MARYLAND DEPARTMENT OF TRANSPORTATION
AND THE MARYLAND TRANSIT ADMINISTRATION

AND

PURPLE LINE TRANSIT PARTNERS LLC

TECHNICAL PROVISIONS
PART 2, DESIGN BUILD REQUIREMENTS

EXECUTION VERSION

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Part 2 – Design Build Requirements

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PART 2A, DESIGN BUILD GENERAL REQUIREMENTS

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1 PROJECT MANAGEMENT

Concessionaire shall manage the Project using a Project Management Plan (PMP).

1.1 Project Management Plan (PMP)

Concessionaire's PMP shall, at a minimum:

- comply with the requirements of the U.S. Department of Transportation, Federal Transportation Administration, *Project and Construction Management Guidelines,* and the Contract Documents;
- clearly state, detail, and describe the approach and intended results to demonstrate compliance with the scope, goals, and objectives of Project;
- identify and comply with all applicable codes, standards, specifications, regulatory requirements, and directives and/or requests from the Authority Having Jurisdiction (AHJ);
- be ISO 9001 and ISO 17024 compliant;
- coordinate and incorporate all other Project plans;
- coordinate and incorporate Project Execution Plans as required by the Third Party Agreement Requirements, and Part 2A, Sections 18.3 and 19.3 of the Technical Provisions;
- identify by cross-reference all other plans;
- identify by signature page and date, the title of the qualified professionals who are responsible for planning, reviewing, approving, reporting, monitoring, controlling, implementing, revising, and issuing the PMP, including revisions;
- identify required resources and competencies for defined roles and activities for all aspects of the Project;
- identify training requirements by defined roles and activities;
- identify document and data control responsibilities for review and approval;
- identify the procedures for document review, submittal, revisions and approvals;
- identify the procedures for schedule, budget, and finance management;
- indicate by statement and certification that Concessionaire is responsible for Quality Control and Quality Assurance (QC and QA);
- identify the methods to identify and control non-conformances, and the corrective actions and the schedule to perform the corrective action;
- identify the recording and reporting procedures for non-conformance activities, the corrective actions, and the preventative actions to eliminate recurrences;
- identify the audit procedures, audit reporting process, and audit reporting schedule; and
- develop and update the PMP to facilitate external audits, including those performed by Owner.

Owner will perform obligations under the Technical Provisions explicitly stated as Owner's responsibility; all other obligations in the Technical Provisions not expressly assigned to Owner or explicitly assigned to Concessionaire are Concessionaire's responsibility. Concessionaire's PMP shall be structured to include the time periods during which the following Work is accomplished:

- Design Work;
- Construction Work;
- testing, certification, and commissioning;
- Rail Activation; and
- O&M Work.

Concessionaire's development of the PMP shall be consistent with and build on those elements of the Project Management Plan submitted as part of the Proposal.

Concessionaire shall submit the PMP for Review and Approval within 60 calendar days after Financial Close. The PMP shall be Approved before commencement of D&C Work. Concessionaire shall update and resubmit the PMP for Review and Approval annually or whenever there is a significant change to the PMP.

1.2 Summary of Submittals

Item	Section	Submittal	Action
1	1.1	Project Management Plan	Review and Approval

2 PROJECT TEAM

2.1 Project Team Requirements

Concessionaire's Key Personnel for the Project require Owner approval.

Key Personnel Resumes and References submitted with the SOQ or Proposal as supplemented, if applicable, in response to Owner queries, are considered preapproved. Key Personnel shall not be changed or replaced without Owner's Review and Approval. Concessionaire shall submit Resumes and References for replacement of Key Personnel for Review and Approval a minimum of 21 calendar days prior to planned replacement.

2.2 Resumes and References

Resumes and references shall be not more than two pages for each person. Concessionaire shall provide three references for each person for work performed on projects within the past five years; provided, however, that where the person has worked on less than three projects during the past five years, the Proposer shall (a) affirmatively state that such person has worked on less than three projects during the past five years; (b) include references for each of such projects; and (c) include references for projects worked beyond the past five years so that the number of references equals three in total.

References for each person shall be previous owners, clients, or employers and shall include the name, position, company, or agency, and current postal and email addresses and phone numbers.

2.3 Key Personnel

2.3.1 Project Manager

The Project Manager shall have full responsibility for the execution of the Work on behalf of Concessionaire. The Project Manager shall have at a minimum 15 years of experience in a senior position within an organization where he/she had responsibility for (a) at least one P3 Project with a capital construction cost of more than $250 million and a concession term greater than 15 years or (b) integrating design, construction, operations, and maintenance on at least one rail and/or transit project that is, as of January 1, 2014, in operation. The Project Manager shall be located at the Project Site from the issuance of the Financial Close until the end of the Term.

2.3.2 Engineer of Record

The Engineer of Record shall have a bachelor's degree or equivalent and shall be a licensed professional engineer under the laws of the State of Maryland that performs the design and analysis, and is in "responsible charge" in accordance with Title 14 of the Business Occupations and Professionals Article of the Annotated Code of Maryland on behalf of Concessionaire for the preparation of the Design Documents. The Engineer of Record shall have experience on at least one transit, rail project, or highway design-build project with a capital construction cost of no less than $250 million. The Engineer of Record shall have at least 15 years of relevant design experience. The Engineer of Record may also serve the role as the Design Manager. The Engineer of Record shall be located at the Project Site from issuance of Financial Close until all major design milestones have been completed and available when requested by Owner until 12 months after Final Completion.

2.3.3 Design Manager

The Design Manager is the individual responsible for managing the Project's design on an operational level on behalf of Concessionaire. The Design Manager shall have experience on at least one transit, rail project, or highway design-build project with a capital construction cost of no less than $250 million. The Design Manager shall have at least 15 years of relevant design management experience. The Design Manager shall be located at the Project Site from Financial Close until all major design milestones have been completed and available when requested by Owner until12 months after Final Completion.

The Design Manager shall have a bachelor's degree or equivalent and be a licensed professional engineer or equivalent.

2.3.4 Construction Manager

The Construction Manager shall be the individual responsible on a day-to-day basis for the activities of construction from the commencement of Construction Work to Final Completion of the Project. The Construction Manager shall have experience as a project/construction manager on at least one transit, rail project, or highway design-build project with a capital construction cost of no less than $250 million. The Construction Manager shall be located at the Project Site from Financial Close until no less than 2 months after Final Completion and will be available until all Design Work and Construction Work-related disputes and claims are resolved.

The Construction Manager shall have a bachelor's degree or equivalent.

2.3.5 Operations Manager

The Operations Manager shall be the individual responsible for oversight of all operation activities of the Project on behalf of Concessionaire. Operations activities are expected to include the training, supervision, and provision of all operations personnel necessary to ensure that the Project provides safe, effective, and reliable service.

