Appendix E: Basis of Design Report

BASIS OF DESIGN REPORT

CONTRACT NUMBER B-62040/B-80143

**CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE
BUS RAPID TRANSIT SYSTEM**
IN THE BOROUGH OF
STATEN ISLAND, NEW YORK

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Revised June 16, 2023

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SECTION 1: INTRODUCTION

1.1 INTRODUCTION

The Basis of Design Report provides guidance for conceptual-level engineering for the Staten Island North Shore Bus Rapid Transit (BRT) and associated improvements. This level of engineering is appropriate to support a robust environmental review for the project as it will establish the limits of disturbance and operations parameters to be analyzed for each technical analysis area. When the project progresses to final design, more detailed design criteria will be developed and published.

This report provides further context and justifications for the station development, roadway and engineering work behind the proposed design as shown on the plan set. The maintenance and support needs for the proposed BRT vehicles are not included in this report.

The proposed alignment is comprised of varying types of right-of-way (ROW) segments including at-grade, elevated viaduct and below-grade open-cut sections, with street running portions along South Avenue and an exclusive two-lane median busway on Richmond Terrace between Nicholas Street and the St. George Terminal. On the portion of the proposed alignment that uses the former North Shore Railroad right-of-way (NSRR ROW), the proposed BRT service would operate within a two-lane, dedicated busway with the potential passing lanes at certain stations. Access to the proposed busway would be provided at four locations: in Arlington, at Bard Avenue, at an extended Alaska Street, and at Nicholas Street in St. George.

As the BRT service travels west from the existing bus terminal at St. George, the BRT would operate on Richmond Terrace in a new, approximately 0.5-mile exclusive dedicated median busway. The exclusive BRT alignment would transition from Richmond Terrace to the former NSRR ROW at Nicholas Street via a new ramp. The at-grade segment of the former NSRR ROW generally abuts the waterfront as it travels west. The North Shore's shoreline has been notably altered because of both continuous natural erosion and severe weather events. Additionally, larger vessels passing through the Kill van Kull because of the Bayonne Bridge modification are anticipated to further exacerbate erosion. At present, the former NSRR ROW and bulkhead near Sailors' Snug Harbor has sustained substantial storm damage and has largely been submerged by the Kill van Kull. Design for this area include shifting the proposed busway away from the shoreline, closer to Richmond Terrace.

At Heritage Park, the at-grade segment of the exclusive BRT alignment would transition to the former North Shore Railroad viaduct structure (for approximately 1.2 miles) that extends past the NYCDEP Port Richmond Wastewater Treatment Plant (WWTP) and Bodine Creek, shifting slightly inland as it crosses through Port Richmond and over Richmond Terrace. East of the Bayonne Bridge, near John Street, the viaduct transitions to the ROW's open-cut section that extends west toward the existing Arlington Yard freight terminal. The open-cut section is approximately 0.9 miles long with varying widths and is situated between 20 feet to 30 feet below grade. In the western section of the open cut near Van Name and Union Avenues, the BRT would be situated to safely coexist with the existing Arlington Yard rail freight service. Near Roxbury Street, the proposed alignment would leave the open-cut and rise to grade as it transitions to Arlington Station. It would then transition through Arlington where it would join South Avenue from a proposed driveway north of Brabant Street where it would operate without exclusive lanes in mixed traffic along South Avenue to West Shore Plaza.

The proposed BRT service would re-purpose and utilize the existing taxi stand on the bus deck of the St. George Terminal as its eastern terminus and the existing West Shore Plaza shopping center as the western terminus. In between these termini, six new BRT stations, with amenities such as platforms and shelters, and three existing, on-street stops along South Avenue, would be served. The specific locations and layouts of the proposed stations has been determined based on their ability to maximize the transportation goals of the project while minimizing environmental impacts, where practicable.

Proposed Stations by ROW Section			
At-Grade	Elevated Viaduct	Open-Cut	On Street (South Avenue)
• St. George Terminal (Eastern Terminus) • New Brighton Station • Livingston Station • West Brighton Station	• Port Richmond Station	• Elm Park/Morningstar Station • Mariners Harbor Station • Arlington Station	• Forest Avenue Stop • Goethals Road Stop • Teleport Stop • West Shore Plaza (Western Terminus)

It is anticipated that stations in the open-cut and elevated viaduct sections would be accessed via stairs and ADA-compliant ramps or elevators. Stops along South Avenue, where the bus would operate with existing traffic in non-separated lanes, would be similar to existing bus stops on South Avenue. As such, platforms and other station infrastructure are not proposed for the three South Avenue stops. Existing traffic signals along South Avenue are to remain. Additional considerations include the curb-to-curb roadway resurfacing of Richmond Terrace between Nicholas Street and the St. George Terminal to facilitate exclusive dedicated median busway and the design treatment of the submerged ROW proximate to Snug Harbor.

The conceptual level engineering of the project components, identified above, (e.g., station areas, busway, access points, etc.) will be further discussed in this report to support the environmental

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analysis. The Build Alternative will be fully described in the Environmental Impact Statement (EIS).

1.1.1 Application

The material contained in the following sections is intended to provide a uniform basis for conceptual design and is anticipated to undergo further refinement and expansion during the preliminary engineering process and final design.

The information provided herein serves as design guidelines for the project and does not substitute for local codes, engineering judgement and sound engineering practice. Specific exceptions to these criteria may apply in special cases. Exceptions to the criteria presented herein will be documented as part of the conceptual design development.

1.1.2 Objectives

The Basis of Design Report has been developed to serve the following purposes:

- Identify and define relevant project design criteria.
- Identify regulations, standards and guidelines applicable to the design process.
- Provide a mechanism for documenting the appropriate design criteria, regulations, standards and guidelines for the project.

The report will serve as a mechanism for systematically addressing and documenting the evolution of design criteria and exceptions to criteria where appropriate.

1.1.3 Key Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADAAG	American with Disabilities Act Accessibility Guidelines
APTA	American Public Transportation Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASCE	American Society of Civil Engineers
BRT	Bus Rapid Transit
EIS	Environmental Impact Statement
FEMA	Federal Emergency Management Agency
MTA-NYCT	Metropolitan Transportation Authority New York City Transit
NYCDDC	New York City Department of Design and Construction
NYCDOT	New York City Department of Transportation
NYCEDC	New York City Economic Development Corporation

NYSDOT	New York State Department of Transportation
NSRR	North Shore Railroad
PANYNJ	Port Authority of New York and New Jersey
ROW	Right-of-Way
SIR	Staten Island Railway

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SECTION 2: PROJECT ALIGNMENT, CRITERIA AND STANDARDS

2.1 PROJECT ALIGNMENT

2.1.1 Alignment

The Staten Island North Shore BRT project would implement new BRT service between West Shore Plaza and St. George Terminal. The approximately 8-mile proposed BRT alignment would be comprised of approximately 4.8 miles of limited access busway within the former NSRR ROW and approximately 3.2 miles within City streets, such as Richmond Terrace (0.5 miles) and South Avenue (2.7 miles). The proposed BRT alignment is described from west to east to maintain consistency with and appropriately supplement the conceptual design plans that have been prepared for the project. The BRT would operate within mixed traffic along South Avenue before transitioning to a dedicated busway on the former NSRR ROW. The former NSRR ROW is under City of New York ownership and is currently maintained by the New York City Economic Development Corporation (NYCEDC). As shown in **Figure 2.1.1.1**, the proposed alignment would travel through several existing, distinct sections of the former NSRR ROW including a depressed open-cut, an elevated viaduct and an at-grade section to the east.

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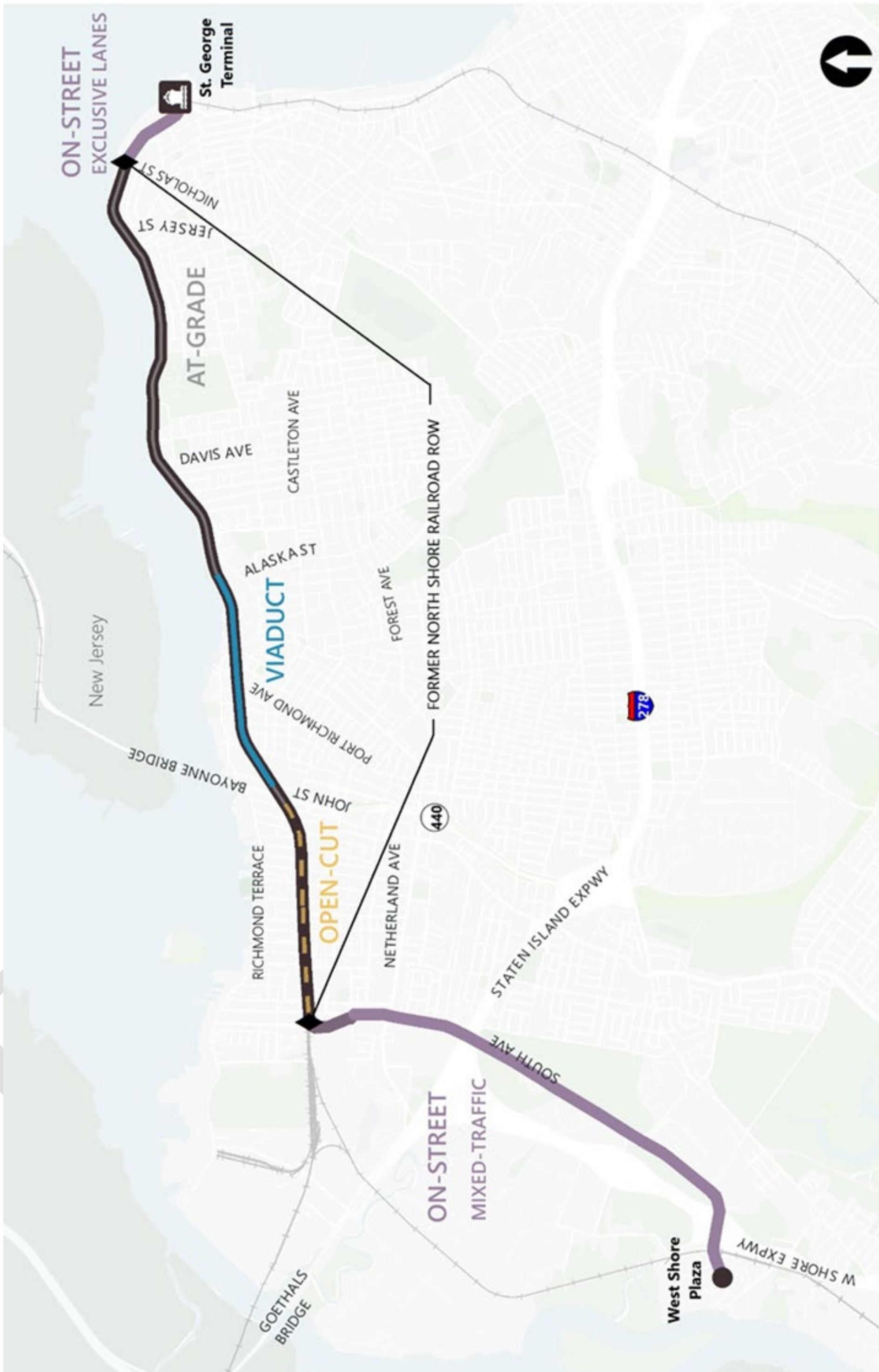

Figure 2.1.1.1 Staten Island North Shore Proposed BRT Alignment

2.2 IMPROVEMENTS FOR PROJECT ALIGNMENT

2.2.1 South Avenue Section

South Avenue is a street under NYCDOT jurisdiction leading from the West Shore Plaza shopping center located on the west side of the Travis Branch Line freight railroad grade crossing of South Avenue to the proposed Arlington Station to the north. Access to the proposed station would be via a proposed driveway on South Avenue north of Brabant Street. The proposed Arlington Station footprint would utilize a portion of property owned by Consolidated Edison (Con Ed). The proposed station design and driveway access has been coordinated with Con Ed to avoid interference with their existing operations.

New curb cuts would be required to access Arlington Station as well as a proposed passenger drop-off from South Avenue. Arlington Station would have an approximately 75-space park-and-ride facility. Each parking space would be 9 feet wide by 18 feet long. A new curb cut leading into Arlington Station would be signalized allowing for a new crosswalk, north of the curb cut, across South Avenue. Refer to Section 6.9 for traffic signal work. Traffic from the passenger drop-off would be stop-controlled. There is 1-foot to 20-feet grade difference between the station and the existing street level along South Avenue requiring a retaining wall behind the passenger drop-off. For further details on this BRT station, see Section 8. West Shore Plaza represents the western terminus of the proposed alignment. Three curbside BRT stops would be located on South Avenue at Forest Avenue, Goethals Road North, and Teleport Drive. Since the BRT would be street-running within South Avenue, no engineering or geometrical modifications would be made to the existing South Avenue cross section or street alignment are proposed. As such, this report does not address South Avenue.

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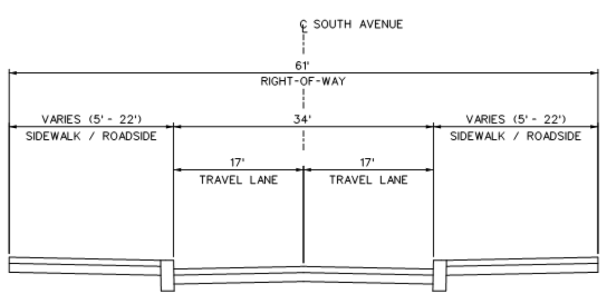

Figure 2.2.1.1 BRT Alignment along South Avenue (North of Forest Avenue)

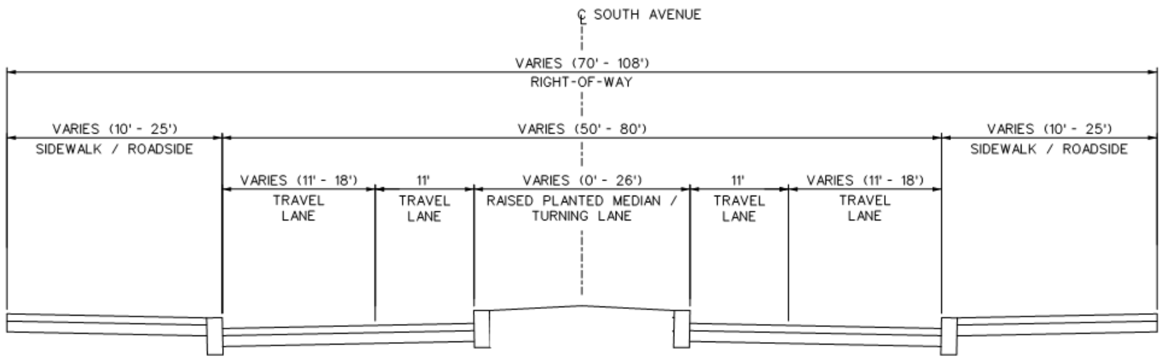

Figure 2.2.1.2 BRT Alignment along South Avenue (South of Forest Avenue)

2.2.2 Former NSRR Section

The BRT alignment would enter the former NSRR section at the proposed driveway north of Brabant Street along South Avenue, where the alignment transitions from mixed traffic to bus-only traffic and continues as an exclusive busway to the Nicholas Street ramp in St. George. The BRT busway is designed to be comprised of two (2) 12-foot wide travel lanes each with two (2)-foot wide shoulders. Bus ramps to allow access for buses onto and off the BRT busway are proposed at Alaska Street and Bard Avenue. Passing lanes are proposed at stations located east of the proposed Alaska Street bus ramp, as the higher volume of buses on the busway is expected and some routes would be passing some stations. Except at stations and at turn lanes, the proposed busway width would be 28 feet, to provide for a continuous two-lane busway. Maintenance roads are not proposed, due the narrow width of the former NSRR ROW, the proximity of the existing street network to most of the former NSRR ROW, and the densely developed nature of the project corridor.

A summary description of the BRT alignment, from Van Name Avenue to the Nicholas Street ramp follows:

Former NSRR Exclusive ROW - Depressed (below-grade, open-cut) section

The BRT alignment on the former NSRR ROW between South Avenue and Van Name Avenue would allow for the existing Arlington Yard freight terminal tracks to operate without impact and

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would also preserve the ability of the PANYNJ to potentially extend the existing yard tail track eastward from Union Avenue to Van Name Avenue in the future. At the South Avenue bridge, the BRT alignment would be located south of and adjacent to the existing yard freight tracks. The southerly abutment and rock slope protection below the deck of the southern-most bridge span would be modified, and an additional retaining wall would be constructed to allow the BRT alignment to occupy the space between the south abutment and southerly-most bridge pier. A potential future extension of the freight rail tail track could potentially require bridge deck and substructure modifications at the north abutments and northern-most bridge spans for the bridges between Union Street and Van Name Avenue (by others). No other modifications are currently anticipated to existing overhead bridge structures as the BRT alignment passes under them.

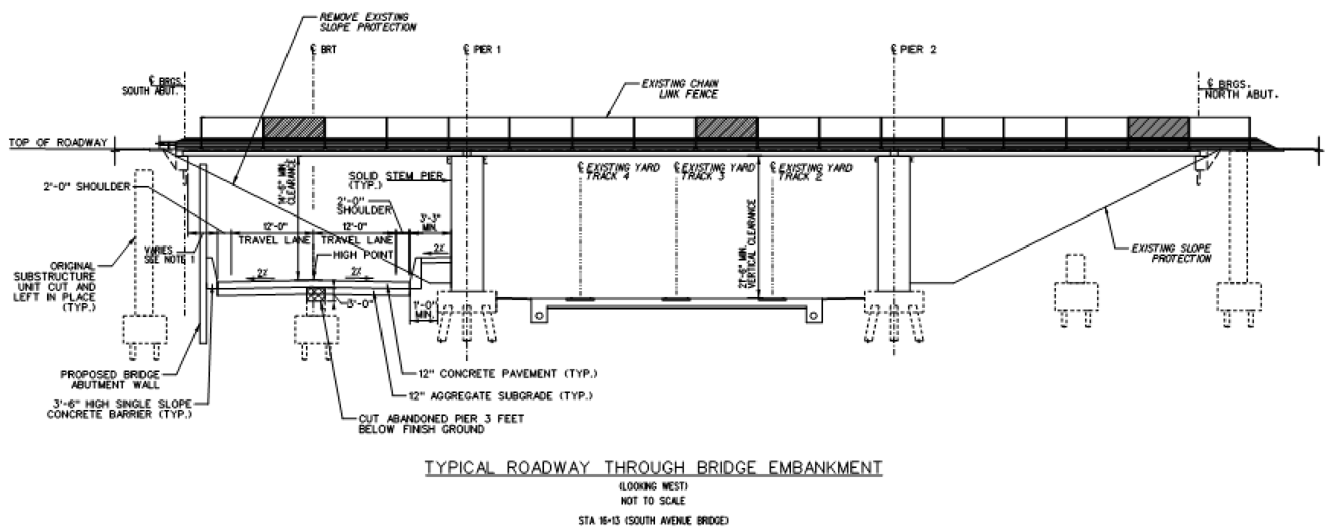

Figure 2.2.2.1 BRT Alignment under South Avenue Bridge

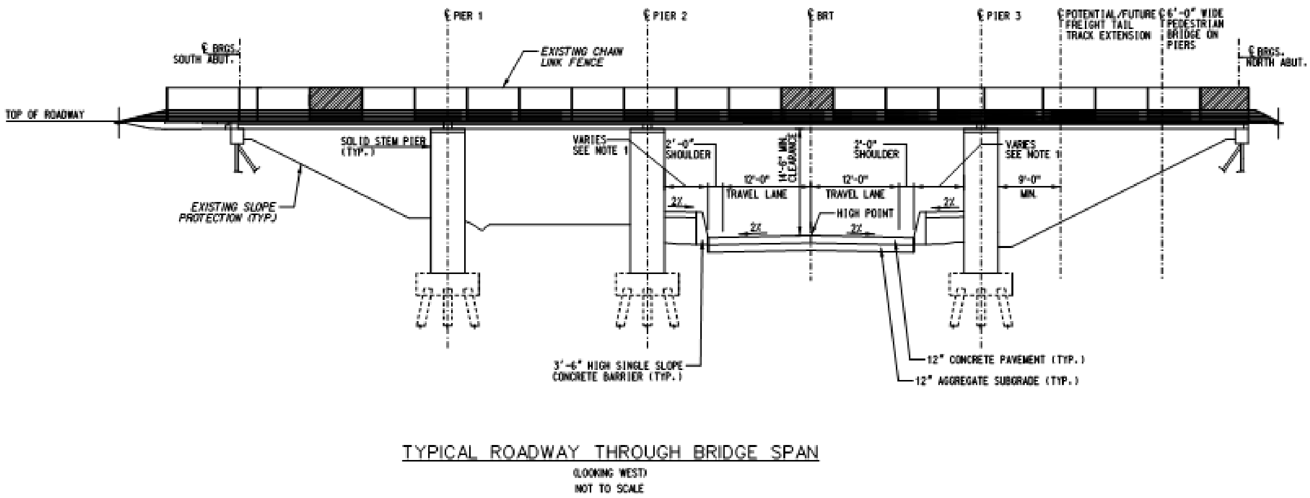

Figure 2.2.2.2 BRT Alignment under Harbor Road Bridge, Union Avenue Bridge, Dehart Avenue Bridge, Van Name Avenue Bridge, Simonson Avenue Bridge, Lake Avenue Bridge, Morningstar Road Bridge and John Street Bridge

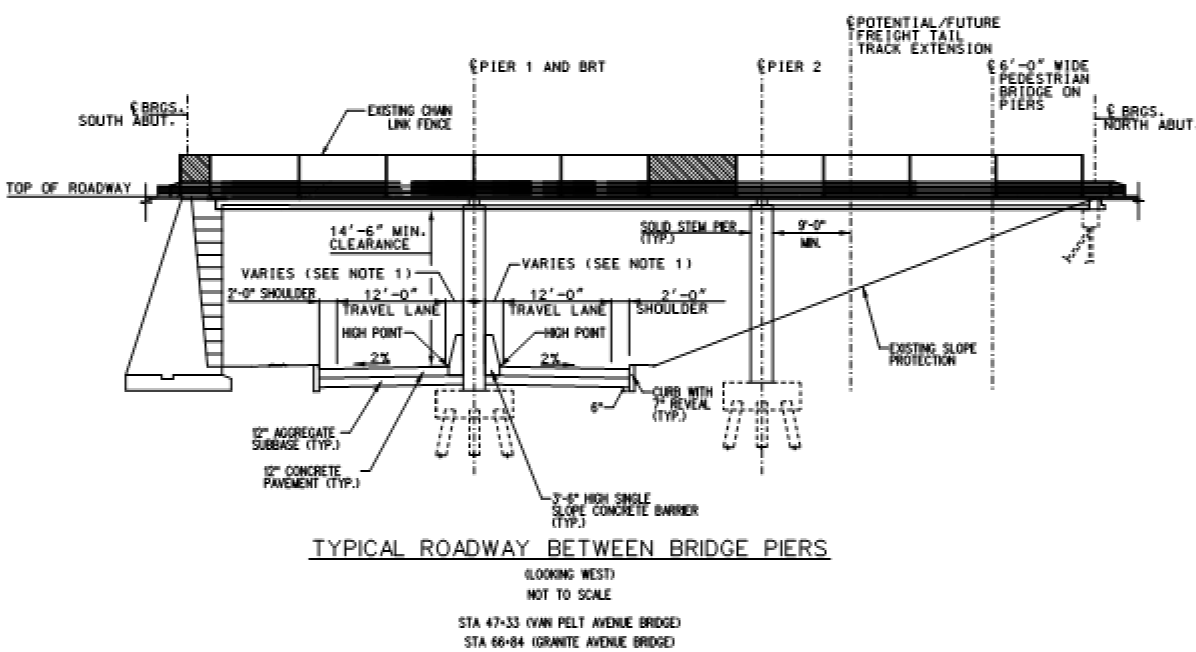

Figure 2.2.2.3 BRT Alignment under Van Pelt Avenue Bridge and Granite Avenue Bridge

The BRT alignment would be depressed below street level in the former NSRR ROW cut, from South Avenue to east of the John Street pedestrian bridge.

To accommodate the proposed busway and to align the busway with the existing South Avenue bridge, Roxbury Street between Lockman and Grandview Avenues would need to be reconfigured. As part of this reconfiguration, the existing 40-foot width of Roxbury Street would be reduced to 30 feet and the existing 15-foot sidewalk width on the south side of the street would be reduced to 10 feet. Utility work associated with the street reconstruction is also anticipated. More specifically, since the existing 12" diameter watermain, was installed in 1953, a replacement is required in accordance with NYCDEP watermain replacement age criteria. This criteria requires the replacement any distribution water main installed prior to and including 1970. The existing 6-foot wide pedestrian walkway and stairs connecting Roxbury Street to South Avenue, would need to be reconstructed and realigned. This would require the removal of the existing retaining wall and installation of two new retaining walls due to the grade separation to adjacent properties. The proposed street reconstruction would include the removal of another existing retaining wall and installation of two new retaining walls due to the grade separation between Roxbury Street and the existing Arlington Yard freight tracks as the BRT alignment enters this section between them. Lateral clearance from the face of retaining wall along the track side would be approximately 10 feet from the centerline of adjacent track (as per AREMA, a minimum 9 feet from centerline track is required). As directed by NYCEDC and PANYNJ, a 12-foot high crash wall, in accordance with the latest AREMA code, would be installed between the BRT alignment and the existing Arlington Yard freight tracks. The length of the crash wall would account for a potential eastward extension of the Arlington Yard freight tail track from Union Avenue to Van Name Avenue (1,500 linear feet) and potentially up to Granite Avenue (2,600 linear feet). The conceptual level BRT alignment does not preclude the potential expansion of Arlington Yard tail track which may occur independent of the BRT project in the future.

In this section, the existing grades allow for adequate vertical clearances for the BRT. The removal of the existing, abandoned and degraded former NSRR single track as well as remnant station platforms would be required. Currently, this track is not in-service. Several station platforms would be provided in this section including drainage, and a typical roadbed section. This area is significantly overgrown and in need of clearing to remove garbage, invasive vegetation and debris prior to construction.

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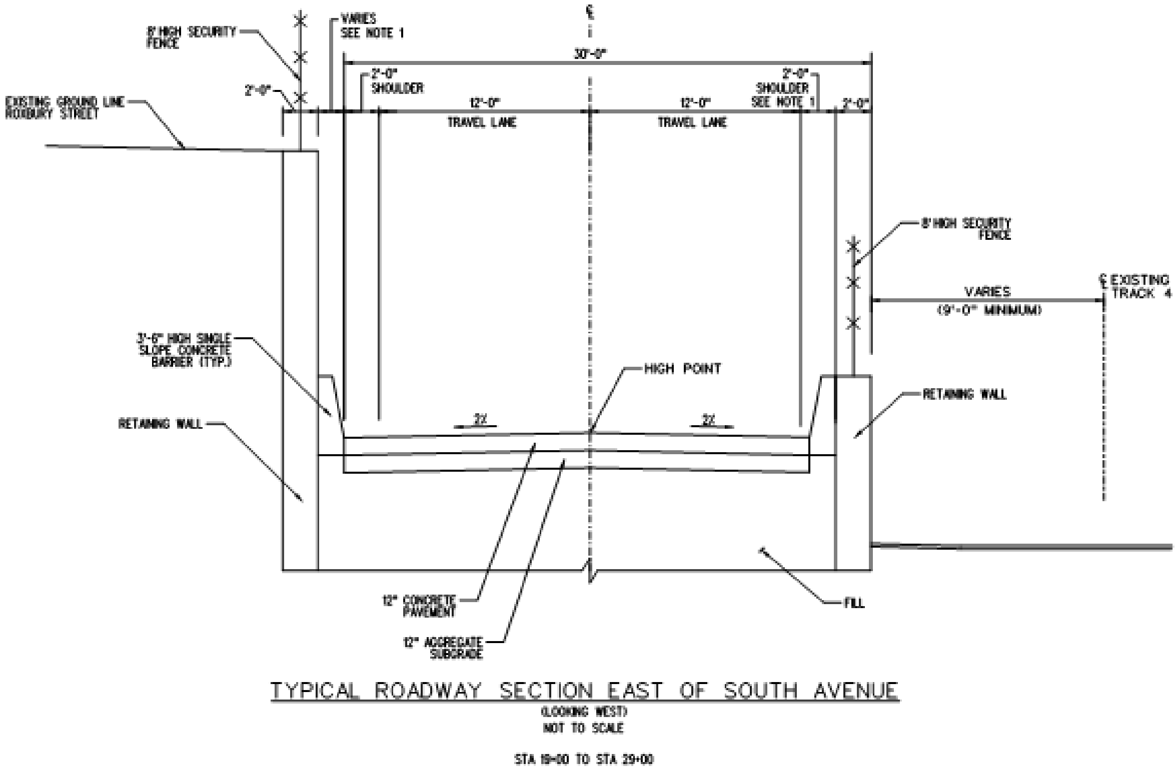

Figure 2.2.2.4 BRT Alignment Along Roxbury Street with Retaining Walls

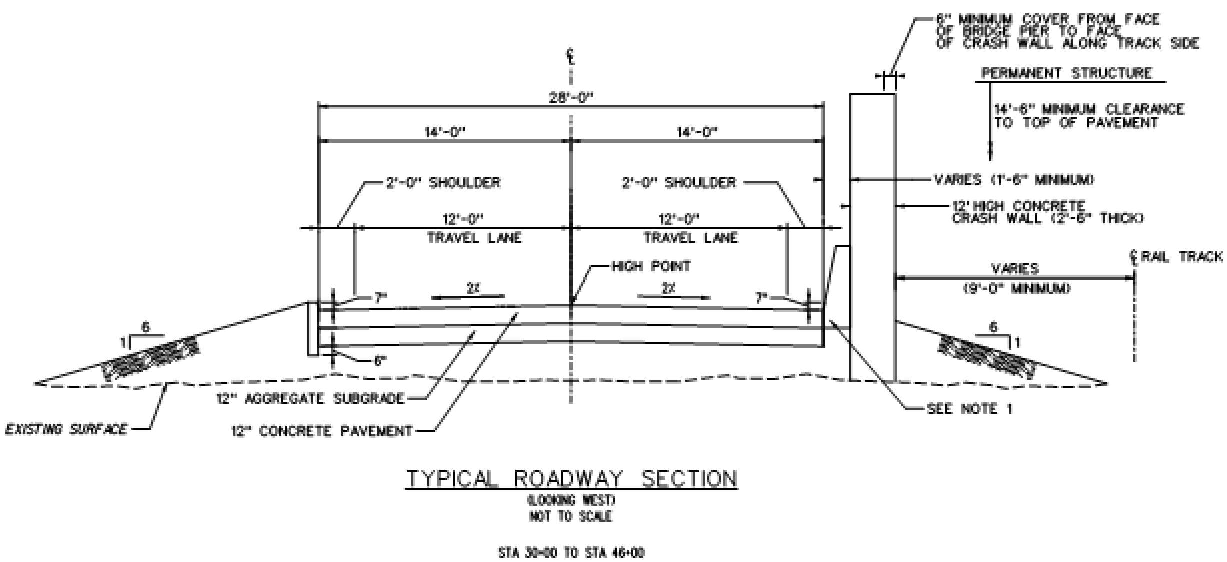

Figure 2.2.2.5 BRT Alignment with Crash Wall

The proposed Mariners Harbor Station would be located in this depressed open-cut section between Van Pelt Avenue and Van Name Avenue. There is roughly a 20-foot grade difference from the bottom of the open-cut to the existing street level. A station plaza entrance is proposed, and a new 10-foot wide sidewalk would be installed along the north side of Heusden Street from Van Pelt Avenue and Van Name Avenue. The existing 30-foot roadway width of Heusden Street would remain with existing stop-controlled intersections maintained at both ends. For further details on this BRT station, see Section 8. A new Erastina Place walkway and pedestrian bridge would be constructed along the northern portion of ROW to provide access for passengers to walk to Mariners Harbor Station from either Union Avenue or Dehart Avenue. For further details on Erastina Place pedestrian walkway and bridge and anticipated structural work on Union Avenue Bridge, Dehart Avenue Bridge and Van Pelt Avenue Bridge, see Section 9.

The proposed Elm Park/Morningstar Station would also be situated in this depressed open-cut section, under the Bayonne Bridge. There is a 20-foot grade difference from the existing street level at Morningstar Road, a 14-foot grade difference from the existing street level at Eaton Place, and a 10-foot grade difference from the existing street level at Newark Avenue. New station plaza areas would be constructed along Morningstar Road, Newark Avenue and Eaton Place. For further details on this BRT station, see Section 8. The Port Authority of New York & New Jersey (PANYNJ) has reviewed the proximity of the proposed BRT station to the Bayonne Bridge pier footings and has indicated that the proposed station placement is acceptable from a structural perspective.

Former NSRR Exclusive ROW – Elevated (Port Richmond Viaduct) section

The BRT alignment would transition from the depressed open-cut to at-grade east of the John Street pedestrian bridge and then to elevated on the existing Port Richmond Viaduct west of the Treadwell Avenue (undergrade) bridge. The BRT would make use of a rehabilitated Port Richmond Viaduct, which extends 3,840 feet from STA. 97+75 (west of Treadwell Avenue) to STA 136+55 (west of Alaska Street ramp). On the viaduct structure, appropriate superstructure modifications would be made to accommodate the BRT including the removal and replacement of parapets, certain bridge deck sections and old rail platforms and staircases. Along the Port Richmond Viaduct, adjacent commercial and residential properties have been developed since the viaduct was constructed with building structures constructed near the former NSRR ROW. Due to the proximity of these existing building structures and the constrained access by work crews, precast roadway decking without the corbel below is an alternate for these locations. These adjacent commercial and residential properties are:

- Block 1084 Lot 41, Station 99+74 LT

- Block 1076 Lot 14, Station 103+00 LT
- Block 1076 Lot 8, Station 104+00 LT
- Block 1076 Lot 5, Station 105+00 LT
- Block 1076 Lot 58, Station 105+90 RT
- Block 1074 Lot 86, Station 108+50 LT
- Block 1073 Lot 23, Station 110+20 RT
- Block 1073 Lot 107, Station 111+53 LT
- Block 1073 Lot 104, Station 112+50 LT
- Block 1004 Lot 1, Station 114+50 LT
- Block 1004 Lot 27, Station 116+60 LT
- Block 1004 Lot 7, Station 115+00 RT
- Block 1004 Lot 15, Station 116+55 RT
- Block 1004 Lot 19, Station 117+15 RT

The proposed Port Richmond Station would be located in this elevated section from Maple Avenue to Park Avenue with about a 21-foot grade difference from the existing street level. The station configuration was determined by the existing factors of the viaduct structure. A new station plaza area would be constructed along Port Richmond Avenue. For further details on this BRT station, see Section 8.

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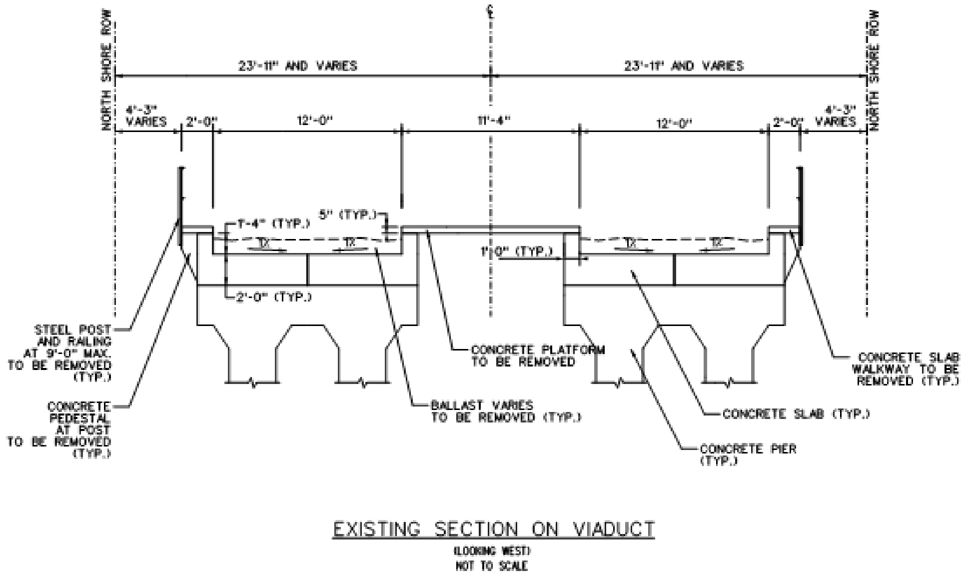

Figure 2.2.2.6   Existing Port Richmond Viaduct (Double Bent)

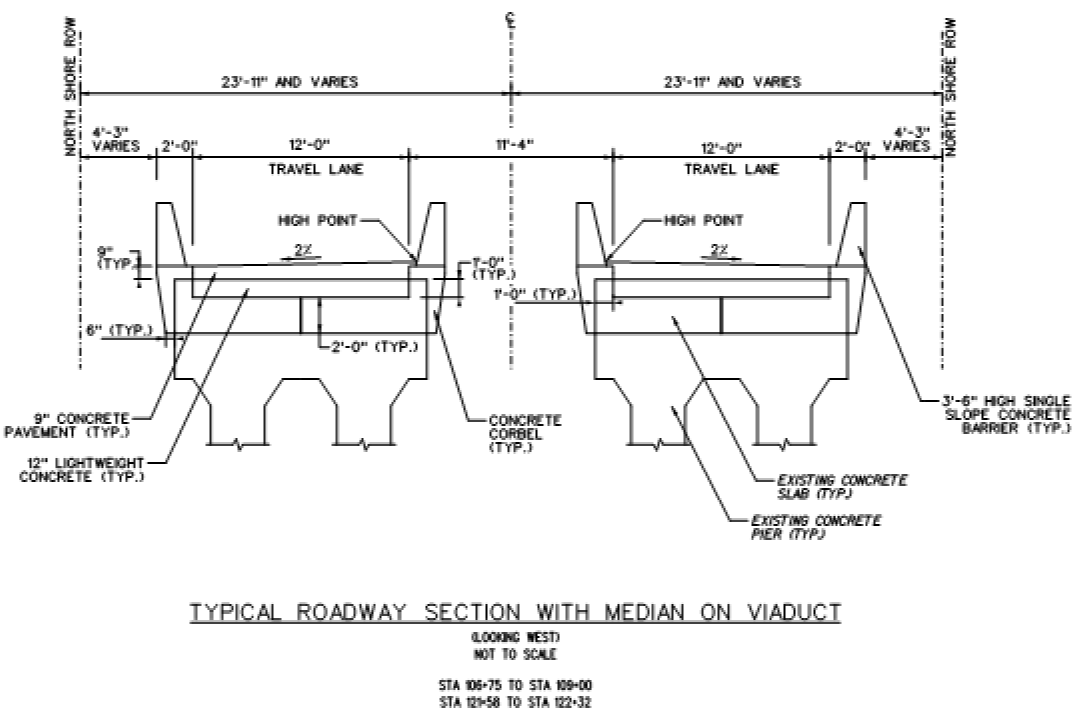

Figure 2.2.2.7   BRT Alignment with median along rehabilitated Port Richmond Viaduct

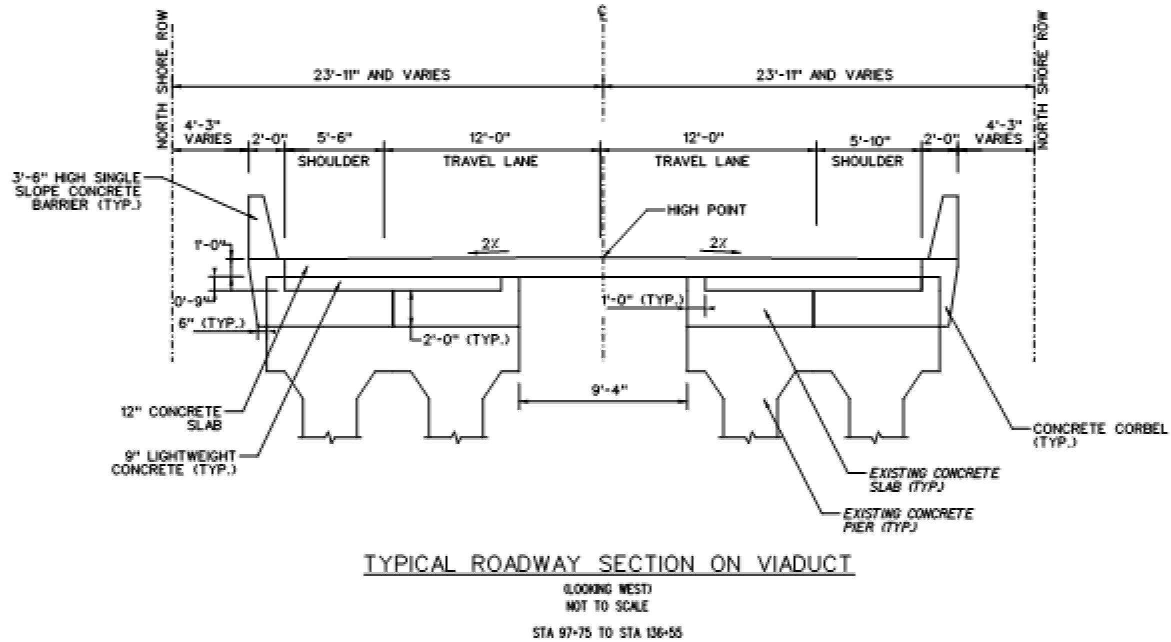

Figure 2.2.2.8 BRT Alignment along rehabilitated Port Richmond Viaduct

Modified Former NSRR Exclusive ROW – At-Grade Sections

At the east end of the Port Richmond Viaduct, the former NSRR ROW is generally located between Richmond Terrace and the Kill van Kull. The former NSRR ROW is proposed to be modified (Modified Alignment) for the BRT, to enable existing maritime industries adjacent to or occupying the existing ROW to maximize waterfront access for their business functions while enabling the proposed BRT alignment to be shifted inland closer to Richmond Terrace.

Moving east from the viaduct the proposed BRT alignment would pass through the existing driveway to Heritage Park, creating an at-grade crossing (intersection) between the BRT and the driveway. To maintain access to Heritage Park, roadway and signal improvements for both pedestrian and vehicles would be added to control access at the grade crossing. See Section 6.9 for traffic signal work. The existing exterior paved parking lot located south of Heritage Park would be removed to allow the BRT alignment to occupy the space. West of the proposed signalized grade crossing to Heritage Park, a new curb cut to allow access for buses onto and off the BRT alignment would be provided from the intersection of Richmond Terrace and Alaska Street. A new ramp (Alaska Street ramp) extending north from this curb cut to the BRT alignment would be constructed. The Alaska Street ramp would be constructed on MTA-NYCT owned land and would be comprised of two (2) 13-foot wide travel lanes each with two (2)-foot wide shoulders. Buses entering and exiting the new Alaska Street ramp, at both ends of the ramp, would be stop controlled. Along the BRT alignment, 130-foot long turn bays for each direction are included to remove stopped buses from through traffic. The length of each turn bay would be sufficiently long to store two (2) articulated buses likely to accumulate during a critical period so the lane may operate independent of the through lanes. The storage length should be sufficient to prevent vehicles spilling back from the auxiliary lane into the adjacent BRT through lane.

The two maritime businesses located along both the north and south sides of the former NSRR ROW are:

- Caddell Dry Dock (ROW is owned by the City of New York) located from Tompkins Court to Davis Avenue (2,900 feet), and
- Atlantic Salt located from Clinton Avenue to the western end of Bank Street (2,300 feet). The city-owned ROW transects the Atlantic Salt property.

MTA-NYCT determined in consultation with these businesses and the City of New York that a shift in the ROW alignment closer to Richmond Terrace would enable the companies to maximize their waterfront and operational access, both of which are essential to its business function while enabling the proposed busway to be shifted inland closer to Richmond Terrace, bringing the alignment closer to potential customers. This shift would be accomplished via a land exchange between the City and the respective businesses (Caddell Dry Dock and Atlantic Salt). The proposed alignment shifts south towards Richmond Terrace would increase the width of contiguous space available for business use and significantly reduce the need for business operations to cross the busway alignment. The modified alignment proposed along the frontage of these businesses would require partial or complete removal of several buildings impacted by the BRT alignment. See Appendix F for list of private properties.

At Caddell Dry Dock their primary driveway at Broadway and Richmond Terrance would be maintained, and the proposed busway would be signalized. See Section 6.9 for traffic signal work. The horizontal curvature of the BRT alignment at this grade crossing (intersection) was coordinated with the owner to minimize existing building impacts therefore reducing the operating speed to 32 mph.

The proposed West Brighton Station is at-grade with the Caddell Dry Dock site and located between Broadway and N. Burgher Avenue. There is 1-foot to13-foot grade difference between the BRT alignment and the existing Richmond Terrace street level along the Caddell Dry Dock site. As such, a retaining wall would be required. For further details on this proposed BRT station, see Section 8.

At both maritime business locations (Caddell Dry Dock and Atlantic Salt), the proposed profile is 6 to 12 feet above sea level due to these constraints, and the busway could be subject to tidal flooding. Maintenance of the bulkhead is the responsibility of the private property owners.

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At Atlantic Salt, the modified BRT alignment would run adjacent to Richmond Terrace and through the lowest level of what remains of former 4-story brick and steel framed building that was partially removed in 2019. The space on the lowest level once carried rail through the structure. This building's lower level space was evaluated for reuse to allow for the BRT alignment to run through it. Installation of roadside barrier protection in each direction would be necessary due to proximity of the existing columns that would remain. It is recommended a lower posted speed limit of 15 MPH be considered as the installation of roadside barrier protection would decrease the available shoulder width as the BRT operates through the building structure. The remaining Atlantic Salt building structure was not inspected for this project, however the property owner stated that a structural conditions survey was performed for the lower level, but it was not provided or evaluated for this report. A land swap would include the remaining lower level building space that also serves to support Richmond Terrace along the building's 840-foot length and would be owned and maintained by NYC. Atlantic Salt's access at Richmond Terrace could be maintained with construction of a ramp over the BRT alignment to be constructed by the private property owner. Property access at Jersey Street would be maintained.

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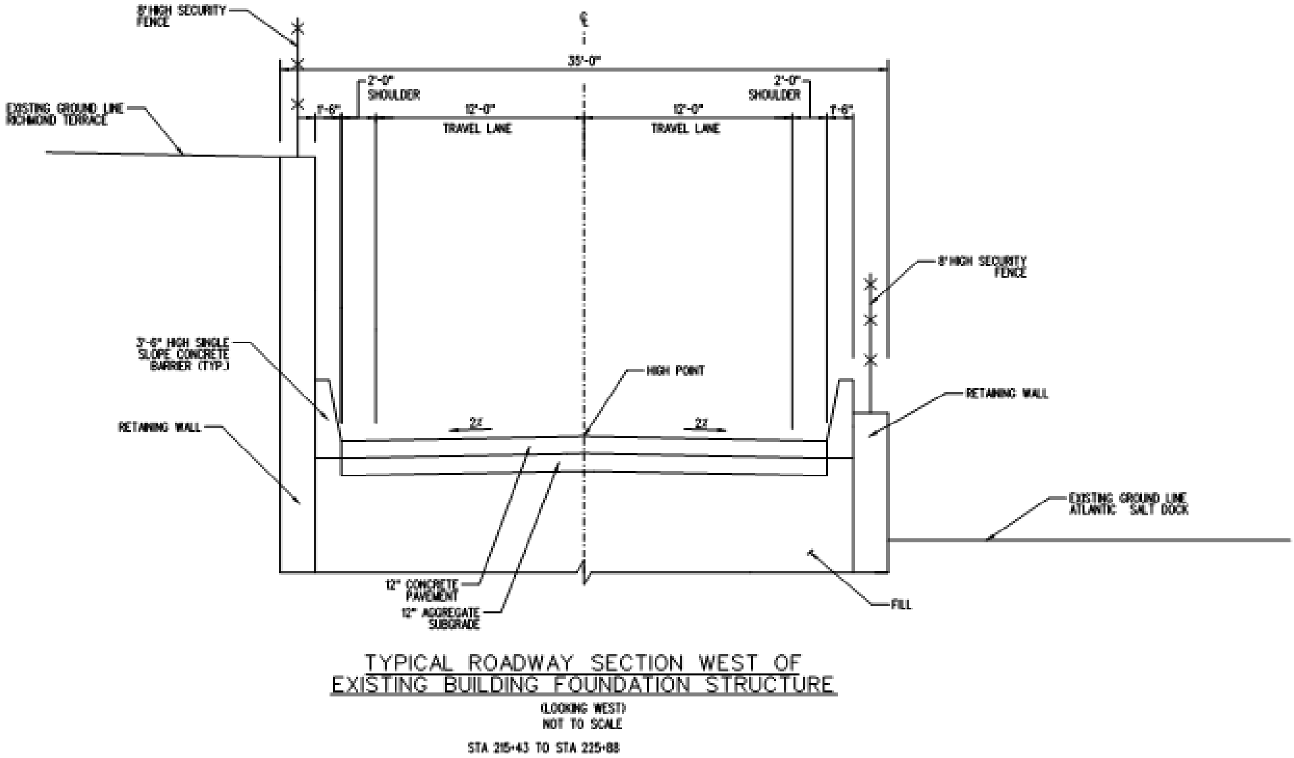

Figure 2.2.2.9 BRT Alignment West of Atlantic Salt's Existing Building Foundation Structure

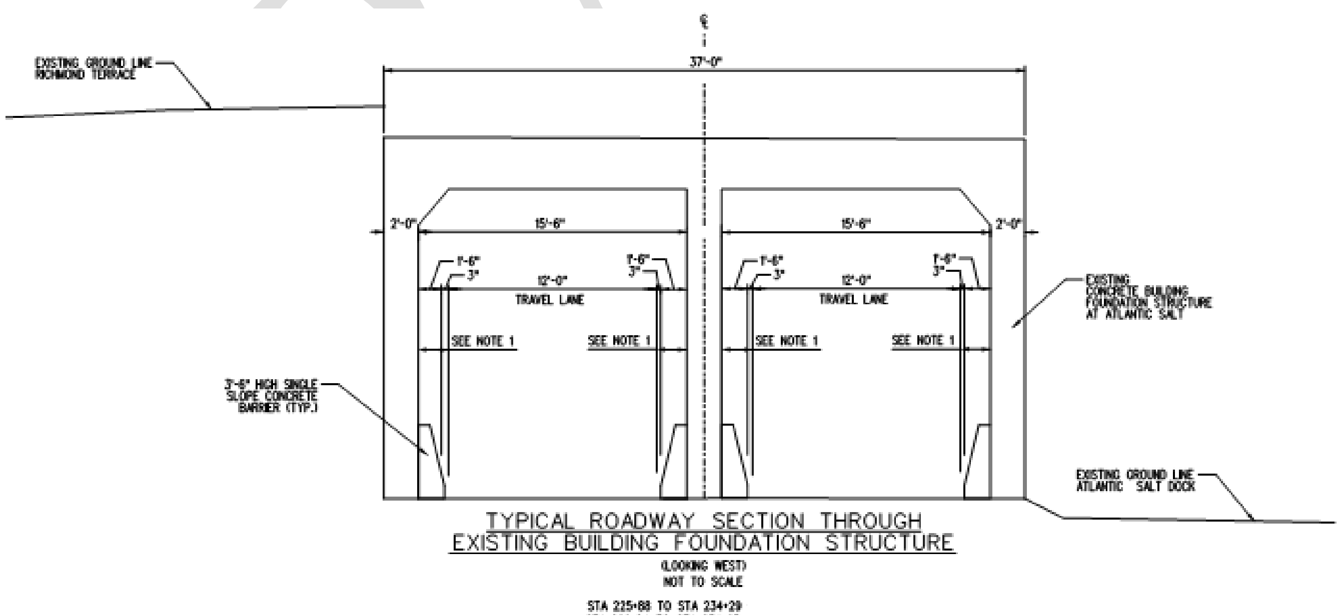

Figure 2.2.2.10 BRT Alignment Along Atlantic Salt's Existing Building Foundation Structure

Modified Former NSRR Exclusive ROW – Elevated (Snug Harbor) Section

For section from Davis Avenue to Clinton Avenue, between the two maritime businesses mentioned above, the former NSRR ROW is against (and partially consumed by) the Kill van Kull at an elevation of 4 to 10 feet above sea level. The ROW has not been maintained since the cessation of passenger and freight service and has eroded into the Kill van Kull along a portion of this area due to coastal erosion from tidal action, ships' wakes and storm events. Ships' wakes are expected to intensify with the introduction of Panamax-size vessels. These larger vessels are now anticipated to appear with greater frequency now that projects such as the enlarged Panama Canal, and locally the channel dredging of the Kill van Kull and the raising of the Bayonne Bridge are fully completed. To protect the future transit assets from erosion and service from being disrupted by flooding, a BRT was conceptually engineered as an elevated busway landward of the Kill van Kull shoreline, north of Richmond Terrace, with a proposed elevation of approximately 36 feet above sea level at its highest point. Further details in establishing this alignment are presented in Section 13 – Resiliency. To achieve this elevation, a concrete viaduct structure is proposed. Further details are in Section 9.6 – Snug Harbor Alignment. The alignment would utilize portions of the former NSRR ROW (where possible), requiring the use of parkland in City ownership. The existing former NSRR ROW that would not be utilized could be improved and could be swapped for park property giving the City the ability to improve the property closest to the waterfront.

The BRT alignment proposes two stations to be located at both ends of this elevated section. At the western end, Livingston Station would be at-grade and located on a Consolidated Edison owned site between Davis Avenue and Bard Avenue. The station would include a park-and-ride facility that would accommodate approximately 72 parking spaces. Each parking space would be 9-feet wide x 18-feet long. This station would allow for direct access from the park-and-ride, a designated drop off/pick up area, and a convenient sidewalk connection. The station park-and-ride facility has been coordinated with Consolidated Edison. The western portion of the site would be dedicated for Consolidated Edison parking that would accommodate approximately 45 parking spaces with additional space to store three (3) mobile electric generators. Each parking space would be 9-feet wide x 18-feet long and each space for mobile electric generator would be approximately 8.5-feet wide x 45-feet long. Consolidated Edison has indicated these generators are kept plugged into electric service from adjacent utility poles onsite to ensure that the batteries are charged and ready to go to mitigate emergency issues. For further details on this BRT station, see Section 8.

East of Livingston Station, Bard Avenue would allow access for buses onto and off the BRT alignment. Buses entering the BRT alignment from Bard Avenue will be stop controlled and the existing signalized intersection at Richmond Terrace and Bard Avenue will be maintained. Bard Avenue would be reconstructed from Richmond Terrace to the shore.

This section of Bard Avenue is a dead end with the existing roadway width varying from 40-foot to 50-foot, existing 5-foot wide east sidewalk and with no west sidewalk. A new 5-foot wide sidewalk on the west side of Bard Avenue would be included with the park-and-ride facility. No watermain work is anticipated with Bard Avenue reconstruction.

At the eastern end on this section, New Brighton Station would be elevated from the shoreline below but at grade with Richmond Terrace between Tysen Street and Clinton Street. New pedestrian signalization is anticipated at the intersection of Richmond Terrace and Clinton Street for pedestrian access. See Section 6.9 for traffic signal work. For further details on this BRT station, see Section 8.

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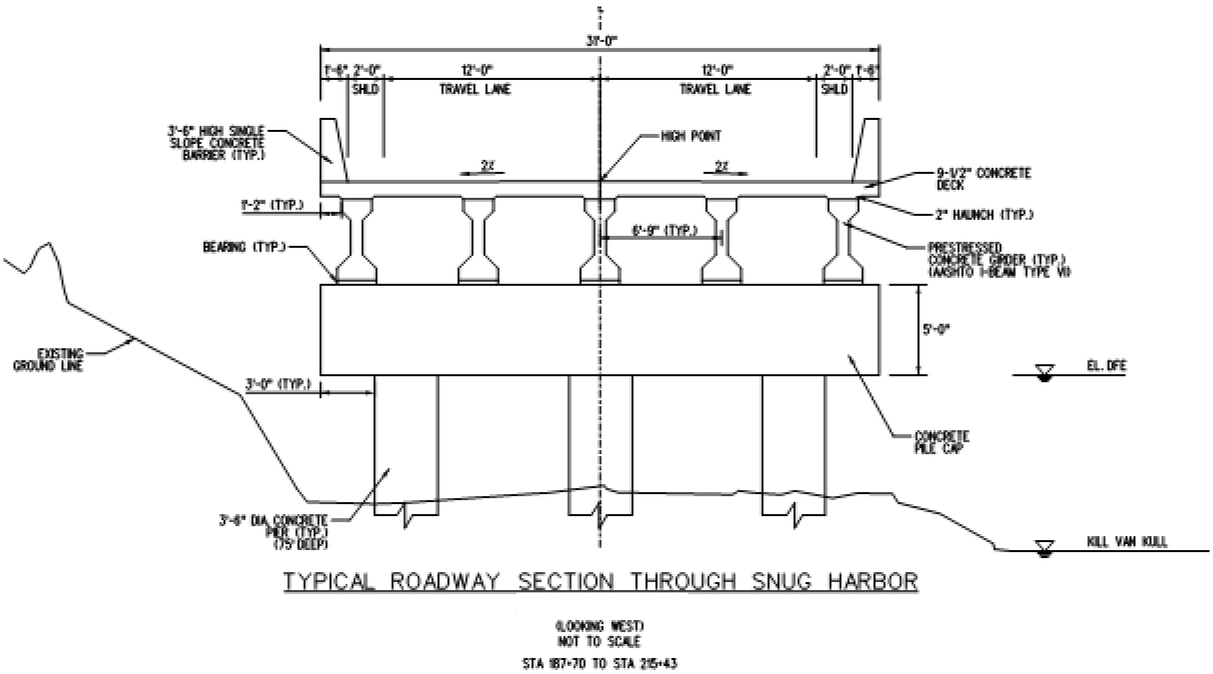

Figure 2.2.2.11   BRT Alignment Along Snug Harbor

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Former NSRR Exclusive ROW – At-Grade Section

East of the Atlantic Salt site, the BRT alignment would follow the original former NSRR ROW between Jersey Street and the proposed, elevated Nicholas Street ramp, roughly paralleling and to the north of Bank Street. Along this section, a grade difference exists between Bank Street and Richmond Terrace with an existing slope between Jersey Street and Westervelt Avenue and an existing retaining wall beginning from Westervelt Avenue and continuing east to St. George Terminal. The Richmond Terrace roadway elevation at Jersey Street is approximately 20 feet above sea level and rises to approximately to 38 feet above sea level at Nicholas Street while Bank Street roadway elevation at Jersey Street is approximately 9.5 feet above sea level and rises to approximately to 11 feet above sea level at Nicholas Street. The BRT alignment would occupy the space between Richmond Terrace and Bank Street. With the introduction of the BRT alignment, Bank Street roadway alignment, east of the turnaround that ends Jersey Street, would shift approximately 20 feet north and gradually transition back to the existing roadway alignment at Nicholas Street. The turnaround located on Bank Street, east of Jersey Street, would remain.

The BRT alignment would cross Jersey Street at-grade, where Bank Street begins. Jersey Street is a public roadway that is also used by trucks entering and exiting the Atlantic Salt site. Bank Street provides access for private vehicles to the former New York Wheel Parking Garage. Currently Jersey Street between Richmond Terrace and Bank Street is on a steep longitudinal slope (8.33%). By introducing an at-grade intersection with the BRT alignment to Jersey Street between Richmond Terrace and Bank Street, the grade would be raised by approximately 4 feet to improve the Jersey Street longitudinal slope to 5% by reducing the severity of the steep grade without cutting off access to the waterfront and businesses. Flattening the grade on Jersey Street while maintaining truck-turning radii at the busway intersection would improve the throughput for heavy vehicles stopped on Bank Street.

Along Bank Street, from the dead end located in front of the Atlantic Salt site to Nicholas Street, street reconstruction of the existing 24-foot roadway width and 5-foot north sidewalk width would be required to allow the BRT alignment to occupy the space between Richmond Terrace and Bank Street. Water main work is not anticipated with the street reconstruction as the existing 8 inch diameter watermain along Jersey Street was installed in 2000 and the existing 8 inch diameter watermain along Bank Street, from the dead end located in front of the Atlantic Salt site to approximately 90 feet east of the turnaround, was installed in 2000, as NYCDEP water main replacement age criteria apply to any distribution water main installed prior to and including 1970. Relocation of existing hydrants are anticipated as curbs would be relocated.

The busway intersection would be approximately 130 feet from the intersection with Richmond Terrace and 35 feet from the intersection with Bank Street. The grade crossing would be protected and signalized, with a hardwire connection to the Jersey Street / Richmond Terrace intersection. See Section 6.9 for traffic signal work.

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A line of soil stockpiles, covered by tarps and partially vegetated for maintenance, extends along the ROW between Bank Street and the Richmond Terrace retaining wall just north of the North Shore Esplanade. The soil was excavated primarily during construction of the former New York Wheel parking garage. It is assumed that disposition of the stockpiles by the City or future NY Wheel tenant will occur prior to construction and that no contamination from the stockpiled material will remain in the ROW

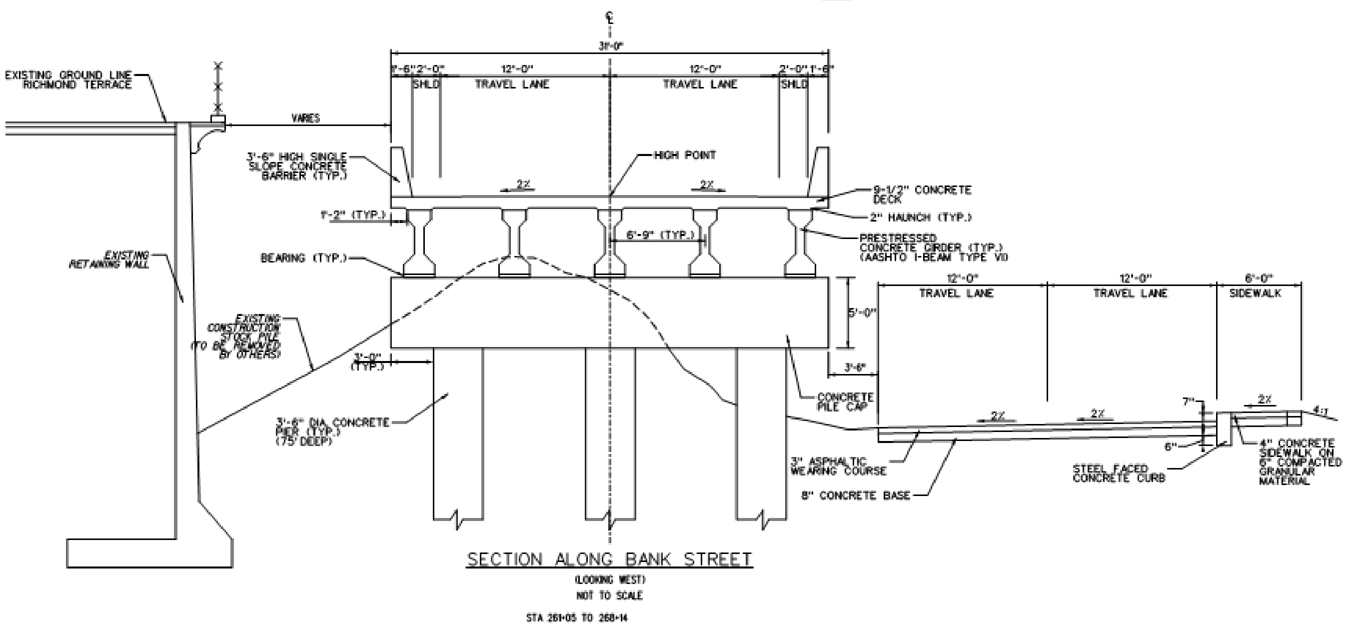

Figure 2.2.2.13 Nicholas Street Ramp Along Bank Street

2.2.3 Richmond Terrace Section

The BRT alignment would ascend to Richmond Terrace section via a 709-foot long elevated ramp structure which addresses the approximately 25 feet grade separation between Richmond Terrace and Bank Street, at Nicholas Street and would share this intersection with the existing access ramp to the former New York Wheel Garage ramp. The BRT alignment would transition from exclusive busway to dedicated median Bus-Only lanes within Richmond Terrace from Nicholas Street at its western end to the crosswalk leading to St. George Terminal just west of the intersection with Bay Street at its east end.

The median BRT would be comprised of two (2) 11-foot wide travel lanes each with (1)-foot wide striped area on both sides, to provide separation from regular traffic along Richmond Terrace, with priority given to transit at traffic signals. Traffic signals are discussed further in Section 6.9 In the vicinity of Nicholas Street, the existing Richmond Terrace consists of a two-way, four-lane roadway with a 4-foot wide raised median and sidewalks.

From Nicholas Street to Schuyler Street, some changes to Richmond Terrace would be made to accommodate the BRT. NYCDOT has requested the configuration allow for shared/through turn bays/lanes along Richmond Terrace between Schuyler Street and Wall Street. The New York City Police Department (NYPD) has requested that the configuration maintain existing 90-degree parking and 120th Precinct driveway access along Richmond Terrace from Hamilton Avenue to Wall Street. This would require reconstruction of all exterior stairs, including retaining wall and berm, leading up to the 120th Police Precinct Station House and Staten Island Family Courthouse fronting Richmond Terrace. To accommodate the above requests and allow the BRT median Bus-Only lanes to occupy the street cross-section, existing 4-foot wide raised medians would need to be removed from Stuyvesant Place to Schuyler Street, narrowing the south sidewalk width from Stuyvesant Place to Wall Street. Narrowing of the north sidewalk width 140 feet east of Wall Street would be necessary to the cross section. Curb to curb roadway resurfacing along Richmond Terrace would be required from Nicholas Street to Bay Street.

The BRT dedicated median Bus-Only lanes would start and terminate at the crosswalk leading to St. George Terminal, just west of Bay Street, and would be in mixed traffic operations east of this point to the Richmond Terrace intersection with the ramp to the St. George Terminal bus ramp. Four-foot-wide raised medians would be reconstructed and realigned from Schuyler Street to Bay Street.

At Bay Street, the BRT alignment would enter the St. George Terminal in the alignment of existing Upper Level Ferry Terminal Viaduct to access the existing bus deck. The BRT alignment within St. George Terminal would utilize the existing queue area for taxis to allow for a high-quality transfer between the bus deck and the ferry terminal. For further details on this BRT station, see Section 8.

Watermain work is anticipated with the narrowing of the south sidewalk width from Stuyvesant Place to Wall Street as NYCDEP water main replacement age criteria apply to any distribution watermain installed prior to and including 1970. There is a section of existing 12-inch diameter watermain, installed in 1936, and an existing 24-inch diameter watermain, installed in 1911, that located along Stuyvesant Place and entering Richmond Terrace heading west under and close to the south sidewalk work. In addition, there is an existing 12-inch diameter watermain, installed in 1948, along the south sidewalk from Hamilton Avenue to Wall Street. The relocation of existing hydrants is anticipated as curbs would be relocated.

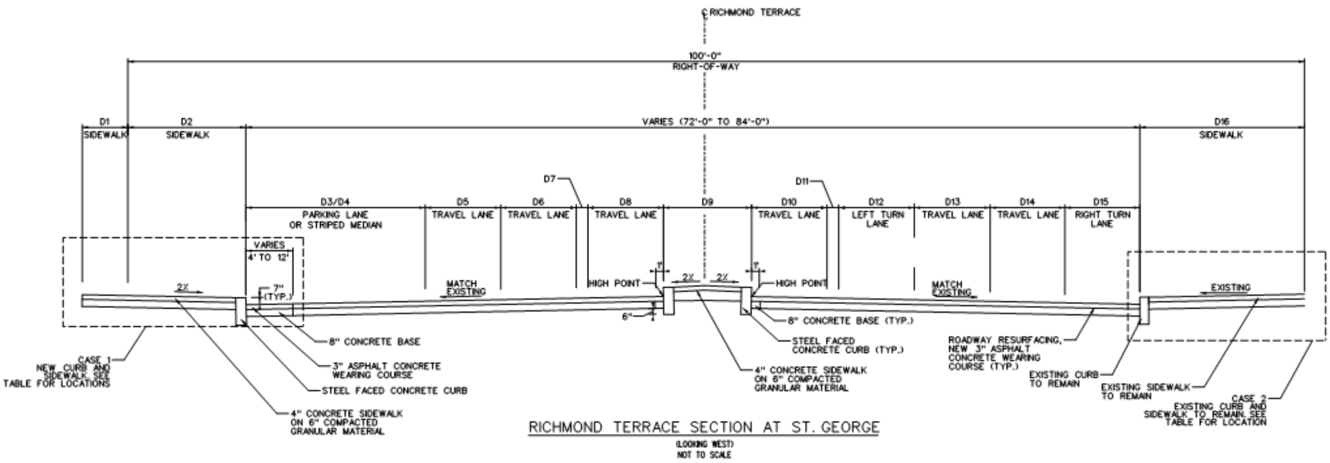

Figure 2.2.3.1 BRT Alignment Along Richmond Terrace at St. George. For cross section width values see below table.

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Richmond Terrace at St. George Cross Section Width Table

Cross Section Width Description	Location				
	Nicholas Street to Stuyvesant Place	Stuyvesant Place to Hamilton Avenue	Hamilton Avenue to Wall Street	Wall Street to Schuyler Street	Schuyler Street to Bay Street
Back of ROW Width - D1 (ft)	-	-	3*	-	-
West Sidewalk Width - D2 (ft)	14	10*	2*	14	14
Southbound Parking Lane Width - D3 (ft)	-	-	18	-	-
Southbound Striped Shoulder Width - D4 (ft)	-	-	-	2	-
Southbound Travel Lane Width - D5 (ft)	11	11	11	11	12
Southbound Travel Lane Width - D6 (ft)	11	10	11	10	10
Southbound Striped Area Width - D7 (ft)	1	1	-	1	1
Southbound BRT Travel Lane Width - D8 (ft)	11	11	11	11	11
Roadway Median Width - D9 (ft)	4	-	-	-	4*
Northbound BRT Travel Lane Width - D10 (ft)	11	11	11	11	11
Northbound Striped Area Width - D11 (ft)	1	1	-	1	1
Northbound Left Turn Lane Width - D12 (ft)	-	10	-	-	-
Northbound Travel Lane Width - D13 (ft)	11	10	10	10	10
Northbound Travel Lane Width - D14 (ft)	11	11	11	11	12
Northbound Right Turn Lane Width - D15 (ft)	-	-	-	10	-
East Sidewalk Width - D16 (ft)	14	14	14	8*	14

*Denotes new sidewalk and curbs are required. See conceptual drawings for limits along block face.

2.3 CODES, STANDARDS, REGULATIONS, GUIDELINES, MANUALS, AND REFERENCED STANDARDS

The project will be designed to conform with Codes, Standards and Regulations of Governing Agencies unless otherwise specified herein, would utilize the current editions including interim specifications. See Appendix D for listings.

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SECTION 3: EXCLUSIONS AND EXCEPTIONS TO DESIGN

The conceptual-level engineering for the Staten Island North Shore BRT and associated improvements meets all stated criteria, however there are exceptions to standard design practices and guidelines which are further described in this report. The list of exclusions to the conceptual-level engineering are as follows:

- Geotechnical investigation/soil borings;
- Physical soil testing;
- Environmental Phase II sampling and chemical soil testing;
- Groundwater sampling and testing;
- Lead, asbestos and PCB assessment surveys;
- Concrete and steel physical and destructive testing;
- Test pits for utility interferences;
- Ground Penetrating Radar (GPR) for existing/retired utility confirmation;
- GPR for potential unknown obstructions in excavation areas such as unidentified underground storage tanks;
- Electrical survey of the old SIR power system;
- Sewer condition survey via video taping.
- BRT vehicle maintenance and support facilities

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SECTION 4: VEHICLE CHARACTERISTICS

4.1 CRITICAL FACTORS

The busway geometry has been designed for the following elements:

- Articulated Bus (AASHTO A-BUS)
- Intercity Bus (AASHTO BUS-45)
- Intercity Bus (AASHTO BUS-40)
- Emergency vehicle (AASHTO SU-40 to account for FDNY ambulance and NYPD)
- Snow Removal vehicle (AASHTO SU-40 to account for DSNY Plowable Trucks)

4.2 BUSES

BRT buses would be Low or No-Emission (Low-No) Bus through the busway that replaces aging diesel fuel buses with battery-electric or fuel cell-powered vehicles and includes other modernizations.

Replacing traditional buses with electricity-powered buses that generate low or no emissions would lessen reliance on fossil fuel, reduce greenhouse gas emissions and improve operating efficiency. It is anticipated that BRT charging would occur at the existing Castleton Bus Depot (see Section 11 for additional detail).

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SECTION 5: CRITICAL PHYSICAL CONSTRAINTS

5.1 FORMER NORTH SHORE RAILROAD RIGHT-OF-WAY

The proposed improvements have been designed to remain within the existing former NSRR ROW with various physical space limitations. A list of investigated physical constraints are provided below and described within this report.

- Existing Arlington Yard freight terminal tracks and tail track (and potential future extension)
- Existing overhead local bridges and Bayonne Bridge approach piers and footings
- Delineated inland wetlands
- Consolidated Edison property and driveway access south of the proposed Arlington Station
- Consolidated Edison shared use space agreement at the proposed Livingston Station
- Maintain existing access to Heritage Park
- Maintain existing access to Caddell Dry Dock from Broadway
- Maintain portion of 1483 Richmond Terrace building at Caddell Dry Dock
- Maintain existing curb cut access to Bard Avenue from gas station
- Maintain existing pedestrian access to shoreline from Richmond Terrace at Snug Harbor
- Maintain existing access to Atlantic Salt from Jersey Street
- Existing tunnel structure at Atlantic Salt
- Maintain existing access at Jersey Street
- Maintain existing turnaround along Bank Street, east of Jersey Street
- Existing Richmond Terrace retaining wall from Westervelt Avenue to St George Terminal
- Properties owned or under jurisdiction of NYC Department of Parks and Recreation
- Existing access ramp to the former New York Wheel Garage ramp
- Nicholas Street Ramp/Richmond Terrace access
- Richmond Terrace ROW width from Nicholas Street to Bay Street
- Maintain existing NYCDEP sewer crossings

5.2 WETLANDS

The proposed improvements have been designed with consideration for delineated inland wetlands. Flagged inland wetlands are identified for this project at three areas along the BRT alignment:

- West of South Avenue, and south of the freight rail right-of-way at Arlington Yard. The wetlands are located south and west of the proposed Arlington Station.

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- Alaska Street ramp west to NYCDEP Port Richmond Wastewater Treatment Plant
- Creek crossing at Snug Harbor east of Bard Avenue and south of Richmond Terrace

Additionally, freshwater and tidal wetlands are mapped both east and west of South Avenue in the Staten Island Industrial Park and the Modified alignment is located adjacent to open water along the Kill Van Kill.

5.3 LANDFILL

The proposed project has been conceptually designed to account for and avoid the former A&A Landfill, located west of South Avenue at Arlington.

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SECTION 6: CIVIL

6.1 GENERAL

This section presents the design criteria for general civil design for the project, including the design of roadways, grading, traffic control devices, drainage, and maintenance and protection of traffic during construction.

6.2 ROADWAY AND GRADING DESIGN

6.2.1 Responsible Agency

The design of new facilities and replacement of existing facilities, including roadways owned and/or maintained by agencies would be in accordance with the current standards of the agencies having jurisdiction over that facility. Other agencies that would have design jurisdiction over roadways, parking facilities, stations and pedestrian facilities are the Metropolitan Transportation Authority-New York City Transit (MTA-NYCT), New York State Department of Transportation (NYSDOT), New York City Department of Design and Construction (NYCDDC) and New York City Department of Transportation (NYCDOT).

6.3 ROADWAYS

6.3.1 General

New and reconstructed pavements have been designed to provide adequate support capacity for the projected traffic volumes for a 20-year design life of the pavement structure. Roadway design in City ROW would be in conformance with the specifications and design guidelines of NYCDOT. The criteria set forth in this section are applicable to the design of alterations of existing streets and sidewalks, new streets, parking lots and access roads.

6.3.2 Pavement Design

The design of pavement structures outside of the exclusive BRT busway and access roadways would be performed in accordance with the pavement design requirements of NYCDOT. For City streets, pavement material including full depth asphalt, full depth concrete and a composite pavement section, (concrete base with asphalt wearing course) would be evaluated to determine the most appropriate and cost-effective solution based on soil types, traffic characteristics and traffic volume. Additional pavement considerations arise from the weight and heat from idling bus fleet vehicles especially in the summer when ambient and air and pavement temperatures are at their highest. This could screen out asphalt pavement entirely which is susceptible to pavement rutting and shoving in high volume areas such as bus stops. NYCDOT uses 12’ thick concrete bus pads at all stops to combat this problem. Since the busway would be used by other buses including

BRT vehicles, the use of concrete pavement should be further studied in the next design phase based upon determination of how all user fleets will be propelled (i.e., electric, diesel or natural gas).

For the conceptual-level engineering, pavement for the exclusive BRT busway and access roadways have been designed to be a 12-inch concrete pavement over a 12-inch subbase course as this would provide a longer life and reduced maintenance cost over asphalt pavement. With 12-inch concrete pavement for the BRT busway, no bus pads at stations would be necessary, as per NYCDOT design standards. An appropriate concrete pavement surface texture (i.e. diamond grind) should be selected to limit tire noise and increase skid resistance of vehicles utilizing the BRT busway and access roadways.

Pavement Summary Table

From Station	To Station	Pavement Type	Description	Area (SY)
10+25	16+00	12” concrete pavement 12” aggregate subgrade	Arlington Station BRT	8292
10+80	14+07	12” concrete pavement 12” aggregate subgrade	Arlington Station Parking Lot	2342
15+19	15+89	12” concrete pavement 12” aggregate subgrade	Arlington Station Ped. Drop-Off Area	298
16+00	97+70	12” concrete pavement 12” aggregate subgrade	BRT Alignment	25644
18+85	29+19	3” asphalt wearing course 8” concrete base	Roxbury Street	3058
97+70	136+50	9” concrete pavement 12” lightweight concrete	Viaduct BRT (excluding bridges)	9023
99+08	99+71	12” concrete pavement 14” lightweight concrete	Treadwell Avenue Bridge	168
101+69	102+31	12” concrete pavement 14” lightweight concrete	Sharpe Avenue Bridge	165
106+11	106+80	12” concrete pavement 14” lightweight concrete	Faber Avenue Bridge	184
108+93	109+60	12” concrete pavement 14” lightweight concrete	Maple Avenue Bridge	179

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Pavement Summary Table (continue)

From Station	To Station	Pavement Type	Description	Area (SY)
113+53	114+38	12" concrete pavement 12" lightweight concrete	Port Richmond Avenue Bridge	227
117+74	118+57	12" concrete pavement 12" lightweight concrete	Park Avenue Bridge	222
122+37	123+04	12" concrete pavement 12" lightweight concrete	Richmond Terrace Bridge	179
136+50	188+00	12" concrete pavement 12" lightweight concrete	BRT Alignment	20230
142+04	142+70	12" concrete pavement 12" aggregate subgrade	Alaska Street Ramp	2271
147+29	147+63	3" asphalt wearing course 8" concrete base	Tompkins Court Crossing	279
155+15	155+62	3" asphalt wearing course 8" concrete base	Broadway Crossing	375
174+02	174+39	3" asphalt wearing course 8" concrete base	Caddell Crossing	124
180+00	186+60	12" concrete pavement 12" aggregate subgrade	Livingston Station Parking Lot	5995
186+60	187+16	3" asphalt wearing course 8" concrete base	Bard Avenue Ramp	581
188+00	215+00	9.5" concrete deck	Elevated Busway	8784
215+00	261+00	12" concrete pavement 12" aggregate subgrade	BRT Alignment	14311
261+00	268+50	9.5" concrete deck	Nicholas Street BRT Ramp	2334
243+00	243+53	3" asphalt wearing course 8" concrete base	Jersey Street Crossing	455
241+22	268+15	3" asphalt wearing course 8" concrete base	Bank Street	7965
267+91	293+96	3" asphalt wearing course	Richmond Terrace (mixed use), resurfacing	21902
280+19	284+74	3" asphalt wearing course 8" concrete base	Hamilton Ave to Wall Street (parking)	818

6.3.3 Soil Conditions

All known and available soil conditions from previous projects, including soil borings, monitoring wells and test pits in the project area, were gathered and examined for assessing the physical suitability of the in-situ soil strata for subgrade drainage and bearing capacity for the various improvements along the BRT alignment and at station locations. For further details on soil conditions, see Section 10.

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6.4 ROADWAY GEOMETRY

6.4.1 General

Geometric design is in accordance with New York State Department of Transportation (NYSDOT), New York City Department of Transportation (NYCDOT) standards, New York City Department of Design and Construction (NYCDDC) Guidelines and Directives Manual, and A Policy on Geometric Design of Highways and Streets, of the American Association of State Highway and Transportation Officials (AASHTO). This section includes basis of design for design speeds, horizontal alignment and vertical alignment.

6.4.2 Design Speeds

The BRT alignment, as requested by the MTA-NYCT Department of Buses, has been designed for an operating speed of 40 mph, with the posted speed at 35 mph, except through the following geometrically constrained locations:

- Maintain operating speed of 15 mph entering and exiting Arlington Station
- Maintain operating speed of 32 mph at curve through Caddell Dry Dock's primary grade crossing
- Maintain operating speed of 20 mph through Atlantic Salt's building foundation structure

The Alaska Street ramp has been designed for an operating speed of 20 mph with normal crown sections. Local streets have been designed for an operating speed of 25 mph or the posted operating speed whichever is greater with normal crown sections.

