table 6. Alignment Alternative J FA/EE Shaft Launch/Retrieval Site Construction[1]

TBM Launch/Retrieval Sites[4]	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 104+267 – Launch[2]	15	24-hours per day	130	125
Station 108+160 - Retrieve	12	24-hours per day	35	50
Station 113+102 - Launch	18	24-hours per day	160	125

TBM Launch/Retrieval Sites[4]	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 140+281 – Alt. FA/EE Site[3]	12	24-hours per day	40	50
Station 141+601 – Launch	15	24-hours per day	125	125
Station 151+097 – Retrieval	12	24-hours per day	40	50

[1]For Stations, Switch Boxes, and Portals, please see respective sections
[2]Adjacent to rail line – Potential to use rail line for muck removal
[3]Dimensions of retrieval shaft assumed at this time (35 m x 35 m)
[4] Stationing indicates approximate center point of FA/EE facilities, not the launch/retrieval shaft

Table 7. Alignment Alternative J1 FA/EE Shaft Launch/Retrieval Site Construction[1]

TBM Launch/Retrieval Sites[4]	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 104+263 – Launch[2]	15	24-hours per day	105	125
Station 108+154 - Retrieve	12	24-hours per day	35	50
Station 113+100 - Launch	18	24-hours per day	140	125
Station 134+482 – Launch	15	24-hours per day	90	125
Station 140+318 – Alt. FA/EE Site[3]	12	24-hours per day	35	50
Station 141+638 – Launch	15	24-hours per day	110	125
Station 151+133 – Retrieval	12	24-hours per day	40	50

[1]For Stations, Switch Boxes, and Portals, please see respective sections
[2]Adjacent to rail line – Potential to use rail line for muck removal
[3]Dimensions of retrieval shaft assumed at this time (35 m x 35 m)
[4] Stationing indicates approximate center point of FA/EE facilities, not the launch/retrieval shaft

6.3 TUNNEL MINING

Alignment alternatives J and J1 include approximately 39.05 kilometers (24.26 miles) and 45.16 kilometers (28.06 miles) of tunnels, respectively, with an additional ~3.97 km (2.47 miles) of additional tunnels for the Camden Yards Station alternative. Tunneling will be performed using TBMs with minimal surface impacts except at TBM launch and retrieval sites. Tunnel construction consists of a variety of activities. These include TBM procurement and mobilization, preparation of the work area and assembly of the machine and its components, and tunnel excavation. Tunnel excavation will take approximately 7 months for 1.6 kilometers (1 mile) length at an assumed advance rate of 9.15 meters (30 feet) per day, but varies, depending on the ground conditions encountered, site and work area constraints, and the number of TBMs used. The TBM drives are anticipated to encounter:

- Soft ground along most of the drive, with potential stretches where bedrock may be encountered, depending on station alternative selected in Baltimore, MD.
- High groundwater levels
- Portions under urban areas and major roadways

Considering the soil types and groundwater conditions expected along the tunnel sections, which will require active-face support, a closed-face TBM will be required. Based on the available preliminary information on the geological and hydrogeological conditions and the critical impact of groundwater to the tunneling activities, use of an Earth Pressure Balance Machine (EPBM) or slurry TBM is considered at this stage to be the most appropriate for the anticipated subsurface conditions. Alternatively, a Mix Shield TBM could be used if the final profile includes mixed-face conditions or hard bedrock stretches, which may be encountered in the vicinity of the Washington, D.C. Station, the middle of the alignment where it swings back west, or the Camden Yards Station alternative.

TBM tunnels in soft ground are typically supported by precast segments, which are installed behind the cutter head as the excavation progresses, producing a continuous lining along the tunnel length with a circular, uniform geometry. Additionally, the annulus between the installed lining segments and excavated ground is grouted. Segmental linings are equipped with gasketed joints to inhibit groundwater inflow to the tunnel. The lining segments will be cast remotely and shipped to the site, with sufficient segments stored on-site at all times for a pre-determined period of excavation progress.

A single large-bore TBM tunnel with an outside diameter of approximately 15 meters (~50 feet) will provide optimal advance rate performance while providing the cross-sectional area required for two guideways and emergency egress. Technology and capabilities of present-day TBMs allow for unimpeded tunneling and enhanced risk management. The alignment will be designed such that TBM tunneling will be performed under approximately one tunnel diameter of ground cover to minimize surface impact. Tunnel sections of the alignments will have no surface impacts to utilities.

The excavated materials are removed through the tunnel using conveyor belt systems or closed spoil transport pipelines. A significant effort will be required to manage muck removal for a tunnel of this size. At an estimated advance rate of 9.15 meters (30 feet) per day, soil removal totaling over 2,600 cubic yards per day is be anticipated for each TBM, weighing over 3,900 U.S. tons. This amount of muck requires removal by approximately 200-265 dump trucks per day (250-320 dump trucks per day for 16.5 m diameter TBM at BWI Airport) depending on size of trucks used (10 – 14 cu yard trucks typical; 10 cu yard trucks assumed for all calculations) (Table 8, 9).

A tunnel drive consists of a series of activities. The TBM excavation advance is typically 1.2 to 1.5 meters (4 to 5 feet) by means of hydraulic jacks, which push against the previously installed tunnel lining ring. Following a complete “push” to advance the TBM, the hydraulic jacks are retracted, and the next lining ring is installed. This process is repeated as the tunnel advances from one station to the next. When starting a tunnel drive from a shaft or station excavation, a heavy steel frame is typically erected to allow a rigid structure for the TBM to react against so that it can start to push forward. Temporary precast concrete segmental liners are erected behind the TBM, which allow for continued advancement. The initial tunnel lining segments erected within the shaft are later removed once the TBM is fully “buried” and is tunneling continuously. Following tunnel excavation, the TBMs may be retrieved. An alternative to retrieving the TBM is to dismantle the TBM underground with the shield (outer shell) left in place. Sometimes, from a traffic management standpoint, due to traffic impacts at the retrieval shaft, retrieving the TBM is less desirable than dismantling it. Such a scenario may occur when retrieving the TBM that will break through into the Mount Vernon Square East station.

The pre-cast concrete liners are fabricated off-site and delivered to the site by truck. Truck loads for segments are estimated to be 6 to 10 per day for the duration of tunneling based on an estimated overall excavation rate of 9.15 meters (30 feet) per day. Segments needed for at least several days’ production are generally stored at the work site to allow for continuous tunneling. Tunneling operations are typically continuous, 6 days per week (25 days month) assumed herein for calculations, and typically consist of three 8-hour shifts per day based on schedule and working time restrictions.

The equipment required to support TBM operation will include gantry/boom cranes, erectors for positioning lining segments, excavators, dump trucks and pay loaders. Additionally, a substation and electrical grid connection or generators for the TBM operation will be required as well as a grouting plant for grouting the annulus between the segmental lining and soil. For slurry TBMs, a separation plant will also be required as discussed in section 6.2. Tables 8 and 9 show TBM drives with estimated durations (assuming approximately 300 working days per year), hours of operation, and trip generation for trucks and workers for alternatives J and J1, respectively.

Table 8. Alignment Alternative J Tunnel Boring

TBM Drive Number	Tunnel Boring–Alternative J	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)[1]	Est. Worker Vehicle Trips
1	Station 101+100 to Station 104+179	13.5	24-hours per day	200 – 265	150
2	Station 104+329 to Station 108+142	17	24-hours per day	200 – 265	150
3	Station 113+012 to Station 108+177	21	24-hours per day	200 – 265	150
4	Station 113+162 to Station 118+348	23	24-hours per day	200 – 265	150
5	Station 141+517 to Station 135+175	28	24-hours per day	200 – 265	150
6[2]	Station 146+395 to Station 141+667	19	24-hours per day	200 – 265	150
7a, b[3]	Station 143+603 to Station 146+395	23	24-hours per day	250 – 320	150
8	Station 146+626 to Station 152+820	27	24-hours per day	200 – 265	150
Camden Yards Station Alternative[4]					
8-Alt	Station 196+538 to Station 200+990	19.5	24-hours per day	200 – 265	150
9a	Station 204+970 to Station 201+025	17	24-hours per day	200 – 265	150
9b	Station 205+199 to Station 206+958	8	24-hours per day	200 – 265	150

[1] Provided range for 10 to 14 cu yard dump trucks
[2] TBM run using a 15 m diameter TBM for the center express tunnel at BWI and from the South Switch Box to the FA/EE at 141+667
[3] TBM runs using a 16.5 m diameter TBM for two outer Platform tunnels for local BWI trains. Est. duration shown includes both runs (7a, 7b), each from S. Switch Box to the N. Switch Box, or vice versa, with walk-through of station. Distance shown excludes anticipated length of station box.
[4] Stationing for Camden Yards Station Alternative alignment used.

Table 9. Alignment Alternative J1 Tunnel Boring

TBM Drive Number	Tunnel Boring–Alternative J	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)[1]	Est. Worker Vehicle Trips
1	Station 104+175 to Station 101+100	13.5	24-hours per day	200 – 265	150
2	Station 104+325 to Station 108+137	17	24-hours per day	200 – 265	150
3	Station 113+037 to Station 108+172	21	24-hours per day	200 – 265	150
4	Station 113+187 to Station 118+061	21	24-hours per day	200 – 265	150
5	Station 134+452 to Station 128+696	25	24-hours per day	200 – 265	150
6	Station 141+553 to Station 134+602	30.5	24-hours per day	200 – 265	150
7[2]	Station 146+431 to Station 141+703	19	24-hours per day	200 – 265	150
8a, b[3]	Station 143+639 to Station 146+431	23	24-hours per day	250 – 320	150
9	Station 146+662 to Station 152+856	27	24-hours per day	200 – 265	150
Camden Yards Station Alternative[4]					
9-Alt	Station 196+538 to Station 200+990	19.5	24-hours per day	200 – 265	150
10a	Station 204+970 to Station 201+025	17	24-hours per day	200 – 265	150
10b	Station 205+199 to Station 206+958	8	24-hours per day	200 – 265	150

[1] Provided range for 10 to 14 cu yard dump trucks
[2] TBM run using a 15 m diameter TBM for the center express tunnel at BWI and from the South Switch Box to the FA/EE at 141+667
[3] TBM runs using a 16.5 m diameter TBM for two outer Platform tunnels for local BWI trains. Est. duration shown includes both runs (7a, 7b), each from S. Switch Box to the N. Switch Box, or vice versa, with walk-through of station. Distance shown excludes anticipated length of station box.
[4] Stationing for Camden Yards Station Alternative alignment used.

6.4 MUCK QUANTITIES AND DISPOSAL

Disposal of excavated soils will require an extensive plan to be developed by the contractor. Options for disposal of the material in a useful manner include use as daily cover at local county landfills, grading for large development/re-development projects, smoothing the grade at SCMAGLEV support facility sites, etc. Estimated volumes for shafts (Table 10, 11), and tunneling (Table 12) for alignment alternatives J and J1 are shown below. These values assume a soil bulking factor of 1.25 for the volume of material.

Soils will not be dewatered and will require testing prior to disposal according to State environmental guidelines and requirements. Transportation of spoils to final destination can be via dump truck or potentially heavy rail (CSX). For total estimated spoils across all elements of the project see Section 14.0.

Table 10. Alignment Alternative J FA/EE Shafts for Launch/Retrieval

Shaft Station (Launch/Retrieve)	Shaft Dimensions (L x W x H) (ft)	Estimated Volume Spoils (yd^3)
Station 104+267 (Launch)	500 x 100 x 165	479,000
Station 108+160 (Retrieve)	115 x 115 x 146	92,000
Station 113+102 (Launch)	500 x 100 x 260	705,000
Station 140+281 (Alt. FA/EE Site)	115 x 115 x 150	114,000
Station 141+601 (Launch)	500 x 100 x 150	470,000
Station 151+097 (Retrieval)	115 x 115 x 175	111,000

[1]For Stations, Switch Boxes, and Portals, please see respective sections

Table 11. Alignment Alternative J1 FA/EE Shafts for Launch/Retrieval

Shaft Station (Launch/Retrieve)	Shaft Dimensions (L x W x H) (ft)	Estimated Volume Spoils (yd^3)
Station 104+263 (Launch)	500 x 100 x 165	386,000
Station 108+154 (Retrieve)	115 x 115 x 146	90,000
Station 113+100 (Launch)	500 x 100 x 265	618,000
Station 134+482 (Launch)	500 x 100 x 138	322,000
Station 140+318 (Alt. FA/EE Site)	115 x 115 x 150	92,000
Station 141+638 (Launch)	500 x 100 x 173	402,000
Station 151+133 - Retrieval	115 x 115 x 175	107,000

[1]For Stations, Switch Boxes, and Portals, please see respective sections

Table 12. Estimated Volume Spoils of Tunneling for Alignment Alternatives

Station Alternative	Tunneling Length (km)	Estimated Total Volume Spoils (yd^3)
ALIGNMENT ALTERNATIVE: J		
Mount Vernon Square East to Cherry Hill	39.05	11,605,000
Mount Vernon Square East to Camden Yards	43.01	12,750,000
ALIGNMENT ALTERNATIVE: J1		
Mount Vernon Square East to Cherry Hill	45.13	13,360,000
Mount Vernon Square East to Camden Yards	49.10	14,505,000

7. VIADUCT CONSTRUCTION

7.1 OVERVIEW

Alignment alternatives J and J1 consist of approximately 14.2 kilometers (8.8 miles) and 7.6 kilometers (4.8 miles) of elevated viaduct, respectively. The Alternative J alignment follows the BW Parkway along the east side through federal lands including the PRR, Fort Meade, and the USDA BARC. The viaduct will run through open and forested lands adjacent to the BW Parkway. Both alternatives cross wetlands for part of the route and have existing residences approximately 25 meters (80 feet) from the right-of-way line for Alt J and 20 meters (65 feet) for Alt J1.

A single viaduct structure approximately 14-meters (46-feet) wide will carry two guideways. The structure will be built with precast concrete superstructure elements supported on precast concrete hammerhead piers with drilled shaft foundations. Concrete straddle bents will be required at some existing roadway and waterway crossings. The typical span of the viaduct structure will be approximately 38 meters (125 feet). Longer spans of approximately 50 meters (165 feet) will be used at locations where the alignment crosses waterway features or existing infrastructure.

Elevated viaduct portions of alternatives J and J1 alignments cross over several existing roadways. The SCMAGLEV viaduct will span over the roadways with a minimum under clearance of approximately 7.62 meters (25 feet) measured to the underside of the viaduct girder. The profile grade line (guideway level) will be 10 meters above the ground. A minimum lateral clearance of 16 meters (52.5 feet) from edge of the travel lane of an existing roadway to the pier columns will be maintained where possible. At locations where the minimum lateral clearance cannot be achieved, the viaduct pier columns will be protected with concrete barriers.

Impacts to the existing roadways will generally be limited to viaduct piers constructed in the existing roadway medians and construction of roadway barriers to protect pier columns adjacent to the existing roadways. Temporary disruptions to traffic, or lane shifting or closures, may be required during the construction of the substructure and the erection of the superstructure at spans over roadways, and for conveyance of material and equipment.

Both alignment alternatives, J and J1, cross wetlands and rivers/creeks at various locations. Span arrangements are selected to minimize impacts.

Elevated viaduct ramp structures are also proposed for the Trainset Maintenance Facilities (TMF) connecting them to the mainline viaduct. Similar to the mainline viaduct structure, precast concrete superstructure supported on precast or cast-in-place concrete piers with drilled shaft foundations are proposed for the ramps.

The ramps for the BARC West TMF alternative connecting to mainline alternative J will require crossing over the BW Parkway and construction in the BW Parkway median. Similarly, the BARC Airstrip and MD 198 TMF alternatives will require ramps crossing the BW Parkway to connect to mainline alternative J1.

7.2 SUBSTRUCTURE

The substructure can be constructed utilizing a combination of conventional and precast construction methods. Based on the predominant soil type and rock elevation within the project limits, drilled shafts are considered the most feasible foundation type. Alternatives of two 3.05 meters (10 feet) shafts, four 1.52 meters (5 feet) shafts, and four 1.83 meters (6 feet) shafts per bent with cast in place pile cap are considered viable. The pier bent columns could be constructed using cast-in-place construction, however the use of precast construction methods is recommended to reduce construction duration. The pier bent columns could be constructed with precast segments, post-tensioned with the pile caps.

The equipment anticipated to construct the foundation, footings and piers for the viaduct structure will include drill rigs, cranes, excavators, dump trucks, pay loaders, bulldozers, rock drills, sheet pile vibrators/hammers, flatbed delivery trucks, concrete trucks, concrete pump trucks, and general construction vehicles.

7.3 SUPERSTRUCTURE

Various methods of construction were evaluated for the superstructure of the elevated viaduct, including Span-by-Span Method (Figure 13), Balanced Cantilever Method (Figure 14), Incremental Launching Method, Full-Span Precast Launching Method (Figure 15), Movable Scaffolding System and conventional Cast-in-Place construction.