The Operations Manager shall be available from Financial Close and then be assigned full time to the Project and located at the Project Site from no less than 12 months prior to Final Completion or Safety and Security Certification, whichever occurs first for the duration of the O&M Period.

The Operations Manager shall possess relevant operations experience on rail or transit systems of a similar nature, size, and complexity for a minimum of 15 years, with no less than 10 years in a management or supervisory position.

2.3.6 Maintenance Manager

The Maintenance Manager shall be the individual responsible for oversight of all maintenance and capital replacement activities of the Project on behalf of Concessionaire. The Maintenance Manager shall have at least 15 years of progressive experience in the daily maintenance and capital replacement activities for operating rail or transit systems of comparable scope and complexity, including the tracks, Stations, maintenance facilities, Platforms, and vehicles.

The Maintenance Manager shall be available from Financial Close and then be assigned full time to the Project and located at the Project Site from no less than one year prior to Final Completion or Safety and Security Certification, whichever occurs first for the duration of the O&M Period.

2.3.7 Quality Program Manager

The Quality Program Manager is the individual retained by Concessionaire with the authority and responsibility for quality management, quality system-related activities for all Work, including the establishment and maintenance of, and compliance with the quality management plan or equivalent report/Submittal. The Quality Program Manager shall have no Project responsibilities other than quality assurance and quality management and control of the Project, and shall be independent from staff and duties associated with the execution/production of the Work.

The Quality Program Manager shall be working full time and exclusively for the Project during Design Work and Construction Work and be available as required during the O&M Period.

The Quality Program Manager shall have a bachelor’s degree or equivalent. The Quality Program Manager shall have 10 years of quality management experience on rail, transit, or other design-build projects and have undertaken training in the use and application of Quality Programs including the application of ISO 9001:2008.

2.3.8 Economic Empowerment Manager

The Economic Empowerment Manager is the individual with the authority and responsibility for (a) reporting on, reducing barriers, and leveling the playing field for the participation of small businesses, including DBE/MBE firms; (b) workforce development programs; and (c) community workforce partnerships, including training and apprenticeships. The Economic Empowerment Manager shall be full time and located at the Project Site from Financial Close to no less than one year after Revenue Service Availability. The Economic Empowerment Manager shall have no Project responsibilities other than the duties described above and shall be independent from management and staff associated with the procurement and execution/production of the Work, except that once the conditions of Revenue Service Availability have been achieved, the Economic Empowerment Manager may be assigned to other Project responsibilities reasonably related (such as reporting, fiscal processing, compliance, public affairs, or other related activities). The Economic Empowerment Manager shall have a bachelor’s degree or equivalent and shall have prior experience with projects which had to comply with 49 CFR Part 26.

2.4 Summary of Submittals

Item	Section	Submittal	Action
1	2.1	Resumes and References	Review and Approval

3 DESIGN

This Section contains requirements for the Design Work process for the Project. In addition to the Design-Build Period, the requirements of this Section shall apply to all design and construction activities during the O&M Period.

3.1 Design Requirements

Concessionaire shall provide design studies, reports, documents, plans, and specifications as required by the Contract Documents, and as required for Concessionaire to provide a complete Project and to operate and maintain the Project in accordance with the requirements of the Contract Documents. Concessionaire shall:

- manage and perform the Design Work pursuant to the requirements of the Contract Documents;
- manage and perform the Quality Control and Quality Assurance for the Design Work;
- manage, coordinate, and obtain all necessary approvals and permits from Owner, Utility Owners and Third Parties;
- prepare all Design Documents under the direct supervision of Concessionaire’s Lead Design Firm; and
- verify pertinent dimensions and other relevant existing conditions in the field prior to the Submittal of the design plans.

Design plans and specifications, together with all pertinent supporting documents and data, shall be subject to Review by Owner, Third Parties, and Utility Owners in accordance with the Third Party Agreement Requirements and Owner Utility Agreements.

References to Laws/Standards in these Technical Provisions are as may be amended from time to time.

Third Party, Utility, County or locality specific requirements, to the extent cited, apply only with respect to that portion of the Work performed for such Third Party, Utility, County, or AHJ.

3.2 Integrated Design Process

Concessionaire shall utilize an integrated design process to design all elements of the Project in a synchronized manner so that the Project is designed as an integrated whole and functions effectively and efficiently for the intended purpose.

Concessionaire shall identify all requirements, including design, construction, operations, and maintenance that apply to the design of each element of the Project.

Concessionaire shall address the highest-level performance requirements as matters of priority to determine the impact of these requirements on individual Project elements.

Concessionaire's integrated design process shall identify, catalog, and track the status of all interfaces between different Project elements. Interface management shall include the assignment of design responsibilities, coordination requirements, the completion of the designs, the assignment of construction responsibilities, the assignment of inspection responsibilities, the assignment of test responsibilities, and the execution of inspections and tests to demonstrate the correct functionality of the interfaces.

Concessionaire shall provide coordinated services inclusive of reviews and permitting by Owner, Utility Owners, and Third Parties.

Concessionaire’s design process shall demonstrate to Owner through each design submission that individual elements have been designed to integrate with the Project as a whole and will support the intended purpose.

3.3 Design Document Organization

Concessionaire shall arrange Design Documents in a systematic order and identify them with alpha/numeric designations based on discipline designations, locations, and sequential numbering in accordance with the Owner’s CADD Standards.

3.3.1 Design Certification

Concessionaire shall provide Design Certification by the Engineer of Record that each design Submittal is:

- consistent and compliant with all applicable requirements of the Contract Documents;
- consistent will all other elements of the Project;
- accurate, complete, and in a form and level of detail that is appropriate to the design stage to which it applies; and
- coordinated among all requirements of the Contract Documents, including at a minimum, Design Work, Construction Work, and O&M Work.

3.3.2 Supervision and Seals

Prior to delivering any Release for Construction Documents to Owner or to any of Concessionaire’s construction teams, the contents of the Release for Construction Documents shall be individually signed and sealed by the licensed professional engineer under the laws of the State of Maryland responsible for the specific content included in the documents. The Engineer of Record shall sign and seal the title sheet.

3.4 Design Exceptions and Waivers

Requests for Design Exceptions or Design Waivers shall be considered a Deviation in accordance with the Agreement.

Concessionaire shall be solely responsible for acquiring approval from Owner, Utility Owners, and Third Parties as may be required.

Concessionaire shall obtain all necessary Deviation approvals before submission of Final Design Documents.

3.5 Existing Conditions

Concessionaire shall ensure that the condition of existing buildings, structures, roadways, sidewalks, paths, trails, lighting, and signal equipment, or other property that is to remain in place or is to be modified is not adversely affected by the performance of the Work. Concessionaire shall perform appropriate property pre-condition surveys and associated monitoring, and shall repair any damage determined to be caused by the Work.

3.6 Design Stages

Concessionaire shall classify design Submittals in accordance with the following general design stages:

- Preliminary Design;
- Intermediate Design; and

- Final Design.