6.4.3 Horizontal Alignment

The BRT alignment has been designed using the following criteria:

- Through/Turn/Passing Lane Width: 12 feet (per AASHTO)
- Shoulder Width: Minimum. of 2 feet (per AASHTO), except at locations when the BRT alignment has limited horizontal clearance when traveling under or through existing structures to remain
- Minimum Radius of Curvature: 762 feet (per AASHTO LOCAL STREETS 40 MPH Design Speed), except for locations noted above with operating speed less than of 40 mph
    - Turning radii to accommodate an articulated bus (A-BUS) design vehicle, as requested by the MTA-NYCT
- Lateral Clearance Along Railroad Tracks: Minimum of 9 feet to centerline of track (per AREMA)
- No Superelevation: MTA-NYCT stated that buses have difficultly moving from a hard

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stop especially during inclement weather therefore increasing the cross-slope to maintain higher speeds does not consider stopped traffic

6.4.4 Vertical Alignment

The BRT alignment has been designed using the following criteria:

- Vertical Grading
  - Minimum of 0.5%, to provide a positive drainage gradient (per AASHTO), except as noted along Port Richmond Viaduct and through building foundation structure at Atlantic Salt
  - Maximum of 3.5%, as requested by the Metropolitan Transportation Authority Department of Buses to limit passenger discomfort
- Vertical Clearance
  - Minimum of 14.5 feet (as per NYSDOT Bridge Manual)
    - Atlantic Salt provided limited survey of the existing tunnel structure. Cross sections indicate a vertical clearance of approximately 13.72 feet at the eastern end of the structure along a longitudinal structural beam adjacent to the north face of centerline columns.
  - Minimum for pedestrian bridges to be 1 foot over the minimum vertical clearance. An additional 6 inches is desirable for future resurfacing (as per NYSDOT Bridge Manual)
    - BRT Stations with proposed pedestrian bridges are Arlington Station, West Brighton Station, Livingston Station and New Brighton Station.
- Stopping Sight Distance
  - 305 feet (per AASHTO 40 MPH Design Speed on Level Roadways)
  - 287 feet (per AASHTO 40 MPH Design Speed on 3.5% Upgrades)
  - 318 feet (per AASHTO 40 MPH Design Speed on 3.5% Downgrades)
- Design Rate of Vertical Curvature, (K Value)
  - 44 (per AASHTO 40 MPH for Crest Vertical Curves)
  - 64 (per AASHTO 40 MPH for Sag Vertical Curves)
- Vertical Curve
  - See Vertical Curve Table for K Value and Minimum Length of Proposed Vertical Curve

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Vertical Curve Table

Station of Point of Vertical Inflection (PVI)	Elevation of PVI	Length of Vertical Curve (ft)	Grade into Curve, % (G1)	Grade out of Curve, % (G2)	Minimum length of Vertical Curve (ft)	K Value of Proposed Curve
11+51.020	28.750	100	-0.500	0.500	64.000	100.000
23+52.340	34.760	50	0.500	-0.600	48.400	45.455
63+62.620	10.700	100	-0.600	0.600	76.800	83.333
85+27.470	23.750	50	0.600	0.700	6.400	500.000
97+96.930	32.570	50	0.700	0.270	18.920	116.279
115+52.690	37.380	50	0.270	-0.820	47.960	45.872
136+40.000	20.250	50	-0.820	-0.550	17.280	185.185
142+50.420	16.900	50	-0.550	-0.780	10.120	217.391
156+26.430	6.150	100	-0.780	0.500	81.920	78.125
168+84.030	12.460	50	0.500	-0.500	44.000	50.000
175+71.900	9.020	100	-0.500	0.500	64.000	100.000
187+16.940	14.690	200	0.500	3.500	192.000	66.667
191+76.490	30.780	150	3.500	0.500	132.000	50.000
202+48.910	36.170	50	0.500	-0.500	44.000	50.000
215+45.640	29.750	100	-0.500	-2.000	66.000	66.667
224+80.450	11.080	150	-2.000	-0.160	117.760	81.522
235+31.820	9.410	100	-0.160	0.700	55.040	116.279
242+96.990	14.750	100	0.700	-0.500	52.800	83.333
246+49.010	13.000	150	-0.500	1.200	108.800	88.235
264+15.930	34.230	50	1.200	0.500	30.800	71.429

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6.5 ROADSIDE SAFETY DESIGN

Roadway

Roadside safety design is an essential component of the total roadway design and has been considered during the conceptual design process. The goals of the roadside safety design are to create an unencumbered roadside recovery area which allows for errant vehicles to recover and supports a safe roadside design. Since not all roadside hazards can be removed, installing roadside barriers to shield unmovable objects or embankments may be an appropriate treatment. Barriers are hazards in and of themselves and should only be used when the barrier is less of a hazard than the object itself. Three main types of road barriers include flexible barriers, rigid barriers, and semi-rigid barriers. Roadside barriers considered along the BRT alignment consist of a permanent concrete barrier that is designed to redirect a vehicle into a path parallel to the barrier and generally require very little maintenance. Guide rails may be acceptable as an alternate.

Along the Port Richmond Viaduct, precast concrete barrier anchored to the precast concrete full depth deck locations with close proximity of existing building structures would be used. Bridge railing may be acceptable as an alternate during future design.

End treatments and crash cushions would be used to minimize the severity of impacts with fixed objects by gradually decelerating an impacting vehicle to a stop or redirecting it around the object of concern. An end treatment or terminal is normally used at the end of a roadside barrier where traffic passes on only one side of the barrier and in one direction only.

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Impact Attenuator Table

Station	RT/LT	Design Speed (MPH)
32+10	RT	40
38+20	RT	40
41+30	RT	40
46+70	RT	40
47+13	LT	40
47+63	RT	40
52+80	LT	40
56+80	LT	40
55+50	RT	40
59+60	LT	40
58+40	RT	40
67+75	LT	40
66+60	LT	40
67+20	RT	40
66+20	RT	40
73+00	RT	40
81+50	LT	40
97+84	RT	40
105+75	LT	40
109+25	RT	40
121+70	LT	40
122+90	RT	40
134+60	LT	40
140+47	RT	40
148+74	RT	40
154+00	LT	40
157+63	RT	40
174+94	RT	40
225+88	RT	40

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Concrete Roadside Barrier Table

From Station	To Station	RT/LT	Barrier Length (ft)	Barrier Type
15+70	16+70	LT	100	Single-Slope Concrete Half-Section (NYSDOT)
32+10	33+00	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
38+20	39+10	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
41+30	42+20	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
46+70	47+60	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
47+13	47+63	LT	50	Single-Slope Concrete Half-Section (NYSDOT)
47+13	47+63	RT	50	Single-Slope Concrete Half-Section (NYSDOT)
51+90	52+80	LT	90	Single-Slope Concrete Half-Section (NYSDOT)
51+80	52+70	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
55+90	56+80	LT	90	Single-Slope Concrete Half-Section (NYSDOT)
55+50	56+40	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
58+70	59+60	LT	90	Single-Slope Concrete Half-Section (NYSDOT)
58+40	59+30	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
66+85	67+75	LT	90	Single-Slope Concrete Half-Section (NYSDOT)
66+60	67+20	LT	60	Single-Slope Concrete Half-Section (NYSDOT)
66+60	67+20	RT	60	Single-Slope Concrete Half-Section (NYSDOT)
66+20	67+10	RT	90	Single-Slope Concrete Half-Section (NYSDOT)
73+90	74+70	LT	80	Single-Slope Concrete Half-Section (NYSDOT)
73+00	74+40	RT	140	Single-Slope Concrete Half-Section (NYSDOT)
78+95	81+50	LT	255	Single-Slope Concrete Half-Section (NYSDOT)
79+00	80+80	RT	180	Single-Slope Concrete Half-Section (NYSDOT)
97+84	134+60	LT	3676	Single-Slope Concrete Half-Section (NYSDOT)
97+84	134+60	RT	3676	Single-Slope Concrete Half-Section (NYSDOT)
105+75	109+25	LT	350	Single-Slope Concrete Half-Section (NYSDOT)
105+75	109+25	RT	350	Single-Slope Concrete Half-Section (NYSDOT)
121+70	122+90	LT	120	Single-Slope Concrete Half-Section (NYSDOT)
121+70	122+90	RT	120	Single-Slope Concrete Half-Section (NYSDOT)
187+70	212+60	LT	2490	Single-Slope Concrete Half-Section (NYSDOT)
187+70	212+60	RT	2490	Single-Slope Concrete Half-Section (NYSDOT)
214+00	234+30	LT	2030	Single-Slope Concrete Half-Section (NYSDOT)
214+00	234+30	RT	2030	Single-Slope Concrete Half-Section (NYSDOT)
225+88	234+29	LT	841	Single-Slope Concrete Half-Section (NYSDOT)
225+88	234+29	RT	841	Single-Slope Concrete Half-Section (NYSDOT)
261+05	268+14	LT	709	Single-Slope Concrete Half-Section (NYSDOT)
261+05	268+14	RT	709	Single-Slope Concrete Half-Section (NYSDOT)

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Railroad

A 12-foot high concrete crash wall, in accordance with the latest AREMA code, has been included between the BRT alignment and the rail in the depressed open-cut section, per the request of NYCEDC and PANYNJ. The limits of the crash wall account for a potential future eastward extension of the yard tail track from Union Avenue to Van Name Avenue. This potential freight rail extension, which would occur independent of the proposed BRT project, would allow the PANYNJ to enable longer trains to be assembled.

Crash Wall Table

From Station	To Station	RT/LT	Wall Length (ft)	Wall Width (ft)	Exposed Face of Wall Height (ft)
30+00	52+52	LT	2264	2.5	12

6.6 GRADING

Preliminary grading along the BRT alignment has been designed to maintain consistency with existing topographic conditions. The existing terrain in the project area is comprised of land with flat slopes to gradual slopes. Preliminary grading has been designed per the following criteria:

- Cut and fill slopes to be one vertical to six horizontal (1V:6H), per AASHTO, or as recommended by the Geotechnical Engineer in the next phase of design.
- Roadside slopes to be 1V:4H, maximum, as per AASHTO, but to be flattened as required for sight distance round curved alignments. Disturbance of existing roadside areas, especially those including vegetation and landscaping, to be minimized.
- Soil to be protected against erosion during construction and in final conditions using methods including, but not limited to, erosion control mats, sodding, application of geotextile fabrics to stabilize areas, and application of gravel or coarse rock.
- Roadway maintenance components such as surface maintenance, roadside and drainage maintenance, shoulder and approaches maintenance, snow and ice control, bridge maintenance and traffic service have been considered to minimize the occurrence of systemic failures and to mitigate their impacts when failures do occur.
- Pedestrian access to BRT station plaza and park-and-ride areas has been provided in accordance with the ADA Accessibility Guidelines.

Construction of the Proposed Project would require excavation and grading of the ground surface. Erosion and sediment control measures would be implemented during these soil disturbing activities, of one or more acres, in accordance with the latest edition of the New York State

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Standards and Specifications for Erosion and Sediment Control (Blue Book) and the Stormwater Pollution Prevention Plan (SWPPP) prepared to meet the requirements of State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity. Implementation of erosion and sediment control measures as outlined in the SWPPP would allow for groundwater recharge and minimize the potential for sediment discharges to infiltration basins or to New York's waters. The SWPPP would include procedures for stormwater runoff and sediment control to prevent contaminated sediment runoff into groundwater, nearby wetlands and New York's waters.

6.6.1 Retaining Walls

In areas where concrete or block type retaining walls are needed as a grading feature, back and front slopes have been designed to minimize the height of walls. The architectural treatment of exposed wall surfaces could be considered to lessen the visual impacts of the retaining walls and to be compatible with the context of the surrounding community's character, proportions/massing and building material types. Mechanically stabilized earth retaining walls may be acceptable as an alternate. Proprietary wall treatments made be substituted for traditional concrete retaining walls, as these products offer pleasing aesthetics and reduced cost while meeting the engineering metrics for internal, external and global stability.

Retaining walls are proposed at the following locations:

- New retaining wall is required to address the grade separation between the proposed BRT driveway north of Brabant Street and Consolidated Edison substation existing driveway.
- New retaining wall is required to address the grade separation behind the proposed BRT Arlington Station Kiss-and-Ride and Arlington Station.
- Remove existing retaining wall and install two new retaining walls due to the grade separation between Roxbury Street and the existing CSX freight yard as the BRT alignment enters the former NSRR Section between them. Face of retaining wall along the tracks would be 10 feet from the centerline of adjacent track (per AREMA, a minimum 9 feet from centerline track to face of wall is required)
- Remove existing retaining wall which conflicts with BRT alignment and install new retaining walls to support the reconstructed realigned 6-foot wide pedestrian walkway that connects Roxbury Street to South Avenue.
- New retaining walls are required to address the grade separation along the eastbound platform at Mariners Harbor Station between Van Pelt Avenue and Van Name Avenue.
- New retaining walls are required to address the grade separation at the new bus ramp to allow for access for buses onto and off the BRT alignment at Alaska Street.
- New retaining walls are required to address the grade separation between the BRT alignment and Richmond Terrace along the Caddell Dry Dock frontage.
- New retaining wall is required to address the grade separation between the BRT

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alignment and Kill van Kull along Livingston Station.

- For Snug Harbor, bridge approach at both ends would be constructed on fill before becoming a bridge structure. Refer to Section 9.6 – Snug Harbor Alignment. New retaining walls are required to address the grade separation between the fill-supported bridge approach and surrounding areas.
- New retaining walls are required to address the grade separation between the BRT alignment, Atlantic Salt site and Richmond Terrace along the Atlantic Salt frontage.
- At the proposed Nicholas Street ramp, the ramp would be constructed on fill before becoming a bridge structure. Refer to Section 9.8 – Nicholas Street Ramp. A new retaining wall is required to address the grade separation between the filled-supported ramp and Bank Street.

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Proposed Retaining Wall Dimensions

From Station	To Station	RT/LT	Wall Type	Wall Length (ft)	Wall Width (ft)	Exposed Face of Wall Height (ft)
10+77	15+47	RT	Retaining Wall	470	2	1 to 20
14+00	16+41	RT	Retaining Wall	342	2	1 to 20
16+41	29+24	RT	Retaining Wall with 8' Security Fence	1283	2	1 to 16
15+14	30+00	LT	Retaining Wall with 8' Security Fence	1490	2	4 to 7
16+40	16+74	RT	Retaining Wall with 8' Security Fence	65	2	10 to 12
17+50	18+62	RT	Retaining Wall with 8' Security Fence	113	2	1 to 2
47+53	48+51	RT	Retaining Wall	99	2	18 to 21
49+94	51+93	RT	Retaining Wall	231	2	18 to 20
140+47	142+18	RT	Retaining Wall	358	2	1 to 10
142+52	143+06	RT	Retaining Wall	231	2	1 to 9
148+74	153+20	RT	Retaining Wall with 8' Security Fence	435	2	4 to 12
148+50	154+00	LT	Retaining Wall w/ 8' Security Fence	550	2	Min. 1, Max 4
157+63	173+80	RT	Retaining Wall w/ 8' Security Fence	1616	2	1 to 13
174+94	179+04	RT	Retaining Wall w/ 8' Security Fence	422	2	2 to 11
180+51	187+68	LT	Retaining Wall w/ 8' Security Fence	734	2	1 to 17
187+17	187+72	RT	Retaining Wall	65	2	3 to 6
215+42	225+85	RT	Retaining Wall w/ 8' Security Fence	1049	2	1 to 13
215+42	225+85	LT	Retaining Wall w/ 8' Security Fence	1049	2	1 to 20
234+28	241+90	RT	Retaining Wall	766	2	1 to 20
240+00	242+57	LT	Retaining Wall	257	2	1 to 5
248+03	261+05	LT	Retaining Wall	1316	2	6 to 20

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6.6.2 Pavement Cross Slopes

A summary of the pavement cross slope criteria for this projects' paved areas is in accordance with NYCDOT, NYSDOT and AASHTO requirements shown in the table below.

Desirable Cross Slopes in Non-Superelevated Pavement Areas Table

Pavement Area	Desirable Cross Slope
Portland cement concrete and bituminous concrete pavement roads	2%
Roadway Shoulders	2% min 6% max
Paved parking and pedestrian pathway areas	2% min 5% max
City Streets	1.5% min 4.2% max

The cross slopes for the busway and the access ramps would be 2% with no superelevation. City street grades follow 1.5% to 4.2% for the cross section of the City streets. The minimum slopes for parking and pedestrian pathways generally provide for both safe passage of pedestrians and for adequate storm water runoff. The maximum difference between roadway cross slopes and roadway shoulders, known as the "rollover" cannot exceed 4% which defines the upward maximum limit of 6%.

6.6.3 Vertical Clearance

Above Roadways
See Section 6.4.4. for clearance requirements.

Above Railroads
The American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering indicates the vertical clearance (from top of high rail for the entire full horizontal width) is 23-foot. The CSX Industrial Sidetrack Manual - Standard Clearance Matrix is comparable to AREMA and also recommends a 23-foot vertical clearance above the top of rail.

The PANYNJ has indicated the current clearance requirements for the Howland Hook connecting tracks located within the former NSRR ROW is Plate H (double stack). The American Association of Railroads (AAR) Plate H standard consists of two high cube containers in a well car which accounts for a static vertical clearance of 20'-2". In addition to the state vertical clearance, an additional 4 inches are required for dynamic envelop clearance, totaling 20.5 feet for the double-stack vertical clearance requirement which is within New York State Railroad Law Section 51-a.

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This regulation states that the vertical clearance (involving railroads) is 22 feet between the top of the rail and any overhead wire, bridge, viaduct or obstruction.

6.7 PEDESTRIAN FACILITIES

6.7.1 Accessible Ramps and Curb Cuts

Locations of curb cuts and accessible pedestrian ramps would be in accordance with the applicable provisions of NYSDOT's Standard Sheets, NYCDOT's Street Design Standards and the USDOT's Standards for Accessible Transportation Facilities (to comply with ADAAG)

Accessible ramps with curb cuts to be provided are in accordance with the following criteria:

- Restore or replace any existing pedestrian ramps to current standards.
- New pedestrian ramps to be provided at intersections where a sidewalk exists, and the curb returns are modified as part of this project. Pedestrian ramps and curb cuts would be provided to accommodate temporary and permanently relocated sidewalks.
- Pedestrian ramps and curb cuts would be provided at intersections locations where new curbs and sidewalks would be constructed as part of this project.
- Pedestrian ramps and curbs would be provided at accessible parking spaces

Curbs along City Streets and the BRT alignment

When new steel faced concrete curbs are constructed, the height of the vertical curb face above the finished pavement elevation would be a maximum of 7 inches, as per NYCDOT standards. The curb face would be decreased to no less than a minimum of 4 inches along existing City streets and sidewalks to meet existing conditions and mitigate impacts to adjacent properties.

Curbs at BRT Stations

The height of the vertical curb face of steel faced concrete curbs above the finished pavement elevation would be 16 inches to match the bus floor height and provide level boarding for passengers.

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Curb Table

From Station	To Station	RT/LT	Steel-Faced Curb Reveal	Description	Length (ft)
10+25	16+00	RT/LT	7”	Arlington Station Area	4060
11+70	13+10	RT	16”	Arlington Station Platform	140
11+70	13+10	LT	16”	Arlington Station Platform	140
15+19	15+89	RT	7”	Arlington Station Kiss-N-Ride Area	228
15+78	15+90	RT	7”	South Avenue (city street)	302
18+85	29+19	RT	7”	Roxbury Street	2074
16+00	240+00	RT/LT	7”	BRT Alignment	42511
49+94	51+34	RT	16”	Mariners Harbor Station Platform	140
48+18	49+58	LT	16”	Mariners Harbor Station Platform	140
76+05	77+45	RT	16”	Elm Park/Morningstar Station Platform	140
76+05	77+45	LT	16”	Elm Park/Morningstar Station Platform	140
111+00	112+40	RT	16”	Port Richmond Station Platform	140
115+00	116+40	LT	16”	Port Richmond Station Platform	140
142+04	142+70	RT	7”	Alaska Street Ramp	1053
158+88	160+28	RT	16”	West Brighton Station Platform	140
158+88	160+28	LT	16”	West Brighton Station Platform	140
183+60	185+00	RT	16”	Livingston Station Platform	140
183+60	185+00	LT	16”	Livingston Station Platform	140
180+00	186+60	RT	7”	Livingston Station Parking Lot	2013
212+55	213+95	RT	16”	New Brighton Station Platform	140
212+55	213+95	LT	16”	New Brighton Station Platform	140
240+00	267+91	RT/LT	7”	BRT Alignment	5117
241+22	268+15	LT	7”	Bank Street	4962
267+91	293+96	RT/LT	7”	Richmond Terrace	2714
294+50	294+50	LT	16”	St. George Station Platform	283

6.7.2 Sidewalks and Raised Medians

Sidewalks along or that interface with City streets (predominantly along Richmond Terrace, South Avenue, Roxbury Street, Heusden Street, Morningstar Road, Newark Avenue, Eaton Place, Port Richmond Avenue, Heritage Park crossing, Broadway crossing at Caddell Dry Dock, Elizabeth Avenue crossing at Caddell Dry Dock, Bard Avenue, Bank Street and Jersey Street) and all station areas would be in accordance with ADAAG, NYSDOT and NYCDOT Design Guidelines. At a minimum, all sidewalks would be 5 feet in clear width. Existing sidewalks and raised medians disturbed by the project would be repaired replaced in kind.

6.7.3 Crosswalks

Crosswalks along the BRT alignment or that interface with City streets (South Avenue at the new Arlington Station curb cut, Heritage Park crossing, the Broadway and Elizabeth Avenue crossings at Caddell Dry Dock, Bank Street at Jersey Street and predominantly along Richmond Terrace at

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St. George) would be in accordance with the standards of ADAAG, NYSDOT and NYCDOT Design Guidelines. At a minimum at signalized crossings, crosswalks should be wide enough to accommodate pedestrian flow in both directions within the duration of the pedestrian signal phase. The location of the pedestrian ramp should be carefully coordinated with respect to the crosswalk lines. The bottom of the pedestrian ramp should be situated within the parallel boundaries of the crosswalk markings and should be perpendicular to the face of the curb, or bottom grade break, without warping in the sidewalk or pedestrian ramp.

6.7.4 Visibility from Adjacent Properties

The architectural treatment of pedestrian facilities, including egress and access stairs, have been designed to be compatible with all surrounding development as it relates to building character, proportions/massing and building materials.

6.8 DRAINAGE DESIGN

Drainage design and stormwater management are critical requirements in the design. Drainage includes the process of removing storm runoff by artificial conveyance and the area from which waters are drained. Drainage features would be provided to protect the roadway, adjacent properties, and the traveling public from water, while maintaining water quality and protecting other environmental resources. Storm runoff would be directed toward the necessary features of the drainage system.

See Appendix A for Preliminary Drainage Report.

6.8.1 New Culverts

New culverts for carrying natural waterways and new storm sewers underneath the BRT alignment would be in accordance with the standards and requirements of the New York State Department of Environmental Conservation (NYSDEC), NYSDOT and NYCDEP.

6.8.1.1 Relocation or Modification

Relocation or modification of existing drainage facilities belonging to other agencies or private owners would be designed in accordance with the applicable design criteria and standard requirements of those entities. Existing capacities and materials would be compatible with the existing drainage system. In general, required relocation of existing drainage facilities would be “replacement-in-kind” or “of equal construction”.

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6.8.1.2 New Drainage Connections

New drainage connections into existing storm drainage system would be in conformance with the requirements and standards of NYCDEP.

During construction, dewatering or any activity impacting groundwater elevations system would be in accordance with the requirements of NYSDEC. Dewatering discharge flows to the existing drainage system would be permitted through NYCDEP.

6.8.1.3 Water Quality

Water quality discharge would be in conformance with the requirements and standards of NYSDEC General Permit for Stormwater Discharge, as outlined in the latest edition of the New York State Stormwater Management Design Manual.

Water quality for the storm water discharge during construction would be in accordance with the requirements of Article 17, Titles 7, 8 and Article 70 of the NYS Environmental Conservation Law.

6.8.2 Hydrology and Hydraulic Design

6.8.2.1 Drainage Design Standards:

Hydrologic analysis would be in accordance with the procedures and criteria as described in the current version of the U.S. Natural Resources Conservation Services Technical Release No. 55 (TR-55) for State owned systems, or Rational Method for NYCDEP systems. New roadway drainage hydraulic design would be in accordance with NYCDEP Rules Governing the Design and Construction of Private Sewers and Drains, for closed drainage systems, NYCDEP Criteria for Detention Facility Design (November 2012), and NYCDEP Sewer Design Standards (January 2009). New roadway drainage design for facilities where NYSDOT holds jurisdiction would be designed in accordance with the NYSDOT Highway Design Manual, Chapter 8. New roadway drainage design for facilities where NYCDOT holds jurisdiction would be designed in accordance with NYCDEP Rules and Regulations. The maximum allowable spread would be half the width of the travel lane for the design storm.

6.8.2.2 Connections to Existing Systems

Where connections to existing systems are proposed, downstream conditions would be checked to confirm that the existing system has adequate capacity to accommodate proposed conditions. The review would include an investigation of outlet conditions to determine the type of outlet control under which the existing system(s) is operating. Connections to existing sewer systems would be in accordance with New York City Sewer Use Regulation Title 15, Chapter 19 (New York City Department of Environmental Protection Site Connection Permit).

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6.8.3 Storm Sewers

6.8.3.1 General

Storm sewers would be designed in accordance with NYSDOT Highway Design Manual, Chapter 8 NYCDEP Rules and Regulations Governing the Construction of Private Sewers and Drains.

The minimum diameter for catch basin connections to City sewers would be 12 inches. The minimum diameter for storm/combined sewer lines would be 15 inches.

Under no circumstances would storm drainage be diverted to sanitary sewer systems. Connections to combined sewers may be permitted provided all stipulations regarding site detention of with New York City Sewer Use Regulation Title 15, Chapter 19 (NYCDEP Site Connection Permit) are adhered to.

Drainage structures would be provided at changes in pipe slope, alignment, size, and at multiple pipe intersections. Recommended and maximum manhole spacing would be as required in NYCDEP Sewer Design Standards.

Catch basins would be Type 1 or Type 3 and would have hoods.

6.8.3.2 Pipe Materials

Pipe materials would be made of reinforced concrete or ductile iron pipe, Class 56 within City streets.

6.8.4 Culvert Inlets and Outlets

6.8.4.1 General

All inlets would be designed with grates. An investigation into the need for debris control at proposed culvert inlets would be performed in accordance with FHWA HEC-9.

6.8.4.2 Erosion Control

Erosion control measures would be considered during the design in an effort to prevent siltation of channels, wetlands, streams and sewer systems. Silt fences, vegetation covers, erosion control mats, sodding, hay bales, or other measures would be utilized to prevent erosion both during construction and in final conditions.

6.8.5 Underdrains

Underdrains would be designed in accordance with NYSDOT Highway Design Manual, Section

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9.3.8.

Underdrain cleanouts would be provided at 300 feet centers, maximum. A cleanout would be provided for each 90-degree bend and for each two 45-degree bends.

6.9 TRAFFIC SIGNALS

6.9.1 General

Along the alignment, the BRT would require modifications to existing signalized intersections, as well as new signalized intersections at key crossing points. These modifications are described below, in order from the eastern end of the alignment in St. George to the western end of the alignment in Arlington. Please note that while the descriptions below note that many signals or crossings would be maintained, these may need to be physically shifted or slightly relocated in order to accommodate the changes in roadway geometry.

- Intersections along Richmond Terrace, from pedestrian crossing in front of the Ferry Terminal, to the entrance ramp at Nicholas Street, would be outfitted with LRT (Light Rail Transit)-style signal heads, as specified in the Manual on Uniform Traffic Control Devices (MUTCD) Section 4D.27.18. These dedicated transit-only signals would control movement along the center busway. These LRT-style signal heads would be in addition to the existing signal heads present at each of these intersections, which would remain in place and would continue to control the non-transitway movements. At the intersections between the ferry terminal and Nicholas Street, all existing signalized pedestrian crossings would be maintained. At these intersections, the MTA and NYCDOT will study the activation of TSP equipment in order to prioritized bus operations along this corridor.

  MUTCD allows for LRT style signals to be used on busways. They are visibly different than general green/yellow/red ball signals, and as a result there’s a reduced chance of driver confusion. For a scenario on Richmond Terrace where we have a busway very close and immediately parallel to general purpose lanes, we run the risk of drivers misinterpreting the busway signals for their own if we use conventional ball signals. The different style signal head is the only distinguishing feature. Please see the snip below from MUTCD. We’re discussing dedicated signal heads shown in the first column top row for the BRT approaches.

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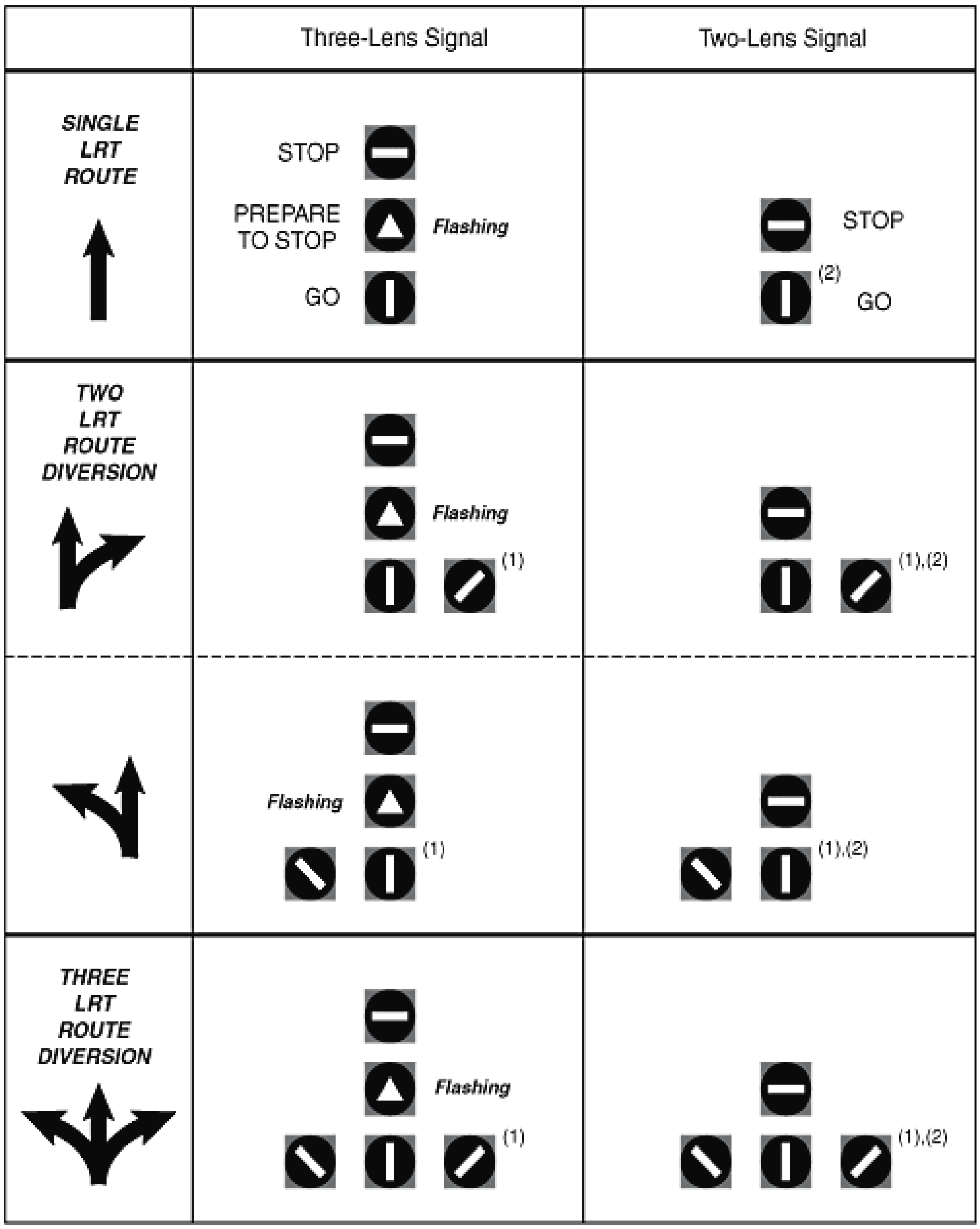
Figure 10D-1. Examples of Light Rail Transit Signals



Notes:
All aspects (or signal indications) are white.
(1) Could be in single housing.
(2) “Go” lens may be used in flashing mode to indicate “prepare to stop”.

- At Richmond Terrace and the pedestrian crossing in front of the Ferry Terminal and the Richmond County Surrogate's Court, the existing crosswalk and crosswalk signals would remain. The existing vehicle signals for general purpose lanes would remain. Additional LRT-style signals would be deployed in each direction to control access to/from the busway. Generally, the busway would be given the same phase as general-purpose traffic along Richmond Terrace.

- At Richmond Terrace and Schuyler Street, signage would be added to indicate that northbound left turns from Richmond Terrace onto Schuyler Street are prohibited. Also, signs would be added to prohibit crossings across Richmond Terrace, which is currently not marked with a crosswalk. All signage changes will be coordinated with NYCDOT's Brough Engineering group.

- At Richmond Terrace and Wall Street, the existing crosswalks and crosswalk signals would remain. The existing vehicle signals for general purpose lanes would remain. Additional LRT-style signals would be deployed in each direction to control access to/from the busway. At this location, the busway would be given its own phase, separate from the general-purpose traffic along Richmond Terrace and along Wall Street. The signal would operate as a three-phase signal.

- At Richmond Terrace and Hamilton Avenue, the existing crosswalks and crosswalk signals would remain. The existing vehicle signals for general purpose lanes on Richmond Terrace would remain. Additional LRT-style signals would be deployed in each direction to control access to/from the busway. Generally, the busway would be given the same phase as general-purpose traffic along Richmond Terrace. Signage would be added to indicate that northbound left turns from Richmond Terrace onto Hamilton avenue are prohibited.

- At Richmond Terrace and Stuyvesant Place, this intersection would be newly signalized. Crosswalks would be provided across Stuyvesant Place, as well as across Richmond Terrace on both sides of Stuyvesant place. Each crosswalk would have associated crosswalk signals. General traffic in the northbound and southbound directions of Richmond Terrace would be given new green/yellow/red ball signals. Traffic making a northbound left from Richmond Terrace onto Stuyvesant Place would be accommodated in a new left turn bay and would be given a green/yellow/red left arrow signal head. Generally, the busway would be given the same phase as through movements for general purpose traffic along Richmond Terrace. The northbound left would be given its own phase.

- At Richmond Terrace and Nicholas Street, the existing crosswalks and crosswalk signals

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would remain. The existing vehicle signals for general purpose lanes on Richmond Terrace and Nicholas Street would remain. Additional LRT-style signals would be deployed in each direction to control access to/from the busway. Generally, the busway would be given its own phase separate from general purpose traffic along Richmond Terrace and Nicholas Street.

- A new signal at Jersey Street and Bank Street, tied into the controller at Richmond Terrace and Jersey Street. New green/yellow/red ball signals would be provided for the northbound approach of Jersey Street and for the eastbound/westbound approaches at Bank Street. Additional LRT-style signals would be deployed in each direction to control access to/from the busway. Generally, the busway would be given its own phase separate from general purpose traffic. Crosswalks and crosswalk signals would be provided across the busway and Bank Street. The MTA and NYCDOT will study the activation of TSP equipment at this location in order to prioritize bus operations along the busway.

- At Bard Avenue, there would be an entrance to the busway. This entrance would be accessed via Bard Avenue and would be controlled by a lift-gate that can be opened by a signal from bus drivers. This entrance would be stop controlled for buses turning onto the busway. No signals would be required at this location.

- On Caddell Dry Dock property, near Elizabeth Avenue, there would be a new signal providing access across the busway between the northern portion and southern portion of Caddell property. There would be one crosswalk across the busway and associated crosswalk signals. There would be new green/yellow/red ball signals for the northbound/southbound approaches. LRT-style signals would be deployed in each direction to control access to/from the busway. Signage would indicate that no turns would be permitted onto or off of the busway. The MTA and NYCDOT will study the activation of TSP equipment at this location in order to prioritize bus operations along the busway. The default phase would allow the crossing to go unless the busway phase is called.

- On Caddell Dry Dock property, at Broadway, there would be a new signal providing access across the busway between the northern portion and southern portion of Caddell property. There would be one crosswalk across the busway and associated crosswalk signals. There would be new green/yellow/red ball signals for the northbound/southbound approaches. LRT-style signals would be deployed in each direction to control access to/from the busway. Signage would indicate that no turns would be permitted onto or off of the busway. The MTA and NYCDOT will study the activation of TSP equipment at this location in order to prioritize bus operations along the busway. The default phase would allow the crossing to go unless the busway phase is called. The signal would also be tied into the

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phasing of the signal at Richmond Terrace and Broadway.

- Within Heritage Park, near Tompkins Court, there would be a new signal providing access across the busway between the to the park and the parking lot. There would be one crosswalk across the busway and associated crosswalk signals. There would be new green/yellow/red ball signals for the northbound/southbound approaches. LRT-style signals would be deployed in each direction to control access to/from the busway. Signage would indicate that no turns would be permitted onto or off of the busway. The MTA and NYCDOT will study the activation of TSP equipment at this location in order to prioritize bus operations along the busway. The default phase would allow the crossing to go unless the busway phase is called.

- A new ramp would extend from the intersection of Richmond Terrace to the busway at Alaska Street. The southbound approach of the ramp to Richmond Terrace would be controlled by a stop sign. Richmond Terrace would remain uncontrolled. Where this new ramp intersects with the busway, the northbound approach of the ramp would be controlled by a stop sign. Eastbound and westbound movement on the busway would be uncontrolled.

- On South Avenue, immediately north of the intersection of South Avenue and Brabant Street, there would be a new signalized intersection controlling access into/out of the new Arlington Station bus terminal. New green/yellow/red ball signals would be provided for the northbound and southbound approaches of South Avenue, and for the eastbound approach of the bus terminal entrance. One crosswalk and associated crosswalk signals would be provided across South Avenue immediately north of the intersection, and one crosswalk and associated crosswalk signals would be provided across the bus terminal entrance.

- No modifications to the control devices would be made to any of the intersections between Arlington Station and West Shore Plaza.

6.9.2 New Traffic Signals

New vehicle and pedestrian traffic signals and appurtenances in connection with traffic controls required for the BRT alignment would be designed in conformance with the requirements and standards of NYCDOT.

6.9.3 Relocation or Modification

Relocation or modification of existing vehicle and pedestrian traffic signals and appurtenances would be designed in accordance with the applicable design criteria and standard requirements of NYCDOT. Existing equipment would be compatible with the existing traffic signal system. In general, the required relocation of existing traffic signal equipment would be "replacement-in-kind" or "of equal construction".

New traffic signal equipment would be compatible with the existing traffic signal system and would be in conformance with the requirements and standards of NYCDOT.

During construction, existing traffic signal services would not be interrupted. Existing signalized intersections, along city streets, would be temporarily signalized until installation of new traffic signal equipment are energized. Temporary traffic signals would be coordinated with NYCDOT.

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SECTION 7: UTILITIES

7.1 GENERAL

This section presents the basis of design for new utility construction, and the support, maintenance, relocation and restoration of existing utilities encountered or affected by the North Shore BRT Project construction. The proposed design would avoid impacts to major facilities. However, utility replacement and relocations would be necessary where a line conflicts with the proposed improvements, or where facilities lack cover over the utility that would otherwise be reduced to cover less than the allowable minimum.

Where utility plates were provided by the owners of record, the following tables summarizes the various utilities affected by the North Shore BRT Project. The overall utility investigation is not considered complete until the remaining private property access has been granted and coordination has taken place.

NYCDEP Sewer Impact Table

Location	Replacement of Lines ONLY	Existing to Remain	Notes
On-Street Exclusive Lanes: Richmond Terrace			
10”, 16”, 18”, 20”, 22”, and 24” combined sewers in Richmond Terrace	-	*	
Regulator and 30” CSO in Hamilton Avenue	-	*	
Former North Shore Railroad (At-Grade Section)			
Regulator and CSO (unknown size) in Saint Peter’s Place	*	-	150 LF
Regulator and 72” x 54” CSO in Jersey Street	*	-	150 LF
Regulator and 15” CSO in Franklin Avenue	-	*	
27” Storm Outfall in Lafayette Avenue	*	-	150 LF
Regulator, 36” CSO, and Storm Outfall (unknown size) in Clinton Avenue	*	-	150 LF
Regulator and CSO (unknown size) west of Snug Harbor	*	-	150 LF
Regulator and 20” CSO in Kissel Avenue		*	
Regulator and 18” CSO in Bard Avenue	*	-	150 LF
84” Storm Outfall in Davis Avenue	*	-	150 LF
Regulator and 12” CSO in Elizabeth Avenue	*	-	150 LF

Location	Replacement of Lines ONLY	Existing to Remain	Notes
Regulator, 12” CSO, and 36” x 45" Storm Outfall in Bement Avenue	*	-	150 LF
Regulator and 15” CSO in Broadway	*	-	150 LF
96” x 60" Storm Outfall in Alaska Street	-	*	
Former North Shore Railroad (Viaduct)			
Regulator and 20” CSO between Taylor Street and Alaska Street	-	*	
Regulator and 18” CSO in Bodine Street	-	*	
12” Storm Outfall in Herberton Avenue	-	*	
15” Sanitary Sewer, 12” Storm Sewer, and 54” Interceptor in Richmond Terrace	-	*	
6” Sanitary Sewer and 12” Storm Sewer in Park Avenue	-	*	
12” Sanitary and 40” x 36" Combined Sewer in Port Richmond Avenue	-	*	
9” Sanitary Sewer in Maple Avenue	-	*	
6” Sanitary Sewer and 18” Storm Sewer in Faber Street	-	*	
8” Sanitary Sewer in Sharpe Avenue	-	*	
8” Sanitary Sewer in Treadwell Avenue	-	*	
104” x 60" Combined Sewer in Nicholas Avenue	-	*	
Former North Shore Railroad (Open Cut)			
6” Sanitary Sewer in John Street	*	-	150 LF
6” Sanitary Sewer in Eaton Place	*	-	150 LF
26” x 39" Sanitary Sewer in Morningstar Road	*	-	150 LF
24” Combined Sewer in Winant Street	*	-	150 LF
12” Combined Sewer in Houseman Avenue	*	-	150 LF
12” Combined Sewer in Lake Avenue	*	-	150 LF
12” Sanitary Sewer in Simonson Avenue	*	-	150 LF
9” Sanitary Sewer in Van Pelt Avenue	*	-	150 LF
6” Sanitary Sewer in Union Avenue	*	-	150 LF
24” Sanitary Force Main in Lockman Avenue	*	-	150 LF
10” Sanitary Sewer in Roxbury Street	-	*	

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Location	Replacement of Lines ONLY	Existing to Remain	Notes
12” Storm Sewer in Roxbury Street	-	*	
On-Street Mixed Traffic: South Avenue			
6”, 8”, 10”, 36”, 42” Sanitary Sewers in South Avenue	-	*	
24”, 91”, 98”, 120”, 192” Storm Sewers in South Avenue	-	*	
12”, 18”, 24”, 36” Combined Sewers in South Avenue	-	*	
16” Force Main in South Avenue	-	*	

NYCDEP Watermain Impact Table (Installed prior to and including 1970)

Location	Replacement of Lines ONLY	Support & Protect	Existing to Remain	Notes
On-Street Exclusive Lanes: Richmond Terrace				
16" watermain in Richmond Terrace, from Bay Street to Schuyler Street (1948)	-	-	*	
12" watermain in Richmond Terrace, from Schuyler Street to Wall Street (1948)	-	-	*	
12" watermain in Richmond Terrace, from Wall Street to Hamilton Avenue (1948)	*	-	-	450 LF
8" watermain in Richmond Terrace, from Wall Street to Hamilton Avenue (2001)	-	-	*	
12" watermain in Richmond Terrace, from Stuyvesant Place to Nicholas Street (1936)	*	-	-	320 LF
24" watermain in Richmond Terrace, from Stuyvesant Place to Nicholas Street (1911)	*	-	-	320 LF
Former North Shore Railroad (At-Grade Section)				
8" watermain in Jersey Street (2000)	-	*	-	130 LF
8" watermain in Bank Street (2000)	-	*	-	700 LF
6" watermain in Broadway (1994)	-	-	*	
Former North Shore Railroad (Viaduct)				
12" watermain in Richmond Terrace (1955)	-	-	*	
20" watermain in Richmond Terrace (1999)	-	-	*	
8" watermain in Park Avenue (1997)	-	-	*	

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Location	Replacement of Lines ONLY	Support & Protect	Existing to Remain	Notes
12" watermain in Port Richmond Avenue (1916)	-	-	*	
8" watermain in Maple Avenue (1938)	-	-	*	
8" watermain in Faber Street (1938)	-	-	*	
8" watermain in Sharpe Avenue (1931)	-	-	*	
8" watermain in Treadwell Avenue (1931)	-	-	*	
12" watermain in Nicholas Avenue (1961)	-	-	*	
Former North Shore Railroad (Open Cut)				
12" watermain in Eaton Place (1937)	*	-	-	220 LF
12" watermain in Morningstar Road, west side (1966)	-	-	*	
12" watermain in Morningstar Road, east side (1986)	-	*	-	170 LF
12" watermain in Granite Avenue overpass (1991)	-	-	*	
8" watermain in Lake Avenue overpass (1990)	-	-	*	
8" watermain in Simonson Avenue overpass (1991)	-	-	*	
8" watermain in Van Name Avenue overpass (1990)	-	-	*	
12" watermain in Van Pelt Avenue overpass (1993)	-	-	*	
8" watermain in Dehart Avenue overpass (1931)	-	-	*	
12" watermain in Union Avenue overpass (1931)	-	-	*	
12" watermain in Harbor Road overpass (1994)	-	-	*	
12" watermain in South Avenue overpass (2001)	-	*	-	160 LF
12" watermain in Roxbury Street (1953)	*	-	-	1000 LF
On-Street Mixed Traffic: South Avenue				
N/A	-	-	*	

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General Utility Impact Table

Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
On-Street Exclusive Lanes: Richmond Terrace					
Bay Street to Schuyler Street	Electrical duct bank 8-5" H	-	-	*	
Bay Street to Schuyler Street	Electrical duct bank 4-6" H	-	-	*	
Bay Street to Schuyler Street	Street Lighting	-	-	*	
Bay Street	Traffic Signals	*	-	-	Modify to include proposed Light Rail Transit Activated Traffic Signal
Schuyler Street to Wall Street	Electrical duct bank 8-5" H	-	-	*	
Schuyler Street to Wall Street	Electrical duct bank 4-6" H	-	-	*	
Schuyler Street to Wall Street	Electrical duct bank 2-4" C	-	-	*	
Schuyler Street to Wall Street	FDNY Fire Communication Conduit	-	-	*	
Schuyler Street to Wall Street	Street Lighting	*	-	-	Median street light poles removed; Additional street light poles would be required
Wall Street	Traffic Signals	*	-	-	Modify to include proposed Light Rail Transit Activated Traffic Signal
Wall Street to Hamilton Street	Electrical duct bank 8-5" H	-	-	*	

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
Wall Street to Hamilton Street	Electrical duct bank 4-6" H	-	-	*	
Wall Street to Hamilton Street	Electrical duct bank 2-4" C	-	*	-	450 LF
Wall Street to Hamilton Street	FDNY Fire Communication Conduit	-	*	-	100 LF
Wall Street to Hamilton Street	Street Lighting	*	-	-	Median street light poles removed; Additional street light poles would be required
Hamilton Street	Traffic Signals	*	-	-	New proposed Light Rail Transit Activated Traffic Signal
Hamilton Street to Stuyvesant Place	Electrical duct bank 8-5" H	-	-	*	
Hamilton Street to Stuyvesant Place	Electrical duct bank 4-6" H	-	-	*	
Hamilton Street to Stuyvesant Place	Electrical duct bank 2-4" C	-	*	-	200 LF
Hamilton Street to Stuyvesant Place	Street Lighting	*	-	-	Median street light poles removed; Additional street light poles would be required
Stuyvesant Place	Traffic Signals	*	-	-	Modify to include proposed Light Rail Transit Activated Traffic Signal
Stuyvesant Place to Nicholas Street	Electrical duct bank 8-5" H	-	-	*	

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
Stuyvesant Place to Nicholas Street	Electrical duct bank 4-6" H	-	-	*	
Stuyvesant Place to Nicholas Street	Electrical duct bank 2-4" C	-	*	-	200 LF
Stuyvesant Place to Nicholas Street	10" Gas Main	-	*	-	200 LF
Stuyvesant Place to Nicholas Street	FDNY 6 PR	-	-	*	
Stuyvesant Place to Nicholas Street	Street Lighting	*	-	-	Median street light poles removed; Additional street light poles would be required
Nicholas Street	Traffic Signals	*	-	-	Modify to include proposed Light Rail Transit Activated Traffic Signal
Former North Shore Railroad (At-Grade Section)					
Bank Street	Overhead Wires (electrical/communication)	*	-	-	860 LF
Bank Street	Electrical conduit	*	-	-	2300 LF
Bank Street	Street Lighting	*	-	-	New street lighting pole every 140 LF
Bank Street & Jersey Street	Traffic Signals	*	-	-	New proposed Light Rail Transit Activated Traffic Signal
Jersey Street	2" Gas Main	-	-	*	
Jersey	Overhead Wires	*	-	*	120 LF

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
Street	(electrical/communication)				
Along NSRR ROW (Nicholas Street to Bard Avenue)	Electrical duct bank 4-5" F (1 RET)	-	*	-	2230 LF
Bard Avenue	Overhead Wires (electrical/communication)	*	-	-	120 LF
Along NSRR ROW (Bard Avenue to Davis Avenue)	Overhead Wires (electrical/communication)	*	-	-	600 LF
Along NSRR ROW @ Elizabeth Avenue	Traffic Signals	*	-	-	New proposed Light Rail Transit Activated Traffic Signal
Along NSRR ROW (Davis Avenue to Broadway)	Electrical duct bank 4-5" C (RET), 4-3.5" F (RET), 4-5" F (1 RET)	-	*	-	5300 LF
Broadway	8” Gas Main	-	-	*	
Broadway	Overhead Wires (electrical/communication)	-	*	-	200 LF
Along NSRR ROW @ Broadway	Traffic Signals	*	-	-	New proposed Light Rail Transit Activated Traffic Signal

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
Along Abandoned Tracks (End of Viaduct to Alaska Street ramp))	Electrical duct bank 4-3.5" F (RET), 4-5" F (1 RET)	-	-	*	
Along NSRR ROW @ Heritage Park driveway	Traffic Signals	*	-	-	New proposed Light Rail Transit Activated Traffic Signal
Former North Shore Railroad (Viaduct)					
Richmond Terrace	8" Gas Main	-	-	*	
Richmond Terrace	8" Gas Main	-	-	*	
Richmond Terrace	Overhead Wires (electrical/communication)	-	*	-	100 LF
Park Avenue	Gas Main (unknown size)	-	-	*	
Park Avenue	Overhead Wires (electrical/communication)	-	*	-	100 LF
Port Richmond Avenue	FDNY 4 PR	-	-	*	
Port Richmond Avenue	6" Gas Main	-	-	*	
Port Richmond Avenue	12" Gas Main	-	-	*	

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
Port Richmond Avenue	Overhead Wires (electrical/communication)	-	*	-	100 LF
Maple Avenue	6" Gas Main	-	-	*	
Maple Avenue	Overhead Wires (electrical/communication)	-	*	-	100 LF
Faber Street	6" Gas Main	-	-	*	
Faber Street	Overhead Wires (electrical/communication)	-	*	-	100 LF
Sharpe Avenue	8" Gas Main	-	-	*	
Sharpe Avenue	Overhead Wires (electrical/communication)	-	*	-	100 LF
Treadwell Avenue	8" Gas Main	-	-	*	
Treadwell Avenue	Overhead Wires (electrical/communication)	-	*	-	100 LF
Nicholas Avenue	8" Gas Main	-	-	*	
Nicholas Avenue	8" Gas Main	-	-	*	
Nicholas Avenue	Overhead Wires (electrical/communication)	-	*	-	100 LF
Along Abandoned Tracks (Sharpe Avenue to Nicholas Avenue)	Electrical duct bank 4-3.5" F (RET), 4-5" F (1 RET)	-	*	-	850 LF

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
Former North Shore Railroad (Open Cut)					
Along Abandoned Tracks (Nicholas Avenue to Eaton Place)	Electrical duct bank 4-3.5" F (RET), 4-5" F (1 RET)	-	*	-	1500 LF
Morningstar Road	Gas Main with Steel Casing (unknown size)	-	-	*	
Morningstar Road	8” Gas Main with 12” Steel Casing	-	-	*	
Morningstar Road	FDNY 3” Dia. Fiberglass Fire Communication Conduit	-	-	*	
Morningstar Road	Overhead Wires (electrical/communication)	-	-	*	
Granite Avenue	12” Gas Main with 16” Steel Casing	-	-	*	
Granite Avenue	Overhead Wires (electrical/communication)	-	-	*	
Lake Avenue	6” Gas Main with 10” Steel Casing	-	-	*	
Lake Avenue	Overhead Wires (electrical/communication)	-	-	*	
Simonson Avenue	12” Gas Main with 16” Steel Casing	-	-	*	
Simonson Avenue	Overhead Wires (electrical/commu	-	-	*	

Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
	nication)				
Van Name Avenue	Gas Main with Steel Casing (unknown size) (RETIRED)	-	-	*	
Van Name Avenue	Overhead Wires (electrical/communication)	-	-	*	
Van Pelt Avenue	6” Gas Main with 16” Steel Casing	-	-	*	
Van Pelt Avenue	12” Gas Main with 16” Steel Casing	-	-	*	
Van Pelt Avenue	Overhead Wires (electrical/communication)	-	-	*	
DeHart Avenue	Overhead Wires (electrical/communication)	-	-	*	
Union Avenue	6” Gas Main with 10” Steel Casing	-	-	*	
Union Avenue	Overhead Wires (electrical/communication)	-	-	*	
Harbor Road	8” Gas Main with 12” Steel Casing	-	-	*	
Harbor Road	Overhead Wires (electrical/communication)	-	-	*	
Harbor Road	FDNY 6 PR	-	-	*	
South Avenue	12” Gas Main with 16” Steel Casing	-	*	-	160 LF
South Avenue	4 – 5” Con Ed Ducts	-	*	-	160 LF

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Location	Utility Description	New or Modification Required	Support & Protect	Existing to Remain	Notes
South Avenue	8 – 4" Bell Atlantic Tel. Ducts	-	*	-	160 LF
South Avenue	Overhead Wires (electrical/communication)	-	*	-	160 LF
South Avenue @ BRT Driveway	Traffic Signals	*	-	-	New proposed Light Rail Transit Activated Traffic Signal
South Avenue @ Arlington Station	Electrical Substation	-	*	-	Additional coordination required
Roxbury Street	Overhead Wires (electrical/communication)	*	-	-	1000 LF
Roxbury Street	Street Lighting	*	-	-	New street lighting pole every 140 LF
On-Street Mixed Traffic: South Avenue					
South Avenue	N/A	-	-	*	

The following principles and criteria would guide the design of utility relocations.

7.1.1 Service Interruption

Existing utility services would not be interrupted. If a temporarily relocated parallel system would be required, existing utilities would be restored upon completion of work. In the case of a new utility relocation, the new utility would be operational before or coincident with the termination of the existing service.

7.1.2 Replacements

Utility replacements for existing utilities would be designed to provide service essentially equal to that offered by the existing installations.

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Upsizing of existing facilities may be included but the cost would not be part of this project. Future utility projects would be coordinated with each owner so that future upgrades to their facilities are not precluded by the BRT project.

7.1.3 Deep Excavations

Utility work requiring deep excavations (greater than 5 feet) would utilize either an open excavation with side slopes appropriate for the given soil conditions or a properly support of excavation to prevent cave-ins, washouts, and settlements.

7.1.4 Restoration of Areas Disturbed by Utility Work

All pavement and landscape areas restoration related to utility coordination in former NSRR ROW and City streets would conform to the current regulations, specifications and practices of the NYSDOT, NYCDOT and MTA-NYCT. Restored pavements would be the same materials and widths that existed prior to construction, except that for instances where the existing paving materials are considered obsolete, the restoration would meet current specifications and practice of the appropriate agency.

7.2 COORDINATION WITH UTILITIES

Effort would be made to avoid impacts to major public and private facilities.

7.2.1 Compatibility and Future Expansion

The design of utility relocations would be compatible with the existing utility system being modified. To extent possible, the designs would not preclude available future utility plans for the project area.

7.2.2 High-Volume Roadway Crossings

Utility crossings of the BRT alignment would be kept to a minimum. Proposed utility crossings of high-volume roadways would also be encased, in concrete or casing pipe to minimize disruption to traffic during maintenance operations. Utility crossings would be as perpendicular to the trackway or roadway alignment as possible.

7.2.3 Construction Methods within the former NSRR ROW

The engineering specifications for pipeline / utility occupancies of the railroad having jurisdiction would be followed. Pipelines under railroad tracks and across railroad operating ROW would be encased in a larger pipe or conduit called a casing pipe. Casing pipe would be required for all pipelines carrying oil, gas, petroleum products, or other flammable or highly volatile substances under pressure, and all non-flammable substances. For non-pressure sewer or drainage crossings the casing pipe may be omitted when the pipe strength is capable of withstanding railroad loading, if approved by the railroad having jurisdiction.

The casing pipe would be laid across the entire width of the ROW. Casing pipe would extend beyond the ROW when the ROW on either side of the tracks is less than the minimum length of casing required.

Pipelines laid longitudinally along the former NSRR ROW would be located as far as practicable from tracks or other important structures. If located within 25 feet of the centerline of any track the carrier pipe would be encased.

Pipelines would be located, where practicable, to cross tracks at approximately right angles to the tracks, but preferably at not less than 45 degrees.

Any replacement or modification of an existing carrier pipe and/or casing would be considered a new installation and would be subject to the requirements of the design criteria.

Pipelines and casings would be suitably insulated from underground conduits carrying electric wires.

New utility crossings under would be made by boring, jacking or tunneling. Open-trench methods may be used under streets, and parking lots, and aerial structures.

7.3 UTILITY VERIFICATION

The project would impact existing utilities. To define the extent of impact and develop an optimal resolution, existing utilities were verified, using record utility data from "as-built" plans of former NSRR facilities and record drawings from utility agencies and companies.

7.4 CASING PIPE

7.4.1 General

Casing pipe would be of metal or concrete and of leak proof construction. Casing pipe would be designed for the earth and/or other pressures present, and for railroad live load while within railroad property. The dead load of earth would be considered 120 pounds per cubic foot. Railroad live load would be Cooper E-80 with 50 percent added for impact.

The inside diameter of the casing pipe would be such as to allow the carrier pipe to be removed subsequently without disturbing the casing or the roadbed. For steel pipe casings, the inside diameter of the casing pipe would be at least 2 inches greater than the largest outside diameter of

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the carrier pipe joints or couplings for carrier pipe less than 6 inches in diameter, and at least 4 inches greater for carrier pipe 6 inches and over in diameter.

For flexible casing pipe, a minimum vertical deflection of the casing pipe, of 3 percent of its diameter plus 1/2 inch, would be provided so that no loads from the roadbed, track, traffic or casing pipe itself are transmitted to the carrier pipe. When insulators are used on the carrier pipe, the inside diameter of the flexible casing pipe would be at least 2 inches greater than the outside diameter of the carrier pipe for pipe less than 8 inches in diameter; at least 3-1/4 inches greater for pipe 8 inches to 16 inches, inclusive, in diameter; and at least 4-1/2 inches greater for pipe 18 inches and over in diameter. In no event would the casing pipe diameter be greater than is necessary to permit the insertion of the carrier pipe.

7.4.3 Depth of Installation

Casing pipe under railroad tracks and across railroad rights-of-way would not be less than 5-1/2 feet from base of rail to top of casing at its closest point. On other portions of rights-of-way where casing is not directly beneath any track, the depth from ground surface, or from bottom of ditches, to top of casing would not be less than 4 feet.

Pipelines are subject to railroad loading and would require a casing when within the line of track live load influence.

Where pipeline is laid more than 50 feet from centerline of track, the minimum cover would be 3 feet.

7.5 GAS PIPELINES

7.5.1 Loads on Pipelines

Pipes installed within BRT alignment or City street ROW would be designed to support the dead loads imposed by earth, subbase, pavement, track, ballast, structures, and vehicular loads when the pipe is operated under all ranges of pressure from maximum internal to zero.

7.5.2 Cathodic Protection

Steel carrier pipe would be protectively coated and provided with a cathodic protection system in accordance with the corrosion control requirements of CFR Title 49 Part 192 Subpart 1 and the current standards of the utility company.

7.6 WATER SUPPLY PIPELINES (POTABLE, NON-POTABLE AND FIRE LINES)

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7.6.1 Loads on Pipelines

Pipes installed within BRT alignment or City street ROW would be designed to support the dead loads imposed by earth, subbase, pavement, structures and vehicular loads when the pipe is operated under ranges of pressure from maximum internal to zero.

7.6.2 Minimum Size and Capacity of Mains

Water mains removed from service would be replaced by pipes of equal size, and appurtenances would provide services at least equivalent to those replaced, and would be in accordance with applicable Federal, State and local standards, and the applicable standards of ANSI and AWWA. Water mains would be designed to the NYCDEP and Fire Department of New York (FDNY) criteria. New water main would not be less than 6 inches in diameter.

7.6.3 Construction of Mains

All water mains including valves, fire, hydrants and thrust blocks would be installed on undisturbed material or on properly compacted backfill with appropriate cover.

Construction of new water mains and appurtenances would be in accordance with NYCDEP and the applicable standards of ANSI and AWWA.

7.6.4 Water Services

Construction of water services to the site would comply with NYCDEP.

7.6.5 Water Mains

Pipe used for distribution water mains would consist of ductile iron pipe, Class 56, with bituminous outside coating and double interior cement mortar lining with a seal coat of asphalt material. Straight runs of pipe would be restrained joint type pipes with gasket. All valves and fittings would be of the mechanical joint end type, with fittings lined and coated. Fire hydrants would be in accordance with NYCDEP, FDNY and MTA-NYCT requirements. Pipes, values and appurtenances would be in accordance with applicable Federal, State and local standards, and the applicable standards of ANSI and AWWA. Water mains would be designed to the criteria of and would be approved by NYCDEP.

7.6.6 Clearance

The minimum separation of water mains and sanitary sewers would be 10 feet horizontal or 1 foot 6 inches vertical. The sanitary sewer would always be located under the water main.

7.7 STORM SEWERS

Design

Design of replacement, relocation or extension of existing storm drains would be designed in conformance with the requirements and standards of NYSDEC, NYSDOT and NYCDEP. See Section 6.7 – Drainage Design

Velocity Criteria

Storm drains would be designed with a hydraulic slope that would provide a minimum velocity of 3.0 fps for less than 0.7 cfs and 25 fps for 0.7 cfs and greater when flowing full, based on Manning's formula with a roughness coefficient of n = 0.013. The maximum velocity would be 15 fps, as per NYCDEP.

7.8 OIL STATIC CABLES

No oil static cables appear to be located within the BRT alignment; however, all design, construction, and maintenance are deferred to Consolidated Edison.

7.9 ELECTRICAL POWER FACILITIES

7.9.1 General

All support, maintenance, relocation and restoration of existing underground and overhead electric utility lines throughout the project area would be coordinated with Consolidated Edison

As dictated by space limitations and cost, electric facilities would be relocated outside the limits of excavations and excavation support systems.

Electric facilities would be maintained complete in place, providing that the support system can satisfactorily retain the line and grade of the facility and that the retention of duct structures within the limits of construction is practical.

7.9.2 Clearances

Clearances for overhead lines outside and crossing the BRT alignment would be in accordance with the standards of Consolidated Edison. Minimum clearances would be in accordance with the National Electrical Safety Code.

7.9.3 Temporary Service

Electric facilities would be temporarily supported while being maintained in service, either within or beyond the limits of construction excavation, until such time as replacement facilities are provided. Temporary duct systems and manholes would be provided to serve the same utility

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function as existing facilities with respect to accessibility, manhole size, required number of ducts and structure protection for equipment, cable and service personnel. The number of temporary ducts would be minimized by coordination with the utility company to assure the utilization of maximum temporary capacity and the exclusion of unnecessary spare ducts.

7.9.4 Split Ducts

Split ducts, when encased for permanent retention, would be a straight, rigid metallic conduit or FRP line, without bends or curves wherever practical.

7.9.5 Coordination

Electric utility companies would be consulted during the preparation of designs, plans and specifications to assure that the method of handling the facilities is in accordance with their standards and the service requirements.

7.9.5.1 Lighting Design Criteria

The installation of project-related lighting would consist of two general types: replacement lighting to restore existing fixtures and new lighting for facilities created by the project. Replacement lighting would be designed to provide illumination equal to current levels. New lighting would be designed to meet or exceed applicable codes and standards, including Institute of Illuminating Engineers Standards, electrical codes, would be in accordance with the requirements of the NYSDOT, NYCDOT or MTA-NYCT. Design details such as mounting heights, equipment requirements, and system electrical specifications would be based on the standards, practices, and codes that apply to the facility. See Section 8.5.3 for recommended station lighting requirements

7.10.5.2 Lighting Equipment

To maintain consistent illumination on a given facility and to simplify future maintenance, the lighting of the maintaining agency. Lighting designs would be based on the performance specifications for these materials.

7.10.5.3 Lighting Maintenance

Future maintenance of the lighting systems installed or modified by the project would be the responsibility of the agency having jurisdiction over the lighted facility.

7.10 TELEPHONE/COMMUNICATIONS FACILITIES

7.10.1 General

Maintenance, relocation and support of existing telephone/communication facilities would be in

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accordance with the requirements of the utility company, e.g. Verizon, Spectrum, FDNY, NYC Police Department or another owner agency, as applicable.

Telephone facilities would be relocated outside the limits of excavations and excavation support systems.

Underground telephone facilities would be maintained complete in place providing that the support system can satisfactorily retain the line and grade of the facility, and that the retention of duct structures within the limits of construction is practical.

7.10.2 Clearances

Clearances for overhead lines outside railroad property would be in accordance with the standards adopted by the utility companies involved. Minimum clearances specified in the National Electrical Safety Code would be met inside railroad property.

7.10.3 Temporary Service

Underground telephone facilities would be temporarily supported while being maintained in service, either within or beyond the limits of construction excavation, until such time as replacement facilities are provided. Temporary duct systems and manholes would be provided to serve the same utility function as existing facilities with respect to accessibility, manhole size, required number of ducts and structure protection for equipment, cable and service personnel. The number of temporary ducts would be minimized by coordination with the utility company to assure the utilization of maximum temporary capacity and the exclusion of unnecessary spare ducts.

7.10.4 Split Duct

Split duct, when encased for permanent retention, would be a straight, rigid metallic conduit line, wherever practical without bends or curves.

7.10.5 Coordination

Owners of telecommunication utility companies would be consulted during the preparation of designs, plans and specifications to assure that the method of handling the facilities is in accordance with their standards and is consistent with service requirements.

7.10.5.1 Design Criteria

Lighting design would be prepared to provide sufficient illumination for the safe use and operation of the facility, per NYCDOT, to be lighted and would typically involve meeting the minimum criteria for average illumination and uniformity of illumination applicable to the facility. Design

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details such as mounting heights, equipment requirements, and system electrical specifications would be based on the standards, practices, and codes that apply to the facility.

7.10.5.2 Equipment

To maintain consistent illumination on a given facility and to simplify future maintenance, the lighting of the maintaining agency. Lighting designs would be based on the performance specifications for these materials.

7.10.5.3 Maintenance

Future maintenance of the lighting systems installed or modified by the project would be the responsibility of the agency having jurisdiction over the lighted facility.

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SECTION 8: STATIONS

8.1 GENERAL

There are eight side-loading stations proposed for the North Shore BRT project. Each station would have Eastbound and Westbound platforms for travel from St. George Terminal, located on the east side of Staten Island, oriented towards Arlington Station to the west. The dedicated busway portion of the alignment has dedicated lanes for the BRT only. Additional on-street bus stops would be provided along South Avenue where the BRT would operate in shared traffic lanes. The following sub-sections outline the station guidelines for a well-designed BRT, station configurations for each site and station elements analysis and studies for optimal use. For all stations the station configuration and access points are identified based on the optimal passenger circulation and two means of egress. The platforms are side-loading staggered or aligned based on the ROW. There would be no crosswalks through the ROW for normal operations. For several stations, a pedestrian overpass is included to avoid passenger and bus traffic intersection. These prototypical stations are developed to represent standard components, such as canopies, shelters, seating, and lighting, etc. The station would be branded for a unified identity for the BRT corridor. This BRT system is the first for NYCT and new branding guidelines would be developed.

8.2 BUS RAPID TRANSIT (BRT)

When designing a station for a BRT Corridor it is important to understand its characteristics. The Institute for Transportation & Development Policy (ITDP) defines a BRT Corridor as a dedicated roadway serving bus routes only, making this mode of transit more efficient overall. A few of the basic characteristics of a true BRT system include a dedicated right of way, busway alignment, off-board fare collection, platform level boarding, and a focus on safety. The Federal Transit Administration recommends bus headways to be 10-12 minutes at maximum and at peak hour to be 5-10 minutes or less. ITDP breaks down the guidelines into the following:

<u>Dedicated right of way:</u> the core of BRT is lanes fully dedicated to rapid transit vehicles, off-limits to other traffic to allow BRT to travel unimpeded similar to rail lines. The dedicated right of way needs to be greater than 1.9 miles to be classified as a true BRT.

<u>BRT alignment:</u> the goal is to avoid conflict with other traffic and curb activity, minimizing delays. High-scoring configurations include median-aligned busways that sit in the center of the two-way road.

<u>Platform Level Boarding:</u> increasing comfort and ease, BRT vehicle doors glide open, flush with elevated platforms so all riders, including those with strollers, wheelchairs, or limited mobility can board quickly.

Focus on Safety: Requires safety features, such as safe and frequent pedestrian crossings in built-up areas.

Tactile cues: detectable warning tiles much be at least 24" deep and must be applied at all curb ramps for their entire width, or at any location where pedestrians cross into another modal zone.

Color: Use color consistently to delineate modal zones and edges; color repetition reinforces legibility, and should be employed at conflicted zones, flush crossings, or likely sites for encroachment. Color-coded detectable warning strips can draw attention to conflict points.

Lighting: Pedestrian-scale lighting, typically including lamps less than 25 feet high increases comfort and safety around stops. (~10-15 foot-candles)

8.3 PRECEDENT ANALYSIS AND COMPARISON

Precedents of existing and planned BRT systems were researched and presented to the MTA-NYCT. These examples were used to help guide the planning and design of the Staten Island North Shore BRT. Refer to the Appendix B for a summary of the presentation.

The following comparison chart helps with understanding the design criteria a BRT requires.

	LA METRO BUSWAY LOS ANGELES, CALIFORNIA	CTfastrak HARTFORD, CONNECTICUT	SILVER LINE BOSTON, MASS	EAST BUSWAY PITTSBURGH, PENNSYLVANIA	TRANSITWAY OTTAWA, CANADA	VivaNext ONTARIO, CANADA	TransMilenio BOGOTA, COLOMBIA	RIT CURITIBA, BRAZIL	JANMARG BRTS AHMEDABAD, INDIA	R-NET AMSTERDAM, NETHERLANDS
RIDERSHIP DAILY	22,500	18,000	36,000	25,000	200,000	77,000	2,400,000	2,000,000	350,000	40,000
COST	$484 MILLION	$567 MILLION	$822 MILLION	$100 MILLION	$440 MILLION IN 1983	$1.4 BILLION	$1.4 BILLION	$88 MILLION IN 1974	$290 MILLION	$350 MILLION
LENGTH MILES	14.3 MILES	9.4 MILES	12 MILES	20.8 MILES	38 MILES	21 MILES	71 MILES	37 MILES	78 MILES	35 MILES
BUS	2438 BUSES 4 MIN HEADWAY @PEAK	580 BUSES 7 MIN HEADWAY @PEAK	101 BUSES 4 MIN HEADWAY @PEAK	58 BUSES 2 MIN HEADWAY @PEAK	850 BUSES 4 MIN HEADWAY @PEAK	500 BUSES 10 MIN HEADWAY @PEAK	1240 BUSES 2 MIN HEADWAY @PEAK	1980 BUSES 1.5 MIN HEADWAY @PEAK	250 BUSES 2.5 MIN HEADWAY @PEAK	143 BUSES
STATIONS	14 STATIONS	10 STATIONS	21 STATIONS	44 STATIONS	28 STATIONS	36 STATIONS	148 STATIONS	21 STATIONS	157 STATIONS	15 STATIONS
PLATFORMS AVERAGE SIZE	210' x 15' 3150 SF	120' x 15' 1800 SF	160' x 15' 2400 SF	120' x 15' 900 SF	180' x 20' 3600 SF	180' x 15' 2700 SF	160' x 20' 3200 SF	155' x 15' 2325 SF	135' x 20' 2700 SF	90' x 10' 900 SF
BRT RATING	BRONZE	SILVER	NOT TRUE BRT	BRONZE	BRONZE	NOT RATED	GOLD	GOLD	SILVER	NOT RATED
FUTURE PLANS	+ LRT (TRANSIT CORIDOR)	+ BRT (EXPANSION)	+ BRT (REAL BRT SYSTEM)	+ BRT (EXPANSION)	→ LRT (CONVERT BRT TO LRT)	+ BRT (EXPANSION)	+ LRT (TRANSIT CORIDOR)	+ LRT (TRANSIT CORIDOR)	+ LRT (TRANSIT CORIDOR)	TRANSIT CORIDOR + BRT

Figure 8.3.1: Above is a table comparing each of the BRT precedents reviewed.

8.4 STATION CONFIGURATION

The station configurations were studied for each typology to understand the different requirements.

The existing ROW consists of three different typologies of station locations that are at-grade, elevated and in an open-cut. Each station configuration includes the BRT side-loading platform itself, a semi-sheltered waiting area on each platform, pedestrian egress routes, stairs, ramps and elevators accordingly per existing site conditions. Additional station elements were considered for space allocation and are described later in Section 8.5 of this report.

The recommended station configurations are highlighted in the following sections.

Station	**Station Type**	**Platform Type**	**Platform Dimensions**
Arlington Station	At grade	Side Platforms, Terminal, Park & Ride	15’ x 140’
Mariners Harbor Station	Open cut	Side Platforms, Standard	15’ x 140’
Elm Park/ Morningstar Station	Open cut	Side Platforms, Standard	15’ x 140’
Port Richmond Station	Elevated	Side Platforms, Standard	12’ x 200’
West Brighton Station	At grade	Side Platforms, Standard	15’ x 140’
Livingston Station	At grade	Side Platforms, Standard, Park & Ride	15’ x 140’
New Brighton Station	At grade	Side Platforms, Standard	15’ x 140’
St. George Terminal	At grade	Side Platform, Terminal	Existing platform dimensions

Figure 8.4.1: BRT Station Table

8.4.1 Typical Station Platform Sizing

The typical station platform is determined by the length and buffer zone for a standard 40-foot electric bus. The 140-foot platform would accommodate three standard buses with two door entry to be stopped at a given moment. When all the buses are loaded at peak hours, there would be 6 points of entry from the platform. A similar logic with respect to points of entry would apply for articulated buses in the event that a decision is made to operate them at some point in the future.

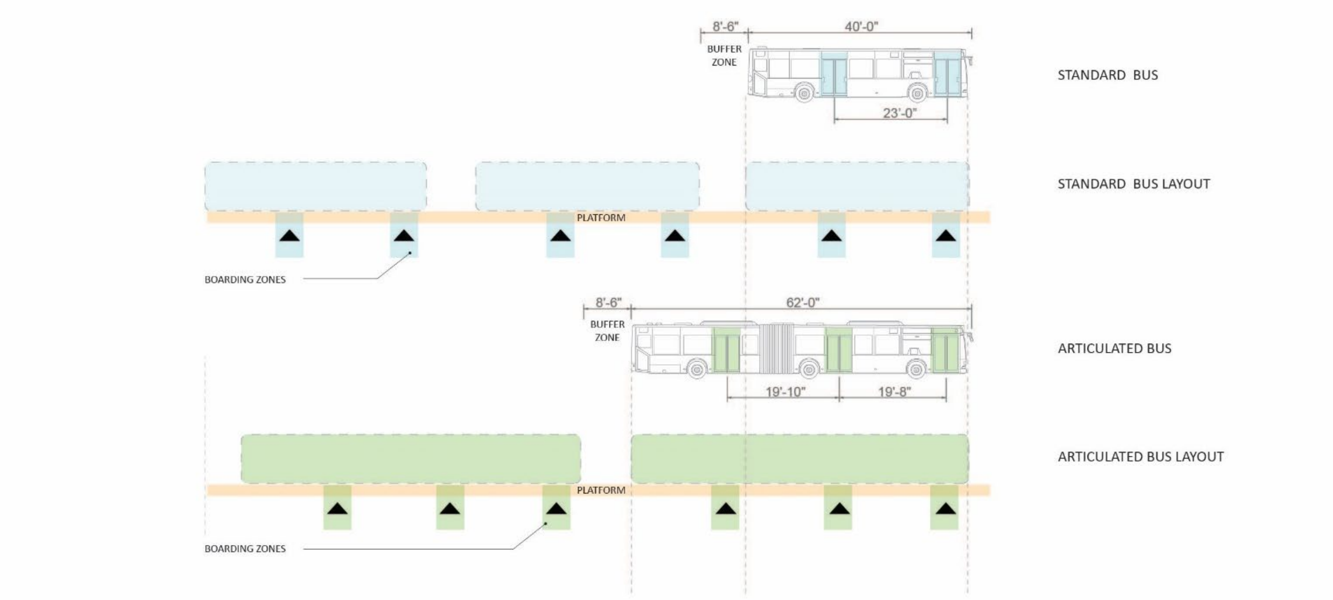


Figure 8.4.1.1: Above is a diagram indicating the boarding zones for the two bus types and the extend of the platform edge tiles. The standard bus occupancy is about 40 seats with standing room totaling about 75 passengers. The articulated bus occupancy is about 50 seats with standing room totaling about 98 passengers.

Each point of entry would have a boarding zone clearance of 5’ x 8’ minimum per ADA requirements. The edge of the platform is to be detailed with the standard 2’ platform edge tiles per agency guidelines. The bus station platform height was determined to match the bus floor height of 16 inches to maintain level boarding.

The standard and articulated bus studies allow for a recommendation of a 140-foot typical station platform length, a 15 foot platform width, and level-boarding at a height of 16 inches.

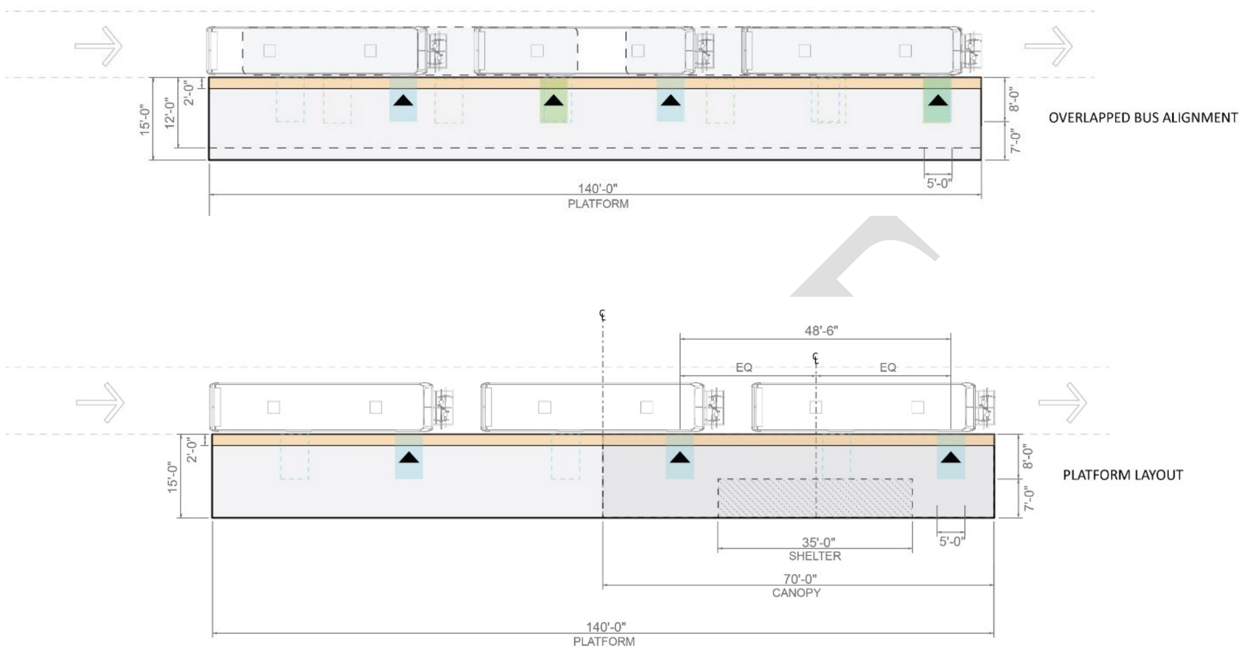
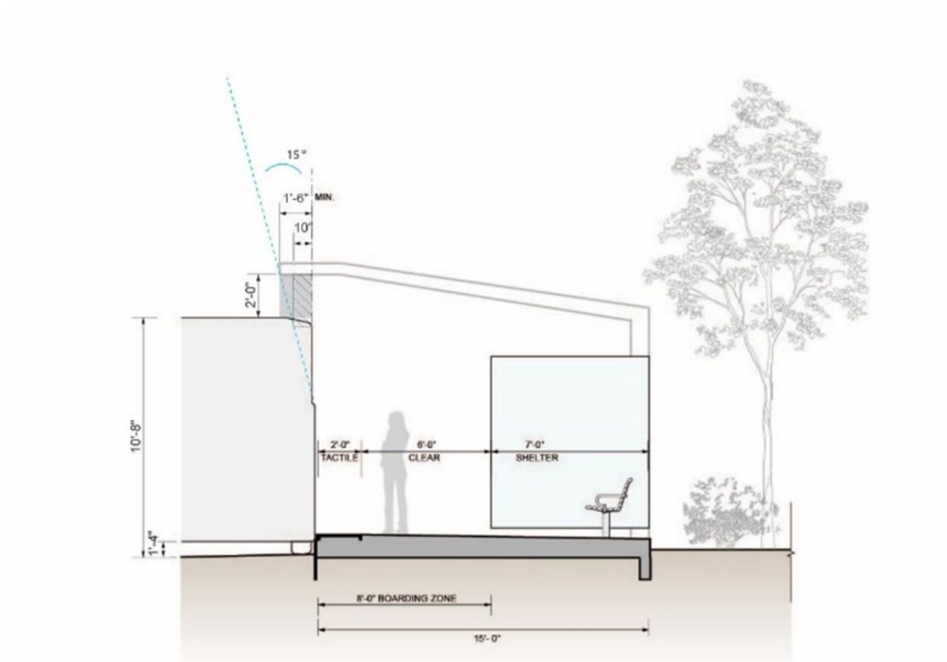


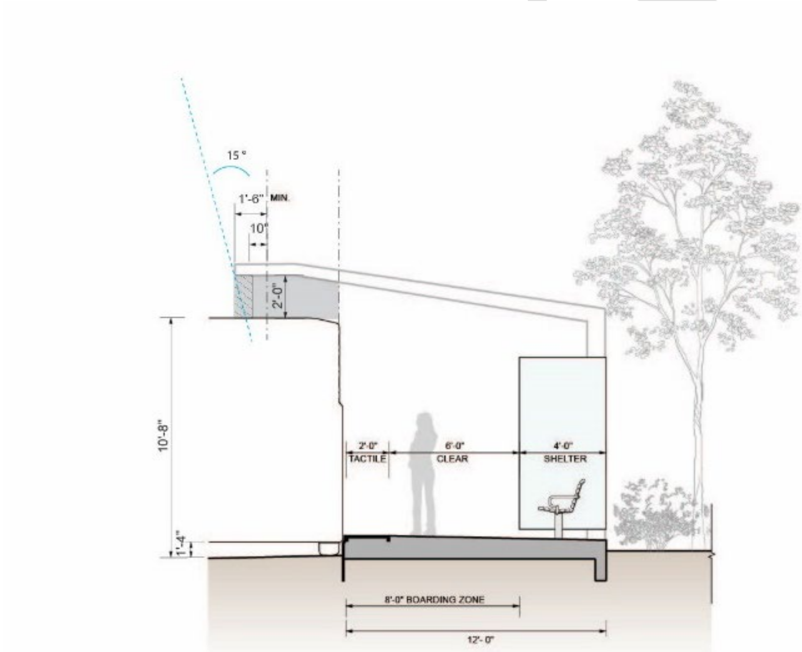
Figure 8.4.1.2: Above is a diagram that illustrates the bus door alignments and platform, canopy and shelter sizing.

A further analysis of the standard bus arrangement at peak hours, allows for a recommendation for a typical 70-foot minimum canopy coverage and a 35-foot minimum shelter coverage. The canopy covers three points of entry for a two-door standard bus.