Span-by-Span construction for the segmental precast superstructure is considered the most feasible for the proposed span lengths and accessibility to the site.

Balanced Cantilever construction can be used for longer spans for the river and major roadway/interchange crossings; however post-tensioning is required to be performed with each installed segment, which will increase the construction duration.

Incremental Launching Method is not commonly used in the United States and is not considered cost effective for this project site due to requirements of specialized construction equipment and contractor knowledge and experience.

Full-Spans Precast Launching Method will require bigger gantry systems which will add to the project cost; also transporting full span precast superstructure units to the site is not feasible.

Construction with Cast-in-Place concrete superstructure, using construction methods such as the Movable Scaffolding System and conventional forming, is not recommended due to the extensive construction duration.

All of these methods will be reviewed in detail during final design and discussion with contractors. Assuming Span-by-Span construction, precast bridge superstructure segments of a width of 3.17 meters (10.5 feet) will be delivered to the laydown areas on flatbed trucks from one or more precast plants. Precast elements will be transported from the laydown yard to the active work front for installation using trucks and launching gantries mounted on completed viaduct sections.

Figure 13. Span-by-Span Construction Method, Evans Crary Bridge (Courtesy of ASBI)

Figure 14. Balanced Cantilever Construction Method (Courtesy of WSP/Pace)

Figure 15. Full Span Launching Construction Method (Courtesy of SHCG)

7.4 CONSTRUCTION LOGISTICS

For schedule optimization, the elevated viaduct is proposed to be constructed in approximate 2,500 meters (8,200 feet) sections so that some of the major construction activities can be synchronized. One or more contractors will be responsible for building the viaduct structure. Close coordination between crews working in each section and conveyance of material and equipment across sections will be undertaken.

The right-of-way width for the viaduct sections is 22 meters (70 feet). An additional width of 6 meters (20 feet) will be provided for temporary use during construction. A construction access road will be provided on each side of the piers for the conveyance of material and equipment from the local road access points and between the construction sections.

Figure 16. Laydown/Storage Areas (Courtesy of WSP/Pace)

Topsoil/organic material will be stripped and removed prior to construction and disposed offsite. The excavated subsoil from the viaduct foundation can be partially reused within the right of way for grading. The ground within the ROW will need to be stabilized and compacted for the construction equipment and drill rigs to be transported to each substructure unit. Barges and or temporary bridges may be needed to cross water bodies. Stockpiling of spoils, material, and equipment adjacent to the structure pier bents is generally prohibited.

For the J Alignment three work fronts are anticipated, each with access via local roads to an offsite laydown yard of approximately 105 meters by 175 meters (340 feet by 570 feet), or 1.8-hectare (4.4 acres), having a storage capacity of at least a quarter of each 2,500 meters (8,200 feet) construction section.

For the J1 Alignment two work fronts are anticipated, each with access via local roads to a laydown yard of similar area and storage capacity as the J Alignment. Areas for storage/laydown, and potentially segment casting, will be provided for the precast superstructure segments before being trucked to the project site for erection, similar to Figure 16. The following laydown area locations have been identified:

1. Suburban Airport at the project site, Figure 17.
2. Undeveloped commercial land owned by Konterra Associates LLC at I-95/MD Route 200 interchange about 4.8 kilometers (3 miles) west of project site, Figure 18.
3. The open lot/remains of the former Landover Mall owned by Landover Mall LTD Partnership on Brightseat Road at the I-495/MD Route 202 interchange near University of Maryland College campus in Glenarden about 11.3 kilometers (7 miles) south of project site, Figure 19.

These potential storage/laydown areas can also accommodate the storage of the precast substructure elements and other construction material and equipment. The Suburban Airport site is approximately 20.2 hectare (50 acres) and its location is a convenient storage/laydown area due to its proximity to the project site. The mid-section of the viaduct for the J1 alternative can be accessed directly from the Suburban Airport within the ROW and that of the J alternative can be accessed via Brock Bridge Road to

MD Route 197. The northern section of the viaduct can be accessed via Brock Bridge Road to MD Route 198 and MD Route 32, and the southern section can be accessed via Brock Bridge Road to MD Route 197 to local roads as illustrated in Figure 17. The Brock Bridge Road Bridge over the Patuxent River has a posted weigh limit of 5 Tons and a bridge reinforcement or replacement may be required. To avoid local bridge replacement, alternatively the Brock Bridge Road access to MD Route 198.

The undeveloped land owned by Konterra Associates LLC is accessible from I-95 and MD Route 200 and is approximately 65 hectares (160 acres). The access to the project site from the Konterra storage location can be via Contee Road to MD Route 197 towards the mid-section of the elevated viaduct, from I-95 to MD Route 32 and MD Route 198 to access the northern section and via MD Route 197 to local roads to access the southern section as shown in Figure 18.

The former Landover Mall lot is approximately 16.2 hectare (40 acres) and is accessible from I-95 and MD Route 202 (Figure 19). Access to the project site can be via I-95 to MD Route 201 to Powder Mill Road and Beaver Dam Road to the southern. Other routes to access the northern portion of the viaduct from this site can be as indicated for the Konterra storage location.

In addition, smaller construction access and laydown yards will be provided along each alignment for use by the contractors. They are shown on the DEIS drawings, and range in size from 2 acres to 10 acres.

The laydown areas for J alignment include:

- 200 meters by 80 meters open land near Powder Mill Road at STA 122+00
- 200 meters by 90 meters Harley Davidson site at STA 124+500
- 300 meters by 200 meters site near Route 32 Interchange at STA 133+00.

Laydown areas for J1 alignment include

- the storage area at Suburban Airport site
- 200 meters by 100 meters open land near Powder Mill Road at STA 121+500

Figures 17, 18 and 19 show proposed construction access roads to viaduct work zones via local roads. See Section 15 further details on access roads. The access road information is used for preliminary planning and will be further reviewed and potentially modified during final design and in consultation with contractors.

Figure 17. Proposed Haul Routes from Suburban Airport Site

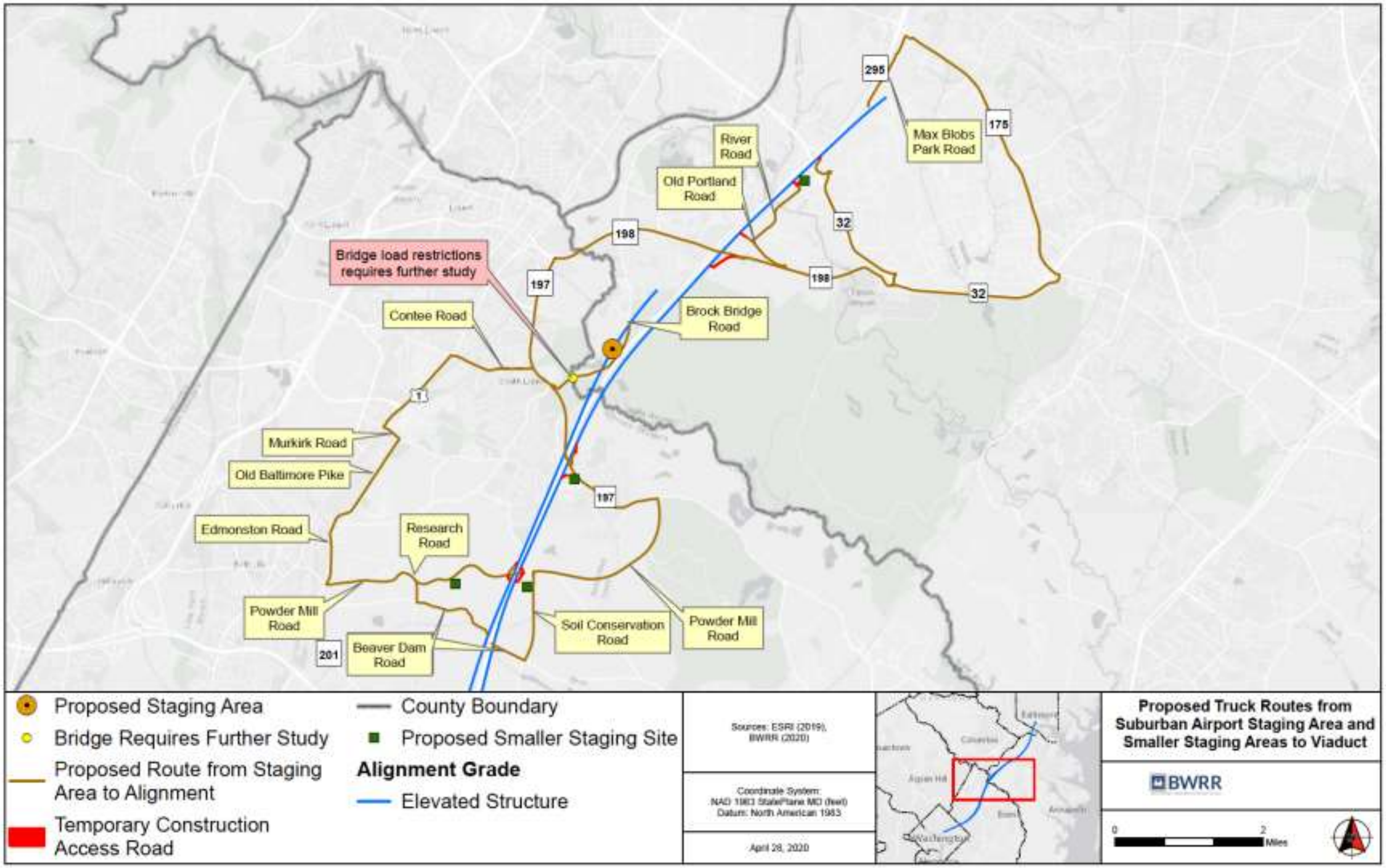


Figure 18. Proposed Haul Routes from Konterra Storage Location

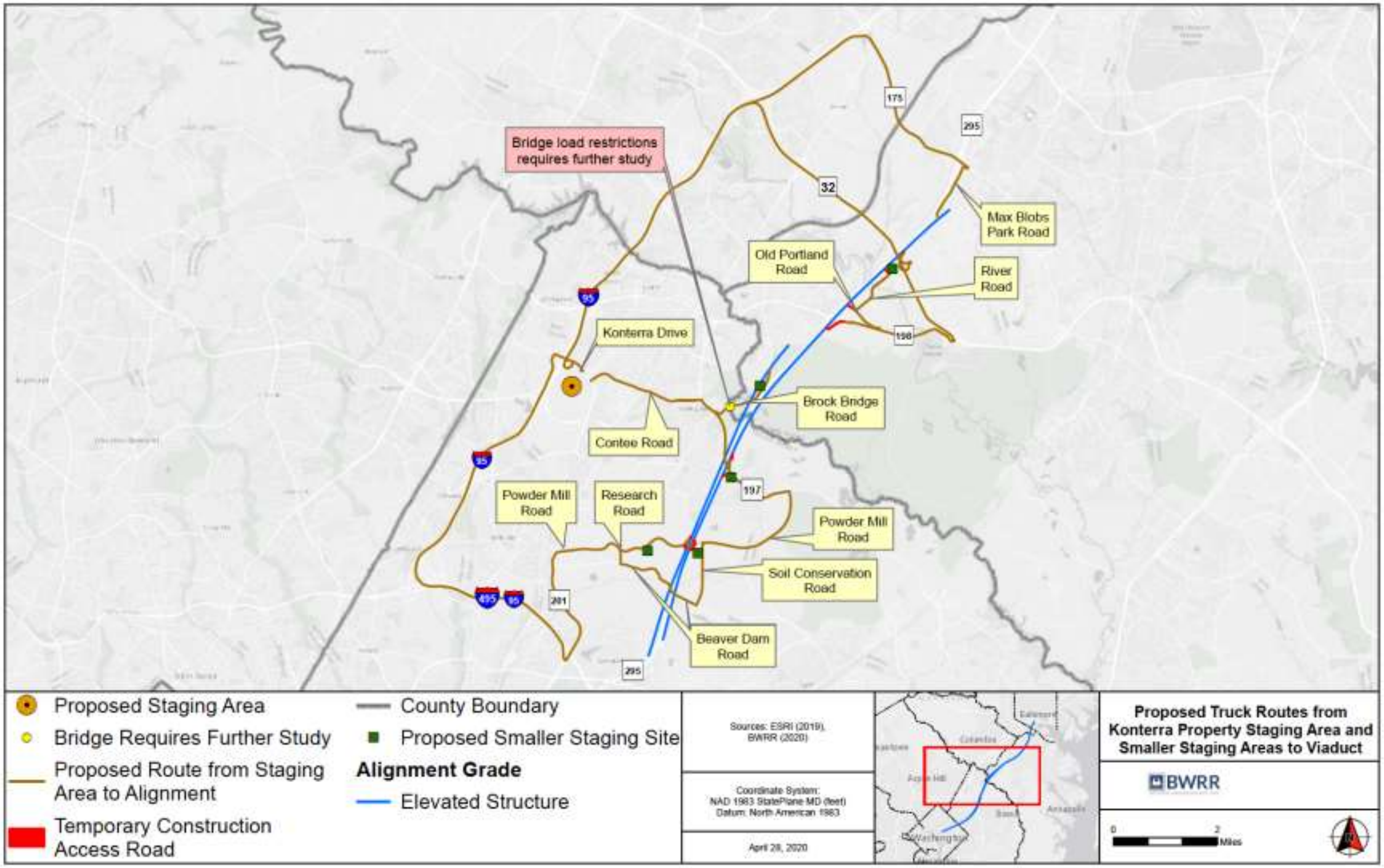
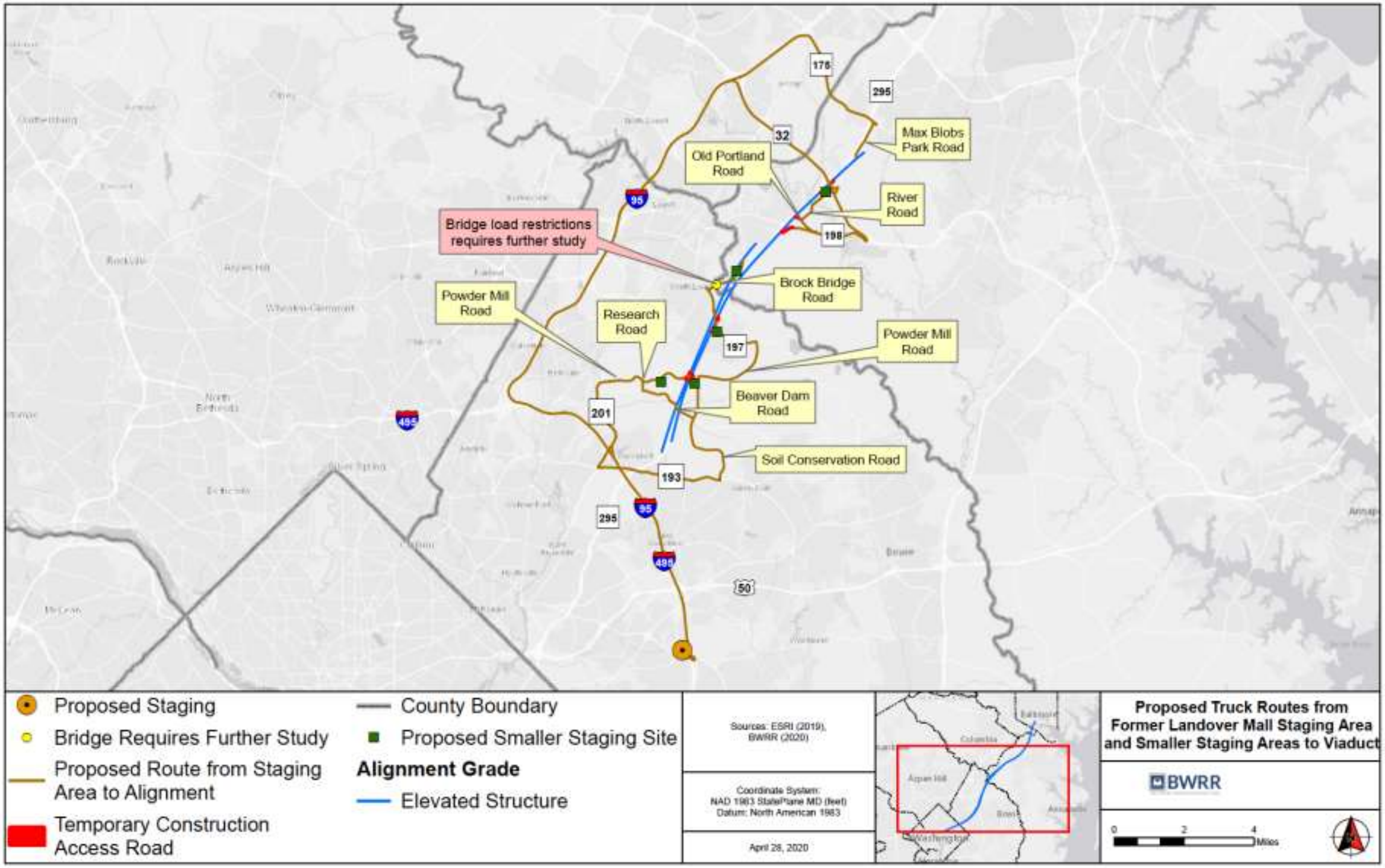


Figure 19. Proposed Haul Routes from Former Landover Mall



7.5 CONSTRUCTION DURATION

The construction of the substructure including drilled shafts, footings and hammerhead bents is estimated to be performed with four (4) crews and that of straddle bents with two (2) crews. For both Alignment Alternatives, the substructure for the all sections of the viaduct can be constructed in parallel with an estimated construction duration of 26 months per section. For each pier, a production rate of 1 week for the drilled shafts, 2 weeks for the footing, 1.5 weeks for the hammerhead bent and 2 weeks for a straddle bent is estimated.