Concessionaire shall determine the appropriate level of design completion for each stage using the requirements of the Contract Documents, Good Industry Practice, and the designated Submittal requirements for each stage in order to ensure all Project requirements are met.

Except where required elsewhere in the Contract Documents, design of different Project elements, engineering disciplines, and geographic sections of the Project shall be:

- initiated at Preliminary Design or Intermediate Design stage; and
- include a minimum of two Submittals, which shall include Final Design and either Preliminary Design or Intermediate Design.

Concessionaire shall determine if the required design stage Submittals will satisfy all Third Party Agreement Requirements and Owner Utility Agreements. Concessionaire shall be responsible for preparing additional Submittals for Third Parties and Utility Owners as necessary to prosecute the Work.

3.7 Release for Construction Documents

Release for Construction Documents (RFCD) shall be used by Concessionaire to construct the Project. The RFCD shall include plan sheets, specifications, shop drawings, working drawings, and other pertinent information as applicable. The RFCD may only be issued by Concessionaire after all previous comments related to the elements, whether in the subject Submittal or not, have been addressed and appropriately incorporated, non-conformances have been corrected, and appropriate approvals and permits have been obtained.

Concessionaire shall submit Release for Construction Documents for Information before commencing the Construction Work contained in the RFCD.

3.8 Conformed Release for Construction Documents

Concessionaire shall at all times maintain a conformed, electronic .pdf format, set of all RFCD plans, specifications, and shop drawings. The conformed RFCD shall also include formally issued revisions made after release for construction, but are not construed as as-built records.

The conformed RFCD shall be electronically accessible to the Owner from Project and remote locations at all times. The conformed RFCD shall contain master indexes such that relevant plans, specifications, or shop drawings can be easily located.

3.9 Interface Management

Concessionaire shall implement an interface management process to ensure that all Project elements, systems, and facilities interface with each other and with outside systems, elements, and facilities throughout the Term.

The disciplines requiring interface monitoring include interfaces within a single discipline, interfaces between disciplines, interfaces with disciplines outside the Project but within the Owner, and interfaces with Third Parties and Utility Owners. These interfaces are defined further as:

- Project to Project within a single discipline or sub discipline. e.g. communications/CIB to communications/telephones;
- Project discipline to other Project disciplines. e.g. communications cables with Station conduits;
- Project disciplines to existing Owner systems and equipment. e.g. Project MDOT CIB network with existing MDOT CIB network;

- Project disciplines to non-Owner external systems (e.g. Train control/AVL with county and MDSHA traffic signals); and
- Project disciplines to various Owner departments (e.g. fare collection with Owner Treasury).

There are two classifications of interfaces:

- equipment to equipment Interfaces; and
- equipment to human interfaces.

3.9.1 Systems and Facilities

The Project systems and facilities interface with each other and with outside systems and facilities. Concessionaire shall include all Project elements in the interface control process.

3.9.2 Project External Interfaces

Concessionaire shall provide interfaces with other systems and facilities that are external to the Project, including, at a minimum:

- existing Owner systems and equipment;
- Owner systems to be constructed by others to support the Project;
- Systems and facilities to be constructed by Concessionaire for Third Parties and Utility Owners as part of the Project;
- existing and to be constructed by others systems and facilities owned and operated by Third Parties and Utility Owners. These include, but are not limited to, traffic signal systems, Utilities, WMATA, PEPCO supply power, and existing road and bridge infrastructure; and
- physical locations of Owner departments where Owner employees are tasked with monitoring of Project systems.

3.9.3 Internal Equipment to Equipment Interfaces

The Project LRVs and operational systems and facilities shall interface and operate with each other to deliver safe, reliable, and efficient service to Users. These interfaces include three sub-categories of interface:

- system to system interfaces are mostly communication-based interfaces that implement electronic hand shaking between two systems. This type of interface consists of physical and/or logical connections between two interfacing systems and information (voice/ video/ data) that is transmitted between them, and shall include a communication protocol (e.g. Transmission Control Protocol/Internet Protocol or other) that governs the nature of the information transmission;
- system to facility interfaces include physical interfaces in which a facility may provide a physical support for a systems device or an electrical/electronic interface in which a system may control or monitor the status of a facility element; and
- facility to facility interfaces are the physical coordination of different facilities elements and typically involve form, fit, and structural integrity (e.g. embedded conduit or equipment rooms).

3.9.4 Equipment to Human Interfaces

The Project LRVs and operational systems shall interface with human operators through numerous conventional means which are established by building codes and also, for more complex functions, by Graphical User Interfaces (GUI) implemented on systems workstations. These workstations may be located at the OCC, BOCC, Security Center, and other locations throughout the Project as required by Concessionaire's Concept of Operation. The workstations shall be provided, as a minimum, as elements of the LRVs, Train Control, Traction Power, communications, control and monitoring, fire and security, and fare and MEP systems. These interfaces shall allow the operations and maintenance personnel to view the information presented in an ergonomic and logical format, and to interact with the systems for changing views, issuing commands, and performing other related functions. These interfaces may include existing standard designs and custom designs based on functional requirements and ergonomic factors. Concessionaire shall furnish, install, program, and configure these GUIs and workstations, including the updating of all GUI databases as required.

3.9.5 Interface Management

Concessionaire shall develop and execute an interface management program to identify and develop all interfaces and integration needed to support the Project and including all necessary steps to be taken throughout the design, construction, and testing of the Project. This interface management program shall include, at a minimum, the following steps:

- identification and classification of all interfaces – a process initially conducted during Preliminary Design and then updated as necessary throughout the rest of the Project by which Concessionaire shall review all Project requirements to identify and define the interfaces;
- assignment of responsibilities among Concessionaire's organization for designing, constructing, and testing the interfaces;
- specification and deployment of tools required to manage and organize interfaces, present attributes clearly, and allow all stakeholders to coordinate interfaces;
- definition and design of interface attributes and functionality, including physical connection, data type, medium, and other interface details as appropriate;
- formal sign-off by the responsible designers and/or operators on all sides of the interface that the interface design is acceptable;
- means (inspection or test) to be used to verify the correct functionality interfaces; and
- provision for continued peer review of identified and new interfaces, and revisiting the process before each.

3.9.6 Interface Control Manual (ICM)

Concessionaire shall develop and maintain a comprehensive ICM. This manual shall include two key tools for managing interfaces:

- the Interface Control Matrix – a database to track all details and design, manufacture, construction, and testing responsibilities for each interface; and
- the Interface Control Form – to collect input data for the Interface Control Matrix.

Concessionaire shall define both of these documents.

For the Preliminary Design, Concessionaire shall prepare and submit for Review and Comment the initial ICM, including the Interface Control Matrix, the database, and the Interface Control Form. Concessionaire shall provide a means to confirm that the interface has been coordinated and accommodated in the associated systems and affected system, facility, or human counterpart.