Each platform would have a minimum of one point of access and two means of egress, sometimes a designated emergency egress route would be required based on site conditions. Stairs, ramps, and elevators would be required based on site conditions. All stations would be ADA accessible with a ramp or elevator serving each platform if the conditions require it.



Diagrammatic 15' wide platform



Diagrammatic 12' wide platform

Figure 8.4.1.3: Above is a diagram that illustrates the bus door alignments and platform, canopy and shelter sizing.

The average platform width is 15 feet for the boarding zone clearance and shelter. For the elevated station the platform width would be 12 feet. With both platform widths, a minimum of 6' clear outside the 2' tactile edge should be maintained. This allows for two wheelchairs to pass and maintains ample space for the boarding area and shelters.

The recommended typical platform is approximately 140 feet long, and 15 feet wide with a height of 16 inches to accommodate level boarding.

The platforms at the open-cut and elevated viaduct locations would be heated to minimize future maintenance and enhance passenger safety.

8.4.2 Arlington Terminal Station Configuration

The Arlington Terminal Station configuration was affected by multiple existing factors at the specific site. The site has an approximately 20-foot grade difference from the existing street level at South Avenue to the proposed station area. The design implements a route to establish an efficient passenger circulation to and from the platforms.

The proposed station configuration would utilize the site's elevation differences and a pedestrian overpass is proposed to enhance passenger circulation and safety. The proposed overpass would allow for a smoother transition for the pedestrian and passenger, minimizing the number of crosswalks that intersect with the BRT roadways. The overpass would connect the street level to the BRT platforms. There would be elevators and stairs at the east ends of the platforms to connect to the overpass. On the opposite end of the platform would be a gated emergency egress route. A park-and-ride is proposed and would be located adjacent to the eastbound platform for convenience.

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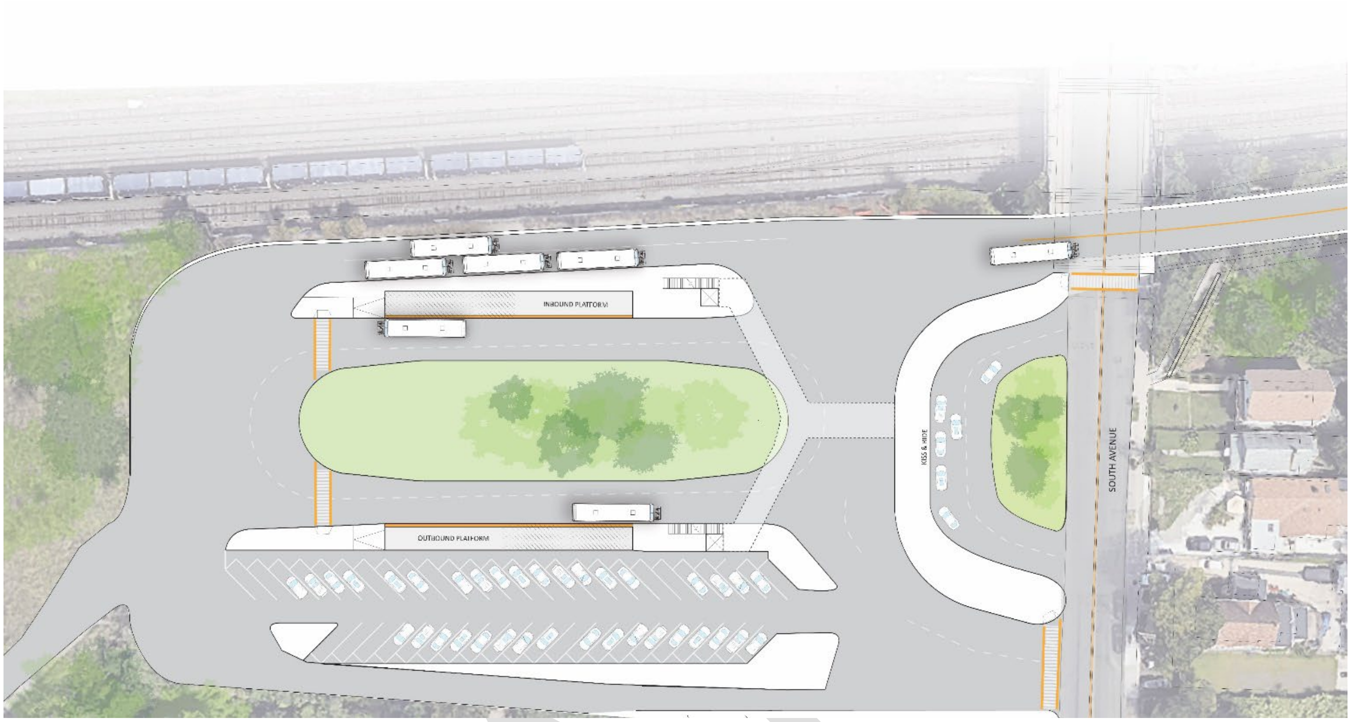

Figure 8.4.2.1: Above is a diagram that illustrates the recommended option for the station.

The necessary bus circulation would be maintained with the configuration and would not be interrupted by passengers entering the station. A Kiss-and-Ride is also proposed off South Avenue. Overall, this configuration optimizes the use of the existing site conditions and allows for a fluid, safer user experience.

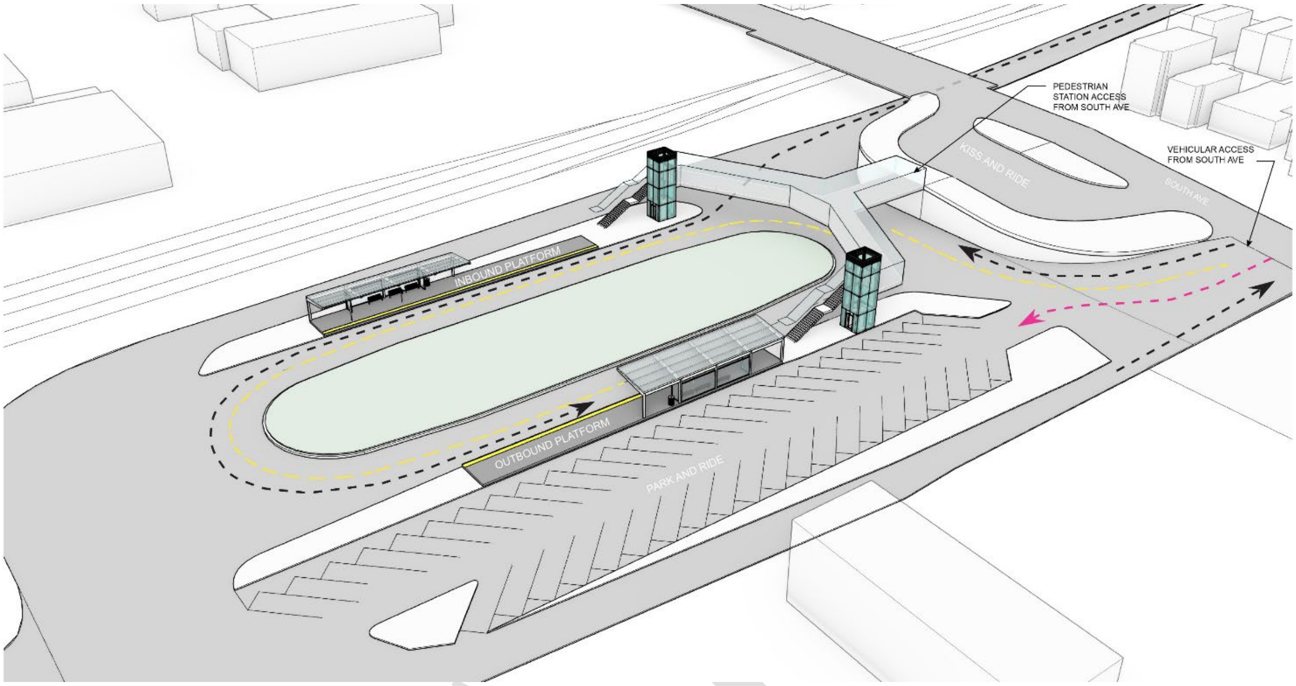

Figure 8.4.2.2: Above is a 3D diagram that illustrates the recommended option for the station.

The platforms would be 140 feet long and 15 feet wide. The eastbound and westbound platforms would be arranged parallel to each other for a leveled site.

8.4.3 Mariners Harbor Station Configuration

The Mariners Harbor Station configuration was influenced by the existing factors at the specific site. The proposed station would be located in an open-cut with about a 20-foot level difference from the existing street level at Van Pelt Avenue and Van Name Avenue to the BRT corridor. The design would implement a route to establish an efficient pedestrian and passenger circulation to and from the platforms.

This option would use stairs and elevators to connect the pedestrians to and from the street level. There would be elevators and stairs at one end of the platforms. On the other end of the platform is a stair connecting to the street level. This configuration would maintain two means of egress.

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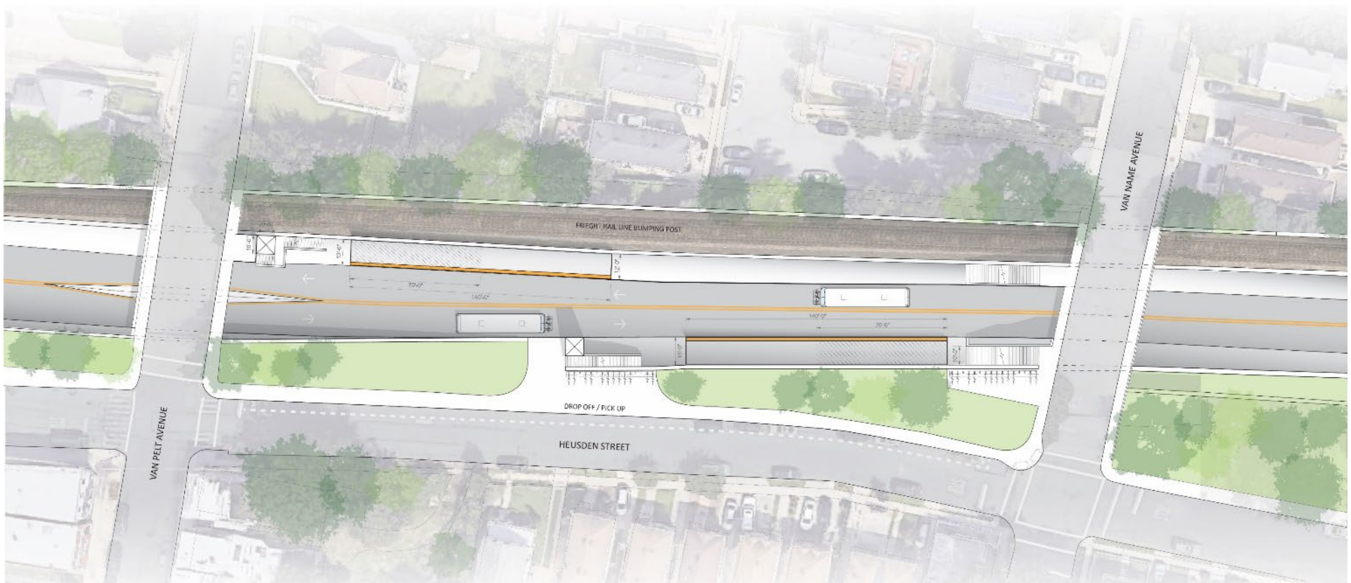

Figure 8.4.3.1: Above is a diagram that illustrates the recommended option for the station.

The platforms would be 140 feet long and 15 feet wide. The eastbound and westbound platforms would be staggered to maximize the platform size in the available right-of-away. The lane and platform placement would be controlled by the existing freight tracks and bridge structures to the north. As a result, this location only allows for one lane in each direction.

8.4.4 Elm Park/Morningstar Station Configuration

The Elm Park/Morningstar Station configuration would be situated within an open cut with about a 20-foot level difference from the existing street level at Morningstar Road, a 14-foot difference at Eaton Place, and a 10-foot level difference at Newark Avenue to the proposed BRT alignment. The design would implement a route to establish an efficient pedestrian and passenger circulation to and from the platforms.

This configuration would use stairs, elevators and sloped walkways to connect the pedestrians to and from the street level. As a result of this configuration the number of elevators required would be minimized.   There would be elevators and stairs at one the end of the platforms on Morningstar Road. A ramp with multiple switch backs would connect to the street level at the other end of the platforms. The adjacent context allows for larger entry areas for three of the station entrances which would provide the opportunity to establish designated bike storage areas and drop off/ pick up areas.

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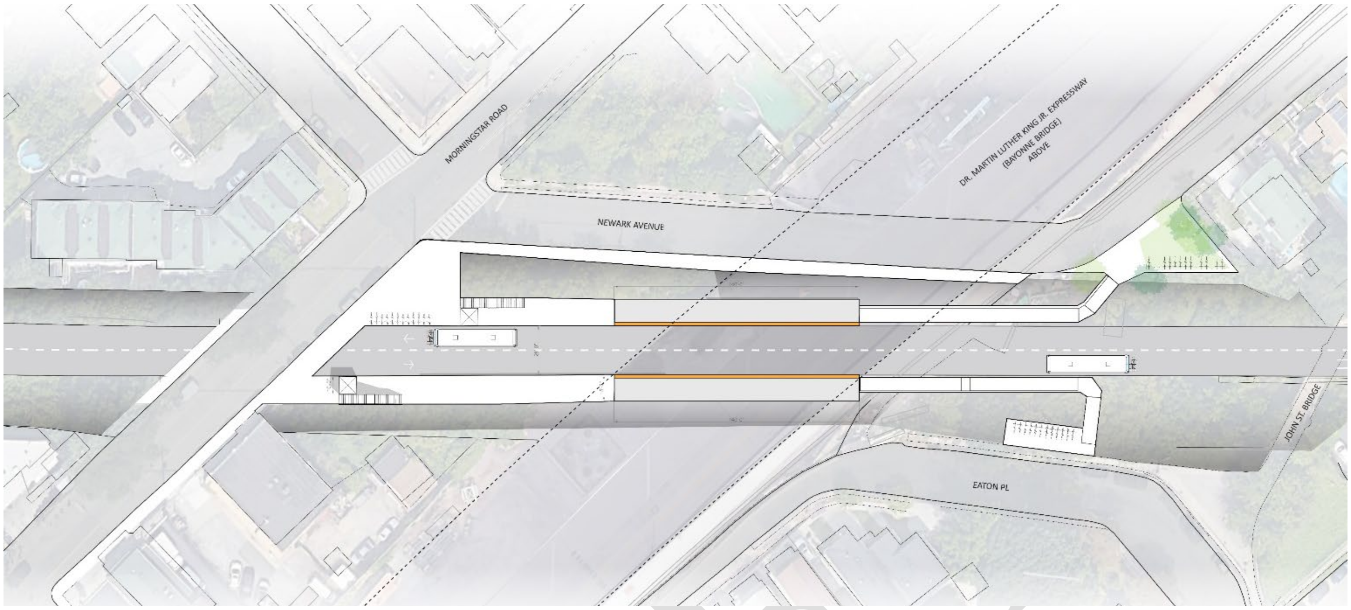

Figure 8.4.4.1: Above is a diagram that illustrates the recommended option for the station.

The platforms would be 140 feet long and 15 feet wide. The eastbound and westbound platforms would be arranged parallel to each other on the site to minimize the level difference as the open cut is sloping up.

8.4.5 Port Richmond Station Configuration

The proposed Port Richmond Station would be located between Maple and Park Avenues, spanning Port Richmond Avenue. The station configuration would be influenced by the dimensions of the existing viaduct structure, with platforms approximately 200 feet in length and 12 feet wide with one BRT lane in each direction. The eastbound and westbound platforms would be staggered to maximize the platform size in the available right-of-way. Stairs, elevators, and a plaza entry would be located on adjacent lots to the northeast and southwest of the viaduct to connect pedestrians to and from the street level. One elevator and stair tower would be situated to provide access to each platform. A gated stair leading back to street level would also be provided on each platform for emergency egress

The proposed station configuration would require using two adjacent lots for the vertical circulation elements and to create a plaza entry. See Appendix F - Property Matrix. This proposed configuration would create the ideal flow of circulation for the passengers. The adjacent lots would create a community space aiding in the neighborhood revitalization. The plaza entries would also allow additional space for bike storage, drop off/pick up area and back-of-house spaces.

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Figure 8.4.5.1: Above is a diagram that illustrates the recommended option for the station.

8.4.6 West Brighton Station Configuration

The West Brighton Station would be located along Richmond Terrace just west of North Burgher Avenue The proposed station would be configured on an “at-grade” site with a slight level difference from the existing street at Richmond Terrace to the BRT corridor. The proposed station design would implement efficient pedestrian and passenger circulation to and from the platforms. A sloped walkway to connect pedestrians to and from Richmond Terrace would be provided. At the east end of each platform, elevators and stairs would connect to a pedestrian overpass. A gated crosswalk to maintain two means of egress would be provided at the west end of the platforms that would be used for secondary egress and emergency access. Property acquisition would be required for the proposed station as two commercial businesses would be displaced.

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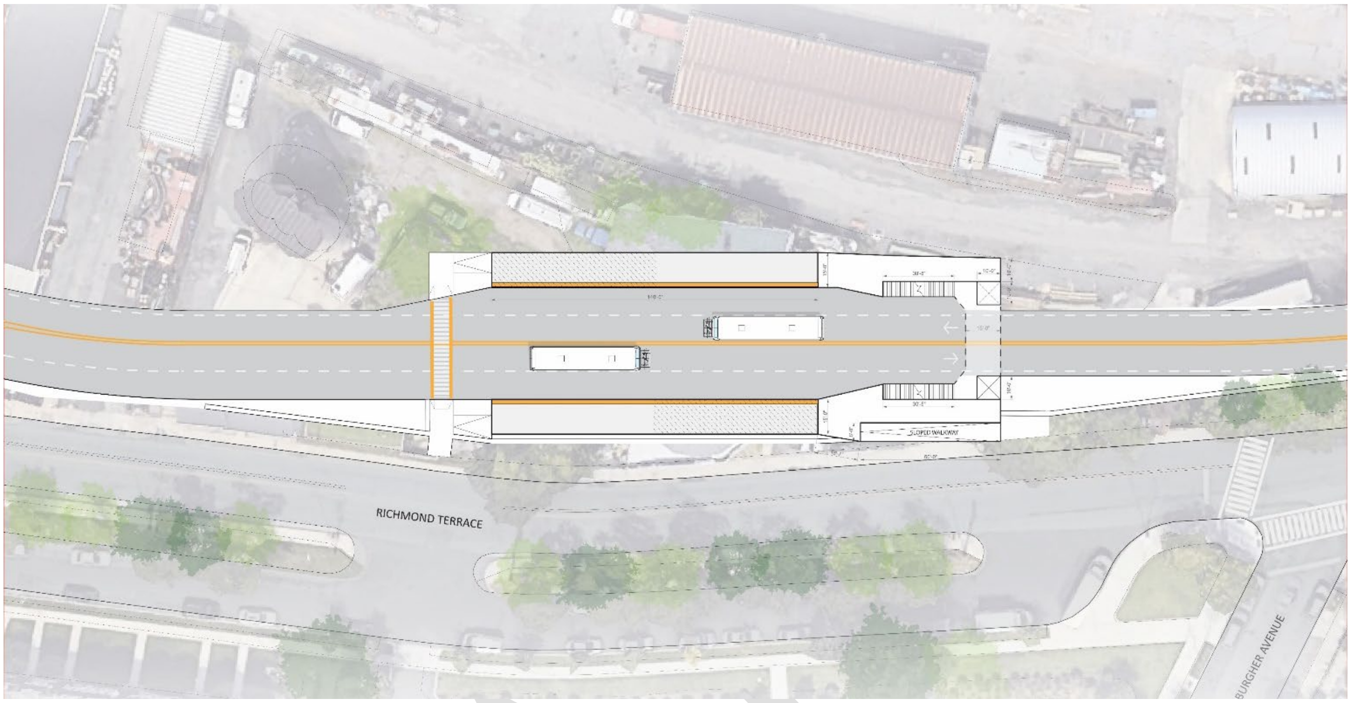

Figure 8.4.6.1: Above is a diagram that illustrates the recommended option for the station.

The platforms would be140 feet long and 15 feet wide. The eastbound and westbound platforms would be parallel to each other on the site to minimize the level difference and ROW footprint. The alignment in this location would allow for a second lane in each direction that would typically be used to bypass stopped buses.

8.4.7 Livingston Station Configuration

A one-block section from Bard Avenue to Davis Avenue that currently contains a Con Edison surface parking lot would be developed for the proposed Livingston Station. The city-owned ROW transects the parking lot, which includes two parcels to the north and south of the right-of-way under Con Edison ownership. At present, this lot is used for customer parking for Con Edison's Davis Avenue facility, storage for mobile emergency generators, and as an emergency staging area to park equipment prior to field deployment. Based on coordination with Con Edison, MTA-NYCT has configured the proposed Livingston Station in such a way as to accommodate the continuation of these uses with the project in place.

The proposed station layout would preserve approximately 45 Con Edison customer parking spaces as well as provide sufficient space for the mobile emergency generators.

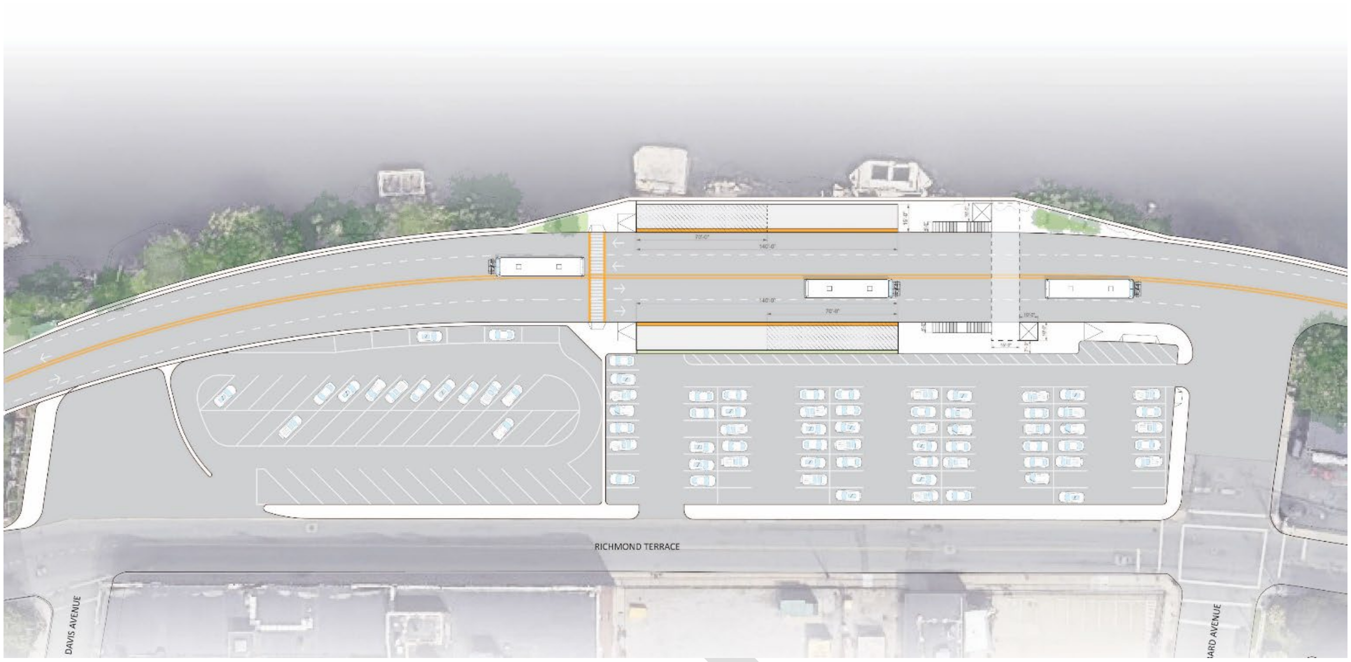

Figure 8.4.7.1: Above is a diagram that illustrates the recommended option for the station.

The proposed station would include two parallel platforms that would each be 15 feet wide and 140 feet long. The proposed busway through the station area would feature a four-lane configuration to allow for one passing lane in each direction. The station would also include an approximately 72-space park-and-ride facility with a drop-off area along the eastbound platform.

8.4.8 New Brighton Station Configuration

The proposed New Brighton Station would be located just west of the Atlantic Salt property, fronting Richmond Terrace between Tysen Street and Clinton Avenue. The station would be generally parallel to Richmond Terrace. The station would feature parallel platforms, elevators, stairs, and a pedestrian overpass. A gated crosswalk would be included for emergency egress.

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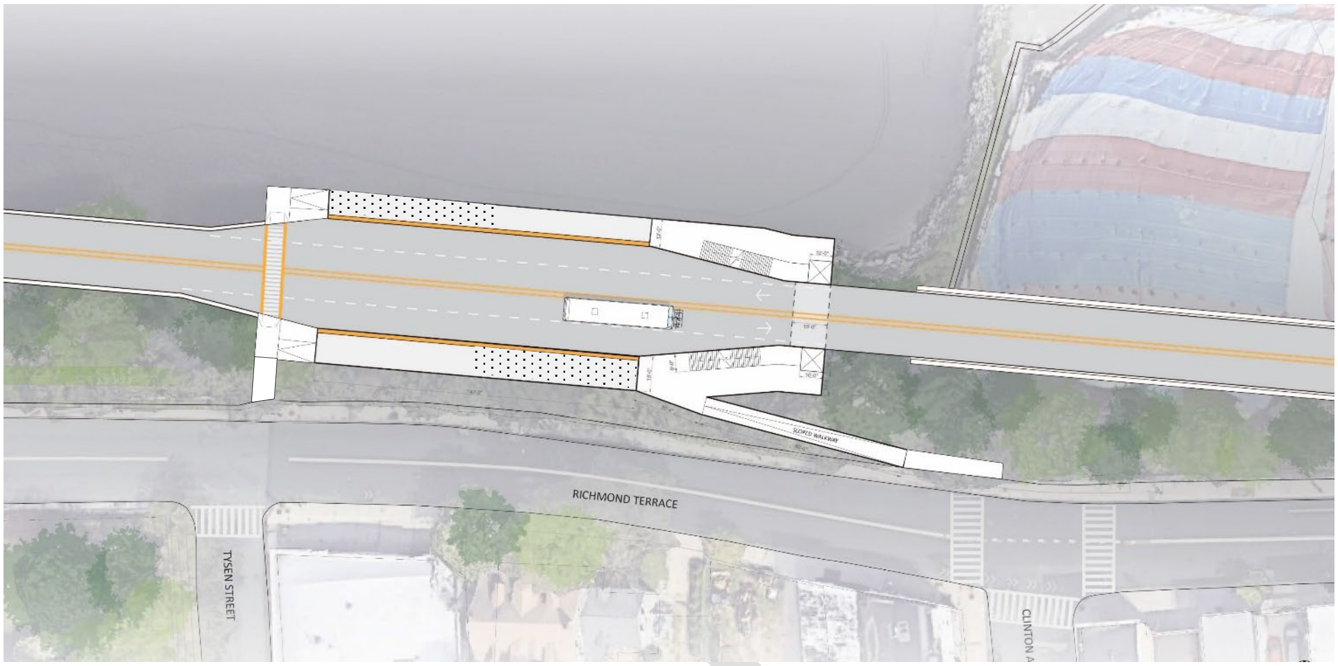

Figure 8.4.8.1: Above is a diagram that illustrates the recommended option for the station

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8.4.9 St. George Terminal Station Configuration

The proposed terminal station in St. George would repurpose the existing taxi stand on the bus deck at St. George Terminal for BRT use. The design for this station would utilize the existing layout, platform, and means of egress for the BRT. The station standard elements would be implemented in this location to maintain the BRT branding. Additional investigation would be required to determine the best constructability and staging plan for the use of the existing taxi platform for the BRT platform.

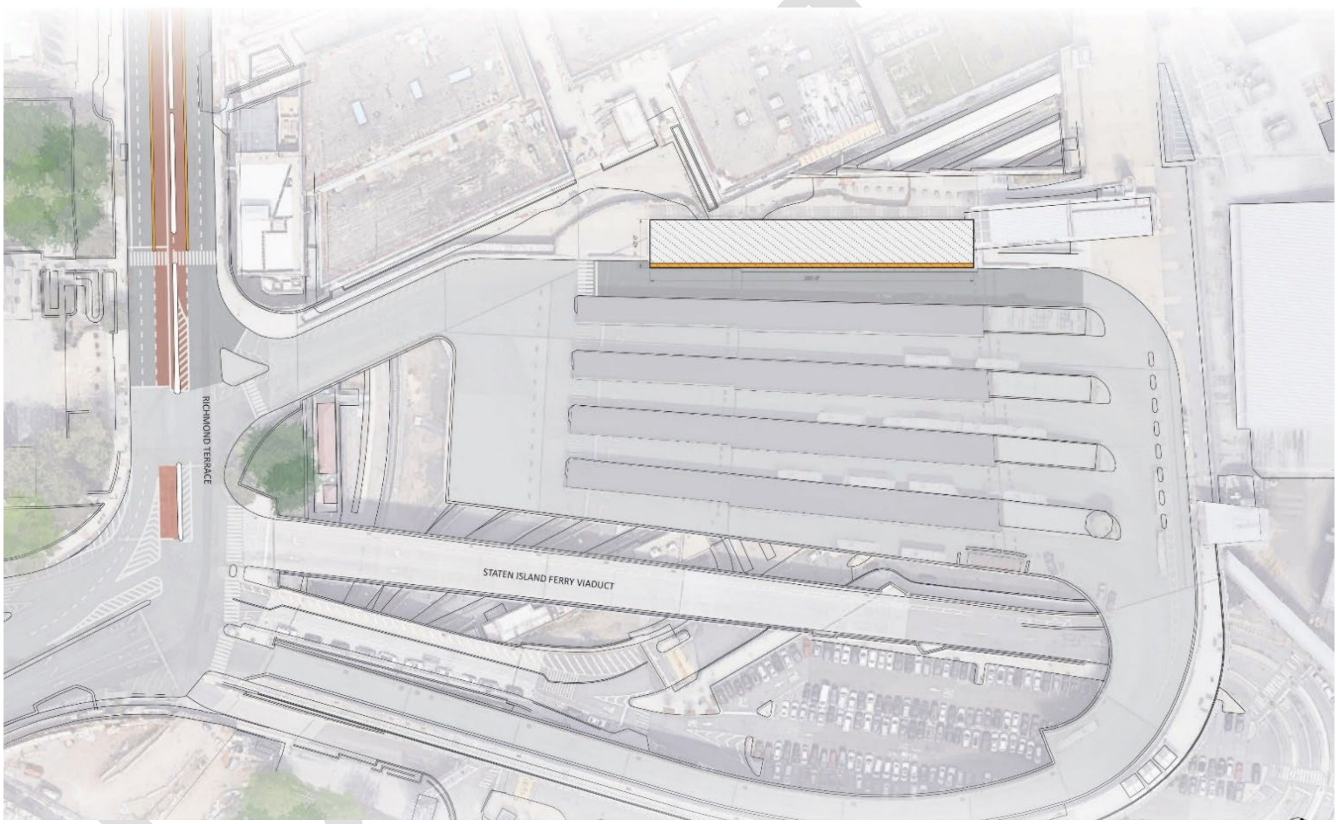

Figure 8.4.9.1: Above is a diagram that illustrates the recommended option for the station.

8.5 STATION ELEMENTS

Each station configuration would include the BRT side-loading platform itself, a sheltered waiting area on each platform, pedestrian egress routes, stairs, ramps and elevators accordingly per existing site conditions.

In the following sub-sections, the recommended station elements are highlighted for the proposed stations.

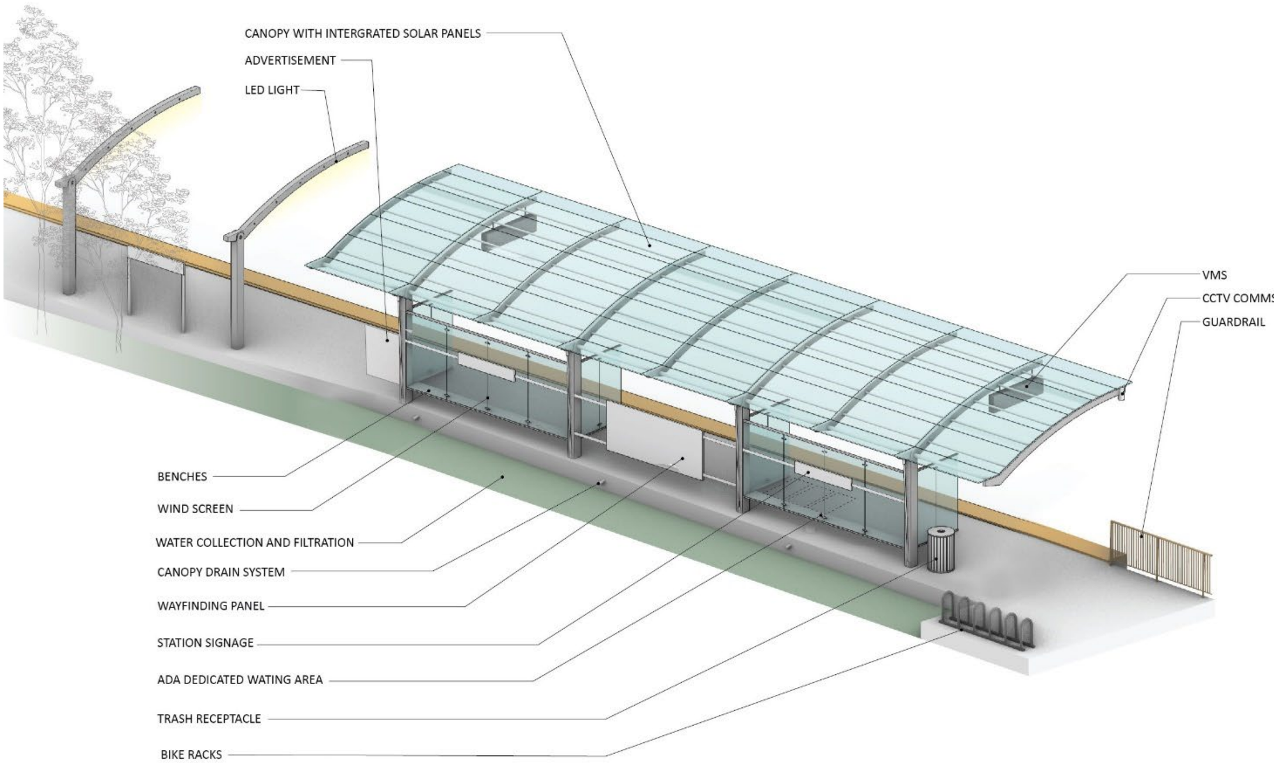

Figure 8.5.1.1: Above is a diagram that illustrates the station elements. Architectural design is conceptual and subject to change

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8.5.1 Platform Size:

Refer to Section 8.4 for the platform size that is determined by the studies done for the standard and articulated buses.

The recommended typical platform at a 140’ length, 15’ width and 16” height for level-boarding.

There is an exception at the Port Richmond Station due to existing condition of the elevated viaduct and at St George’s Terminal due to the existing bas platforms. The recommended minimum platform width at the proposed Port Richmond Station would be 12 feet.

The platforms at the open-cut and elevated locations would be heated to minimize future maintenance and enhance passenger safety.

8.5.2 Canopy

The canopy sizing was determined by pervious bus alignment studies done for platform sizing.

The minimum length of the canopy is 70’ with a 1’6” minimum bus overhang. The canopy is intended to protect passengers waiting on the platform, house the bus shelter, and any additional station elements that need protection. The initial size recommendation should be reexamined after ridership information is provided to determine if additional coverage is required at main station locations.

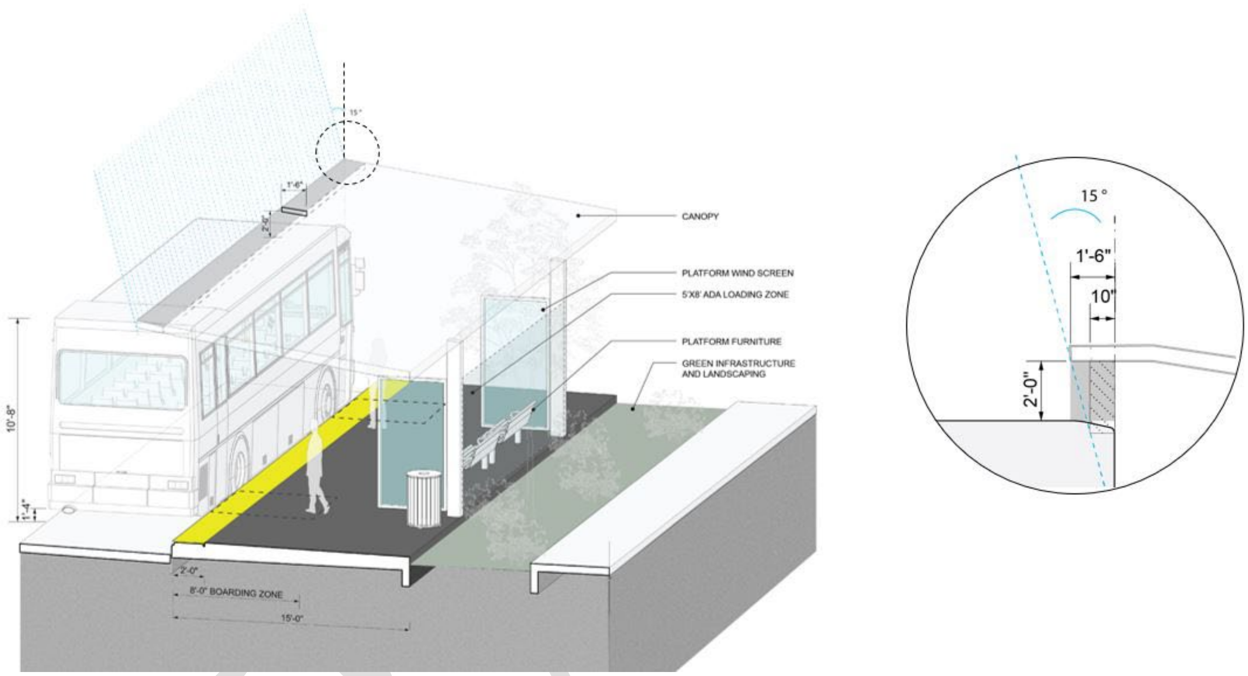

Figure 8.5.2.1: Above is a diagram that illustrates the bus door alignments and platform, canopy and shelter sizing and some station elements. The diagram is generic, not representative of any design.

The canopy is to be aligned to the edge of the platform in the direction of the bus traffic.

Canopy design options were developed and reviewed by MTA-NYCT and the preferred option is summarized in the following section. The following option was the favored option of MTA-NYCT for it is simple form constructability. The canopy design concept is representative at this stage of design. Architectural elements would be refined as the project advances.

8.5.2.1 Option A | Macro-Contextualism

Staten Island has developed its unique identity from its existing conditions as an island. Isolated, it currently connected by iconic infrastructure, such as the St. George Terminal, the Goethals Bridge and the Bayonne Bridge.

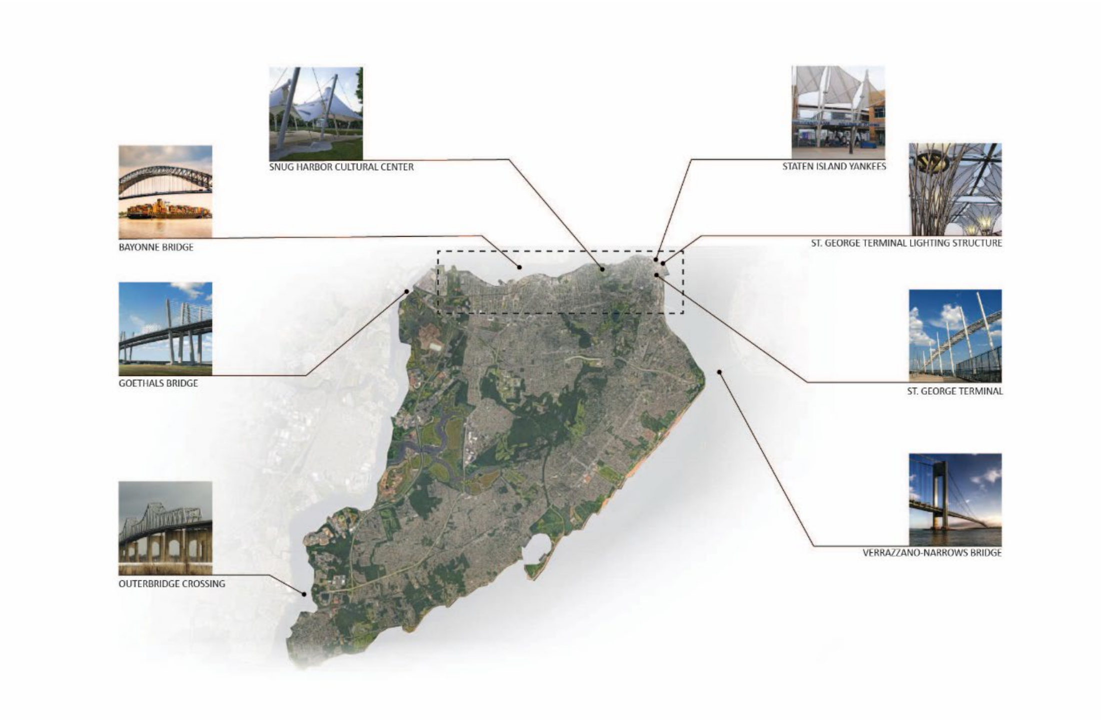

Figure 8.5.2.1.1: Above is a conceptual diagram that illustrates iconic infrastructure in Staten Island.

When bringing in a new BRT system into the North Shore neighborhood, it is important to respond to Staten Island's historical iconic infrastructure as symbol of connection to the local communities. This option draws from the macro-context of the region. This canopy option is the recommended option.

The canopy is inspired from the slanted supporting columns of the Goethals Bridge, the overarching gesture of the Bayonne Bridge and tensile structure that could be found in the North Shore neighborhood, the canopy structure design is an assembly of the existing architectural language.

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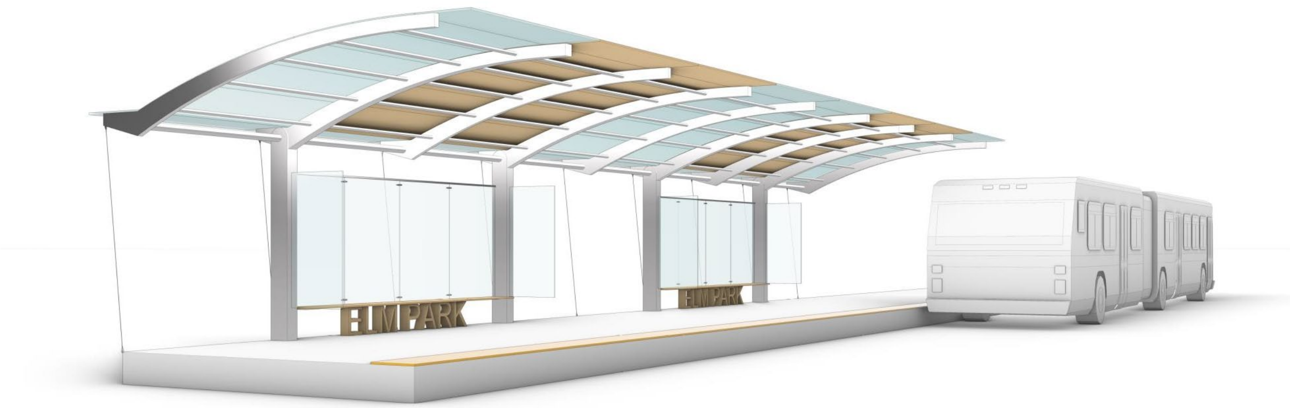
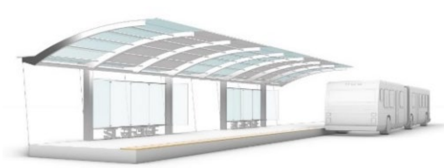
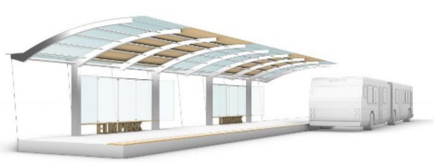


Figure 8.5.2.1.2: Above is a conceptual rendering of the canopy option.

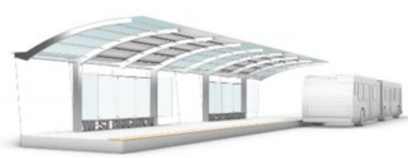
The canopy roof is arched outrigged from four columns, extending over the platform area and partially over the buses.



COMMERCIAL
TEMPERED GLASS PANELS



RESIDENTIAL
WOOD PANELS



INDUSTRIAL
METAL PANELS

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Figure 8.5.2.1.3: Above is a diagram of Staten Island North Shore zoning and the conceptual rendering of the canopy option based on location and land use.

By varying the texture and details of the canopy enclosure system, each station reflects the specific context of the neighborhood in which it is located.

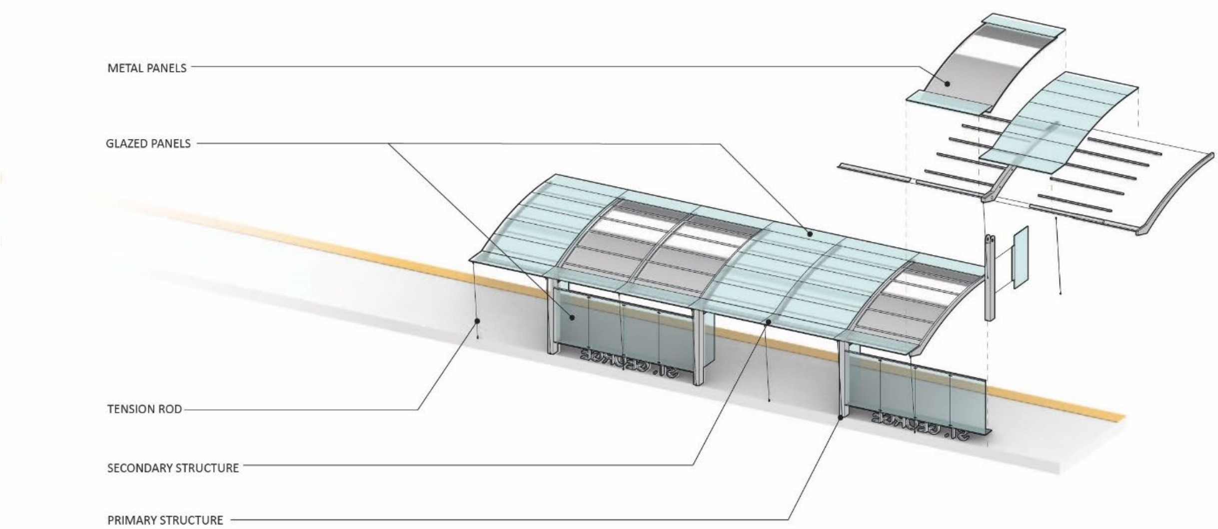

Figure 8.5.2.1.4: Above is a conceptual diagram of the canopy option materiality.

The materiality for the option is based on the where each site is located. For example, at an industrial location metal panels will be used.

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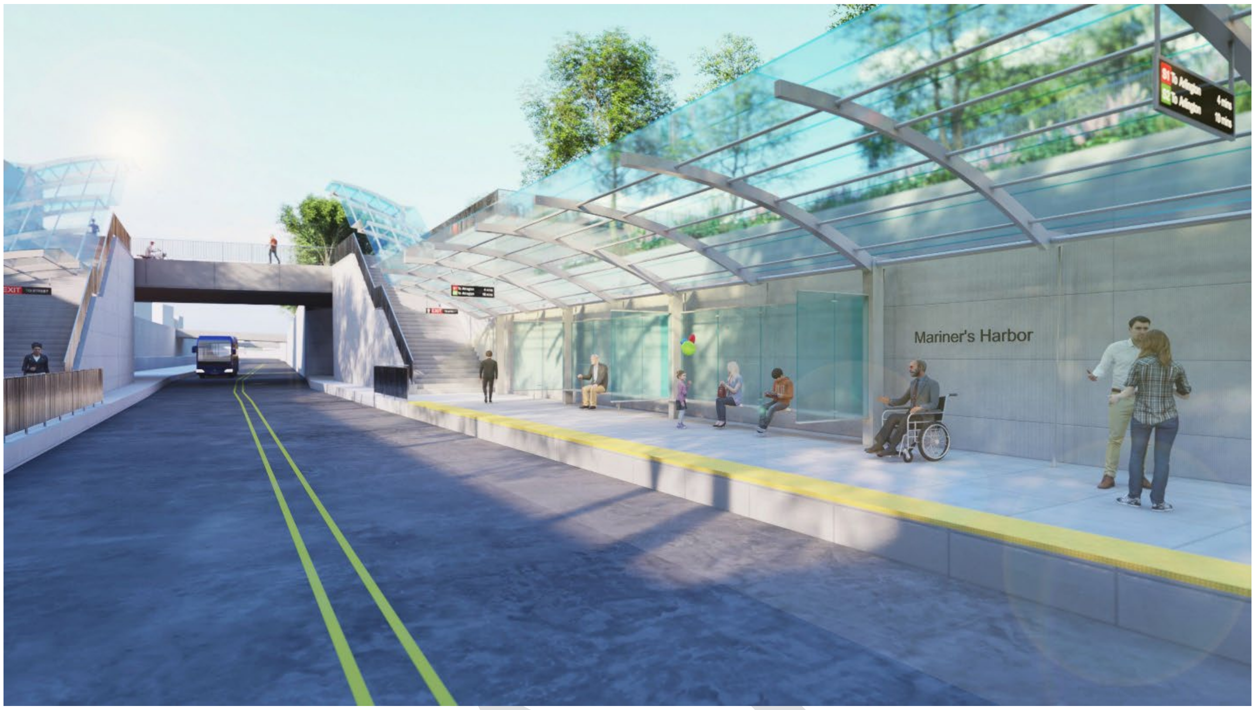

Figure 8.5.2.1.5: Above is a conceptual rendering of the canopy option at Mariners Harbor Station.

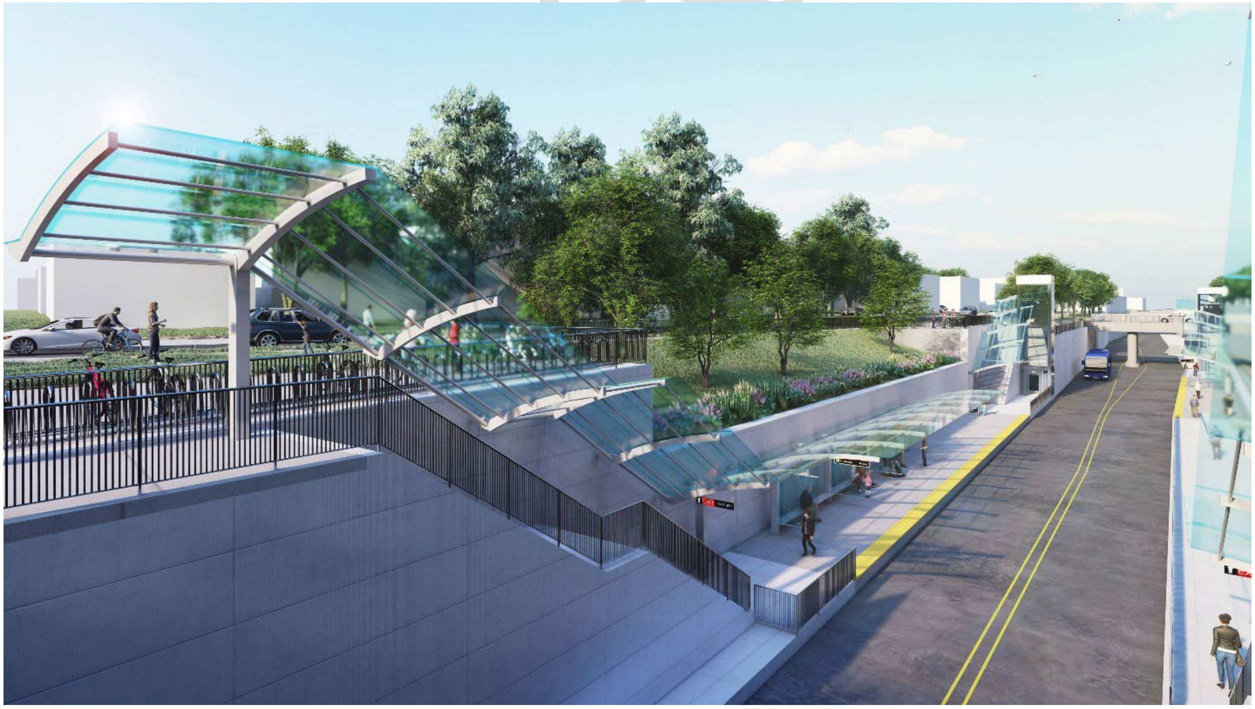

Figure 8.5.2.1.6: Above is a conceptual rendering of the canopy option at Mariners Harbor Station.

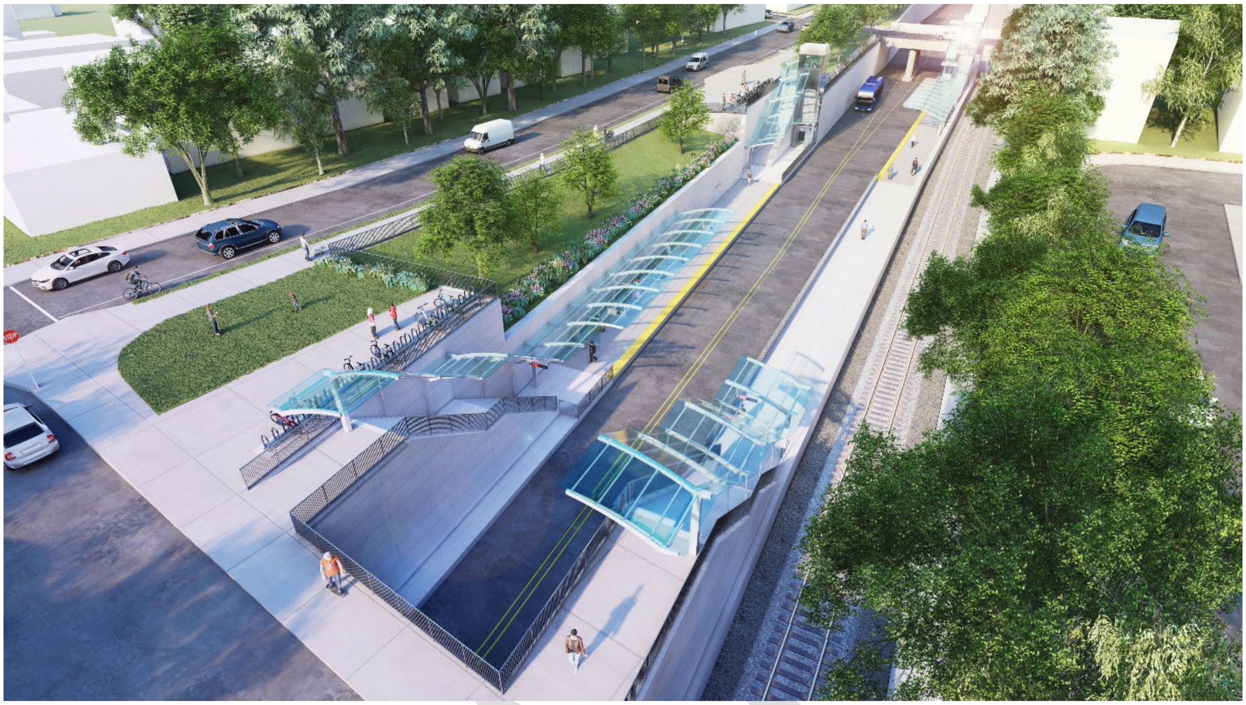

Figure 8.5.2.1.7: Above is a conceptual rendering of the canopy option at Mariners Harbor Station.

8.5.3 Lighting

The recommended approach to the lighting design is to maximize natural daylighting and ensure the proper lighting levels to maintain a safe passenger experience. The illumination levels would follow NYCT's design guidelines for station areas. Per these guidelines the stairs would be 20-25 foot-candles, passages and platforms 15-20 foot-candles, and platform edge 20-25 foot-candles.

The design and location of fixtures should consider future maintenance and replacement.

Emergency lighting, along with emergency signage, should maintain minimum requirements per the code requirements during an emergency for the safe evacuation of occupants.

8.5.4 Advertisement and Public Art

The potential for the incorporation of advertisement and public art space in proposed station areas would be addressed in a future phase of design. To maintain consistent character in the community, the spaces for advertisement and public art are maintained at each station canopy. Vertical surfaces and additional billboards or screen displays at the platform areas should be incorporated to allow for a well-integrated design with other station elements.

The station areas and surrounding context present great opportunities for enriching the station with

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a cultural connection to the existing communities. Each location has an opportunity to create an identity while still maintaining the efficient station functions. Further station development requires coordination for Arts for Transit to develop the scope and not to preclude art integration.

8.5.5 Trash Receptacles

To maintain consistent cleanliness on a given facility and to simplify future maintenance, trash and recycling receptacles are recommended to be located adjacent to station entrances, walkways and platforms. Coordination with NYCT is required for the maintenance and the spatial requirements of any storage. The design of the receptacles would comply to NYCT design guidelines.

8.5.6 Benches

Benches are recommended at the platform and station plaza areas. The benches at the platform should be placed under the canopy for weather protection. All benches should comply with ADA requirements, and in addition there should be a minim of two ADA designated waiting areas in the weather protected platform area. The location of the benches on the platform should maintain a minimum of 10’ clearance from the platform edge. The benches should be designed per NYCT’s guidelines and need to be securely anchored per typical details. Leaning benches should also be considered at station where ridership is higher, or where the platform width of 15’ cannot be maintained.

8.5.7 Wind Screen Shelter

A minimum of a 35-foot wind screen shelter is recommended at the center of the canopy. The proposed shelter would be semi-protected with three sides, while the side facing the platform edge would be open for ease of circulation. Glass is recommended for the wind screen vertical surfaces due to its durability and visibility. Alternative materials and opacities can be considered for the back face of the wind screen in station areas that are adjacent to residential communities. On side is recommended to discourage the creation of hidden corners.

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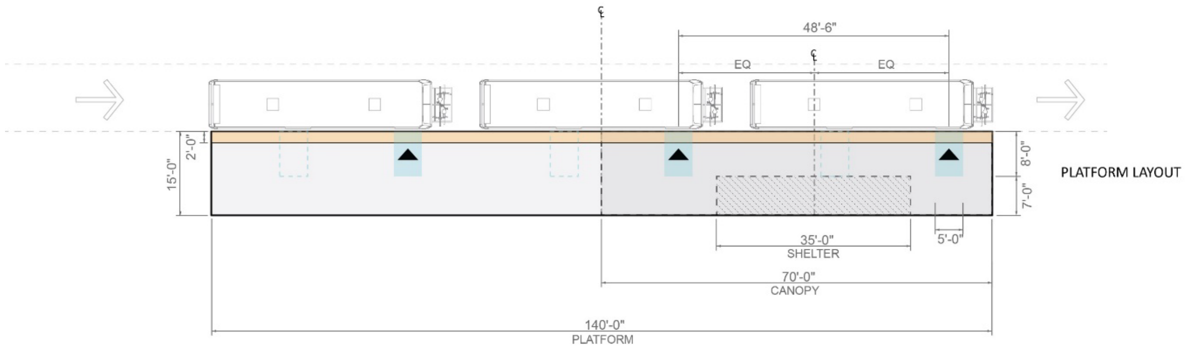

Figure 8.5.7.1: Above is a diagram for the minimum wind screen shelter location.

8.5.8 Sustainability and Green Infrastructure

There are many elements that can be incorporated into the station design to encourage a greener, more sustainable design. When developing the stations each site should be analyzed in detail to determine the existing ecological conditions and opportunities for green infrastructure. Where applicable, a water collection and filtration behind the platforms is recommended. This could be combined with the landscaping to create rain gardens or even planter boxes to collect water. Maintaining permeability porosity in surfaces is encouraged to reduce water runoff. Trees and other plants could be used to create natural shading canopies to help maintain a more comfortable environment and enhance the microclimate. Recycled and locally sourced material would be used in the canopy design at each platform, to the extent practicable.

Reducing energy consumption would be achieved by designing transparent canopies for daylighting and promoting reusable energy like solar panels. Carbon emission could also be reduced with the promotion of the bicycle ridership to the station instead of cars. Bicycle parking is highly encouraged at each station.

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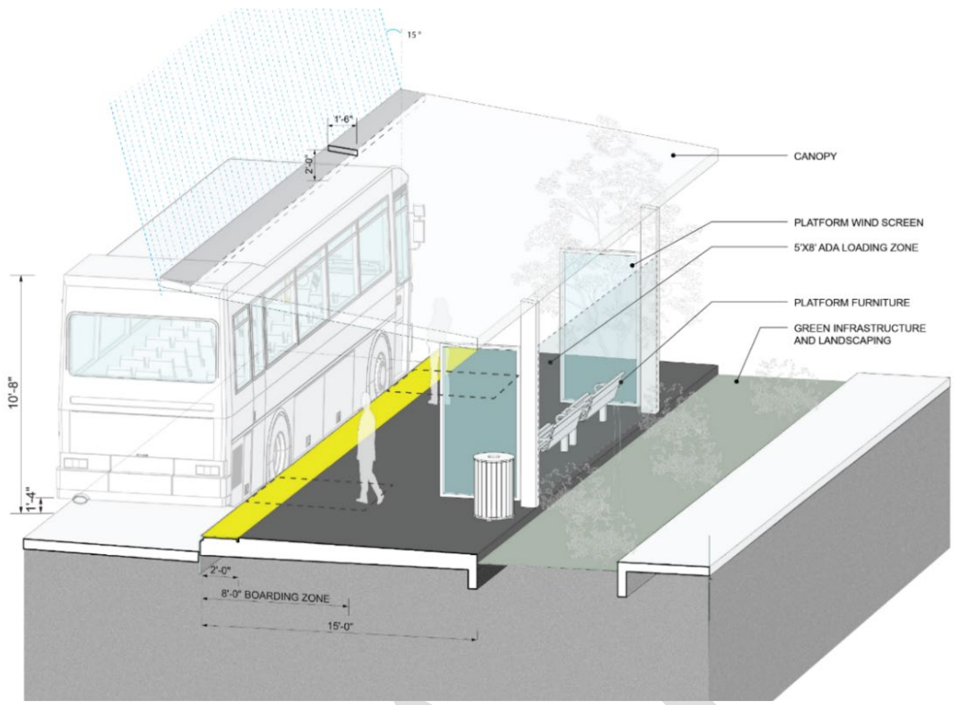

Figure 8.5.8.1: Above is a diagram for the green infrastructure.

8.5.9 ADA Waiting Area

A minimum of two designated 32 inch by 48 inch spots are recommended under the canopy closest to the station access. These spots should be identifiable by signage or floor designations. Passenger assistance communication systems should be located adjacent to these areas, in additional to any other requirements.

8.5.10 Signage and Wayfinding Panel/Customer Information Center

The station designs should consider the placement of signage to improve and maintain visibility during every day and emergency situations. The recommended signage is Station identification, egress, ADA, and room identification following the typical agency and ADAAG guidelines. The station area should be identifiable with markers and clear signs.

Customer information signs (CIS) should also be used and well-integrated with the design and artwork. To maintain a fluid passenger experience, live update of services and system maps are recommended to at each platform. Station branding and logos should be incorporated throughout the system and used as a beacon for identifying the station.

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8.5.11 VMS

Variable messaging system (VMS) would be used at a minimum at all the platform locations. Additional systems are encouraged at the station entrance areas for passenger convenience. These elements should be considered early in the design process to produce a layout that works with the signage, communications and other systems.

8.5.12 CCTV & Communication System

To maintain service safety, CCTV systems should provide full station coverage per agencies requirements, including station entrances and plazas.

8.5.13 Bicycle Parking and Racks

Facilities for bicycles should be considered for every station to promote a more accessibility and environmentally friendly alternative to driving. These also discourage illegal securing of bicycles to station or street elements. These facilities need to be well incorporated to the station design and should be explored early in the design process. The quantity of spots should be determined by ridership at each station.

8.5.15 Guardrail

Guardrails would be provided at all elevated areas and along alignment to prevent passenger access. They should be designed to match the overall design language and follow code requirements. The finishes are recommended to be stainless steel for high durability and modern appearance.

8.5.16 Fare Collection

One Metro New York (OMNY) contactless fare system is assumed which will streamline the boarding process and help sustain timely service.

8.5.17 Platform Edge Tiles

To maintain safety, 2-foot-wide tactile tiles would be installed at the platform edges. These should follow NYCT's and ADA requirements with the typical yellow finish.

8.5.18 Back of House

Required supporting spaces for the operation and maintenance of the system need to be determined

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with close coordination with NYCT. The next step requires a program study that conforms requirement with appropriate MTA user groups. The station areas presented in this report leave open areas that can be designated for back-of-house space. Potential options include the utilization of space underneath stairs, at the end of platforms, or beneath existing pedestrian overpass structures.

8.5.19 Materiality

The proposed stations would be exposed to a variety of outdoor weather conditions and this factor should be considered for every material selection. Durability and ease of maintenance should comply with the NYCT life cycle requirements. For each canopy design, the recommended materials are powder coated/painted steel, safety laminated glass, tempered glass, wood soffit (Grade A wood fire rated/exterior rated for transit), standard stainless-steel panels, stainless steel handrail and guardrail, and aluminum panels concrete platforms. The floor materials should be slip resistance and comply with the minimum requirements for coefficient of friction. The prominent presence of these stations in their context requires early consideration of visual perception, reflectance and sound absorption. The overall goal is to use modular systems for cost effectiveness and ease of maintenance.

8.5.20 Stair, Ramp, Elevator

Vertical circulation quantity and sizing needs to be determined from the ridership at each station. The planning study uses a range of 5’9’ to 8’0” wide stairs depending on the site conditions. The largest size reasonable for each location was assumed without any ridership information for a conservative design. Each station has been designed to be ADA accessible. Elevators are proposed at most stations because of the typologies and requirement of a pedestrian overpass at the station. A minimum of one elevator at each platform would be provided. A pass-through configuration of the elevator doors is the most convenient for passengers and this use was considered at each location. The locations of the Vertical Circulation Elements (VCEs) are shown in highly visible area from within and outside the station for better wayfinding. A queuing length of 15 feet for stairs and 10 feet for elevators was maintained. Once ridership information is gathering a confirmation of these dimensions would be required. Additionally, each elevator is paired with a set of stairs to promote similar circulation patterns of all passengers. Safety has also been considered with the use of all glass elevators to promote visibility. Canopy coverage should be maintained at the entrance to and at the vertical circulation elements, allowing a protected travel path from the entrance to the platform area.

SECTION 9: STRUCTURAL

9.1 GENERAL

This section defines the structural engineering requirements for bridges and retaining walls. All existing structures identified for reuse were visually inspected and assessed to verify that the groupings exhibited the same relative physical condition based upon age, previous damage and maintenance.

Many existing structures that carry the BRT alignment have been identified for reuse. These structures were grouped based on similarities (i.e., those having the same structure type, widths and span lengths and a representative structure of the structure type was load rated). These structures include the Nicholas Avenue, Treadwell Avenue and Park Avenue bridges. See Appendix C: Structure Load Rating Calculations. Nicholas Avenue is a large steel thru-plate girder bridge and is unique for this project since there are no other structures that are comparable to it. Treadwell Avenue has concrete encased longitudinal W-beams. The bridges at Sharpe and Maple Avenues and Faber Street are similar in design to Treadwell Avenue. Park Avenue is a steel plate girder bridge (Port Richmond Avenue and Richmond Terrace are similar to Park Avenue).

Other existing structures were not identified for replacement because they are functionally obsolete for the proposed use. Accordingly, these structures were not load rated.

9.2 LOADS

All new design and design check of existing structure would meet the minimum the load requirements of followings:

- AASHTO 7th edition with all interims
- NYSDOT LRFD Bridge Design Specification
- NYSDOT Bridge Design Manual
- NYSDOT Bridge Inspection Manual
- ASCE 7

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9.3 ROADWAY BRIDGES

Roadway Bridge Table

Bridge Name	BIN	From Station – To Station	Spans	Bridge Type	Existing Vertical Clearance (ft)	Vertical Clearance (ft)*	Approx. Bridge Length (ft)	Approx. Bridge Width (ft)
South Avenue	2-24920-0	15+80 – 16+30	3	Prestressed Box Beam	21.3 – 21.9	18.15	150	50
Harbor Road	2-24918-0	32+50 – 33+00	4	Prestressed Box Beam	21.8	20.43	137	50
Union Avenue	2-24917-0	38+50 – 39+00	4	Prestressed Box Beam	16.5 – 21.7	20.15	136	50
DeHart Avenue	2-24916-0	41+50 – 42+00	4	Prestressed Box Beam	19.0 – 19.9	20.02	133	50
Van Pelt Avenue	2-24914-0	47+05 – 47+55	3	Prestressed Box Beam	15.6 – 20.0	20.37	100	50
Van Name Avenue	2-24913-0	52+00 – 52+50	3	Prestressed Box Beam	18.6 – 19.3	19.19	120	50
Simonson Avenue	2-24912-0	55+90 – 56+40	3	Prestressed Box Beam	18.7 – 20.4	19.18	120	50
Lake Avenue	2-24911-0	58+70 – 59+20	3	Prestressed Box Beam	18.7 – 19.6	19.30	121	50
Granite Avenue	2-24910-0	66+60 – 67+10	4	Prestressed Box Beam	17.2 - 19.1	21.50	143	50
Morningstar Road	2-24909-0	73+75 – 74+25	4	Prestressed Box Beam	19.2 – 19.3	19.78	160	50
Bayonne Bridge					91.9 – 93.2			
John Street	2-24907-0	80+20 – 80+35	2	Steel Girder	19.4 – 19.9	19.23	88	15

*Vertical clearance from bottom of bridge to top of BRT roadway

9.3.1 South Avenue Bridge (BIN 2-24920-0)

The bridge carrying South Avenue over the existing active railroad tracks consists of a 3-span continuous adjacent prestressed box beams resting on reinforced concrete abutments and piers. The piers are founded on piles and the abutments are stub abutments founded on piles with block slope embankment protection in front and steel sheet piling acting as wing walls. The vertical clearance from bottom chord to the existing top-of-rail is approximately 21.3 feet. No load rating was performed for this structure as the BRT alignment passes under it.

The bridge was replaced in 1998 and carries utilities, with the existing substructure was cut and removed but remains in place below grade, as per record data provided by NYCDOT. Part of the original substructure will be removed to accommodate the new roadway alignment. The BRT alignment will be passing under Span 1 (south span) which will require construction of a wall to retain the existing soil in front of the abutment. The superstructure for Span 1 would need to be removed via stage construction to perform the substructure work below. The bridge carries utilities which will be affected during stage construction.

Roadway Bridge Utility Table

Bridge Name	Utilities
South Avenue	12" Dia. Water Main 12" Dia. Gas Main with 16" Dia. Steel Casing 4 – 5" Dia. Con Ed Ducts 8 – 4" Dia. Bell Atlantic Tel. Ducts 12" Dia. Storm Pipe (At North Abutment) Overhead Wires

9.3.2 Harbor Road Bridge (BIN 2-24918-0)

The bridge carrying Harbor Road over the existing active railroad track consists of a 4-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers are founded on piles. The south end of the bridge is supported by a typical wall type abutment. The north end of the bridge is resting on a stub abutment founded on piles with slope embankment in front and steel sheet piling wing walls. The vertical under clearance from bottom chord to the existing track rail is 21.8 feet. No load rating was performed for this structure.

The most recent reconstruction was completed in 1992 and carries utilities, as per record data provided by NYCDOT. The BRT alignment would be passing under Span 2 (second span from the south) with all work to construct the busway below and will not require alteration of the bridge structure. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Harbor Road	12" Dia. Water Main 8" Dia. Gas Main with 12" Dia. Steel Casing Overhead Wires

9.3.3 Union Avenue Bridge (BIN 2-24917-0)

The bridge carrying Union Avenue over the existing abandoned railroad tracks consists of a 4-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers are founded on piles and the abutments are stub abutments founded on piles with block slope embankment protection in front and steel sheet piling wing walls. An existing active railroad tail track bumping post is located approximately 20 feet west of the bridge. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 19.6 feet. No load rating was performed for this structure as the BRT alignment passes under it.

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The bridge was replaced in 1987 and carries utilities, as per record data provided by NYCDOT. The BRT alignment would be passing under Span 3 (second span from the north) with all work to construct the busway below and would not require alteration of the bridge structure. On the east fascia of the existing bridge, part of the existing bridge railing and fencing would be removed to access a pedestrian bridge. The pedestrian bridge would provide access to Mariners Harbor Station. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Union Avenue	8” Dia. Water Main 6” Dia. Gas Main with 10” Dia. Steel Casing Overhead Wires

9.3.4 DeHart Avenue Bridge (BIN 2-24916-0)

The bridge carrying DeHart Avenue over the existing abandoned railroad tracks consists of a 4-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers are founded on piles and the abutments are stub abutments founded on piles with block slope embankment protection in front and steel sheet piling acting as wing walls. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 19.0 feet. No load rating was performed for this structure as the BRT alignment passes under it.

The bridge was replaced in 1995 and carries utilities, as per record data provided by NYCDOT. The BRT alignment would be passing under Span 2 (second span from the south) with all work to construct the busway below and would not require alteration of the bridge structure. On the both the east and west fascia of the existing bridge, part of the existing bridge railing and fencing would be removed to access a proposed pedestrian bridge to Mariners Harbor Station. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
DeHart Avenue	8” Dia. Water Main Overhead Wires

9.3.5 Van Pelt Avenue Bridge (BIN 2-24914-0)

The bridge carrying Van Pelt Avenue over the existing abandoned railroad tracks consists of a 3-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers are founded on piles. The south end of the bridge is supported by a concrete abutment. The north end of the bridge is resting on a stub abutment founded on piles with slope embankment in front and steel sheet piling acting as wing walls. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 19.5 feet. No load rating was performed

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for this structure because the BRT alignment passes under it.

The bridge was replaced in 1990 and carries utilities, as per record data provided by NYCDOT. The BRT alignment will be passing under both Span 1 (south span) and Span 2 (middle span) with all work to construct the busway below and will not require alteration of the bridge structure. On the west fascia of the existing bridge, part of the existing bridge railing and fencing would be removed to access a proposed pedestrian bridge to access to Mariners Harbor Station. On the east fascia of the existing bridge, part of the sidewalk on the bridge deck would be widened to accommodate walkway access to Mariners Harbor Station. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Van Pelt Avenue	12" Dia. Water Main 12" Dia. Gas Main with 16" Dia. Steel Casing Overhead Wires

9.3.6 Van Name Avenue Bridge (BIN 2-24913-0)

The bridge carrying Van Pelt Avenue over the existing abandoned railroad tracks consists of a 3-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers are founded on piles. The south end of the bridge is supported by a concrete abutment. The north end of the bridge is resting on a stub abutment founded on piles with slope embankment in front and steel sheet piling acting as wing walls. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 19.5 feet. No load rating was performed for this structure because the BRT alignment passes under it.

The bridge was replaced in 1990 and carries utilities, as per record data provided by NYCDOT. The BRT alignment will be passing under Span 2 (middle span) with all work to construct the busway below and will not require alteration of the bridge structure. On the west fascia of the existing bridge, part of the existing bridge railing and fencing would be removed to access two new walkway access to Mariners Harbor Station. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Van Name Avenue	8" Dia. Water Main Overhead Wires

9.3.7 Simonson Avenue Bridge (BIN 2-24912-0)

The bridge carrying Simonson Avenue over the existing abandoned railroad tracks consists of a 3-span continuous prestressed box beams which are resting on reinforced concrete abutments and piers. The piers are founded on piles and the abutments are stub abutments founded on piles with slope embankment in front and steel sheet piling acting as wing walls. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 18.7 feet. No load rating was performed for this structure because the BRT alignment passes under it.

The most recent reconstruction was completed in 1990 and carries utilities, as per record data provided by NYCDOT. The BRT alignment would be passing under Span 2 (middle span) with all work to construct the busway below and would not require alteration of the bridge structure. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Simonson Avenue	8” Dia. Water Main 12” Dia. Gas Main with 16” Dia. Steel Casing Overhead Wires

9.3.8 Lake Avenue Bridge (BIN 2-24911-0)

The bridge carrying Lake Avenue over the existing abandoned right-of-way consists of a 3-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers and stub abutments are founded on piles with stone embankment protection in front. A crib wall was provided near the North Abutment. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 18.7 feet. No load rating was performed for this structure because the BRT alignment passes under it.

The most recent reconstruction was complete in 1988 and carries utilities, as per record data provided by NYCDOT. The BRT alignment would be passing under Span 2 (middle span) with all work to construct the busway below and would not require alteration of the bridge structure. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Lake Avenue	8” Dia. Water Main 6” Dia. Gas Main with 10” Dia. Steel Casing Overhead Wires

9.3.9 Granite Avenue Bridge (BIN 2-24910-0)

The bridge carrying Granite Avenue over the existing abandoned railroad right-of-way consists of a 4-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers and stub abutments are founded on piles with stone slope

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embankment protection in front. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 18.6 feet. No load rating was performed for this structure because the BRT passes under it.

The most recent reconstruction was completed in 1990 and carries utilities, as per record data provided by NYCDOT. The BRT alignment would be passing under both Span 2 (second span from the south) and Span 3 (second span from the north) with all work to construct the busway below and would not require alteration of the bridge structure. Utilities carried by the bridge structure would not be disturbed.

Roadway Bridge Utility Table

Bridge Name	Utilities
Granite Avenue	12” Dia. Water Main 12” Dia. Gas Main with 16” Dia. Steel Casing Overhead Wires

9.3.10 Morningstar Road Bridge (BIN 2-24909-0)

The bridge carrying Morningstar Road over the existing abandoned railroad tracks consists of a 4-span continuous adjacent prestressed box beams which are resting on reinforced concrete abutments and piers. The piers and stub abutments are founded on piles with stone slope embankment protection in front. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 19.2 feet. No load rating was performed for this structure because the BRT passes under it.

The bridge was replaced in 1984 and carries utilities, as per record data provided by NYCDOT. On the east fascia of the existing bridge, part of the bridge railing and fencing will be removed to access the widen east sidewalk on the bridge deck to accommodate a new plaza access to the proposed bus station. The BRT alignment would be passing under Span 3 (second span from the north) with all work to construct the busway below. Utilities carried by the bridge structure would be protected during the bridge widening construction.

Roadway Bridge Utility Table

Bridge Name	Utilities
Morningstar Road	12” Dia. Water Main 12” Dia. Water Main 8” Dia. Gas Main with 12” Dia. Steel Casing 3” Dia. Fiberglass Fire Communication Conduit Overhead Wires

9.3.11 John Street Bridge (BIN 2-24907-0)

The bridge carrying John Street over the existing abandoned railroad tracks is a 2-span continuous structure used for pedestrians only. The bridge superstructure consists of steel stingers and floor

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beams. The bridge substructure includes reinforced concrete abutments and piers. The piers are founded on piles. The north end of the bridge is supported by a wall abutment. The south end of the bridge is resting on a wall abutment with approximately 1V:8H slope embankment in front. The vertical clearance from bottom chord to the existing abandoned track top-of-rail is 19.4 feet.

The most recent reconstruction was completed in 1995 and carries no utilities, as per record data provided by NYCDOT. No load rating was performed for this structure because the BRT alignment passes under it. The BRT alignment would be passing under Span 2 (north span) with all work to construct the busway below and would not require alteration of the bridge structure.

9.3.12 Bayonne Bridge

The bridge carrying Route 440 and pedestrians over the former NSRR ROW is an arch bridge spanning the Kill van Kull connecting Bayonne, New Jersey with Staten Island, New York City. The roadbed of the bridge was raised to accommodate Panamax-size sea vessels in the Kill van Kull with construction completed in 2019.

The existing right-of-way/railroad bed underneath the Bayonne Bridge was raised to street level for construction and used as a temporary contractor's storage yard. Since the completion of the raising of Bayonne Bridge, the fill in the right-of-way has been removed in order to restore the right-of-way to its existing conditions/elevation.

9.4 ERASTINA PLACE PEDESTRIAN BRIDGE

The proposed pedestrian walkway on the north side of the former NSRR ROW would provide access for passengers from either Union Avenue or Dehart Avenue to the Mariners Harbor BRT station at Van Pelt Avenue. The pedestrian walkway would of two bridges spanning the north embankment of the open cut. More specifically, one bridge from Union Avenue to Dehart Avenue would span approximately 255 linear feet. The second bridge from Dehart Avenue to Van Pelt Avenue would span approximately 505 linear feet. Currently, an existing asphalt path at street grade exists only from Erastina Place to Dehart Avenue and would be used to facilitate the walkway construction and final path location.

The proposed structure type for the two proposed pedestrian bridges has been designed to be a prefabricated steel truss with precast concrete deck sections founded on concrete piers. The depth of piles are assumed to be 75 feet below grade for the conceptual level engineering design as preliminary borings were not performed for the project. The decision to provide bridges rather than retaining walls to support the pedestrian path was made because the construction excavation and cast-in-place concrete volumes are significantly less in terms of cubic yards. The proposed pedestrian bridges would interconnect at the north abutment of each city street bridge at the top of deck elevation of Union, Dehart, and Van Pelt Avenues. These pedestrian bridges would be level with the existing top of sidewalk elevation of each city street bridge.

An advantage of this bridge structure type is that it is a curbless structure and that aids in discharging stormwater runoff by evenly distributing runoff on each side of the bridge deck structure as opposed to collecting runoff in a closed bridge scupper system. Drainage would discharge to a stone slope embankment below for infiltration without significant erosion.

9.5 PORT RICHMOND VIADUCT

Port Richmond Viaduct Bridges Table

Bridge Name	From Station – To Station	Spans	Bridge Type	Approx. Bridge Length (ft)	Approx. Bridge Width (ft)
Nicholas Avenue	93+49 – 94+51	1	Single Bridge, Steel Thru-Plate Girder	102	33
Treadwell Avenue	99+08 – 99+71	3	Double Bridge, Concrete Encased Longitudinal W-Beam	63	40
Sharpe Avenue	101+69 – 102+31	3	Double Bridge, Concrete Encased Longitudinal W-Beam	62	40
Faber Street	106+11 – 106+80	3	Double Bridge, Concrete Encased Longitudinal W-Beam	69	40
Maple Avenue	108+93 – 109+60	3	Double Bridge, Concrete Encased Longitudinal W-Beam	67	40
Port Richmond Avenue	113+53 – 114+38	3	Double Bridge, Steel Plate Girder	85	36
Park Avenue	117+74 – 118+57	3	Double Bridge, Steel Plate Girder	83	36
Richmond Terrace	122+37 – 123+04	3	Double Bridge, Steel Plate Girder	67	27
Bodine Creek	129+12 – 129+57	1	Single Bridge, Steel Longitudinal W-Beam	45	30

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9.5.1 Nicholas Avenue Bridge

The Nicholas Avenue Bridge crosses over Nicholas Avenue between Riverside Lane/Port Lane and Slaight Street. The bridge is adjacent to the viaduct structure. The street crossing beneath the bridge is one lane in each direction and with parking lanes and sidewalks on each side.