Using precast segmental Span-by-Span construction, 38 meters (125 feet) to 50 meters (165 feet) spans are estimated to be erected at a rate of one span per day and fully constructed at a rate of three spans per week including post-tensioning, grouting and closure pours. Three gantries may be used to erect the superstructure for the J Alignment and two gantries for the J1 Alignment utilizing one gantry per two construction sections. A construction duration of 8 months per 2,500 meters (8,202 feet) section of the superstructure is estimated. Tables 13 and 14 show locations of each viaduct section with total estimated durations, hours of operation, and trip generation for trucks and workers for alternatives J and J1, respectively.

Table 13. Alignment Alternative J Viaduct Construction

Elevated Viaduct Alternative J	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 120+022–Station 122+522	34	7:00 am–4:00 pm	30	60
Station 122+522–Station 125+022	34	7:00 am–4:00 pm	30	60
Station 125+022–Station 127+522	34	7:00 am–4:00 pm	30	60
Station 127+522–Station 130+022	34	7:00 am–4:00 pm	30	60
Station 130+022–Station 132+522	34	7:00 am–4:00 pm	30	60
Station 132+522–Station 134+230	28	7:00 am–4:00 pm	30	60

Table 14. Alignment Alternative J1 Viaduct Construction

Elevated Viaduct Alternative J1	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 120+194–Station 122+694	34	7:00 am–4:00 pm	30	60
Station 122+694–Station 125+194	34	7:00 am–4:00 pm	30	60
Station 125+194–Station 127+836	35	7:00 am–4:00 pm	30	60

Tables 15 and 16 show the location with total estimated durations, hours of operation, and trip generation for trucks and workers for TMF ramp construction. The MD-198 ramps for alternative J1 are longer and have complex crossings of the BW Parkway and the MD-198 interchange, which will take more time. The ramp sections are smaller than those of the mainline viaduct, however the complex geometry and proximity to the BW Parkway, local roads and other facilities is factored into the above durations.

Table 15. Alignment Alternative J TMF Ramps Construction

Elevated Viaduct Alternative J	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
BARC West				
NB Station 30+000 to Station 32+355	30	7:00 am–4:00 pm	30	60
SB Station 40+000 to Station 42+122	26	7:00 am–4:00 pm	26	52
BARC Airstrip				
NB Station 30+000 to Station 32+730	33	7:00 am–4:00 pm	14	30
SB Station 40+000 to Station 42+971	34	7:00 am–4:00 pm	30	60
MD-198				
NB Station 200+000 to Station 201+100	14	7:00 am–4:00 pm	14	30
SB Station 100+000 to Station 101+700	22	7:00 am–4:00 pm	30	60

Table 16. Alignment Alternative J1 TMF Ramps Construction

Elevated Viaduct Alternative J1	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
BARC West				
NB Station 100+00 to Station 102+935	34	7:00 am–4:00 pm	30	60
SB Station 200+00 to Station 202+659	32	7:00 am–4:00 pm	30	60
BARC Airstrip				
NB Station 100+00 to Station 103+582	Segment 1 – 34 Segment 2 – 10	7:00 am–4:00 pm	30	60
SB Station 100+00 to Station 102+271	28	7:00 am–4:00 pm	28	60
MD-198				
NB Station 200+000 to Station 205+500	Segment 1 – 34 Segment 2 – 32	7:00 am–4:00 pm	30	60
SB Station 100+000 to Station 101+000 (joins with NB)	14	7:00 am–4:00 pm	28	60

7.6 SITE CONSTRAINTS

Various environmental constraints and restrictions at sensitive sites have been identified along the elevated viaduct structure. Both alignment alternatives run along the BW Parkway which is maintained by the National Park Service (NPS) south of its intersection with MD Route 175 (approximate Station 136+700.00 along the J alignment). No commercial or construction vehicles/trucks will be allowed on the BW Parkway, therefore the access for construction vehicles and delivery trucks for precast segments is alternatively planned for via I-95, I-495, MD Route 200, MD Route 202 and other local roads as previously identified.

Both alignment alternatives run through forested areas and parks owned by the National Park Service (NPS); other federal government land such as PRR, Fort Meade, and the USDA BARC; Maryland National Capital Park and Planning Commission (MNCPPC), and Maryland City Park. In addition, both alignment alternatives cross wetlands, floodways and rivers/creeks including the Beck Branch River, Beaverdam Creek, Patuxent River and Little Patuxent River. Disturbances to these areas will be minimized by locating material and equipment storage and laydown areas off site, reducing construction access, and by optimizing the pier locations where necessary. A reforestation plan for the impacted areas will be coordinated through the EIS as appropriate.

Construction of cofferdams will be required for the in-water pier construction and access through the adjacent properties may require temporary easements.

There are power transmission lines and distribution lines running across the proposed location of the viaduct for both alignment alternatives, J and J1. In some cases, the power lines will need to be relocated prior to viaduct construction. The power lines also may impose constraints on construction equipment and activities. Coordination with Baltimore Gas & Electric (BGE) and Potomac Electric Power Company (PEPCO) is in progress.

Monitoring of vibration and noise will be performed during the construction of the viaduct adjacent to existing structures and sensitive soils/areas, and communities. The structure will be monitored for deflection and post-tension losses and settlement during construction to satisfy strict deflection and settlement requirements for this project.

Potential areas of impact for each Alignment Alternative are provided in Tables 17 and 18.

Table 17. Alignment Alternative J – Potential Areas of Impact for the Viaduct Section

Property Name/Owner	Approximate Limits of Impact	Impact/Restrictions
Residential	Station 118+350 to Station 118+500	Noise Restrictions during Construction
National Aeronautics and Space Administration	Station 118+350 to Station 118+900	Deforestation/Reforestation; ROW impact; Temporary closure of Explorer Road during construction
United States/GSA - USDA Agricultural Land	Station 118+900 to Station 120+500	Deforestation/Reforestation; ROW impact
Beck Branch River/ Wetlands/Floodways	Station 120+000 to Station 120+200	Minimize wetland impact for Pier Construction; ROW impact
Beaverdam Creek/ Wetlands/Floodways	Station 120+400 to Station120+600	Minimize wetland impact for Pier Construction; ROW impact
Baltimore-Washington Parkway/ National Park Services (NPS)	Station 120+300 to Station 122+500	Deforestation/Reforestation; NPS maintained open and forested areas and Parkway Ramps – Access restriction
United States Secret Service James J. Rowley Training Center	Station 122+150 to Station123+050	Deforestation/Reforestation; ROW impact
Baltimore-Washington Parkway/ National Park Services (NPS)	Station 123+050 to Station126+100	Deforestation/Reforestation; NPS maintained open and forested areas and Parkway Ramps – Access restriction

Property Name/Owner	Approximate Limits of Impact	Impact/Restrictions
PEPCO High Tension Transmission Towers/Power Lines	Station 123+850 to Station123+950	Utility Relocation
Washington Sub Sanitary Comm. & Baltimore-Washington Parkway	Station 125+525 to Station126+150	ROW impact
Patuxent River/ Wetlands/Floodways	Station 125+525 to Station126+300	Minimize wetland impact for Pier Construction; ROW impact
United Stated Dept. of Interior/Patuxent Research Refuge	Station 126+150 to Station129+800	Deforestation/Reforestation; ROW impact
Baltimore-Washington Parkway/ National Park Services (NPS)	Station 127+600 to Station133+900	Deforestation/Reforestation; NPS maintained open and forested areas and Parkway Ramps – Access restriction
BGE High Tension Transmission Towers/ Power Lines	Station 129+300 to Station131+200	Utility Relocation
District of Columbia	Station 131+525 to Station 132+675	Deforestation/Reforestation; ROW impact
Little Patuxent River/ Wetlands/Floodways	Station 131+470 to Station131+950	Minimize wetland impact for Pier Construction; ROW impact
National Security Agency (NSA) - Fort Meade	Station 133+225 to Station135+250	Deforestation/Reforestation; ROW impact

Table 18. Alignment Alternative J1 – Potential Areas of Impact for the Viaduct Section

Property Name/Owner	Approximate Limits of Impact	Impact/Restrictions
City of Greenbelt Preserve	Station 118+125 to Station 118+475	Deforestation/Reforestation; ROW impact
City of Greenbelt Ballfields and Observatory	Station 118+475 to Station 118+650	ROW impact

Property Name/Owner	Approximate Limits of Impact	Impact/Restrictions
City of Greenbelt Preserve	Station 118+650 to Station 119+500	Deforestation/Reforestation; ROW impact
United States/GSA - USDA	Station 119+500 to Station 121+500	Open and forested areas – Deforestation/Reforestation; ROW impact
USA GSA/USDA Farm	Station 120+050 to Station 120+200	Open and forested areas – Deforestation/Reforestation; ROW impact
Beck Branch River & Beaverdam Creek/Wetlands/Floodways	Station 120+300 to Station 120+400	Minimize wetland impact for Pier Construction; ROW impact
USA GSA/USDA Farm	Station 120+950 to Station 121+000	Open and forested areas – Deforestation/Reforestation; ROW impact
Baltimore-Washington Parkway/ National Park Services (NPS)	Station 121+200 to Station 125+700	Deforestation/Reforestation; NPS maintained open and forested areas and Parkway Ramps – Access restriction
Residential adjacent to NPS/BW Parkway	Station 123+300 to Station123+800	Forested areas & developed residential - Deforestation/Reforestation; ROW impact
PEPCO High Tension Transmission Towers/Power Lines	Station 123+800 to Station 123+900	Utility Relocation
Residential & Park adjacent to NPS/BW Parkway	Station 123+900 to Station124+500	Open area parks/forested areas & developed residential & park - Deforestation/Reforestation; ROW impact
Commercial adjacent to NPS/BW Parkway	Station 125+500 to Station125+850	Forested areas & developed commercial - Deforestation/Reforestation; ROW impact
Maryland-National Capital Park and Planning Commission (MNCPPC)	Station 125+750 to Station125+925	Forested areas – Deforestation/Reforestation; ROW impact
Patuxent River/ Wetlands/Floodways	Station 125+500 to Station126+200	Minimize wetland impact for Pier Construction; ROW impact
Maryland City Park	Station 126+000 to Station126+500	Forested Area - Deforestation/Reforestation; ROW impact

Property Name/Owner	Approximate Limits of Impact	Impact/Restrictions
Suburban Airport	Station 126+600 to Station127+700	ROW Acquisition
Anne Arundel County Open Space	Station 127+750 to Station 128+350	Forested Area - Deforestation/Reforestation; ROW impact

8. STATION CONSTRUCTION

Alignment alternatives J and J1 include an underground station in Washington, D.C., an underground station at BWI Airport, and underground and above-ground station alternatives in Baltimore, MD. For underground stations, the preferred method of construction uses top-down techniques, where surface access can be maintained, similar to methods used for stations in the Washington Metro system. Support of excavation, typically using slurry walls, is installed around the perimeter of the station footprint; the station area is excavated from street level to the required depth in order to pour the station concrete arch roof and continue excavation under the roof until desired depth is reach and a bottom plug and base slab are constructed; and the station box is constructed. This is typically referred to as top-down, bottom-up construction. Additional support of excavation is provided by temporary cross-lot braces and/or tie backs. The top of the hole will be permanently covered as the construction work continues downward to maintain some degree of surface use. Top-down construction will be phased to minimize lane closures during construction.

Excavated material will need to be removed from the site by trucks. Coordination between the planned excavation, the location of excavation machinery, and the establishment of a route for trucks to enter and exit the site will be undertaken. While the struts bracing the slurry wall will be pre-loaded to design load, if necessary underpinning can be used for buildings in proximity to the station, depending on existing foundations, which will be investigated in greater detail during detailed design. Due to the large station width (up to approximately 31.7m, or 105 feet) in soft ground conditions tunneling techniques such as the New Austrian Tunneling Methods (NATM), also termed Sequential Excavation Methods (SEM), are not viable.

Cast-in-place concrete will be used for all below-grade construction. Below-grade portions of stations and switch boxes will be designed to resist hydrostatic lateral and uplift pressures. They will receive a waterproof membrane system around and under the concrete construction.

In Washington, D.C., the Mount Vernon Square East station will temporarily impact New York Avenue from 7th Street NW to North Capitol Street, with construction to a depth of approximately 46 to 52 meters (150 to 170 feet). This length includes construction of the cross-over cavern for trains entering and exiting the station. The construction will be primarily within soft ground conditions and bedrock at the deepest portion of the station. Station construction will also include a connection tunnel to the Washington, D.C. Convention Center that will cross 7th Street and require top-down construction. Connection of the tunnel at the Convention Center will require further coordination with the Convention Center owners.

The station box for Mount Vernon Square East Station will likely be constructed using slurry walls to provide stiff support of the excavation and prevent groundwater inflow and lowering of groundwater level, which could result in settlement of the adjacent soft ground. Construction will likely also include a ground improvement/compensation grouting program to further mitigate the potential for surface settlements during construction. Means and methods of station box construction will be at the discretion of the contractor.

The BWI Airport station will be an underground station approximately 64 meters (210 feet) deep. The existing Hourly Garage in the center of the terminal will be demolished to accommodate slurry wall braced, open-cut construction of the station. A new Ground Transportation Center (GTC) will be built above the station. The switch boxes are located towards the northern and southern edges of the BWI property, outside of airport security zones. The switchboxes will be built using open-cut construction, likely using slurry wall support of excavation.

Three TBM tunnels run between BWI Station and the north and south switchboxes. The central TBM tunnel [15 m diameter (49 ft)] will be utilized for express train traffic, while the outer two TBM tunnels [16.5 m diameter (54 ft)] will each carry a local guideway and platform through the station box. It is envisioned TBMs for the three station tunnels will be staged and launched from the north and south switchboxes, with two TBM runs required for the two local guideway and platform tunnels. Each TBM pass will require walking the TBMs through the station box, which entails construction of a special cradle for the TBMs (Figure 20a, b). For the two local TBM runs, the TBM will need to be turned around upon completing its first run and relaunched for the second run. A specialty turntable (Figure 21a) can be used to turn and reposition the TBM for the second run (Figure 21b, c), after which the trailing gear can be removed from the completed tunnel and reattached to the relocated cutter head (Figure 21d). The TBM is able to then relaunch for the second run.