For the Intermediate Design, Concessionaire shall prepare and submit for Review and Comment the current version of the Interface Control Manual, including the Interface Control Matrix, the supporting database, and the Interface Control Form. Concessionaire shall provide a means to confirm that the interface has been coordinated and accommodated in the associated systems and affected system, facility, or human counterpart.

For the Final Design, Concessionaire shall prepare and submit for Review and Comment the current version of the ICM, including the Interface Control Matrix, the supporting database, and the Interface Control Form. Concessionaire shall provide a means to confirm that the interface has been coordinated and accommodated in the associated systems and affected system, facility, or human counterpart.

After the completion of Integration Testing, Concessionaire shall update the ICM as a Record Document and submit for Information.

As an alternative to the above listed Interface Control Manual Submittals, Concessionaire may provide personnel as designated by Owner with continuous access to Concessionaire's interface management system.

3.9.7 Interface Control Tools

Exhibit 3.1 identifies the documentation that shall be developed to support the Interface Control process:

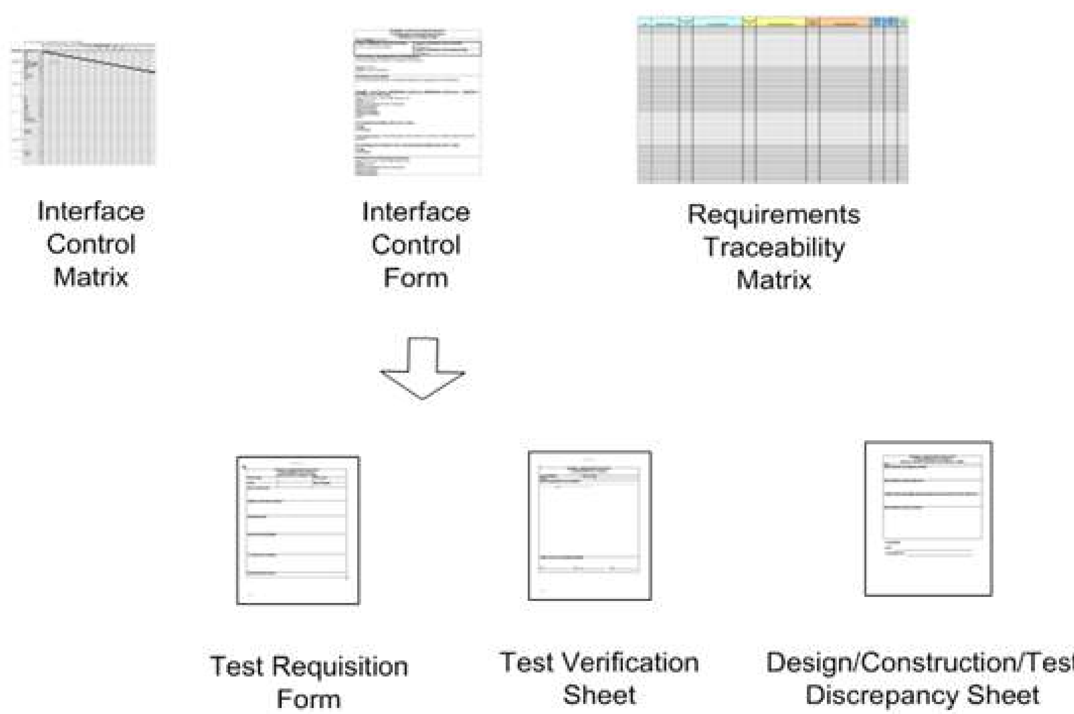


Exhibit 3.1 – Interface Management Document/Tool Structure

Concessionaire shall use the following tools or alternate functional equivalents to identify and document interfaces: data flow diagrams and accompanying interface descriptions, the Interface Control Matrix, Interface Control Forms, and detailed system interface diagrams. The following sections describe these interface control tools.

3.9.7.1 Data Flow Diagram and Accompanying Interface Descriptions

The data flow diagram shall facilitate the identification of System and GUI between core systems and external systems. These are shown as bubble diagrams depicting which systems have interfaces and how that interface functions (one-way or two-way) via arrows. Concessionaire shall submit the data flow diagram as part of the design documentation for each facility and system.

3.9.7.2 Interface Control Matrix

The Interface Control Matrix shall show all of the Project systems' and facilities' internal and external interfaces. Each interface shall be assigned a unique designation for tracking purposes. The details of each interface shall be captured in a separate Interface Control Form with a title and filename corresponding to this numbering scheme. Therefore the Interface Control Matrix shall indicate interface(s) between core and target systems, and point the reader to where the details of that interface can be found.

3.9.7.3 Interface Control Forms

Using the data flow diagram, Interface Control Matrix, and associated numbering scheme, a unique alphanumerical name shall be assigned to each interface shown in the initial data flow diagram. The interface control forms shall capture and be used to verify that all of the interface data is acknowledged, coordinated, and incorporated into the system and shall be tested.

The interface management process shall document several attributes for each interface. These attributes shall provide detailed characteristics of each interface such that further definition can be provided.

3.9.7.4 Detailed System Interface Diagrams

The detailed system interface diagrams shall include the following items at a minimum:

- all equipment such as devices, control panels, patch panels, workstations, hardware firewalls, servers, clients;
- connectivity to all equipment in remote locations, including communications rooms, OCC, BOCC, and elevators, along with connections to other communication systems and external systems;
- a legend that shows the physical type of connection (such as RS232, RS-422, RS-485, IP Ethernet (10BT/100BT/1000BT), contact closure) with appropriate notes such as RS-485 Full duplex connection allows up to 256 devices per system controller at up to 4000 foot distances;
- a legend that shows the types of traffic (type of data e.g. IP (unicast, multicast) local/remote client/server connections and/or peering capability;
- all point-to-point and/or point-to-multipoint site connectivity shall be included;
- the interfaces to other communication systems and specific types of data interfaces (analog or data) such as RS-232,422, or 485; copper or fiber optics; data rate speeds

required (kbps);, VLAN (IEEE 802.1q) capability; IEEE 802.1p MAC Quality of Service (QoS) prioritization capability; and Layer 3 Diffserv QoS capability;

- all necessary equipment details and network connectivity specifics, including client/server connectivity, Layer 2 VLAN assignments, and Layer 3 routing between associated equipment (if applicable) between the OCC and remote sites;
- equipment redundancy and cable redundancy if applicable;
- the head-end physical and software requirements (Open Architecture e.g. HP OpenView);
- a recommended QoS assignment that ensures that the data flow is without significant packet congestion or packet delay;
- the PSTN connectivity and its specific equipment and interface types to allow backup recovery; and
- interface details to the existing Owner equipment/locations if applicable.