The structure is a skewed, single span steel thru-plate girder bridge with steel rivets. The length from centerline to centerline of bearing of each abutment is approximately 102 feet and the width is approximately 33 feet as measured in the field. The deck consists of a 2-foot-thick reinforced concrete slab supported by closely spaced steel beams spanning perpendicular from one plate girder to another. The abutments and wing walls are reinforced concrete at both the east and west sides of the bridge. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet from the bottom chord to the top of roadway. A visual inspection was performed on July 30, 2019 for this bridge and it was found to be in fair condition. The lower portions of the steel girders were cleaned and painted within the last 10 years. Because the bridge was identified for reuse, this bridge was load rated to determine its adequacy for rehabilitation in lieu of replacement.

The AASHTO Manual for Bridge Evaluation (MBE) was used to perform the Load Rating for the bridges involved in this project. MBE defines Load Rating as the determination of the live load carrying capacity of an existing bridge. Load Rating is performed at the Inventory and Operating Level. The Inventory Rating generally corresponds to the live load, including loads in multiple lanes that can safely be carried by the bridge for an indefinite period. The Operating Rating is the maximum permissible live load that can be placed on the bridge. This load rating also includes the same load in multiple lanes. Allowing unlimited usage at the Operating level will reduce the life of the bridge. The load rating is generally expressed as a Rating Factor for a live load. The HL-93 rating factors would generally be: Inventory 1.0, Operating 1.3. Bridges with an Inventory Rating Factor for HL-93 more than 1 are safe for all legal loads. An Inventory Rating Factor for HL-93 less than 1 identifies vulnerable bridges for further evaluation.

The following table summarizes the various components of the structure for both inventory and operating load ratings:

Nicholas Avenue Bridge Summary Table for Load Rating

Member	Truck Type	Rating Factor at Inventory Level	Rating Factor at Operating Level
Floorbeam	HS-20	1.59	2.11
	TYPE-3	2.99	3.98
	3S-2	3.27	4.37
	3-3	3.17	4.23
	Bus	2.37	3.16
	EV2	1.64	2.18
	EV3*	1.69	2.25
Girder	HS-20	9.76	13.01
	TYPE-3	9.28	12.37
	3S-2	7.66	10.21
	3-3	7.26	9.68
	BUS	13.48	17.98
	EV2	7.61	10.15
	EV3*	6.00	8.00

Notes:

1. The live load used in the load rating includes
   a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
   b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA
2. EV3* uses the smaller value of the two following cases:
   a. EV3 combined with HS-20;
   b. EV3 combined with Type-3;

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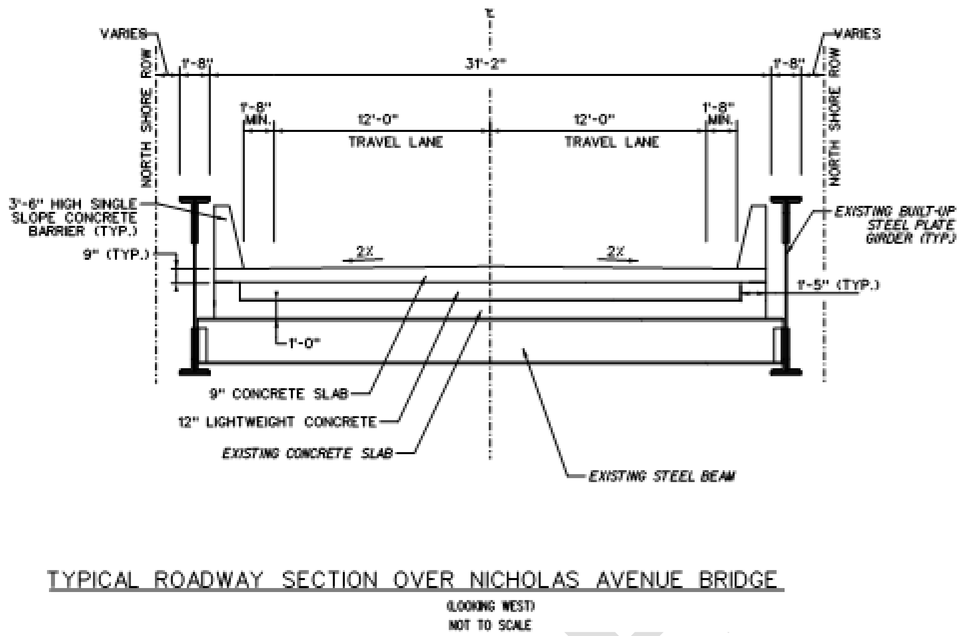

Figure 9.5.1.1 BRT Alignment on Nicholas Avenue Bridge

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9.5.2 Treadwell Avenue Bridge

The Treadwell Avenue Bridge crosses over Treadwell Avenue between Sleight Street and Richmond Terrace. The roadway crossing beneath the bridge provides one lane of traffic in each direction and room for parking along each curb. The structure is a skewed, three span double bridge, consisting of concrete encased longitudinal W-Beams. The length from centerline to centerline of each abutment is approximately 63 feet and the width is approximately 40 feet. The bridge was constructed between 1935 and 1937 and has a minimum vertical clearance of 14 feet. This bridge was load rated as a part of this engineering report, and the recent visual inspection performed on July 30, 2019 did not identify any significant structural deterioration.

The AASHTO Manual for Bridge Evaluation (MBE) was used to perform the Load Rating for the bridges involved in this project. MBE defines Load Rating as the determination of the live load carrying capacity of an existing bridge. Load Rating is performed at Inventory and Operating Level. The Inventory Rating generally corresponds to the live load, including loads in multiple lanes that can safely be carried by the bridge for an indefinite period. The Operating Rating is the maximum permissible live load that can be placed on the bridge. This load rating also includes the same load in multiple lanes. Allowing unlimited usage at the Operating level will reduce the life of the bridge. The load rating is generally expressed as a Rating Factor for a live load. The HL-93 rating factors would generally be: Inventory 1.0, Operating 1.3. Bridges with an Inventory Rating Factor for HL-93 more than 1 are safe for all legal loads. An Inventory Rating Factor for HL-93 less than 1 identifies vulnerable bridges for further evaluation.

The following table summarizes the various components of the structure for both inventory and operating load ratings:

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Treadwell Avenue Bridge Summary Table for Load Rating

Member	Truck Type	Rating Factor at Inventory Level	Rating Factor at Operating Level
SFB2	HS-20	2.08	2.77
	TYPE-3	2.61	3.48
	3S-2	4.54	6.05
	3-3	3.20	4.26
	Bus	6.23	8.30
	EV2	2.29	3.05
	EV3	1.52	2.03

Notes:

1. The live load used in the load rating includes
    a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
    b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
    c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

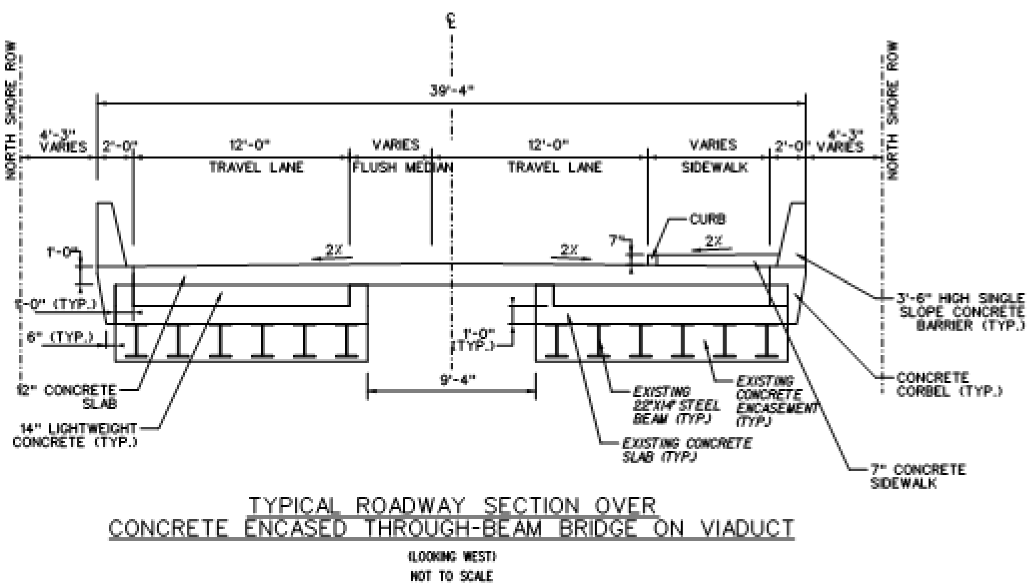

Figure 9.5.2.1 BRT Alignment on Treadwell Avenue Bridge

9.5.3 Sharpe Avenue Bridge

The Sharpe Avenue Bridge crosses over Sharpe Avenue between Grove Avenue and Larkin Street. The roadway crossing beneath the bridge provides one lane of traffic in each direction and room for parking along each curb. The structure is a skewed, three span double bridge, consisting of concrete encased longitudinal W-Beams. The length from centerline to centerline of each abutment is approximately 62 feet and the width is approximately 40 feet. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet. This bridge was not load rated in this engineering report, because the structure is similar Treadwell Avenue Bridge, and the recent visual inspection performed on July 30, 2019 did not identify significant structural deterioration.

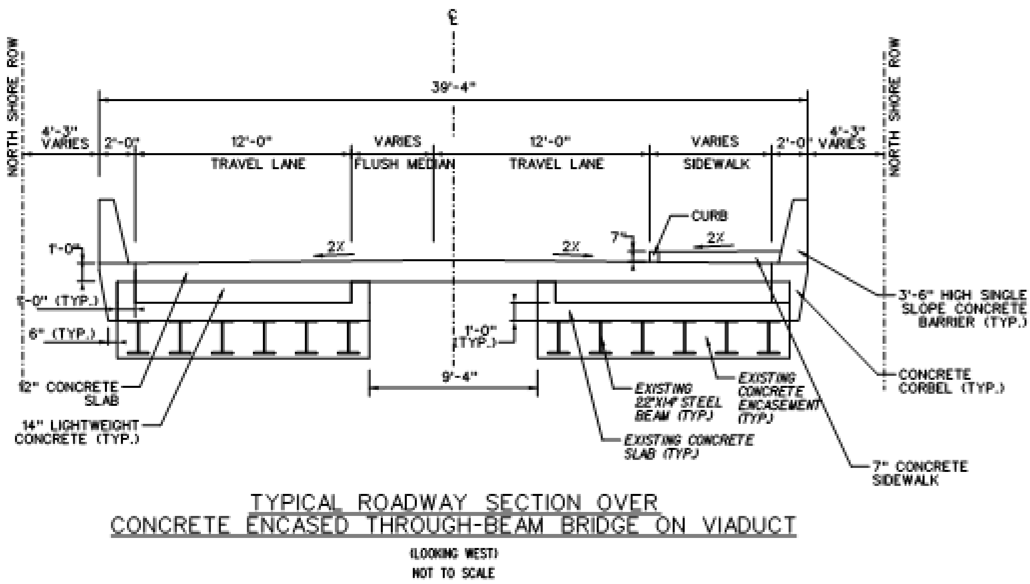

Figure 9.5.3.1 BRT Alignment on Sharpe Avenue Bridge

9.5.4 Faber Street Bridge

The Faber Street Bridge crosses over Faber Street between Grove Avenue and Larkin Street. The roadway crossing beneath the bridge provides one lane of traffic in each direction and room for parking along each curb. The structure is a skewed, three span double bridge. The length from centerline to centerline of each abutment is approximately 69 feet and the width is approximately 40 feet. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet. This bridge was not load rated in this engineering report, because the structure is similar to Treadwell Avenue Bridge, and the recent visual inspection performed on July 30, 2019 did not identify any significant structural deterioration.

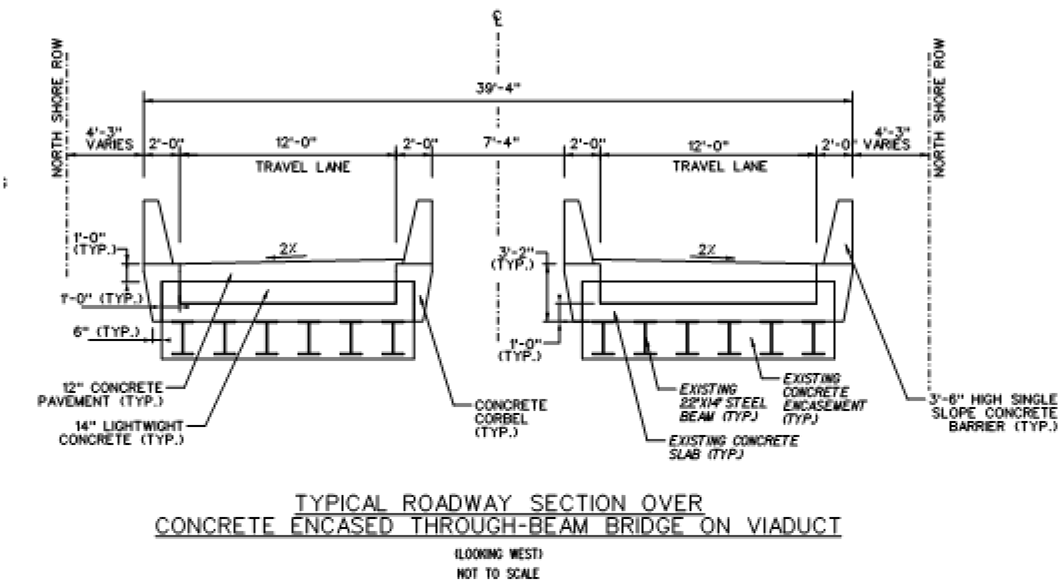

Figure 9.5.4.1 BRT Alignment on Faber Street Bridge

9.5.5 Maple Avenue Bridge

The Maple Avenue Bridge crosses over Maple Avenue between Grove Avenue and Richmond Terrace. The roadway crossing beneath the bridge provides one lane of traffic in each direction and room for parking along each curb. The structure is a skewed, three span double bridge. The length from centerline to centerline of each abutment is approximately 67 feet and the width is approximately 40 feet. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet. This bridge was not load rated in this engineering report, because the structure is similar to Treadwell Avenue Bridge, and the recent visual inspection performed on July 30, 2019 did not identify any significant structural deterioration.

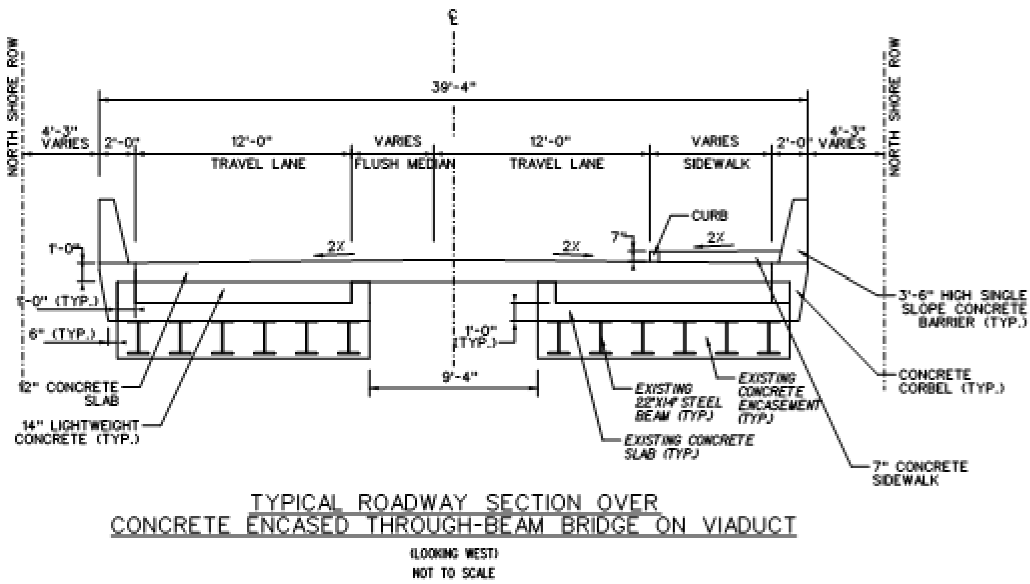

Figure 9.5.5.1 BRT Alignment on Maple Avenue Bridge

9.5.6 Port Richmond Avenue Bridge

The Port Richmond Avenue Bridge crosses over Port Richmond Avenue between Church Street and Ann Street. The roadway is subject to heavy traffic carrying trucks, local bus routes, and private vehicles. The structure is a skewed, three span double plate girder bridge. The length from centerline to centerline of each abutment is approximately 85 feet and the width is approximately 36 feet. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet. This bridge was not load rated in this engineering report, because the structure is similar to Park Avenue Bridge, and the recent visual inspection performed on July 30, 2019 did not identify significant structural deterioration.

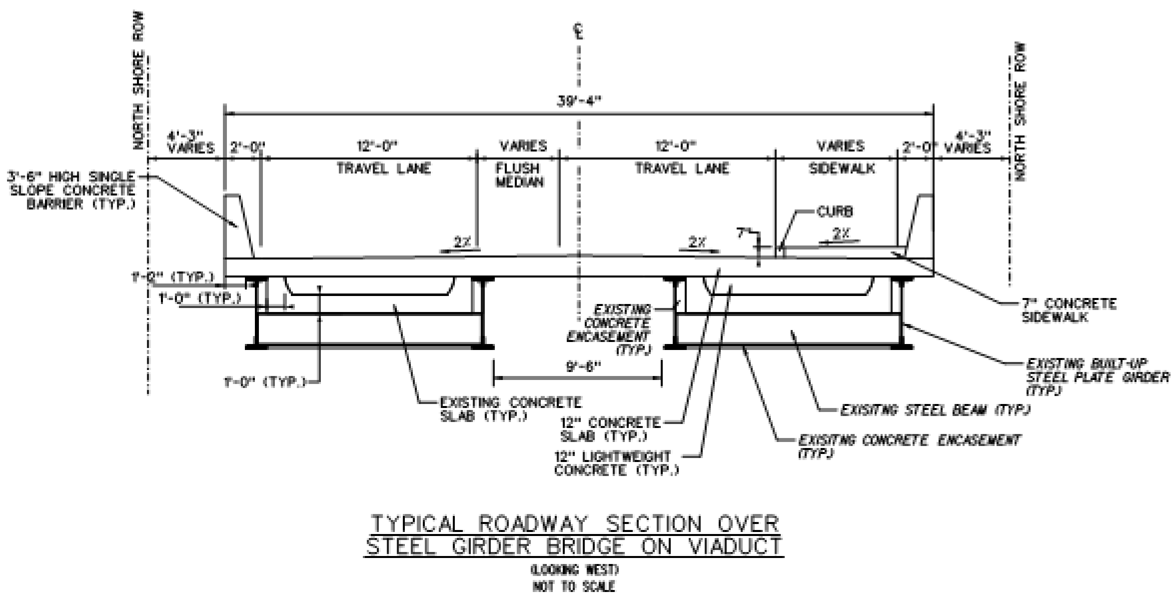

Figure 9.5.6.1 BRT Alignment on Port Richmond Avenue Bridge

9.5.7 Park Avenue Bridge

The Park Avenue Bridge crosses over Park Avenue between Church Street and Ann Street. The structure is a skewed, three span double plate girder bridge. The length from centerline to centerline of each abutment is approximately 83 feet and the width is approximately 36 feet. The bridge was constructed between 1935 and 1937 and has a minimum vertical clearance of 14 feet. This bridge was load rated as a part of this engineering report, and the recent visual inspection performed on July 30, 2019 did not identify any significant structural deterioration.

The AASHTO Manual for Bridge Evaluation (MBE) was used to perform the Load Rating for the bridges involved in this project. MBE defines Load Rating as the determination of the live load carrying capacity of an existing bridge. Load Rating is performed at the Inventory and Operating Level. The Inventory Rating generally corresponds to the live load, including loads in multiple lanes that can safely be carried by the bridge for an indefinite period. The Operating Rating is the maximum permissible live load that can be placed on the bridge. This load rating also includes the same load in multiple lanes. Allowing unlimited usage at the Operating level will reduce the life of the bridge. The load rating is generally expressed as a Rating Factor for a live load. The HL-93 rating factors would generally be: Inventory 1.0, Operating 1.3. Bridges with an Inventory Rating Factor for HL-93 more than 1 are safe for all legal loads. An Inventory Rating Factor for HL-93 less than 1 identifies vulnerable bridges for further evaluation.

The following table summarizes the various components of the structure for both inventory and operating load ratings:

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Park Avenue Bridge Summary Table for Load Rating

Member	Truck Type	Rating Factor at Inventory Level	Rating Factor at Operating Level
Floorbeam	HS-20	2.96	3.94
	TYPE-3	5.57	7.42
	3S-2	6.11	8.14
	3-3	5.91	7.89
	Bus	4.41	5.88
	EV2	2.82	3.77
	EV3	3.05	4.07
Girder	HS-20	1.87	2.49
	TYPE-3	2.57	3.43
	3S-2	2.47	3.29
	3-3	2.92	3.89
	BUS	4.49	5.99
	EV2	2.29	3.05
	EV3	1.46	1.95

Notes:

1. The live load used in the load rating includes

   a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);

   b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;

   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

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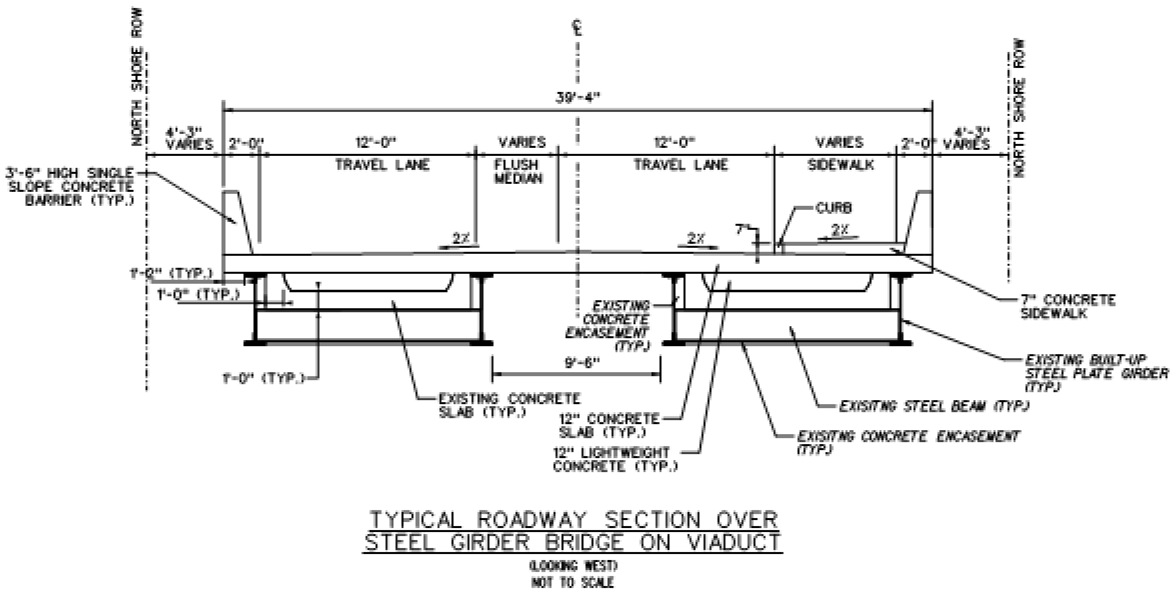

Figure 9.5.7.1 BRT Alignment on Park Avenue Bridge

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9.5.8 Richmond Terrace Bridge

The Richmond Terrace Bridge crosses over Richmond Terrace between Herberton Avenue and Park Avenue. The roadway is subject to heavy traffic carrying trucks, local bus routes, and private vehicles. The structure is a skewed, three span double plate girder bridge. The length from centerline to centerline of each abutment is approximately 67 feet and the width is approximately 27 feet. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet. This bridge was not load rated in this engineering report, because the structure is similar to Park Avenue Bridge, and the recent visual inspection performed on July 30, 2019 did not identify any significant structural deterioration.

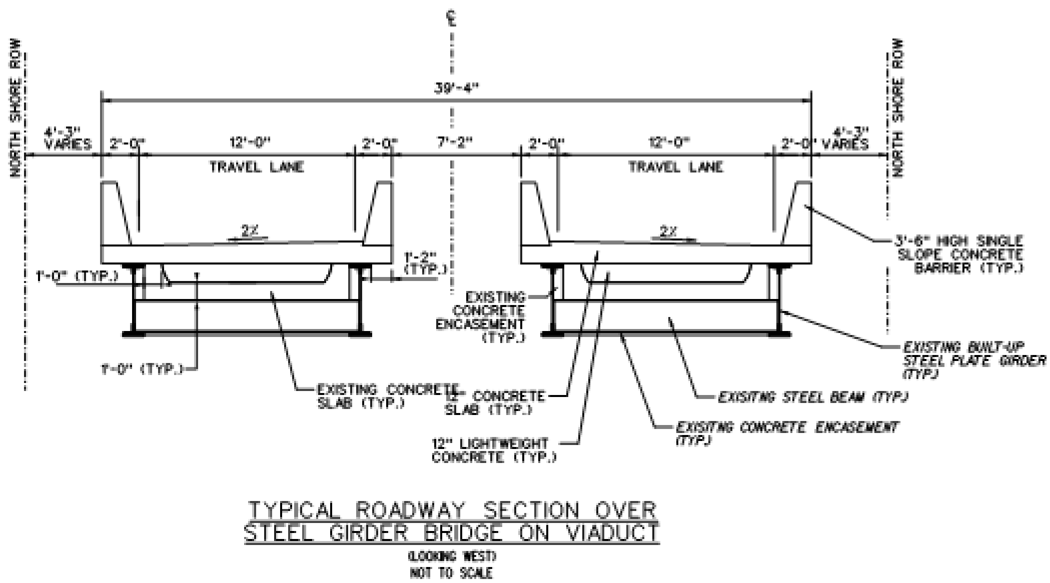

Figure 9.5.8.1 BRT Alignment on Richmond Terrace Bridge

9.5.9 Bodine Creek Bridge

The Bodine Creek runs underneath this single span bridge supported by steel longitudinal W-Beams. The length from centerline to centerline of each abutment is approximately 45 feet and the width is approximately 30 feet. The bridge was constructed circa 1935 and has a minimum vertical clearance of 14 feet. This bridge was not load rated in this engineering report, because the structure is similar to Nicholas Avenue Bridge, and the recent visual inspection performed on July 30, 2019 did not identify any significant deterioration.

9.6 SNUG HARBOR ALIGNMENT

From Bard Avenue to Clinton Avenue, the former NSRR ROW is against the Kill van Kull at an elevation of 4 to 10 feet above sea level. The ROW has not been maintained since the cessation of passenger and freight service and has eroded into the Kill van Kull along most of this length due to coastal erosion from tidal action, ships' wakes and storm events. The potential for wake action to intensify is expected with the introduction of Panamax-size vessels now that projects such as the enlargement of the Panama Canal, the navigational channel dredging of the Kill van Kull and the raising of the Bayonne Bridge (at the local level) are fully completed. To protect this newly proposed transit infrastructure in a resilient manner (e.g., new construction as opposed to the rehabilitation of the existing North Shore Railroad ROW) from erosion and service from being disrupted by flooding, the BRT alignment was conceptually engineered along the Snug Harbor waterfront. The proposed alignment consist of an elevated busway landward of the Kill van Kull shoreline, north of Richmond Terrace, with a proposed elevation of approximately 36 feet above sea level at its highest point. Additional detail regarding the resiliency establishing this alignment are presented in Section 13 – Resiliency. To achieve this elevation, a concrete viaduct structure is proposed. An allowance for grade-separated crossings of the transit operations is provided with the Modified alignment.

This alignment would involve the construction of an elevated busway south of the existing ROW and just north of Richmond Terrace. While the busway would primarily utilize city-owned right-of-way, this design option would require the conversion of approximately 0.36 acre of existing parkland from the shoreline portion of the Snug Harbor Cultural Center and Botanical Garden to right-of-way.

This BRT alignment begins following a sag curve in the vertical alignment after Bard Avenue with a total span of 2,773 linear feet. It increases in elevation to STA 202+48.91 at its highest elevation (EL 36.17 feet) and begins to decrease in elevation. This section of the BRT alignment ends following a crest curve in the vertical alignment after the proposed New Brighton Station located between Tysen Street and Clinton Avenue. Approach ramps at both ends of the busway would be constructed on fill contained by a retaining wall before transitioning to a bridge structure. The bridge deck, approximately 31-feet wide, would be reinforced concrete supported on prestressed concrete girders resting on reinforced concrete substructure units founded on piles. The depth of piles is assumed to be 75 feet below grade for the conceptual level engineering design as preliminary borings were not performed for the project. Typical pier spacing is anticipated to be 120 feet along the tangent section and 80 feet along the horizontal curved section.

At approximately STA 207+00, pedestrians would still be able to access the Snug Harbor waterfront at Richmond Terrace by crossing beneath the busway via the existing granite stairs. The vertical clearance at the first stair landing from the bottom of prestressed concrete girders is approximately 14-feet. The vertical clearance at the second landing from the bottom of prestressed concrete girders is approximately 17-feet.

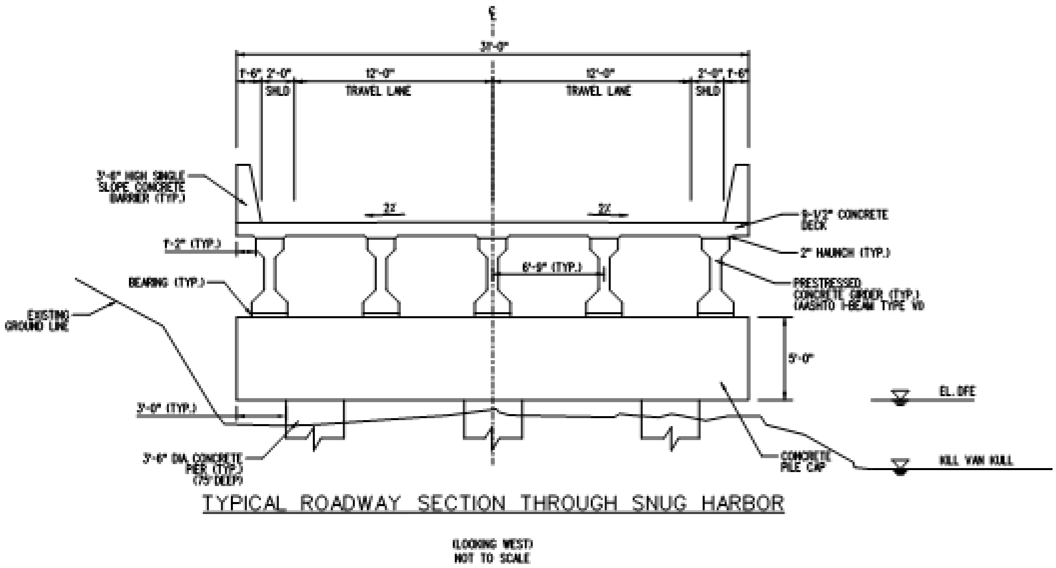

Figure 9.6.1.1

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9.7 ATLANTIC SALT EXISTING TUNNEL STRUCTURE

An existing tunnel structure on the Atlantic Salt property is located north of and parallel to Richmond Terrace. The tunnel structure, which is currently in ~~not~~ used~~,~~ lies at dock level and is below the grade of Richmond Terrace. A multi-story building that previously sat atop the tunnel structure and at grade with Richmond Terrace was removed in 2019. The proposed BRT alignment would operate through the existing tunnel structure which is at grade with Atlantic Salt's dock. Along the north wall, exposed and facing the Kill van Kull, are several vertical openings of varying sizes located between existing columns. Elevation along the existing tunnel structure varies. Elevation is approximately 10.9 feet at the western end and approximately 9.6 feet at the eastern end. The existing tunnel structure length, from end to end, is approximately 840 feet with a minimum vertical clearance of approximately 13.72 feet.

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Figure 9.7.1 North face of multi-story building atop the tunnel structure (pre-demolition)

Drawings of the multi-story building and the tunnel structure are not available. Field verification measurements are needed; therefore, assumptions have been made for the interior measurements of the structure. There are three existing column lines supporting the structure spaced transversely at 17 feet from centerline to centerline. The existing columns were assumed to be of equal width (2 feet) with the existing center column line separating the BRT eastbound lane (12-foot width) from the BRT westbound lane (12-foot width). The existing columns would be protected with NYSDOT-style single-sloped concrete barriers therefore limiting the available shoulder width to less than 2 feet as the BRT operates through the existing tunnel structure. For design speed through the existing tunnel structure, see Section 6.4.2.

Per National Fire Protection Association (NFPA) guidelines (NFPA 502) the approximately 840-foot-long tunnel structure that the busway will operate through may require ventilation and/or fire suppression. At this conceptual design stage, the designer has not been able to inspect the privately-owned structure or to assess this need. As such, in the next design phase we recommend a thorough inspection of the structure and an assessment of the need for ventilation and/or fire suppression systems.

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9.8 NICHOLAS STREET RAMP

The proposed Nicholas Street Ramp, located on existing former NSRR ROW, begins following a sag in the vertical alignment at STA 248+00. The ramp lies between and runs parallel to Richmond Terrace and Bank Street. The ramp would be constructed on fill before transitioning to a bridge structure. The fill-supported ramp length is approximately 1,700 feet and would be separated from Bank Street with a retaining wall. The bridge deck, approximately 31-feet wide, would be reinforced concrete supported on prestressed concrete girders resting on reinforced concrete substructure units founded on piles. The bridge deck increases in elevation over the span of approximately 709 feet and transitions into the exiting elevation of Richmond Terrace (EL 36.29 feet). The depth of piles are assumed to be 75 feet below grade for the conceptual level engineering design as preliminary borings were not performed for the project. Typical pier spacing is anticipated to be 120 feet along the tangent section. Removal of existing pedestrian fencing, curb, sidewalk and structural modifications to the existing Richmond Terrace retaining wall to install an expansion joint is anticipated to allow the proposed BRT to enter Richmond Terrace at Nicholas Street. The proposed ramp would share the intersection with the existing access ramp to the former New York Wheel Garage. The new crossing would be signalized for safety. See Section 6.9 for traffic signals.

With the introduction of the BRT alignment, the existing Bank Street roadway alignment, east of the turnaround, would shift approximately 20 feet north and gradually transition back to the existing roadway alignment at Nicholas Street. The turnaround located on Bank Street, east of Jersey Street, would remain. Bank Street's existing 24-foot roadway width and 5-foot sidewalk on the north side of Bank Street would be reconstruction to allow the BRT alignment to occupy the space between Richmond Terrace and Bank Street. Water main work is not anticipated with the street reconstruction as the existing 8-inch diameter watermain along Jersey Street was installed in 2000 and the existing 8-inch diameter watermain along Bank Street, from the dead end located in front of the Atlantic Salt site to approximately 90 feet east of the turnaround, was installed in 2000. Given that these mains were installed prior to 1970, NYCDEP water main replacement criteria does not apply for the watermain infrastructure at this location. The relocation of existing hydrants is anticipated as curbs would be relocated.

A line of soil stockpiles, covered by tarps and partially vegetated for maintenance, extends along the ROW between Bank Street and the Richmond Terrace retaining wall just north of the North Shore Esplanade. The soil was excavated primarily during construction of the former New York Wheel parking garage. The soil has been characterized and will be either reused on the former New York Wheel site below the site cap, as approved by NYSDEC, or properly disposed of off-site. The City and/or future New York Wheel tenant is responsible for the reuse and/or removal of

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this soil. It is assumed that disposition of the stockpiles by the City or future New York Wheel tenant will occur prior to construction and that no contamination from the stockpiled material will remain in the ROW

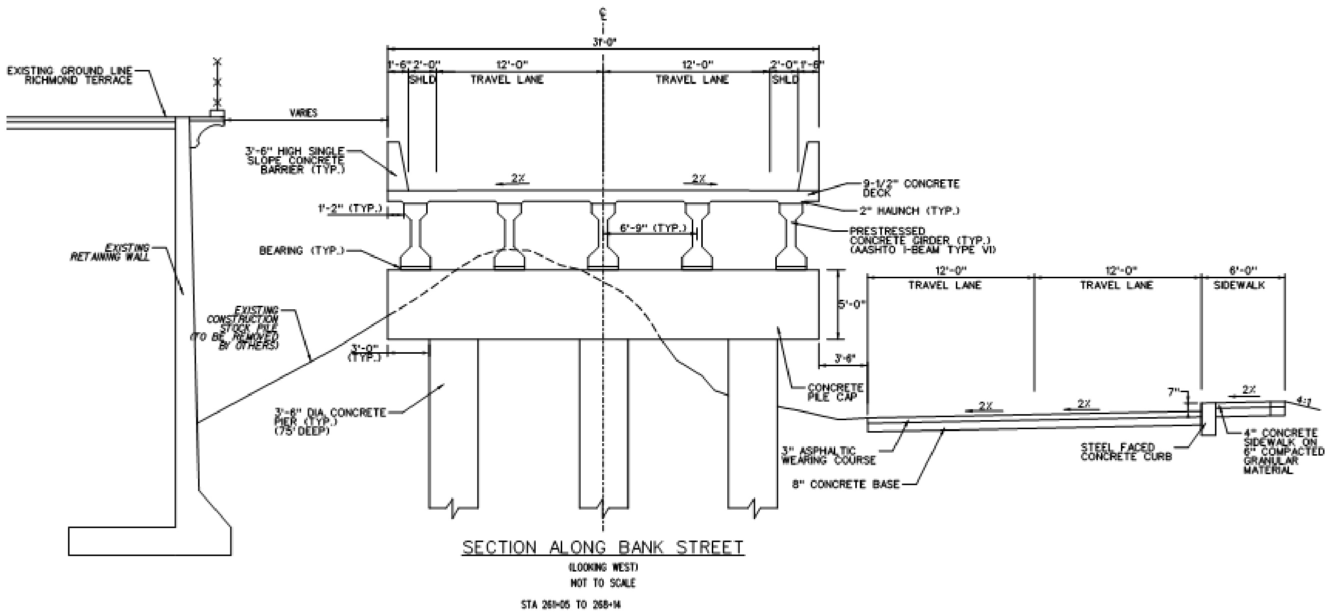

Figure 9.8.1 Nicholas Street Ramp Along Bank Street

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SECTION 10: GEOTECHNICAL

10.1 GENERAL

The purpose of this section is to summarize the in-situ site conditions, geotechnical design parameters, site specific subsurface exploration requirements and laboratory testing programs necessary for the foundation design of bridges, retaining walls, stations, pavements and miscellaneous structures. Limited geotechnical conditions and record information were obtained through available historic data, past agency projects in the area and available as-built documents. All site-specific subsurface explorations would be performed at the time of final design. The geotechnical design criteria for this project for both permanent and temporary construction would be based upon the requirements noted below.

10.2 CODES, STANDARDS, REGULATIONS, GUIDELINES AND MANUALS

For a list of the codes, standards, regulations, guidelines and manual which are being applied to the design of the NYCT North Shore BRT, see section 2.3 of this Design Criteria Manual.

10.3 EXISTING CONDITIONS

10.3.1 Geology

The oldest bedrock strata within the project limits is the Serpentinite unit, which was formed approximately 430 million years ago. The Serpentinite unit forms the basis of Staten Island's relatively rugged topography, including the North Shore's hilly terrain. Overlaying the Serpentinite, in an irregular manner throughout the North Shore, is bedrock from the Triassic Stockton, Lockatong, Passaic and the Jurassic Palisades formation. Unconsolidated deposits include Outwash and Ground Moraine from the Upper Pleistocene deposits of Wisconsinian glacial drift.

10.3.2 Subsurface Information from Existing Boring Logs

Limited existing subsurface information was found during a review of historical data. Subsurface information for two projects provided a general understanding of the subsurface conditions at the west end of the project limits (Replacement of the South Avenue Bridge over Staten Island Railroad) and at the east end of the project limits (Richmond Terrace Retaining Wall Assessment).

The Replacement of the South Avenue Bridge over Staten Island Railroad project as built plans included a soil profile which showed overburden consisting of loose to medium dense clayey silt and silty fine sand. The original and replacement bridges are supported on piles which are assumed to be driven to bedrock approximately 75 feet below the railroad tracks or approximately 92 feet below the top of roadway.

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The Richmond Terrace Retaining Wall Assessment project included 10 borings performed between Westervelt Avenue and Nicholas Street. Subsurface conditions generally consisted of medium dense granular fill overlying medium dense silty sand or very stiff clay or silt. Decomposed bedrock followed by serpentine bedrock underlies the overburden materials.

10.3.3 Existing Foundation Systems

Existing foundation systems are presented in as-built drawings for various bridges along the proposed corridor. As-built bridge drawings for South Avenue, Harbor Road, Union Avenue, De Hart Avenue, Van Pelt Avenue, Van Name Avenue, Simonson Avenue, Lake Avenue, Granite Avenue, Morningstar Road, and John Street provide foundation information. All these bridges convey traffic over the former NSRR ROW.

In general, full height abutments are supported on spread footings supporting between 1.4 and 3.2 tons per square feet of pressure. The bridge piers are supported on spread footings supporting 2.5 to 3.0 tons per square foot of pressure. Stub abutments are founded on piles supporting between 23 and 25 tons of load. The drawings for the Harbor Road bridge indicate that the piles are precast concrete.

10.4 GEOTECHNICAL DESIGN

The narrative below is provided for design guidance only, as no geotechnical investigations were conducted for this project.

10.4.1 Foundation Design

In addition to the applicable AASHTO manual, it must be noted that the requirements per design building codes (NY State and New York City) will also be considered, with the stricter requirements applying.

The selection of a foundation type or types will be based on conditions prevailing at the site, cost, availability, construction requirements, local experience, and environmental and social impact.

10.4.1.1 Shallow Foundations

Shallow foundations would include spread footings for isolated columns, combined footings for supporting the load from more than one structural unit, strip footings, and mats or raft foundations beneath a structure area. Shallow foundations would be used where there is a suitable bearing stratum near the surface and where there are not highly compressible layers or soil susceptible to liquefaction. The suitability of foundation strata for shallow foundation construction would be demonstrated based on settlement and bearing capacity analyses for each structure.

Shallow foundations would be designed to meet the requirements of AASHTO. Shallow foundations will be designed such that the resultant load falls within the middle third of the foundation for non-seismic loading. Foundation design would consider potentially detrimental substances in soil or groundwater, such as chlorides and sulfates, and would provide appropriate protection for reinforcement, concrete and metal piping.

Bearing Capacity:
Shallow foundations would be analyzed for bearing resistance to confirm that the underlying soil can resist the strength limit load combinations without failure. In accordance with AASHTO, the bearing resistance would be taken as the factored resistance at the strength limit state using the appropriate resistance factor based on the analysis method and soil conditions. Additional consideration would be taken of load duration in relation to foundation soil type and groundwater conditions when selecting a resistance factor.

Shallow foundations would be evaluated for their performance under seismic loading in accordance with AASHTO. Shallow foundations subjected to seismic loads will be sized such that at least half of the foundation area remains in contact with the soil and the applied loads do not exceed the bearing resistance of the soil under extreme limit state design.

Settlement:
Immediate settlements for granular soils and both primary and secondary consolidation settlements for cohesive soils would be considered. Shallow foundations would be designed to keep estimated settlements within the tolerable movements as specified in AASHTO.

Sliding and Overall Stability:
Shallow foundations would be analyzed for sliding stability and overall (global failure) stability. Failure by sliding would be investigated for footings that support horizontal or inclined load and/or are founded on slopes using the resistance factors based on foundation type and soil conditions. Overall stability of spread footings would be investigated using Service I load combinations and appropriate resistance factors. Passive earth pressure in front of the foundation would not be considered in the evaluation of sliding and overturning failures.

10.4.1.2 Deep Foundations

A deep foundation system would be used where a shallow foundation cannot be designed to carry the applied loads or displacements safely or when liquefaction can occur. Deep foundations will also be used where scour, erosion, or unacceptable settlement might occur, and where the soil conditions permit its use, even though the bearing capacity of the soil will be sufficient to make the use of shallow foundations practicable.

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Deep foundations would include driven piles, micropiles and drilled shafts. Alternative pile types, including driven steel H-piles, Monotube and Tapertube piles, pipe piles, prestressed concrete piles, micropiles, and other pile types consistent with those used successfully in the project area, would be considered. Drilled shafts, including conventional and post-grouted types, would also be considered as appropriate from technical, cost and constructability aspects. When designing deep foundations to be installed in populated areas, consideration would be given to the impact of noise and vibration to the environment. Specific noise and vibration limits would be established to conform to local codes.

Piles and drilled shafts will be designed for static loading in accordance with the requirements of AASHTO and FHWA manuals whichever is more stringent. Service limit state design will include the evaluation of settlement due to static loads and downdrag loads, if present, overall stability, lateral squeeze and lateral deformation. Strength limit state design would include the nominal bearing resistance.

Vertical Capacity:
Deep foundations would be analyzed under strength limit state design for axial compression and uplift resistance, using static analysis methods in accordance with AASHTO. An appropriate resistance factor would be applied to determine the factored nominal bearing resistance in accordance with AASHTO. When the capacity is verified by static and or dynamic field tests, the factored nominal bearing resistance would be based on the field tests. Deep foundation capacity and serviceability requirements under seismic loading would conform to the requirements specified in AASHTO. Where liquefaction can occur, the pile buckling capacity would be substantiated.

Downdrag (Negative Skin Friction):
The design of deep foundations would consider the effect of negative skin friction from existing ongoing ground settlement, liquefaction, construction dewatering, placement of fill or embankments, or pile installation. Downdrag loads would be determined by considering the load transfer distribution along the deep foundation element as well as the group layout. The magnitude of the downdrag load would be applied as additional dead load on the deep foundation.

Group Spacing and Performance:
The design of deep foundations would consider soil properties, type of foundation and group effects due to spacing of foundation elements.

Settlement:
The design of deep foundations would consider the limits on total and differential settlement

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caused by the structure loads. Settlement induced by the deep foundation group in the subsoil would be evaluated. In addition, settlement of the individual deep foundation elements would also be evaluated. The foundation would be designed to keep the settlement within the allowable values as specified in AASHTO.

Lateral Load Capacity:
Deep foundations would be designed to adequately resist the lateral loads transferred to them from the structure without exceeding the allowable deformation of the structure or overstressing the foundation elements. The lateral load resistance of the individual and group of deep foundation elements would be analyzed. The analysis would consider nonlinear soil pressure-displacement relationships, soil-structure interaction, group action, groundwater, and cyclic and static and dynamic loading conditions. The deep foundation performance evaluation would include the determination of vertical and horizontal movements, rotation, axial load, shear, and bending moment for the foundation elements and the bending stresses in the batter piles due to the weight of liquefied soils.

Where the lateral resistance of the soil surrounding the piles is inadequate to resist the applied loads, batter piles would be provided. Batter piles would not be flatter than one horizontal to three vertical. Where battered piles are proposed, the design would consider the potential for such battered piles encroaching on property outside the ROW and interfering with underground and aboveground structures, facilities, and utilities. The use of battered drilled shafts would not be considered.

When liquefaction of soils can occur, lateral resistance calculations would assume zero soil support or residual strength for liquefied soils from the design water level to the bottom of the zone of potential liquefaction. The lateral displacement (transverse and longitudinal) in either direction at the superstructure level would be limited to a value consistent with the design limits of the superstructure and expansion joints. The calculations for the horizontal movement of the foundations, substructure, superstructure and bearings would be based on elastic seismic loads (R =1).

Wave Equation Analyses:
The constructability of a pile design and the development of pile driving criteria would be performed using a wave equation computer program. The use of dynamic pile driving formulae would not be an acceptable method for developing driving criteria or performing drivability studies.

10.5 RETAINING WALL DESIGN

The narrative below is provided for design guidance only, as no geotechnical investigations were

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conducted for this project. Conventional and non-conventional retaining walls would be evaluated for use along the project alignment. Conventional walls would include gravity, cantilever, steel sheet piling, and soldier pile and lagging types. Non-conventional walls would include mechanically stabilized earth walls or Prefabricated Modular Gravity Block Walls.

The design of all earth retaining structures would conform to AASHTO and FHWA manuals and current engineering practice. These walls would be designed to resist all anticipated dead and live, vertical and lateral loads. These loads would include those induced by soil, groundwater, live load, surcharge and construction equipment, etc. Estimation of loads due to pedestrian, or road and external stability analyses would be in accordance with the requirements of AASHTO.

Lateral earth pressure would be estimated based on the anticipated movement of the structure. For adequately yielding retaining structures, active earth pressure based on Rankine earth pressure theory would be used. However, where the movement of the structure is not enough to mobilize active pressures, the lateral pressure on the structure would be evaluated on the basis of anticipated movements, site specific subsurface conditions and construction methods as specified in AASHTO. Hydrostatic pressure induced by the groundwater would be included in the lateral pressures. Lateral pressure induced by surcharge loads applied at the ground surface behind the wall would be included, as appropriate.

10.6 EMBANKMENT DESIGN

The narrative below is provided for design guidance only, as no geotechnical investigations were conducted for this project.

10.6.1 Slope Stability

Slope (overall) stability analyses would be performed to confirm that the embankment slope has adequate resistance against global slope stability under static loads. Circular and wedge type failures would be conducted if necessary, for potential occurrence for each embankment configuration and slope. Overall stability would be investigated using Service I load combinations and appropriate resistance factors. Where the geotechnical parameters are well defined a resistance factor of 0.75 can be used. Where the geotechnical parameters are based on limited information or the slope contains or supports a structural element a resistance factor of 0.65 would be used.

10.6.2 Bearing Capacity

Embankments would be designed such that the bearing resistance of the underlying soil has a maximum resistance factor of 0.45 against a general bearing capacity failure for loads from the embankment and against any traffic and surcharge loading.

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10.6.3 Settlement

Embankments would be designed to keep estimated total long-term settlements limited to four inches during a period of 10 years after construction completion. Differential settlement both within fill sections and across fill/structure interfaces would be limited to 1 inch within a 50-foot length.

10.7 GROUNDWATER LEVELS

The groundwater levels used in the design of the temporary and permanent works would be based on review of all available information and the data collected from additional subsurface exploration programs performed by the designer. Long-term variations in the groundwater level and the possibility of future significant changes in groundwater elevation would be considered in the next design phase when establishing the design groundwater levels. The stages or condition of groundwater levels that the design would consider for next design phase are as follows:

- Construction Level
- Normal "High" Level
- Normal "Low" Level
- Flood Level

10.7.1 Construction Level

The construction level would consider all events during the time span that represents construction. It would consider all aspects of the proposed temporary works and the case of an excavation over or adjacent to the works at a later date.

10.7.2 Normal "High" Level

The normal 'high' level would be based on the maximum groundwater level at the structure location, including perched groundwater levels, measured during the course of the subsurface exploration program.

10.7.3 Normal "Low" Level

The normal 'low' level would be based on the minimum groundwater level at the structure location, measured during the subsurface exploration program.

10.7.4 Flood Level

Refer to Section 13

10.8 INSTRUMENTATION AND MONITORING

Design criteria for instrumentation and monitoring would be developed at the next phase of this project. Key objectives of the instrumentation and monitoring include but are not limited to the

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following:

- Monitor the performance of the excavations by measuring the ground movements caused by excavations, and
- Measure groundwater inflows to compare with baseline values and to verify the performance and need for control measures

Instrumentation and monitoring would include surface instruments and survey monitoring points.

10.8.1 Surface Instrumentation

Surface instrumentation for monitoring excavations would consist of optical survey control points, inclinometers with settlement casings, and piezometers. The objectives would be to monitor the slope stability, groundwater levels, and the ground surface settlements during excavations. In addition, the adjacent buried pipelines must also be monitored with utility monitoring points and in-place inclinometer arrays to verify that the pipelines are not disturbed by adjacent excavations.

10.8.2 Noise and Vibration

Noise and vibration are critical issues both for environmental reasons and for protection of adjacent structures. Construction noise in urban areas is a major environmental issue that must be controlled. Noise tolerances or restrictions for the project would be based on the adherence to local noise ordinances for New York (e.g. New York City Noise Code). These noise ordinances define allowable noise levels related to times of day and the zoned land usage. The maximum allowable noise levels may vary according to the specific locale.

Vibrations, typically from blasting, can cause structural damage due to low frequencies. Limits on peak particle velocity would be determined during Final Design based and consider the type and condition of the structures. These parameters would be measured by noise meters and seismographs.

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SECTION 11: MAINTENANCE FACILITIES

11.1 MAINTENANCE FACILITIES

No improvements are proposed. The use of the existing MTA-NYCT Castleton Bus Depot, located in the West Brighton neighborhood of Staten Island, is assumed without modifications for the additional vehicles needed, including new electric vehicles to be used on the proposed S1 and S2 routes. All bus charging for the BRT routes will be at Castleton Bus Depot.

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SECTION 12: SURVEYING AND MAPPING

12.1 SURVEY DATA COLLECTION

The base mapping used for the development of the current conceptual design is the result of numerous survey and data collection efforts completed in 2018, 2019 and 2020. The survey effort was broken into two distinct efforts: Utility Survey and Topographic Survey. The two surveys have been performed with the intent to support future design development and final design efforts, with the understanding that field changes since the surveys have been completed could require additional survey and/or validation. The survey efforts are further described below.

12.2 UTILITY SURVEY

Preliminary Subsurface Utility Engineering (SUE) Survey was performed by Naik Consulting Group. The preliminary SUE investigations took place during the 2020 spring season. The services provided include, but are not limited to, records research, and surface geophysical methods. The utility survey consists of a comprehensive investigation of existing utilities, both public and private, in determining the approximate presence or absence of the same.

All data was collected and depicted in accordance with the American Society of Civil Engineers (ASCE) published Standard 38-02 titles Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data. The standard defined SUE and set guidance for the collection and depiction of subsurface utility information. The ASCE standard presents a system to classify the quality of existing subsurface utility data, in accordance with four Quality Levels (QL):

- QL-D: Development of a composite utility plot on base information derived from existing records and/or oral recollection.
- QL-C: Development of a composite utility plot on base mapping with the benefit of surveyed utility surface features and using professional judgment in correlating this information to quality level D information.
- QL-B: Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of the subsurface utilities.
- QL-A: Precise horizontal and vertical location of utilities obtained by the actual exposure test hole, typically performed by air/vacuum excavation (or verification of previously exposed or surveyed utilities).

For this investigation, the utility data was primarily collected by the following effort:

The first was requesting and collecting utility records, reports, drawings, plans and/or plates from all known responsible utility owners within the vicinity of the project scope, as provided by the designer. Additional reports, records and plans were provided from a previous utility data

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collection effort. All documentation was in receipt of, has been categorized as QL-D, and was catalogued.

The reference information procured from various resources for this investigation included:

Utility Plates were requested of the following public/private utility owners within the project limits (documents were not received from all entities):

- Altice/Cablevision
- Buckeye Pipeline
- Century Link
- Consolidated Edison
- Empire City Subway
- FDNY Bureau of Facilities Management, Plant Operations, Engineering Unit
- Level3 Communication
- MTA-NYCT
- National Grid
- NYCDEP

Where utility plates were provided by the owners of record, the utility lines have been labelled accordingly, indicating ownership.

The overall utility investigation is not considered complete until the remaining private property access has been granted and coordination has taken place. Utility investigations performed within the public ROW have not benefited from documentation/plates the City may possess.

12.3 TOPOGRAPHIC

Topographic survey data was collected through both aerial photogrammetry and ground based conventional survey. The ground-based survey via ground-based laser scanning concentrated on areas that were obstructed in the aerial mapping which includes bridge clearance survey from South Avenue to John Street along the open-cut and along the Snug Harbor area.

The project horizontal datum is NAD83 NY Long Island State Plane and the vertical datum is the North American Vertical Datum of 1988 (NAVD88).

The aerial survey effort includes imagery that was flown on December 4, 2018 at an altitude of 5,465-feet above mean terrain for 10cm GSD. The mapping by GEOD Corporation (Newfoundland, New Jersey) was performed by skilled technicians under the direct supervision of certified photogrammetrists to meet or exceed American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data (EDITION 1,

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VERSION 1.0. - NOVEMBER 2014) for 10cm imagery. Absolute horizontal accuracy would be 24.5cm at the 95% Confidence Level, the absolute vertical accuracy would be 19.6cm at the 95% Confidence Level, while the relative vertical accuracy (from point to the next point) should be 6cm. This is appropriate for the 1" = 100' Concept Development Mapping with 2ft contours. See tables below:

Horizontal Accuracy Standards for Digital Geospatial Data				
	Absolute Accuracy			Relative Accuracy
Horizontal Accuracy Class (cm)	RMSEx&y (cm)	RMSEr (cm)	Horizontal Accuracy at 95% Confidence Level (cm)	Orthoimagery Mosaic Seamline Mismatch (cm)
10	≤ 10	≤ 14.1	≤ 24.5	≤ 20

Vertical Accuracy Standards for Digital Elevation Data						
	Absolute Accuracy			Relative accuracy (where applicable)		
Vertical Accuracy Class (cm)	$RMSE_z$ Non-Vegetated (cm)	NVA at 95% Confidence Level (cm)	VVA at 95th Percentile (cm)	Within-Swath Hard Surface Repeatability (Max Diff) (cm)	Swath-to-Swath Non-Vegetated Terrain ($RMSD_z$) (cm)	Swath-to-Swath Non-Vegetated Terrain (Max Diff) (cm)
10	≤ 10	≤ 19.6	≤ 30	≤ 6	≤ 8	≤ 20

In areas along the open-cut and Snug Harbor shoreline that were obscured by the aerial flight, supplemental topographical and planimetric ground survey via ground-based laser scanning were performed by NAIK Consulting Group (New York, NY). NAIK also established a horizontal control traverses on the ground in 2019 to tie-in the aerial survey throughout the route of the project.

Property lines are derived from the New Jersey Geographic Information Network – 2007 NJ High Resolution Orthoimagery and are to be consider approximate.

Inland wetlands were identified in the field and flagged by Amy Green Associates. See Section 5.2 for locations of these flags.

The two surveys were used to support the Conceptual Design and would be used for future Design Development efforts. The Topographic Survey has been provided with the Conceptual Design Drawings.

12.4 SURVEY CONTROL

Horizontal Control

All horizontal controls are based on the North American Datum of 1983 (NAD 83). The coordinate system is the NY State Plane Coordinate System (NYSPCS), NY83-LIF-NAD83, Long Island

The precision of any secondary horizontal ground control surveys will be Second Order Class II, 1:20,000. All subsequent horizontal surveys will, as a minimum, have a precision of 1:10,000, Class A-2.

Vertical Control

The North American Vertical Datum of 1988 (NAVD 88) is the standard used by many other agencies and is the reference datum for the published FEMA flood elevations. NAVD 88 was utilized as the project-wide vertical datum for all work within the project extent in New York.

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SECTION 13: RESILIENCY

13.1 COASTAL FLOOD RESILIENCY

13.1.1 General

The purpose of this section is to summarize the relevant coastal flood resiliency design criteria, including the Design Flood Elevation (DFE) criteria for the BRT. The DFE is defined as the location-specific peak elevation of the coastal design flood, including sea level rise (SLR) and freeboard, relative to the North American Vertical Datum of 1988 (NAVD 88). The DFE criteria presented in this Chapter are consistent with methodologies described in the *New York City Transit (NYCT) Flood Resiliency Design Guidelines (DG 312).*

13.1.1.1 Coastal Flooding Parameters

Meteorological conditions during tropical (hurricane) and extra tropical (nor'easter) storms (i.e. high winds and low atmospheric pressure) result in increases in sea level, referred to as storm surge. The combination of the storm surge, wave setup and astronomical tide produces the storm tide which in the absence of waves, is known as the stillwater elevation (SWEL). In addition to the SWEL, wind-driven waves that ride along the surface can contribute to higher levels of coastal flooding. The SWEL plus the greater of: (1) the maximum wave crest elevation, and (2) the maximum vertical extent of wave uprush on a shore or structure (wave run-up) determines the Base Flood Elevation (BFE).

BFE values for BRT locations are defined by the currently projected 1-percent annual probability storm surge elevations published on the latest applicable Flood Insurance Rate Maps (FIRMs). The 1-percent annual probability storm (sometimes referred to as the 100-year storm) is a storm that has a 1 percent chance of occurring in any given year. The area that would be flooded in a 100-year storm is mapped by FEMA on FIRMs. The maps also indicate the BFE, which is the elevation of flooding relative to NAVD 88 resulting from the 1-percent annual probability storm within the floodplain.

Flood zones are geographic areas that FEMA defines accordingly to varying levels of flood risk. Definitions of FEMA Flood Zone Designations are as follows.

High Risk Areas

- Zone A - Area inundated by 1% annual chance flooding, no BFE has been determined.
- Zone AE - Area inundated by 1% annual chance flooding, BFE has been determined.
- Zone AH - Area inundated by 1% annual chance flooding (usually areas of ponding), BFE has been determined; flood depths range from 1 to 3feet.
- Zone AO - Area inundated by 1% annual chance flooding (usually sheet flow on sloping

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terrain), average depths have been determined; flood depths range from 1 to 3 feet. For areas of alluvial fan flooding, velocities have also been determined

- Zone AR - Area inundated by flooding, BFE or average depths have been determined. This is an area that was previously, and will again, be protected from the 1% annual chance flood by a Federal flood protection system whose restoration is Federally funded and underway
- Zone A99 - Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No BFE has been determined.

High Risk Coastal Areas

- Zone V - Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. No BFE has been determined.
- Zone VE - Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. BFE has been determined

13.1.1.2 Sea Level Rise and Freeboard Adjustments

Flood elevations published by FEMA do not presently include the effects of SLR and freeboard. Per FEMA and ASCE, freeboard is a factor of safety, expressed in feet above a flood level and compensates for potential model and mapping inaccuracies and the many uncertainties that could contribute to flood heights, such as wave action, constricting or funneling obstructions, and other hydrological effects that are not accounted for in the modeling. In addition, locations near the waterfront have additional flood height uncertainty owing to the generation, propagation, and transformation of incoming waves. The DFE for the BRT have been based on an adjustment of + 2 feet, which has been added to the BFE to account for factors mentioned above. This criterion assumes the BRT would not be in service during storm events exceeding the DFE and takes into consideration the existing grade elevations of adjacent roadways that would be utilized by the BRT but are not raised as part of the project.

13.1.1.3 Design Flood Elevations

FEMA FIRMs indicates the former NSRR ROW is either adjacent to or falls within flood zones with varying BFEs and is summarized below:

- Existing Arlington Yard fall within several Zone AE with BFE of 11 and 12
- Zone A is located just south of the former NSRR ROW, west of South Avenue and north of Cable Way.
- The eastern section of the Port Richmond Viaduct, from Richmond Terrace to its end at STA 137+00, falls within two (2) Zone AE with BFE of 11 and 12.

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- Zone AE with BFE of 11 is located just south of the former NSRR ROW between the eastern end of Port Richmond Viaduct up at Heritage Park entrance driveway.
- Former NSRR ROW from the Heritage Park entrance driveway up to Bard Avenue is along the shoreline and falls within several Zone AE with BFE of 11, 12, 13 and 14. Zone AE with BFE of 14 is located between Davis Avenue and Bard Avenue.
- Former NSRR ROW from Bard Avenue, through Snug Harbor, and up to Lafayette Avenue is along the shoreline and falls within several Zone AE with BFE of 11, 12 and 13. Zone VE with BFE of 14 is located between Lafayette Avenue and Franklin Avenue.
- Former NSRR ROW from Franklin Avenue up to Nicholas Street is along the shoreline and falls within several Zone AE, with BFE of 11, 12, 13 and 16, and Zone VE with BFE of 14, 15 and 17 is located between Davis Avenue and Bard Avenue.

One of the most critical locations along the BRT is through Snug Harbor, from Bard Avenue to Clinton Avenue, due to the proximity to the shoreline. For the design through Snug Harbor, the BFE has been determined to be 14 feet due to BFE of adjacent flood zones at both ends. The alignment through Snug Harbor would consist of a reinforced concrete bridge deck, approximately 31-feet wide, supported on prestressed concrete girders resting on reinforced concrete substructure units founded on piles. The superstructure would be located above the DFE. Factoring in the +2 feet to include the effects of SLR and freeboard, the DFE at Snug Harbor, from Bard Avenue to Clinton Avenue is 16 feet.

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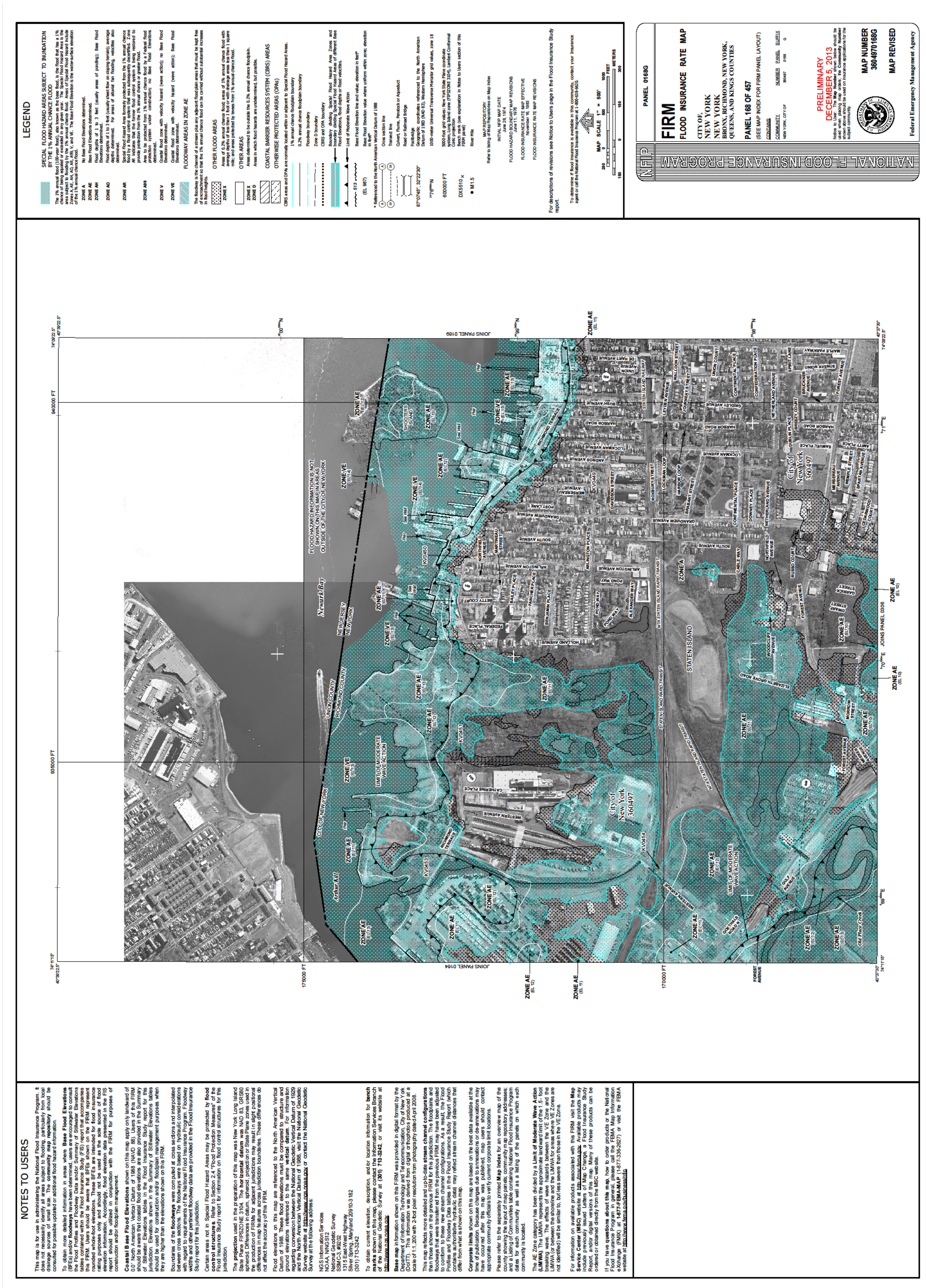

Figure 13.1.1.3.1 FEMA FIRM Map Number 3604970168G (Preliminary 12/5/2013)

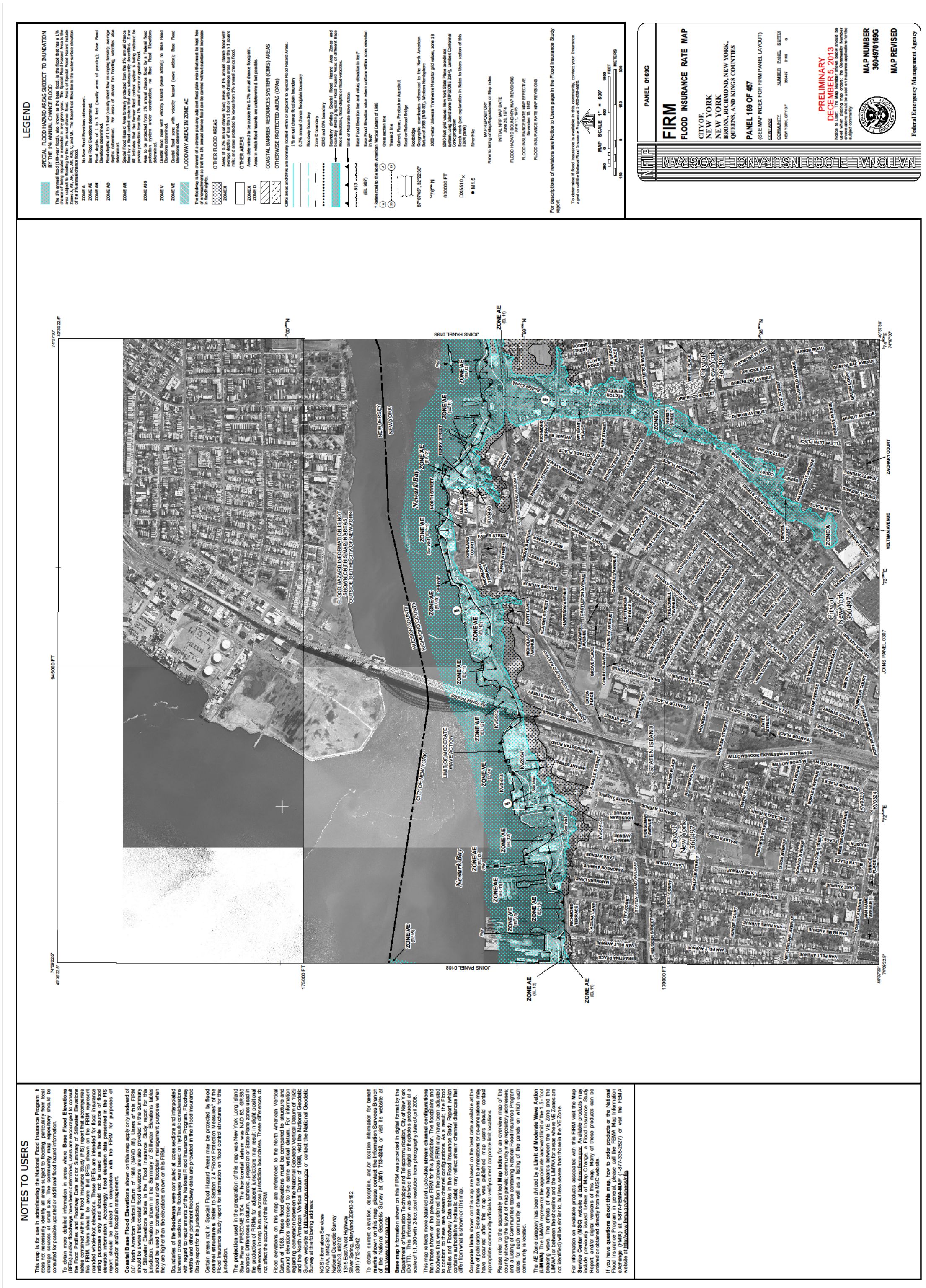

Figure 13.1.1.3.2 FEMA FIRM Map Number 3604970169G (Preliminary 12/5/2013)

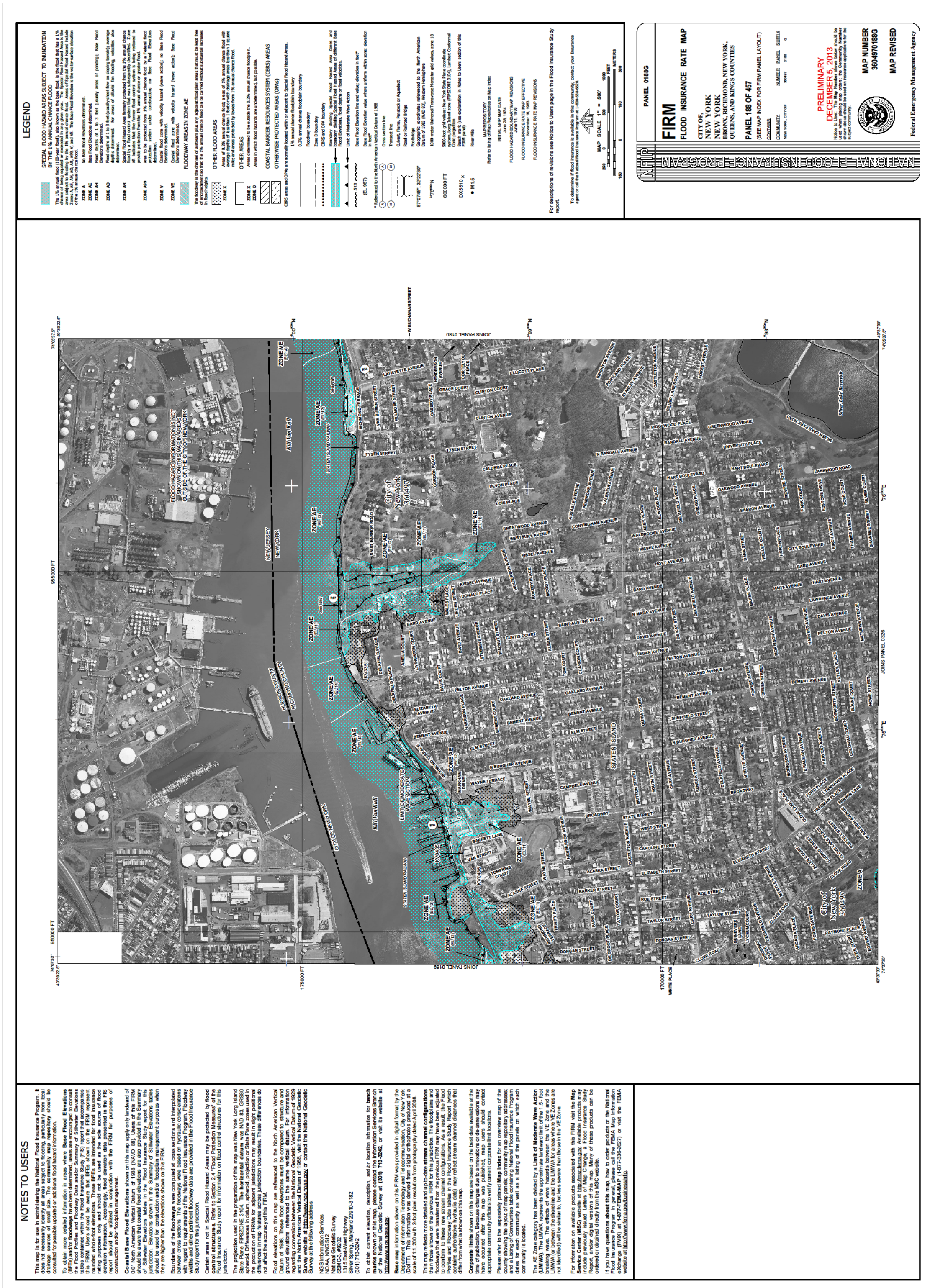

Figure 13.1.1.3.3 FEMA FIRM Map Number 3604970188G (Preliminary 12/5/2013)

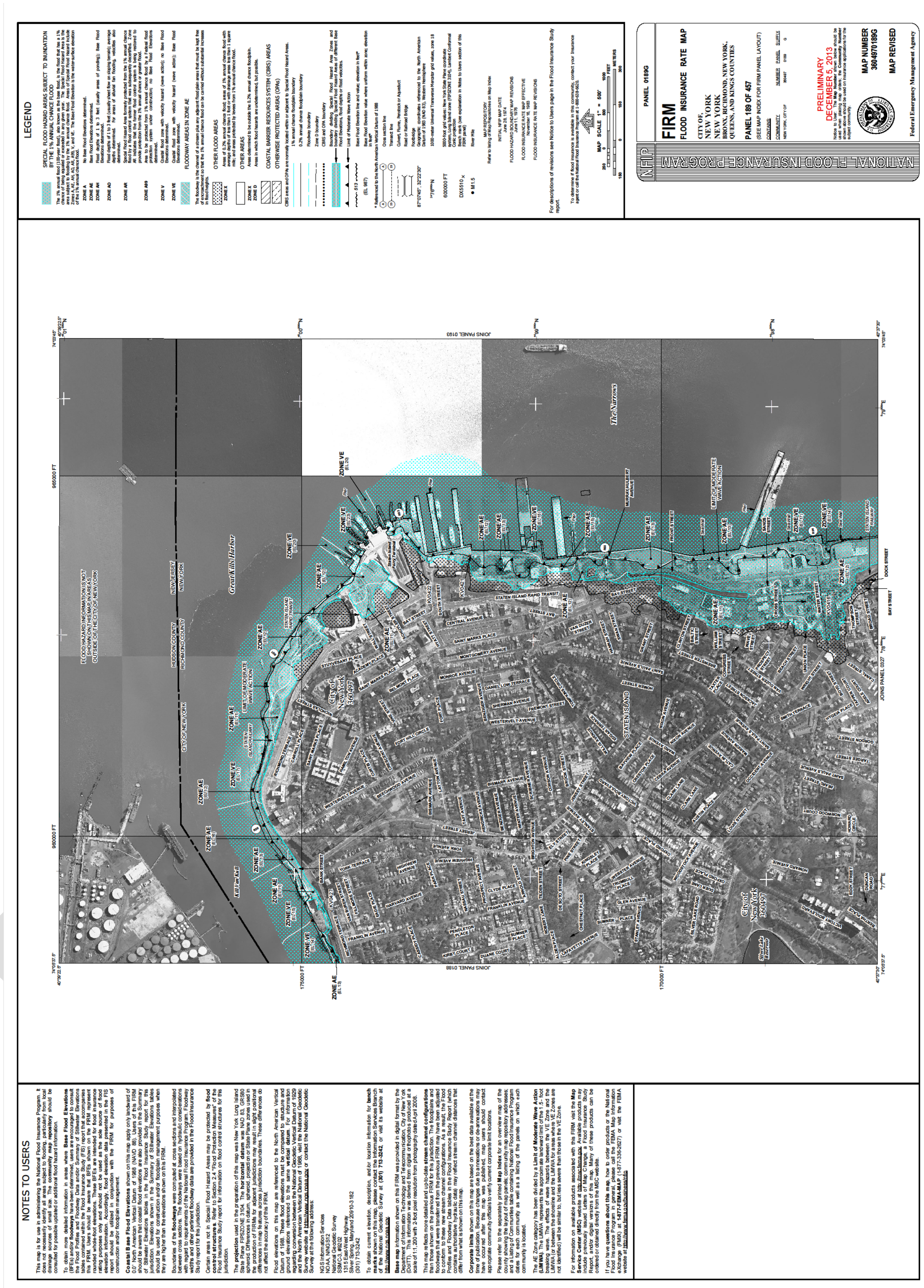

Figure 13.1.1.3.4 FEMA FIRM Map Number 3604970189G (Preliminary 12/5/2013)

SECTION 14: CONSTRUCTABILITY

14.1 GENERAL

(IN PROGRESS)

Information presented in this section and analyzed throughout the Constructability Report is based on conceptual engineering and is likely to evolve as the engineering advances. Accordingly, the preliminary sequencing plan and overall construction schedule developed for the proposed BRT construction activities represents a reasonable estimate of how the project could be constructed, based on conceptual engineering; this plan is likely to change as engineering evolves. As final design and construction advances, the project owner will identify opportunities to advance the project more efficiently and with reduced impact through innovation and use of improved technologies, and to leverage Design-Build (DB) for procurement methods, project delivery, and long-term maintenance, where possible.

See Appendix I for Constructability Report. (IN PROGRESS)

Construction of the BRT would result in some temporary disruptions in the surrounding areas. In order to minimize the duration of the construction period, the implementation of an expedited construction schedule by the design build contractor should be emphasized and prioritized in the bid documents. To be conservative, the construction impact analysis assumes that active construction would last as long as three years; however the goal of the design-build contract bidding competition will be to reduce that period and the construction duration at any one location so as to minimize the effects of construction activities on nearby communities.

The geographic and topographic conditions provide a constrained and linear construction zone. A project with such varying scope and limited accessibility resulted in the need to break down the construction into 11 sections to facilitate the construction of the project. Construction in some of these geographical sections would extend throughout the 3-year construction period while construction in others could be completed within a matter of a few months. See Figure 14.1.1 for the Section layout.

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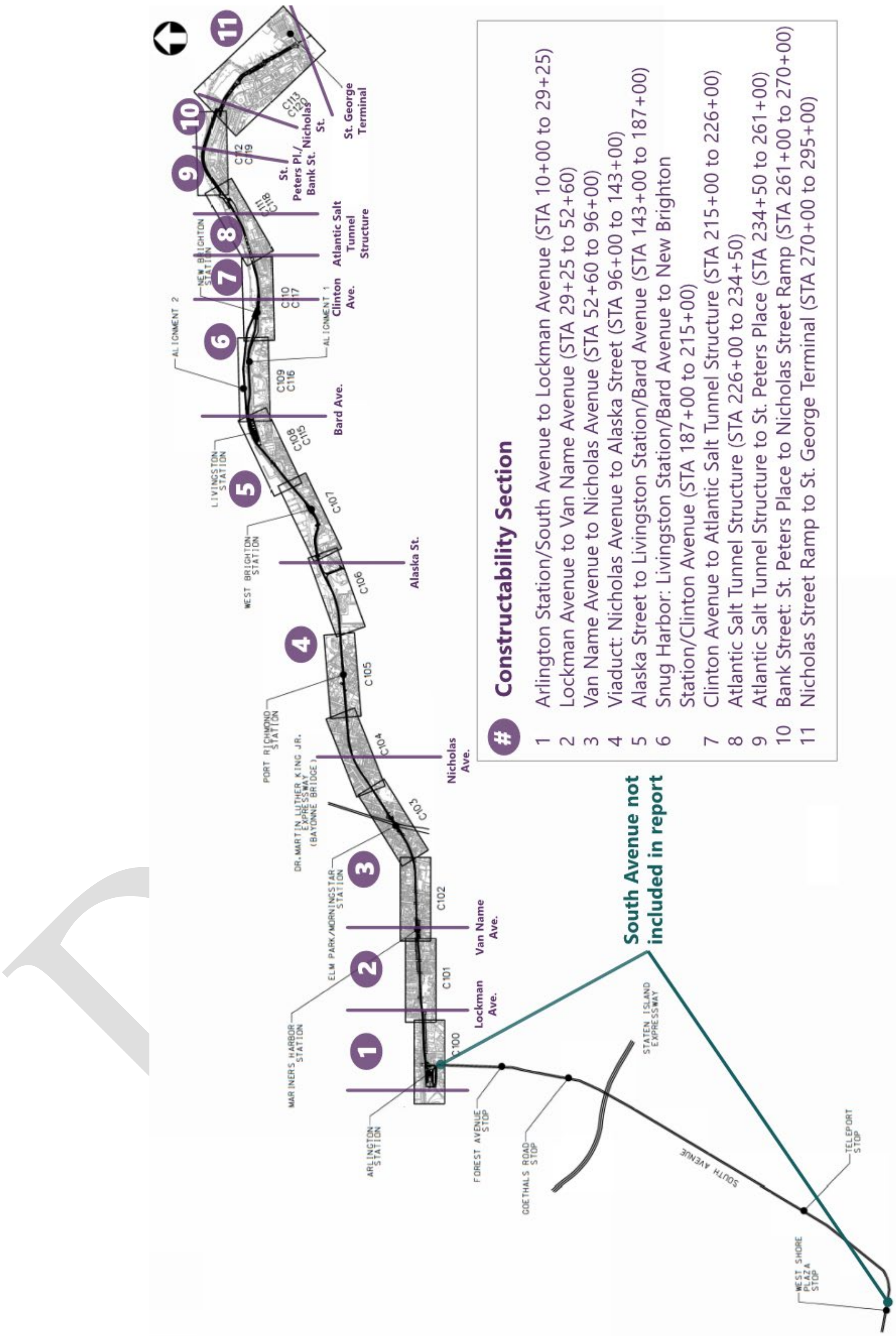

Figure 14.1.1   Staten Island North Shore Proposed BRT Constructability Sections

14.2 PROJECT PRELIMINARY SCHEDULE

This project lends itself to the Design-Build method of construction since, once all the necessary properties are acquired, a continuous and uninterrupted construction corridor within the contractor's control would be available. The preliminary construction schedule is based on the construction method and strategy noted in the Section 3.0 of the Constructability Report, by Section.