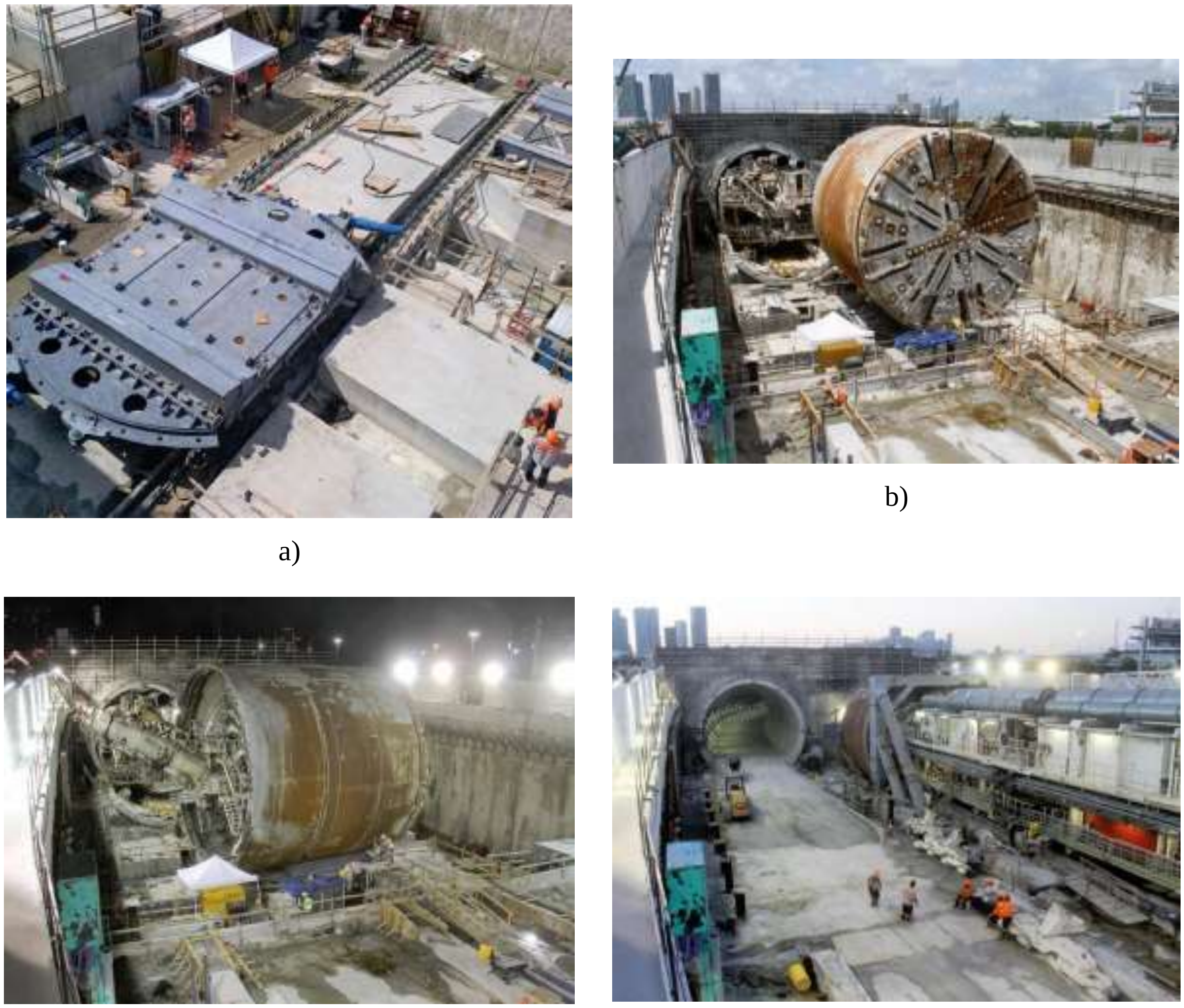
The BWI station box itself will likely be constructed using slurry walls to ensure dewatering and associated settlement does not occur and impact adjacent terminal structures. The BWI station construction will have temporary impacts on the airport terminal circulation road during construction; however, the construction traffic should be controlled such that it will not need to circulate past the terminal entrances. The station will ultimately have at least two underground entrances to airport terminals.

Figure 20. Examples of TBM cradles at a) Beacon Hill Station, Seattle, WA, and b) Automated People Mover Tunnels, Dulles International Airport, Dulles, VA.

a)

b)

Figure 21. Use of a turntable (a) to turn the TBM shield (b, c) for the Port of Miami Tunnels and reattached trailing gear (d) for TBM relaunch.



a) b) c) d)

The Baltimore Cherry Hill above-ground station alternative and approaches will be built on elevated structure. It will be constructed using conventional building materials and methods, primarily with a combination of cast-in-place concrete and structural steel. The station crosses over an existing CSX railroad track and MTA light rail station with two tracks. Precast pre-stressed concrete structural elements may be used to minimize disruptions in spanning over the active transportation infrastructure.

The station will require modifications to local roadways and pose temporary traffic disruptions during construction. The bored tunnel will emerge from the ground south of the station via a cast-in-place concrete portal structure and become elevated on a rising concrete viaduct structure. The station will be connected to a new parking garage via an elevated pedestrian bridge and vertical transportation tower. All foundations are expected to utilize deep driven pile or drilled shaft elements.

The Camden Yards SCMAGLEV station alternative in Baltimore is an underground station with a depth of up to 46 meters (150 feet) and a width between approximately 53 meters (174 ft) and over 80 meters

(263 ft) in soft ground conditions, possibly extending into bedrock, with the widest points at the main surface station entrances. The proposed station alignment does not follow the street grid and is too wide to use conventional tunneling techniques such as Sequential Excavation Method (SEM) soft ground under existing buildings. Consequently, the construction requires demolition of all buildings above the station box and switchboxes, for a length of 881 meters (2,890 ft). Buildings to be demolished include:

- Federal Reserve Bank (partial)
- Old Otterbein Church (historic)
- Convention Center (partial)
- Bank of America (full)
- US Courthouse (full)

The station construction will also impact the Martin Luther King (MLK) Boulevard viaduct, possibly requiring piers to be relocated, and will have to carefully thread below the Howard Street tunnel and the MARC train tracks along Howard Street.

Alternative station locations were considered north, south and east of the proposed location; however, no location was found that did not have similar impacts to significant residences, business and/or government facilities due to the alignment orientation that is out of line with the street grid.

The station construction will impose temporary traffic disruptions on Howard Street, MLK Boulevard, Conway Street and Pratt Street, all major thoroughfares in Baltimore.

The equipment anticipated to perform the station construction for the civil and architectural elements will include cranes, excavators, slurry wall excavators, dump trucks, pay loaders, rock drills, sheet pile vibrators/hammers, concrete trucks, generators, and concrete pump trucks. Table 19 provides estimated construction durations, hours of operation, and trip generation for trucks and workers for all station alternatives. Table 20 contains estimated volumes of excavated materials.

Table 19. Station Construction

Station Construction Alternatives J and J1	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Washington DC – MT Vernon Square East				
Civil	48	7:00 am–4:00 pm	250 - 350	150
Architectural	24	7:00 am–4:00 pm	100	100
BWI Airport				
Civil (Station Box)	42	24-hours per day	220	150
N. Switch Box	24	24-hours per day	220	50
S. Switch box	24	24-hours per day	220	50
Architectural	24	24-hours per day	50	100

Station Construction Alternatives J and J1	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Baltimore – Cherry Hill				
Civil	30	7:00 am–4:00 pm	150	50
Architectural	24	7:00 am–4:00 pm	50	100
Baltimore – Camden Yards				
Civil (Station Box)	48	7:00 am–4:00 pm	200 - 250	150
Cherry Hill MOW Switch Box	18	7:00 am–4:00 pm	100	50
Architectural	24	7:00 am–4:00 pm	100	100

Table 20. Station Spoils Quantities

Station Alternatives J and J1	Dimensions (L x W x D) (ft)	Est. Volume Spoils (yd^3)
Washington DC – MT Vernon Square East		**3,322,000**
Station Box	1745 x 104 x 150	1,272,000
Switch Box	1920 x 95 x 170	1,246,000
Main Station Access/Egress	Varies x Varies x 150	645,000
Station Egress	Varies x Varies x 160	84,000
Operational Space	Varies x Varies x 170	75,000
BWI Airport Station – Alt. J		**4,684,000**
Station Box	540 x 220 x 246	2,115,000
N. Switch Box	765 x Varies x 245	1,318,000
S. Switch Box	765 x Varies x 232	1,251,000
BWI Airport Station – Alt. J1		**3,974,000**
Station Box	540 x 220 x 200	1,898,000
N. Switch Box	765 x Varies x 187	1,008,000
S. Switch Box	765 x Varies x 198	1,068,000

Station Alternatives J and J1	Dimensions (L x W x D) (ft)	Est. Volume Spoils (yd^3)
Camden Yards Station		**2,625,000**
Cherry Hill MOW Switch Box	758 x Varies x 100	433,000
Station Box	2880 x Varies x 125	2,192,000

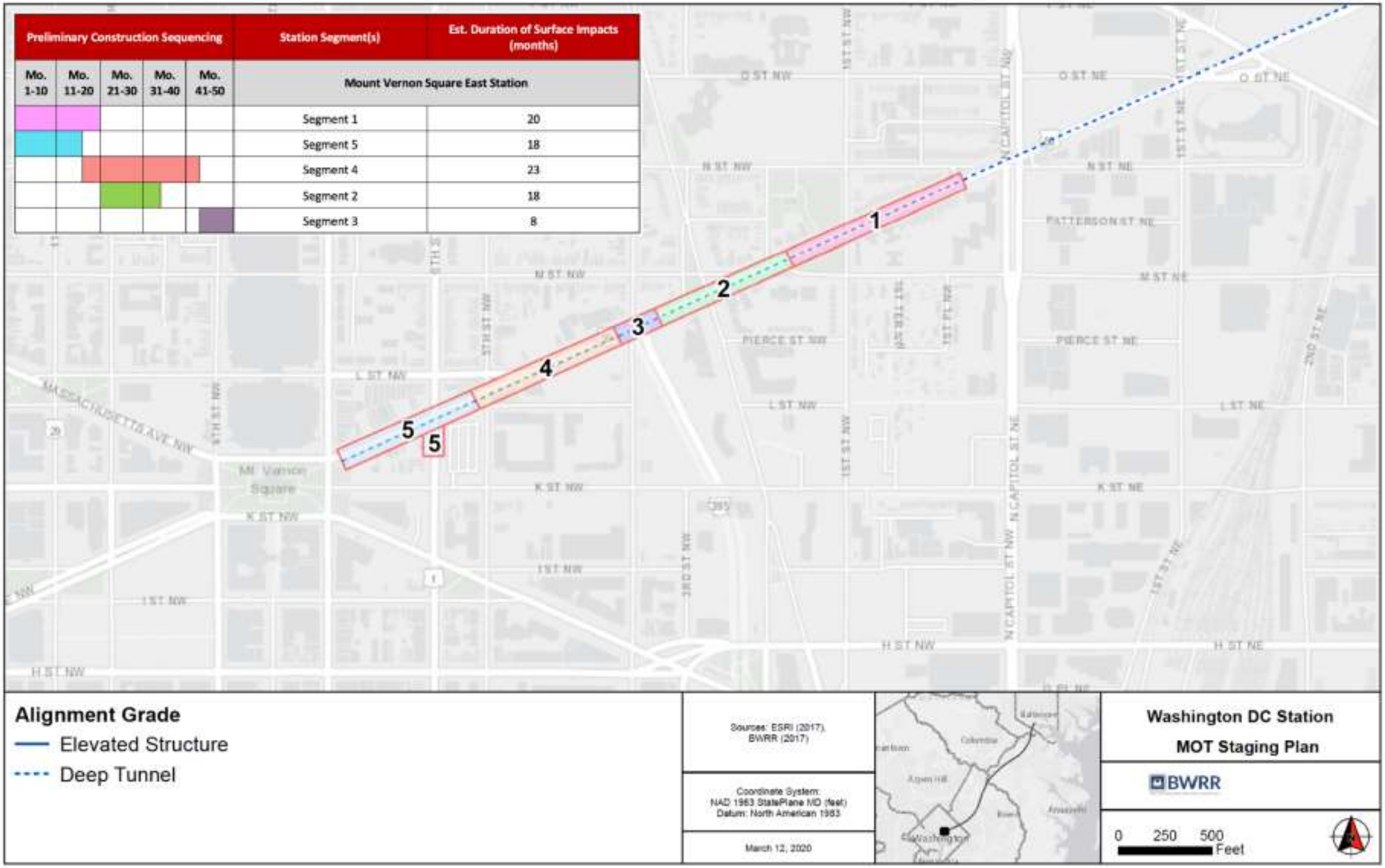
8.1 GENERAL CONSTRUCTION SEQUENCE

Station construction for Washington, D.C. as discussed above will entail multiple stages for 5 segments (Figure 22) along the station alignment. This staging allows maintenance of traffic flow throughout the construction process. A general breakdown of the anticipated duration of surface impacts for construction of the Washington, D.C. and Camden Yards station are shown in Table 21. The times presented for the Mount Vernon Square East station are estimated duration of surface impact of construction, until the permanent arch is emplaced and road surfaces and pavement restored. Excavation and construction will continue below the restored surface followed by installation of final lining and then architectural works, systems, etc. The construction sequencing in Table 21 is also preliminary and was developed with the intention to minimize traffic impact. A similar construction methodology is assumed for the Camden Yards Station to minimize the duration of surface impacts, particularly with respect to the rail service and I-395. As such, a preliminary staged construction sequence for Camden Yards (Figure 23), similar to Mount Vernon Square East station is also assumed and outlined in Table 21.

Table 21. Construction staging for Mt. Vernon Square East and Camden Yards Station alternative and estimated duration of surface impacts

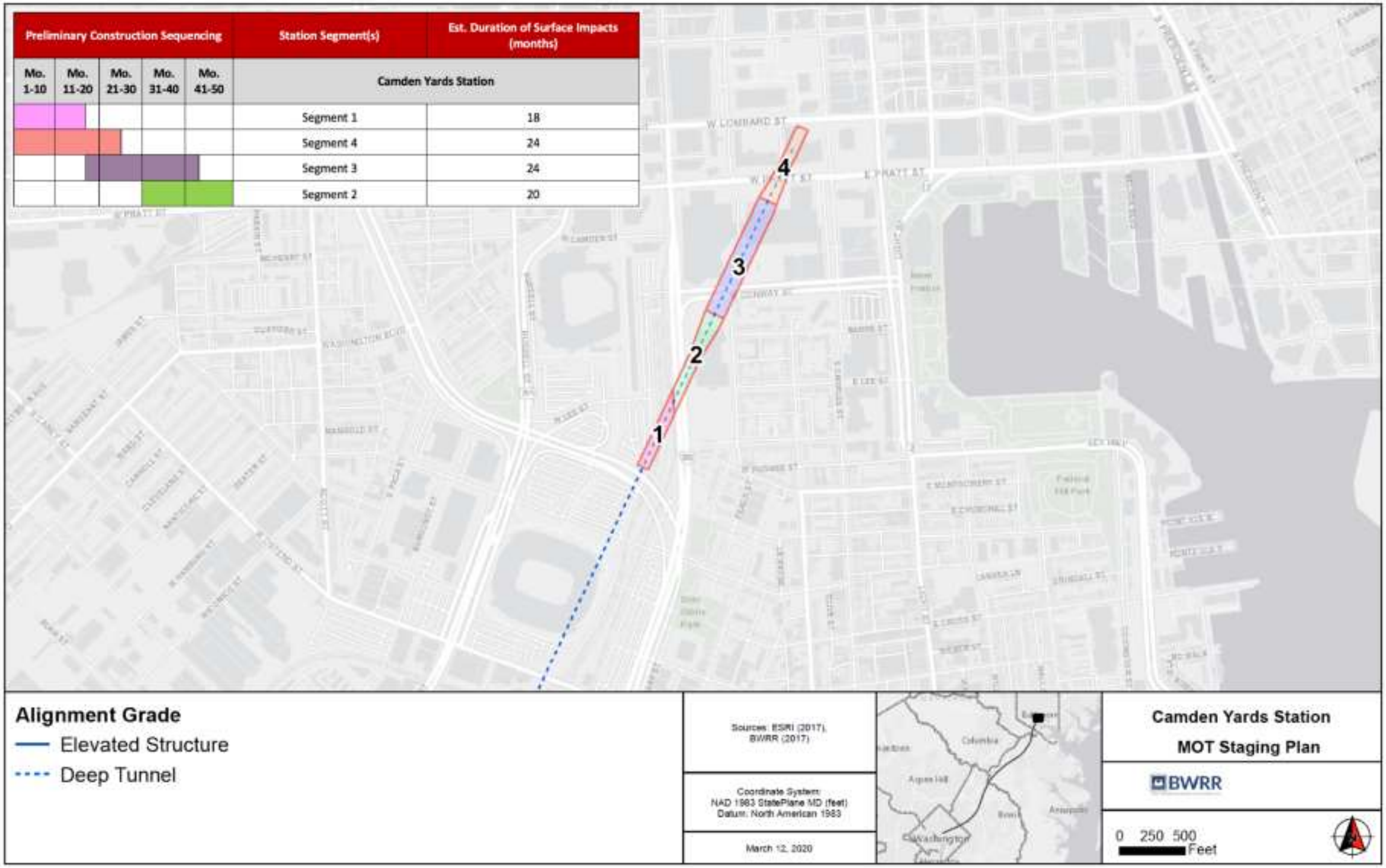
Preliminary Construction Sequencing					Station Segment(s)	Est. Duration of Surface Impacts (months)
Mo. 1-10	Mo. 11-20	Mo. 21-30	Mo. 31-40	Mo. 41-50	Mount Vernon Square East Station	
					Segment 1	20
					Segment 5	18
					Segment 4	23
					Segment 2	18
					Segment 3	8
					Camden Yards Station	
					Segment 1	18
					Segment 4	24
					Segment 3	24
					Segment 2	20

Figure 22. Construction Staging Segments for Mount Vernon Square East Station



Preliminary Construction Sequencing					Station Segment(s)	Est. Duration of Surface Impacts (months)
Mo. 1-10	Mo. 11-20	Mo. 21-30	Mo. 31-40	Mo. 41-50	Mount Vernon Square East Station	
					Segment 1	20
					Segment 5	18
					Segment 4	23
					Segment 2	18
					Segment 3	8

Figure 23. Construction Staging Segments for Camden Yards Station Alternative



Preliminary Construction Sequencing					Station Segment(s)	Est. Duration of Surface Impacts (months)
Mo. 1-10	Mo. 11-20	Mo. 21-30	Mo. 31-40	Mo. 41-50	Camden Yards Station	
					Segment 1	18
					Segment 4	24
					Segment 3	24
					Segment 2	20

9. TRANSITION PORTALS

Short sections of cut-and-cover tunneling and open cut construction will be used for the transitions between the viaduct and TBM tunnel sections and for TBM launch locations located along the deep tunnel. Implementation of cut-and-cover tunneling will require installation of support of excavation (slurry walls, bored pile walls, soldier pile and lagging, or shotcrete) depending on ground conditions and proximity to sensitive structures. Slurry walls or bored pile walls may be used at the Cherry Hill portal. Depending on the limits of disturbance, in general, tieback support or internal strutting will be used for deeper excavations. Open cut construction will be similar to cut-and-cover tunneling, without installation of a roof slab and ground restoration

The equipment anticipated to construct the transition portal will include gantry or boom cranes, excavators, dump trucks, loaders, generators, grouting plant, rock drills, sheet pile vibrators/hammers, concrete trucks, and concrete pump trucks. Tables 22 and 23 identify the locations with estimated durations, hours of operation, and trip generation for trucks and workers for alternatives J and J1, respectively. Estimated total volumes of excavated materials are presented in Tables 24 and 25.