3.10 Common Design Documents

Certain types of Design Documents are required for all Project elements and engineering disciplines. In addition to the Submittal requirements listed in each Section of the Technical Provisions, Concessionaire shall prepare and submit the following Design Documents for every Project element and engineering discipline.

3.10.1 Design Criteria Report

The Contract Documents provide design criteria for some Project elements. Concessionaire shall develop design criteria for the remaining Project elements. The Design Criteria Report shall identify how the requirements of the Contract Documents have been interpreted in terms of the configuration, performance, and all other requirements.

The first submittal related to a Project element shall include, or be preceded by, a Design Criteria Report.

3.10.2 Basis of Design Report

Concessionaire shall create and maintain a comprehensive Basis of Design Report (BODR) for the Project.

The first submittal related to a Project element shall include a BODR. Each BODR submitted shall be a portion of the overall BODR.

Concessionaire shall submit the Basis of Design Report Record Document for Information upon completion of all elements of the BODR.

The BODR Record Document shall be logically organized wherein each of the major Work elements are organized, including:

- Table of Contents;
- Executive Summary;
- Project Controls; and
- Design Work.

The BODR shall address the following as applicable to each Project element:

- design methodology and approach;

- key assumptions:
  - identify applicable design criteria, considerations, influences, and factors;
  - identify concurrent design activities;
  - address Third Party activities and resolution;
  - identify construction approach, including sequence, phasing and staging (if applicable); and
  - identify significant revisions from the Book 4 Contract Drawings, ROD, FEIS, and any associated revisions to governmental approvals.
- operations and maintenance design methodology:
  - identify and describe 24/7 daily operation modes and staffing;
  - identify and describe special event operation modes and staffing;
  - identify and describe 24/7 daily maintenance systems and staffing; and
  - identify and describe system failure and recovery sequences and scenarios (note: including internal and external events, i.e. component failure and weather).

3.10.3 Specifications

Written specifications shall be provided that document the requirements for materials, equipment, systems, standards and workmanship for the Work and performance of related services. At a minimum Final Design and RFCD Submittals shall include specifications.

3.10.4 Not Used

3.10.5 Calculations

Concessionaire shall prepare and submit calculations for Project elements including, at a minimum, structural elements, final geometry, pavement, hydraulics, hydrology, storm water management, mechanical, electrical, plumbing, track, LRV and systems. Concessionaire shall prepare and submit calculations necessary to support that the design meets contract requirements for design life of all Project elements.

3.11 Operations and Maintenance Submittals during Design

Certain Submittals related to O&M Work identified in Part 3 of the Technical Provisions are required to support the Design of the Work as follows:

- Operating Plan including appendices – 90 days after Financial Close in accordance with Part 3, Section 1.1 of the Technical Provisions; and
- Rail Fleet Management Plan - 90 days after Financial Close in accordance with Part 3, Section 1.2 of the Technical Provisions.

3.12 Summary of Submittals

Item	Section	Submittal	Action
1	3.4	Request for Design Exceptions or Design Waivers	Review and Approval
2	3.7	Release for Construction Documents	Information
3	3.9.6	Interface Control Manual – Preliminary Design	Review and Comment
4	3.9.6	Interface Control Manual – Intermediate Design	Review and Comment
5	3.9.6	Interface Control Manual – Final Design	Review and Comment
6	3.9.6	Interface Control Manual – Record Document	Information
7	3.10.2	Basis of Design Report Record Document	Information

4 GEOTECHNICAL

4.1 Overview

Concessionaire shall establish a geotechnical program as necessary to support the Work.

Concessionaire shall develop and execute plans to monitor and protect existing structures. Additional precautions shall be used where blasting, pile driving, or other ground-borne vibrations sources are expected.

4.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards, including, at a minimum, the following:

- American Railway Engineering and Maintenance of Way Association (AREMA), Manual for Railway Engineering;
- AASHTO Manual on Subsurface Investigations;
- AASHTO LRFD Bridge Design Specifications;
- FHWA Technical Manual for Design and Construction of Road Tunnels – Civil Elements;
- FHWA Manual of Subsurface Investigations, Publication No. FHWA NHI-01-031;
- MDSHA Standard Specifications for Subsurface Explorations;
- USBM RI 8507;
- WMATA Adjacent Construction Project Manual; and
- NFPA.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in 7.2.6 of the Agreement.

4.3 Owner-Provided Subsurface Data

The Owner has completed a preliminary subsurface exploration program. The preliminary site exploration program consisted of Standard Penetration Test (rings with rock coring, pressure meter testing, sonic borings, seismic refraction testing, acoustical tele-viewer, groundwater monitoring wells, and a laboratory testing program. Concessionaire may view and photograph available rock core samples upon request to Owner.

Geotechnical Data Reports (GDR) are provided in Book 5 Engineering Data. Concessionaire shall form its own interpretation of the existing geotechnical data and satisfy itself through its own investigations, if elected, as to the suitability and sufficiency of the geotechnical data, and the form and nature of the subsurface conditions.

A Geotechnical Baseline Report (GBR) for the area of the Plymouth Tunnel is provided in Book 5 Engineering Data. Concessionaire shall form its own interpretation of the existing geotechnical data and satisfy itself as to the suitability and sufficiency of the geotechnical data, and the form and nature of the subsurface conditions. The Owner neither assumes nor implies any warranty regarding the GBR, except to the extent that the Agreement provides for the GBR to be used as the basis for determining whether Differing Site Conditions exist.

Preliminary Geotechnical Engineering Reports (PGER) and Geotechnical Interpretive Reports (GIR) are provided as Reference Documents. The Owner neither assumes nor implies any warranty regarding the PGERs or GIRs, except as expressly set forth in the Agreement.

4.4 Subsurface Exploration Program

Concessionaire shall prepare and implement a subsurface exploration program with all field and laboratory testing necessary to characterize the geotechnical conditions and to perform all geotechnical and foundation design and analyses. The subsurface exploration program shall contain, at a minimum, the following elements:

- Subsurface Exploration Plan;
- Geotechnical Planning Reports (GPR);
- Geotechnical Engineering Reports (GER);
- Foundation Design Reports (FDR); and
- Geotechnical Tunnel Reports.

The requirements for each of the elements are described in the sections below.

4.4.1 Subsurface Exploration Plan

Concessionaire shall prepare a Subsurface Exploration Plan, including the following elements at a minimum:

- exploration methods, and reporting and documentation procedures;
- field organization, safety equipment, and precautions/procedures;
- methods and procedures to obtain Right of Entry;
- procedures for avoiding damage to Utilities and adjacent structures;
- Work zone safety and maintenance of traffic procedures;
- site restoration and disposal of spoils
- Standard Operation Procedures (SOP) in the event of incidents or injuries;
- Health and Safety Plan; and
- updated contact list of personnel to be contacted in the event of an emergency.

Concessionaire shall submit the Subsurface Exploration Plan for Review and Comment prior to commencing any geotechnical investigations.