This schedule is developed with the following assumptions:

- FEIS is completed by September 2022
- DB Procurement process is completed in advance of award and Notice to Proceed (NTP) by September 2023
- Property acquisition will be completed well in advance of construction on any section.
- 5-day work week with standard holidays for all administrative activities
- 5-day work week with standard holidays reduced efficiencies during winter months (December to February) for all construction activities.
- All durations are based on one 10-hour shift.
- No concrete bridge deck pours December through March.
- No work in the Atlantic Salt area (which spans Section 7, 8 and 9) in October through February.
- Activity durations are determined by reasonable production rates and experience on similar previous projects.
- Construction activities are phased where logistically possible to minimize the construction duration of any section.

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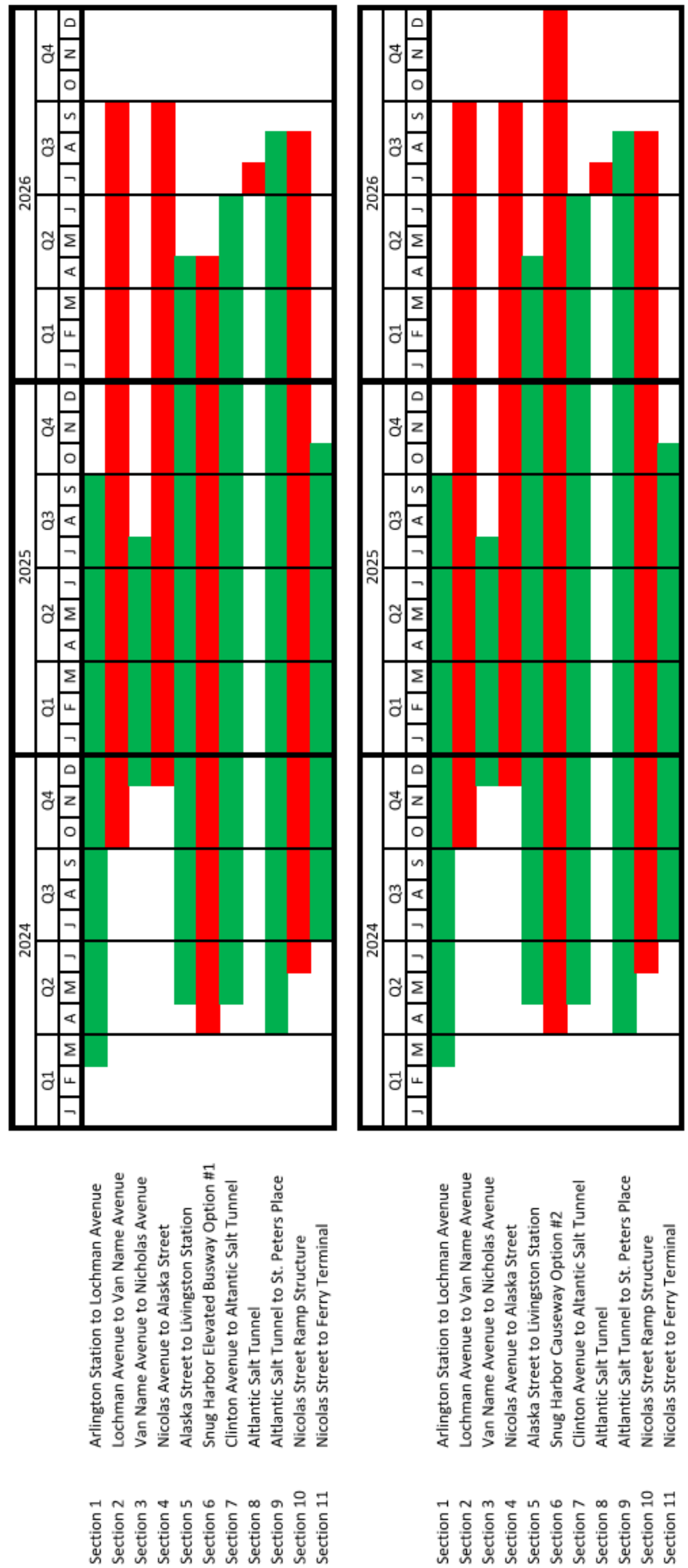

Figure 14.2.1 Staten Island North Shore Proposed BRT Constructability Sections

SECTION 15: COST ESTIMATES

15.1 COST SUMMARY

(IN PROGRESS)

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APPENDIX A: PRELIMINARY DRAINAGE REPORT

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SECTION 1: INTRODUCTION AND OBJECTIVES

INTRODUCTION

This Preliminary Drainage Report presents a conceptual-level drainage design and recommendations for the North Shore Bus Rapid Transit (BRT) and associated improvements. The level of engineering contained herein is appropriate to support conceptual-level cost estimating and to provide early action recommendations for permitting.

OBJECTIVES

The Preliminary Drainage Report has been developed to serve the following purposes:

- Develop a drainage strategy that considers current regulations of the environmental agencies that have jurisdiction within the project area.
- Identify major drainage infrastructure, such as detention and infiltration facilities, that will likely be needed for successful implementation of the BRT.
- Provide early action recommendations (pertaining to drainage) for consideration.

KEY ABBREVIATIONS

FHWA	Federal Highway Authority
NYCDEP	New York City Department of Environmental Protection
NYCDOT	New York City Department of Transportation
NYCEDC	New York City Economic Development Corporation
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency

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SECTION 2: APPLICABLE CRITERIA AND STANDARDS

2.1 CODES, STANDARDS, REGULATIONS, GUIDELINES, MANUALS, AND REFERENCED STANDARDS

Unless otherwise specified herein, the current editions including current interim specifications of the following codes and manuals would govern.

2.1.1 National

American Society of Civil Engineers (ASCE)

- ASCE Manual No. 37 Design and Construction of Sanitary and Storm Sewers

Federal Highway Administration (FHWA)

- FHWA HEC-9 Debris-Control Structures
- FHWA Hydraulic Design Series #3 (HDS #3)
- FHWA Hydraulic Design Series #4 (HDS #4)
- FHWA-IF-02-034 GEC-05: Evaluation of Soil and Rock Properties

U.S. Army Corps of Engineers (USACE)

- Coastal and Hydraulics Laboratory: EM 1110-2-1100, Coastal Engineering Manual, 2002

US Department of Transportation (USDOT)

- Hydraulic Engineering Circular No. 12 (HEC-12)
- USDOT Hydraulic Engineering Curriculum (HEC-22) Drainage of Highway Pavements

2.1.2 New York State

New York Codes Rules and Regulation (NYCRR)

- Part 602, Application for Long Island Wells (Kings, Queens, Nassau, Suffolk)

2.1.3 New York City

New York City Department of Environmental Protection (NYCDEP)

- NYCDEP Sewer Design Standards
- NYCDEP Rules and Regulations
- New York City Sewer Use Regulation, Title 15, Chapter 19 (Site Connection Permit)

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APPLICABLE LAWS AND REGULATIONS

All Federal laws, regulations, and executive orders affecting project development, including but not limited to Section 404 of the Clean Water Act, shall be addressed to the maximum extent practicable.

Other appropriate Federal, State and Local laws and regulations will be observed including:

State

New York

Freshwater Wetlands Act

- Environmental Conservation Law Article 24
- 6 NYCRR Parts 662-664

NYS Waterfront Revitalization and Coastal Resources Act

- Environmental Conservation Law Article 34

NYS Wild, Scenic, and Recreational Rivers Act and Regulations

- Environmental Conservation Law Articles 15 & 27

State Environmental Quality Review (SEQR)

- Environmental Conservation Law Article 8
- 17 NYCRR Part 15

State Pollution Discharge Elimination System (SPDES)

- Environmental Conservation Law Article 17 Title 8

Tidal Wetlands Act

- Environmental Conservation Law Article 25
- 6 NYCRR Part 661

Water Quality Certification

- 6 NYCRR Part 608.7

Federal

Land and Water Conservation Fund

- 16 USC 460 Act

Rivers and Harbors Act Section 9

- 33 USC 401 (525-533)
- 23 USC 144th

River and Harbor Act Section 10 (US Army Corps of Engineers Permit)

- 33 USC 403

Water Quality Certification

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- 33 USC 1341 (Section 401 of the Federal Executive Order 11990, Protection of Wetlands

Water Pollution Control Act

- DOT Order 5660.1A

US Army Corps of Engineers

- 33 CFR 320-325

Section 404 permit

- 40 CFR 230, 231

US Army Corps of Engineers and US Coast Guard Permits

- 33 CFR 115

US Coastal Zone Management Act

- 16 USC 1451

US Wild, Scenic & Recreational Rivers Act

- 16 USC 1271

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SECTION 3: EXISTING DRAINAGE INVESTIGATION

3.1 SOURCES OF DATA

Elevations used in the drainage investigation are based on various sources:

a) Existing ground elevations are based on project mapping in the project datum (NAVD 88).
b) Sewer planimetric information is based on record drawings obtained from New York City Department of Environmental Protection (NYCDEP) in New York. Since the topographic mapping available at this stage of the project does not show manholes or inlets, the sewers from the record plans were incorporated into the project mapping using the street curb lines as reference points to determine the general location of facilities within the roadways. Where sewer invert information was available, it was converted from the source datum to the project datum (NAVD 88).

3.2 EXISTING DRAINAGE FACILITIES

The project mapping available at this stage of the project is not sufficiently detailed to show inlets, manholes, etc. that could be used to determine what drainage facilities might exist along the areas of the project. Complete record drainage information does not seem to be available along the former North Shore Railroad Right-of-Way (NSRR ROW), but some basic conclusions about the existing facilities can be made with the information at hand:

a) In the cut sections, the existing ground elevation is lower than the inverts of sewers in the adjacent streets. From investigation of the topographic mapping, there are no natural watercourses to which runoff can be discharged. There seem to be no pump stations in the cut sections, so it can be concluded that most likely runoff is simply infiltrated to the ground in these areas.
b) NYCDEP noted in the October 31, 2019 meeting, the previous rail line along the former NSRR ROW would have had a drainage system. Staten Island's North Shore has drainage areas served by separate storm sewer. From site investigation along the Port Richmond Viaduct, there are existing downspouts located at several undergrade bridge crossings. These are likely discharge points and should be discharge points for the BRT alignment treated stormwater runoff.
c) Caddell Dry Dock and Atlantic Salt, maritime industries located between Richmond Terrace and the Kill van Kull, have indicated private drainage exists within their respective property which discharge stormwater directly to the Kill van Kull. No connection of the BRT would be allowed to existing private drainage systems, but further investigation is recommended to limit the impacts to existing private drainage systems.

3.3 DRAINAGE JURISDICTION

Sewers in Staten Island are maintained and controlled by the New York City Department of Environmental Protection (NYCDEP). Drainage (storm) connections to NYCDEP sewers are only

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allowed to what NYCDEP refers to as “drainage plan” sewers. NYCDEP policy dictates that an applicant must have property frontage on the drainage plan sewer to have the connection approved. The preliminary investigation has found that in some locations, the project does not have frontage on sewers where connections are needed, but further investigation is needed since data is incomplete at this point.

It is also noted here that because NYCDEP is under a consent decree to reduce combined sewer overflows, they have greatly reduced the rate at which storm connections may be made to combined sewers. This generally involves release rate reduction strategies such as detention facilities. The preliminary investigation has found that where a connection is needed, the allowable rate is much less than the required rate – this is discussed further in the following section.

A municipal separate storm sewer system (MS4) is a publicly-owned conveyance or system of conveyances (including but not limited to streets, ditches, catch basins, curbs, gutters, and storm drains) that is designed or used for collecting or conveying stormwater and that discharges to surface waters of the State. Proposed outfalls to natural watercourses would need application to and approval by NYCDEP as they are the MS4 with jurisdiction in New York City. Notice of Intent (NOI) will need to be filed with New York State Department of Environmental Conservation (NYSDEC). Kill van Kull is both tidal and navigable, and any construction in tidal or navigable waters will need to be reviewed and approved by the U.S. Army Corps of Engineers (USACE). There would be no flow limitations discharging to tidal waters, but the design would need to include appropriate outlet protection. As per NYCDEP SPDES permit, stormwater design would need to account for pollutants of concern (POC). The SPDES permit indicates that floatables are the POC for Kill van Kull, and so facilities would need to be included to take floatables out of the stormwater before the discharge point.

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SECTION 4: CONCEPTUAL DRAINAGE DESIGN

4.1 DRAINAGE AREAS

The project drainage areas were determined by dividing the proposed BRT alignment between high and low points. This resulted in 7 drainage areas where new drainage facilities are proposed (*See Figure 1)*.

The following table shows the limits of each drainage area.

DRAINAGE AREA	DRAINAGE AREA (START)	LOW POINT	DRAINAGE AREA (END)	TOTAL DRAINAGE AREA (Acre)
1	10+00.00	11+51.02	23+52.34	3.14
2	23+52.34	63+62.62	95+00.00	5.28
3	95+00.00	95+00.00	115+52.69	1.61
4	115+52.69	156+26.43	168+84.03	4.44
5	168+84.03	175+71.90	202+48.91	3.24
6	202+48.91	235+31.82	242+96.99	2.97
7	242+96.99	246+49.01	265+65.27	1.72

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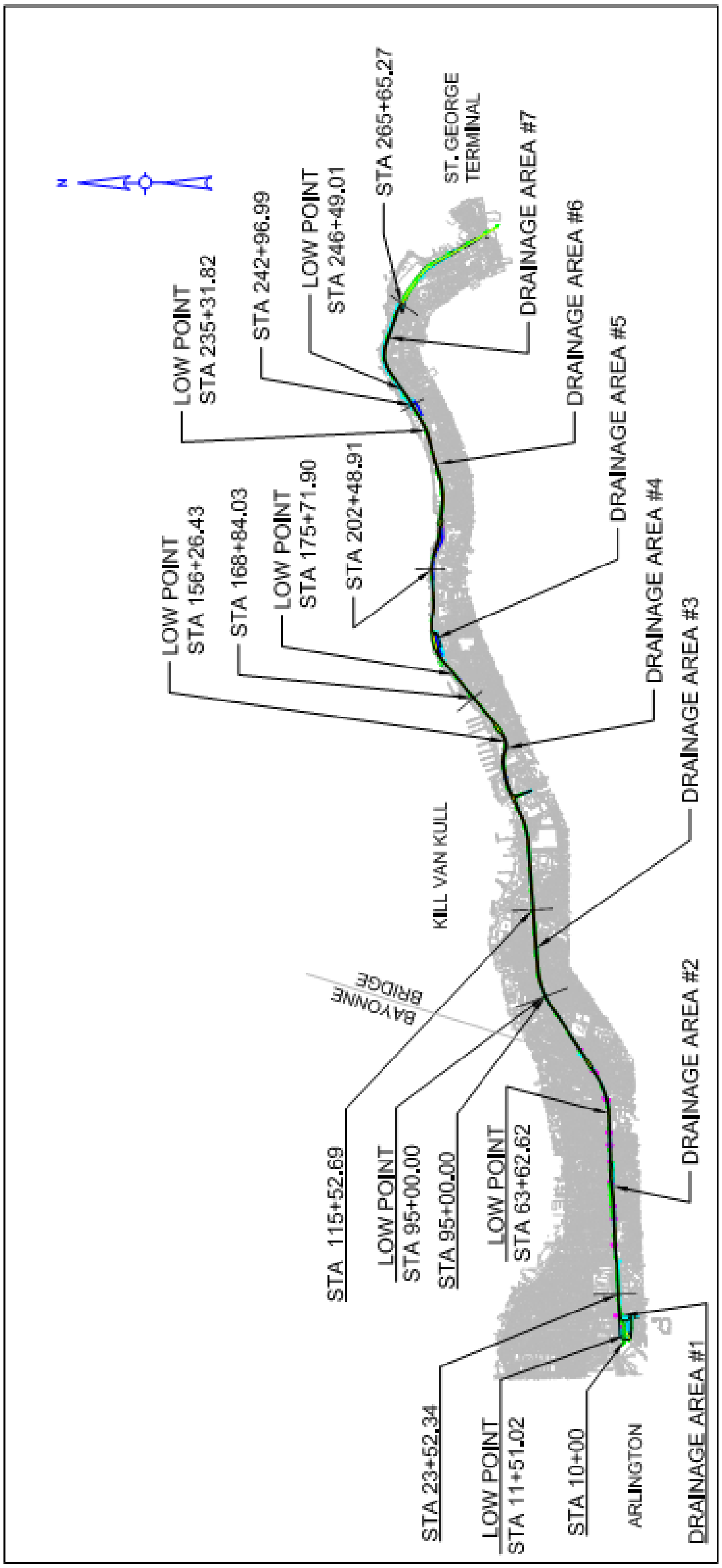

Figure 1- DRAINAGE AREA MAP

4.2 PRELIMINARY DRAINAGE APPROACH

The preliminary investigation found that in Staten Island, the allowable rate at which connections could be made by the project to NYCDEP drainage plan sewers is much less than the rate that would be required from the expected drainage area discharge given by the rational method. NYCDEP allows a drainage connection by property owners to a drainage plan sewer only where that property has frontage on the sewer, and then only for a 100-foot depth of the property. The allowable rate (Q_{ALL}) is proportional to the site area (A_S) within those limits and is given by $Q_{ALL} = A_S / 24{,}400$ in Staten Island Combined or $Q_{ALL} = C_Z * A_S / 7{,}230$ in Staten Island Storm, where C_Z is based on zoning. See Section 6 - NYCDEP DETENTION FACILITY CALCULATIONS. Due to a 2005 consent decree, NYCDEP has further reduced the rate that stormwater can be discharged to a drainage plan sewer, with the new standard being only 10% of the former rate, or $0.10 * Q_{ALL}$.

The following table shows the calculated allowable rate based on NYCDEP criteria and the required discharge based on the rational method. See Section 6 - NYCDEP DETENTION FACILITY CALCULATIONS.

DRAINAGE AREA	APPROX. FRONT-AGE (FT)	AVG. DEPTH (FT)	AREA (SF)	ALLOW-ABLE Q (CFS)	TOTAL DRAINAGE AREA (Acre)	RATIONAL METHOD Q (CFS)
1	0	0	0	0	3.14	15.89
2	230	100	23,000	0.943	5.28	26.71
3	148	100	14,800	0.607	1.61	8.12
4	1278	100	127,800	5.238	4.44	22.45
5	459	100	45,900	1.881	3.24	16.40
6	2599	100	259,900	10.652	2.97	15.04
7	58	100	5,8000	0.238	1.72	8.72

The table shows that there is 1 drainage area that have no frontage on the drainage plan sewer, so no connection would be allowed. In areas where a connection would be allowed, the allowable rate is a small fraction of the required rate given by the rational method. Therefore, a mitigation strategy, such as infiltration or direct discharge, when BRT alignment is close to the shoreline, will also be considered. As indicated in Section 3.2, NYCDEP noted the previous rail line along the former NSRR ROW would have had a drainage system. Along the Port Richmond Viaduct, there are existing downspouts located at several undergrade bridge crossings. These are likely discharge points and should be discharge points for the BRT alignment treated stormwater runoff.

Preliminary borings were not performed for the project. Limited available geotechnical data were obtained and show that groundwater is high in the project areas close to wetlands and the shoreline.

- NYCEDC Richmond Terrace Retaining Wall Assessment, Final Report, 5 test pits were

performed along the bottom of retaining wall which shows ground water level with a range of 1.82 feet to 4.22 feet below grade.
- NYCEDC Reactivation of the Staten Island Railroad, borings were performed along the existing freight track located below-grade in an open-cut from South Avenue to Union Avenue which shows ground water level with a range of 2 feet to 35 feet below grade.

DETENTION APPROACH

The preliminary detention facility was designed following the NYCDEP Criteria for Detention Facility Design for the entire project area in order to quantify the detention facilitates needed per drainage area. The concept is to excavate drainage detention facilities under the BRT alignment that would serve as runoff storage areas for the peak period of the storm events. Access via a manhole cover would be provided for maintenance cleaning. The results, given in Section 6, show the quantity of 8-feet diameter detention rings or 10-feet diameter detention rings that would be sufficient to detain a 10-year storm. The detention rings, approximately 5.55-feet deep, will discharge through an outlet control structure with either reentrant orifice tube or with a flush orifice tube, and then to a NYCDEP drainage plan sewer. See Section 6 for a detail of the outlet control structure. To avoid clogging and maximize the subsurface storage depth, minimum size orifice tube outlet is 2-inches in diameter. NYCDEP will require a Declaration of Maintenance, recorded as a deed Restriction against the property when the diameter of the orifice tube outlet is less than 3-inches in diameter. Drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12' diameter ductile iron pipes.

Borings were not performed to confirm the ground water level for drainage areas. Detention facilities must be located a minimum of 3 feet above the ground water table to prevent possible ground water infiltration into the sewer system.

DRAINAGE MITIGATION APPROACH BY INFILTRATION

For the drainage mitigation strategy when the BRT alignment is located inland away from the shore, a conceptual infiltration facility was designed. The available boring data seems to indicate that groundwater level appears low enough (approx. 6 to 8 feet below surface), and the soils generally consist of sand with some silt and gravel at the west end of the project limits. An open-bottom infiltration chamber system may be able to meet stormwater runoff reduction requirements and maximize available land space by providing infiltration below grade. Drainage infiltration concept, using a low-head system like Chambermaxx (see Section 7 for details), is to excavate the drainage infiltration facilities under the BRT alignment to maximize stormwater storage volume in the footprint. Chamnbermaxx system with a low-profile shape is ideal for sites with a relatively high groundwater table. The concept is to have a local infiltration chamber grouping located at each pair of catch basins (one on each side of the roadway). First, catch basin spacing was designed to limit the gutter spread to a maximum of 6' into the travel lane, which resulted in a spacing of 333 feet (see Section 9 for gutter spread calculation). Then the storm infiltration chambers were

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sized for each section of roadway per the calculated 333-foot catch basin spacing. Hydrocad was used to size the required Chambermaxx grouping to hold and infiltrate the 100-year storm, assuming an infiltration rate of 6” per hour. The result was a 2 x 15 configuration of standard chambers at each pair of catch basins. The drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes and 12-inch diameter ductile iron pipes. One extra benefit of infiltrating stormwater is that water quality is not an issue as there is no requirement to treat stormwater if it is being discharged directly to the ground. See Section 7 for infiltration calculations and details.

DRAINAGE MITIGATION APPROACH BY DIRECT DISCHARGE

For the drainage mitigation strategy when the BRT alignment is located near along the shore, stormwater runoff would be directed to a hydrodynamic separator to be treated and then discharged directly to the Kill van Kull. Hydrodynamic separators are stormwater management devices that use cyclonic separation to control water pollution by screening, separating and trapping pollutants such as trash, debris, sediment, and hydrocarbons from stormwater runoff. New York City DEP’s SPDES permit shows that floatables are a pollutant of concern (POC) for Kill van Kull). The concept is to have manufactured treatment devices (such as CDS by Contech) spaced along the roadway to treat the runoff from groups of catch basins and then discharge to Kill van Kull. A catch basin spacing of 333 feet was determined to limit the gutter spread to a maximum of 6’ into the travel lane (see Section 9 for gutter spread calculation). Hydrocad results from the infiltration design were used to determine the runoff from each 1000’ long section of roadway in the required design storms. In New York State, the device is required to treat all runoff from the 90th percentile storm and bypass the runoff from the 100-year storm. The resultant figures, 0.95 cfs (90th percentile) and 5.85 cfs (100-year) were input to Contech’s Design-your-own Hydrodynamic Separator (DYOHDS) web program to size the required CDS device. The results, given in Section8, show that the Model CDS-5 (5-foot diameter) device would be needed every 1000 feet. The drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes, 12-inch diameter ductile iron pipes and 18-inch diameter ductile iron pipes. See Section 8 for direct discharge drainage calculations and details.

4.3 DESCRIPTION OF DRAINAGE FACILITY DESIGN BY DRAINAGE AREA

The following sections describe the issues involved and mitigations strategy in each of the designated drainage areas:

4.3.1 Drainage Area 1 (Sta. 10+00.00 to Sta 23+52.34): Depressed (below-grade open-cut) Section

The BRT alignment enters the former NSRR Section at the proposed driveway north of Brabant Street along South Avenue and continues as an exclusive busway along the former NSRR ROW depressed (below grade, open-cut) section. This drainage area includes Arlington Station with a total drainage area of 136,877 square feet. Current BRT alignment design calls for a 12-inch concrete pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. There is no frontage on this sewer, so by NYCDEP rules a connection is not allowed, but an exception to policy could be sought. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either seventy-nine (79) 8-feet diameter detention rings or forty-nine (49) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12’ diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY INFILTRATION

As this drainage area along the BRT alignment is located inland away from the shore, an infiltration facility was designed under the BRT alignment to maximizes stormwater storage volume in the footprint. The preliminary infiltration facility design to provide the maximum volume required for the storm with a 100-year storm would be 24 rows x 20 Chambermaxx chambers, for the western terminus station area, and two (2) 333 linear feet segments, requiring 2 rows x 15 Chambermaxx chambers each, along the BRT corridor. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes and 12-inch diameter ductile iron pipes.

4.3.2 Drainage Area 2 (Sta. 23+52.34 to Sta. 95+00.00): Depressed (below-grade in an open-cut) Section

The BRT alignment transitions from depressed below street level near existing grades in the former NSRR cut to at-grade east of John Street pedestrian bridge, with a total drainage area of 230,091 square feet. Current BRT alignment design calls for a 12-inch concrete pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. The total frontage on this sewer is 230 linear feet, which results in an allowable release rate of 0.943 cfs. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either One hundred-thirty-nine (139) 8-feet diameter detention rings or eighty-six (86) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12’ diameter ductile iron pipes.

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DRAINAGE MITIGATION APPROACH BY INFILTRATION

As this drainage area along the BRT alignment is located inland away from the shore, an infiltration facility was designed under the BRT alignment to maximizes stormwater storage volume in the footprint. The preliminary infiltration facility design to provide the maximum volume required for the storm with a 100-year storm would be twenty-two (22) 333 linear feet segments, requiring 2 rows x 15 Chambermaxx chambers each, along the BRT corridor. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes and 12-inch diameter ductile iron pipes.

4.3.3 Drainage Area 3 (Sta. 95+00.00 to Sta. 115+52.69): Elevated (Port Richmond Viaduct) Section

The BRT alignment transitions from at-grade east of John Street pedestrian bridge to elevated on the existing Port Richmond Viaduct west of the Treadwell Avenue (undergrade) Bridge, with a total drainage area of 69,978 square feet. Current BRT alignment design calls for a 12-inch concrete pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. The total frontage on this sewer is 148 linear feet, which results in an allowable release rate of 0.607 cfs. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either thirty-eight (38) 8-feet diameter detention rings or twenty-three (23) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12' diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY INFILTRATION

As this drainage area along the BRT alignment is located inland away from the shore, an infiltration facility was designed under the BRT alignment to maximizes stormwater storage volume in the footprint. The preliminary infiltration facility design to provide the maximum volume required for the storm with a 100-year storm would be six (6) 333 linear feet segments, requiring 2 rows x 15 Chambermaxx chambers each, along the BRT corridor. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes and 12-inch diameter ductile iron pipes.

4.3.4 Drainage Area 4 (Sta. 115+52.69 to Sta. 168+84.03): Elevated (Port Richmond Viaduct) Section to At-Grade Section

The BRT alignment transitions from elevated on the existing Port Richmond Viaduct west of the Treadwell Avenue (undergrade) Bridge to at-grade west of the Alaska Street ramp, with a total drainage area of 193,342 square feet. Current BRT alignment design calls for a 12-inch concrete

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pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. The total frontage on this sewer is1,278 linear feet, which results in an allowable release rate of 5.238 cfs. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either one hundred fifteen (115) 8-feet diameter detention rings or seventy-one (71) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12’ diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY INFILTRATION

As this drainage area (Sta. 115+52.69 to Sta. 136+55) along the BRT alignment is located inland away from the shore, an infiltration facility was designed under the BRT alignment to maximizes stormwater storage volume in the footprint. The preliminary infiltration facility design to provide the maximum volume required for the storm with a 100-year storm would be six (6) 333 linear feet segments, requiring 2 rows x 15 Chambermaxx chambers each, along the BRT corridor. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes and 12-inch diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY DIRECT DISCHARGE

As this drainage area (Sta. 136+55 to Sta. 168+84.03) along the BRT alignment is located near along the shore, stormwater runoff would be directed to a hydrodynamic separator to be treated and then discharge directly to the Kill van Kull. The preliminary direct discharge facility design to provide the maximum volume required for the storm with a 100-year storm would be three (3) 1,000 linear feet segments, requiring three (3) CDS-5 hydrodynamic separators and three (3) outfalls to the Kill van Kull. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes, 12-inch diameter ductile iron pipes and 18-inch diameter ductile iron pipes.

4.3.5 Drainage Area 5 (Sta. 168+84.03 to Sta. 202+48.91: At-Grade Section to Elevated (Snug Harbor) Section

The BRT alignment transitions from at-grade west of the Alaska Street ramp to elevated east of Bard Avenue on proposed concrete viaduct structure through Snug Harbor, with a total drainage area of 141,261 square feet. Current BRT alignment design calls for a 12-inch concrete pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

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DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. The total frontage on this sewer is 459 linear feet, which results in an allowable release rate of 1.881 cfs. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either eighty-two (82) 8-feet diameter detention rings or fifty-one (51) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12' diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY DIRECT DISCHARGE

As this drainage area along the BRT alignment is located near along the shore, stormwater runoff would be directed to a hydrodynamic separator to be treated and then discharge directly to the Kill van Kull. The preliminary direct discharge facility design to provide the maximum volume required for the storm with a 100-year storm would be three (3) 1,000 linear feet segments, requiring three (3) CDS-5 hydrodynamic separators and three (3) outfalls to the Kill van Kull. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes, 12-inch diameter ductile iron pipes and 18-inch diameter ductile iron pipes.

4.3.6 Drainage Area 6 (Sta. 202+48.91 to Sta. 242+96.99): Elevated (Snug Harbor) Section to At-Grade Section

The BRT alignment transitions from elevated east of Bard Avenue on proposed concrete viaduct structure through Snug Harbor to at-grade east of the Atlantic Salt site, with a total drainage area of 129,504 square feet. Current BRT alignment design calls for a 12-inch concrete pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. The total frontage on this sewer is 2,599 linear feet, which results in an allowable release rate of 10.652 cfs. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either seventy-five (75) 8-feet diameter detention rings or forty-six (46) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12' diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY DIRECT DISCHARGE

As this drainage area (Sta. 136+55 to Sta. 168+84.03) along the BRT alignment is located near along the shore, stormwater runoff would be directed to a hydrodynamic separator to be treated and then discharge directly to the Kill van Kull. The preliminary direct discharge facility design

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to provide the maximum volume required for the storm with a 100-year storm would be four (4) 1,000 linear feet segments, requiring four (4) CDS-5 hydrodynamic separators and four (4) outfalls to the Kill van Kull. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes, 12-inch diameter ductile iron pipes and 18-inch diameter ductile iron pipes.

4.3.7 Drainage Area 7 (Sta. 242+96.99 to Sta. 265+65.27): At-Grade Section to the elevated Nicholas Street Ramp

The BRT alignment transitions from at-grade east of the Atlantic Salt site to the proposed elevated concrete ramp at Nicholas Street, with a total drainage area of 75,105 square feet. Current BRT alignment design calls for a 12-inch concrete pavement over a 12-inch subbase course with stormwater runoff collected at an on-site detention facility for discharge.

DETENTION APPROACH

Maximum release rate, Q_{RR}, to which the site stormwater flow rate to the combined sewer system will be restricted would be the greater of 0.25 cubic feet per second (cfs) or 10% of the Allowable Flow. The total frontage on this sewer is 58 linear feet, which results in an allowable release rate of 0.238 cfs. The preliminary detention facility design to provide the maximum volume required for the storm with a 10-year return frequency is either forty-one (41) 8-feet diameter detention rings or twenty-five (25) 10-feet diameter detention rings. Detention drainage system would also consist of Type 1 catch basins (as per NYSDOT, maximum 300-feet spacing), 4-foot diameter precast manholes and 12’ diameter ductile iron pipes.

DRAINAGE MITIGATION APPROACH BY DIRECT DISCHARGE

As this drainage area (Sta. 136+55 to Sta. 168+84.03) along the BRT alignment is located near along the shore, stormwater runoff would be directed to a hydrodynamic separator to be treated and then discharge directly to the Kill van Kull. The preliminary direct discharge facility design to provide the maximum volume required for the storm with a 100-year storm would be three (3) 1,000 linear feet segments, requiring three (3) CDS-5 hydrodynamic separators and three (3) outfalls to the Kill van Kull. Drainage system would also consist of Type 1 catch basins (spaced 333-feet part), 4-foot diameter precast manholes, 12-inch diameter ductile iron pipes and 18-inch diameter ductile iron pipes.

SECTION 5: RECOMMENDATIONS

Preliminary Drainage Report defines the existing drainage conditions within the limits of the proposed BRT improvements and identifies the schematic drainage system requirements needed for the preliminary engineering detailed in the Conceptual-Level Design for the Project. The drainage analysis has determined that runoff from the Project could be mitigated for the seven (7) drainage areas. Drainage Area 1 (Sta. 10+00.00 to Sta 23+52.34) has no sewer frontage as only a

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8-inch diameter sanitary sewer exist along South Avenue and no connection would be allowed. In areas where a connection would be allowed, the allowable rate is a small fraction of the required rate given by the rational method.

Initial drainage detention approach, which followed the NYCDEP Criteria for Detention Facility Design, indicated seven (7) drainage areas with a total required detention volume of approximately 132,600 cubic feet which would require five hundred and sixty-six (566) 8-feet diameter detention rings or three hundred and fifty (350) 10-feet diameter detention rings. Richmond Terrace, from Nicholas Street to Bay Street, was not accounted for as this section of the BRT alignment would operate within the Richmond Terrace ROW and existing City drainage system would be maintained. Detention facilities would need to be located a minimum of 3 feet above the ground water table to prevent possible ground water infiltration into the sewer system and 10 ft. minimum away from structural foundation.

When the BRT alignment is located inland away from the shore, stormwater runoff can be mitigated by infiltration along Drainage Area 1, Drainage Area 2, Drainage Area 3 and the western portion of Drainage Area 4, west of the terminal end of the Port Richmond Viaduct, which would remove and reduce the required detention volume by approximately 70,300 cubic feet. This is a reduction of approximately 53%. This would eliminate three hundred (300) 8-feet diameter detention rings or one hundred and eighty-six (186) 10-feet diameter detention rings. As mentioned above, one extra benefit of infiltrating stormwater is that water quality is not an issue as there is no requirement to treat stormwater if it is being discharged directly to the ground.

When the BRT alignment is located near or along the shore, stormwater runoff can be mitigated by direct discharge along the eastern portion of Drainage Area 4, east of the terminal end of the Port Richmond Viaduct, Drainage Area 5, Drainage Area 6 and Drainage Area 7, which would remove and reduce the required detention volume by approximately 62,300 cubic feet. This is a reduction of approximately 47%. This would eliminate two hundred and sixty-six (266) 8-feet diameter detention rings or one hundred and sixty-four (164) 10-feet diameter detention rings.

As mentioned above, NYSDEC and USACE would be involved as Kill van Kull is a tidal and navigable body. There would be no flow limitations discharging to tidal waters, but the design would need to include appropriate outlet protection. As per NYCDEP SPDES permit, stormwater design would need to account for pollutants of concern (POC). The SPDES permit indicates that floatables are the POC for Kill van Kull, and so facilities would need to be included to take floatables out of the stormwater before the discharge point.

Borings should be performed in the next design phase to confirm the ground water level for the entire project area.

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A few additional ways detention volume can be provided is by poured-in-place reinforced concrete tanks, reinforced concrete and corrugated metal pipes, steel and fiberglass tanks, gravel beds, slotted vertical reinforced concrete rings and gravel beds, perforated pipe and gravel beds, storm water storage modules, solid HDPE pipes, perforated HDPE pipes and gravel beds, above ground ponds, rain gardens, and rain water reuse or recycling systems. For infiltrating stormwater to ground, permeability tests should be performed in the next design phase to confirm the viability of infiltration for the entire project area.

Since NYCDEP drainage plans were not available for the project area, obtain all drainage plans to confirm that all sewers are on the drainage plan.

Since the allowable rate is a small fraction of the required rate for the several drainage areas where a connection would be allowed, recommend continued coordination with NYCDEP to inquire what will be allowed following the determination on jurisdiction of the land the BRT is built on.

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SECTION 6: DETENTION FACILITY CALCULATIONS AND DETAILS

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CLIENT	MTA - NYCTA	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	Staten Island North Shore - BRT	HG	KL	4019716	
SUBJECT	Alignment #1 - Conceptual Detention Facility Design - NYCDEP site connection	Date	Date	REVISION	SHEET NO.
		5/17/2019	8/20/2019	0	1

Objective:

Determine the number of structures requered for all detention facilities along the BRT alignment.

References:

NYCDEP Criteria for Detention Facility Design (Rev. 2012)

Desing Criteria:

The detention facility is designed to provide the maximum volume required for the storm with a 10 year return frequency (tv).

Calculation made using the Rational Method

The maximum release rate, to which the site storm water flow rate to the combined sewer is Q_{DRR}= 0.25 cfs

Detention Facilities with a variable outflow controlled by means of an outlet orifice

Flush orifice tube outlets used to restrict the flow rate from detention facilities to the maximum release rate, Q_{DRR}= 0.25 cfs

Given

Site Areas - See attached scketch

Runoff coefficient for Asphalt and Contrete is C = 0.85; thefore C_{WT} = C

Rainfall Intensity, I = 5.95 in/hr

Q_{DRR} = 0.25 cfs

d_O = 2 in Control Manhole Dimension: 4ft W x 6ft L

Developed Storm Flow, $Q_{DEV} = A_T \times I \times C$

Duration of the storm in minutes with a 10 yr. return frequency, t_V,

$$t_V = 0.27(C_{WT} A_t / Q_{DRR})^{0.5} - 15$$

t_V = the duration of the storm in min. with a 10 yr. return frequency requiring the maximum detention volume with a variable outflow

C_{WT} = the weighted runoff coefficient for the area tributary to the detention facility

A_t = the area tributary to the detention facility in ft^2

Q_{DRR} = the detention facility maximum release rate in cfs

Maximum required detention volume, V_V

$$V_V = [0.19 C_{WT} A_t / (t_V + 15) - 40 Q_{DRR}]\, t_V$$

V_V = the maximum required detention volume in ft^3 with a variable outflow

Maximum storage depth, S_{DF}

$$S_{DF} = 1{,}400 (Q_{DRR})^2 / (d_O)^4 + d_O / 24$$

S_{DF} = the maximum storage depth in ft. for a Flush orifice tube

Q_{DRR} = the detention facility maximum release rate in cfs

d_O = the nominal dia. of the orifice tube outlet in in.

Developed Storm Flow				Duration of Storm with 10yrs. Return Frequency		Required Detention Vol.	Max. Storage Depth
Site	Site Area, A_T		Q_{DEV}	Q_{DRR}	t_V	V_V	S_{DF}
#	sf	Acre	cfs	cfs	min	cf	ft
1	*136,877*	*3.14*	*15.88*	*0.25*	*169.19*	*18,613.50*	*5.55*
2	*230,091*	*5.28*	*26.70*	*0.25*	*223.81*	*32,587.54*	*5.55*
3	*69,978*	*1.61*	*8.14*	*0.25*	*116.70*	*8,847.27*	*5.55*
4	*193,342*	*4.44*	*22.46*	*0.25*	*203.91*	*27,046.07*	*5.55*
5	*141,261*	*3.24*	*16.39*	*0.25*	*172.12*	*19,263.65*	*5.55*
6	*129,504*	*2.97*	*15.02*	*0.25*	*164.16*	*17,522.22*	*5.55*
7	*75,105*	*1.72*	*8.70*	*0.25*	*121.44*	*9,581.56*	*5.55*
	976,158	*22.41*					

STV 100 Years

CLIENT:	MTA - NYCTA	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT:	Staten Island North Shore - BRT	HG	KL	4019716	
SUBJECT:	Alignment #1 - Conceptual Detention	Date	Date	REVISION	SHEET NO.
	Facility Design - NYCDEP site connection	5/17/2019	8/20/2019	0	2

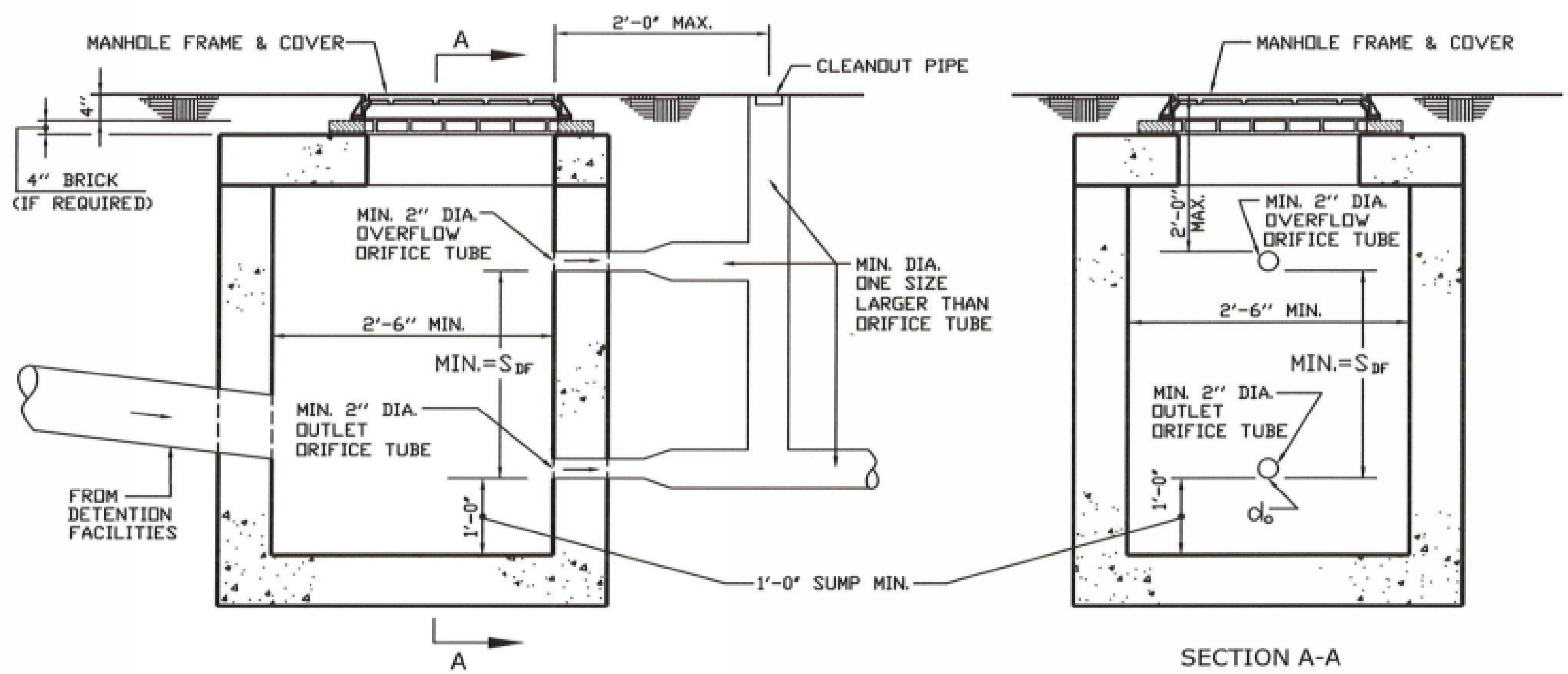
Calculation of Number of Detention Structures

Total Volume of Detention System, $\mathbf{V_{DS}} = V_V$
$\mathbf{V_{CM}}$ = Volume of Water in Control Manhole = W x L x S_{DF} = 4' x 6' x 5.55' = 133.20 cf
$\mathbf{V_{DR}}$ = Volume OF Water In Detention Rings   Therefore, $V_{DR} = V_{DS} - V_{CM}$

8 FT Dia. Detention Ring Volume, **8Dia** $\mathbf{V_{DR}} = \prod D^2 \times S_{DF}$ =   234.42   CF/ea
10 FT Dia. Detention Ring Volume, **10Dia** $\mathbf{V_{DR}} = \prod D^2 \times S_{DF}$ =   379.71   CF/ea
Number of Detention Rings, $\mathbf{N = V_{DR} / 1V_{DR}}$

Site	V_{CM}	V_{DR}	8ft Dia. Detention Rings					10ft Dia. Detention Rings				
#	cf	cf	N_{Calc}	N_{Used}	V_{DR}	V_{DS}	$V_{DS} > V_V$	N_{Calc}	N_{Used}	V_{DR}	V_{DS}	$V_{DS} > V_V$
1	133.20	18,480.30	78.83	79	18,519.2	18,652.4	Yes	48.67	49	18,605.79	18,738.99	Yes
2	133.20	32,454.34	138.45	139	32,584.38	32,717.6	Yes	85.47	86	32,655.06	32,788.26	Yes
3	133.20	8,714.07	37.17	38	8,907.96	9,041.2	Yes	22.95	23	8,733.33	8,866.53	Yes
4	133.20	26,912.87	114.81	115	26,958.30	27,091.5	Yes	70.88	71	26,959.41	27,092.61	Yes
5	133.20	19,130.45	81.61	82	19,222.44	19,355.6	Yes	50.38	51	19,365.21	19,498.41	Yes
6	133.20	17,389.02	74.18	75	17,581.50	17,714.7	Yes	45.80	46	17,466.66	17,599.86	Yes
7	133.20	9,448.36	40.31	41	9,611.22	9,744.4	Yes	24.88	25	9,492.75	9,625.95	Yes

DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER & SEWER OPERATIONS



OUTLET AND OVERFLOW ORIFICE TUBES SAME SIZE AND
OUTLET TUBE IS FLUSH WITH WALL

$S_{DF} = 1,400(Q_{RR}/d_o^2)^2 + d_o^2/24$

S_{DF} = THE MAXIMUM STORAGE DEPTH IN FT. FOR
A FLUSH OUTLET ORIFICE TUBE

Q_{DRR} = THE DETENTION MAXIMUM RELEASE RATE IN CFS

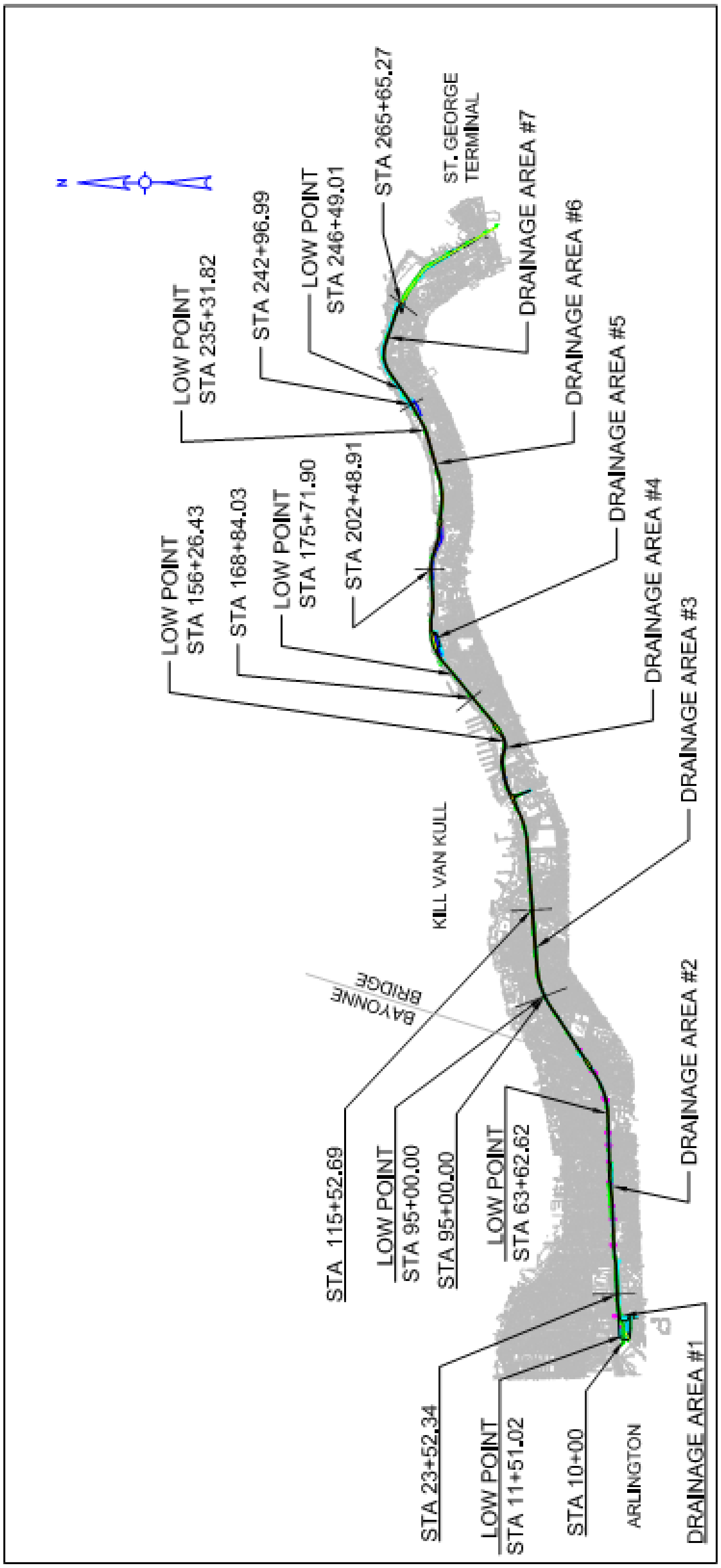
d_o = THE NOMINAL DIA. OF THE ORIFICE TUBE IN INCHES

SAMPLE-2

OUTLET CONTROL STRUCTURE WITH FLUSH ORIFICE TUBE

N.T.S.

REVISED-SEPTEMBER 7, 2012
MARCH 29, 2012
VM/YL


LOW POINT
STA 235+31.82
STA 242+96.99
LOW POINT
STA 246+49.01
STA 265+65.27
ST. GEORGE
TERMINAL
DRAINAGE AREA #7
DRAINAGE AREA #6
DRAINAGE AREA #5
DRAINAGE AREA #4
DRAINAGE AREA #3
DRAINAGE AREA #2
DRAINAGE AREA #1
LOW POINT
STA 156+26.43
STA 168+84.03
LOW POINT
STA 175+71.90
STA 202+48.91
KILL VAN KULL
BAYONNE
BRIDGE
STA 115+52.69
LOW POINT
STA 95+00.00
STA 95+00.00
LOW POINT
STA 63+62.62
STA 23+52.34
LOW POINT
STA 11+51.02
STA 10+00
ARLINGTON

SECTION 7: INFILTRATION CALCULATIONS AND DETAILS

STV 100 Years

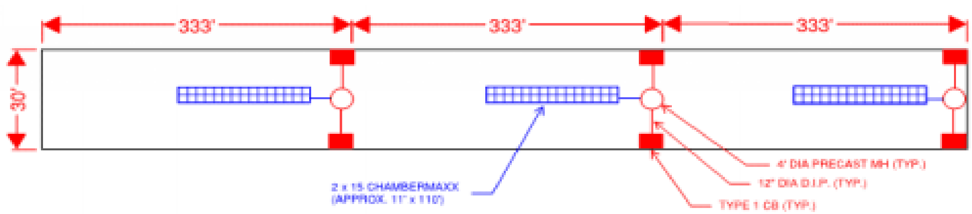
CLIENT	MTA-NYCT	**MADE BY**	**CHECKED BY**	**PROJECT NO.**	
PROJECT	North Shore BRT - Staten Island	PCA	KL	4019716	
SUBJECT	Conceptual Drainage - Alternate	**DATE**	**DATE**	**REV.**	**SHEET**
Roadway from West Terminal to end of Viaduct		3/9/2020	3/30/2020	0	1

<u>CHAMBERMAXX DESIGN, ROADWAY FROM STA. 16+00 TO 136+55</u>

START	16+00
END	136+55
LENGTH	12055
333' SEGMENTS	36
START VIADUCT	97+75
VIADUCT LENGTH	3880
333' VIADUCT SEGMENTS	12

<u>ASSUMPTIONS:</u>
DESIGN STORM: 100 YEAR
INFILTRATION RATE = 6"/HR
ROADWAY WIDTH = 30'
CB SPACING = 333' (MAX. SPREAD = 6')

<u>CHAMBERMAXX CHAMBERS:</u>		<u>EXCAVATION:</u>	
30 EA PER 333' SEGMENT	<u>1080</u> EA		
<u>STONE (e = 0.40):</u>		157.1 CY PER 333' SEGMENT	5655.6 CY
102.2 CY PER 333' SEGMENT	<u>3679.2</u> CY		
<u>TYPE 1 CATCH BASIN:</u>		8' x 8' x 10' = 640 CF = 24 CY	
2 EA PER 333' SEGMENT	<u>72</u> EA	24 CY PER EA	1728 CY
<u>4' DIA. PRECAST MANHOLE:</u>		8' x 8' x 10' = 640 CF = 24 CY	
1 EA PER 333' SEGMENT	<u>36</u> EA	24 CY PER EA	864 CY
<u>12" DIA. D.I.P.</u>		4.5' x 6' x 1' = 27 CF = 1 CY	
30 LF PER 333' SEGMENT	<u>1080</u> LF	1 CY PER LF	1080 CY
<u>8" DIA. D.I.P. DOWNSPOUT:</u>			
50 LF PER 333' VIADUCT SEGMENT	<u>600</u> LF		<u>9327.6</u> CY TOTAL



CLIENT	MTA-NYCT	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	North Shore BRT - Staten Island	PCA	KL	4019716	
SUBJECT	Conceptual Drainage - Alternate	DATE	DATE	REV.	SHEET
West Terminal		3/9/2020	3/30/2020	0	1

CHAMBERMAXX DESIGN, WEST TERMINAL

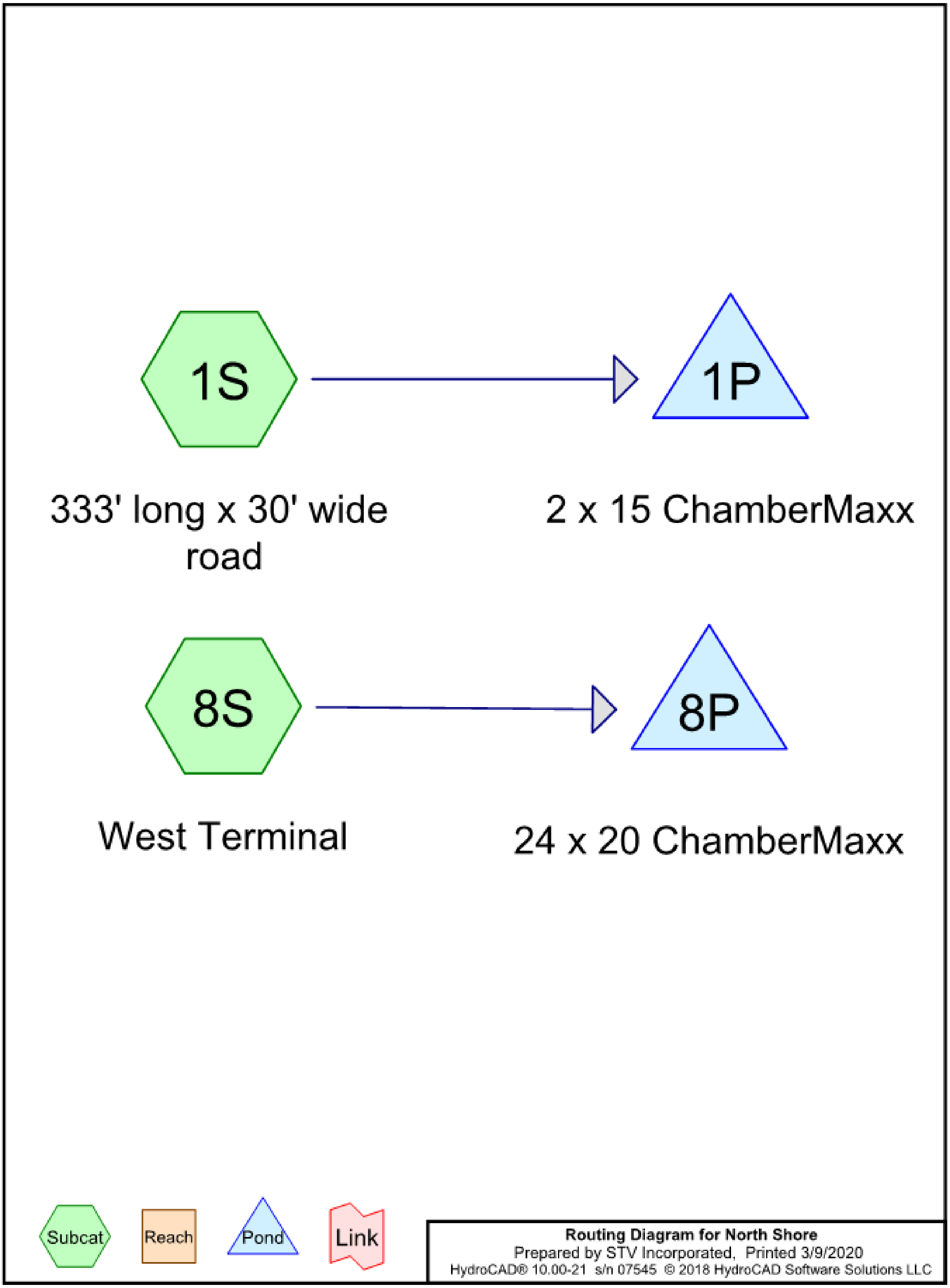
TOTAL AREA APPROX. 144,000 SF

CHAMBERMAXX CHAMBERS:
24 ROWS x 20 CHAMBERS PER ROW — 480 EA
STONE (e = 0.40):
(SEE HYDROCAD DESIGN) — 1304.2 CY
TYPE 1 CATCH BASIN:
16 EA
4' DIA. PRECAST MANHOLE:
4 EA
12" DIA. D.I.P.
80 LF

ASSUMPTIONS:
DESIGN STORM: 100 YEAR
INFILTRATION RATE = 6"/HR

EXCAVATION:

CHAMBERMAXX	
TOTAL FROM HYDROCAD:	2182 CY
8' x 8' x 10' = 640 CF = 24 CY	
24 CY PER EA	384 CY
8' x 8' x 10' = 640 CF = 24 CY	
24 CY PER EA	96 CY
4.5' x 6' x 1' = 24 CF = 1 CY	
1 CY PER LF	80 CY
	2742 CY TOTAL


1S
1P
333' long x 30' wide road
2 x 15 ChamberMaxx
8S
8P
West Terminal
24 x 20 ChamberMaxx
Subcat
Reach
Pond
Link
Routing Diagram for North Shore
Prepared by STV Incorporated, Printed 3/9/2020
HydroCAD® 10.00-21 s/n 07545 © 2018 HydroCAD Software Solutions LLC

Summary for Pond 1P: 2 x 15 ChamberMaxx

Inflow Area = 0.230 ac,100.00% Impervious, Inflow Depth = 8.61" for 100-yr 24-hour event
Inflow = 1.95 cfs @ 12.09 hrs, Volume= 0.165 af
Outflow = 0.17 cfs @ 11.25 hrs, Volume= 0.165 af, Atten= 91%, Lag= 0.0 min
Discarded = 0.17 cfs @ 11.25 hrs, Volume= 0.165 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 3.47' @ 13.00 hrs Surf.Area= 0.028 ac Storage= 0.057 af

Plug-Flow detention time= 102.6 min calculated for 0.164 af (100% of inflow)
Center-of-Mass det. time= 102.5 min (842.5 - 740.0)

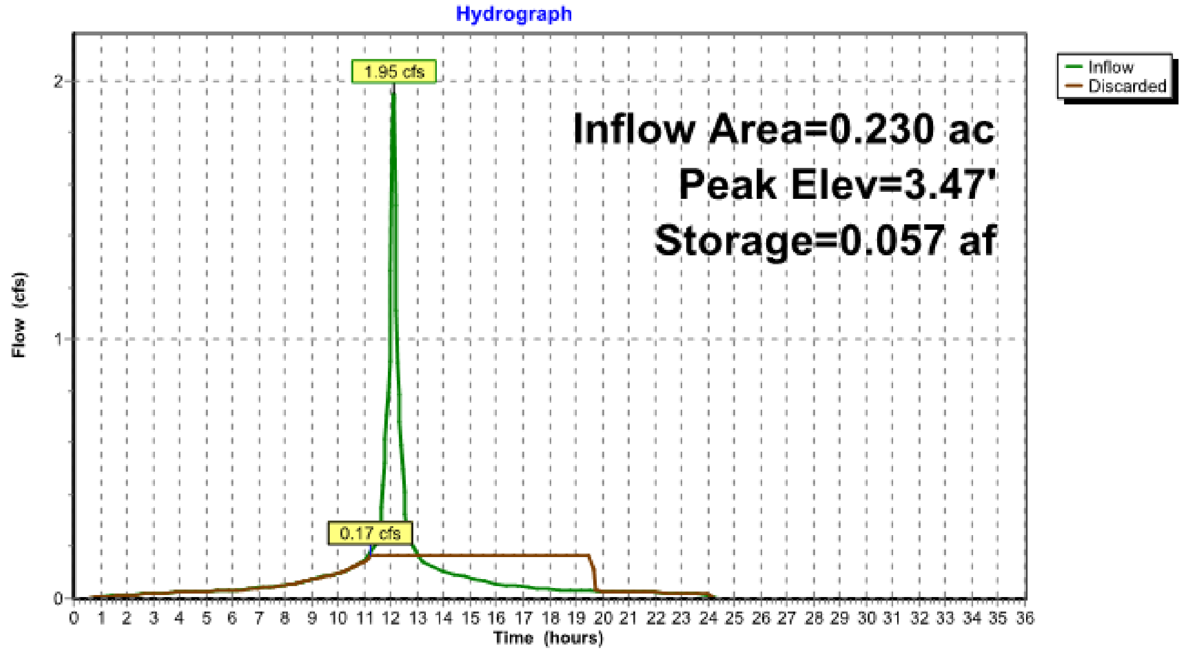
Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.025 af	**11.03'W x 109.07'L x 3.52'H Field A**
			0.097 af Overall - 0.034 af Embedded = 0.063 af x 40.0% Voids
#2A	0.50'	0.033 af	**Contech ChamberMaxx 2016** x 30 Inside #1
			Inside= 49.6"W x 25.2"H => 6.63 sf x 7.12'L = 47.2 cf
			Outside= 49.6"W x 30.0"H => 6.92 sf x 7.12'L = 49.3 cf
			Row Length Adjustment= +0.32' x 6.63 sf x 2 rows
		0.058 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**6.000 in/hr Exfiltration over Horizontal area**

Discarded OutFlow Max=0.17 cfs @ 11.25 hrs HW=0.04' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.17 cfs)

Pond 1P: 2 x 15 ChamberMaxx



Summary for Subcatchment 1S: 333' long x 30' wide road

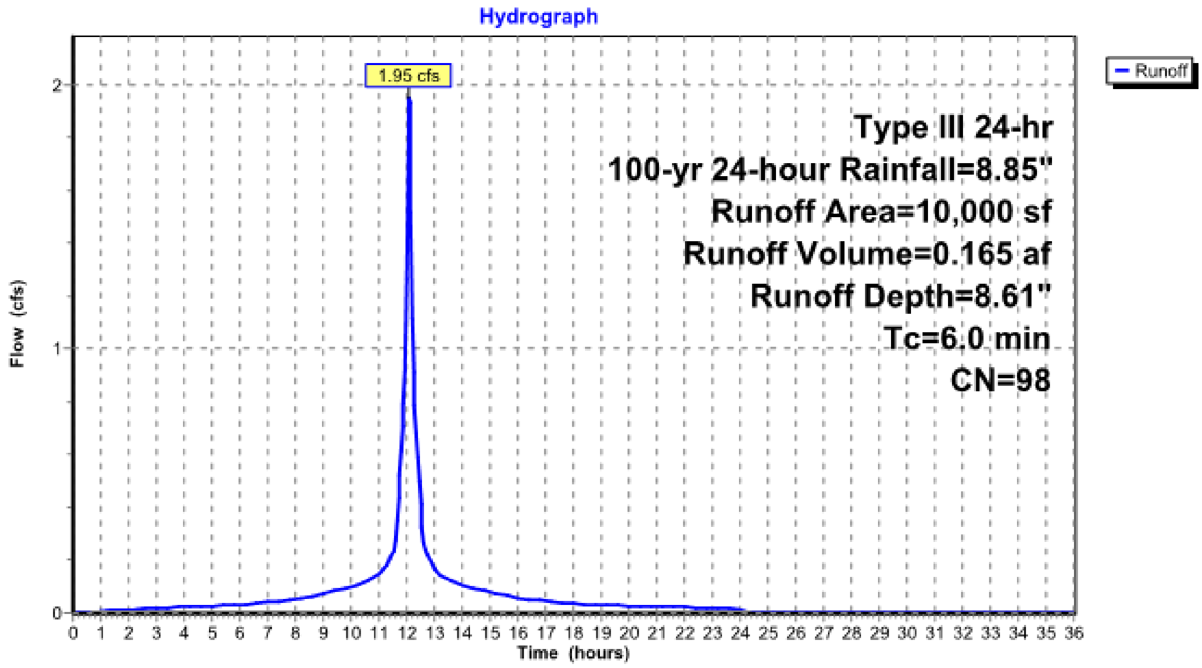
Runoff = 1.95 cfs @ 12.09 hrs, Volume= 0.165 af, Depth= 8.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr 24-hour Rainfall=8.85"

Area (sf)	CN	Description
10,000	98	Paved roads w/curbs & sewers, HSG A
10,000		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Subcatchment 1S: 333' long x 30' wide road



Summary for Pond 8P: 24 x 20 ChamberMaxx

Inflow Area = 3.306 ac,100.00% Impervious, Inflow Depth = 8.61" for 100-yr 24-hour event
Inflow = 28.06 cfs @ 12.09 hrs, Volume= 2.372 af
Outflow = 2.32 cfs @ 11.20 hrs, Volume= 2.372 af, Atten= 92%, Lag= 0.0 min
Discarded = 2.32 cfs @ 11.20 hrs, Volume= 2.372 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 3.48' @ 13.03 hrs Surf.Area= 0.384 ac Storage= 0.838 af

Plug-Flow detention time= 109.4 min calculated for 2.369 af (100% of inflow)
Center-of-Mass det. time= 109.2 min (849.2 - 740.0)

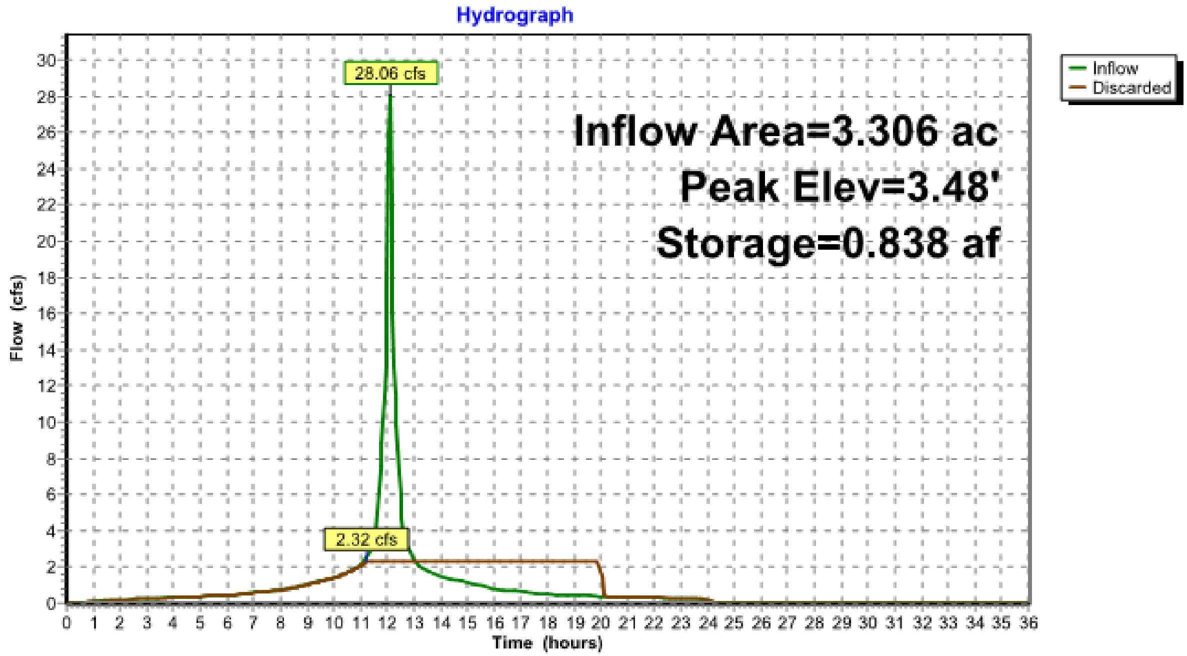
Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.323 af	**115.53'W x 144.65'L x 3.52'H Field A** 1.352 af Overall - 0.544 af Embedded = 0.808 af x 40.0% Voids
#2A	0.50'	0.521 af	**Contech ChamberMaxx 2016** x 480 Inside #1 Inside= 49.6"W x 25.2"H => 6.63 sf x 7.12'L = 47.2 cf Outside= 49.6"W x 30.0"H => 6.92 sf x 7.12'L = 49.3 cf Row Length Adjustment= +0.32' x 6.63 sf x 24 rows
		0.845 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**6.000 in/hr Exfiltration over Horizontal area**

Discarded OutFlow Max=2.32 cfs @ 11.20 hrs HW=0.04' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 2.32 cfs)

Pond 8P: 24 x 20 ChamberMaxx



Summary for Subcatchment 8S: West Terminal

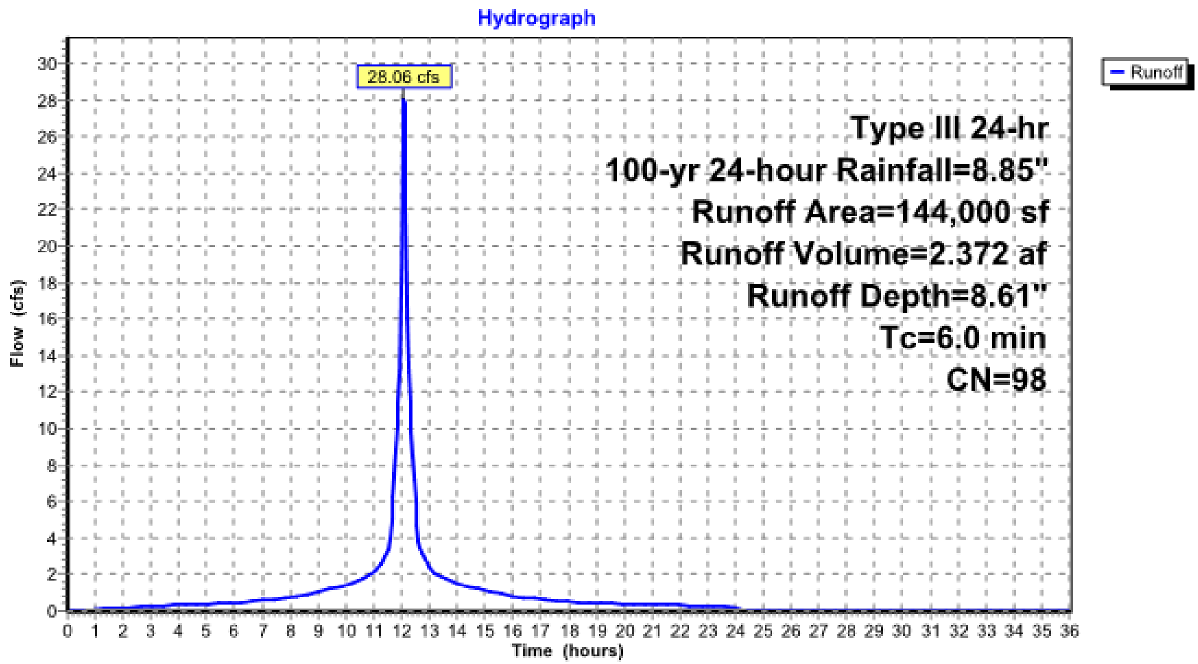
Runoff = 28.06 cfs @ 12.09 hrs, Volume= 2.372 af, Depth= 8.61"

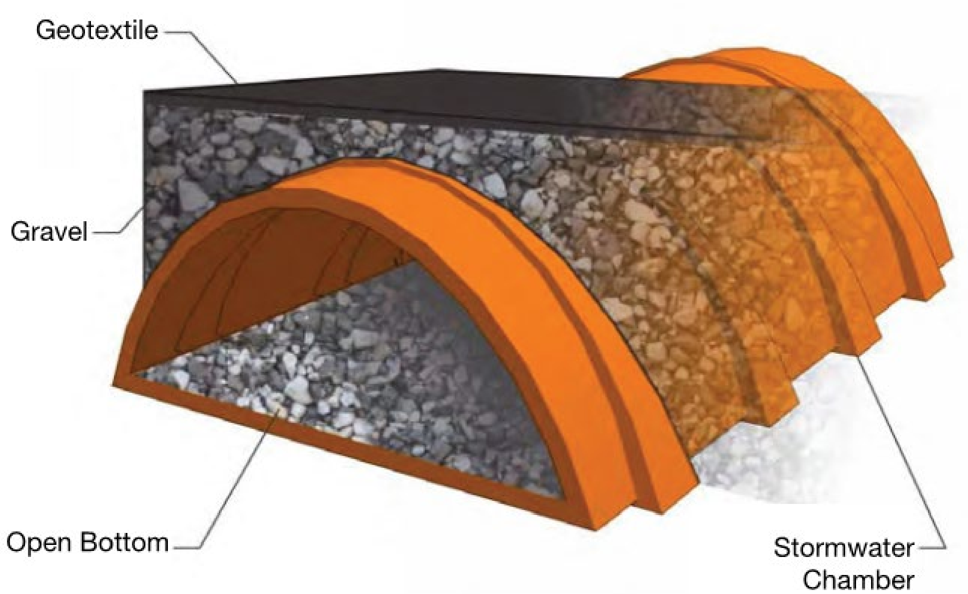
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr 24-hour Rainfall=8.85"

Area (sf)	CN	Description
144,000	98	Paved roads w/curbs & sewers, HSG A
144,000		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Subcatchment 8S: West Terminal

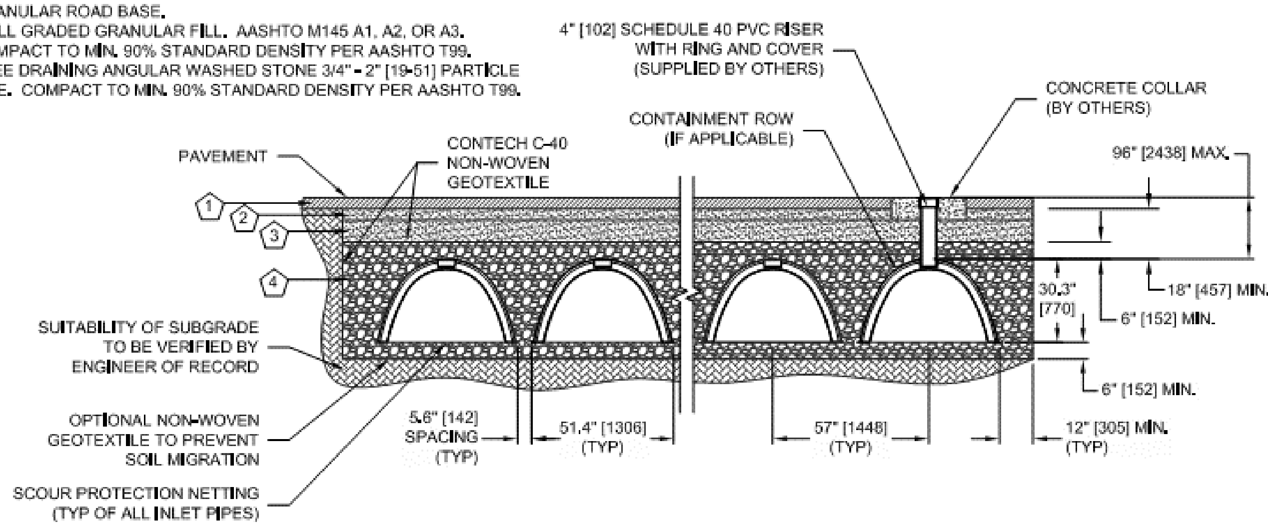




LOW-HEAD STORMWATER CHAMBER TYPICAL DETAIL

KEY

1. RIGID OR FLEXIBLE PAVEMENT.
2. GRANULAR ROAD BASE.
3. WELL GRADED GRANULAR FILL. AASHTO M145 A1, A2, OR A3. COMPACT TO MIN. 90% STANDARD DENSITY PER AASHTO T99.
4. FREE DRAINING ANGULAR WASHED STONE 3/4" - 2" [19-51] PARTICLE SIZE. COMPACT TO MIN. 90% STANDARD DENSITY PER AASHTO T99.



TYPICAL SECTION VIEW
(H20/H25 LIVE LOAD)
PER AASHTO 12

SECTION 8: DIRECT DISCHARGE CALCULATIONS AND DETAILS

STV 100 Years

CLIENT	MTA-NYCT	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	North Shore BRT - Staten Island	PCA	KL	4019716	
SUBJECT	Conceptual Drainage - Alternate	DATE	DATE	REV.	SHEET
Roadway from end of Viaduct to end of Busway		3/9/2020	3/30/2020	0	1

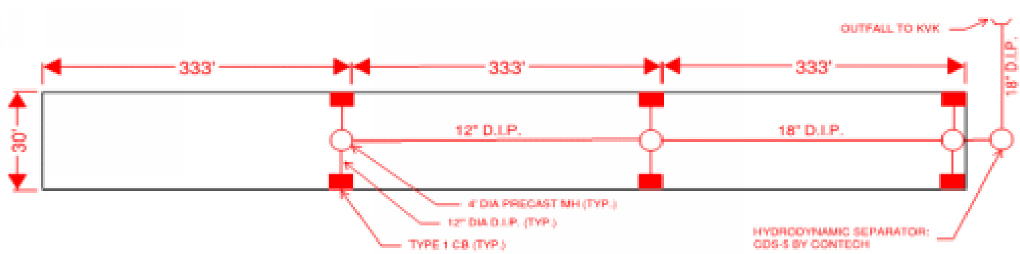
CDS DESIGN, ROADWAY FROM STA. 136+55 TO 265+65

START	136+55
END	265+65
LENGTH	12910
1000' SEGMENTS	13

ASSUMPTIONS:

DESIGN STORM: 100 YEAR
ROADWAY WIDTH = 30'
CB SPACING = 333' (MAX SPREAD = 6')

			EXCAVATION:	
CDS-5 HYDRODYNAMIC SEPARATORS:			8' x 8' x 15' = 960 CF = 36 CY	
1 EA PER 1000' SEGMENT	13	EA	36 CY PER EA	468 CY
TYPE 1 CATCH BASIN:			8' x 8' x 10' = 640 CF = 24 CY	
6 EA PER 1000' SEGMENT	78	EA	24 CY PER EA	1872 CY
4' DIA. PRECAST MANHOLE:			8' x 8' x 10' = 640 CF = 24 CY	
3 EA PER 1000' SEGMENT	39	EA	24 CY PER EA	936 CY
12" DIA. D.I.P.			4.5' x 6' x 1' = 24 CF = 1 CY	
400 LF PER 1000' SEGMENT	5200	LF	1 CY PER LF	5200 CY
18" DIA. D.I.P.			4.5' x 6' x 1' = 27 CF = 1 CY	
400 LF PER 1000' SEGMENT	5200	LF	1 CY PER LF	5200 CY
				13676 CY TOTAL



CONTECH ENGINEERED SOLUTIONS

Hydrodynamic Separation Product Calculator

North Shore Busway

1000' long roadway segment

CDS CDS-5-C

Project Information					
Project Name	North Shore Busway			**Option #**	A
Country	UNITED_STATES	**State**	New York	**City**	Staten Island

Contact Information			
First Name	Peter	**Last Name**	Albohn
Company	STV Incorporated	**Phone #**	862-327-9803
Email	peter.albohn@stvinc.com		

Design Criteria					
Site Designation	1000' long roadway segment			**Sizing Method**	Treatment Flow Rate
Screening Required?	No	**Treatment Flow Rate**	0.94	**Peak Flow (cfs)**	5.85
Groundwater Depth (ft)	10 - 15	**Pipe Invert Depth (ft)**	5 - 10	**Bedrock Depth (ft)**	>15
Multiple Inlets?	No	**Grate Inlet Required?**	No	**Pipe Size (in)**	18.00
Required Particle Size Distribution?	No	**90° between two inlets?**	N/A		

Treatment Selection				
Treatment Unit	CDS	**System Model**	CDS-5-C	
Target Removal	80%	**Particle Size Distribution (PSD)**	New York Redevelopment	

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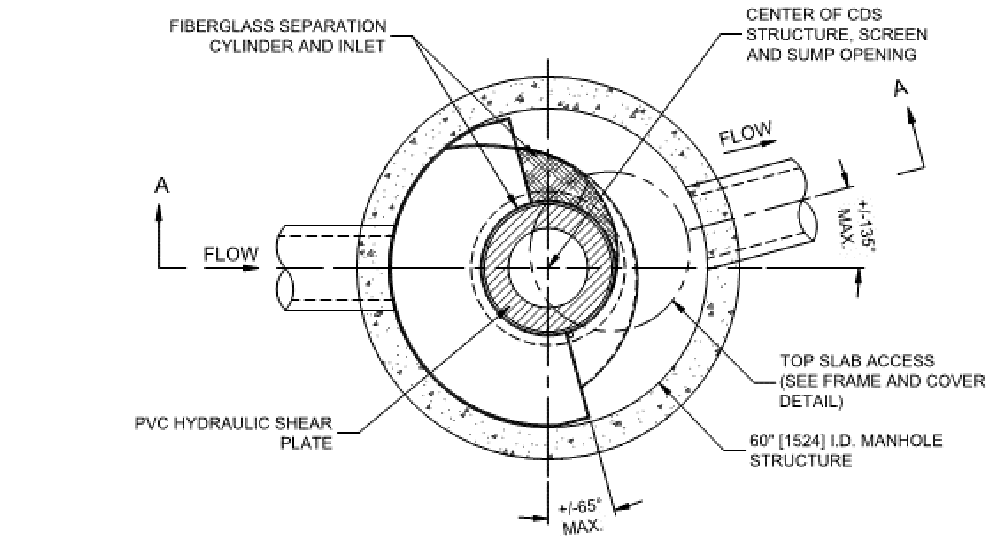
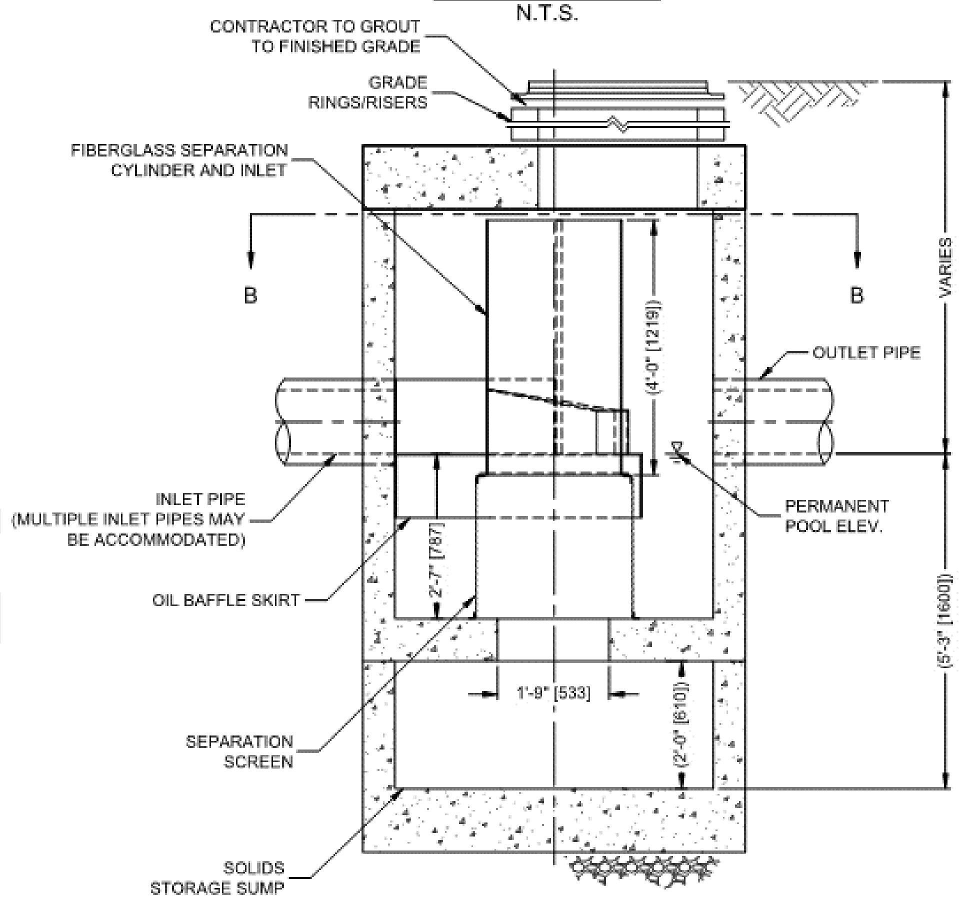


PLAN VIEW B-B
N.T.S.