Table 22. Alignment Alternative J Transition Portals Construction

Transition Portals Alternative J	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 118+348	27	24-hours per day	145	150
Station 135+175	16	24-hours per day	100	150
Station 152+820[1]	20	7:00 am – 4:00 pm	100	150

[1]Cherry Hill Station Alternative only

Table 23. Alignment Alternative J1 Transition Portals Construction

Transition Portals Alternative J1	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 118+061	27	24-hours per day	240	150
Station 128+696	16	24-hours per day	75	150
Station 152+856[1]	20	7:00 am – 4:00 pm	100	150

[1]Cherry Hill Station Alternative only

Table 24. Alignment Alternative J Transition Portals Spoils Quantities[1]

Transition Portal	Approximate Dimensions of SOE (L x W x D) (ft)[1]	Est. Volume Spoils (yd^3)
Station 118+348	5046 x 100 x 90	981,000
Station 135+175	1939 x 100 x 102	402,000
Station 152+820[2]	2667 x 100 x 100	480,000

[1]Dimensions are approximate and based on deepest point of the open cut.
[2]Cherry Hill Station Alternative only

Table 25. Alignment Alternative J1 Transition Portals Spoils Quantities[1]

Transition Portal	Approximate Dimensions of SOE (L x W x D) (ft)[1]	Est. Volume Spoils (yd^3)
Station 118+061	6483 x 100 x 128	1,608,000
Station 128+696	1578 x 100 x 106	294,000
Station 152+856[2]	2697 x 100 x 110	485,000

[1]Dimensions are approximate and based on deepest point of the open cut.
[2]Cherry Hill Station Alternative only

10. TRAINSET MAINTENANCE FACILITY (TMF)

The TMF will comprise buildings, guideways, and paved parking lots that will create impervious surfaces requiring retention. The TMF location connects to the main line via guideway ramps that are elevated viaduct. Stormwater retention areas will be contained within the TMF footprint.

The equipment anticipated to construct the footings and piers for the TMF's facilities, storage yards and ramps will include cranes, excavators, dump trucks, pay loaders, rock drills, caisson drill rig, sheet pile vibrators/hammers, flatbed delivery trucks, bulldozers, concrete trucks, and general construction vehicles. Precast bridge deck segments will be installed using trucks or launching gantries. Buildings and parking lots will require additional types of equipment, such as paving machines, rollers, and aerial lifts.

The MD-198 TMF site has a significant variation in existing ground elevation, dropping approximately 30 meters (100 feet) from west to east across the facility. The eastern half of the facility will be constructed on retaining walls up to 30 meters high, surmounted by 20 meter (65 foot) high maintenance shop buildings. The northeast corner of the TMF impacts the Little Patuxent River, which will have to be rerouted in a new channel to the east. The complex site conditions for the MD-198 facility will add a year to the construction duration.

Table 26 shows the estimated durations, hours of operation, trip generation for trucks and workers. Table 27 provides cut and fill quantities. A bulk factor of 1.25 has been applied to all quantities.

Table 26. TMF Alternatives Construction

Trainset Maintenance Facility Alternative	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
BARC West	78	7:00 am–4:00 pm	100	150
BARC Airstrip	78	7:00 am–4:00 pm	100	150
MD-198	90	7:00 am–4:00 pm	100	150

Table 27. TMF Alternatives Cut and Fill Quantities

All quantities are in cubic yards	Alternative J		Alternative J1	
	Cut	Fill	Cut	Fill
BARC West	1,469,000	3,197,000	3,065,000	2,341,000
BARC Airstrip	4,241,000	724,000	6,571,000	190,000
MD-198 TMF	-	16,135,000	-	16,135,000

11. SUBSTATIONS

Alignment alternatives J and J1 include 6 above ground open air substations, occupying areas ranging between approximately 2 hectares (5 acres) to 8 hectares (20 acres) each. The substation site locations are listed below:

- One substation in Washington, DC (Station 104+400)
- One substation in viaduct section (Station 124+300 for Alt J and 127+000 for Alt J1)
- One substation in Lansdowne, MD (Station 151+000)
- One substation in Baltimore (Station 155+460)
- Two smaller substations will be required at the site of the TMF Alternatives (BARC West, BARC Airstrip, MD-198)

The equipment anticipated to construct the substations will include cranes, excavators, dump trucks, pay loaders, backhoe, bulldozers, trailer, concrete trucks mixers, concrete pump, and vibrating roller. Tables 28 and 29 indicate the locations with estimated durations, hours of operation, and trip generation for trucks and workers for alternatives J and J1, respectively.

Table 28. Alignment Alternative J Substation Construction

Substation Alternative J	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 104+500	24	7:00 am–4:00 pm	6	100
Station 124+300	24	7:00 am–4:00 pm	6	100
BARC West TMF Alt. (x2)	24	7:00 am–4:00 pm	6	100
BARC Airstrip TMF Alt. (x2)	24	7:00 am–4:00 pm	6	100
MD-198 TMF (x2)	24	7:00 am–4:00 pm	6	100
Station 151+000	24	7:00 am–4:00 pm	6	100
Station 155+460	24	7:00 am–4:00 pm	6	100

Table 29. Alignment Alternative J1 Substation Construction

Substation Alternative J1	Est. Duration (Months)	Est. Operating Hours	Est. Truck Trips (per day)	Est. Worker Vehicle Trips
Station 104+500	24	7:00 am–4:00 pm	6	100
Station 127+700	24	7:00 am–4:00 pm	6	100
BARC West TMF Alt. (x2)	24	7:00 am–4:00 pm	6	100
BARC Airstrip TMF Alt. (x2)	24	7:00 am–4:00 pm	6	100
MD-198 TMF Alt. (x2)	24	7:00 am–4:00 pm	6	100
Station 151+000	24	7:00 am–4:00 pm	6	100
Station 155+460	24	7:00 am–4:00 pm	6	100

12. MAINTENANCE OF WAY (MOW) FACILITIES

Two MOW facilities are required for the project, one in the northern portion of the route and one in the southern portion of the route.

For alignment alternatives J and J1, the northern MOW facility will be located in Cherry Hill for the Cherry Hill station alternative or in Westport for the Camden Yards station alternative. The Cherry Hill MOW ramps connect to the mainline south of the Cherry Hill station. The Westport MOW requires an underground switchbox and tunnel portal to connect to the mainline.

For BARC TMF alternatives, the southern MOW facility will be co-located with the TMF facility. The MOW facility will connect to the mainline using the TMF ramps. For MD-198 TMF alternative, the southern MOW facility will be located at Station 123+300 for alternative J and at Station 122+600 for alternative J1. Both MOW facilities connect to the mainline ramps that are aerial or at grade.

Equipment, durations, hours of operation, and trip generation for trucks and workers are similar to substations in the previous section.

Cut and fill quantities for the MOW facility sites are provided in Table 30. Earthwork quantities for the MOW facilities co-located with the two BARC TMF alternatives are included in the TMF quantities in Section 10.0. A bulk factor of 1.25 has been applied to all quantities.

Table 30. MOW Facility Cut and Fill Quantities

All quantities are in cubic yards	Location	Cut	Fill
Alternative J1 MOW Facility Associated with MD-198 TMF	Station 122+600	-	165,000
Alternative J MOW Facility Associated with MD-198 TMF	Station 123+300	173,000	-
Cherry Hill MOW Facility for Cherry Hill Station Alternative	Station 153+400	120,000	280,000
Westport MOW Facility for Camden Yards Station Alternative (includes quantities for MOW ramp and associated tunnel portal and switchbox)	Station 204+500	960,000	-

13. ROADWAY RELOCATIONS

Several roads will be relocated or reprofiled as part of the project. The equipment anticipated for this work will include cranes, excavators, dump trucks, pay loaders, backhoe, bulldozers, trailer, concrete trucks mixers, concrete pump, and vibrating roller. Impacted roadways include the following:

- Explorer Road (Alternative J)
- Springfield Road (BARC Airfield TMF)
- Springfield Road (Alternative J1 southern MOW for MD-198 TMF)
- River Road (MD-198 TMF)
- West Patapsco Avenue (Cherry Hill station)
- Annapolis Road (Cherry Hill station)

Cut and fill quantities associated with roadway relocations total approximately 10,000 cubic yards of cut and 85,000 cubic yards of fill, including a 1.25 bulk factor.

14. SPOILS SUMMARY

The estimated volumes of spoils for each Alignment and Station Alternative are summarized in Table 31. A bulk factor of 1.25 has been applied. Cut and fill quantities associated with TMFs, MOW facilities and roadway relocations are not included. Those quantities are provided separately in Sections 10.0, 12.0 and 13.0.

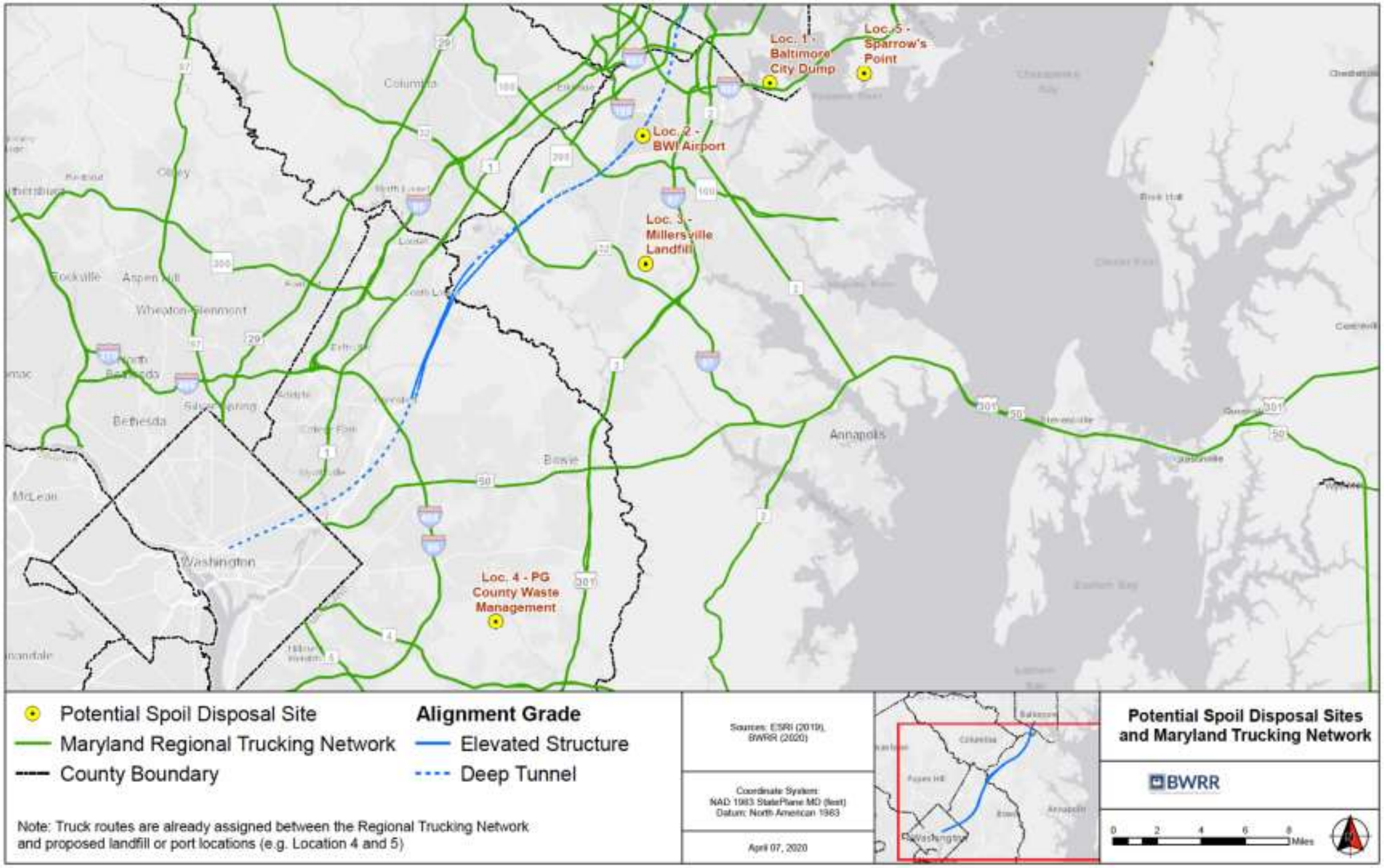
Table 31. Summary of Total Spoils for Alignment Alternatives J & J1

Alternative	Est. Volume Spoils (cubic yards)
Alignment Alternative J	
Cherry Hill Station Alternative	23,445,000
Camden Yards Station Alternative	26,735,000
Alignment Alternative J1	
Cherry Hill Station Alternative	25,060,000
Camden Yards Station Alternative	28,345,000

The volume of soils anticipated to be produced by the project will be disposed of pursuant to a coordinated plan developed during final design. Given the depth and nature of the soils, which are anticipated to be clean and undisturbed, the material can potentially be useful as daily cover for local landfills (e.g. Millersville Landfill, Baltimore City Dump, PG County Waste Management) and/or fill for local or future projects (e.g. Sparrow's Point redevelopment, BWI Airport).

Figure 24 shows the regional trucking network and how it can be used to connect the spoil site haul network to the disposal sites, minus the last 1-3 miles to the disposal sites, which should already have designated routes for trucks to follow. Additionally, Maryland Environmental Services has expressed interest in use of the excavated soils for local stabilization projects.

Figure 24. Potential Spoil Disposal Sites and Trucking Network to Deposit as Needed Throughout the Region



15. ACCESS ROADS

During construction, temporary access roads will be required along viaduct structures for the delivery of materials (Tables 32 and 33). Measures in particularly sensitive areas, such as wetlands, will be available to minimize surface disruption during viaduct construction.

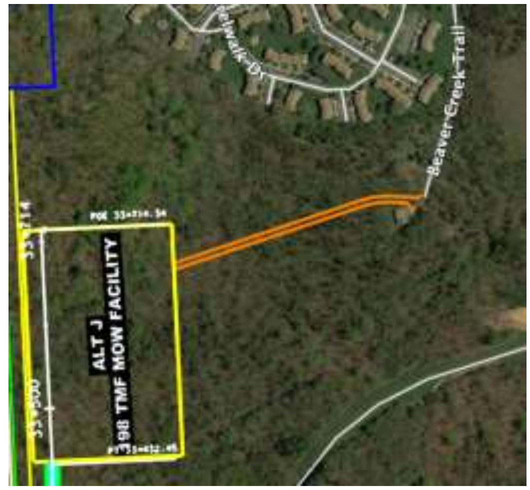
The spacing and locations of emergency access stairs from the viaduct section will be coordinated with the FRA Office of Safety and local emergency response providers. Stairs will be located adjacent to existing roadways or in otherwise accessible areas to avoid construction of new roadways.

Table 32. Alignment Alternative J Access Roads Construction

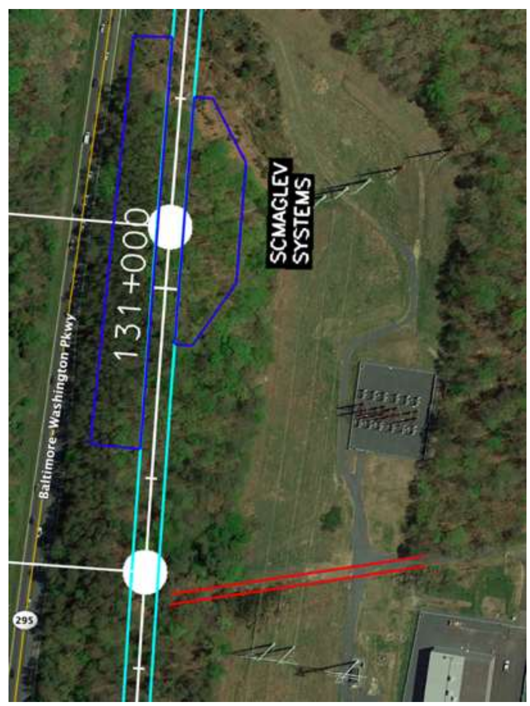
Facility	Approximate Station	Road Access	
MVE Station		Existing roads	
FA/EE	104+300	Existing roads (Adams Place NE)	
FA/EE	108+100	Existing roads (Kenilworth Avenue)	

Facility	Approximate Station	Road Access	
FA/EE	113+100	New access road from Riverdale Rd.	
South Portal	118+500	New roadway along alignment corridor from Beaver Dam Road from Soil Conservation Road	
BARC West		New access roads from Odell Road and relocation of Odell Rd.	