4.4.2 Geotechnical Planning Reports

Concessionaire shall prepare GPRs for individual Project elements or logical groups of Project elements. Each GPR shall include the following elements at a minimum:

- description of geology and ground types to be encountered for the Project element;
- description of the existing geotechnical information used in developing the GPR;
- narrative describing the interpretation of the pertinent geotechnical data used as a basis for preliminary selection, design, and installation of the proposed foundation elements;

- assessment of the engineering properties of all soil types, including the expected average and range of soil strengths and deformation properties and the preliminary design parameters for all soil and rock types;
- description of the planned supplemental subsurface exploration program, including any variations or changes to the subsurface exploration;
- definition of the investigation, engineering, and design approach and code requirements that will be followed in order to develop the Project element; and
- details of field and laboratory testing programs.

The GPR shall be prepared, signed, and sealed by a licensed professional engineer under the laws of the State of Maryland. Concessionaire shall submit the GPR for Review and Comment prior to commencing any geotechnical investigations.

4.4.3 Geotechnical Engineering Report

Concessionaire shall prepare GERs for individual Project elements or groups of Project elements, which shall cumulatively cover all elements of the Project. Each GER shall be organized in accordance with the AASHTO *Manual on Subsurface Investigations* and the Subsurface Exploration Plan, including the following at a minimum:

- description of the Project element in enough detail to support the evaluations and recommendations in the report;
- definition of the geotechnical conditions as evaluated from field and laboratory test data and used in the development of the geotechnical design;
- summary of any design and analysis performed;
- plan showing locations of borings, rock coring, geophysical testing, and other in situ testing; and
- results of the field and laboratory testing.

The GER shall address design recommendations and construction considerations for site-specific topics, including, at a minimum:

- recommended site specific seismic design criteria and seismic site class;
- site description, including identification of existing above and below ground structures that may be affected by the proposed construction or that weigh on the geotechnical evaluations and recommendations;
- description of subsurface conditions, including a fence diagram and soil parameters used with estimated range of soil parameters;
- boring logs and laboratory testing results used for the recommendations;
- recommended ground improvement method(s);
- use of lightweight fills;
- corrosion potential of soils;
- impact of proposed construction to existing adjacent structures, Utilities, and groundwater;
- dewatering recommendations and concerns;

- recommended culvert foundations and minor Structure foundations, e.g. OCS, overhead/cantilevered signs, high-mast lighting foundations, headwalls;
- vibration and deformation monitoring, including threshold and limiting criteria for each instrument to avoid damage to nearby above and below ground structures;
- support of excavation requirements;
- evaluations and recommendations for embankment and cut slope stability for slopes greater than or equal to 20 feet in height or as otherwise required;
- any settlement or ground movement issues that may affect existing or proposed facilities;
- recommended pavement design;
- recommended field sampling and testing procedures for materials; and
- recommended verification and proof testing of foundations and tie-backs.

The GER shall be prepared, signed, and sealed by a licensed professional engineer under the laws of the State of Maryland. Concessionaire shall submit the GER for Review and Comment prior to or simultaneously with the Intermediate Design Submittal for the subject element.

4.4.4 Foundation Design Reports

Concessionaire shall prepare separate FDRs for each structure, retaining wall, and closely related structures. The organization of the reports shall be in accordance with AASHTO *Manual on Subsurface Investigations* and the Project Subsurface Exploration Plan. The FDRs shall include, but not be limited to:

- Project description to include foundation loads, settlement/deflection criteria, height of walls/abutments, and other design constraints;
- site description, including identification of existing above and below ground structures that may be affected by the proposed construction;
- description of subsurface conditions, including a fence diagram and soil parameters used;
- boring logs and laboratory testing results used for the report;
- recommended site specific seismic design criteria and seismic site class;
- engineering analysis, including seismic analysis;
- scour evaluation;
- erosion evaluation;
- dewatering recommendations and concerns;
- vibration and deformation monitoring, including threshold and limiting criteria for each instrument, to avoid damage to nearby above and below ground structures;
- support of excavation requirements;
- recommended field sampling and testing procedures for materials;
- recommended verification and proof testing of foundations and tiebacks;
- foundation recommendations;
- results of corrosion testing and recommendations for corrosion protection; and

- construction monitoring and inspection considerations.

Concessionaire’s foundation recommendations shall include design parameters, foundation types evaluated and recommended, foundation design elevations, recommended ground improvement measures, stability of retaining walls, structures and embankment slopes and seismic performance criteria. The FDR shall also document that any settlement of the proposed Structure or of adjacent existing Structures will allow for acceptable serviceability throughout the life of the Structure.

The FDR shall be prepared, signed, and sealed by a licensed professional engineer under the laws of the State of Maryland.Concessionaire shall submit the Foundation Design Report for Review and Comment prior to or simultaneously with the Intermediate Design Submittal for the subject element.

4.4.5 Geotechnical Tunnel Report

In addition to the above required reports, Concessionaire shall prepare a separate Geotechnical Tunnel Report addressing all tunnels included on the Project, including, at a minimum, the following elements:

- geotechnical data for the tunnel, including a description for the subsurface exploration program, methods for subsurface exploration, a subsurface exploration location plan, and subsurface exploration records. The subsurface exploration records include boring logs, observation well logs and slug test records, packer permeability test results, laboratory soil and rock test results, field water level measurements, and field gas measurements;
- geotechnical interpretation of the available geotechnical data, subsurface conditions, and ground behavior likely to influence the excavation support selection, excavation activities, and underground construction. This report also presents geotechnical design parameters of subsurface materials, for both temporary and permanent conditions, that will be used in designing the structural elements;
- structural design criteria for structures, including tunnels, below grade structures, support of excavation and transition structures. The design criteria shall set forth, but not be limited to, the following;
    - Codes and Standards;
    - references;
    - LRV dynamic clearance envelope;
    - materials;
    - design loads and load combinations;
    - methods of structural analysis and design; and
    - structural seismic design.
- evaluation of the method of tunneling to be used on any tunnel and recommendations based on the data contained in the other reports, studies, observations and other means relevant to the Project. If the Sequential Excavation Method (SEM) is to be used, then this report shall address the number of headings and their excavation sequence, the type of initial and final ground support, the effects of lowering the ground water to adjacent structures, any ground improvement required, and other relevant requirements;
- presentation of the logistics and requirements involved with the tunnel construction, which includes at a minimum:

- o outlining the staging of construction I and coordinating with the construction schedule;
  - o identifying the number and type of equipment required;
  - o identifying the staging area to start the tunnel excavation and mucking operations;
  - o identifying areas for stockpiling materials, such as shotcrete/concrete batch plant and steel sets .;
  - o estimating the number of truck loads required to haul away the excavated material and haul in required materials;
  - o identifying truck routes to an approved dumping site; and
  - o identifying areas for treatment of construction water and discharge locations.
- presentation of the results of Concessionaire's settlement analysis. The analysis shall simulate the effects of tunneling and dewatering to compute ground surface settlements for a predetermined width on either side of the tunnel centerline. The surface settlements shall be used to evaluate the impact of tunneling on the building structures, roadways, and Utilities located on either side of the tunnel. Concessionaire shall use PLAXIS, FLAC, UDEC, or other Owner-approved computer applications.