ELEVATION A-A
N.T.S.

HYDRODYNAMIC SEPARATOR (CDS-5) STANDARD DETAIL

SECTION 9: ROADWAY GUTTER SPREAD CALCULATIONS

CLIENT	MTA-NYCT	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	North Shore BRT - Staten Island	PCA	KL	4019716	
SUBJECT	Conceptual Drainage - Alternate	DATE	DATE	REV.	SHEET
Roadway Gutter Spread		3/9/2020	3/30/1930	0	1

From Hydrocad, each 333' of 30' wide roadway generates 1.95 cfs in the 100 year storm

Inlet on each side of roadway: 1.95 / 2 = 0.975 cfs

Considering average roadway profile slope of 0.50%, limit spread to 6' of roadway:

HEC-22 Gutter Spread

Units: English

Input	
Flow Q (cfs):	.975
Cross slope S_x (%):	2.0
Grade S_L (%):	.5
Mannings n:	0.016
Composite section only (W > 0).	
Depressed width W (ft):	4
Depression depth a (in):	1.2
Mannings n_w:	.016

Results	
Spread T (ft):	5.977
Depth at curb d (in):	2.634
Average velocity V (ft/s):	1.750
Depressed slope S_w (%):	4.500

Revised: 28 Feb 2018.

Viaduct area where roadway profile slope = 0.27% may require more frequent inlets.

APPENDIX B: RECORD DOCUMENT LIST

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SECTION 1: AGENCY LIST

1.0 Agency Roles, Responsibility and Contact Information

Agency	Role	Project Responsibility
Federal		
Federal Transit Administration (FTA)	Federal Lead agency for potential NEPA environmental review	Federal Sponsor; Native American Coordination; NEPA Review; Section 4(f); Section 106; Federal Funding
U.S. Army Corp of Engineers (USACE)	Permitting responsibility under Section 404 of the Clean Water Act (discharge of dredged or fill material into navigable waters)	Waterfront, bulkhead & water resources
State		
Department of Environmental Conservation (DEC)	Permitting responsibility under Section 401 Water Quality Certification (consistency with Clean Water Act regulations for work in the water bodies); Article 25 tidal wetlands regulatory program, Article 24 freshwater wetlands regulatory program; Article 15 protection of waters regulatory program, Endangered and Threatened Species of Fish and Wildlife	Waterfront & water resources
Parks, Recreation and Historic Preservation (State Historic Preservation Office) (SHPO)	Consultation with the NYS Historic Preservation Office under Section 106, National Historic Preservation Act	Parkland issues and historic resources including Sailors Snug Harbor. As noted in the Draft Scoping Document, MTA NYCT will evaluate the potential for Parkland Alienation, which if necessary, may require New York State legislature authorization for the alienation of mapped parkland.
Department of State (DOS), Division of Coastal Resources	Consistency with the State's Coastal Zone Management Plan	NY State Coastal Management Program Consistency Review
City		
Office of the Deputy Mayor (DM)	Oversees and coordinates the operations of the Economic Development Corporation. Serves as a liaison with city, state, and federal agencies and other agencies responsible for the City's economic development and infrastructure	Deputy Mayor for Housing and Economic Development
NYC Department of City Planning (NYCDCP)	Oversees land use planning and consistency with New York City's public policies	Land use actions; consistency with community planning efforts (Brownfield Opportunity Areas); New York City LWRP consistency review

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NYC Department of Environmental Protection (NYCDEP)	NYC DEP mission is to “provide services that promote the health and wellbeing” of city residents	Resiliency and watershed issues
NYC General Council / NYC Law Department (NYC Law)	NYC Law provides legal representation for NYC, the NYC Mayor, other elected officials, and City agencies	Ensure alignment of project design, construction, and operation with City policies and environmental regulations, ROW ownership/conveyance mechanisms
New York City Economic Development Corporation (NYCEDC)	Provide consistency with economic and other goals of New York City. Measures potential economic effects from the operation of the Proposed Project	Land acquisitions and coordination; St. George development; Land use vision / economic development and coordination
New York City Fire Department (FDNY)	The FDNY comprises a highly skilled emergency response team that provides fire protection and other critical public safety services and enforces public safety codes throughout NYC’s five boroughs, including Staten Island	FDNY will be notified about and consulted on any planned construction activities and anticipated impacts on traffic / access to ensure emergency services continue to operate effectively in the project area during construction and operation phases
New York City Police Department (NYPD)	NYPD is responsible for policing the city and performing a range of public safety, law enforcement, traffic management, counter-terror, and emergency response roles	NYPD will play a key role in providing traffic management during the project’s construction phase; project leads will inform NYPD and consult with them on any planned construction activities; anticipated impacts on traffic / access to support public safety; NYPD will also be engaged on parking issues impacted by the project, including public parking impacts and impacts to police vehicle parking
NYC Department of Citywide Administrative Services (DCAS)	Manages, leases, and purchases city real property	Land inventory
NYC Department of Transportation (NYCDOT)	Consultation and review of transportation analysis	Richmond Terrace, St. George Ferry Terminal, South Avenue, Viaduct Bridges over NYCDOT roadways, traffic signals, sidewalks, bike lanes, pedestrian crossings
NYC Landmarks Preservation Commission (LPC)	Coordinates potential effects to cultural resources	Historic issues
NYC Department of Parks & Recreation (NYCDPR)	Maintains city’s parks system, preserving and maintaining the ecological diversity of the city's natural areas	Parks issues including Heritage Park
NYC Department of Cultural Affairs (NYCDCA)	The NYC DCA provides access to art and culture for New Yorkers	Vision of how BRT can support development of cultural resources along the project

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		corridor and contribute to community enrichment
Other		
Port Authority of New York and New Jersey (PANYNJ)	A joint venture between New York and New Jersey, PANYNJ oversees a large portion of the region's transportation infrastructure, including bridges, tunnels, airports, and seaports	Coordination regarding open cut section of ROW; access beneath Bayonne Bridge

2.0 Agency Contact Information

Agency	Contact Information
Federal	
Federal Transit Administration	
Lead Contact	Nuria Fernandez, Administrator Office of the Administrator Federal Transit Administration 1200 New Jersey Avenue, SE Washington, DC 20590 United States Phone: 202-366-4040 Kjane.williams@dot.gov denise.garris.ctr@dot.gov
Local Contact	Stephen Goodman Regional Administrator Federal Transit Administration One Bowling Green New York, NY 10004 Phone: 212-668-2170 Fax: 212-668-2136 Stephen.Goodman@dot.gov
Local Contact	Donald Burns Director, Planning & Program Development Federal Transit Administration One Bowling Green, Room 428 New York, NY 10004 Phone: 212-668-2177 Donald.burns@dot.gov
Local Contact	Dan Moser Community Planner Federal Transit Administration One Bowling Green, Room 429 New York, NY 10004 Phone: 212-668-2326 daniel.moser@dot.gov
U.S. Army Corps of Engineers	

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Lead Contact	Lieutenant General Scott A. Spellmon Commanding General and Chief of Engineers U.S. Army Corps of Engineers HQ 441 G Street NW Washington, DC 20314-1000 202-761-0011
Local Contact	Colonel Alexander Young Commander and District Engineer US Army Corps of Engineers New York District Regulatory Branch, Room 1937 26 Federal Plaza New York, NY 10278-0090 917-790-8000 Thomas.D.Asbery@usace.army.mil
Local Contact	Christopher Minck Regulatory Project Manager Operations Division, Regulatory Branch US Army Corps of Engineers 26 Federal Plaza New York, NY 10278-0090 917-790-8547 christopher.w.minck@usace.army.mil
State	
New York State Department of Environmental Conservation (NYSDEC)	
Lead Contact	Basil Seggos Commissioner New York State Department of Environmental Conservation 625 Broadway Albany, NY 12233-1011 518-402-8545 basilseggos@dec.ny.gov
Local Contact	Stephen Watts Permit Administrator, Region 2 One Hunter's Point Plaza 47-40 21st Street Long Island City, NY 11101 718-482-4997 Dep.r2@dec.ny.gov
Parks, Recreation and Historic Preservation (State Historic Preservation Office)	
Lead Contact	Honorable Erik Kulleseid Commissioner NYS Office of Parks, Recreation and Historic Preservation 625 Broadway Albany NY 12207 518-474-0456 erik.kulleseid@parks.ny.gov

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Local Contact	Leisle Lin NYC Commission Chair NYS Office of Parks, Recreation and Historic Preservation 163 West 125th Street, 17th floor New York, NY 10027 212-866-2740
New York Department of State (DOS)	
Lead Contact	Robert Rodriquez Secretary of State New York Department of State One Commerce Plaza, 99 Washington Ave Albany, NY 12231-0001 518-474-6000 opd@dos.ny.gov
Department of State Local Contact	Matthew Maraglio New York Department of State Office of Planning, Development & Community Infrastructure 99 Washington Ave., Suite 1010 Albany, NY 12231
City	
New York City Department of City Planning (NYCDCP)	
Lead Contact and Chair of the City Planning Commission	Dan Garodnick Director Department of City Planning 120 Broadway 31st Floor New York, NY 10271 212-720-3200
Local Contact	Edith Hsu-Chen Executive Director Department of City Planning 120 Broadway 31st Floor New York, NY 10271 212-720-3400
Local Contact	Catie Ferrara Iannitto Borough Director Department of City Planning Staten Island 130 Stuyvesant Place, 6th Fl. Staten Island NY 10301-2511 718-556-4073
New York City Economic Development Corporation (NYCEDC)	
Lead Contact	Andrew Kimball President & CEO NYCEDC One Liberty Plaza, 165 Broadway New York, NY 10006 212-619-5000
Department of Citywide Administrative Services (NYCDCAS)	

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Lead Contact	Dawn M. Pinnock Commissioner NYC Department of Citywide Administrative Services One Centre Street New York, NY 10007 212-386-6367
New York City Department of Transportation (NYCDOT)	
Lead Contact	Naim Rasheed Assistant Commissioner, Traffic Engineering & Planning Department of Transportation 55 Water Street New York, NY 10041 212-839-6938 nrasheed@dot.nyc.gov
Lead Contact	Eric Beaton Deputy Commissioner Transportation Planning & Management Department of Transportation 55 Water Street, 6th Floor New York, NY 10041 212-839-7710 ebeaton@dot.nyc.gov
Local Contact	Roseann Caruana Staten Island Borough Commissioner Department of Transportation 10 Richmond Terrace #300 Staten Island, NY 10301 212-839-2400
New York City Department of Parks and Recreation (NYCDPR)	
Lead Contact	Sue Donoghue Commissioner New York City Department of Parks & Recreation The Arsenal 830 Fifth Ave New York, NY 10065 212-360-1305
Local Contact	Colleen Alderson Chief, Parklands & Real Estate New York City Department of Parks & Recreation The Arsenal 830 Fifth Ave New York, NY 10065 212-360-3438
Local Contact	Jeffrey Cooper New York City Parks & Recreation-Staten Island 718-667-3545 Jeffrey.cooper@parks.nyc.gov 212-639-9675, Heritage Park Phone
New York City Department of Environmental Protection (NYCDEP)	

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Lead Contact	Rohit. T. Aggarwala Commissioner New York City & Chief Climate Officer Department of Environmental Protection 59-17 Junction Boulevard, 13th Floor Flushing, NY 11373 718-595-6565
Local Contact	Terrell Estesen Environmental Planning and Assessment New York City Department of Environmental Protection 59-17 Junction Boulevard 11th Floor Flushing, NY 11373 718-595-4473 terrelle@dep.nyc.gov
New York City Police Department (NYPD)	
Lead Contact	Edward Caban Police Commissioner New York City Police Department One Police Plaza New York, NY 10038 646-610-5410 pc.office@nypd.org
Local Contact	Stephen Spataro Deputy Inspector New York City Police Department 120th Precinct 78 Richmond Terrace St. George, NY 10301-1905 718-876-8500 pc.office@nypd.org
New York City Fire Department (FDNY)	
Lead Contact	Laura Kavanagh Fire Commissioner 9 Metrotech Center Brooklyn, NY 11201 718-999-2004
New York City Department of Small Business Services (NYCSBS)	
Lead Contact	Kevin Kim Commissioner Department of Small Business Services One Liberty Plaza, 11th Floor New York, NY 10006 212-513-6300

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Other	
Port Authority of New York & New Jersey (PANYNJ)	
Lead Contact	Mary K. Murphy Director of Planning and Regional Development Port Authority of New York and New Jersey Corporate Offices 4 World Trade Center 150 Greenwich Street New York, NY 10007 212-435-7000 Mkmurphy@panynj.gov

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APPENDIX C: SELECTED LOAD RATED CALCULATIONS

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SECTION 1: PORT RICHMOND VIADUCT

1.1 NICHOLAS AVENUE BRIDGE – LOAD RATING CALCULATIONS

STV 100 Years

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y.Cao	GKS	4019716
SUBJECT	NICHOLAS AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING SUMMARY	8/3/2019	9/9/2019	1 of 8

Objective:
Perform load rating for a simple span plate girder bridge

Rating Criteria:

1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
   a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
   b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Rating Summary:

Member	Rating Load	**Legal Load in Tons**	Rating Factor at Inventory Level	Rating Factor at Operating Level	Inventory Rating Load in Tons	Operating Rating Load in Tons
Floorbeam	HS-20	**36**	1.59	2.11	57	76
	TYPE-3	**25**	2.99	3.98	74	99
	3S-2	**36**	3.27	4.37	117	157
	3-3	**40**	3.17	4.23	126	169
	Bus	**19**	2.37	3.16	44	59
	EV2	**28**	1.64	2.18	45	61
	EV3*	**43**	1.69	2.25	72	96
Girder	HS-20	**36**	9.76	13.01	351	468
	TYPE-3	**25**	9.28	12.37	231	309
	3S-2	**36**	7.66	10.21	275	367
	3-3	**40**	7.26	9.68	290	387
	BUS	**19**	13.48	17.98	256	341
	EV2	**28**	7.61	10.15	213	284
	EV3*	**43**	6.00	8.00	257	343

* Note: EV3* uses the smaller value of the two following cases:
1. EV3 combined with HS-20;
2. EV3 combined with Type-3;

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y.Cao	GKS	4019716
SUBJECT	NICHOLAS AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/3/2019	9/9/2019	2 of 8

Objective:
Perform load rating for the floorbeam on Nicolas Avenue Bridge

Rating Criteria:
1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
 a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
 b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
 c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Notes and Assumptions:
1 Use the intermediate floorbeam near the mid-span of the bridge to perform the load rating as this location is the most critical location;
2 Assume the floorbeams are simply supported by girders;
3 Vehicle wheel loads will be distributed to floorbeams first, and then transfer to girders thru floorbeam reactions;
4 Vehicle wheel load configuration and layout are shown in Appendix 1.
5 To be conservative, all wheel loads are placed on top of floorbeams. So the spacing between adjacent axles is slightly less than the standard spacing as shown in the axle load diagram at the bottom left of the individual plans in Appendix 1.

Calculation for Dead Loads:
1. Weight from the components on top of floorbeams:

Concrete:		
Density	150	pcf
Concrete Deck:		
Deck Thickness	12	in
Cross Section Area of the Deck	33.85	sf
Width of Deck	30.625	ft
Equivalent Deck Thickness	13.26	in
Floorbeam Spacing	42	in
Deck unit load:	**0.580**	**klf**

2. Self-weight of one floorbeam: **0.180 klf**

Steel: Refer to Historical Data of Iron and Steel Beams 1873-1952

Density 490 pcf

Floorbeam Area: 52.89 in^2 Use 30WF CB302 30X15

Flange Width bf = 15 in

Flange Thickness tf = 1.125 in

Depth d= 30 in

Web Thickness tw= 0.67 in

Section Modulus S = 555.2 in^3

Yield Strength Fy = 33 ksi

Moment Capacity Mc 1526.80 k-ft

Shear Capacity Vc 1745.37 kips

3. Total Dead Loads:

Line Load Along the Span Length **0.760 klf**

Point Load from Concrete Barrier: **0.000 kips**

Distance from Barrier Load to the End of the Floorbeam:

$d_{barrier}$= 1.167 ft

DL Reactions and Moments on Floorbeams

Floorbeam No.	Beam Length (ft)	Total DL Reaction (kips)	M_{max} due to total DL (k-ft)
1	5.469	2.079	2.842
2	8.854	3.366	7.450
3	12.250	4.657	14.261
4	15.646	5.947	23.263
5	19.031	7.234	34.420
6	22.427	8.525	47.799
7	25.813	9.812	63.319
8	33.000	12.544	103.490
9	33.000	12.544	103.490
10	33.000	12.544	103.490
11	33.000	12.544	103.490
12	33.000	12.544	103.490
13	33.000	12.544	103.490
14	33.000	12.544	103.490
15	33.000	12.544	103.490
16	33.000	12.544	103.490
17	33.000	12.544	103.490
18	33.000	12.544	103.490
19	33.000	12.544	103.490
20	33.000	12.544	103.490
21	33.000	12.544	103.490
22	33.000	12.544	103.490
23	33.000	12.544	103.490
24	33.000	12.544	103.490
25	33.000	12.544	103.490
26	33.000	12.544	103.490
27	33.000	12.544	103.490
28	33.000	12.544	103.490

Calculation for Live Loads:

Live Load Impact Factor: IM= 33%

Floorbeam Span Length: $L_{FB\text{-}M.S.}$ = 33 ft

Comparison between one-lane loading and two-lane loading conditions

Loading Condition	Unit Point Load (kips)	M_{max} (k-ft)	V_{max} (kips)	Multiple Presence Factor (m)	m*M_{max} (k-ft)	m*V_{max} (kips)
One-Lane Loaded	1.0	13.5	1	1.2	16.2	1.2
Two-Lane Loaded	1.0	23	2.51	1.0	23	2.51

* Note: Maximum shear is based on placing the wheel 2ft from the edge of knee brace which is assumed 2.33ft from the C.L. of the girder. So the edge distance is calculated as e =2ft+2.33ft=4.33ft.

Conclusion: Two-lane loading condition governs. The following calculations will use two-lane loading condition.

Calculate Forces and Moments on Floorbeams due to Live Loads

1. Load Type: HS-20

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear: Distance From the Girder to the Nearest Wheel (ft)	Maximum Shear: V_{max} (kips)
Front	FB9	4	122.36	4.33	13.35
Center	FB13	16	489.44	4.33	53.41
Rear	FB17	16	489.44	4.33	53.41

2. Load Type: Type-3

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear: Distance From the Girder to the Nearest Wheel (ft)	Maximum Shear: V_{max} (kips)
Front	FB10	8	244.72	4.33	26.71
Center	FB14	8.5	260.02	4.33	28.38
Rear	FB15	8.5	260.02	4.33	28.38

3. Load Type: 3S2

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear: Distance From the Girder to the Nearest Wheel (ft)	Maximum Shear: V_{max} (kips)
1	FB7	5	152.95	4.33	16.69
2	FB10	7.75	237.07	4.33	25.87
3	FB11	7.75	237.07	4.33	25.87
4	FB17	7.75	237.07	4.33	25.87
5	FB18	7.75	237.07	4.33	25.87

4. Load Type: 3-3

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
1	FB6	6	183.54	4.33	20.03
2	FB10	6	183.54	4.33	20.03
3	FB11	6	183.54	4.33	20.03
4	FB15	8	244.72	4.33	26.71
5	FB19	7	214.13	4.33	23.37
6	FB20	7	214.13	4.33	23.37

5. Load Type: BUS

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
Front	FB10	9.03	276.23	4.33	30.14
Rear	FB16	10.73	328.08	4.33	35.80

6. Load Type: EV2 (Combined with HS20)

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
1	FB9	4	72.41	14.33	5.05
2	FB13	12 & 16	421.97	4.33	45.03
3	FB17	16.75 & 16	474.37	4.33	54.86

Note: In this case, the Emergency Load EV2 is applied on one traffice lane
and Legal Load HS20 applied on the other traffice lane;

7. Load Type: EV3 (Combined with HS20)

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
1	FB9	4	72.41	14.33	5.05
2	FB12	12	160.73	4.33	24.83
3	FB13	16	289.61	14.33	22.34
4	FB17	15.5 & 16	460.58	4.33	52.27
5	FB18	15.5	207.61	4.33	32.07

Note: In this case, the Emergency Load EV3 is applied on one traffice lane
and Legal Load HS20 applied on the other traffice lane;

8. Load Type: EV3 (Combined with Type-3)
Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear: Distance From the Girder to the Nearest Wheel (ft)	Maximum Shear: V_{max} (kips)
1	FB12	12	160.73	4.33	24.83
2	FB13	8	144.80	14.33	11.17
3	FB17	15.5 & 8.5	324.83	4.33	42.81
4	FB18	15.5 & 8.5	324.83	4.33	42.81

Note: In this case, the Emergency Load EV3 is applied on one traffice lane and Legal Load Type-3 applied on the other traffice lane;

Calculation for Load Rating Factors:

a. Rating Factor for Moment on Floorbeam:

Rating Load	Moment Capacity (k-ft)	Max. Moment (k-ft)		Load Factors			Rating Factors	
LL Type	M_c	M_{DL}	M_{LL}	DL	LL, inventory	LL, operating	Inventory	Operating
HS-20	1526.80	103.49	489.44	1.25	1.80	1.35	1.59	2.11
TYPE-3	1526.80	103.49	260.02	1.25	1.80	1.35	2.99	3.98
3S-2	1526.80	103.49	237.07	1.25	1.80	1.35	3.27	4.37
3-3	1526.80	103.49	244.72	1.25	1.80	1.35	3.17	4.23
Bus	1526.80	103.49	328.08	1.25	1.80	1.35	2.37	3.16
EV2	1526.80	103.49	474.37	1.25	1.80	1.35	1.64	2.18
EV3	1526.80	103.49	460.58	1.25	1.80	1.35	1.69	2.25

* Notes: 1. Live Load Factor is in accordance with Table 6A.4.4.2.3a-1 in Reference 1;
2. EV3* uses the smaller value of the two following cases:
a. EV3 combined with HS-20;
b. EV3 combined with Type-3;

b. Rating Factor for Shear on Floorbeam:

Rating Load	Shear Capacity (kips)	Max. Shear (k-ft)		Load Factors			Rating Factors	
LL Type	V_c	V_{DL}	V_{LL}	DL	LL, inventory	LL, operating	Inventory	Operating
HS-20	1745.37	12.54	53.41	1.25	1.8	1.35	17.99	23.99
TYPE-3	1745.37	12.54	28.38	1.25	1.8	1.35	33.87	45.15
3S-2	1745.37	12.54	25.87	1.25	1.8	1.35	37.14	49.52
3-3	1745.37	12.54	26.71	1.25	1.8	1.35	35.98	47.98
Bus	1745.37	12.54	35.80	1.25	1.80	1.35	26.84	35.79
EV2	1745.37	12.54	54.86	1.25	1.80	1.35	17.52	23.35
EV3	1745.37	12.54	52.27	1.25	1.80	1.35	18.38	24.51

* Notes: 1. Live Load Factor is in accordance with Table 6A.4.4.2.3a-1 in Reference 1;
2. EV3* uses the smaller value of the two following cases:
a. EV3 combined with HS-20;
b. EV3 combined with Type-3;

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y.Cao	GKS	4019716
SUBJECT	NICHOLAS AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR GIRDER	8/3/2019	9/9/2019	7 of 8

Objective:
Perform load rating for the girder on Nicolas Avenue Bridge

Rating Criteria:

1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
   a. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   b. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Notes and Assumptions:
1 Assume the vehicle loads are transferred to the girders thru the reactions from the floorbeams;
2 Use girder span length L=102ft-8in;
3 Consider the self-weight of the girder along the entire span length using the girder cross section at the mid-span;

Reactions from Floorbeams Resulting in Maximum Moment on the Girder:

Floorbeam No.	Floorbeam Spacing (ft)	Distance to the Girder End (ft)	DL Reactions (kips)	Max. Reactions due to HS20 Truck (kips)	Max. Reactions due to TYPE-3 Truck (kips)	Max. Reactions due to 3S2 Truck (kips)	Max. Reactions due to 3-3 Truck (kips)	Max. Reactions due to BUS (kips)	Max. Reactions due to EV2 (kips)	Max. Reactions due to $EV3^1$ (kips)	Max. Reactions due to $EV3^2$ (kips)
1	8.167	8.167	2.079								
2	3.5	11.667	3.366								
3	3.5	15.167	4.657								
4	3.5	18.667	5.947								
5	3.5	22.167	7.234								
6	3.5	25.667	8.525				20.030				
7	3.5	29.167	9.812			16.692					
8	3.5	32.667	12.544								
9	3.5	36.167	12.544	13.353					5.05	5.05	
10	3.5	39.667	12.544		26.706	25.872	20.030	30.145			
11	3.5	43.167	12.544			25.872	20.030				
12	3.5	46.667	12.544							24.83	24.83
13	3.5	50.167	12.544	53.413					45.03	22.34	11.17
14	3.5	53.667	12.544		28.376						
15	3.5	57.167	12.544		28.376		26.706				
16	3.5	60.667	12.544								
17	3.5	64.167	12.544	53.413		25.872		35.803	54.86	52.27	42.81
18	3.5	67.667	12.544			25.872				32.07	42.81
19	3.5	71.167	12.544				23.368				
20	3.5	74.667	12.544				23.368				
21	3.5	78.167	12.544								
22	3.5	81.667	12.544								
23	3.5	85.167	12.544								
24	3.5	88.667	12.544								
25	3.5	92.167	12.544								
26	3.5	95.667	12.544								
27	3.5	99.167	12.544								
28	3.5	102.667	12.544								

Notes: 1. $EV3^1$: For Emergency Load EV3 on one traffice lane and Legal Load HS20 on the other traffice lane;
2. $EV3^2$: For Emergency Load EV3 on one traffice lane and Legal Load Type-3 on the other traffice lane;

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y.Cao	GKS	4019716
SUBJECT	NICHOLAS AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR GIRDER	8/3/2019	9/9/2019	8 of 8

Uniform DL Due to Self-weight of Girder:

Critical Section at	Mid-Span		(Girder Section Properties are calculated in Appendix 2)
Area	428.90	in^2	
Density	0.49	kcf	
Original S.W.	1.46	klf	
Modified S.W.	**1.61**	**klf**	

Note: Increase 10% of steel density to include miscellenuous weights from connections, stiffeners and other attachments.

DL Moments on the Typical Sections of the Girder:

Cross Sections	Location	M_{FB_DL} (k-ft)	M_{GR_SW} (k-ft)	M_{DL} (k-ft)
Section-1	0.5L	6981.42	2115.20	9096.62
Section-2	(5/16)*L	5763.22	1846.36	7609.58

Moment Capacity on the Typical Sections:

Cross Sections	Section Modulus (in^3)	Yield Stress (ksi)	M_y (k-ft)
Section-1	15494.51	33	42609.90
Section-2	14043.27	33	38618.98

LL Moments on the Typical Sections of the Girder:

Cross Sections	Location	M_{HS20} (k-ft)	M_{TYPE3} (k-ft)	M_{3S2} (k-ft)	M_{3-3} (k-ft)	M_{BUS} (k-ft)	M_{EV2} (k-ft)	M_{EV3}^1 (k-ft)	M_{EV3}^2 (k-ft)
Section-1	0.5L	1778.74	1870.44	2265.76	2389.38	1287.09	2280.63	2892.59	2624.63
Section-2	(5/16)*L	1283.16	1396.48	1953.75	1968.53	1048.82	1539.84	1936.01	1646.35

Calculation for Load Rating Factors:

a. Rating Factor for Moment on Girder:

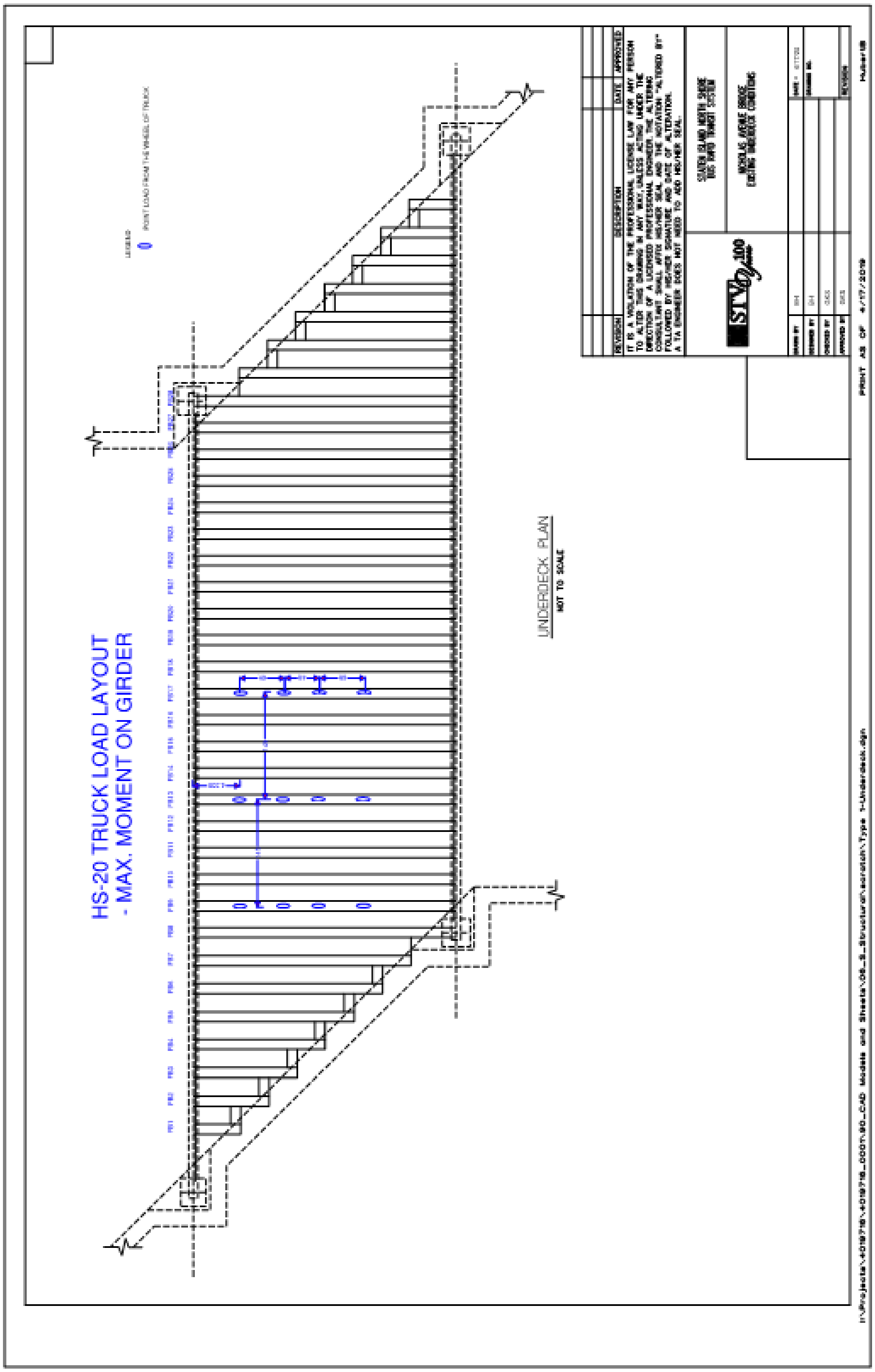
Cross Sections	Rating Load	Moment Capacity (k-ft)	Max. Moment (k-ft)		Load Factors			Rating Factors	
	LL Type	M_y	M_{DL}	$M_{LL,max}$	DL	LL, inventory	LL, operating	Inventory	Operating
Section-1	HS-20	42609.90	9096.62	1778.74	1.25	1.80	1.35	9.76	13.01
	TYPE-3	42609.90	9096.62	1870.44	1.25	1.80	1.35	9.28	12.37
	3S-2	42609.90	9096.62	2265.76	1.25	1.80	1.35	7.66	10.21
	3-3	42609.90	9096.62	2389.38	1.25	1.80	1.35	7.26	9.68
	Bus	42609.90	9096.62	1287.09	1.25	1.80	1.35	13.48	17.98
	EV2	42609.90	9096.62	2280.63	1.25	1.80	1.35	7.61	10.15
	$EV3^1$	42609.90	9096.62	2892.59	1.25	1.80	1.35	6.00	8.00
	$EV3^2$	42609.90	9096.62	2624.63	1.25	1.80	1.35	6.61	8.82
Section-2	HS-20	38618.98	7609.58	1283.16	1.25	1.80	1.35	12.60	16.80
	TYPE-3	38618.98	7609.58	1396.48	1.25	1.80	1.35	11.58	15.44
	3S-2	38618.98	7609.58	1953.75	1.25	1.80	1.35	8.28	11.04
	3-3	38618.98	7609.58	1968.53	1.25	1.80	1.35	8.21	10.95
	Bus	38618.98	7609.58	1048.82	1.25	1.80	1.35	15.42	20.56
	EV2	38618.98	7609.58	1539.84	1.25	1.80	1.35	10.50	14.00
	$EV3^1$	38618.98	7609.58	1936.01	1.25	1.80	1.35	8.35	11.14
	$EV3^2$	38618.98	7609.58	1646.35	1.25	1.80	1.35	9.82	13.10

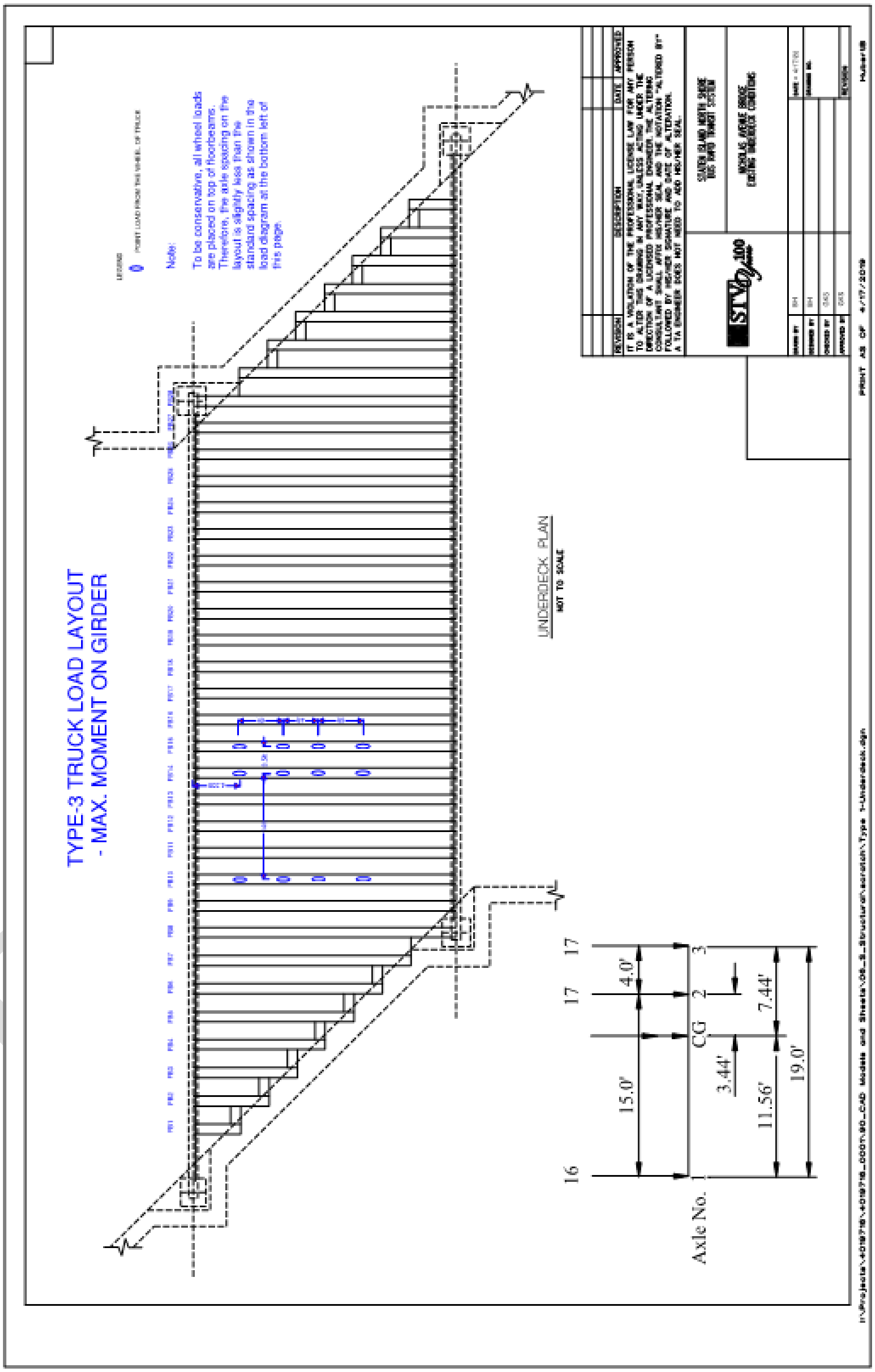
Notes:
1. $EV3^1$: For Emergency Load EV3 on one traffice lane and Legal Load HS20 on the other traffice lane;
2. $EV3^2$: For Emergency Load EV3 on one traffice lane and Legal Load Type-3 on the other traffice lane;

b. Rating Factor for Shear on Girder:

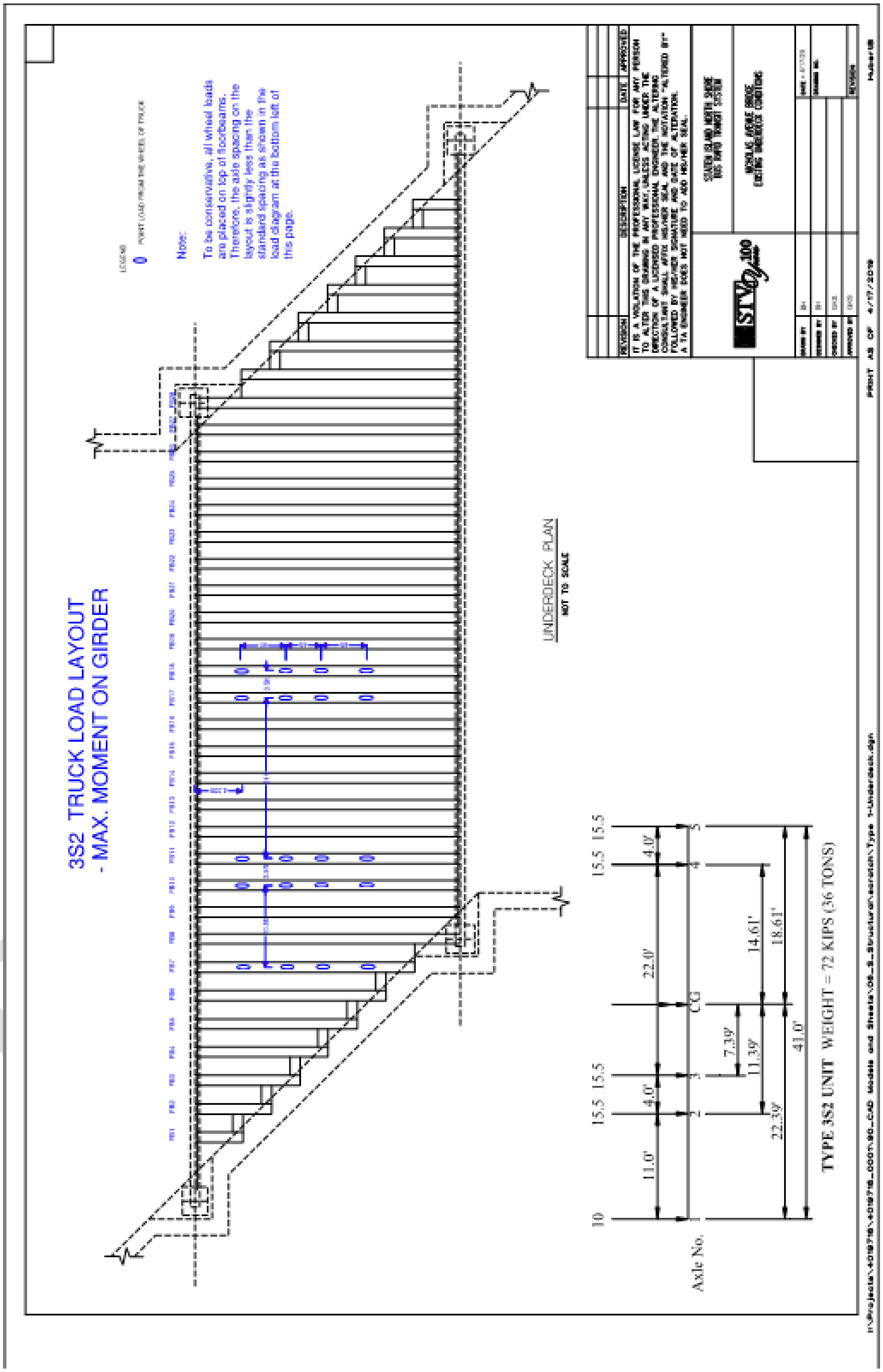
1 Based on engineering judgement, shear does not control.
2 Since no section loss was observed, the shear capacity will not be affected.
3 No further investigation is warranted.

1.2 NICHOLAS AVENUE BRIDGE – LAYOUT OF TRUCK LOADS

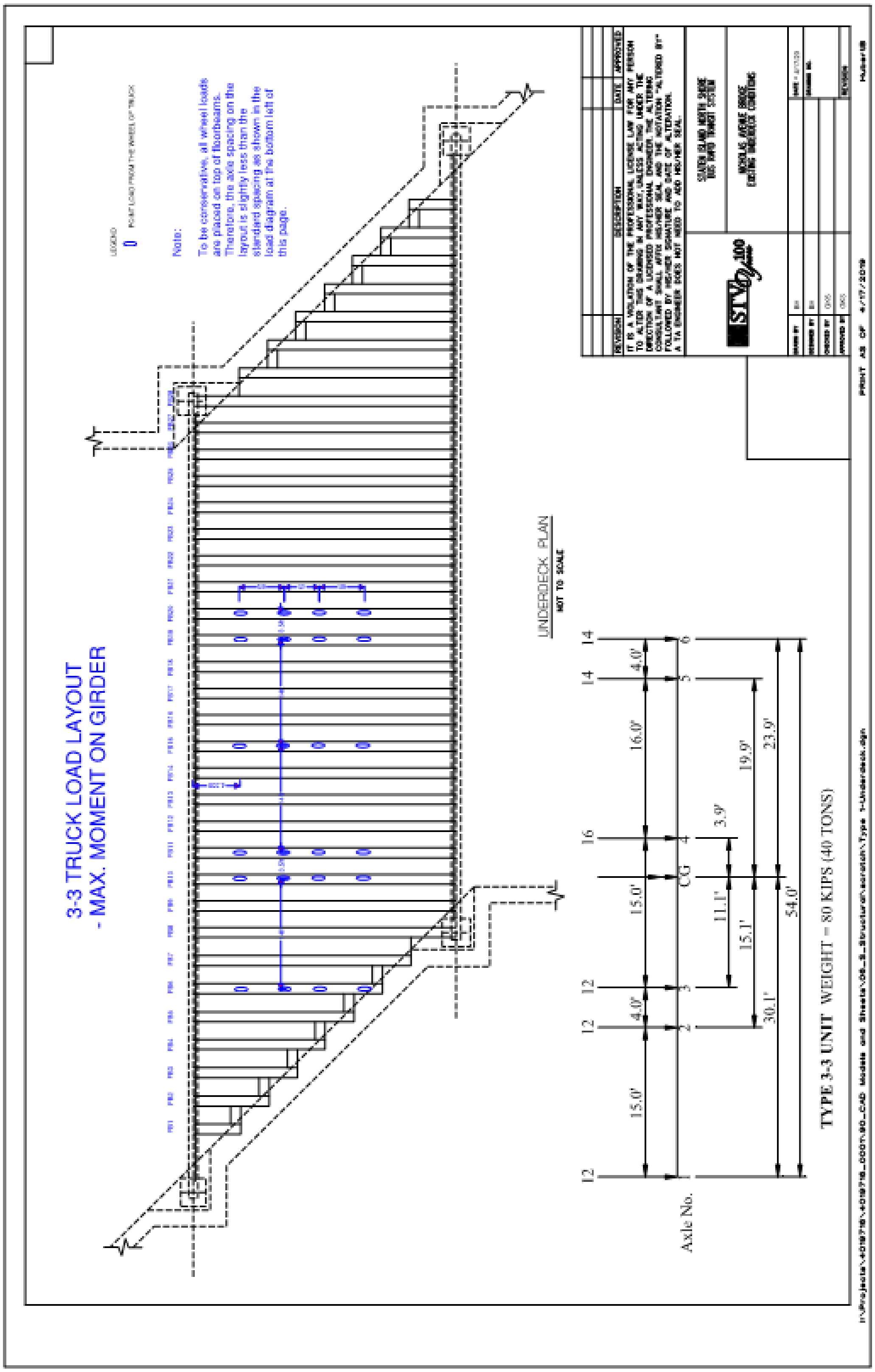




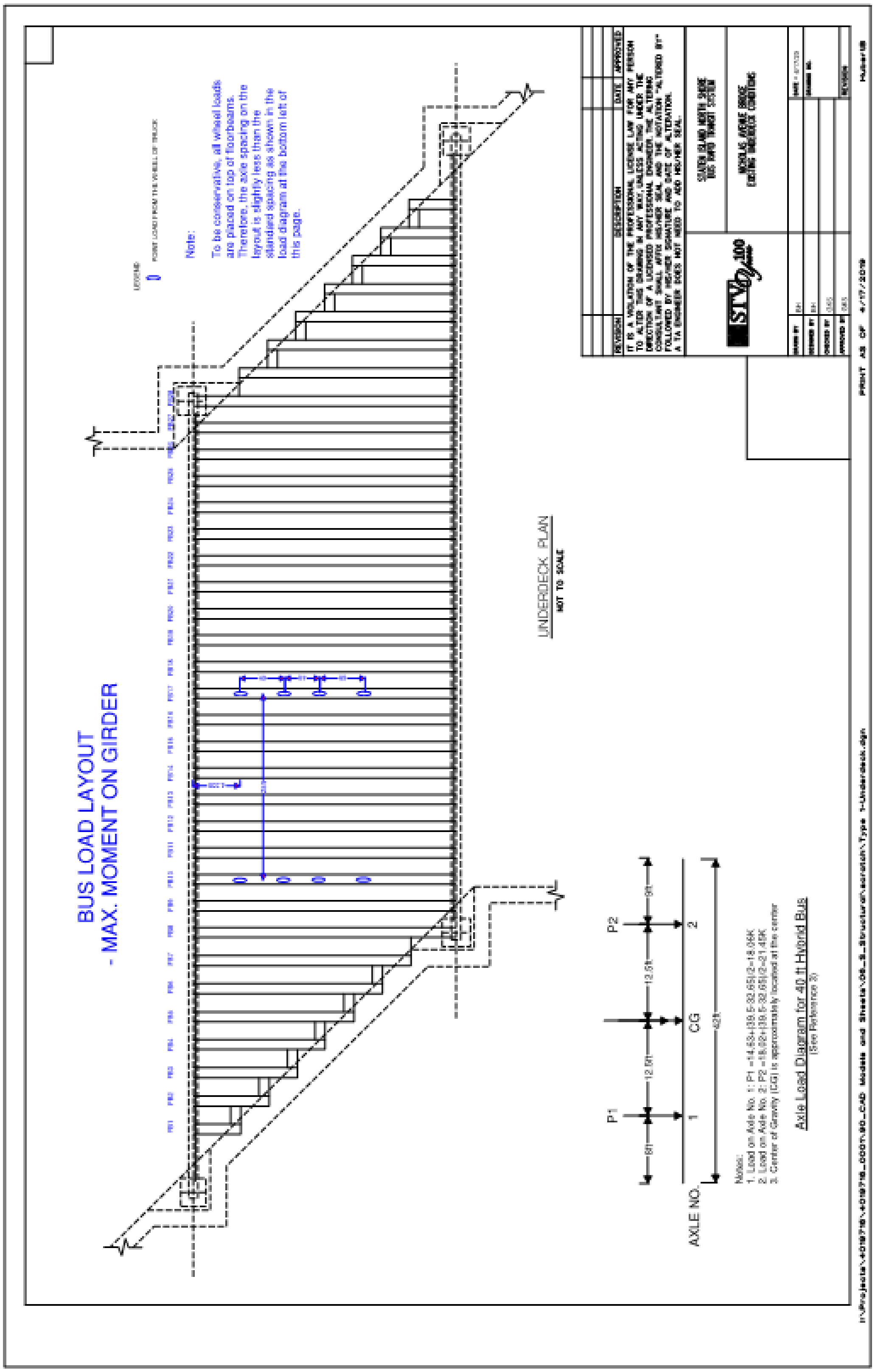
TYPE-3 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom left of this page.
UNDERDECK PLAN
NOT TO SCALE
Axle No.
1
2
3
CG
16
17
17
15.0'
4.0'
3.44'
7.44'
11.56'
19.0'
STV
PRINT AS OF 4/17/2019

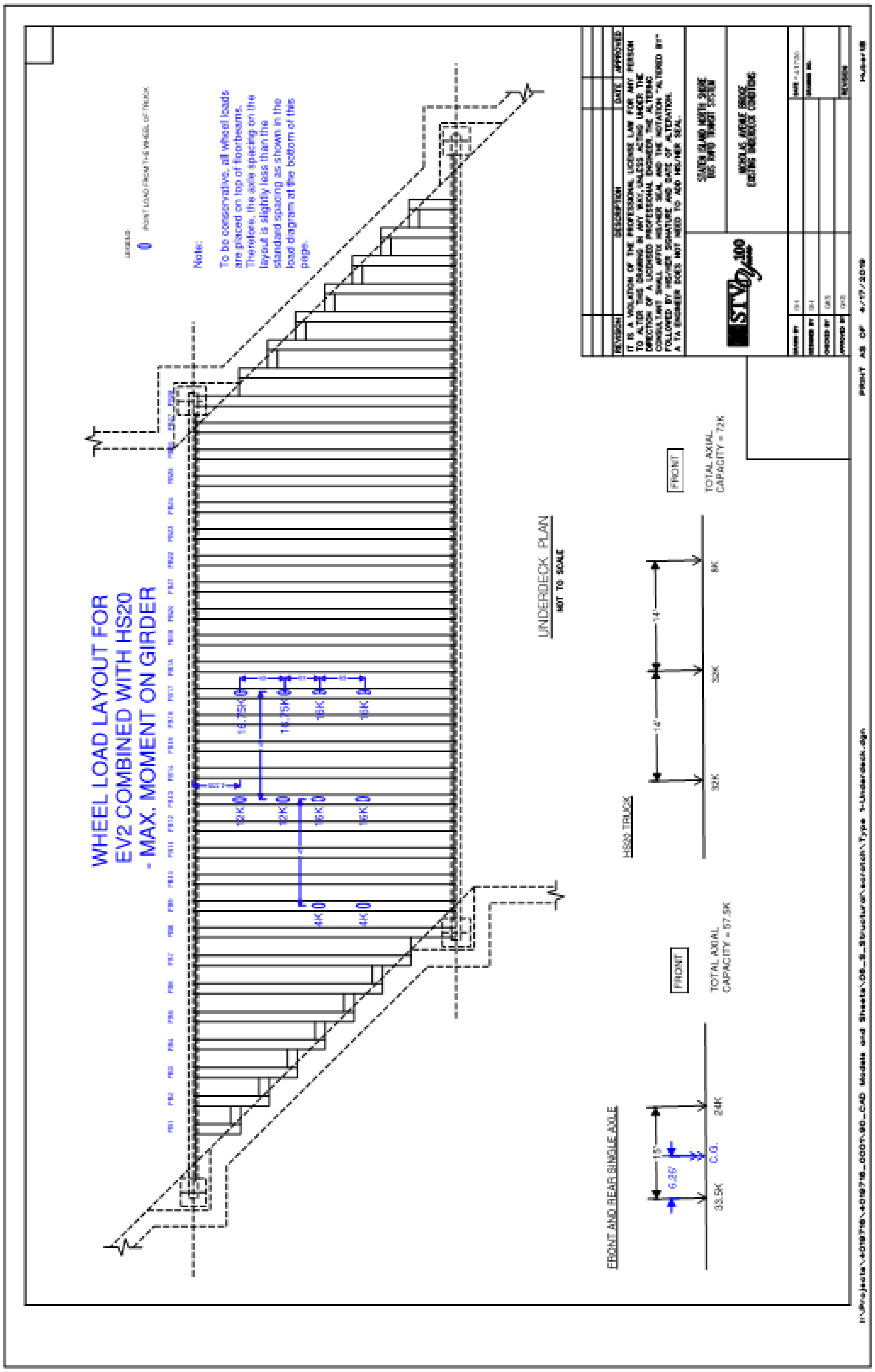

3S2 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom left of this page.
UNDERDECK PLAN
NOT TO SCALE
10
15.5 15.5
15.5 15.5
11.0'
4.0'
22.0'
4.0'
7.39'
11.39'
22.39'
14.61'
18.61'
41.0'
CG
Axle No.
TYPE 3S2 UNIT WEIGHT = 72 KIPS (36 TONS)
PRINT AS OF 4/17/2019

June 16, 2023

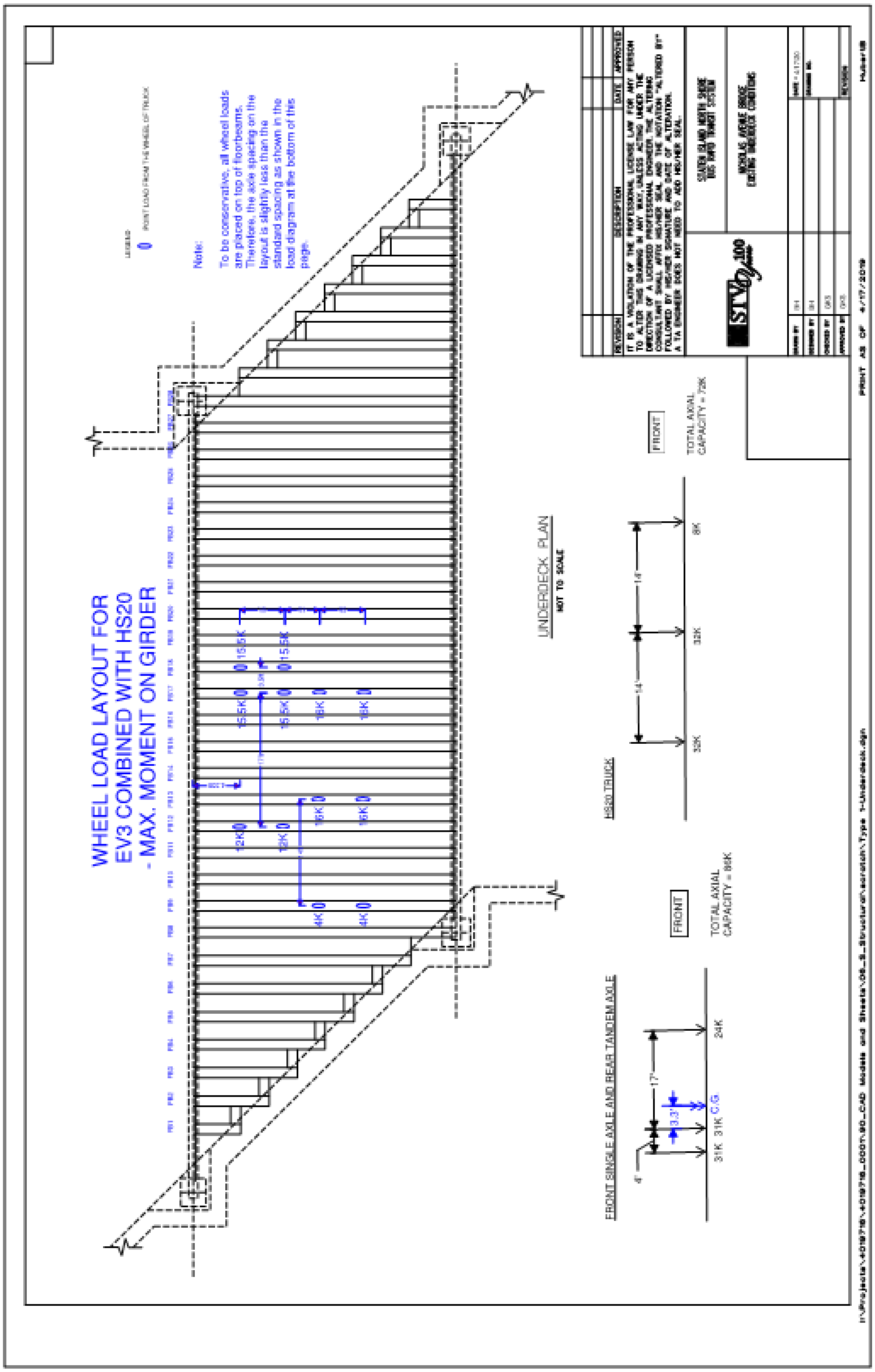


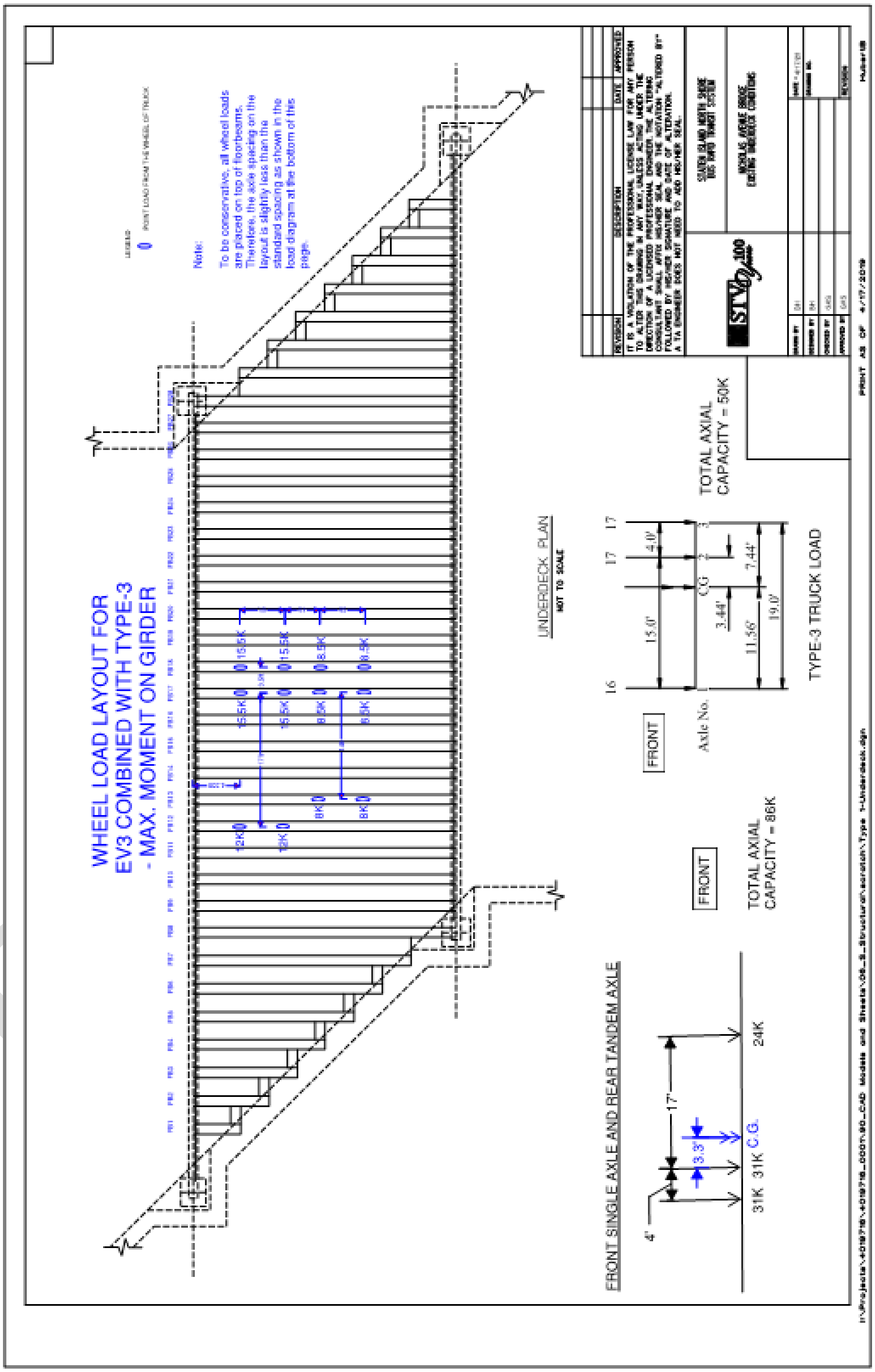
3-3 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom left of this page.
UNDERDECK PLAN
NOT TO SCALE
Axle No.
12
12
12
16
14
14
15.0'
4.0'
15.0'
16.0'
4.0'
CG
3.9'
11.1'
15.1'
19.9'
30.1'
23.9'
54.0'
TYPE 3-3 UNIT WEIGHT = 80 KIPS (40 TONS)


BUS LOAD LAYOUT
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom left of this page.
UNDERDECK PLAN
NOT TO SCALE
AXLE NO.
P1
P2
CG
Axle Load Diagram for 40 ft Hybrid Bus
(See Reference 3)
STATEN ISLAND NORTH SHORE
BUS RAPID TRANSIT SYSTEM
NICHOLAS AVENUE BRIDGE
EXISTING UNDERDECK CONDITIONS

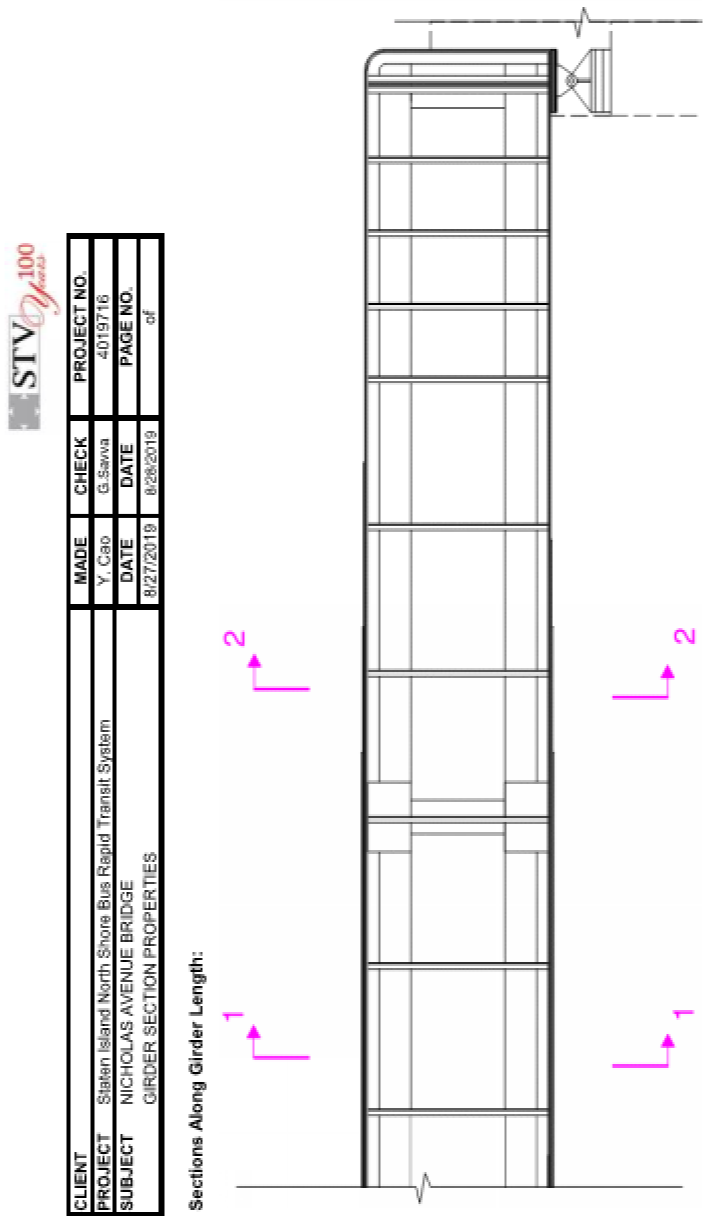

WHEEL LOAD LAYOUT FOR
EV2 COMBINED WITH HS20
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom of this page.
UNDERDECK PLAN
NOT TO SCALE
HS20 TRUCK
32K
32K
8K
14'
14'
FRONT
TOTAL AXIAL CAPACITY = 72K
FRONT AND REAR SINGLE AXLE
33.5K
24K
C.G.
FRONT
TOTAL AXIAL CAPACITY = 57.5K
12K
16K
4K
PRINT AS OF 4/17/2019

June 16, 2023


WHEEL LOAD LAYOUT FOR
EV3 COMBINED WITH HS20
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom of this page.
UNDERDECK PLAN
NOT TO SCALE
FRONT SINGLE AXLE AND REAR TANDEM AXLE
FRONT
TOTAL AXIAL CAPACITY = 86K
HS20 TRUCK
FRONT
TOTAL AXIAL CAPACITY = 72K
31K 31K
24K
32K
32K
8K
14'
14'
17'
4'
3.3'
C.G
155K
155K
155K
155K
12K
12K
16K
16K
16K
16K
4K
4K

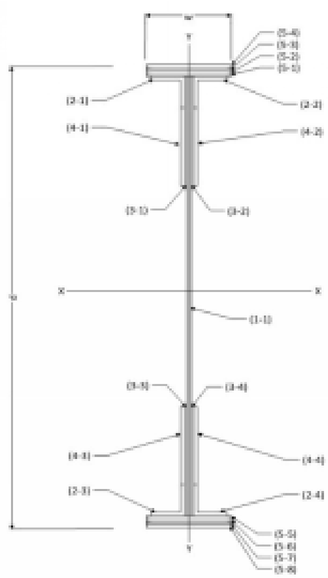

WHEEL LOAD LAYOUT FOR
EV3 COMBINED WITH TYPE-3
- MAX. MOMENT ON GIRDER
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard spacing as shown in the load diagram at the bottom of this page.
UNDERDECK PLAN
NOT TO SCALE
FRONT SINGLE AXLE AND REAR TANDEM AXLE
FRONT
TOTAL AXIAL CAPACITY - 86K
31K 31K C.G.
24K
TOTAL AXIAL CAPACITY - 50K
TYPE-3 TRUCK LOAD
Axle No.

1.3 NICHOLAS AVENUE BRIDGE – GIRDER SECTION PROPERTIES

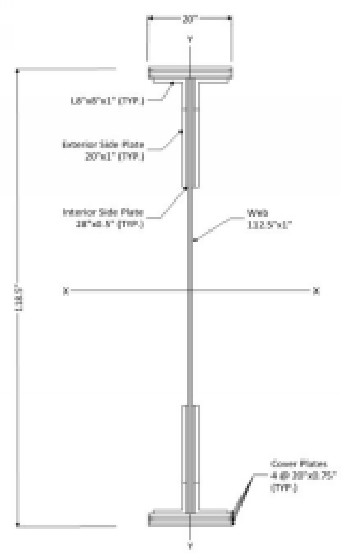


CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
SUBJECT	NICHOLAS AVENUE BRIDGE	DATE	DATE	PAGE NO.
	GIRDER SECTION PROPERTIES	8/27/2019	8/28/2019	of

Section Properties: **Section-1** (at mid-span)



Sketch - a



Sketch - b

Steel Section Input Information:

(manually input cells)

#			
	d, total depth =	118.50	in
	w, total width =	20.00	in

1) Web

1-1) Web

$H_{wo,}$ height of web plate =	112.50	in
$t_{wo,}$ thickness of web plate =	1.00	in

CLIENT		MADE	CHECK	PROJECT NO.
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	GIRDER SECTION PROPERTIES	8/27/2019	8/28/2019	of

2) Flange Angles

2-1) Top Left Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-2) Top Right Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-3) Bottom Left Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

CLIENT		MADE	CHECK	PROJECT NO.
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2-4) Bottom Right Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

3) Interior Side Plates

3-1) Top Left Interior Side Plate		
Plate Height =	28.00	in
Plate Thickness =	0.50	in
3-2) Top Right Interior Side Plate		
Plate Height =	28.00	in
Plate Thickness =	0.50	in
3-3) Bottom Left Interior Side Plate		
Plate Height =	28.00	in
Plate Thickness =	0.50	in
3-4) Bottom Right Interior Side Plate		
Plate Height =	28.00	in
Plate Thickness =	0.50	in

4) Exterior Side Plates

4-1) Top Left Exterior Side Plate		
Plate Height =	20.00	in
Plate Thickness =	1.00	in
4-2) Top Right Exterior Side Plate		
Plate Height =	20.00	in
Plate Thickness =	1.00	in
4-3) Bottom Left Exterior Side Plate		
Plate Height =	20.00	in
Plate Thickness =	1.00	in
4-4) Bottom Right Exterior Side Plate		
Plate Height =	20.00	in
Plate Thickness =	1.00	in

CLIENT		MADE	CHECK	PROJECT NO.
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5) Cover Plates

5-1) Top Cover Plate #1		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-2) Top Cover Plate #2		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-3) Top Cover Plate #3		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-4) Top Cover Plate #4		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-5) Bottom Cover Plate #1		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-6) Bottom Cover Plate #2		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-7) Bottom Cover Plate #3		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-8) Bottom Cover Plate #4		
Plate Width =	20.00	in
Plate Thickness =	0.75	in

*Note: #1 cover plates adjacent to web, #2, #3, #4 are added, built outward from the web.

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
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CALCULATE MOMENT OF INERTIA, Ixx, ABOUT THE X-AXIS:

#	Material	A, Area	y	A*y	I_{so}	y - c_y	A*(y - c_y)^2
		in^2	in	in^3	in^4	in	in^4
1-1)	Web	112.50	59.25	6665.63	118652.34	0.00	0.00
2-1)	Top Left Flange Angle	15.10	5.36	80.94	89.10	-53.89	43852.39
2-2)	Top Right Flange Angle	15.10	5.36	80.94	89.10	-53.89	43852.39
2-3)	Bottom Left Flange Angle	15.10	113.14	1708.41	89.10	53.89	43852.39
2-4)	Bottom Right Flange Angle	15.10	113.14	1708.41	89.10	53.89	43852.39
3-1)	Top Left Interior Side Plate	14.00	17.00	238.00	914.67	-42.25	24990.88
3-2)	Top Right Interior Side Plate	14.00	17.00	238.00	914.67	-42.25	24990.88
3-3)	Bottom Left Interior Side Plate	14.00	101.50	1421.00	914.67	42.25	24990.88
3-4)	Bottom Right Interior Side Plate	14.00	101.50	1421.00	914.67	42.25	24990.88
4-1)	Top Left Exterior Side Plate	20.00	21.00	420.00	666.67	-38.25	29261.25
4-2)	Top Right Exterior Side Plate	20.00	21.00	420.00	666.67	-38.25	29261.25
4-3)	Bottom Left Exterior Side Plate	20.00	97.50	1950.00	666.67	38.25	29261.25
4-4)	Bottom Right Exterior Side Plate	20.00	97.50	1950.00	666.67	38.25	29261.25
5-1)	Top Cover Plate #1	15.00	2.63	39.38	0.70	-56.63	48095.86
5-2)	Top Cover Plate #2	15.00	1.88	28.13	0.70	-57.38	49378.36
5-3)	Top Cover Plate #3	15.00	1.13	16.88	0.70	-58.13	50677.73
5-4)	Top Cover Plate #4	15.00	0.38	5.63	0.70	-58.88	51993.98
5-5)	Bottom Cover Plate #1	15.00	115.88	1738.13	0.70	56.63	48095.86
5-6)	Bottom Cover Plate #2	15.00	116.63	1749.38	0.70	57.38	49378.36
5-7)	Bottom Cover Plate #3	15.00	117.38	1760.63	0.70	58.13	50677.73
5-8)	Bottom Cover Plate #4	15.00	118.13	1771.88	0.70	58.88	51993.98
	Σ	428.90		25412.33	125339.70		792709.95

Calculate Neutral Axis (N.A.) of steel section:

$c_y = \Sigma(A^*y) / \Sigma A$

= 59.25 in. from top

$c_{ybot} = d - c_y$

= 59.25 in. from bottom

Calculate gross moment of inertia, I_{xxg}:

$I_{xxg} = \Sigma\,(I_{so} + A\,(y - c_y)^2)$

= **918049.66** in^4

Calculate gross section modulus, S_{xxg}:

$S_{xxg} = I_{xxg} / c_{ybot}$

= **15494.51** in^3

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
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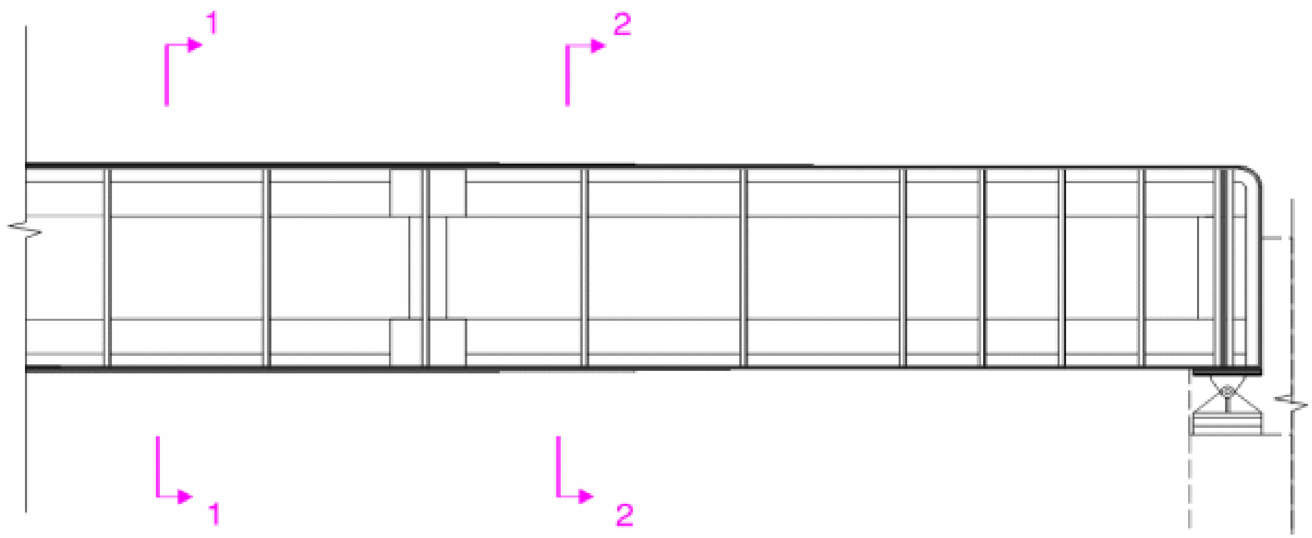
Sections Along Girder Length:



CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
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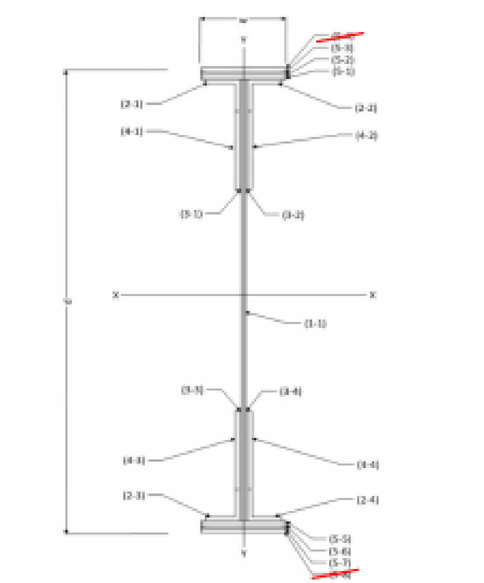
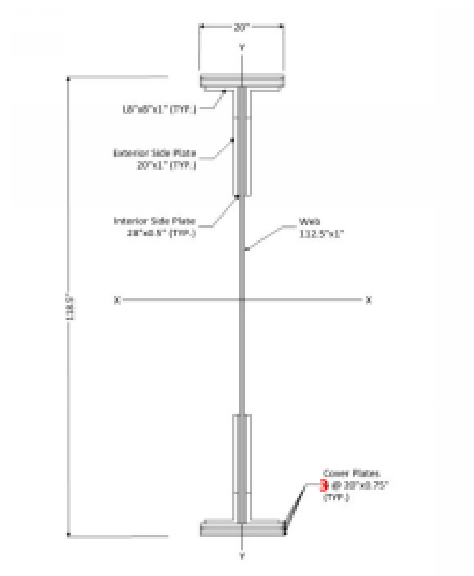
Section Properties: **Section-2** (32'-1" from end support)



Sketch - a



Sketch - b

Steel Section Input Information:

(manually input cells)

#			
	d, total depth =	118.50	in
	w, total width =	20.00	in

1) Web

1-1) Web

H_{wo}, height of web plate =	112.50	in
t_{wo}, thickness of web plate =	1.00	in

		MADE	CHECK	PROJECT NO.
CLIENT				
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
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2) Flange Angles

2-1) Top Left Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-2) Top Right Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-3) Bottom Left Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
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	GIRDER SECTION PROPERTIES	8/27/2019	8/28/2019	of

2-4) Bottom Right Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	8.00	in	
Angle Width =		8.00	in	
Angle Thickness =		1.00	in	
I_{xx} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		89.10	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		2.36	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		15.10	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

3) Interior Side Plates

3-1) Top Left Interior Side Plate

Plate Height =	28.00	in
Plate Thickness =	0.50	in

3-2) Top Right Interior Side Plate

Plate Height =	28.00	in
Plate Thickness =	0.50	in

3-3) Bottom Left Interior Side Plate

Plate Height =	28.00	in
Plate Thickness =	0.50	in

3-4) Bottom Right Interior Side Plate

Plate Height =	28.00	in
Plate Thickness =	0.50	in

4) Exterior Side Plates

4-1) Top Left Exterior Side Plate

Plate Height =	20.00	in
Plate Thickness =	1.00	in

4-2) Top Right Exterior Side Plate

Plate Height =	20.00	in
Plate Thickness =	1.00	in

4-3) Bottom Left Exterior Side Plate

Plate Height =	20.00	in
Plate Thickness =	1.00	in

4-4) Bottom Right Exterior Side Plate

Plate Height =	20.00	in
Plate Thickness =	1.00	in

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
SUBJECT	NICHOLAS AVENUE BRIDGE	DATE	DATE	PAGE NO.
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5) Cover Plates

5-1) Top Cover Plate #1		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-2) Top Cover Plate #2		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-3) Top Cover Plate #3		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-4) Top Cover Plate #4		
Plate Width =	0.00	in
Plate Thickness =	0.00	in
5-5) Bottom Cover Plate #1		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-6) Bottom Cover Plate #2		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-7) Bottom Cover Plate #3		
Plate Width =	20.00	in
Plate Thickness =	0.75	in
5-8) Bottom Cover Plate #4		
Plate Width =	0.00	in
Plate Thickness =	0.00	in

*Note: #1 cover plates adjacent to web, #2, #3, #4 are added, built outward from the web.