Facility	Approximate Station	Road Access	
BARC West		New access roads from Powder Mill Road	
BARC Airstrip		New access roads from Springfield Road	
Viaduct	121+900	New access roads from Powder Mill Road and Soil Conservation Rd.	

Facility	Approximate Station	Road Access	
MD-198 TMF MOW Facility	33+714	New access road from Beaver Creek Trail	
Substation	124+200	New access road from 295 off-ramp	

Facility	Approximate Station	Road Access	
Viaduct Access Road	125+000	New access road from Canadian Way	
Viaduct Access Road	130+000	New access road from commercial property adjacent to Laurel Fort Meade Rd.	

Facility	Approximate Station	Road Access	
MD-198 TMF	201+000	Old Portland Road Relocation	
Viaduct Access Road	130+800	Extension of Old Portland Rd from MD-198 TMF	

Facility	Approximate Station	Road Access	
Viaduct Access Road	131+900	Bridge on River Road	
Viaduct Access Road	132+500	New access road off River Road	
Viaduct Access Road	133+250	New access road off Colony Seven Rd.	

Facility	Approximate Station	Road Access	
North Portal	134+700	North access from Max Blobs Park Road	
FA/EE	140+300	New access road from MD 100 and Harman's Road.	
FA/EE	141+500	Existing access from Railroad Avenue & Old Dorsey Road.	

Facility	Approximate Station	Road Access	
S. BWI Switch Box	143+500	Use of existing airport roads – Mathison Way	
BWI Station		Use of existing airport roads	
N. BWI Switch Box	146+500	Use of existing airport roads – Aviation Blvd. and access from BWI P-Lot	

Facility	Approximate Station	Road Access	
FA/EE and Substation	151+100	Access from existing roads	
Cherry Hill Station		Use of existing roads (Annapolis Road, W. Patapsco Avenue, and Cherry Hill Road). Some roads reprofiled	
Camden Yards Station Alternative		Use of existing roads (Conway Street, Pratt Street)	

Table 33. Alignment Alternative J1 Access Roads Construction

Facility	Approximate Station	Road Access	
MVE Station	-	Existing roads	
FA/EE	104+300	Existing roads (Adams Place NE)	

Facility	Approximate Station	Road Access	
FA/EE	108+100	Existing roads (Kenilworth Avenue)	
FA/EE	113+100	New access road from Riverdale Road	
BARC West	-	New access roads from Odell Road and relocation of Odell Road	
BARC West		New access roads from Powder Mill Road	

Facility	Approximate Station	Road Access	
BARC Airstrip	-	New access roads from Springfield Road	
Viaduct	121+600 122+000	New access roads from Powder Mill Road and Springfield Road	
MD-198 TMF MOW Facility	122+200	Relocation of Springfield Road and access road from relocated road	

Facility	Approximate Station	Road Access	
Viaduct	121+500	Access road from Pesticide Road	
Substation	126+500	New access from Brock Bridge Road	
MD-198 TMF	105+400	Old Portland Road relocation	
FA/EE	134+500	North access from Max Blobs Park Road	

Facility	Approximate Station	Road Access	
FA/EE	140+300	Access roads from MD 100 and Harman's Road	
FA/EE	141+600	Access from Railroad Avenue and Old Dorsey Road	
S. BWI Switch Box	143+500	Use of existing airport roads – Mathison Way	

Facility	Approximate Station	Road Access	
BWI Station	-	Use of existing airport roads	
N. BWI Switch Box	146+500	Use of existing airport roads – Aviation Blvd – accessed from BWI P-Lot	
FA/EE and Substation	151+100	Access from existing roads	
Cherry Hill Station	-	Use of existing roads (Annapolis Road, W. Patapsco Avenue, and Cherry Hill Road). Some roads reprofiled	
Camden Yards Station Alternative	-	Use of existing roads (Conway Street, Pratt Street)	

16. HAUL ROUTES

Anticipated haul routes for construction traffic have been developed for the respective project elements for Alignment J and J1 (including FA/EE locations, substations, tunnel portals, and Stations) and are highlighted in Figures 25 to 35 below. These routes will serve as the primary means for construction traffic to access the major local traffic routes.

Figure 25. Proposed Haul Route for Cherry Hill Portal (Alignment Alternative J & J1)

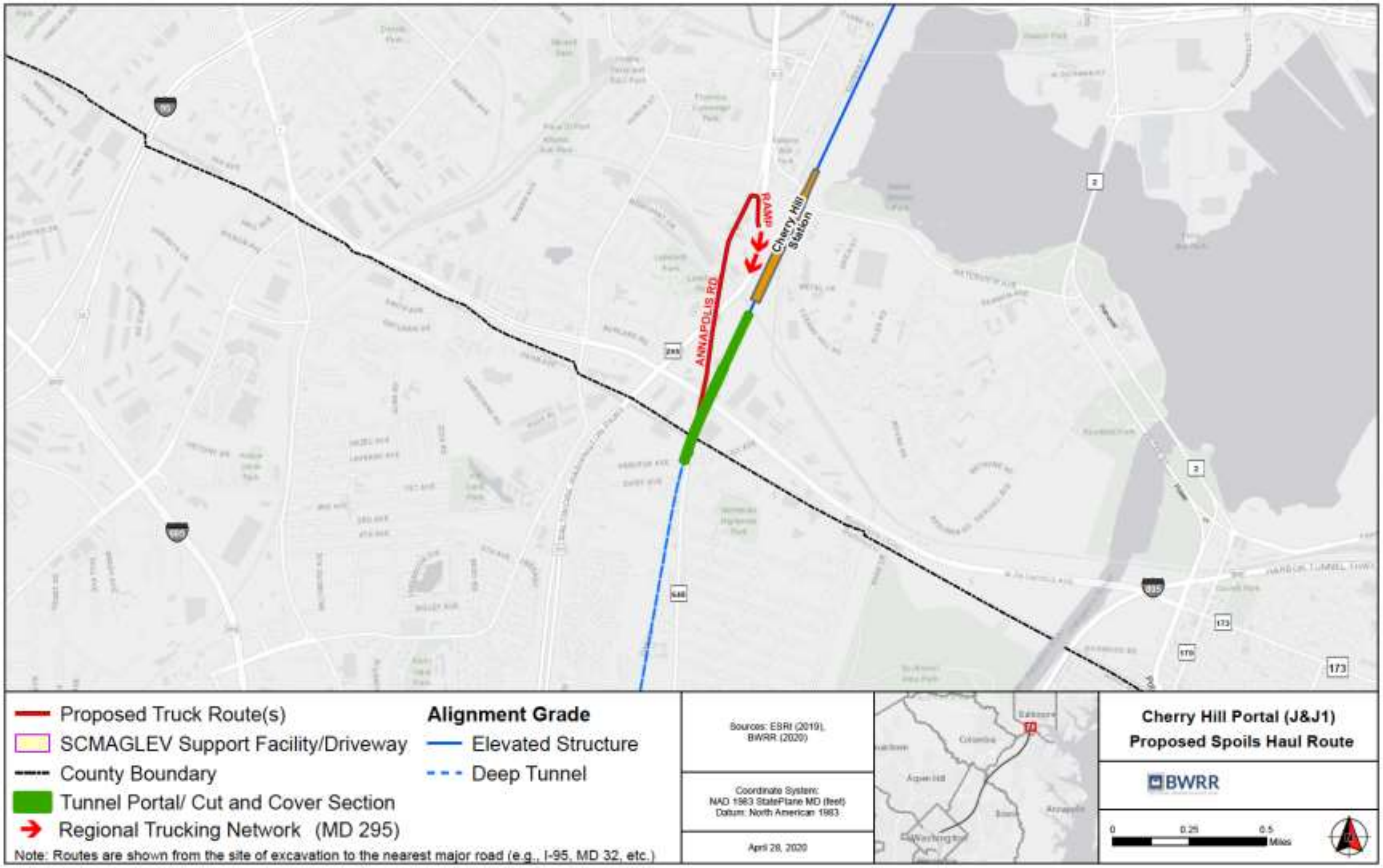


Figure 26. Proposed Haul Route for I-895 FA/EE (Alignment Alternative J & J1)

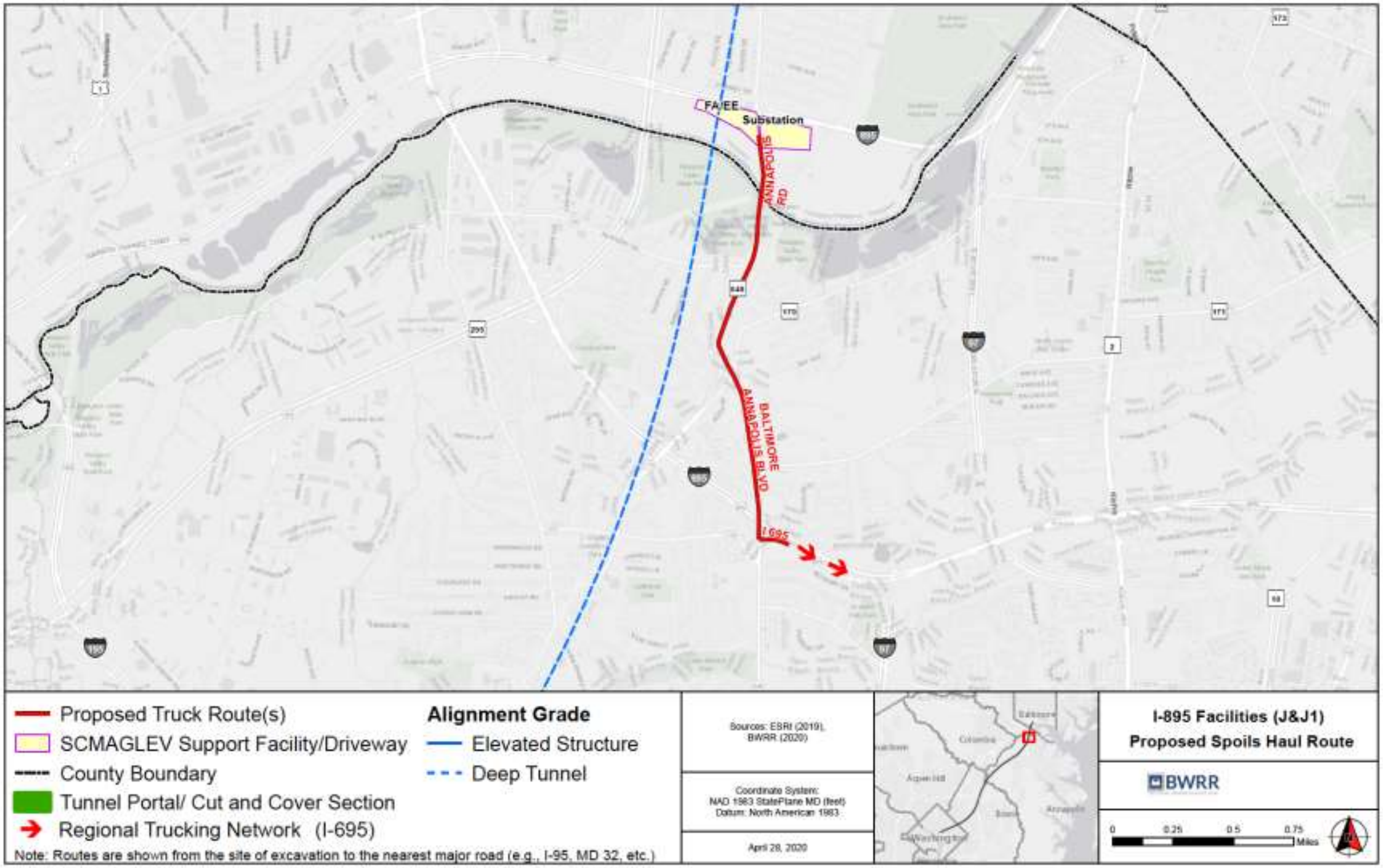


Figure 27. Proposed Haul Route for Harmans FA/EE (Alignment Alternative J & J1)

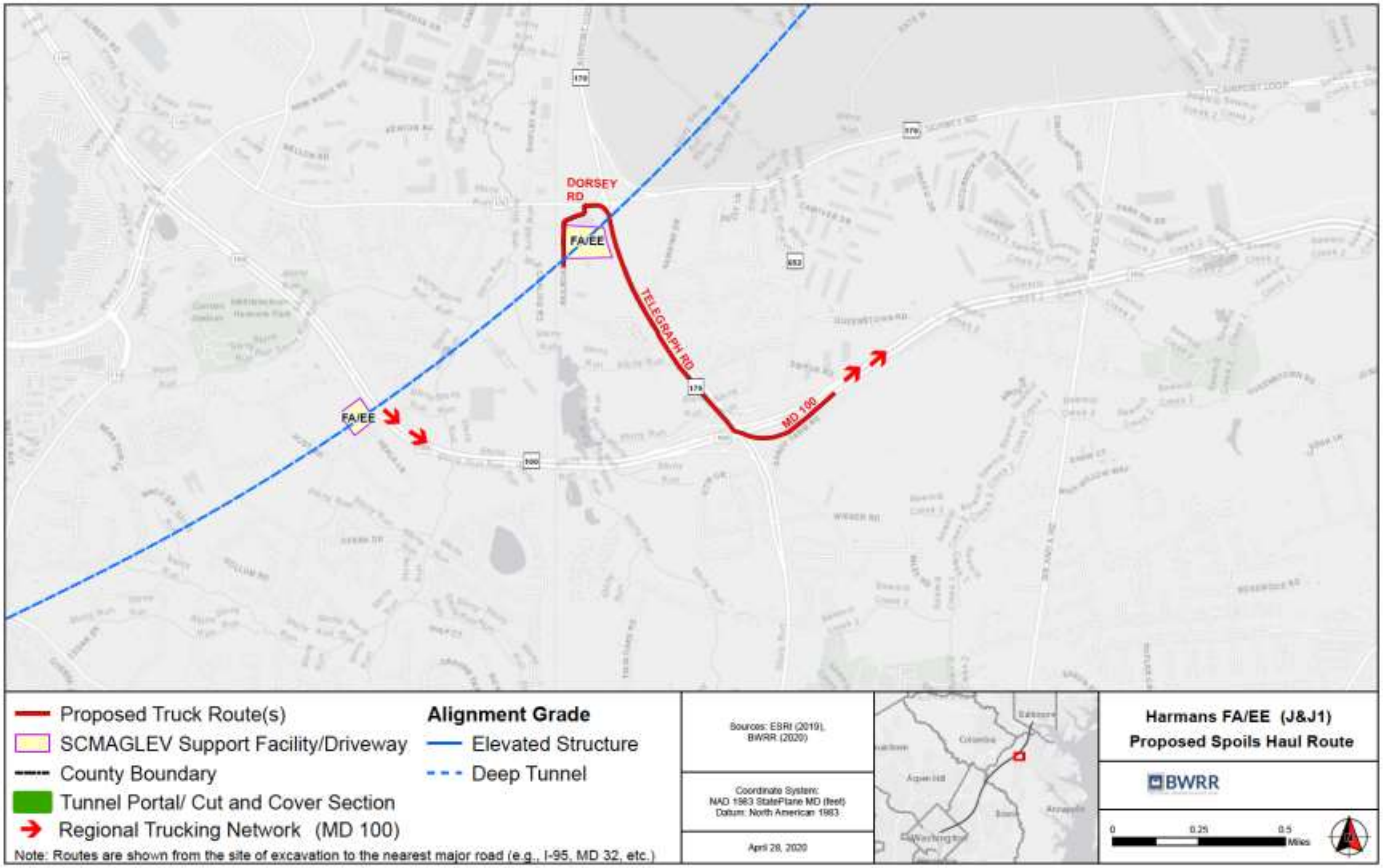


Figure 28. Proposed Haul Route for NSA Portal/ FA/EE (Alignment Alternative J & J1)