The Geotechnical Tunnel Report shall be prepared, signed, and sealed by a licensed professional engineer under the laws of the State of Maryland. Concessionaire shall submit the Geotechnical Tunnel Report for Review and Comment prior to or simultaneously with the Intermediate Design Submittal for the subject element.

4.5 Blasting and Vibration Monitoring Plans

Concessionaire shall control vibrations due to blasting or other work to avoid damage to structures or other property. All blasting operations shall be in accordance with Law and these specifications.

Concessionaire shall prepare a Blasting and Vibration Plan for all blasting within 500 feet of a structure and for all ground-borne vibration within 100 feet of a structure. These values shall be considered minimum distances, and Concessionaire is responsible for establishing the necessary distance based on detailed study and experience. Non-blasting vibrations shall conform to Part 2A, Section 17 of the Technical Provisions, The Blasting and Vibration Plan shall include the following elements at a minimum:

- blasting within a minimum of 500 feet of a structure or other property or will result in ground-borne vibration (e.g., pile driving, vibratory compaction) within 100 feet of a structure or other property;
- necessary public outreach and notification to be coordinated with Owner;
- establishment of local ground-borne vibration propagation characteristics by using a minimum of one small-test charge that is below the threshold level for that location;
- instrumentation, including seismometers or other devices placed in selected locations around a blast site to monitor vibration and air overpressure levels to use in refining the blasting program and document compliance with the limits specified herein;
- seismographs and measurement of blast-induced vibrations shall comply with International Society of Explosives Engineers specifications and guidelines. At a minimum seismometers shall be located at the nearest building or structure to be protected both

parallel and perpendicular to the strike of bedding or foliation and also comply with International Society of Explosives Engineers guidelines;

- air overpressures shall not exceed 0.013 psi (133 dB, based on linear weighting), or as required based on applicable regulations and ordinances;
- ground-borne vibrations shall be monitored and controlled based on peak particle velocities (PPV). Vibrations due to blasting shall not exceed the allowable maximum PPV as shown in the USBM RI 8507, and in no circumstance shall exceed 0.5-inches/sec for above grade structures and 4-inches/sec for underground Utilities at any frequency of motion;
- instrumentation, such as crack monitors, settlement monitoring points, or extensometers, to determine if structures are experiencing any movement as a result of the blasting;
- procedure for adjustments to the charge per delay for any change in condition encountered during Construction Work and as a result of monitored vibration levels; and
- pre-construction condition surveys performed prior to the initiation of blasting and after the completion of the blasting work.

Concessionaire shall notify Owner at least 45 calendar days prior to performing any blasting.

Concessionaire shall, for blasting within 100 feet of a WMATA-owned structure or facility, prepare a Blasting and Vibration Monitoring Plan complying with the requirements of this specification and WMATA requirements.

Blasting and Vibration Monitoring Plans shall be prepared, signed, and sealed by an engineer licensed in the State of Maryland. Concessionaire shall submit the Blasting and Vibration Monitoring Plans for Review and Comment a minimum of 60 calendar days before commencing blasting or vibration producing activities.

Concessionaire shall perform Pre-Construction Surveys, including at a minimum, the following:

- a location plan of each structure;
- a written description of each structure with a sketch of each anomaly or crack;
- photographs and video of the overall structure and detail photographs of each anomaly or crack noted; and
- recommendations for locating crack monitors and other instrumentation.

Concessionaire shall submit Blasting Pre-Construction Surveys for Information a minimum of 30 calendar days before commencing blasting or vibration producing activities.

4.6 Protection of Existing Structures Plan

Concessionaire shall identify and repair all adjacent structures, roadways, utilities, and properties which are damaged as a result of Concessionaire's activities. Concessionaire shall establish a Protection of Existing Structures Plan, including, at a minimum, the following:

- identification of above and below grade structures that might be affected by construction of this Project;
- required preconstruction surveys, including, at a minimum, locations where an excavation will extend below a line sloping down and away at an angle of 45-degrees below the horizontal below an existing building, structure, roadway, trackwork, or underground or

above grade Utility; or when required by AREMA or the published standards of the facility owner;

- establishment of methods used to minimize effects on existing structures and properties;
- procedures and instrumentation required for monitoring existing structures;
- limiting and threshold values determined based on engineering analysis and published literature;
- response actions when limiting and threshold values are measured;
- design and specifications for each instrument;
- instrument locations and elevations;
- installation procedures;
- measures to maintain instruments and protect instruments from damage throughout construction;
- plan for interpreting instrumentation data to compare actual movements with anticipated movements, and for assessing potential causes of observed discrepancies; and
- procedures for controlling groundwater when necessary, including, at a minimum:
    - requirements for groundwater control systems and instrumentation;
    - the necessary piezometric levels to be achieved at each stage of the Project;
    - monitoring of piezometric levels to verify the performance of the groundwater control system using data loggers supplemented by periodic physical readings; and
    - impact on adjacent above and below grade structures likely to be affected.

Concessionaire shall submit the Protection of Existing Structures Plan for Review and Comment at least 60 calendar days before commencing Construction Work.

Concessionaire shall submit Pre-Construction Surveys for Information at least 30 calendar days before commencing Construction Work. Refer to Part 2A, Section 4.5 of the Technical Provisions for requirements of the Pre-Construction Survey.

4.7 Tunneling Monitoring Plan

Concessionaire shall perform geotechnical monitoring during all stages of tunnel Work to ensure the safety and stability of the tunnel and the integrity of any overlying or adjacent structures or Utilities. Excavation and construction of the tunnel shall not commence until all required instrumentation has been installed and base readings established.