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
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	GIRDER SECTION PROPERTIES	8/27/2019	8/28/2019	of

CALCULATE MOMENT OF INERTIA, Ixx, ABOUT THE X-AXIS:

#	Material	A, Area (in^2)	y (in)	A*y (in^3)	I_{xo} (in^4)	$y - c_y$ (in)	$A*(y - c_y)^2$ (in^4)
1-1)	Web	112.50	58.50	6581.25	118652.34	-0.54	32.62
2-1)	Top Left Flange Angle	15.10	4.61	69.61	89.10	-54.43	44733.14
2-2)	Top Right Flange Angle	15.10	4.61	69.61	89.10	-54.43	44733.14
2-3)	Bottom Left Flange Angle	15.10	113.89	1719.74	89.10	54.85	45431.21
2-4)	Bottom Right Flange Angle	15.10	113.89	1719.74	89.10	54.85	45431.21
3-1)	Top Left Interior Side Plate	14.00	16.25	227.50	914.67	-42.79	25631.96
3-2)	Top Right Interior Side Plate	14.00	16.25	227.50	914.67	-42.79	25631.96
3-3)	Bottom Left Interior Side Plate	14.00	102.25	1431.50	914.67	43.21	26141.30
3-4)	Bottom Right Interior Side Plate	14.00	102.25	1431.50	914.67	43.21	26141.30
4-1)	Top Left Exterior Side Plate	20.00	20.25	405.00	666.67	-38.79	30090.92
4-2)	Top Right Exterior Side Plate	20.00	20.25	405.00	666.67	-38.79	30090.92
4-3)	Bottom Left Exterior Side Plate	20.00	98.25	1965.00	666.67	39.21	30750.86
4-4)	Bottom Right Exterior Side Plate	20.00	98.25	1965.00	666.67	39.21	30750.86
5-1)	Top Cover Plate #1	15.00	1.88	28.13	0.70	-57.16	49014.95
5-2)	Top Cover Plate #2	15.00	1.13	16.88	0.70	-57.91	50309.57
5-3)	Top Cover Plate #3	15.00	0.38	5.63	0.70	-58.66	51621.06
5-4)	Top Cover Plate #4	0.00	0.00	0.00	0.00	-59.04	0.00
5-5)	Bottom Cover Plate #1	15.00	116.63	1749.38	0.70	57.59	49743.11
5-6)	Bottom Cover Plate #2	15.00	117.38	1760.63	0.70	58.34	51047.24
5-7)	Bottom Cover Plate #3	15.00	118.13	1771.88	0.70	59.09	52368.25
5-8)	Bottom Cover Plate #4	0.00	118.50	0.00	0.00	59.46	0.00
	Σ	398.90		23550.45	125338.30		709695.58

Calculate Neutral Axis (N.A.) of steel section:

$c_y = \Sigma(A*y) / \Sigma A$

= 59.04 in. from top

$c_{ybot} =$ d - c_y

= 59.46 in. from bottom

Calculate gross moment of inertia, I_{xxg}:

$I_{xxg} = \Sigma (I_{xo} + A (y - c_y)^2)$

= **835033.87** in^4

Calculate gross section modulus, S_{xxg}:

$S_{xxg} = I_{xxg} / c_{ybot}$

= **14043.27** in^3

2.1 TREADWELL AVENUE BRIDGE – LOAD RATING CALCULATIONS

STV 100 Years

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	TREADWELL AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING SUMMARY	8/13/2019	8/20/19	of

Objective:
Perform load rating for a concrete encased steel beam bridge.

Rating Criteria:

1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
   a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
   b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Rating Summary:

Member	Rating Load	**Legal Load in Tons**	Rating Factor at Inventory Level	Rating Factor at Operating Level	Inventory Rating Load in Tons	Operating Rating Load in Tons
SFB2	HS-20	**36**	2.08	2.77	74	99
	TYPE-3	**25**	2.61	3.48	65	87
	3S-2	**36**	4.54	6.05	163	217
	3-3	**40**	3.20	4.26	127	170
	BUS	**19**	6.23	8.30	118	157
	EV2	**28**	2.29	3.05	64	85
	EV3	**43**	1.52	2.03	65	87

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	TREADWELL AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/13/2019	8/20/19	of

Objective:
Perform load rating for one typical beam on Treadwell Avenue Bridge

Rating Criteria:
1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
   a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
   b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Notes and Assumptions:
1 Use SFB2 as one typical beam to perform the load ratings;
2 Assume the beams are simply supported;
3 To be conservative, assume one full wheel load is taken by one beam
4 Concrete encasement will be treated as additional dead load, with concrete cover of 3" at the bottom of the beams and 7" on the side of the exterior beams
5 Assume the dead loads from the weight of walkway and railing are uniformly distributed to every beam;

Calculation for Dead Loads:
1. Weight from the components on top of one beam:

Concrete Slab:

	Density	150 pcf	
	Thickness	12 in	
Beam Spacing		28 in	
Deck unit load:		**0.350 klf**	
Concrete Walkway:			
	Width	48 in	(2ft on each side of the bridge)
	Thickness	5 in	
	Line Load:	0.250 klf	
Railing:	Line Load:	0.100 klf	(50plf on each side of the bridge)
Number of beams:		6	

Line Load due to walkway and railing on one beam:
0.058 klf

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	TREADWELL AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/13/2019	8/20/19	of

2. Self-weight of one floorbeam: **0.109 klf**

Steel: Refer to Historical Data of Iron and Steel Beams 1873-1952

Density	490	pcf	
Beam Area:	31.89	in^2	Use G22 22X13
Flange Width bf =	13	in	
Flange Thickness tf =	0.50	in	
Depth d=	22	in	
Web Thickness tw=	0.50	in	
Section Modulus S =	251.5	in^3	
Moment of Inertia: I =	2766.7	in^4	
Yield Strength Fy =	33	ksi	
Moment Capacity Mc	**691.63**	**k-ft**	

3. Self-weight of concrete encasement of one floorbeam: **0.696 klf**

Concrete:

Density	150	pcf
Encased Width:	28	in
Encased Height:	25	in
Encased Concrete Area:	668.11	in^2

4. Total Dead Loads:

Line Load Along the Span Length **1.213 klf**

Calculate Forces and Moments due to Dead Loads

Beam No.	Beam Length (ft)	Total DL Reaction (kips)	M_{max} due to total DL (k-ft)
1	37.83	22.94	216.99
2	37.83	22.94	216.99
3	37.83	22.94	216.99
4	37.83	22.94	216.99
5	37.83	22.94	216.99
6	37.83	22.94	216.99

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	TREADWELL AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/13/2019	8/20/19	of

Calculation for Live Loads:

Live Load Impact Factor: IM= 33%

Beam Span Length: L = 37.83 ft

Calculate Maximum Moment on SFB2 due to Live Loads

Note: See Appendix-1 for location of wheel loads for individual type of truck.

1. Load Type: HS-20

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
Front	4.92	4	0.42	1.33	2.24	112.42
Center	18.92	16	0.42	1.33	8.97	
Rear	32.92	16	0.42	1.33	8.97	

2. Load Type: Type-3

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
Front	7.36	8	0.42	1.33	4.49	89.47
Center	22.36	8.5	0.42	1.33	4.77	
Rear	26.36	8.5	0.42	1.33	4.77	

3. Load Type: 3S2

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
1	3.92	7.75	0.42	1.33	4.35	51.49
2	7.92	7.75	0.42	1.33	4.35	
3	29.92	7.75	0.42	1.33	4.35	
4	33.92	7.75	0.42	1.33	4.35	

4. Load Type: 3-3

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
1	7.42	8	0.42	1.33	4.49	73.08
2	23.42	7	0.42	1.33	3.93	
3	27.42	7	0.42	1.33	3.93	

* Note: Wheel Load Lateral Distribution Factor is in accordance with Table 4.6.2.2.2b-1 in Reference 2;

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	TREADWELL AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/13/2019	8/20/19	of

5. Load Type: BUS

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
Front	6.42	9.03	0.42	1.33	5.06	37.50
Rear	31.42	10.73	0.42	1.33	6.01	

6. Load Type: EV2

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
Front	12.66	16.75	0.42	1.33	9.39	102.00
Rear	27.66	12	0.42	1.33	6.73	

7. Load Type: EV3

Wheel Location	Distance From the West End of SFB2	Wheel Loads (kips)	Wheel Load Lateral Distribution Factor*	Wheel Load IM Factor	Adjusted Wheel Load	M_{max} (k ft)
Front	11.62	15.5	0.42	1.33	8.69	153.45
Center	15.62	15.5	0.42	1.33	8.69	
Rear	32.62	12	0.42	1.33	6.73	

* Note: Wheel Load Lateral Distribution Factor is in accordance with Table 4.6.2.2.2b-1 in Reference 2;

Calculation for Load Rating Factors:

a. Rating Factor for Moment on Floorbeam:

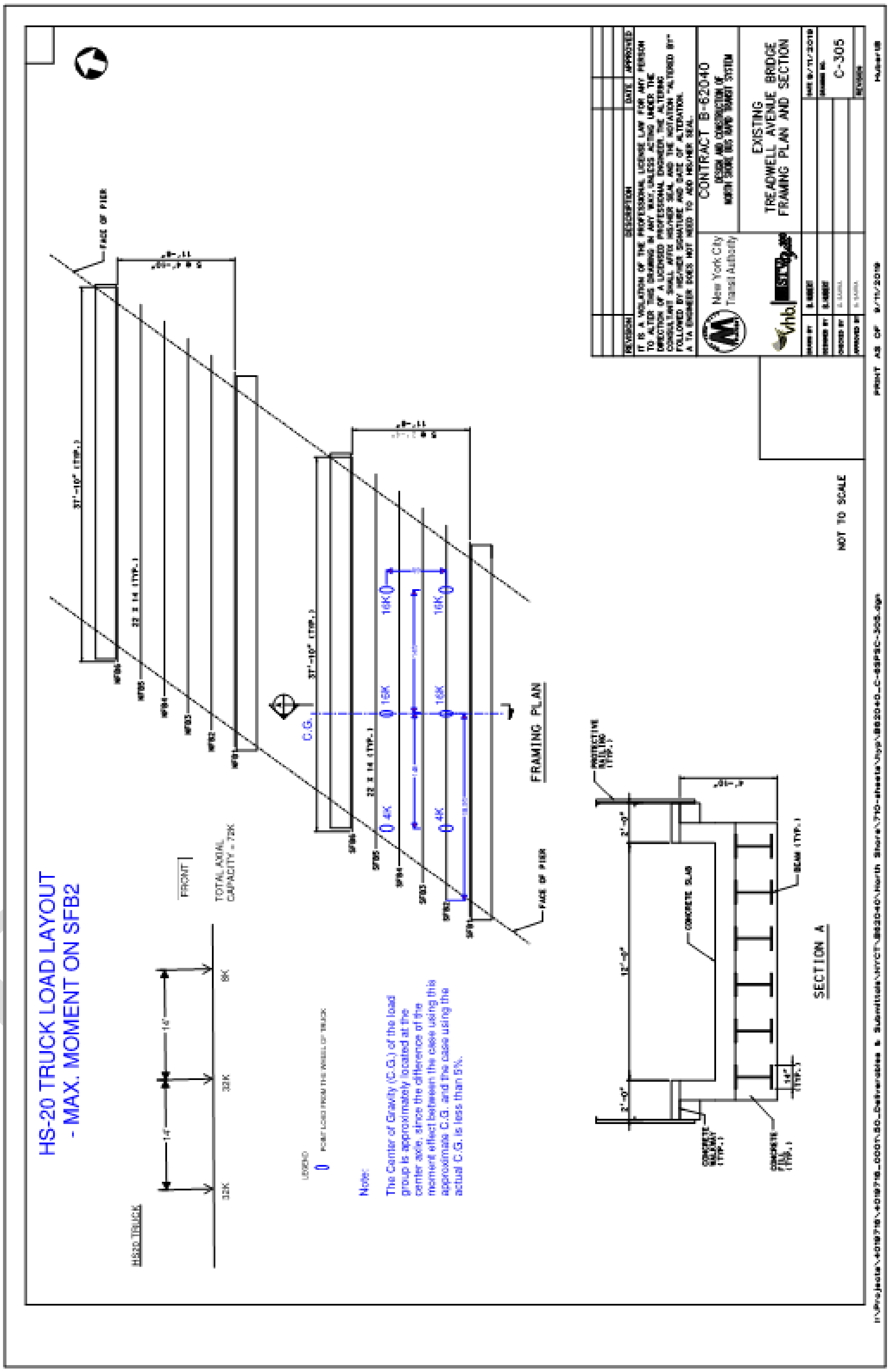
Rating Load	Moment Capacity (k-ft)	Max. Moment (k-ft)		Load Factors			Rating Factors	
LL Type	M_c	M_{DL}	M_{LL}	DL	LL, inventory	LL, operating	Inventory	Operating
HS-20	691.63	216.99	112.42	1.25	1.80	1.35	2.08	2.77
TYPE-3	691.63	216.99	89.47	1.25	1.80	1.35	2.61	3.48
3S-2	691.63	216.99	51.49	1.25	1.80	1.35	4.54	6.05
3-3	691.63	216.99	73.08	1.25	1.80	1.35	3.20	4.26
Bus	691.63	216.99	37.50	1.25	1.80	1.35	6.23	8.30
EV2	691.63	216.99	102.00	1.25	1.80	1.35	2.29	3.05
EV3	691.63	216.99	153.45	1.25	1.80	1.35	1.52	2.03

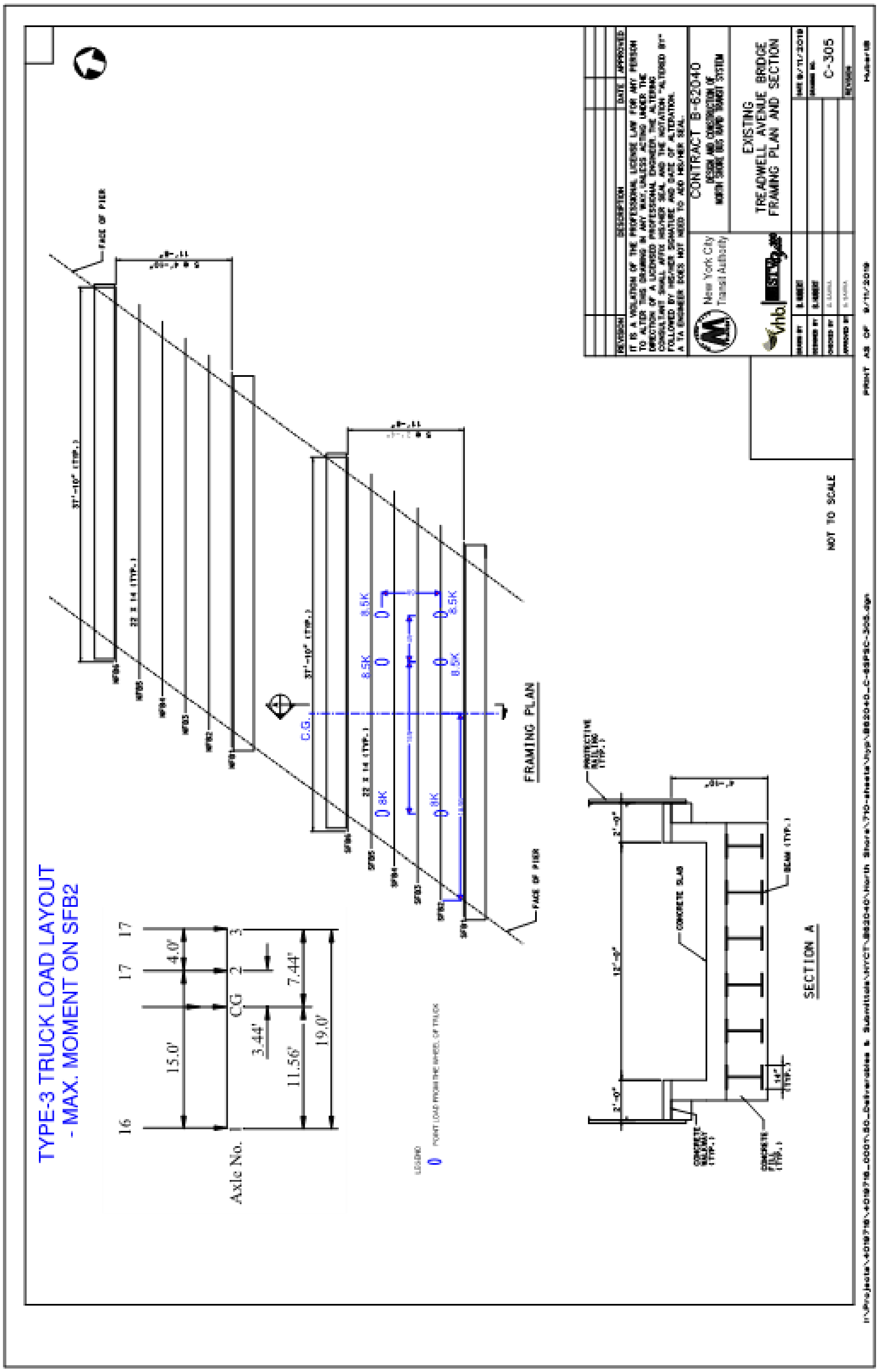
* Note: Live Load Factor is in accordance with Table 6A.4.4.2.3a-1 in Reference 1;

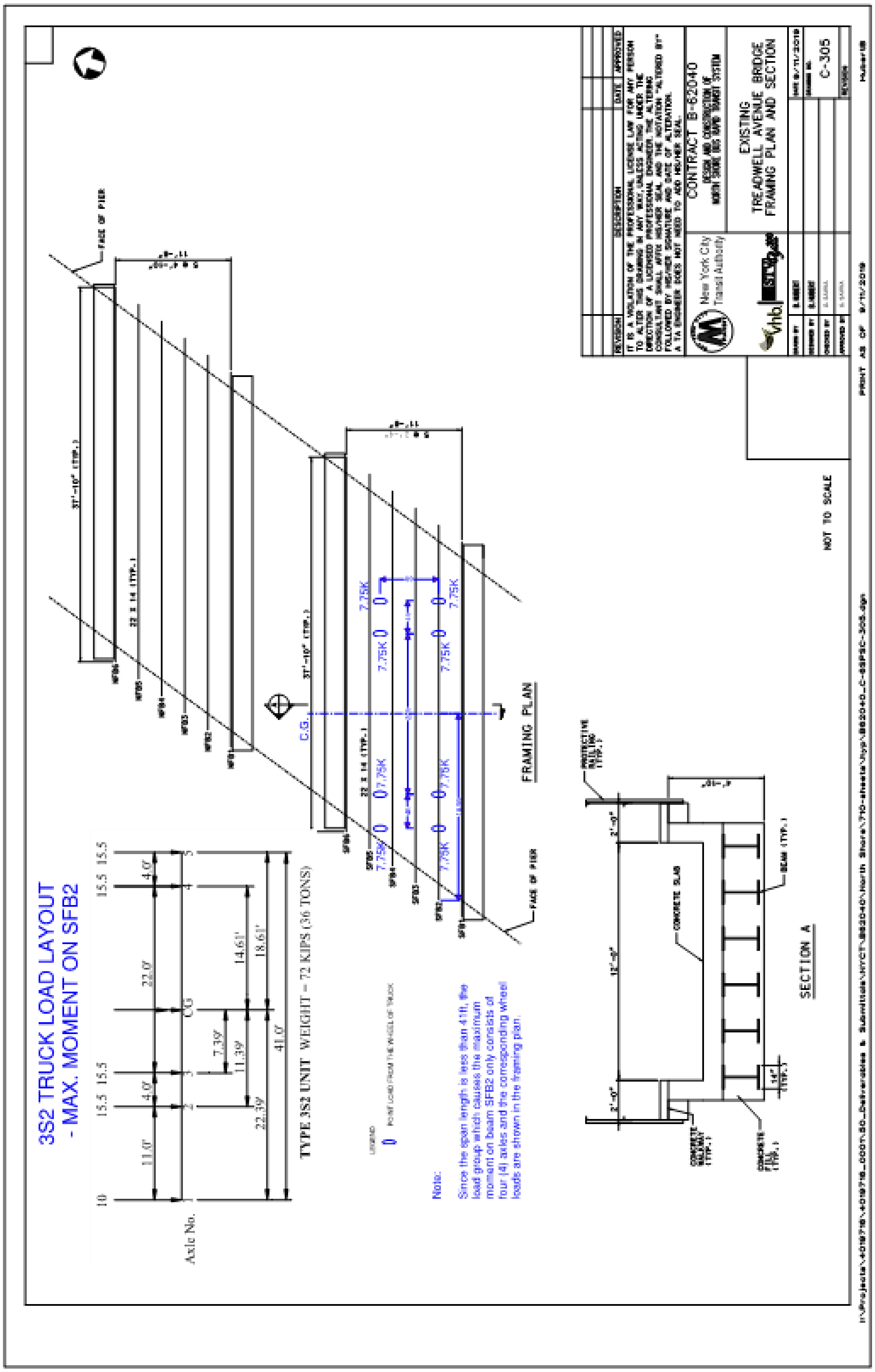
b. Rating Factor for Shear on Floorbeam:

1 Based on engineering judgement, shear does not control.
2 Since no section loss was observed, the shear capacity will not be affected.
3 No further investigation is warranted.

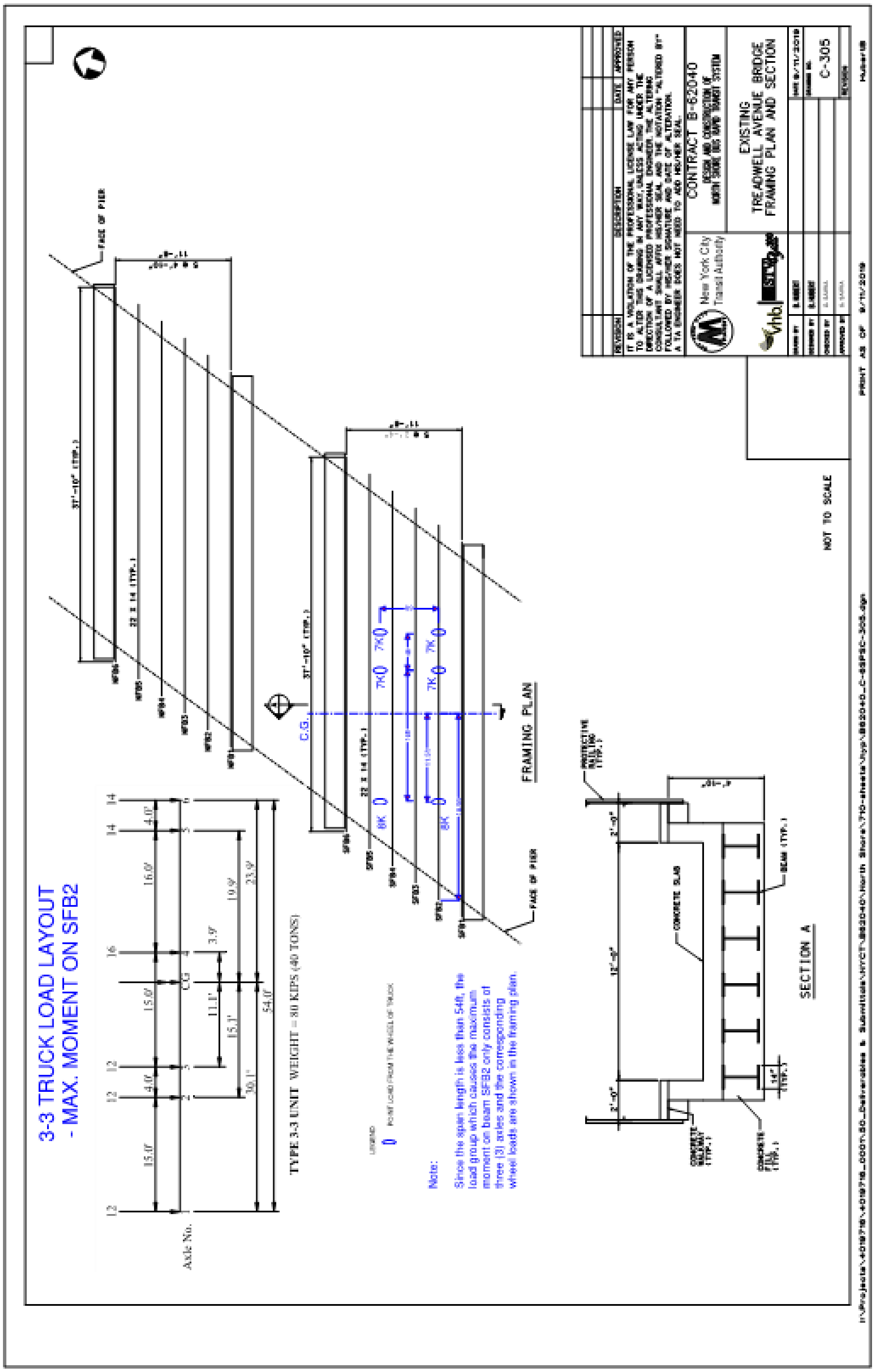
2.2 TREADWELL AVENUE BRIDGE – LAYOUT OF TRUCK LOADS



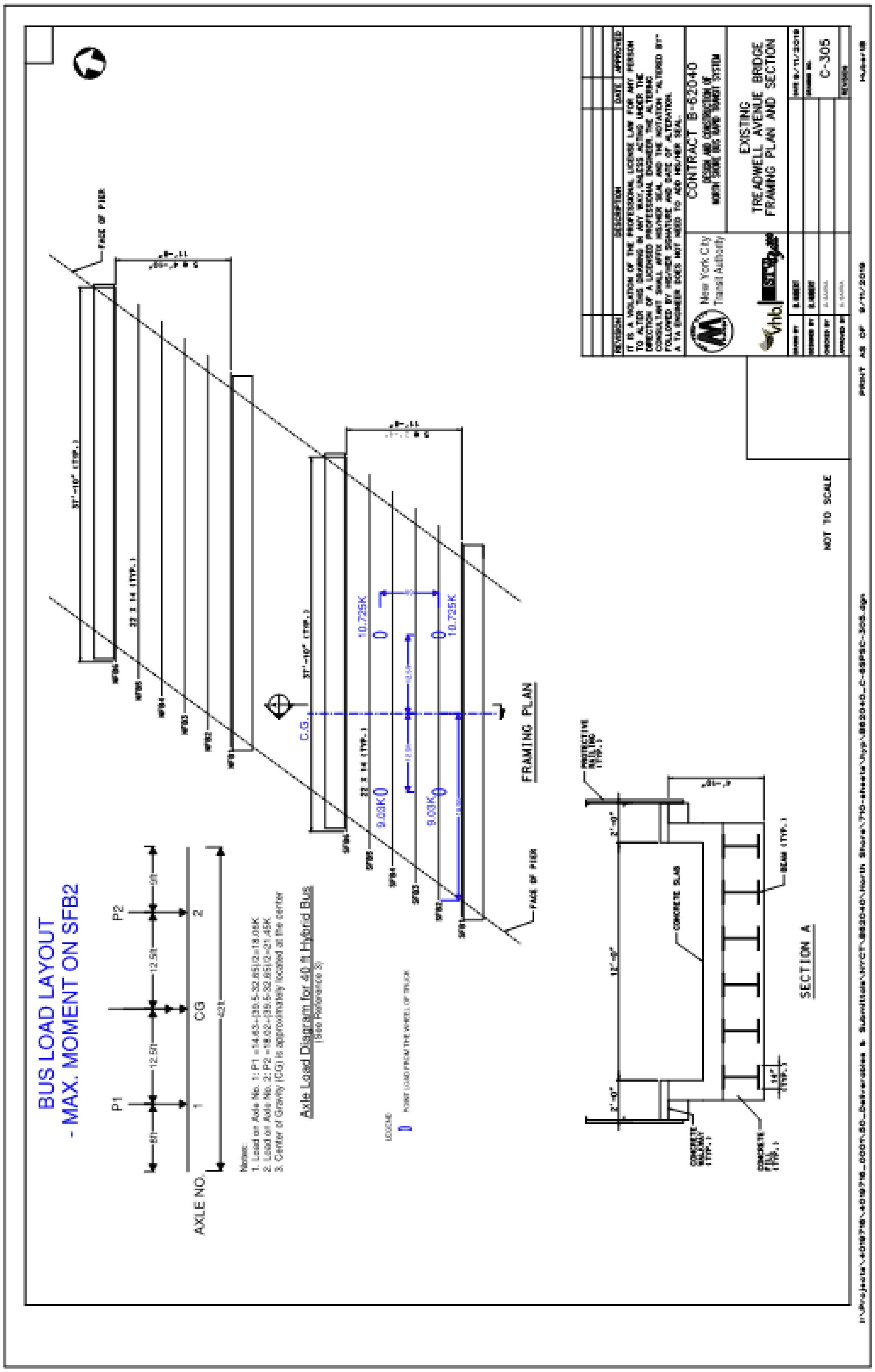

TYPE-3 TRUCK LOAD LAYOUT
- MAX. MOMENT ON SFB2
Axle No.
FRAMING PLAN
SECTION A
NOT TO SCALE
CONTRACT B-62040
EXISTING
TREADWELL AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-305

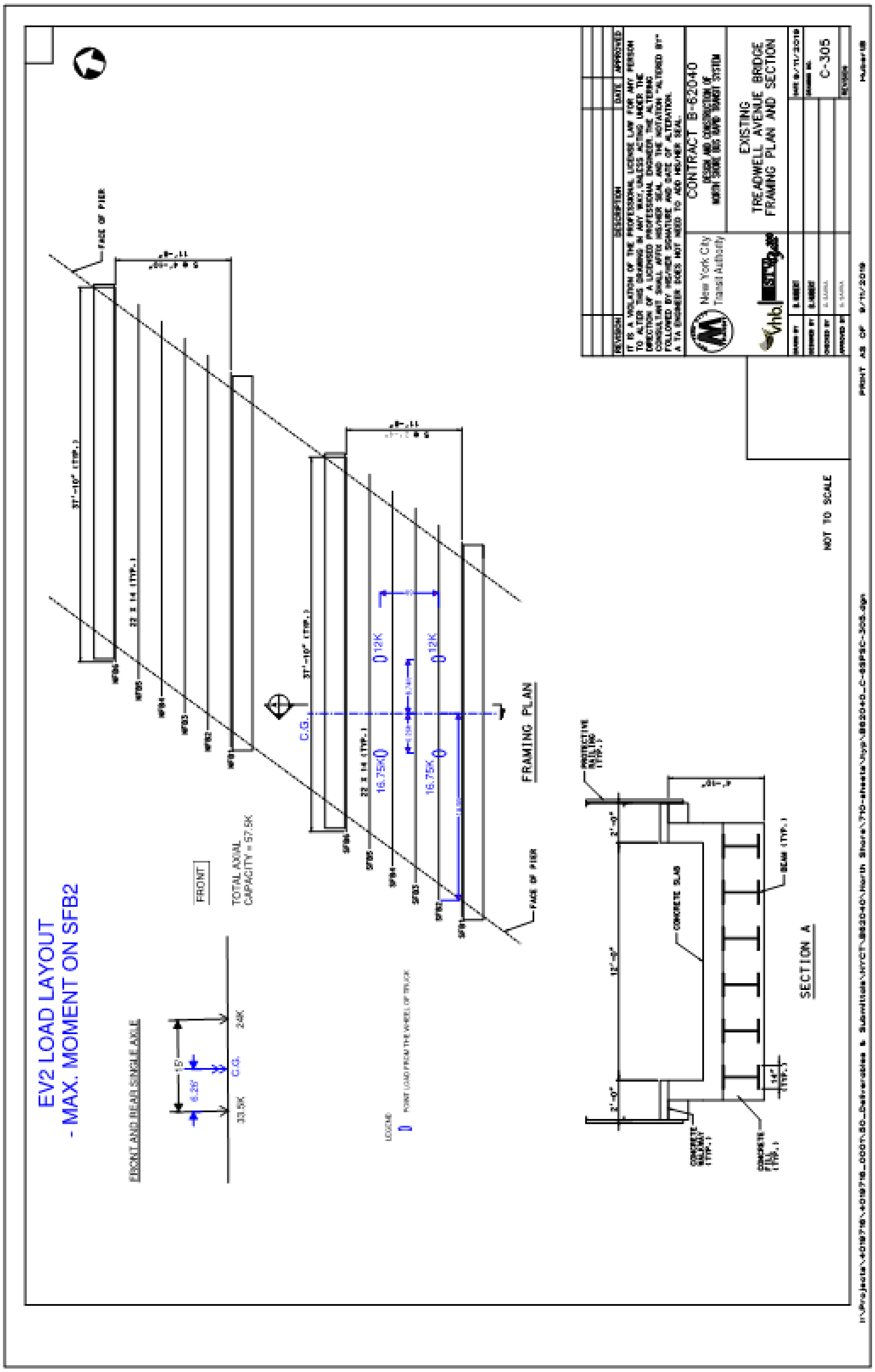

3S2 TRUCK LOAD LAYOUT
- MAX. MOMENT ON SFB2
10
15.5 15.5
15.5 15.5
11.0'
4.0'
22.0'
4.0'
Axle No.
1
2
3
CG
4
5
7.39'
11.39'
14.61'
22.39'
18.61'
41.0'
TYPE 3S2 UNIT WEIGHT – 72 KIPS (36 TONS)
Note:
Since the span length is less than 41ft, the load group which causes the maximum moment on beam SFB2 only consists of four (4) axles and the corresponding wheel loads are shown in the framing plan.
37'-10" (TYP.)
FACE OF PIER
22 X 14 (TYP.)
NFB6
NFB5
NFB4
NFB3
NFB2
NFB1
C.G.
SFB6
SFB5
SFB4
SFB3
SFB2
SFB1
7.75K
FRAMING PLAN
PROTECTIVE RAILING (TYP.)
2'-0"
12'-0"
CONCRETE SLAB
CONCRETE WALKWAY (TYP.)
CONCRETE FILL (TYP.)
14" (TYP.)
BEAM (TYP.)
4'-10"
SECTION A
NOT TO SCALE
REVISION
DESCRIPTION
DATE
APPROVED
IT IS A VIOLATION OF THE PROFESSIONAL LICENSE LAW FOR ANY PERSON TO ALTER THIS DRAWING IN ANY WAY, UNLESS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER. THE ALTERING CONSULTANT SHALL AFFIX HIS/HER SEAL AND THE NOTATION "ALTERED BY" FOLLOWED BY HIS/HER SIGNATURE AND DATE OF ALTERATION. A TA ENGINEER DOES NOT NEED TO ADD HIS/HER SEAL.
New York City Transit Authority
CONTRACT B-62040
DESIGN AND CONSTRUCTION OF NORTH SHORE BUS RAPID TRANSIT SYSTEM
EXISTING TREADWELL AVENUE BRIDGE FRAMING PLAN AND SECTION
C-305
PRINT AS OF 9/11/2019

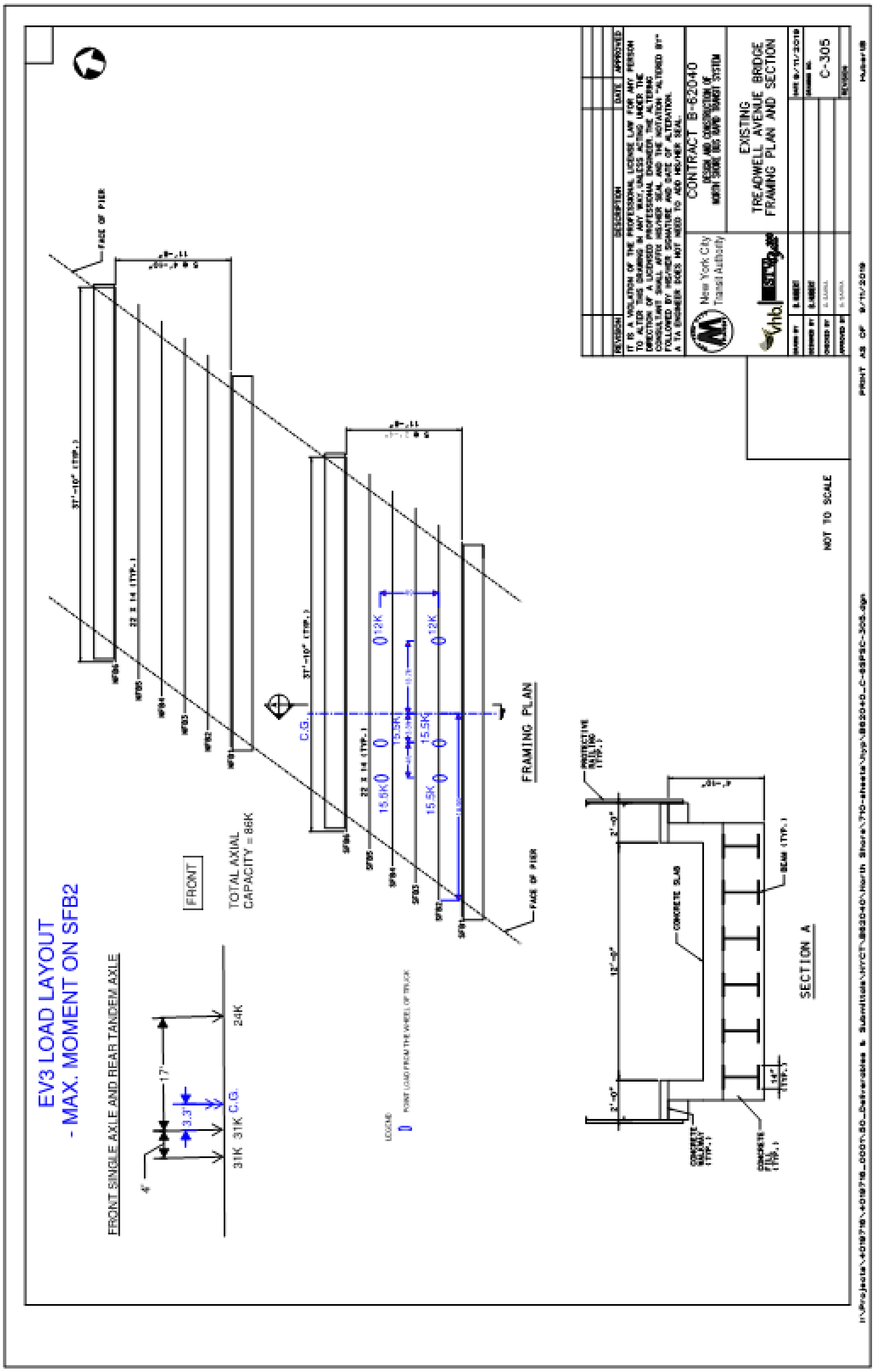
June 16, 2023


3-3 TRUCK LOAD LAYOUT
- MAX. MOMENT ON SFB2
TYPE 3-3 UNIT WEIGHT = 80 KIPS (40 TONS)
Axle No.
Note:
Since the span length is less than 54ft, the load group which causes the maximum moment on beam SFB2 only consists of three (3) axles and the corresponding wheel loads are shown in the framing plan.
FRAMING PLAN
SECTION A
NOT TO SCALE
CONTRACT B-62040
New York City Transit Authority
EXISTING
TREADWELL AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-305

June 16, 2023


BUS LOAD LAYOUT
- MAX. MOMENT ON SFB2
Axle Load Diagram for 40 ft Hybrid Bus
AXLE NO.
P1
P2
CG
10.725K
9.03K
C.G.
FRAMING PLAN
FACE OF PIER
SECTION A
NOT TO SCALE
CONTRACT B-62040
New York City Transit Authority
EXISTING
TREADWELL AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-305


EV2 LOAD LAYOUT
- MAX. MOMENT ON SFB2
FRONT AND REAR SINGLE AXLE
24K
33.5K
C.G.
FRONT
TOTAL AXIAL CAPACITY = 57.5K
FACE OF PIER
37'-10" (TYP.)
22 X 14 (TYP.)
12K
16.75K
FRAMING PLAN
PROTECTIVE RAILING (TYP.)
CONCRETE SLAB
BEAM (TYP.)
SECTION A
NOT TO SCALE
New York City Transit Authority
CONTRACT B-62040
EXISTING
TREADWELL AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-305


EV3 LOAD LAYOUT
- MAX. MOMENT ON SFB2
FRONT SINGLE AXLE AND REAR TANDEM AXLE
31K 31K 24K
C.G.
3.3'
17'
4'
FRONT
TOTAL AXIAL CAPACITY = 86K
15.5K
12K
FRAMING PLAN
FACE OF PIER
37'-10" (TYP.)
22 X 14 (TYP.)
SECTION A
CONCRETE SLAB
BEAM (TYP.)
PROTECTIVE RAILING (TYP.)
NOT TO SCALE
CONTRACT B-62040
New York City Transit Authority
EXISTING
TREADWELL AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-305

June 16, 2023

3.1 PARK AVENUE BRIDGE – LOAD RATING CALCULATIONS

STV 100 Years

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	PARK AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING SUMMARY	8/13/2019	8/20/2019	1 of 8

Objective:
Perform load rating for a simple span thru girder bridge.

Rating Criteria:

1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
   a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
   b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Rating Summary:

Member	Rating Load	**Legal Load in Tons**	Rating Factor at Inventory Level	Rating Factor at Operating Level	Inventory Rating Load in Tons	Operating Rating Load in Tons
Floorbeam	HS-20	**36**	2.96	3.94	106	141
	TYPE-3	**25**	5.57	7.42	139	185
	3S-2	**36**	6.11	8.14	219	293
	3-3	**40**	5.91	7.89	236	315
	BUS	**19**	4.41	5.88	83	111
	EV2	**28**	2.82	3.77	79	105
	EV3	**43**	3.05	4.07	131	175
Girder	HS-20	**36**	1.87	2.49	67	89
	TYPE-3	**25**	2.57	3.43	64	85
	3S-2	**36**	2.47	3.29	88	118
	3-3	**40**	2.92	3.89	116	155
	BUS	**19.0**	4.49	5.99	85	113
	EV2	**28**	2.29	3.05	64	85
	EV3	**43**	1.46	1.95	62	83

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	PARK AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/13/2019	8/20/2019	2 of 8

Objective:
Perform load rating for the floorbeam on Park Avenue Bridge

Rating Criteria:
1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
 a. AASHTO Legal Loads (HS-20, Type-3, 3S2, 3-3);
 b. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
 c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Notes and Assumptions:
1 Use the intermediate floorbeam near the mid-span of the bridge to perform the load rating as this location is the most critical location;
2 Assume the floorbeams are simply supported by girders;
3 Vehicle wheel loads will be distributed to floorbeams first, and then transfer to girders thru floorbeam reactions;
4 Concrete encasement of floorbeams will be treated as additional dead load, with concrete encasement cover of 2"
5 Assume the dead loads from the weight of walkway and railing are carried by girders only

Calculation for Dead Loads:
1. Weight from the components on top of floorbeams:

Ballast:

Density	120	pcf
Thickness	24	in
Floorbeam Spacing	36	in
Deck unit load:	**0.720**	**klf**

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	YC	GKS	4019716
SUBJECT	PARK AVENUE BRIDGE	DATE	DATE	PAGE NO.
	LOAD RATING CALCULATION FOR FLOORBEAM	8/13/2019	8/20/2019	3 of 8

2. Self-weight of one floorbeam: **0.076 klf**

Steel: Refer to Historical Data of Iron and Steel Beams 1873-1952

Density 490 pcf

Floorbeam Area: 22.34 in^2 Use CB211 21X8

Flange Width bf = 8 in

Flange Thickness tf = 0.469 in

Depth d= 21.37 in

Web Thickness tw= 0.469 in

Section Modulus S = 157.6 in^3

Moment of Inertia: I = 1684 in^4

Yield Strength Fy = 33 ksi

Moment Capacity Mc 433.40 k-ft

Shear Capacity Vc 737.22 kips

3. Self-weight of concrete encasement of one floorbeam: **0.228 klf**

Concrete:

Density 150 pcf

Encased Width: 11.5 in

Encased Height: 21 in

Encased Concrete Area: 219.16 in^2

4. Total Dead Loads:

Line Load Along the Span Length **1.024 klf**

Calculate Forces and Moments on a typical floorbeam due to Dead Loads

Floorbeam No.	Beam Length (ft)	Total DL Reaction (kips)	M_{max} due to total DL (k-ft)
1	12.58	6.44	20.27
2	12.58	6.44	20.27
3	12.58	6.44	20.27
4	12.58	6.44	20.27
5	12.58	6.44	20.27
6	12.58	6.44	20.27
7	12.58	6.44	20.27
8	12.58	6.44	20.27
9	12.58	6.44	20.27
10	12.58	6.44	20.27
11	12.58	6.44	20.27
12	12.58	6.44	20.27
13	12.58	6.44	20.27
14	12.58	6.44	20.27

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Calculation for Live Loads:

Live Load Impact Factor: IM= 33%

Floorbeam Span Length: $L_{FB-M.S.}$ = 12.58 ft

Calculate Forces and Moments on Floorbeams due to Live Loads

1. Load Type: HS-20

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
Front	FB2	4	19.17	2.33	6.13
Center	FB6	16	76.66	2.33	24.53
Rear	FB10	16	76.66	2.33	24.53

2. Load Type: Type-3

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
Front	FB2	8	38.33	2.33	12.26
Center	FB7	8.5	40.73	2.33	13.03
Rear	FB8	8.5	40.73	2.33	13.03

3. Load Type: 3S2

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
1	FB1	5	23.96	2.33	7.66
2	FB4	7.75	37.13	2.33	11.88
3	FB5	7.75	37.13	2.33	11.88
4	FB12	7.75	37.13	2.33	11.88
5	FB13	7.75	37.13	2.33	11.88

4. Load Type: 3-3

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
1	FB1	6	28.75	2.33	9.20
2	FB2	6	28.75	2.33	9.20
3	FB7	8	38.33	2.33	12.26
4	FB12	7	33.54	2.33	10.73
5	FB13	7	33.54	2.33	10.73

5. Load Type: BUS

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
Front	FB2	9.03	43.27	2.33	13.84
Rear	FB10	10.73	51.39	2.33	16.44

6. Load Type: EV2

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
Front	FB3	12	57.50	2.33	18.39
Rear	FB8	16.75	80.25	2.33	25.67

7. Load Type: EV3

Maximum Moment and Shear on the Supporting Floorbeams (including IM Factor):

Wheel Location	Supporting Floorbeam	Wheel Loads (kips)	M_{max} (k-ft)	Maximum Shear	
				Distance From the Girder to the Nearest Wheel (ft)	V_{max} (kips)
Front	FB4	15.5	74.27	2.33	23.76
Center	FB5	15.5	74.27	2.33	23.76
Rear	FB10	12	57.50	2.33	18.39

Calculation for Load Rating Factors:

a. Rating Factor for Moment on Floorbeam:

Rating Load	Moment Capacity (k-ft)	Max. Moment (k-ft)		Load Factors			Rating Factors	
LL Type	M_c	M_{DL}	M_{LL}	DL	LL, inventory	LL, operating	Inventory	Operating
HS-20	433.40	20.27	76.66	1.25	1.80	1.35	2.96	3.94
TYPE-3	433.40	20.27	40.73	1.25	1.80	1.35	5.57	7.42
3S-2	433.40	20.27	37.13	1.25	1.80	1.35	6.11	8.14
3-3	433.40	20.27	38.33	1.25	1.80	1.35	5.91	7.89
Bus	433.40	20.27	51.39	1.25	1.80	1.35	4.41	5.88
EV2	433.40	20.27	80.25	1.25	1.80	1.35	2.82	3.77
EV3	433.40	20.27	74.27	1.25	1.80	1.35	3.05	4.07

* Note: Live Load Factor is in accordance with Table 6A.4.4.2.3a-1 in Reference 1;

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b. Rating Factor for Shear on Floorbeam:

Rating Load	Shear Capacity (kips)	Max. Shear (k-ft)		Load Factors			Rating Factors	
LL Type	V_c	V_{DL}	V_{LL}	DL	LL, inventory	LL, operating	Inventory	Operating
HS-20	737.22	6.44	24.53	1.25	1.8	1.35	16.52	22.02
TYPE-3	737.22	6.44	13.03	1.25	1.8	1.35	31.09	41.46
3S-2	737.22	6.44	11.88	1.25	1.8	1.35	34.10	45.47
3-3	737.22	6.44	12.26	1.25	1.8	1.35	33.03	44.05
Bus	737.22	6.44	16.44	1.25	1.8	1.35	24.64	32.86
EV2	737.22	6.44	25.67	1.25	1.8	1.35	15.78	21.04
EV3	737.22	6.44	23.76	1.25	1.8	1.35	17.05	22.73

* Note: Live Load Factor is in accordance with Table 6A.4.4.2.3a-1 in Reference 1;

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Objective:
Perform load rating for the girder on Nicolas Avenue Bridge

Rating Criteria:

1. Load rating is performed at the inventory level and the operating level respectively;
2. Load rating is based on LRFD method;
3. The live load used in the load rating includes
   a. Bus Load: 40ft Hybrid Low Floor, Type: Proterra Catalyst E2;
   b. AASHTO Legal Loads (HS20, Type-3, 3-S2, 3-3);
   c. Emergency Vehicle Loads (EV2 and EV3) as specified by FHWA

Reference:
1. AASHTO Manual for Bridge Evaluation, 2nd Edition 2010
2. AASHTO LRFD Bridge Design Specification, 7th Edition, 2014
3. Bus Load configuration follows the vehicle specification as provided by NYCT
4. FHWA Memorandum on Load Rating for the FAST Act's Emergency Vehicles dated November 3, 2016.

Notes and Assumptions:
1 Assume the vehicle loads are transferred to the girders thru the reactions from the floorbeams;
2 Use girder span length L=53ft-3in;
3 Assume the dead loads from the weight of walkway and railing are carried by girders only
4 Pedestrian loads are not considered since this existing bridge is an abandoned structure

Uniform DL Due to Self-weight of Girder:
Critical Section at Mid-Span (Girder Section Properties are calculated in Appendix 2)

Area	98.75	in^2
Density	0.49	kcf
Original S.W.	0.34	klf
Modified S.W.	**0.37**	**klf**

Note: Increase 10% of steel density to include miscellenuous weights from connections, stiffeners and other attachments.

Uniform DL Due to Concrete Walkway:

Density	150	pcf
Thickness	3	in
Width	24	in
P_{walk} =	75	**plf**

Uniform DL Due to Railing:

P_{rail} = 50 **plf**

Total Uniform DL, P_{DL}: **0.495 klf**

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Reactions from Floorbeams:

Floorbeam No.	Floorbeam Spacing (ft)	Distance to the Girder End (ft)	DL Reactions (kips)	Max. Reactions due to HS20 Truck (kips)	Max. Reactions due to TYPE-3 Truck (kips)	Max. Reactions due to 3S2 Truck (kips)	Max. Reactions due to 3-3 Truck (kips)	Max. Reactions due to BUS (kips)	Max. Reactions due to EV2 (kips)	Max. Reactions due to EV3 (kips)
1	11.750	11.75	20.27			7.66	9.20			
2	3	14.75	20.27	6.13	12.26		9.20	13.84		
3	3	17.75	20.27						18.39	
4	3	20.75	20.27			11.88				23.76
5	3	23.75	20.27			11.88				23.76
6	3	26.75	20.27	24.53						
7	3	29.75	20.27		13.03		12.26			
8	3	32.75	20.27		13.03				25.67	
9	3	35.75	20.27							
10	3	38.75	20.27	24.53				16.44		18.39
11	3	41.75	20.27							
12	3	44.75	20.27			11.88	10.73			
13	3	47.75	20.27			11.88	10.73			
14	3	50.75	20.27							

DL Moments on the Typical Sections of the Girder:

Cross Sections	Location	M_{GR_DL} (k-ft)	M_{FB_DL} (k-ft)	M_{DL} (k-ft)
Section-1	0.5L	175.32	2224.09	2399.41

Moment Capacity on the Typical Sections:

Cross Sections	Section Modulus (in^3)	Yield Stress (ksi)	M_y (k-ft)
Section-1	1763.85	33	4850.59

LL Moments on the Typical Sections of the Girder:

Cross Sections	Location	M_{HS20} (k-ft)	M_{TYPE3} (k-ft)	M_{3S2} (k-ft)	M_{3-3} (k-ft)	M_{BUS} (k-ft)	M_{EV2} (k-ft)	M_{EV3} (k-ft)
Section-1	0.5L	550.22	400.11	416.91	352.48	229.06	449.31	704.68

Calculation for Load Rating Factors:

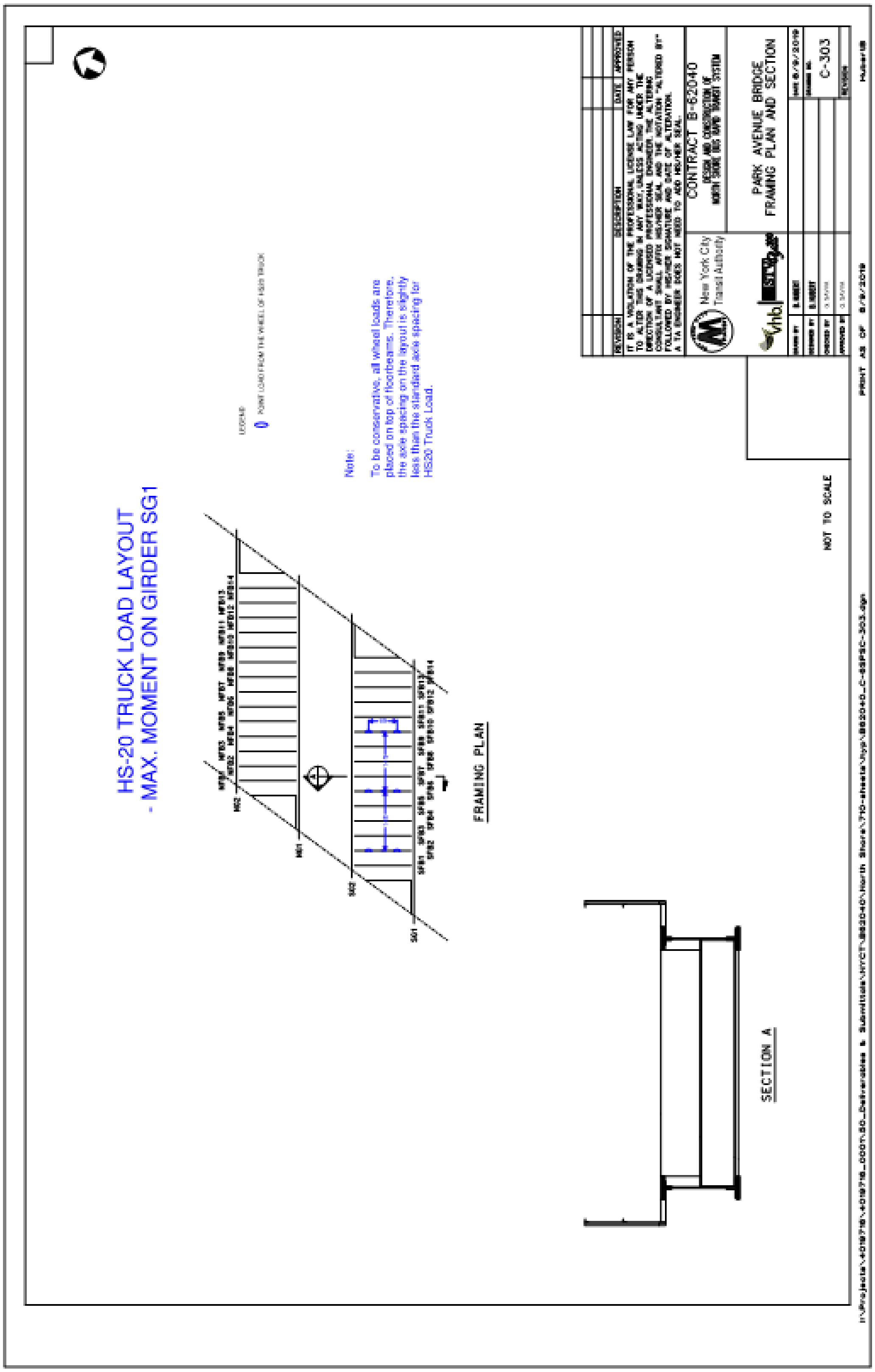
a. Rating Factor for Moment on Girder:

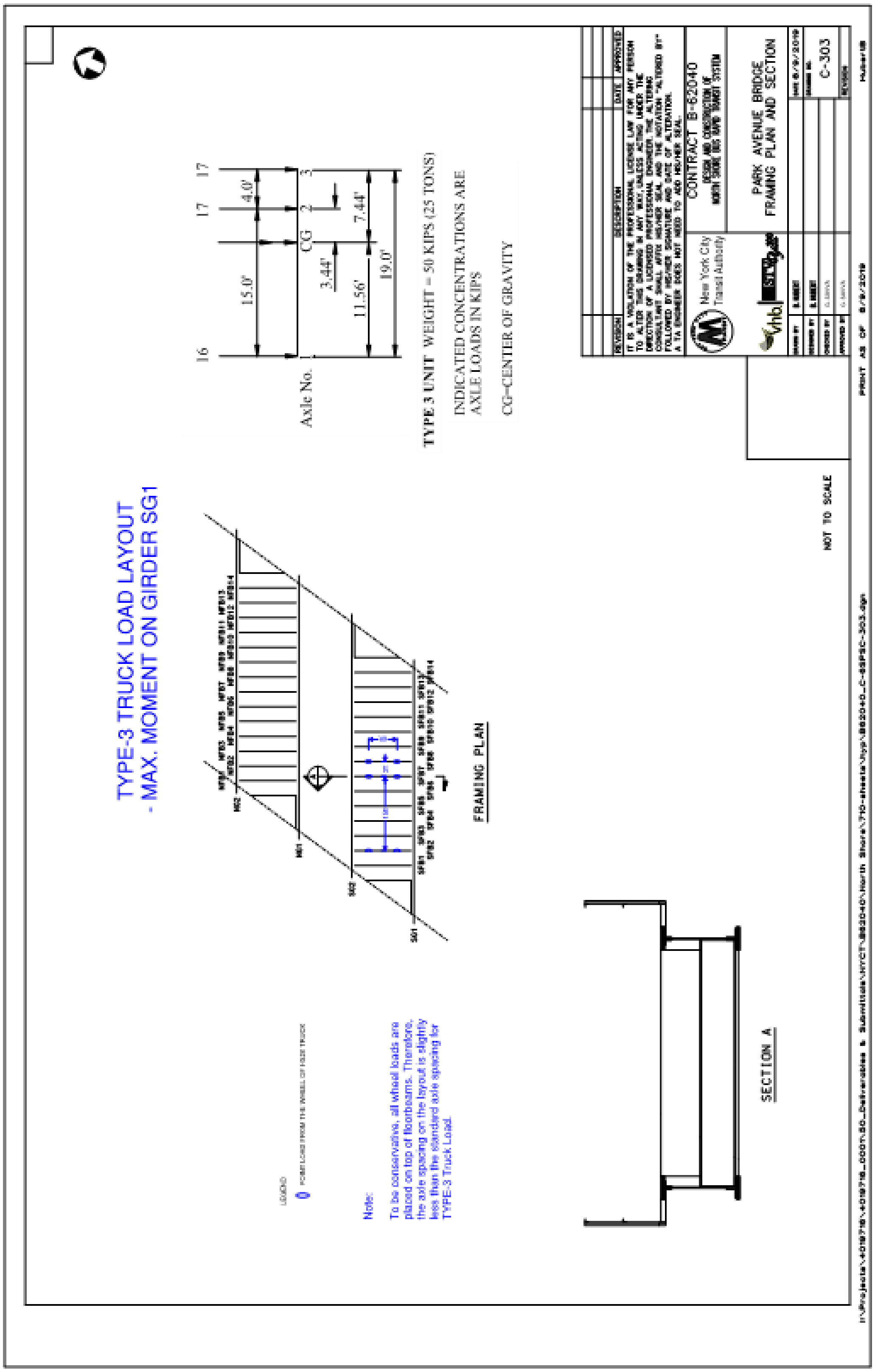
Cross Sections	Rating Load	Moment Capacity (k-ft)	Max. Moment (k-ft)		Load Factors			Rating Factors	
	LL Type	M_y	M_{DL}	M_{LL_max}	DL	LL, inventory	LL, operating	Inventory	Operating
Section-1	HS-20	4850.59	2399.41	550.22	1.25	1.80	1.35	1.87	2.49
	TYPE-3	4850.59	2399.41	400.11	1.25	1.80	1.35	2.57	3.43
	3S-2	4850.59	2399.41	416.91	1.25	1.80	1.35	2.47	3.29
	3-3	4850.59	2399.41	352.48	1.25	1.80	1.35	2.92	3.89
	Bus	4850.59	2399.41	229.06	1.25	1.80	1.35	4.49	5.99
	EV2	4850.59	2399.41	449.31	1.25	1.80	1.35	2.29	3.05
	EV3	4850.59	2399.41	704.68	1.25	1.80	1.35	1.46	1.95

b. Rating Factor for Shear on Girder:

1 Based on engineering judgement, shear does not control.
2 Since no section loss was observed, the shear capacity will not be affected.
3 No further investigation is warranted.

3.2 PARK AVENUE BRIDGE – LAYOUT OF TRUCK LOADS


HS-20 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER SG1
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard axle spacing for HS20 Truck Load.
FRAMING PLAN
SECTION A
NOT TO SCALE
New York City Transit Authority
CONTRACT B-62040
PARK AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-303


TYPE-3 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER SG1
FRAMING PLAN
SECTION A
NOT TO SCALE
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard axle spacing for TYPE-3 Truck Load.
Axle No.
TYPE 3 UNIT WEIGHT = 50 KIPS (25 TONS)
INDICATED CONCENTRATIONS ARE AXLE LOADS IN KIPS
CG=CENTER OF GRAVITY
New York City Transit Authority
CONTRACT B-62040
PARK AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-303

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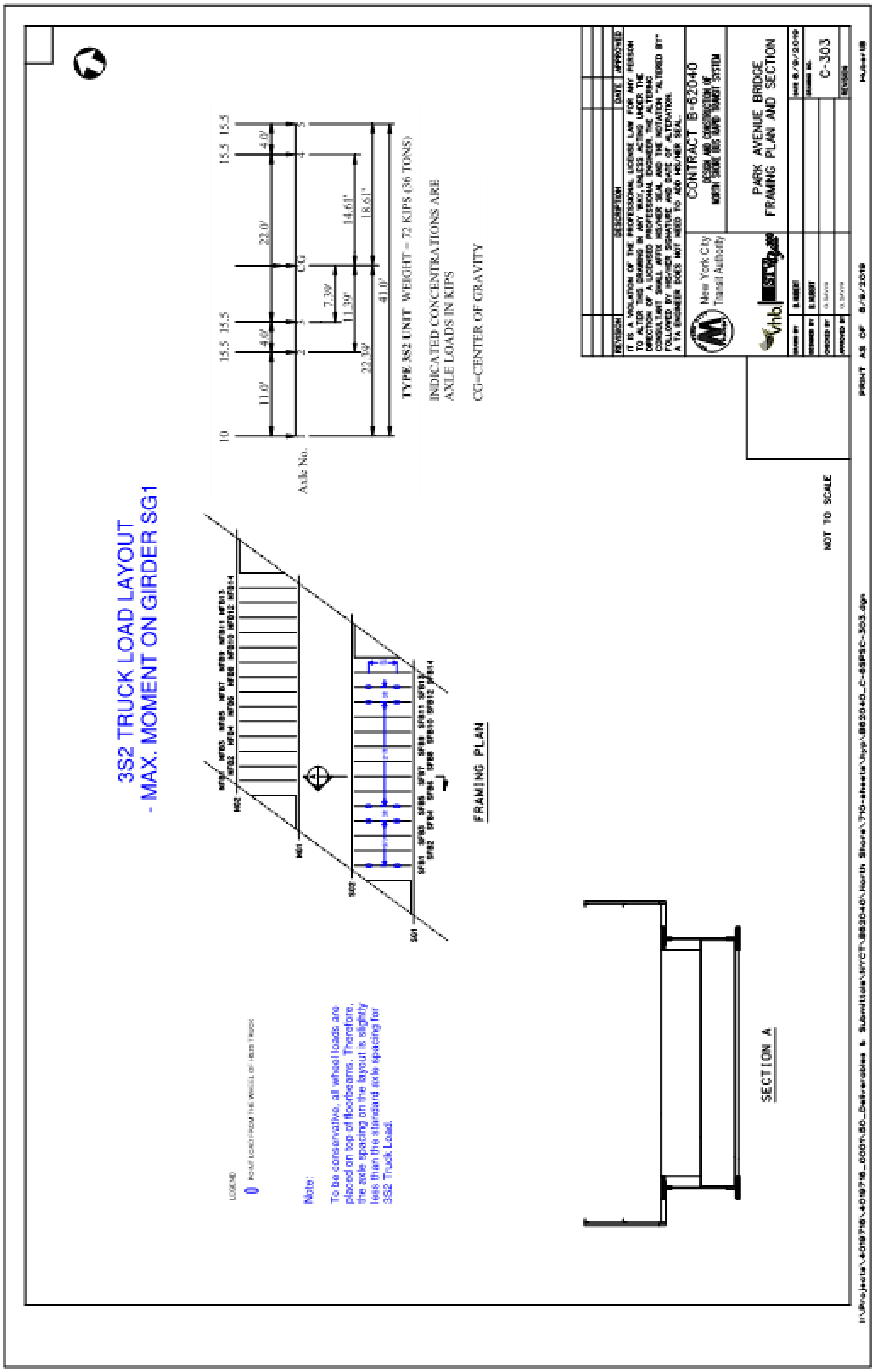
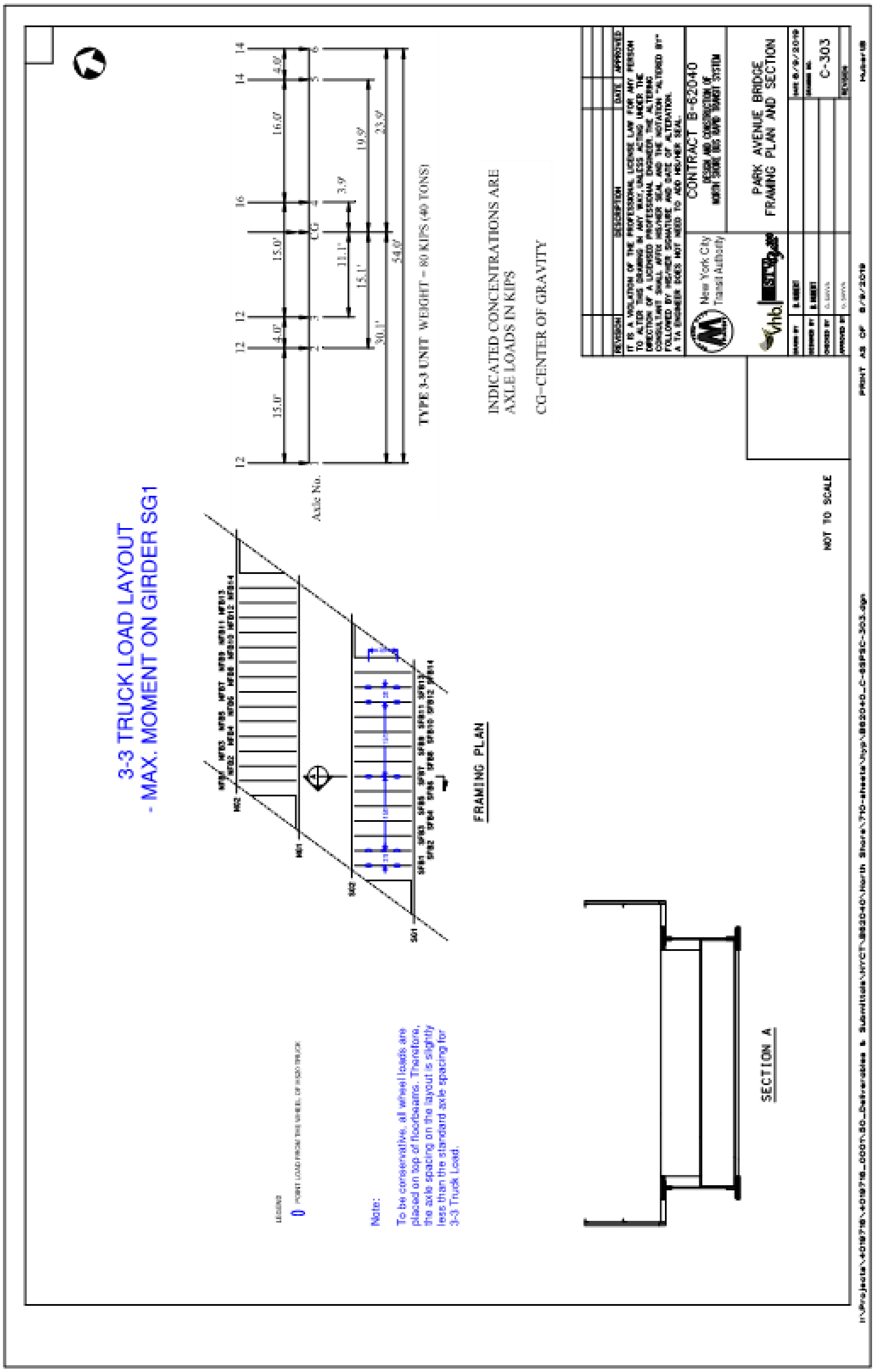
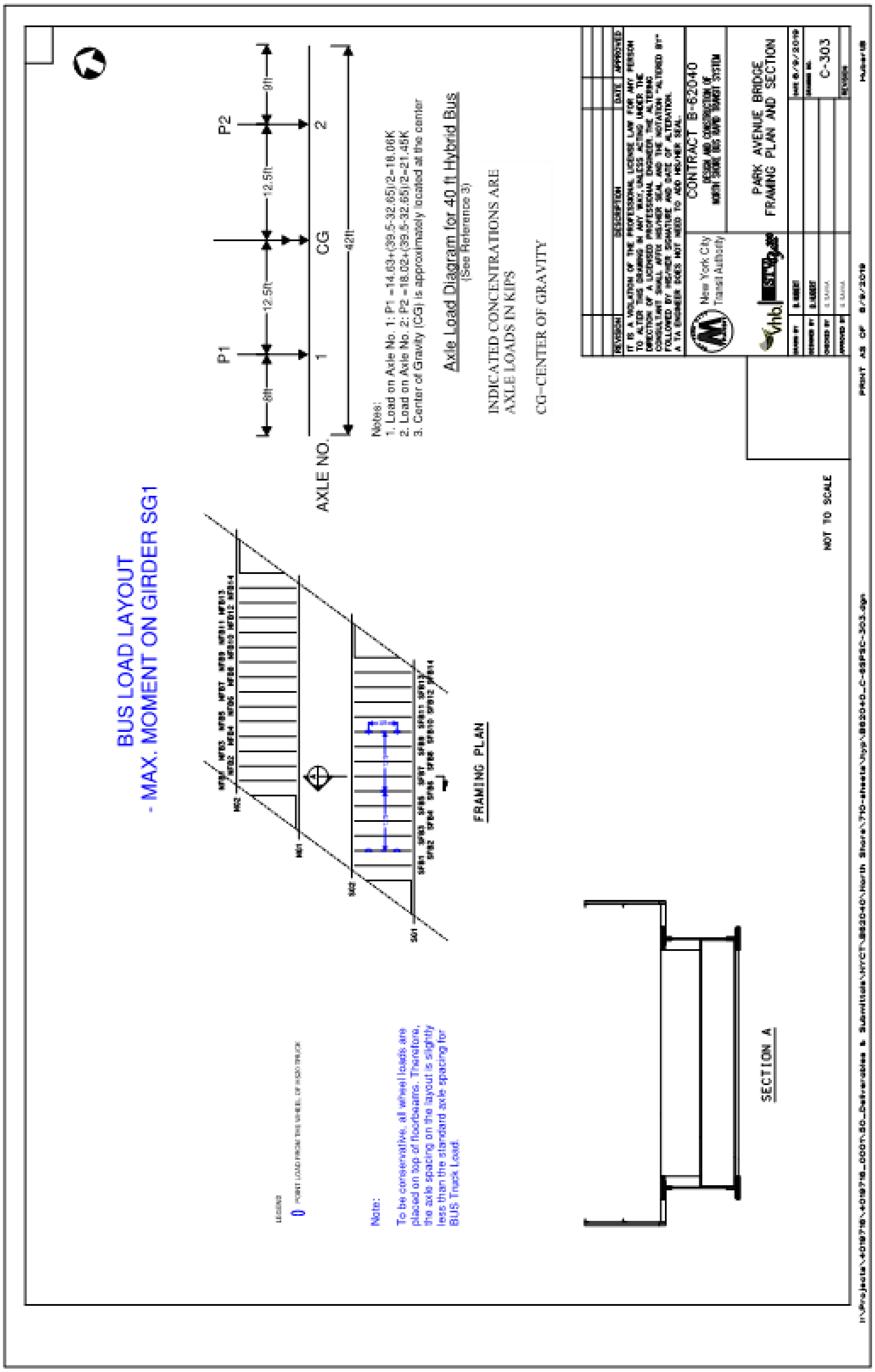
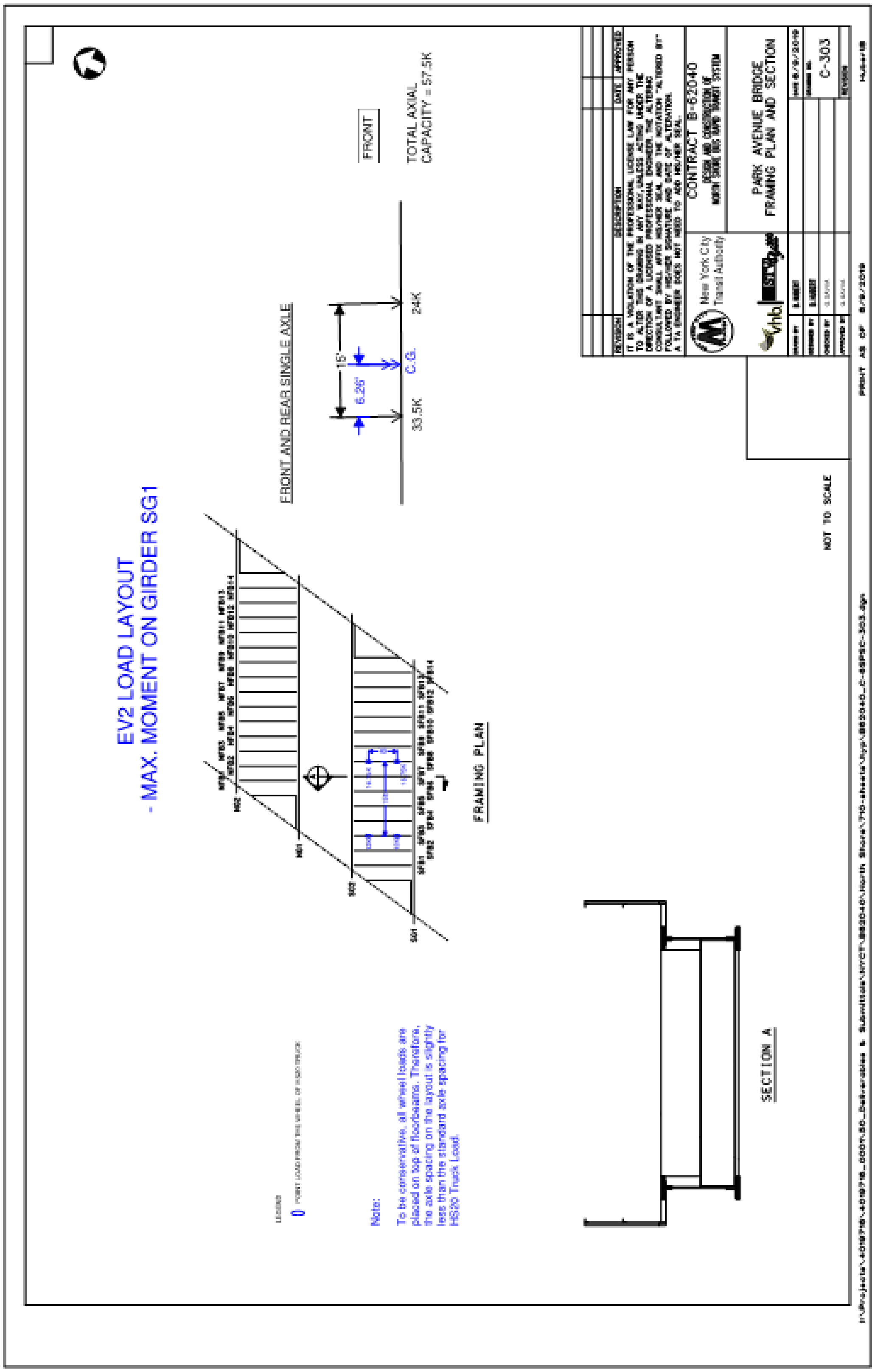

3S2 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER SG1
FRAMING PLAN
SECTION A
NOT TO SCALE
TYPE 3S2 UNIT WEIGHT – 72 KIPS (36 TONS)
INDICATED CONCENTRATIONS ARE AXLE LOADS IN KIPS
CG=CENTER OF GRAVITY
Axle No.
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard axle spacing for 3S2 Truck Load.
New York City Transit Authority
CONTRACT B-62040
PARK AVENUE BRIDGE FRAMING PLAN AND SECTION
C-303

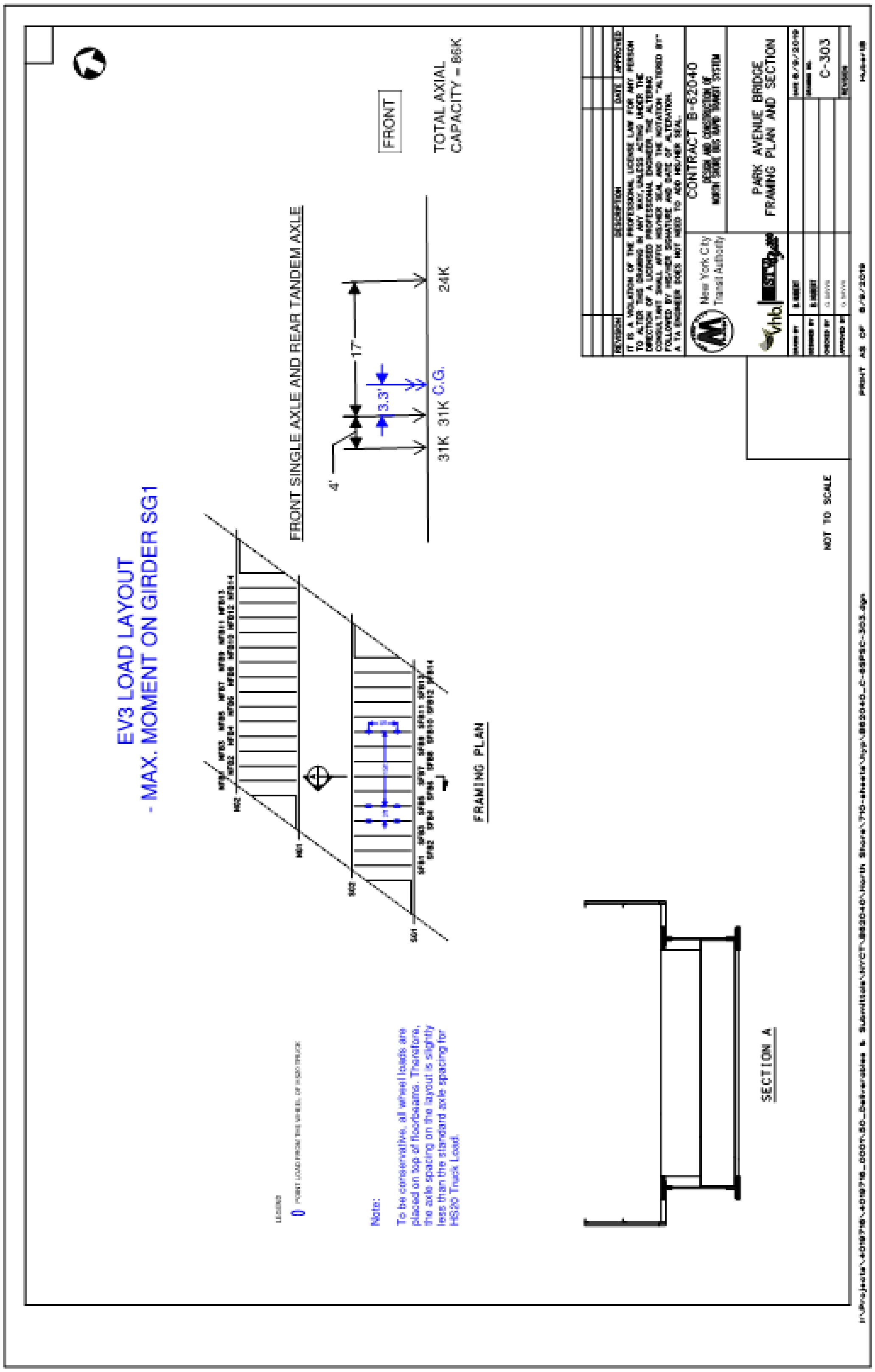

3-3 TRUCK LOAD LAYOUT
- MAX. MOMENT ON GIRDER SG1
Axle No.
TYPE 3-3 UNIT WEIGHT – 80 KIPS (40 TONS)
INDICATED CONCENTRATIONS ARE AXLE LOADS IN KIPS
CG–CENTER OF GRAVITY
FRAMING PLAN
SECTION A
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard axle spacing for 3-3 Truck Load.
NOT TO SCALE
New York City Transit Authority
CONTRACT B-62040
PARK AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-303


BUS LOAD LAYOUT
- MAX. MOMENT ON GIRDER SG1
FRAMING PLAN
SECTION A
P1
P2
CG
AXLE NO.
12.5ft
8ft
9ft
42ft
Notes:
1. Load on Axle No. 1: P1 =14.63+(39.5-32.65)/2=18.06K
2. Load on Axle No. 2: P2 =18.02+(39.5-32.65)/2=21.45K
3. Center of Gravity (CG) is approximately located at the center
Axle Load Diagram for 40 ft Hybrid Bus
(See Reference 3)
INDICATED CONCENTRATIONS ARE
AXLE LOADS IN KIPS
CG–CENTER OF GRAVITY
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard axle spacing for BUS Truck Load.
NOT TO SCALE
New York City Transit Authority
CONTRACT B-52040
PARK AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-303

June 16, 2023


EV2 LOAD LAYOUT
- MAX. MOMENT ON GIRDER SG1
FRONT AND REAR SINGLE AXLE
FRONT
TOTAL AXIAL
CAPACITY = 57.5K
15'
6.26'
C.G.
33.5K
24K
FRAMING PLAN
SECTION A
NOT TO SCALE
Note:
To be conservative, all wheel loads are placed on top of floorbeams. Therefore, the axle spacing on the layout is slightly less than the standard axle spacing for HS20 Truck Load.
CONTRACT B-62040
New York City Transit Authority
PARK AVENUE BRIDGE
FRAMING PLAN AND SECTION
C-303

June 16, 2023



3.3 PARK AVENUE BRIDGE – GIRDER SECTION PROPERTIES

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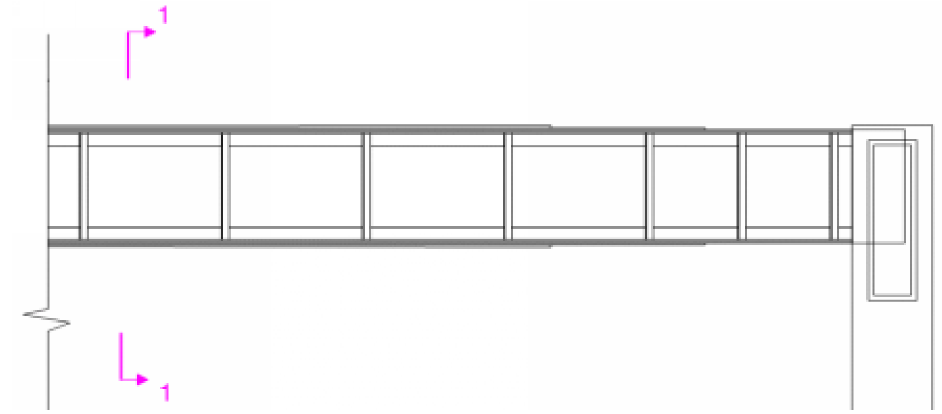
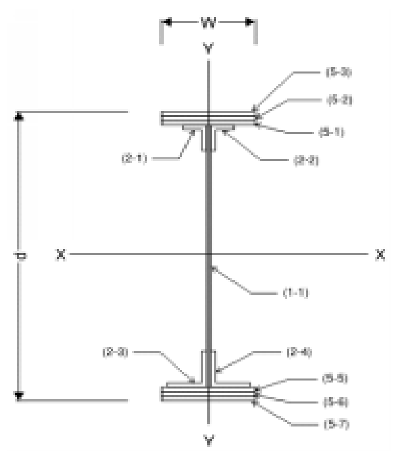
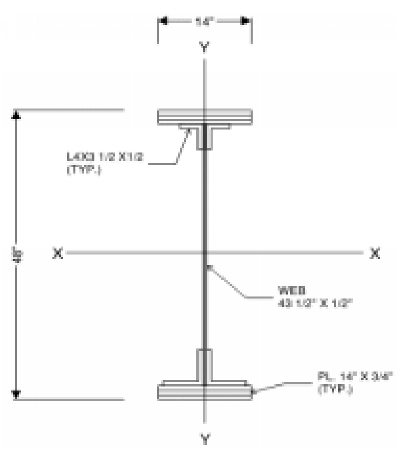
Sections Along Girder Length:



Section Properties: **Section-1** (at mid-span)



Sketch - a



Sketch - b

Steel Section Input Information:

(manually input cells)

	d, total depth =	48.00	in
#	w, total width =	14.00	in

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1) Web

1-1) Web

H_{wp}, height of web plate =		43.50	in	
t_{wp}, thickness of web plate =		0.50	in	

2) Flange Angles

2-1) Top Left Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	4.00	in	
Angle Width =		3.50	in	
Angle Thickness =		0.50	in	
I_{xx} for single angle =		5.30	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		3.76	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		0.99	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		1.24	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		3.50	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-2) Top Right Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	4.00	in	
Angle Width =		3.50	in	
Angle Thickness =		0.50	in	
I_{xx} for single angle =		5.30	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		3.76	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		0.99	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		1.24	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		3.50	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-3) Bottom Left Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	4.00	in	
Angle Width =		3.50	in	
Angle Thickness =		0.50	in	
I_{xx} for single angle =		5.30	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		3.76	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		0.99	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		1.24	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		3.50	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

2-4) Bottom Right Flange Angle

Properties of Single Angle - Section				
Angle Length =	L	4.00	in	
Angle Width =		3.50	in	
Angle Thickness =		0.50	in	
I_{xx} for single angle =		5.30	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
I_{yy} for single angle =		3.76	in^4	Ref, AISC Steel Manual, 15th ed. Table 1-7
x_1 for (I yy) =		0.99	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
y_1 for (I xx) =		1.24	in	Ref, AISC Steel Manual, 15th ed. Table 1-7
A, Area =		3.50	in^2	Ref, AISC Steel Manual, 15th ed. Table 1-7

3) Interior Side Plates

3-1) Top Left Interior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

3-2) Top Right Interior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

3-3) Bottom Left Interior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

3-4) Bottom Right Interior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

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4) Exterior Side Plates

4-1) Top Left Exterior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

4-2) Top Right Exterior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

4-3) Bottom Left Exterior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

4-4) Bottom Right Exterior Side Plate

Plate Height =	0.00	in
Plate Thickness =	0.00	in

5) Cover Plates

5-1) Top Cover Plate #1

Plate Width =	14.00	in
Plate Thickness =	0.75	in

5-2) Top Cover Plate #2

Plate Width =	14.00	in
Plate Thickness =	0.75	in

5-3) Top Cover Plate #3

Plate Width =	14.00	in
Plate Thickness =	0.75	in

5-4) Top Cover Plate #4

Plate Width =	0.00	in
Plate Thickness =	0.00	in

5-5) Bottom Cover Plate #1

Plate Width =	14.00	in
Plate Thickness =	0.75	in

5-6) Bottom Cover Plate #2

Plate Width =	14.00	in
Plate Thickness =	0.75	in

5-7) Bottom Cover Plate #3

Plate Width =	14.00	in
Plate Thickness =	0.75	in

5-8) Bottom Cover Plate #4

Plate Width =	0.00	in
Plate Thickness =	0.00	in

*Note: #1 cover plates adjacent to web, #2, #3, #4 are added, built outward from the web.