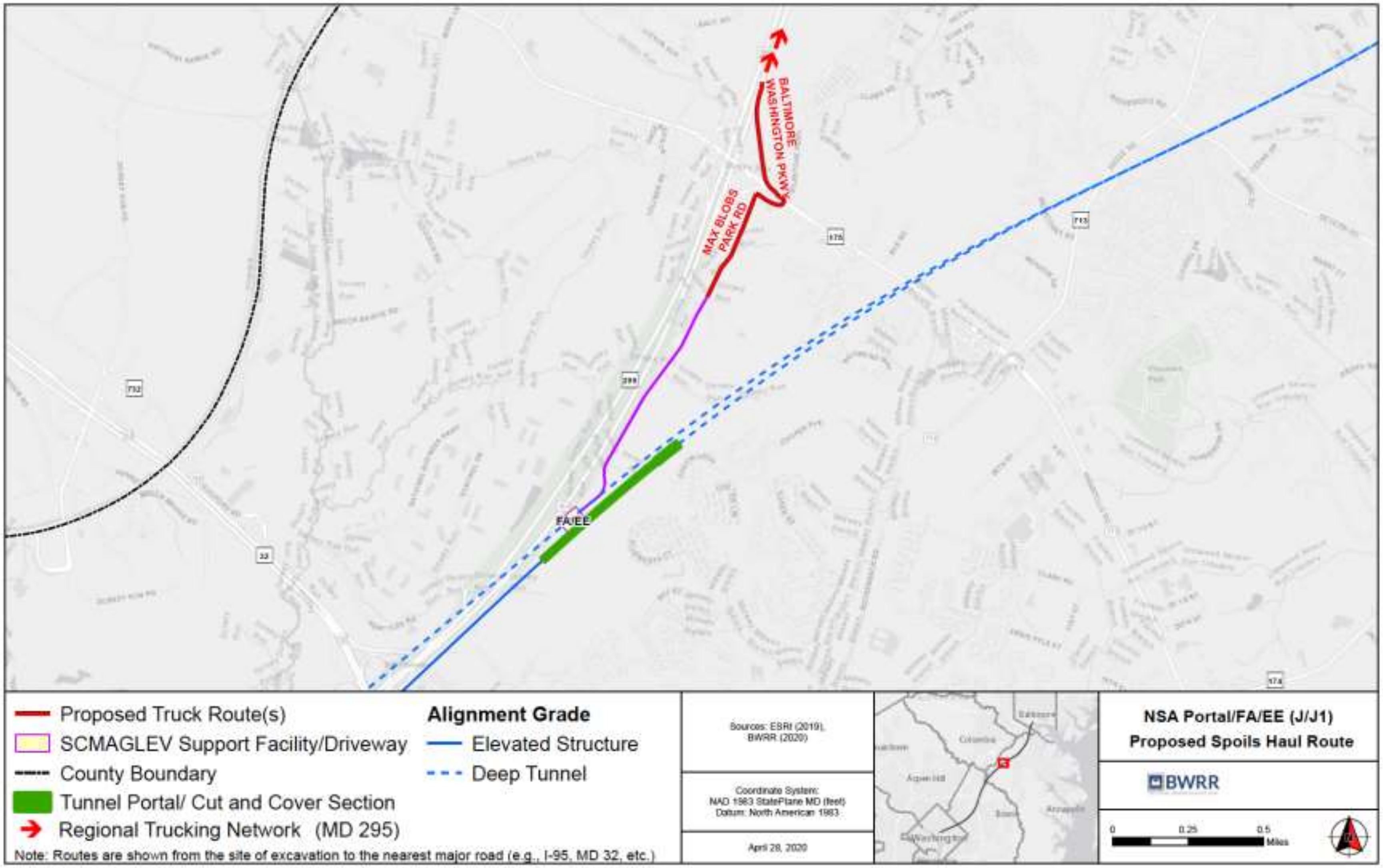


Figure 29. Proposed Haul Route for Maryland City Portal (Alignment Alternative J1)

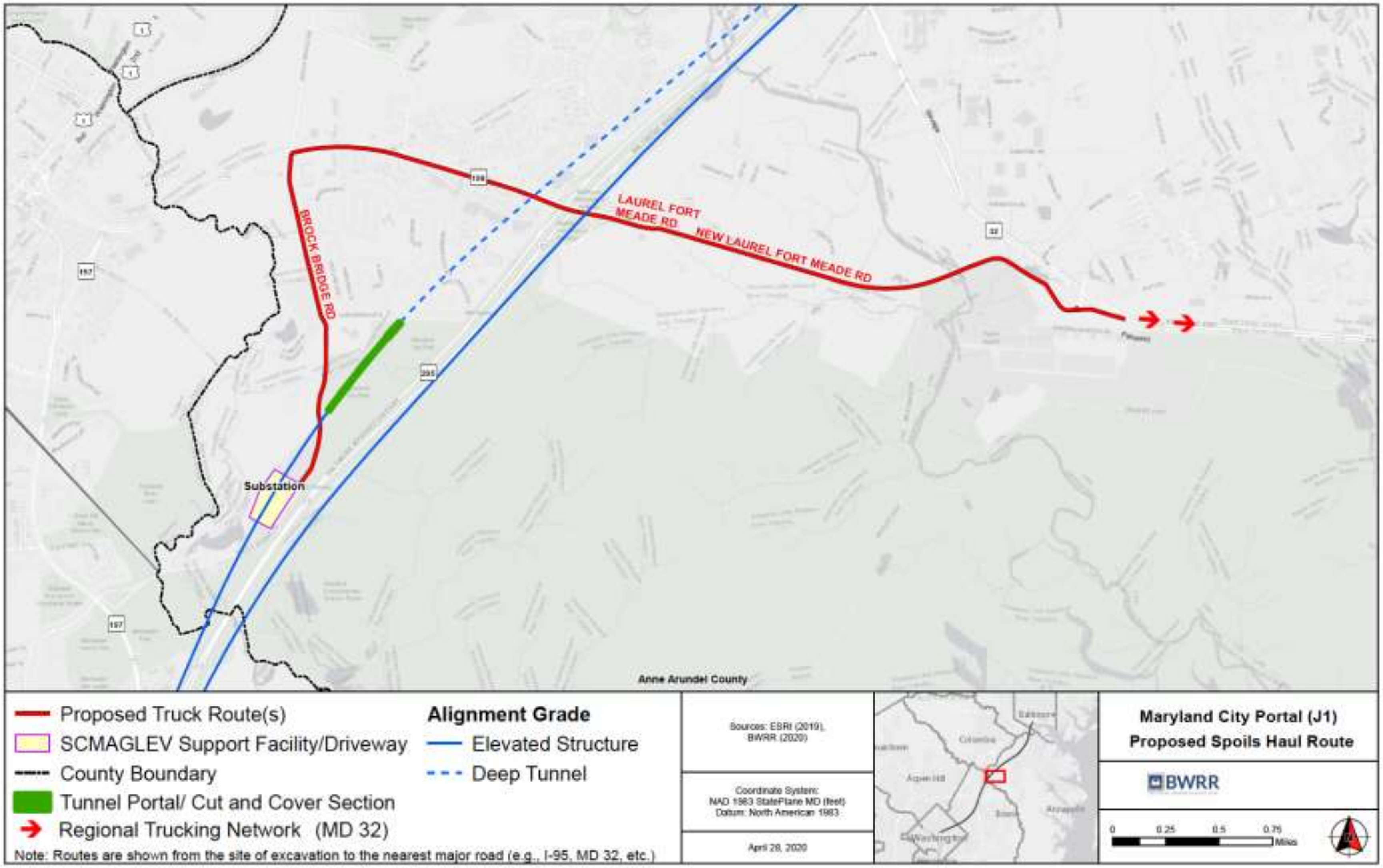


Figure 30. Proposed Haul Route for South Portal (Alignment Alternative J & J1)

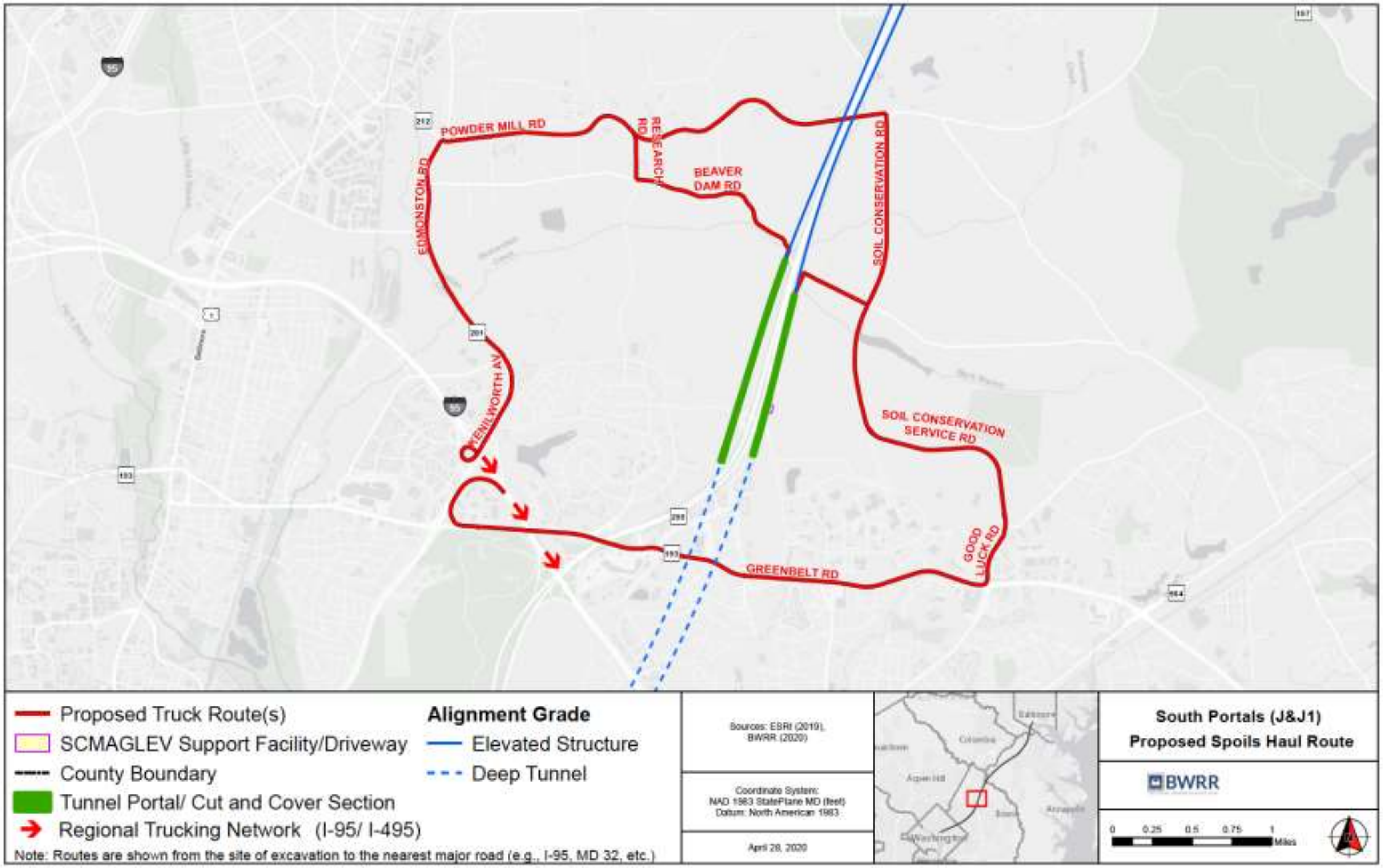


Figure 31. Proposed Haul Route for MD-410 FA/EE (Alignment Alternative J & J1)

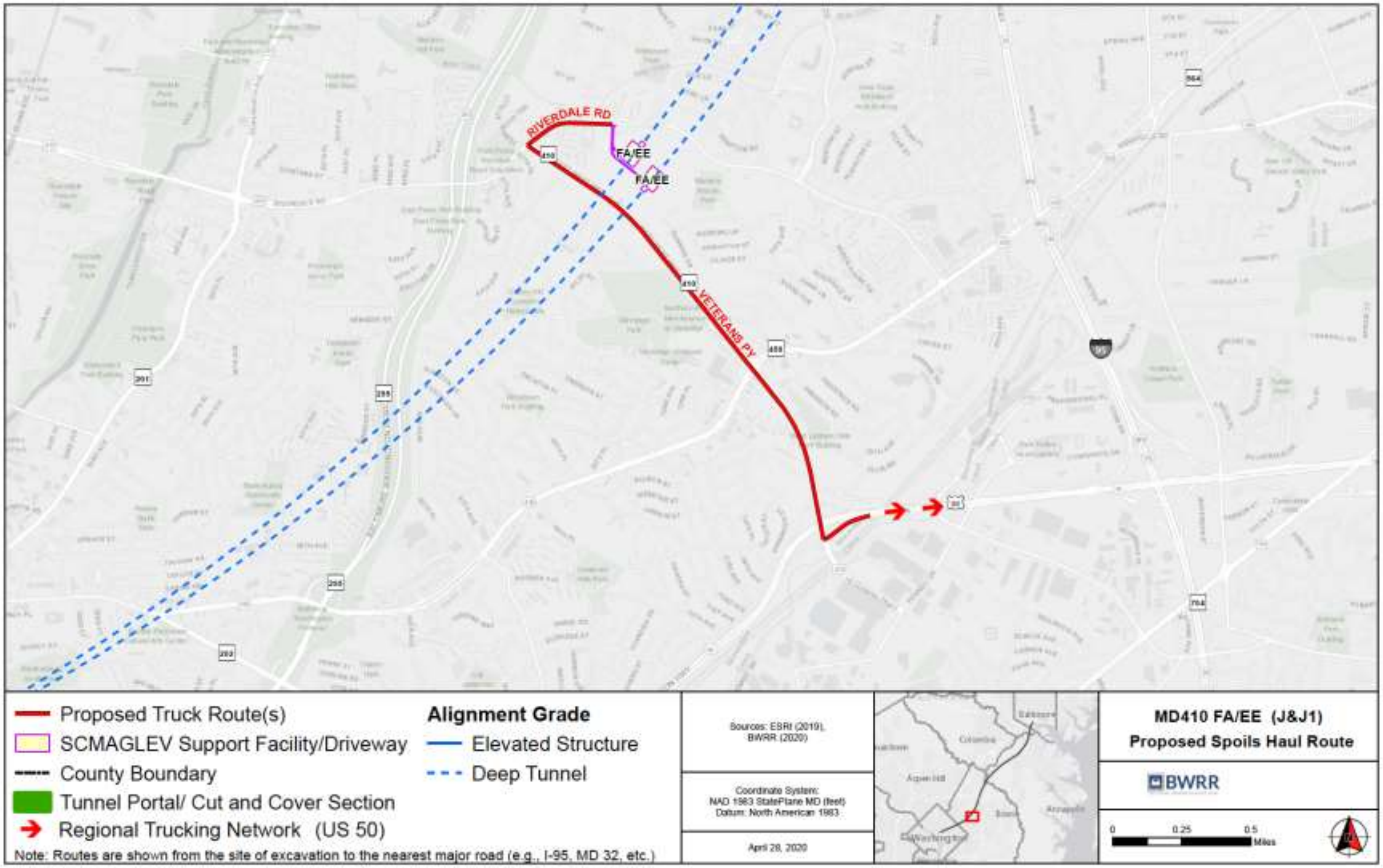


Figure 32. Proposed Haul Route for WSSC FA/EE (Alignment Alternative J & J1)

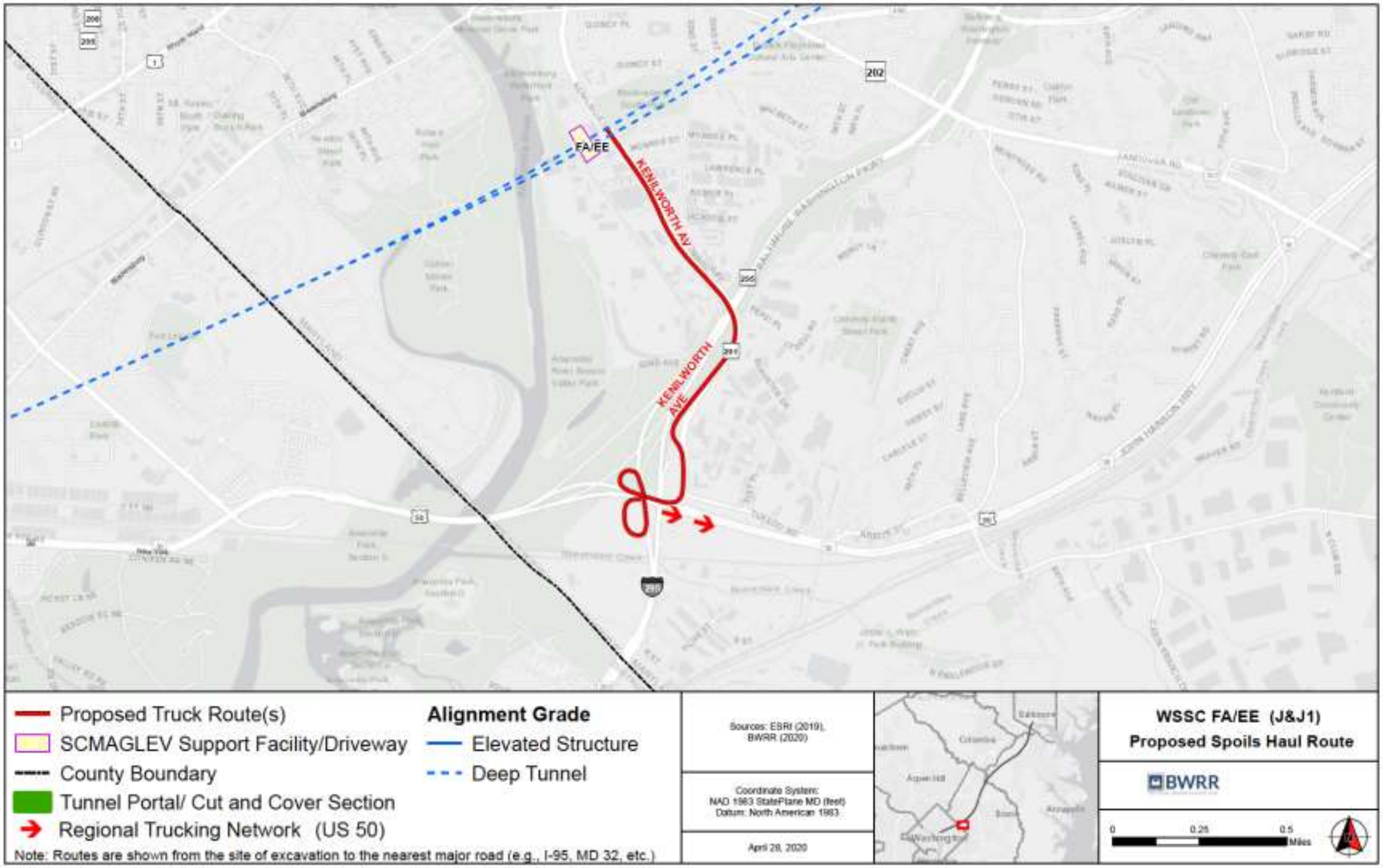


Figure 33. Proposed Haul Route for Langdon FA/EE (Alignment Alternative J & J1)

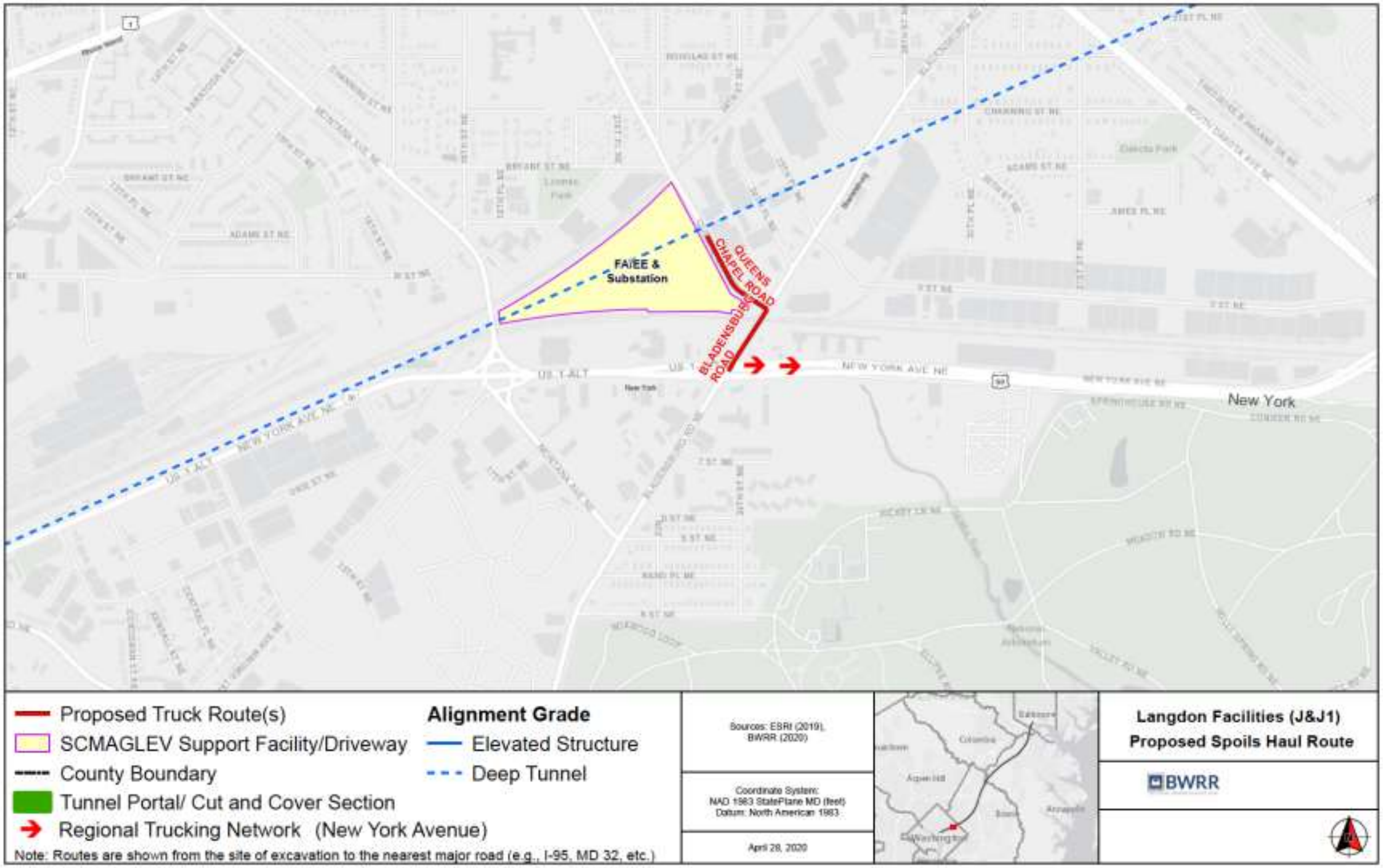


Figure 34. Proposed Haul Route for DC Station (Alignment Alternative J & J1)

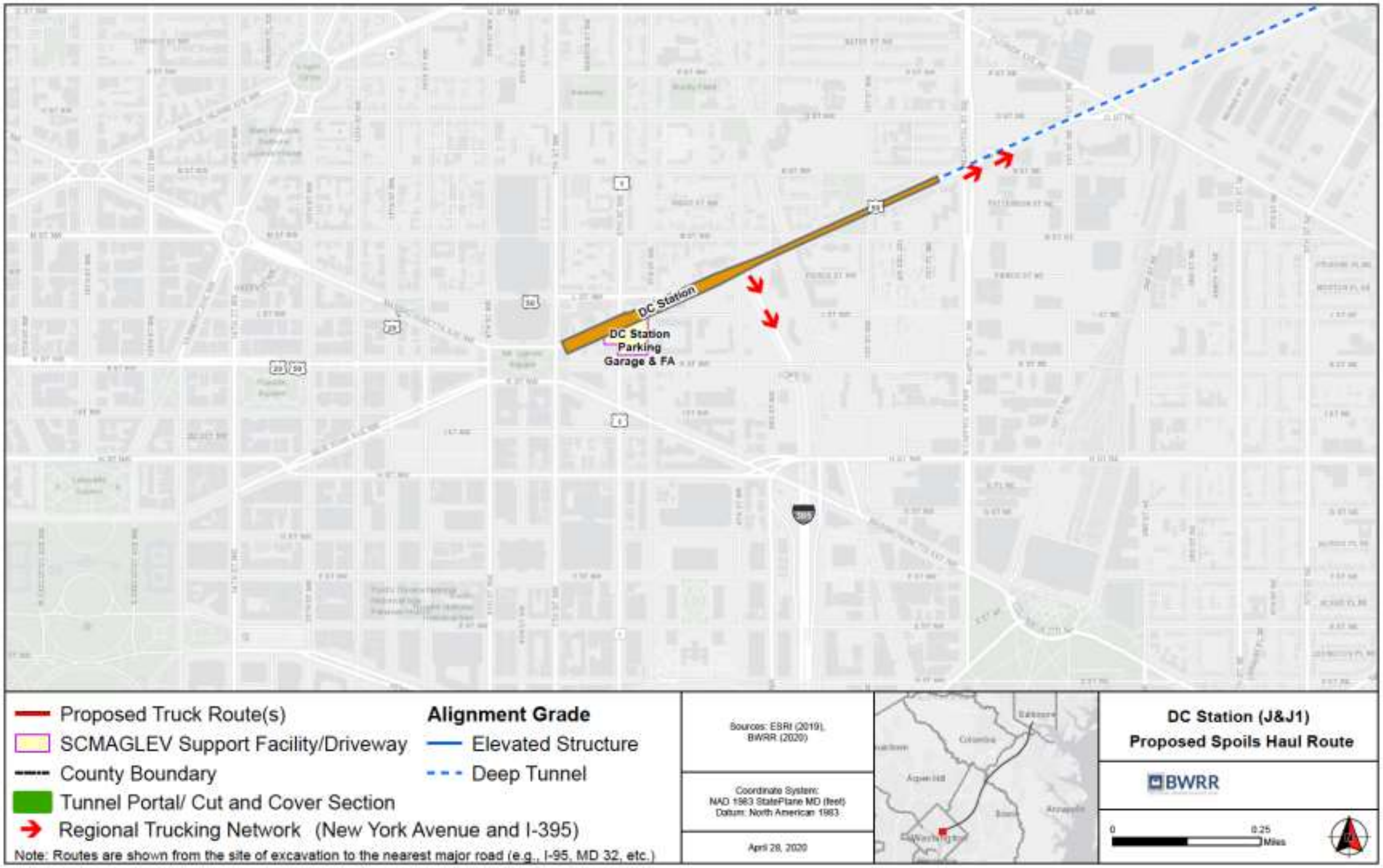
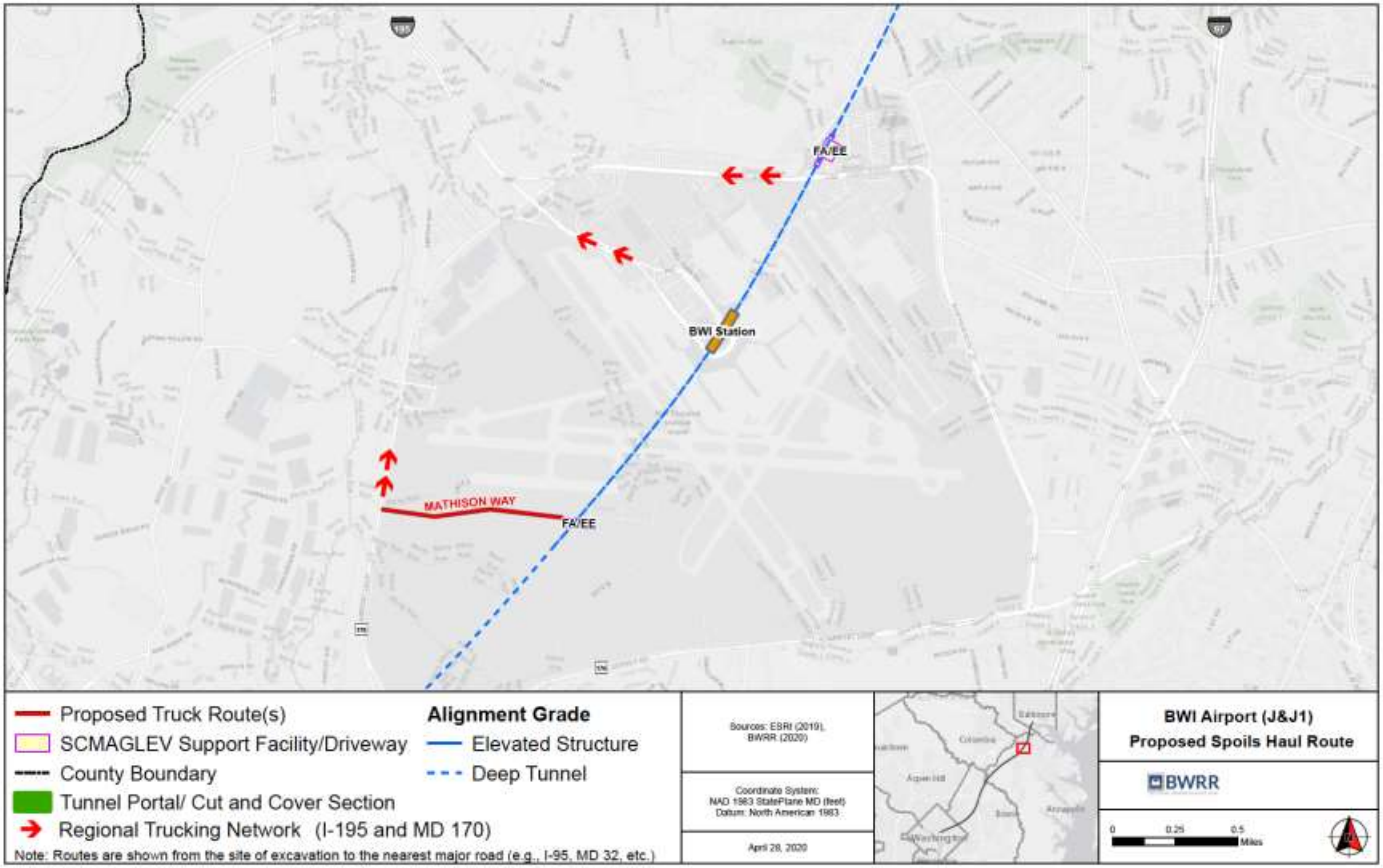


Figure 35 Proposed Haul Route for BWI Airport (Alignment Alternative J & J1)



17. UTILITY IMPACTS

Utility impacts will be addressed by one of several measures: removal, relocation, re-routing, vertical adjustments, or modification. Coordination meetings with utility providers are underway to address and mitigate impacts. Mitigation measures may impact existing travel ways during construction and will be coordinated with the affected government entities accordingly.

17.1 UTILITY IMPACTS EARLY WORKS

Utility Adjustments and Relocations:

- BGE/PEPCO: BWRR will coordinate with BGE/PEPCO for adjustments and utility relocations including design, permitting and Rights of Way acquisition, and construction of the required adjustments and relocations.
- DC Water: BWRR will be responsible for the design, permitting, and construction of relocations. DC Water will review and approve design and inspect the construction works.
- WSSC: BWRR will be responsible for the design, permitting, and construction of relocations. WSSC will review and approve design and inspect the construction works.
- Other Utilities: BWRR will coordinate with the respective utility owners for adjustments and relocations.

17.2 UTILITY IMPACTS FOR ELEVATED VIADUCT STRUCTURE

The elevated viaduct portions of alternatives J and J1 will impact aerial transmission lines, including high-tension transmission lines and distribution lines that are owned and operated by Baltimore Gas & Electric (BGE) and the Potomac Electric Power Company (Pepco), both public utilities owned by Exelon. Alternative J runs parallel to a BGE high-tension transmission line corridor for 1.8 kilometers (1.1 miles) in the vicinity of MD Route 198. The relocations will involve limited burial or raising of the existing lines in the existing alignments. Power corridors will require construction of trenches or above-ground high voltage posts. Construction may require travel lanes to be closed, but can be scheduled for off-peak hours, with lanes open during peak traffic hours.

The alignment alternatives do not cross any major substations. Other utility impacts will be identified and addressed during design development by modifying or relocating the utility as required. Bridge pier locations will be modified where practical during preliminary design to avoid impacting underground utilities. In some cases, utility relocation may be required.

17.3 UTILITY IMPACTS FOR TUNNELS

SCMAGLEV tunnel depths of 15 meters (49 feet) or greater are expected to avoid direct impacts to underground utilities. A major crossing is the DC Water CSO Northeast Boundary tunnel under New York Avenue south of Montana Avenue NE. The SCMAGLEV tunnel will be designed to avoid the CSO tunnel. Other major existing underground utilities will be avoided where possible.

Discussions have been initiated with the Washington Suburban Sanitary Commission (WSSC) about the potential use of a parking lot for one of its administrative facilities as a TBM retrieval shaft and future FA/EE location. No major WSSC infrastructure is expected to be impacted. Underground utility impacts can be expected at transition portals or TBM launch sites, where top-down construction methods will be applied.

17.4 UTILITY IMPACTS FOR PASSENGER STATIONS

Station excavation will impact utilities that are buried in the streets, such as water, sewer, power, gas, and communications systems. As an initial phase of the construction work, utilities will be relocated, replaced, or, in some cases, supported in place, to allow station excavation to proceed. As the design advances, impacted utilities will be identified and designs will be undertaken to address temporary and permanent solutions, as required.

The above-ground station alternative at Cherry Hill will require utility relocation work, at locations of station foundations.