CALCULATE MOMENT OF INERTIA, Ixx, ABOUT THE X-AXIS:

#	Material	A, Area in^2	y in	A*y in^3	I_{xo} in^4	$y - c_y$ in	$A*(y - c_y)^2$ in^4
1-1)	Web	21.75	24.00	522.00	3429.70	0.00	0.00
2-1)	Top Left Flange Angle	3.50	3.49	12.22	5.30	-20.51	1472.31
2-2)	Top Right Flange Angle	3.50	3.49	12.22	5.30	-20.51	1472.31
2-3)	Bottom Left Flange Angle	3.50	44.51	155.79	5.30	20.51	1472.31
2-4)	Bottom Right Flange Angle	3.50	44.51	155.79	5.30	20.51	1472.31
3-1)	Top Left Interior Side Plate	0.00	2.25	0.00	0.00	-21.75	0.00
3-2)	Top Right Interior Side Plate	0.00	2.25	0.00	0.00	-21.75	0.00
3-3)	Bottom Left Interior Side Plate	0.00	45.75	0.00	0.00	21.75	0.00
3-4)	Bottom Right Interior Side Plate	0.00	45.75	0.00	0.00	21.75	0.00
4-1)	Top Left Exterior Side Plate	0.00	6.25	0.00	0.00	-17.75	0.00
4-2)	Top Right Exterior Side Plate	0.00	6.25	0.00	0.00	-17.75	0.00
4-3)	Bottom Left Exterior Side Plate	0.00	41.75	0.00	0.00	17.75	0.00
4-4)	Bottom Right Exterior Side Plate	0.00	41.75	0.00	0.00	17.75	0.00
5-1)	Top Cover Plate #1	10.50	1.88	19.69	0.49	-22.13	5139.91
5-2)	Top Cover Plate #2	10.50	1.13	11.81	0.49	-22.88	5494.29
5-3)	Top Cover Plate #3	10.50	0.38	3.94	0.49	-23.63	5860.48
5-4)	Top Cover Plate #4	0.00	0.00	0.00	0.00	-24.00	0.00
5-5)	Bottom Cover Plate #1	10.50	46.13	484.31	0.49	22.13	5139.91
5-6)	Bottom Cover Plate #2	10.50	46.88	492.19	0.49	22.88	5494.29
5-7)	Bottom Cover Plate #3	10.50	47.63	500.06	0.49	23.63	5860.48
5-8)	Bottom Cover Plate #4	0.00	48.00	0.00	0.00	24.00	0.00
	Σ	98.75		2370.00	3453.86		38878.60

CLIENT		MADE	CHECK	PROJECT NO.
PROJECT	Staten Island North Shore Bus Rapid Transit System	Y. Cao	G.Savva	4019716
SUBJECT	PARK AVENUE BRIDGE	DATE	DATE	PAGE NO.
	GIRDER SECTION PROPERTIES	8/27/2019	8/29/2019	4 of 4

Calculate Neutral Axis (N.A.) of steel section:

$c_y = \Sigma(A^*y) / \Sigma A$

$= 24.00$ in. from top

$c_{ybot} = d - c_y$

$= 24.00$ in. from bottom

Calculate gross moment of inertia, I_{xxg}:

$I_{xxg} = \Sigma (I_{xo} + A (y - c_y)^2)$

$= \underline{42332.46}$ in⁴

Calculate gross section modulus, S_{xxg}:

$S_{xxg} = I_{xxg} / c_{ybot}$

$= \underline{1763.85}$ in³

4.1 PORT RICHMOND VIADUCT SLAB – LOAD RATING CALCULATIONS

STV 100 Years

CLIENT	MTA - NYCTA	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	Staten Island North Shore - BRT	BH	GKS	4019716	
SUBJECT	Typical Viaduct Slab Load Rating	Date	Date	REVISION	SHEET NO.
		5/2/2019	5/9/2019	0	1 of 4

Objective:

Perform load rating for typical 18' viaduct track slab.

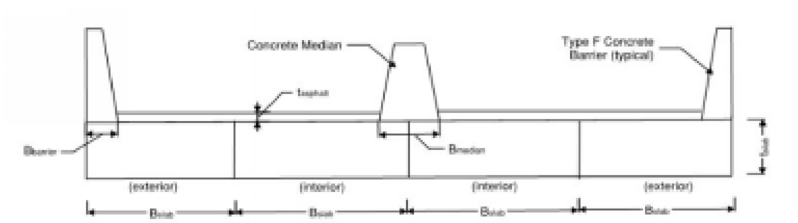
References:

1. AASHTO Standard Specification for Highway Bridges, 17th Edition, 2002.
2. AASHTO Manual for Bridge Evaluation 2nd Edition (2010, 2013 Interim).
3. Staten Island Rapid Transit Rwy Contract Dwgs. 1933, 1934.
4. NYSDOT BD-Sheets, 2014.

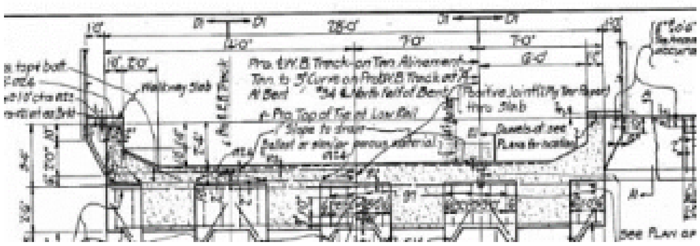
Design Constants:

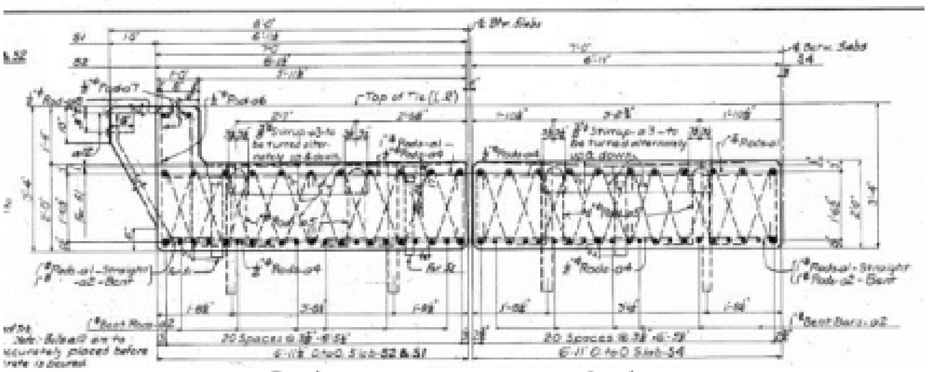
Compressive strength of existing concrete, f'_c:	3	ksi	
Yield stress of existing steel, f_y:	30	ksi	*Ref 2, pg. 6-85, table 6B.5.2.1-1 (Built 1905-1936)*
Unit weight of concrete, γ_{conc}:	0.150	k/ft^3	
Unit weight of asphalt pavement $\gamma_{asphalt}$:	0.145	k/ft^3	
Span length, L:	18	ft	*Ref 3*
Asphalt pavement thickness, $t_{asphalt}$:	0.167	ft	
Concrete slab thickness, t_{slab}:	2	ft	*Ref 3*
Concrete slab width, B_{slab}:	7	ft	*Ref 3*
Bottom width of f-shape barrier, $B_{barrier}$:	1.625	ft	*Ref 4, BD-RCB8E*
Bottom width of median, B_{median}:	2.0	ft	*Ref 4, BD-RCB19E*

Sketch:

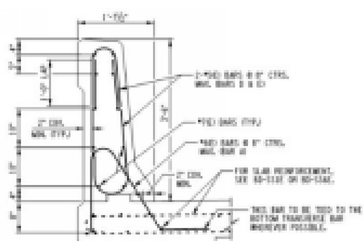


CLIENT	MTA - NYCTA	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	Staten Island North Shore - BRT	BH	GKS	4019716	
SUBJECT	Typical Viaduct Slab Load Rating	Date	Date	REVISION	SHEET NO.
		5/2/2019	5/9/2019	0	2 of 4



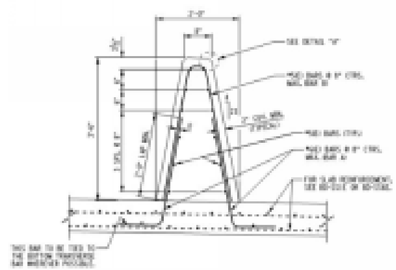


Exterior Interior



(Concrete F-Shape Barrier, Ref. 4)

$D_{barrier}$: 0.65 k/ft



(Concrete Median, Ref. 4)

D_{median}: 0.70 k/ft

Dead Load

Dead load of concrete slab, D_{slab}:	2.10	k/ft	$D_{slab} = t_{slab} \cdot B_{slab} \cdot \gamma_{conc}$
Dead load of interior asphalt pavement, $D_{iasphalt}$:	0.145	k/ft	$D_{iasphalt} = t_{asphalt} \cdot (B_{slab} - \frac{B_{median}}{2}) \cdot \gamma_{asphalt}$
Dead load of exterior asphalt pavement, $D_{easphalt}$:	0.130	k/ft	$D_{easphalt} = t_{asphalt} \cdot (B_{slab} - B_{barrier}) \cdot \gamma_{asphalt}$
Total Interior Dead Load, w_{Dint}:	2.60	k/ft	$w_{Dint} = D_{slab} + D_{iasphalt} + \frac{D_{median}}{2}$
Total Exterior Dead Load, w_{Dext}:	2.88	k/ft	$w_{Dext} = D_{slab} + D_{easphalt} + D_{barrier}$

Proceed using exterior dead load, as it governs

Total Dead Load Moment, M_D: 116.64 k-ft $\quad M_D = \frac{w_{Dext} \cdot L^2}{8}$

Live Load

Vehicle Live Load Moment, M_{LL}:	72.0	k-ft	*Ref 2, pg. 6-123, table C6B-1 (Assume loading for HS-20-44, for potential emergency vehicles).*
Impact Factor, I:	0.35		$I = \frac{50}{L + 125} \leq 0.30$ *Ref 1, sec. 3.8.2.1, formula 3-1*
use	0.30		

Total Live Load Moment, M_{LL+I}: 93.6 k-ft $\quad M_{LL+I} = M_{LL} \cdot (1 + I)$

CLIENT	MTA - NYCTA	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	Staten Island North Shore - BRT	BH	GKS	4019716	
SUBJECT	Typical Viaduct Slab Load Rating	Date	Date	REVISION	SHEET NO.
		5/2/2019	5/9/2019	0	4 of 4

Capacity of Member

ϕ:	0.9		
Bar number:	#8		*Ref 3*
Area of bar, A_b:	1	in^2	*(rectangular bar)*
Number of bars, n:	21		*Ref 3 (20 spaces @ 3'-7/8", therefore 21 bars)*
Area of steel, A_s:	18.90	in^2	*(including 10% section loss from corrosion)*
Depth to reinforcement, d:	21.5	in	*Ref 3 (2' slab - 2.5" cover)*
Thickness of member, b:	12.0	in	
a:	18.53	in	$a = \frac{A_s f_y}{0.85 f'_c b}$
Nominal moment of member, ϕM_n:	520.31	k-ft	$\phi M_n = \phi A_s f_y (d - \frac{a}{2})$

Moment Load Rating Factor (Load Factor Method)

Dead load inventory factor, A_{DI}:	1.30	*Ref 2, pg. 6-81, 6B.4.3*	
Dead load operating factor, A_{DO}:	1.30	*Ref 2, pg. 6-81, 6B.4.3*	
Live load inventory factor, A_{LI}:	2.17	*Ref 2, pg. 6-81, 6B.4.3*	
Live load operating factor, A_{LO}:	1.30	*Ref 2, pg. 6-81, 6B.4.3*	
Inventory rating factor, RF_I:	1.82 > 1.0	OK	$RF_I = \frac{\phi M_n - A_{DI} M_D}{A_{LI} M_{LL+I}}$ *Ref 2, pg. 6-80, 6B.4.1-1*
Operating rating factor, RF_O:	3.03 > 1.0	OK	$RF_O = \frac{\phi M_n - A_{DO} M_D}{A_{LO} M_{LL+I}}$ *Ref 2, pg. 6-80, 6B.4.1-1*

APPENDIX D: CODES, STANDARDS, REGULATIONS, GUIDELINES, MANUALS, AND REFERENCED STANDARDS

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1.0 CODES, STANDARDS, REGULATIONS, GUIDELINES, MANUALS, AND REFERENCED STANDARDS

Codes, Standards and Regulations of Governing Agencies

Unless otherwise specified herein, the current editions including current interim specifications of the followings codes and manuals shall govern.

1.1 National

American Association of State Highway and Transportation Officials (AASHTO)

- AASHTO A Policy on Geometric Design of Highway and Streets
- AASHTO Guide for Design of Pavement Structures
- AASHTO Guidelines for Roadway Lighting
- AASHTO Roadside Design Guide
- AASHTO Manual for Assessing Safety Hardware (MASH)
- AASHTO Guidelines for the Development of Bicycle Facilities
- AASHTO Standard Specifications for Highway Bridges
- AASHTO Guide Specification for Isolation Bearing
- AASHTO GSID-2-I1, Guide Specifications for Seismic Isolation Design, 2nd Edition, Interim
- AASHTO 7th edition with all interims

American Concrete Institute Standards (ACI)

- ACI 201.2R Guide to Durable Concrete
- ACI 305R Hot weather concreting
- ACI 308.1 Standard Specification for Curing Concrete
- ACI 308R Guide to Curing Concrete
- ACI 315 Manual for Standard Practice for Detailing Reinforced Concrete Structures, Scheduling, Dimensioning, Bending and Cutting of Steel Reinforcement for Concrete
- ACI 318 Building Code Requirements for Structural Concrete and Commentary
- ACI 358.1R Analysis and Design of Reinforced Concrete Guideway Structures
- ACI 530/530.1 Building Code Requirements and Specification for Masonry Structures and Related Commentaries
- ACI SP-66 ACI Detailing Manual

American Institute of Steel Construction (AISC)

- AISC 325 Steel Construction Manual
- AISC 327 Seismic Design Manual
- AISC 341 The Seismic Provisions for Structural Steel Buildings
- AISC 360 Specifications for Structural Steel Buildings

American Public Transit Association (APTA)

- Guidelines for Design of Rapid Transit Facilities

American Society for Testing and Materials, by the American Society for Testing Materials (ASTM)

- ASTM A820 Standard Specification for Steel Fibers for Fiber-Reinforced Concrete

American Society of Civil Engineers (ASCE)

- ASCE Manual No. 7 Minimum Design Loads for Buildings and Other Structures
- ASCE Manual No. 37 Design and Construction of Sanitary and Storm Sewers
- SEI, ASCE 37 Design Loads on Structures during Construction
- ASCE Manual No. 24 Flood Resistant Design and Construction
- ASCE Manual of Practice (MOP) 140 Climate-Resilient Infrastructure: Adaptive Design and Risk Management

American Water Works Association (AWWA)

- C600
- C651
- C800

Americans with Disabilities Act Accessibility Guidelines (ADAAG)

American Petroleum Institute (API)

- Recommended Practice for Crossing Highways and Railroads

American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering

American Society of Mechanical Engineers' (ASME) Gas Piping Standards Committee

- Guide for Gas Transmission and Distribution Piping Systems

American Welding Society (AWS)

- Bridge Welding Code
- Structural Welding Code Steel

Federal Highway Administration (FHWA)

- FHWA ED-88-053 Checklists and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications
- FHWA HEC-9 Debris-Control Structures
- FHWA-HI-97-013 & 014 Design and Construction of Driven Pile Foundations, Vol I & II
- FHWA-HI-98-034 Geotechnical Instrumentation
- FHWA-HI-99-012 Training Course in Geotechnical and Foundation Engineering: Geotechnical Earthquake Engineering - Participants Manual
- FHWA-HRT-05-067 Seismic Retrofitting Manual for Highway Structures: Part 2-Retaining Structures, Slopes, Tunnels, Culverts, and Roadways
- FHWA Hydraulic Design Series #3 (HDS #3)
- FHWA Hydraulic Design Series #4 (HDS #4)
- FHWA-IF-02-034 GEC-05: Evaluation of Soil and Rock Properties
- FHWA-IF-99-025 Drilled Shafts – Construction Procedures & Design Methods

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- FHWA-IF-05-023 Road Tunnel Design Guidelines
- FHWA-NHI-00-043, 2000 Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design And Construction Guidelines
- FHWA-NHI-10-016 Drilled Shafts: Construction Procedures and LRFD Design Methods
- FHWA-NHI-06-088 & 089 Soils and Foundations Reference Manual-Volume I & II
- FHWA-NHI-14-007 Geotechnical Engineering Circular No. 7-Soil Nail Walls
- FHWA-IF-99-025 Drilled Shafts: Construction Procedures and Design Methods
- FHWA-NHI-01-031 Subsurface Investigations - Geotechnical Site Characterization
- FHWA-NHI-05-039 Micropile Design and Construction FHWA Suggestions for Temporary Sedimentation and Erosion Control Measures
- FHWA-SA-96-038 Geotechnical Engineering Circular No. 2:
- FHWA-SA-96-069R Manual for Design and Construction of Soil Nail Walls
- FHWA Publication No. FHWA-IF-99-015 Geotechnical Engineering Circular No. 4, Ground Anchors and Anchored System
- FHWA RD 75-128, 129 & 130, 1976 Lateral Support Systems & Underpinning, Vols. I, II, & III
- FHWA-RD-99-138 An Introduction to the Deep Soil Mixing Methods as Used in Geotechnical Applications
- FHWA-SA-02-054 Geotechnical Engineering Circular No. 6, Shallow Foundations
- FHWA-SA-97-070 Micropile Design and Construction Guidelines

Federal Manual of Uniform Traffic Control Devices (MUTCD)

Illuminating Engineering Society of North America (IESNA) Standards

Minimum Federal Safety Standards for Gas Lines

- Title 49 Code of Federal Regulations, Part 192

National Electric Safety Code

National Fire Protection Association

- NFPA 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways

U.S. Army Corps of Engineers (USACE)

- Coastal and Hydraulics Laboratory: EM 1110-2-1100, Coastal Engineering Manual, 2002
- Monitoring Well Design, Installation, and Documentation at Hazardous Toxic and Radioactive Waste Sites Engineering manual 1110-1-4000

US Department of Transportation (USDOT)

- Hydraulic Engineering Circular No. 12 (HEC-12)
- USDOT Hydraulic Engineering Curriculum (HEC-22) Drainage of Highway Pavements
- USDOT Part 195 of Government Requirements for Transportation of Liquids by Pipeline

1.2 New York State

Metropolitan Transportation Authority (MTA)

- New York City Transit (NYCT) Flood Resiliency Design Guidelines (DG 312)

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- New York City Transit (NYCT) Structural Design Guidelines (DG 452)

New York State Department of Transportation (NYSDOT)

- NYSDOT Right-of-Way Procedure Manual
- NYSDOT Specifications and Engineering Instructions
- NYSDOT Standard Specifications for Highway Bridges
- NYSDOT Highway Design Manual
- NYSDOT Region 11 Guide Sheets for Maintenance and Protection of Traffic
- US DOT Reference Guide Outline (National Map Accuracy Standards)
- NYSDOT Standard Specifications, Construction, and Materials
- NYSDOT Standard Sheets
- NYSDOT LRFD Bridge Design Specification
- NYSDOT Bridge Design Manual
- NYSDOT Bridge Inspection Manual

New York State Edition of the International Building Code

New York State Manual of Uniform Traffic Control Devices (MUTCD)

New York State Railroad Law – Section 51-a

New York Codes Rules and Regulation (NYCRR)

- Uniform Fire Prevention and Building Code (the Uniform Code) of New York State, (Title 19 adapted with New York State amendments from the International Code Council (ICC) family of codes, including the International Building Code (IBC))

1.3 New York City

New York City Building Code (NYCBC)

- NYC Building Code, Subchapter 16 - Plumbing and Gas Piping

New York City Department of Environmental Protection (NYCDEP)

- NYCDEP Design Criteria
- NYCDEP Detention Facility Design Criteria
- NYCDEP Bureau of Water Supply Standard Water Main Specifications
- NYCDEP Rules and Regulations
- New York City Sewer Use Regulation, Title 15, Chapter 19 (Site Connection Permit)

New York City Department of Design and Construction

- Guidelines and Directives Manual

New York City Department of Transportation (NYCDOT)

- NYCDOT Rules, Regulations and Guidelines
- NYCDOT Bureau of Highway Operations
- NYCDOT Design Directives
- NYCDOT Division of Street Lighting
- NYCDOT Division of Traffic Signals

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- NYCDOT Standards
- NYCDOT Standard Sheets

1.4 References

National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35

CSX Standard Specifications for the Design and Construction of Private Sidetrack, 2016

1.5 Referenced Standards – Promulgating Agencies

Listed here are the promulgating agencies for the standards referenced in the codes, standards, regulations, guideline and manual listed above, or by other project documents.

- American Association of State Highway and Transportation Officials (AASHTO) Standards.
- American National Standards Institute (ANSI) Standards
- American Petroleum Institute (API) Standards
- Association of American Railroads (AAR)
- American Railway Engineering and Maintenance-of Way Association (AREMA) Standards
- American Society for Testing and Materials (ASTM) Standards
- American Society of Mechanical Engineers (ASME) Standards
- American Water Works Associations (AWWA) Standards
- American Welding Society (AWS) Standard
- Illuminating Engineering Society of North America (IESNA) Standards
- National Fire Protection Association (NFPA) Standards

1.6 Applicable Laws and Regulations

All Federal laws, regulations, and executive orders affecting project development, including but not limited to the regulations of the Council on Environmental Quality and FHWA/FTA implementing NEPA (40 CFR parts 1500-1508, and 23 CFR part 771), the 1990 Clean Air Act Amendments, Section 404 of the Clean Water Act, Executive Order 12898 regarding environmental justice, the National Historic Preservation Act, the Endangered Species Act, and Section 4(f) of the DOT Act, would be addressed to the maximum extent practicable during the NEPA process.

Other appropriate Federal, State and Local laws and regulations will be observed including:

State

New York

Freshwater Wetlands Act

- Environmental Conservation Law Article 24
- 6 NYCRR Parts 662-664

Hazardous Waste Regulations

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- Environmental Conservation Law Articles 19. 27, 37, & 40
- 6 NYCRR Parts 371-373

NYS Historic Preservation Act

- Section 14.09

NYS Waterfront Revitalization and Coastal Resources Act

- Environmental Conservation Law Article 34

NYS Wild, Scenic, and Recreational Rivers Act and Regulations

- Environmental Conservation Law Articles 15 & 27

State Environmental Quality Review Act (SEQRA)

- Environmental Conservation Law Article 8
- 17 NYCRR Part 15

State Pollution Discharge Elimination System (SPDES)

- Environmental Conservation Law Article 17 Title 8

Stormwater Pollution Prevention Plans (SWPPP)

Tidal Wetlands Act

- Environmental Conservation Law Article 25
- 6 NYCRR Part 661

Water Quality Certification

- 6 NYCRR Part 608.7

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APPENDIX E: DATA SOURCES

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1.0 REPORTS AND STUDIES

- APTA Standards Development Program – Recommended Practice – Bus Rapid Transit Stations and Stops (October 2010)
- Get Ready to Connect (GRTC) Bus Rapid Transit Project – Stations Basis of Design Report (Version 3.0 – July 2015)
- Monterey-Salinas Transit (MST) – A Manual for Integrating Public Transit and Land Use in Monterey County (November 2006)
- MTA – NYCT – Planning and Design Guidelines for New Underground Stations (June 2004). 10.05.01.002296-1
- MTA - NYCT -North Shore Alternatives Analysis (NSAA) – North Shore Alternative Analysis Report – NYCT Contract #CM-1387 – Submitted to NYCT by SYSTRA Engineering, Inc. (August 2012 and 2013)
- New York City Department of City Planning (NYCDCP) - West Brighton Brownfield Opportunity Area (March 2016)
- NYCEDC - Design and Resident Engineering Services for the Inspection of Eight (8) Overpasses of the Staten Island Railroad (SIR) – Contract CSA-3001 – Rehabilitation Plan and Report of Findings – Submitted to Turner Construction Company by Dewberry-Goodkind, Inc. (July 2009)
- NYCEDC – Richmond Terrace Retaining Wall Assessment Staten Island, New York – Task 4.0 – Final Report (December 2017, Revision 1)
- NYCDOT – Staten Island Ferry Terminal Bicycle and Pedestrian Improvements Presentation to Staten Island Community Board 1 (June 13, 2017)
- OCTA – Bus Stop Safety and Design Guidelines (March 2004)
- Transportation Cooperative Research Program (TCRP) – Bus Rapid Transit Practitioner's Guide (2007)
- Transportation Cooperative Research Program (TCRP) – Bus Rapid Transit – Volume 2: Implementation Guidelines (2003)

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2.0 DRAWINGS

- Atlantic Salt - #561 Richmond Terrace - Topographic Survey (2010)
- Empire Outlets – New York City Department of Buildings Job Number 520192363 – Foundations Plans, Parking Level 2 and Parking Level 3 plans (8/1/2014)
- MTA – NYCT – Employee Facility and Storeroom Expansion at Castleton Bus Depot – Contract C-40425 (2005)
- MTA – NYCT – Sandy Flood Mitigation St. George Terminal – Contract T-80279 (2018)
- NYCEDC – Ballpark at St. George Station Staten Island, Railway Platform 75% Construction Documents (07/05/00)
- NYCEDC – Reactivation of the Staten Island Railroad – Contract No. 5320014 – As-Built (2006)

- NYCDOT Bridges – Contract No. HBR1217 Rehabilitation of Ramp Structures At The St. George, Staten Island Ferry Terminal – Record As-Built Drawing (2014)
    - Bus Station North (BIN 2269740)
    - Bus Station South (BIN 2269750)
    - Old Viaduct – Bus Exit Ramp (BIN 2269790)
    - Ramp B – Bus Entrance Ramp (BIN 2269770)
    - Ramp C – Commuter and Employee Entrance Ramp (BIN 2269780)
    - Ramp D – Commuter and Employee Exit Ramp (BIN 2269730)
- NYCDOT Roadway Bridges As-Built Drawings
    - Contract No. HBR657 Replacement of South Avenue Bridge Over Staten Island Railroad – Record As-Built Drawing (1999)
    - Contract No. HBRC004 Reconstruction of Harbor Road Bridge Over Staten Island Railroad Corporation – Record As-Built Drawing (1993)
    - Contract No. HBR626 Reconstruction of Union Avenue Bridge Over the Delaware OTSEGO System – Record As-Built Drawing (1988)
    - Contract No. HBRC026 & HBRC027 Reconstruction of Dehart Avenue and John Street Bridges Over the Staten Island Railroad – Record As-Built Drawing (1995)
    - Contract No. HBR1006 & HBR1007 & HBR639 Reconstruction of Simonson, Van Pelt and Granite Avenue Bridges Over the Delaware OTSEGO System – Record As-Built Drawing (1991)
    - Contract No. HBRC003 & HBRC008 Reconstruction of Lake Avenue and Van Name Avenue Bridges Over the Delaware OTSEGO System – Record As-Built Drawing (1989)
    - Contract D500126 Superstructure Replacement On Morningstar Road Bridge Over Staten Island Railroad In New York City – Record As-Built Drawing (1985)
- NYCDOT Transportation Planning and Management Design and Construction – Pavement Marking Plan on Richmond Terrace from Stuyvesant Place to Bay Street Drawing MD-1044_6 (2009)
- New York Wheel – Project No. 51030.07 – CD Progress Drawing Set for MTA Review (08/20/14)
- The Staten Island Rapid Transit Rwy. Co. New York Terminal Lines – Arlington, N.Y. – Bridge No. 212 Over Arthur Kill – Contract No. 1 (June 1955)
- The Staten Island Rapid Transit RY. Pro. Grade Elimination Tower Hill, S.I., N.Y. (1934)

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APPENDIX F: PROPERTY MATRIX

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1.0 PUBLIC PROPERTY - THE CITY OF NEW YORK

SECTION	BLOCK	LOT	STREET ADDRESS	STATION	ROW	LAND EXCHANGE	ACQUISITION	PARKLAND ALIENATION	OPTION		LAND USE	OWNER/JURISDICTION	NOTES
									1	2			
1	2	1	1 RICHMOND TERRACE								TRANSPORTATION/UTILITY	NYC DEPARTMENT OF TRANSPORTATION	ST. GEORGE TERMINAL: WOULD UTILIZE TAXI STAND ON EXISTING BUS DECK FOR BRT TERMINUS
1	2	599	BOROUGH PLACE								PUBLIC FACILITIES	PARKS AND RECREATION	ALIGNMENT CROSSES NORTH SHORE ESPLANADE; CITY-OWNED PROPERTY BUT NOT MAPPED AS PARKLAND PER DCP. DCP ALSO NOTED THAT ESPLANADE MAY BE WITHIN THE MAPPED WIDTH OF RICHMOND TERRACE
1	2	601	RICHMOND TERRACE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
1	9	17	10 HAMILTON AVENUE								PUBLIC FACILITIES	DCAS	**RICHMOND TERRACE:** FAMILY COURT 100 RICHMOND TERRACE ADJACENT TO 120TH; LANE/SIDEWALK USED FOR COMBAT PARKING
1	9	22	100 RICHMOND TERRACE		•						PUBLIC FACILITIES	DCAS	**RICHMOND TERRACE:** FAMILY COURT (NYCL) 100 RICHMOND TERRACE ADJACENT TO 120TH; LANE/SIDEWALK USED FOR COMBAT PARKING
1	9	28	78 RICHMOND TERRACE		•						INSTITUTIONAL	NEW YORK POLICE DEPARTMENT	**RICHMOND TERRACE:** 120TH PRECINCT; LANE/SIDEWALK USED FOR COMBAT PARKING
2	4	10	RICHMOND TERRACE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
2	68	35	RICHMOND TERRACE	•	•	•					TRANSPORTATION/UTILITY	DSBS (EDC)	CITY-OWNED ROW THROUGH WEST END OF ATLANTIC SALT; NEW BRIGHTON STATION AREA & PORTION TO BE EXCHANGED WITH ATLANTIC SALT
2	68	70	RICHMOND TERRACE		•				•		PUBLIC FACILITIES	DSBS (EDC)	
2	75	1	RICHMOND TERRACE					•	•		VACANT	PARKS AND RECREATION	POTENTIAL STRIP USE OF PARKLAND BUT OPTION 1 MAY AVOID
2	75	30	RICHMOND TERRACE					•	•		PUBLIC FACILITIES	PARKS AND RECREATION	
2	75	100	RICHMOND TERRACE		•				•	•	TRANSPORTATION/UTILITY	DSBS (EDC)	
2	75	150	RICHMOND TERRACE					•	•		PUBLIC FACILITIES	PARKS AND RECREATION	POTENTIAL STRIP USE OF PARKLAND BUT OPTION 1 MAY AVOID
3	184	100	RICHMOND TERRACE	•	•	•					TRANSPORTATION/UTILITY	DSBS (EDC)	MAJORITY OF LOT IS TO EXCHANGED WITH CADDELL; EAST END OF LOT USED FOR LIVINGSTON STATION
3	184	188	BARD AVENUE		•						VACANT	DSBS (EDC)	
3	184	400	NORTH STREET	•	•	•					TRANSPORTATION/UTILITY	DSBS (EDC)	CITY-OWNED ROW TO BE EXCHANGED WITH CADDELL
3	185	43	1593 RICHMOND TERRACE		•			•			PUBLIC FACILITIES	PARKS AND RECREATION	HERITAGE PARK PARKING AREA EASTERN SURFACE LOT
3	185	45	1595 RICHMOND TERRACE		•			•			PUBLIC FACILITIES	PARKS AND RECREATION	HERITAGE PARK PARKING AREA EASTERN SURFACE LOT
3	185	48	RICHMOND TERRACE		•			•			PARKING	PARKS AND RECREATION	HERITAGE PARK PARKING AREA EASTERN SURFACE LOT
3	185	100	RICHMOND TERRACE		•	•					TRANSPORTATION/UTILITY	DSBS (EDC)	EASTERN PORTION OF LOT TO BE EXCHANGED WITH CADDELL; PORTION OF HERITAGE PARK PARKING LOT LOOKS TO INFRINGE ON ROW
3	185	49	RICHMOND TERRACE		•						PARKING	PARKS AND RECREATION	HERITAGE PARK PARKING AREA EASTERN SURFACE LOT
4	185	390	RICHMOND TERRACE		•						TRANSPORTATION/UTILITY	DEPT OF ENVIRONMENTAL PROTECTION	
4	185	536	RICHMOND TERRACE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1004	2	RICHMOND AVENUE	•	•						TRANSPORTATION/UTILITY	DSBS (EDC)	PORT RICHMOND STATION
4	1006	28	PARK AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1073	102	PORT RICHMOND AVENUE	•							VACANT LAND	DSBS (EDC)	POTENTIAL PLAZA AREA FOR PORT RICHMOND STATION
4	1073	20	MAPLE AVENUE	•	•						TRANSPORTATION/UTILITY	DSBS (EDC)	PORT RICHMOND STATION
4	1074	13	FABER STREET		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1076	4	GROVE AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1076	6	GROVE AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1076	19	GROVE AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1076	60	FABER STREET		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1084	42	TREADWELL AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1086	22	NICHOLAS AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1116	110	NICHOLAS AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1116	112	NICHOLAS AVENUE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1118	38	IRVING PLACE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1118	40	IRVING PLACE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	
4	1118	41	IRVING PLACE		•						TRANSPORTATION/UTILITY	DSBS (EDC)	

SECTION	BLOCK	LOT	STREET ADDRESS	STATION	ROW	LAND EXCHANGE	ACQUISITION	PARKLAND ALIENATION	OPTION 1	OPTION 2	LAND USE	OWNER/JURISDICTION	NOTES
4	1121	77	JOHN STREET		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1123	116	JOHN STREET		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1124	27	EATON PLACE	●	●						TRANSPORTATION/UTILITY	DSBS (EDC)	STATION WALKWAY/PEDESTRAIN ACCESS TO ELM PARK MORNINGSTAR STATION
5	1125	17	MORNINGSTAR ROAD	●	●						TRANSPORTATION/UTILITY	DSBS (EDC)	ELM PARK MORNINGSTAR STATION
5	1152	36	WINANT STREET		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1155	80	GRANITE AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1161	43	GRANITE AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1165	40	SIMONSON AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1186	2	VAN NAME AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1188	120	VAN NAME AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	RETAINING WALL FOR FREIGHT
5	1186	119	SIMONSON AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	RETAINING WALL FOR FREIGHT
5	1211	20	VAN PELT AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	PROPOSED ERASTINA WALKWAY
5	1188	1	VAN PELT AVENUE	●	●						TRANSPORTATION/UTILITY	DSBS (EDC)	MARINER'S HARBOR STATION
5	1211	1	VAN PELT AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1212	20	DE HART AVENUE	●	●						TRANSPORTATION/UTILITY	DSBS (EDC)	MARINER'S HARBOR STATION
5	1212	24	DE HART AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	PROPOSED ERASTINA WALKWAY
5	1213	133	DE HART AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	PROPOSED ERASTINA WALKWAY
5	1213	21	UNION AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
5	1226	14	BUSH AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
6	1236	100	HARBOR ROAD		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
6	1237	165	LOCKMAN AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
6	1256	1	MERSEREAU AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
6	1257	1	GRANDVIEW AVENUE		●						TRANSPORTATION/UTILITY	DSBS (EDC)	
6	1261	82	SOUTH AVENUE		●						VACANT	DSBS (EDC)	CITY-OWNED LAND WITH EXISTING PEDESTRIAN RAMP TO SOUTH AVENUE BRIDGE; RECONSTRUCTION
6	1261	90	GRANDVIEW AVENUE		●						VACANT	DSBS (EDC)	CITY-OWNED LAND WITH EXISTING PEDESTRIAN RAMP TO SOUTH AVENUE BRIDGE; RECONSTRUCTION
6	1261	79	SOUTH AVENUE		●						VACANT	DSBS (EDC)	CITY-OWNED LAND WITH EXISTING PEDESTRIAN RAMP TO SOUTH AVENUE BRIDGE; RECONSTRUCTION

2.0 PUBLIC PROPERTY - THE STATE OF NEW YORK

SECTION	BLOCK	LOT	STREET ADDRESS	STATION	ROW	LAND EXCHANGE	ACQUISITION	PARKLAND ALIENATION	OPTION 1	OPTION 2	LAND USE	OWNER/JURISDICTION	NOTES
1	2	10	BOROUGH PLACE								TRANSPORTATION/UTILITY	MTA-STATEN ISLAND RAILROAD	ACCESS RAMP TO ST. GEORGE TERMINAL
2	4	11	RICHMOND TERRACE								VACANT	MTA-STATEN ISLAND RAILROAD	BETWEEN ROW & RICHMOND TERRACE; POTENTIAL USE FOR LAYDOWN AREA OR DRAINAGE
2	68	40	RICHMOND TERRACE	●					●	●	VACANT	MTA-STATEN ISLAND RAILROAD	NEW BRIGHTON STATION AREA
2	68	80	RICHMOND TERRACE								VACANT	MTA-STATEN ISLAND RAILROAD	IMMEDIATELY NORTH OF THE ROW; OPTION 1 MAY USE STRIP TAKING
4	185	170	RICHMOND TERRACE		●						VACANT	NEW YORK CITY TRANSIT	MTA PROPERTY: EXTENTSION OF ALASKA STREET
5	1124	32	EATON PLACE		●						VACANT	STATEN ISLAND RAILWAY	MTA PROPERTY: WEST OF JOHN STREET
6	1268	60	NORTHFIELD AVENUE	●			◖				TRANSPORTATION/UTILITY	NEW YORK PUBLIC SERVICE	NORTHERN PORTION OF LOT REQUIRED FOR PROPOSED ARLINGTON STATION

3.0 PRIVATE PROPERTY

SECTION	BLOCK	LOT	STREET ADDRESS	STATION	ROW	LAND EXCHANGE	ACQUISITION	PARKLAND ALIENATION	OPTION 1	OPTION 2	LAND USE	OWNER/JURISDICTION	NOTES
1	2	15	55 RICHMOND TERRACE					-			COMMERCIAL	ST. GEORGE OUTLET DEVELOPMENT, LLC	TAKING OF SIDEWALK IN FRONT OF EMPIRE OUTLETS (ACCESSIBILITY EFFECTS)
2	4	21	561 RICHMOND TERRACE		•	•					MANUFACTURING	REGAL ESTATES LLC A	PER MTA TITLE SEARCH PARCEL I & II OF BL:4, L:21 OWNED BY REGAL ESTATES, LLC; PARCEL III OF BL:4, L:21 OWNED BY CITY OF NEW YORK; CITY-OWNED PORTION TO BE EXCHANGED FOR PRIVATELY-OWNED PORTION OF LOT
2	68	1	RICHMOND TERRACE			•		-	•	•	VACANT	REGAL ESTATES LLC A	LAND EXCHANGE TO ACCOMMODATE ALIGNMENT FOR OPTIONS 1&2
2	184	1	1149 RICHMOND TERRACE	•			•	-			TRANSPORTATION/UTILITY	CON EDISON	LIVINGSTON STATION: PROVIDING DEDICATED CON ED PARKING (45 SPACES) & SPACE FOR 3 GENERATORS
2	184	163	RICHMOND TERRACE	•			•	-			TRANSPORTATION/UTILITY	CON EDISON	LIVINGSTON STATION: PROVIDING DEDICATED CON ED PARKING (45 SPACES) & SPACE FOR 3 GENERATORS
3	184	33	RICHMOND TERRACE			•		-			MANUFACTURING	CADDELL DRYDOCK REPAIR	DISPLACING 2 STORAGE STRUCTURES
3	185	27	1553 RICHMOND TERRACE			•		-			OTHER	CADDELL DRYDOCK REPAIR	IMPACT TO STORAGE AREA
3	185	29	RICHMOND TERRACE			•		-			OTHER	AB40 LLC	IMPACT TO STORAGE AREA
3	185	30	RICHMOND TERRACE			•		-			OTHER	AB40 LLC	IMPACT TO STORAGE AREA
3	185	31	RICHMOND TERRACE			•		-			OTHER	AB40 LLC	IMPACT TO STORAGE AREA
3	184	80	PELTON PLACE			•		-			VACANT	CADDELL DRY DOCK&REPA	ALIGNMENT BISECTS INFORMAL CADDELL SURFACE PARKING (EAST END)
3	184	225	1441 RICHMOND TERRACE			•		-			VACANT	BLOCK 184 LLC	DISPLACES INFORMAL PARKING
3	184	227	RICHMOND TERRACE	•		•		-			VACANT	BLOCK 184 LLC	PROPOSED WEST BRIGHTON STATION AREA (AT EXTREME WEST END OF LOT)
3	184	248	1449 RICHMOND TERRACE	•			•	-			MANUFACTURING	TATUMAL, LLC	PROPOSED WEST BRIGHTON STATION AREA; 1 SINGLE STORY INDUSTRIAL BUILDING DISPLACED
3	184	254	RICHMOND TERRACE	•			•				VACANT	T F QUINLAN SON INC	PROPOSED WEST BRIGHTON STATION AREA; DISPLACES STORAGE AREA
3	184	256	1473 RICHMOND TERRACE	•			•				TRANSPORTATION/UTILITY	T F QUINLAN SON INC	PROPOSED WEST BRIGHTON STATION AREA; DISPLACES 1 SINGLE STORY INDUSTRIAL BUILDING, SHED & STORAGE SPACE
3	184	275	1483 RICHMOND TERRACE			•					MANUFACTURING	CADDELL DRYDOCK REPAIR	
3	184	280	RICHMOND TERRACE			•		-			VACANT	CADDELL DRYDOCK REPAIR	DISPLACES PORTION OF CADDELL PARKING LOT AT BROADWAY ENTRANCE
3	185	1	1551 BROADWAY			•					MANUFACTURING	CADDELL DRYDOCK REPAIR	DISPLACES LOCKER ROOM BUILDING
3	185	21	1535 RICHMOND TERRACE			•					COMMERCIAL	CADDELL DRYDOCK REPAIR	DISPLACES 2 STORY BUILDING
3	185	25	1551 RICHMOND TERRACE			•					VACANT	CADDELL DRY DOCK AND	DISPLACES STORAGE AREA
3	185	28	RICHMOND TERRACE			•					OTHER	CADDELL DRYDOCK REPAIR	DISPLACES STORAGE AREA
3	185	33	RICHMOND TERRACE			•					OTHER	AB40 LLC	DISPLACES STORAGE AREA
3	185	35	RICHMOND TERRACE			•					OTHER	AB40 LLC	DISPLACES STORAGE AREA
3	185	37	1571 RICHMOND TERRACE			•					VACANT	AB40 LLC	DISPLACES STORAGE AREA
3	185	38	RICHMOND TERRACE			•					OTHER	AB40 LLC	DISPLACES TO STORAGE AREA AREA ADJACENT TO HERITAGE PARK PARKING AREA
3	185	52	1615 RICHMOND TERRACE				◖				VACANT	MBDB LLC	MINIMAL STRIP TAKING TO ACCOMMODATE CURB FACE OF BRT ALIGNMENT
3	185	16	1521 RICHMOND TERRACE			•					INDUSTRIAL/MANUFACTURING	CADDELL DRYROCK REPAIR	DISPLACES 1 SINGLE STORY BUILDING
3	185	10	1517 RICHMOND TERRACE								INDUSTRIAL/MANUFACTURING	CADDELL DRYDOCK REPAIR	PROPOSED ALIGNMENT PHYSICALLY AVOIDS BUT ISOLATES BUILDING; POTENTIAL TAKING DUE TO INACCESSIBILITY
3	185	20	RICHMOND TERRACE			•					MISC	CADDELL DRYROCK REPAIR	DISPLACES INFORMAL PARKING/STORAGE AREA

SECTION	BLOCK	LOT	STREET ADDRESS	STATION	ROW	LAND EXCHANGE	ACQUISITION	PARKLAND ALIENATION	OPTION 1	OPTION 2	LAND USE	OWNER/JURISDICTION	NOTES
4	1004	7	69 PORT RICHMOND AVENUE	●			●				INDUSTRIAL/MANUFACTURING	67 PORT RICHMOND AVENUE LLC	TAKING SUPPLY YARD AREA FOR POTENTIAL PLAZA AT PORT RICHMOND STATION
6	1268	209	270 SOUTH AVENUE	●			●				VACANT	SONNY'S PIER LLC	LOT REQUIRED FOR ARLINGTON STATION
6	1268	217	SOUTH AVENUE	●			◐				TRANSPORTATION/UTILITY	NY STATE PUBLIC SERV/CON EDISON	WILL TAKE 12,400 SQ FT (TRIANGLE AREA TO ACCOMMODATE ARLINGTON STATION); PARTIAL TAKING WILL NOT IMAPCT EXISTING CON ED STRUCTURES
6	1243	30	LOCKMAN AVENUE				◐				VACANT	CSX TRANSPORTATION	TRANSITION AREA OUT OF OPEN CUT; STRIP TAKING NEEDED

3.1 Private Property – Impacted Buildings

Arlington (Sonny's Pier)

Block 1268, Lot 209 (Sonny's Pier LLC)

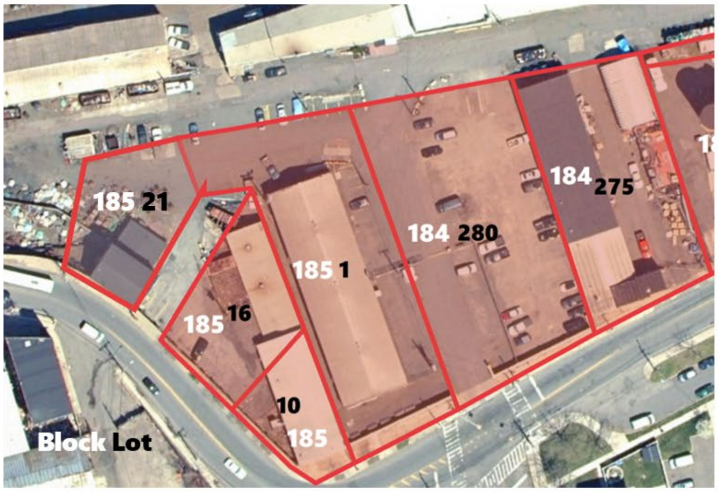
- Removal of 1 single story brick/concrete block structure based on field inspection
- Removal of aggregate & soil piles

Port Richmond (67 Port Richmond Avenue LLC)

Block 1004, Lot 7

- 5,092 sf 1 floor building
- Year Built: 1931 (altered in 2013)
- Building Class: Factory & Industrial Buildings – Light Manufacturing (F5)
- Lot area: 8,389 sf

West Brighton Station & Caddell Dry Dock Near Broadway



Caddell Dry Dock

Block 184, Lot 275
- Combined office & warehouse
  (alignment would displace office – light colored roof)
- 7,080 sf building; 1 floor
- Year Built: 1966 (altered 1995)
- Building Class: Warehouses –Fireproof (E1)

Block 184, Lot 280
- Driveway entrance to Caddell & surface parking area
- Possible guardhouse hut structure

Block 185, Lot 1
- Locker Room
- 8,000 sf single story building
- Year Built: 1940
- Building Class: Factory & Industrial Building – Semi Fireproof (E4)

Block 185, Lot 10
- Warehouse
- 2,450 sf single story building
- Year Built: 1930
- Building Class: Warehouses – Fireproof (E1)

Block 185, Lot 16
- Warehouse
- 1,600 sf single story building
- Year Built: 1930
- Building Class: Warehouses – Fireproof (E1)

Source: ZoLa

Block 185, Lot 21
- 3,928 sf multi-story building
- Year Built: 1930
- Building Class: Office Building-Office Only 2-6 Stories (O2)

West Brighton Station & Caddell Dry Dock Near Broadway

Block 184, Lot 248 (Tatumal, LLC)
- 9,850 sf building; 1 floor
- Year Built: 1966 (altered 1995)
- Building Class: Warehouses –Contractor's Warehouse (E2)

Source: ZoLa

Block 184, Lots 254 & 256 (TF Quinlan Son Inc.)
- 2 buildings; 2,000 sf; 1 floor
- Year Built: 1910
- Building Class: Warehouses –Contractor's Warehouse (E2)

Source: ZoLa

Caddell Dry Dock at Elizabeth Avenue

Block 184, Lot 33

- Removal of 2 temporary storage structures
- 2,000 sf building; 1 floor
- Year Built: 1992
- Building Class: Warehouses –Fireproof (E1)

Source: ZoLa

DRAFT

APPENDIX G: VERTICAL ROADWAY CALCULATIONS

DRAFT

CLIENT	MTA - NYCTA	MADE BY	CHECKED BY	PROJECT NO.	
PROJECT	Staten Island North Shore - BRT	BH	KL	4019716	
SUBJECT	Conceptual Roadway Vertical Curve Design - Alignment 1 and 2	Date	Date	REVISION	SHEET NO.
		3/19/2020	3/19/2020	0	1

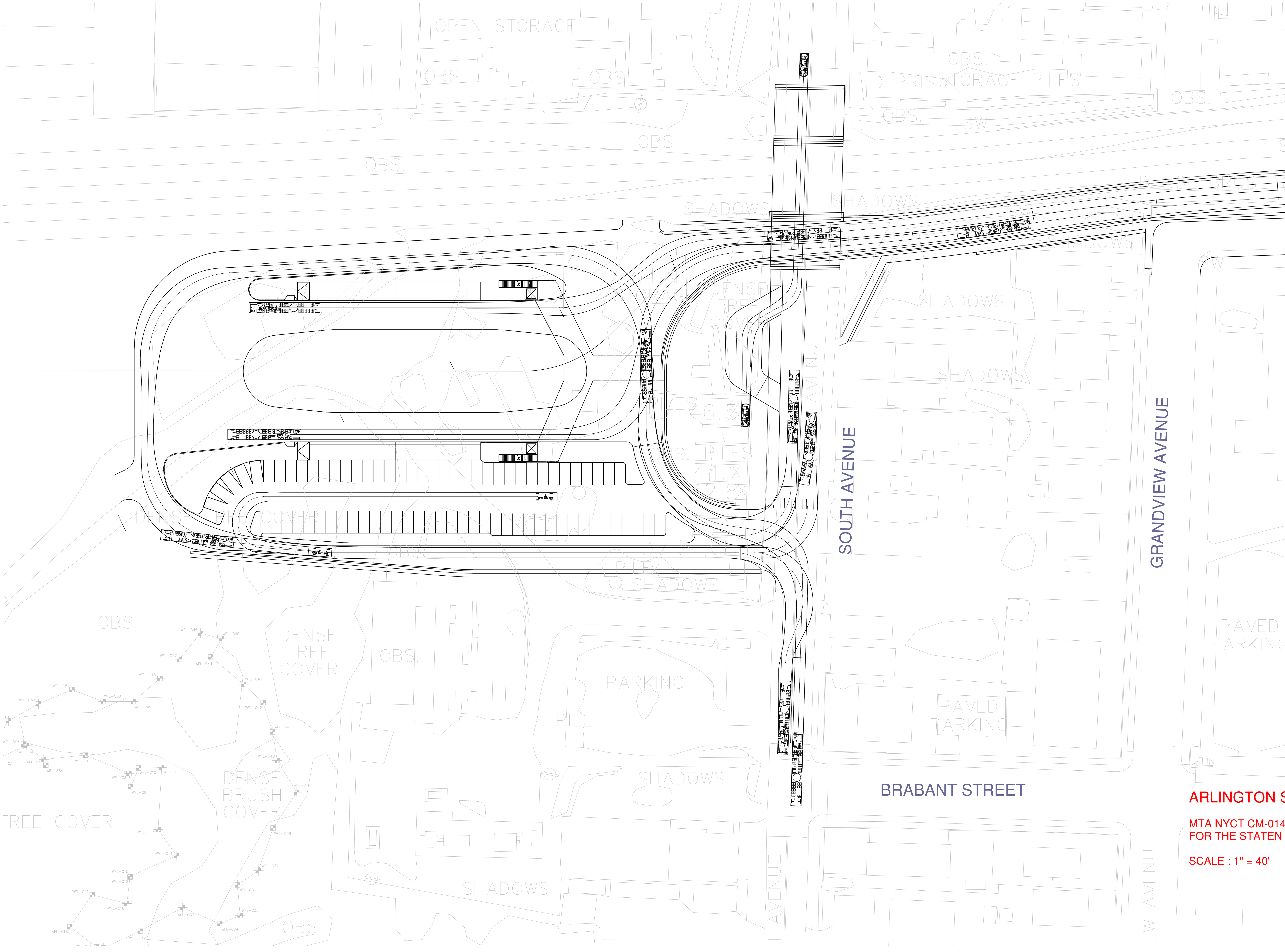
Design Speed (mph)	40
K value for Crest Vetrical Curve	44
K value for Sag Vetrical Curve	64
SIGHT DISTANCE DATA (AASHTO 2018)	
Height of eye (feet)	3.500
Height of object/stopping (feet)	2.000
Height of object/ passing(feet)	3.500
Divergence of light beam (AASHTO = 1 degree)	2.000
Height of headlight (feet)	0.600

*If Headlight Sight Distance reads "N/A", this indicates that the Sag Vertical Curve and the Headlight Sight Distance is too long and could NOT be computed.

INPUT DATA									LOW POINT OR HIGH POINT											SIGHT DISTANCE & K VALVUE			
																				SIGHT DISTANCE			K
Alignment	Vertical Curve No.	Point of Vertical Inflection (PVI) Station	Point of Vertical Inflection (PVI) Elevation	Length of Vertical Curve	Grade into Curve (g1) %	Grade out of Curve (g2) %	Minimum Length of Vertical Curve	Vertical Curve OK OR NOT OK	HP/LP ELEVATION	HP/LP STATION	HP	LP	Algebraic Difference between Slopes	Point of Vertical Curvature (PVC) Station	Point of Vertical Curvature (PVC) Elevation	Point of Vertical Tangency (PVT) Station	Point of Vertical Tangency (PVT) Elevation	Rate of Change of Vertical Curve	Middle Ordinate	Stopping	Passing	Headlight	L/A
1	1	11+51.02	28.750	100.000	-0.500	0.500	64.000	OK	28.875	11+51.02	-	LP	1.000	11+01.02	29.00	12+01.02	29.00	1.00%	0.125	-	-	N/A	100.00
1	2	23+52.34	34.760	50.000	0.500	-0.600	48.400	OK	34.692	23+50.07	HP	-	-1.100	23+27.34	34.64	23+77.34	34.61	-2.20%	0.069	1006.05	1297.73	-	45.45
1	3	63+62.62	10.700	100.000	-0.600	0.600	76.800	OK	10.850	63+62.62	-	LP	1.200	63+12.62	11.00	64+12.62	11.00	1.20%	0.150	-	-	N/A	83.33
1	4	85+27.47	23.750	50.000	0.600	0.700	6.400	OK	22.700	82+02.47	-	-	0.100	85+02.47	23.60	85+52.47	23.93	0.20%	0.006	-	-	N/A	500.00
1	5	97+96.93	32.570	50.000	0.700	0.270	18.920	OK	32.680	98+53.33	-	-	-0.430	97+71.93	32.40	98+21.93	32.64	-0.86%	0.027	2534.65	3280.81	-	116.28
1	6	115+52.69	37.380	50.000	0.270	-0.820	47.960	OK	37.329	115+40.08	HP	-	-1.090	115+27.69	37.31	115+77.69	37.18	-2.18%	0.068	1015.05	1309.40	-	45.87
1	7	136+40.00	20.250	50.000	-0.820	-0.550	17.280	OK	19.832	137+66.85	-	-	0.270	136+15.00	20.46	136+65.00	20.11	0.54%	0.017	-	-	N/A	185.19
1	8	142+50.42	16.900	50.000	-0.550	-0.780	10.120	OK	17.366	141+05.85	-	-	-0.230	142+25.42	17.04	142+75.42	16.71	-0.46%	0.014	4716.96	6111.96	-	217.39
1	9	156+26.43	6.150	100.000	-0.780	0.500	81.920	OK	6.302	156+37.37	-	LP	1.280	155+76.43	6.54	156+76.43	6.40	1.28%	0.160	-	-	N/A	78.13
1	10	168+84.03	12.460	50.000	0.500	-0.500	44.000	OK	12.398	168+84.03	HP	-	-1.000	168+59.03	12.34	169+09.03	12.34	-2.00%	0.063	1104.15	1425.00	-	50.00
1	11	175+71.90	9.020	100.000	-0.500	0.500	64.000	OK	9.145	175+71.90	-	LP	1.000	175+21.90	9.27	176+21.90	9.27	1.00%	0.125	-	-	N/A	100.00
1	12	187+16.94	14.690	200.000	0.500	3.500	192.000	OK	14.107	185+83.61	-	-	3.000	186+16.94	14.19	188+16.94	18.19	1.50%	0.750	-	-	N/A	66.67
1	13	191+76.49	30.780	150.000	3.500	0.500	132.000	OK	31.218	192+76.49	-	-	-3.000	191+01.49	28.16	192+51.49	31.16	-2.00%	0.563	434.72	541.67	-	50.00
1	14	202+48.91	36.170	50.000	0.500	-0.500	44.000	OK	36.108	202+48.91	HP	-	-1.000	202+23.91	36.05	202+73.91	36.05	-2.00%	0.063	1104.15	1425.00	-	50.00
1	15	215+45.64	29.750	100.000	-0.500	-2.000	66.000	OK	30.083	214+62.31	-	-	-1.500	214+95.64	30.00	215+95.64	28.75	-1.50%	0.188	769.43	983.33	-	66.67
1	16	224+80.45	11.080	150.000	-2.000	-0.160	117.760	OK	10.950	225+68.49	-	-	1.840	224+05.45	12.58	225+55.45	10.96	1.23%	0.345	-	-	N/A	81.52
1	17	235+31.82	9.410	100.000	-0.160	0.700	55.040	OK	9.475	235+00.42	-	LP	0.860	234+81.82	9.49	235+81.82	9.76	0.86%	0.108	-	-	N/A	116.28
1	18	242+96.99	14.750	100.000	0.700	-0.500	52.800	OK	14.604	243+05.32	HP	-	-1.200	242+46.99	14.40	243+46.99	14.50	-1.20%	0.150	949.29	1216.67	-	83.33
1	19	246+49.01	13.000	150.000	-0.500	1.200	108.800	OK	13.265	246+18.13	-	LP	1.700	245+74.01	13.38	247+24.01	13.90	1.13%	0.319	-	-	N/A	88.24
1	20	264+15.93	34.230	50.000	1.200	0.500	30.800	OK	34.444	264+76.64	-	-	-0.700	263+90.93	33.93	264+40.93	34.36	-1.40%	0.044	1566.64	2025.00	-	71.43
2	16	224+75.00	11.120	150.000	-2.000	-0.160	117.760	OK	10.990	225+63.04	-	-	1.840	224+00.00	12.62	225+50.00	11.00	1.23%	0.345	-	-	N/A	81.52
2	17	236+10.00	9.280	100.000	-0.160	0.700	55.040	OK	9.345	235+78.60	-	LP	0.860	235+60.00	9.36	236+60.00	9.63	0.86%	0.108	-	-	N/A	116.28
2	18	242+96.99	14.750	100.000	0.700	-0.500	52.800	OK	14.604	243+05.32	HP	-	-1.200	242+46.99	14.40	243+46.99	14.50	-1.20%	0.150	949.29	1216.67	-	83.33
2	19	246+49.01	13.000	150.000	-0.500	1.200	108.800	OK	13.265	246+18.13	-	LP	1.700	245+74.01	13.38	247+24.01	13.90	1.13%	0.319	-	-	N/A	88.24
2	20	264+15.93	34.230	50.000	1.200	0.500	30.800	OK	34.444	264+76.64	-	-	-0.700	263+90.93	33.93	264+40.93	34.36	-1.40%	0.044	1566.64	2025.00	-	71.43

APPENDIX H: VEHICLE TURN ANALYSIS

DRAFT



ARLINGTON STATION

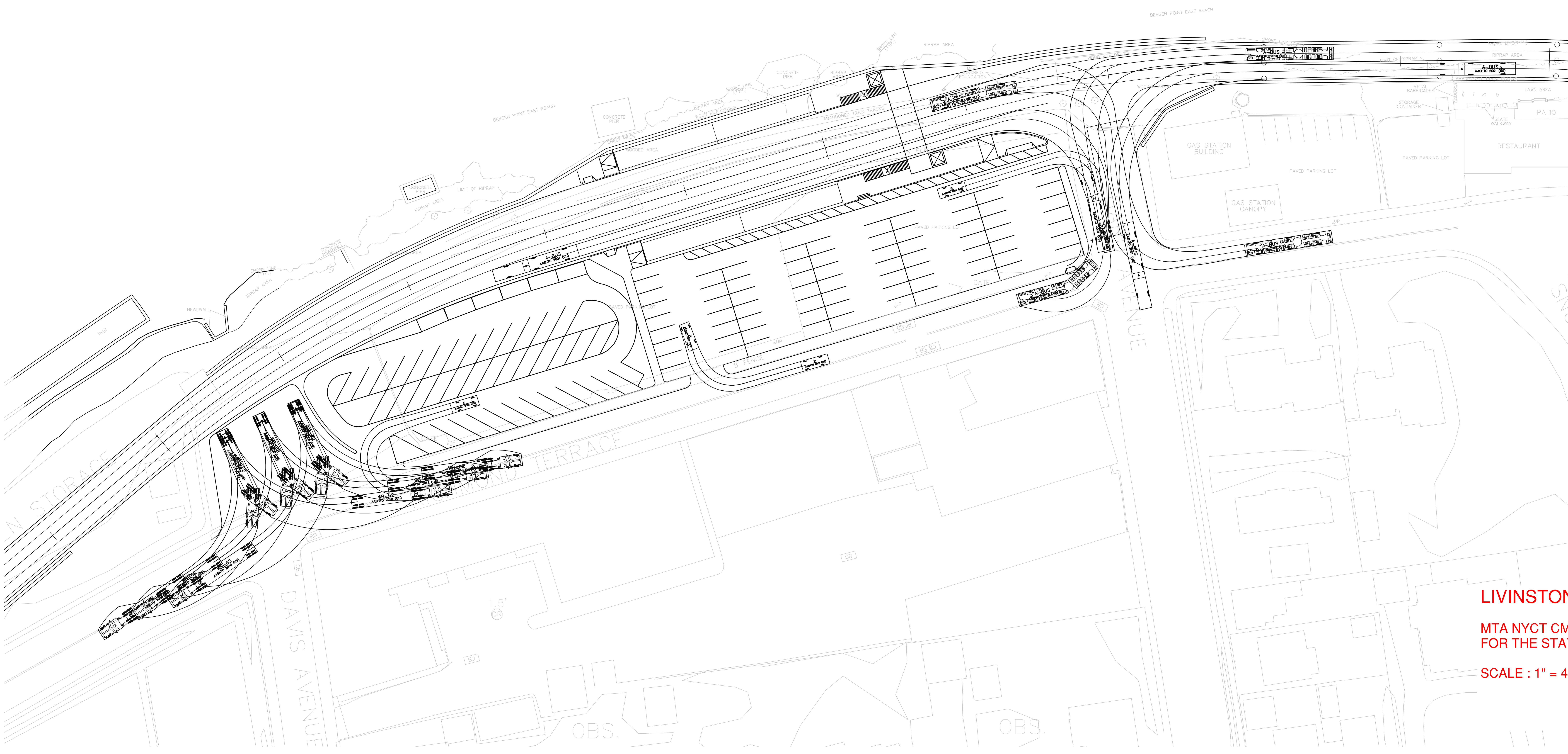
MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

SCALE : 1" = 40'

ALASKA STREET RAMP

MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

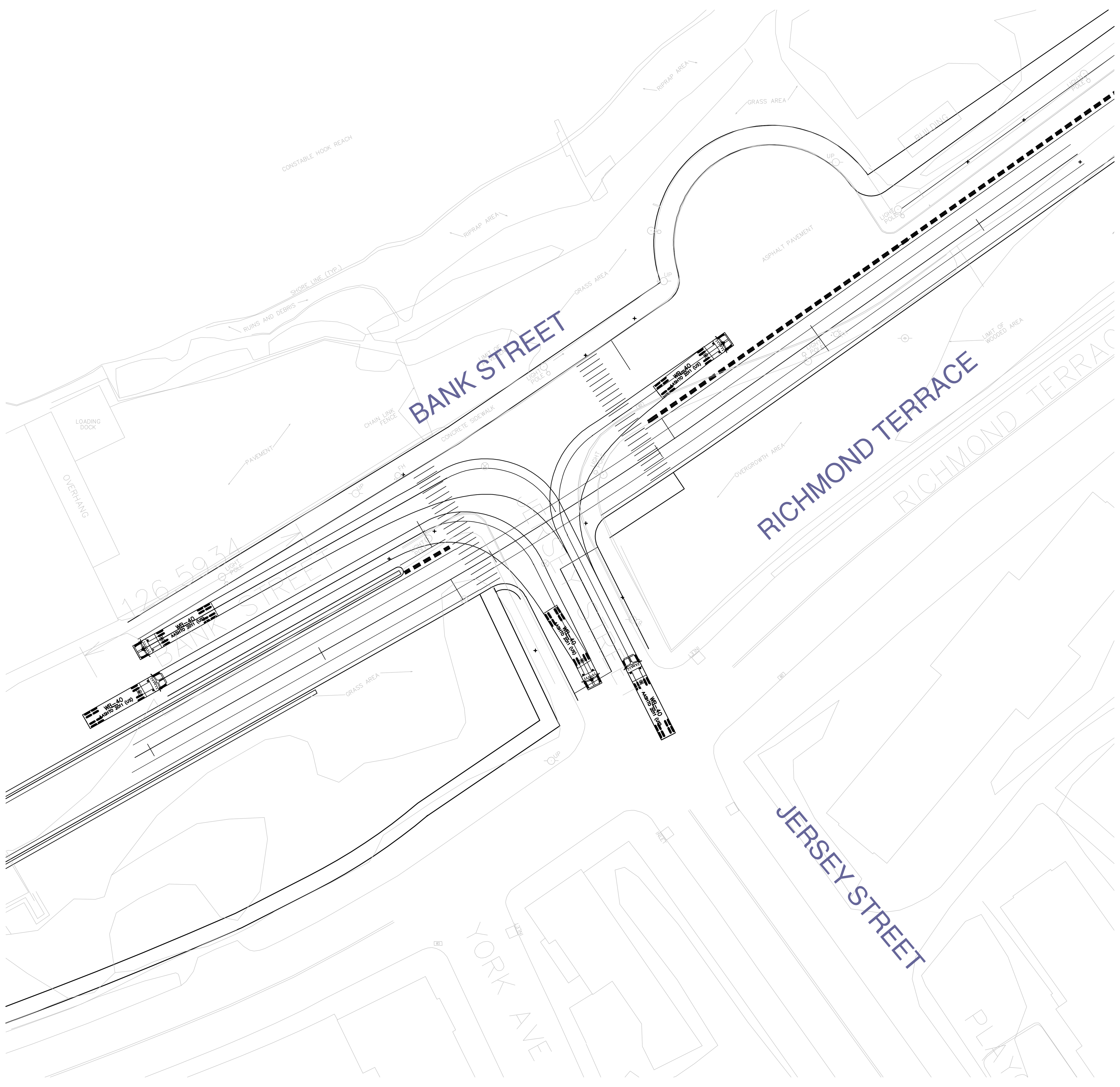
SCALE : 1" = 40'



LIVINSTON STATION

MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

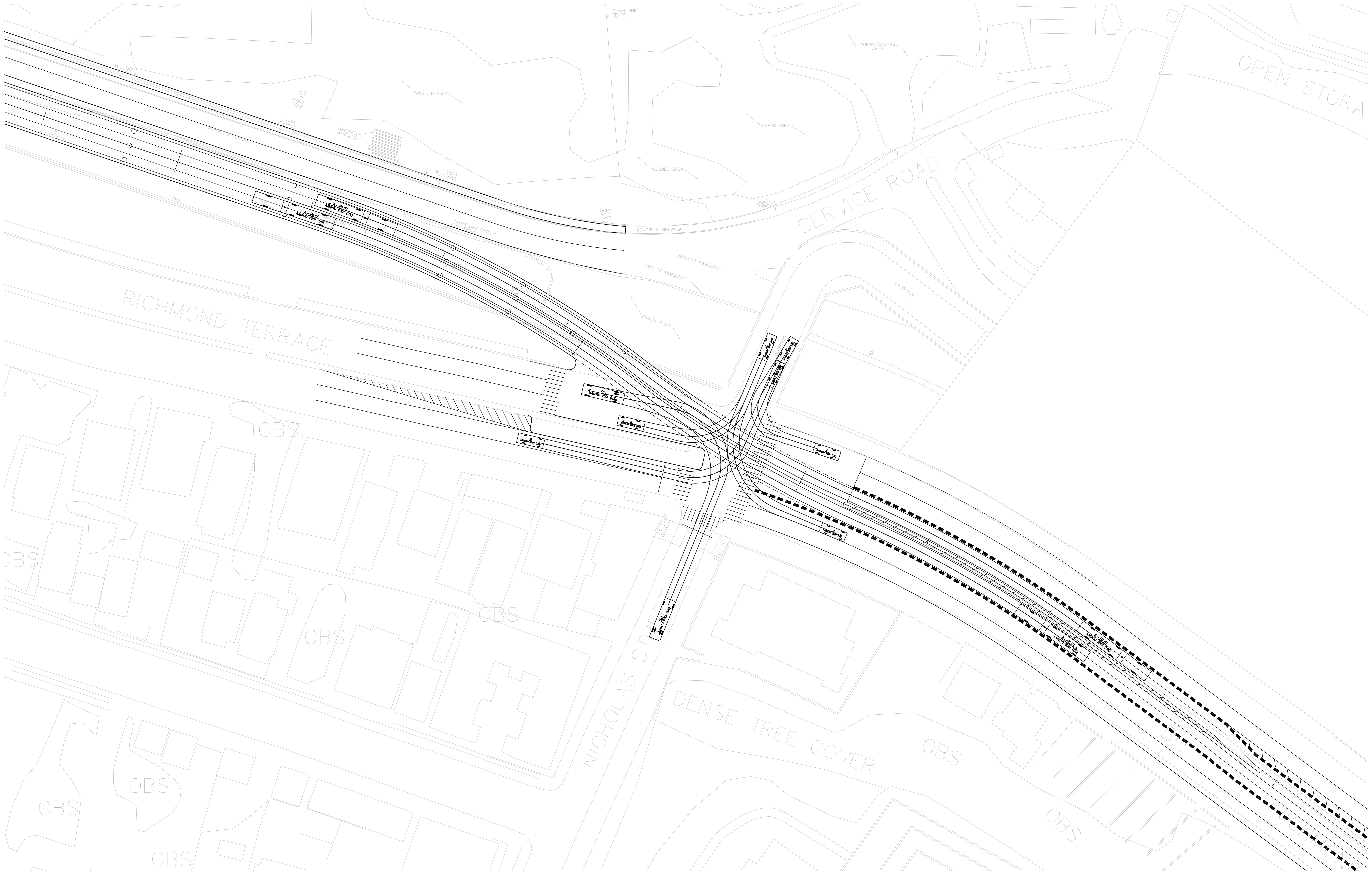
SCALE : 1" = 40'



INTERSECTION OF BANK STREET AND JERSEY STREET

MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

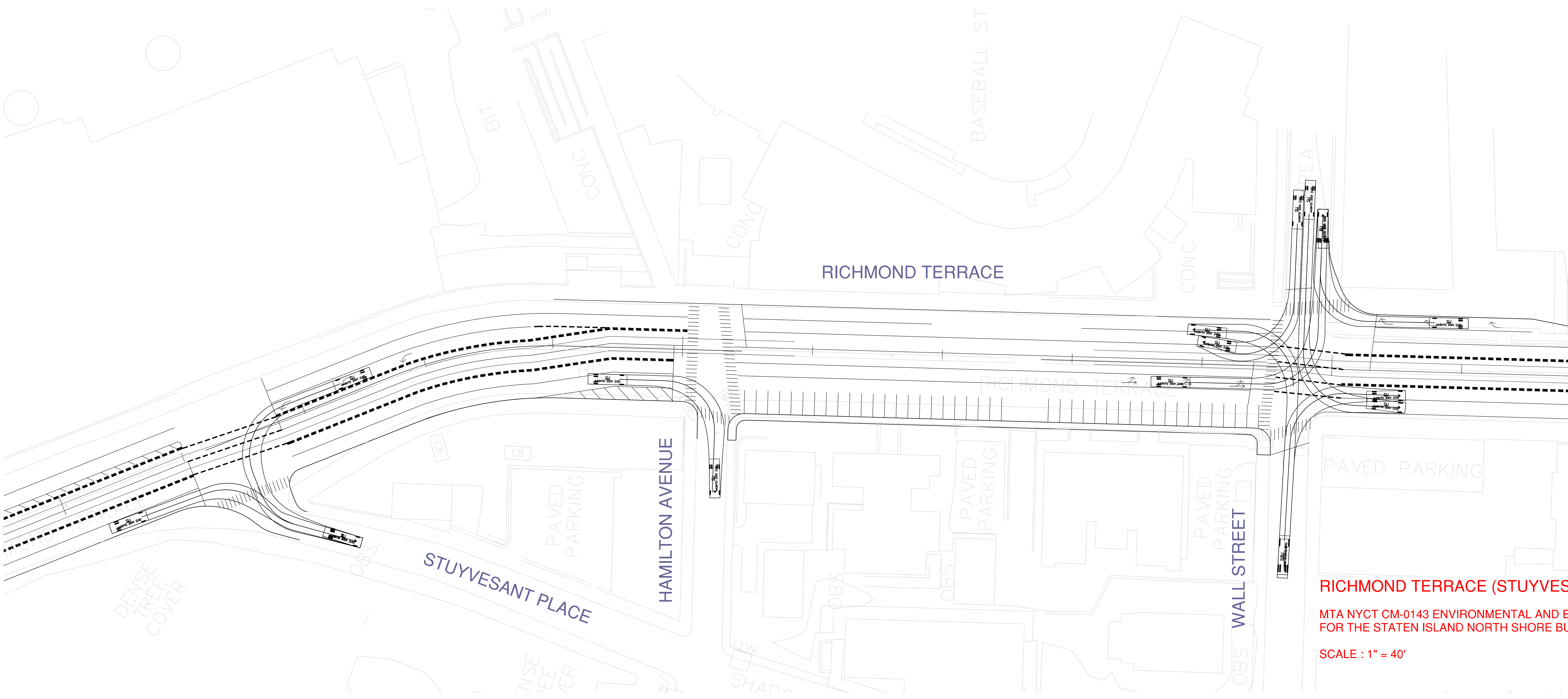
SCALE : 1" = 40'



NICHOLAS STREET RAMP

MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

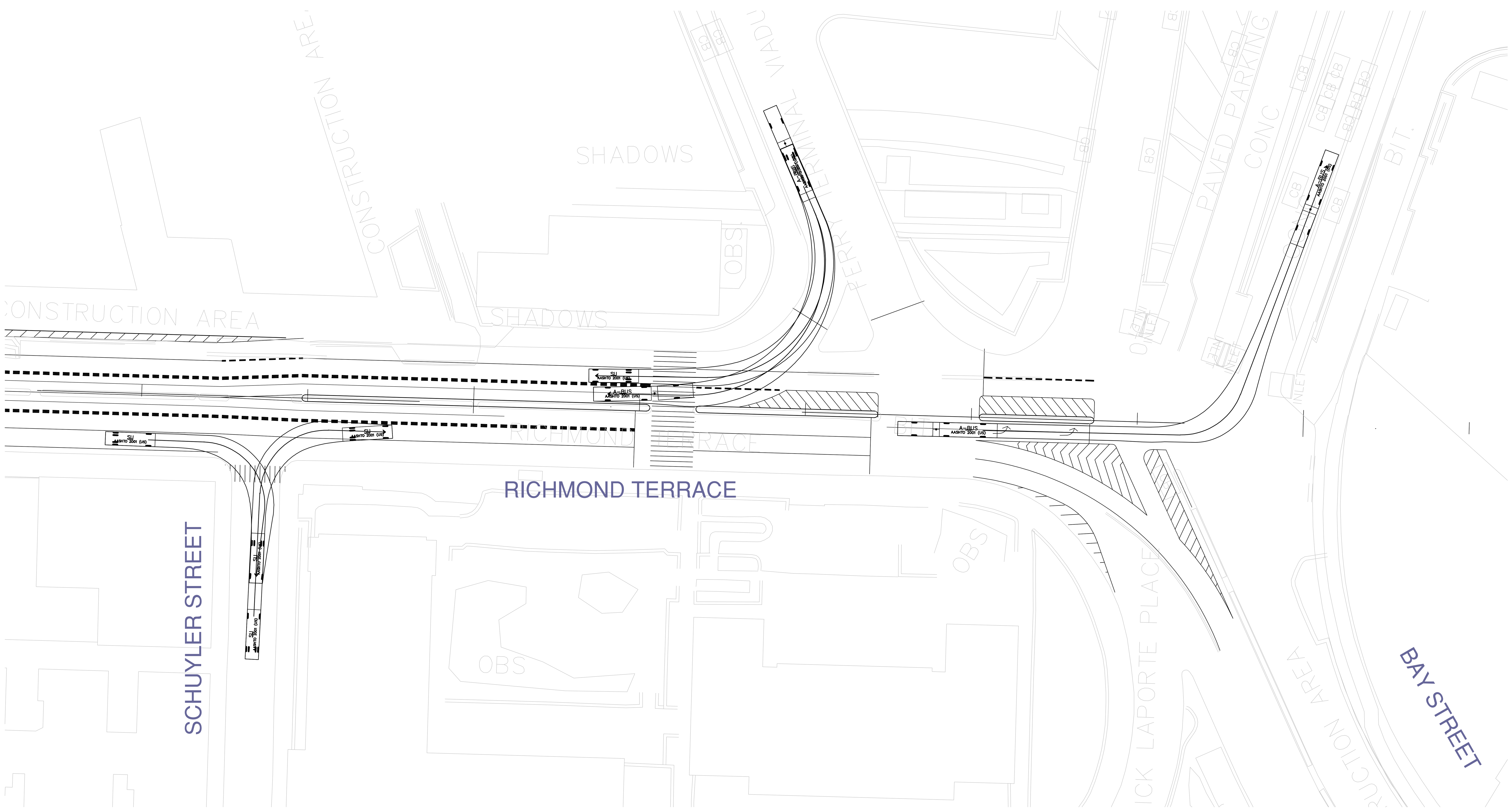
SCALE : 1" = 40'



RICHMOND TERRACE (STUYVESANT PL TO WALL ST)

MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

SCALE : 1" = 40'



RICHMOND TERRACE (SCHUYLER ST TO BAY ST)

MTA NYCT CM-0143 ENVIRONMENTAL AND ENGINEERING SERVICES
FOR THE STATEN ISLAND NORTH SHORE BUS RAPID TRANSIT SYSTEM

SCALE : 1" = 40'