At a minimum, Concessionaire's instrumentation design shall meet the following requirements:

- structure monitoring points shall consist of survey targets, and settlement monitoring points shall be installed on buildings located within the predicted surface settlement zone and up to 20-ft each side of the predicted surface settlement zone. Monitoring points shall be installed on three corners of the building closest to the excavation and any structural columns. Crack gauges shall be installed on any existing cracks determined to be structural or of significant interest;
- surface monitoring point arrays shall be installed every 20 feet along the centerline of the tunnel. A surface monitoring point array shall consist of at least nine monitoring points spaced at 15 feet on-center from the centerline of the tunnel, perpendicular to the tunnel

alignment. A monitoring point array shall be installed near both tunnel portal areas even if it results in closer array spacing;

- deep monitoring points shall be installed within 5 feet of existing Utilities within the predicted settlement zone to monitor ground movement around the Utility. Deep monitoring points shall be installed to the approximate invert of the Utility being monitored. Should the Utility lie in the settlement zone for more than 100 feet, the deep monitoring point spacing shall not exceed 100 feet along the Utility;
- at least one multipoint rod extensometer shall be installed in every third monitoring point array as a replacement for a surface monitoring point. The extensometers shall be located within 15 feet each side of the tunnel centerline. Sensing rings shall be evenly distributed along the length of the instrument and spaced at intervals no more than 5 feet. The lowest sensing ring shall be located no farther than 4 feet from the crown of the excavation;
- convergence of the tunnel initial support shall be monitored by installing and surveying at least five points in-line around the tunnel perimeter every 20 feet. At least one point shall be surveyed on each tunnel wall and at least three points evenly spaced along the tunnel crown. Concessionaire may elect to perform a 3D LiDAR survey in place of surveying points inside the tunnel. If LiDAR is used, Concessionaire shall take periodic physical readings to verify the LiDAR results at a spacing not to exceed 200 feet;
- observation wells shall be installed along the tunnel alignment to monitor the groundwater level. Observation wells shall not be spaced more than 200 feet on-center and shall be located within 20 feet of the tunnel excavation;
- structural, surface, deep monitoring points, and extensometers shall be monitored daily when within 100 feet of an active excavation or tunnel face and shall continue to be read daily until seven days following completion of the excavation. After the excavation is completed the instruments shall be monitored weekly until the permanent support has been installed and then each month for three months following the completion of the permanent support. If significant movement is detected the monitoring frequency shall be immediately increased until movement has ceased; and
- tunnel convergence monitoring points shall be monitored daily when located within 100 feet of an active tunnel face until the excavation is completed. If 3D LiDAR survey is used, monitoring shall be performed daily until the permanent support is installed. If at any time the tunnel convergence monitoring indicates movement, the Concessionaire shall take immediate corrective action and the monitoring frequency shall be increased until movement has ceased.

Observation wells shall be monitored daily when located within 500 feet of any dewatering activities. Observation well monitoring shall continue daily until the permanent support has been completed.

Concessionaire shall submit the Tunneling Monitoring Plan for Review and Comment at least 60 calendar days before commencing tunneling.

Concessionaire shall submit Tunneling Pre-Construction Surveys for Information at least 30 calendar days before commencing tunneling. Refer to Part 2A, Section 4.5 of the Technical Provisions for requirements of the Pre-Construction Survey.

4.8 Test Boring and in Situ Testing Requirements

Subsurface exploration shall be performed in accordance with AASHTO, AREMA, FHWA *Technical Manual for Design and Construction of Road Tunnels*, MDE, requirements of Third Parties, and Exhibit 4.1.

All boring depths shall be great enough to fully penetrate existing fill and soft highly compressible soils, e.g., peat, organic silt, or soft fine-grained soils, into natural, competent material of suitable bearing capacity, e.g., stiff to hard fine-grained soil, medium dense to dense coarse-grained soil, or decomposed rock or bedrock.

Any foundation boring used shall be within 25 feet of the substructure unit to be applicable.

Exhibit 4.1 – Boring Depth and Spacing Requirements

Area of Investigation	Minimum Requirements for Test Borings	Minimum Depth of Test Borings
Bridge Foundations	AASHTO LRFD 10.4.2 Additional borings may be required for wingwalls or top-down construction depending on the length of the wingwall. Add one shallow auger probe with grab samples upstream and one downstream for bridge locations for scour analysis to comply with MDE/MDSHA requirements	Deep Foundations – Minimum 20 feet below estimated pile or shaft tip elevation in soil or 10 feet into rock with recovery greater than 80 percent. For shafts supported on or extending into rock, a minimum of 10 feet of rock core, or a length of rock core equal to at least three times the shaft diameter for isolated shafts or two times the maximum shaft group dimension, whichever is greater, shall be extended below the anticipated shaft tip elevation. Shallow Foundations – two times the estimated footing width for isolated footings or four times footing width for strip footings whichever is greater or 10 feet into rock with recovery of at least 80 percent.
Retaining Walls (General)	AASHTO LRFD 10.4.2 and AASHTO *Manual on Subsurface Investigation* on spacing of 150 for walls > 100 LF, alternating front to back. Minimum of two borings for walls greater than 50-feet long.	Two times wall height, minimum 20 feet in soil, but as per bridge for deep foundations. (Assume deep foundation control at H > 12 feet for fill walls.)
Anchored and Soil Nailed Walls	As per *Retaining Walls (General)*, but add borings on 100-foot spacing in the anchorage zone. [AASHTO LRFD 10.4.2]	Two times wall height in anchorage zone and along face.
Tunnels	FHWA Technical Manual for Design and Construction of Road Tunnels 3.5.2	Minimum 1.0 times the tunnel diameter below the proposed tunnel invert.

Exhibit 4.1 – Boring Depth and Spacing Requirements		
Area of Investigation	**Minimum Requirements for Test Borings**	**Minimum Depth of Test Borings**
Pole Foundations	One per substructure unit for major type structures (e.g., hi-mast luminaires or overhead sign), but not including minor pole foundation structures (e.g., OCS poles). OCS pole foundation boring requirements shall be in general accordance with AREMA Section 8, Section 22.4.2, but shall be no farther apart than 250 feet staggered left to right along alignment.	Minimum 10 feet below estimated pile, shaft tip, or anchor elevation in soil or 10 feet into rock.
Pavement and Track Subgrades	Minimum one boring per 500 feet. [AASHTO *Manual on Subsurface Investigations* 7.4.3.1 and 7.4.4.1] May be used for Pole Foundation borings if borings also comply with Pole Foundation requirements.	Minimum 10 feet below subgrade and 10 feet of rock core at shallow refusal locations where there are no OCS poles; in areas of OCS poles, use criteria for Pole Foundations (above).
Embankments	Height greater than 15 feet, borings no more than 200-foot intervals with at least one each at crest and toe. [AASHTO *Manual on Subsurface Investigations*]	Minimum two times height or refusal on rock. Over soft soils: to a depth where stress increase due to estimated embankment load is less than 10 percent of the existing effective overburden stress at that depth, unless a hard stratum is encountered above this depth and extend to hard material to determine the limits of soft deposits.
Cut Slopes	Depth greater than 15 feet, borings no more than 200-foot intervals with at least one at point of maximum cut. At least one boring at toe and one boring at crest of slope. [AASHTO Manual on Subsurface Investigations]	Two times depth of cut, spoon refusals (50blows/inch) cored at least 10 feet in cut. Boring depths shall be increased in locations where base stability is a concern due to the presence of soft soils, or in locations where the base of the cut is below groundwater level to determine the depth of the underlying pervious strata. For deeper cuts, additional soil borings may be needed to develop a lateral profile.
Culverts	Minimum two borings per culvert for diameters greater than 24 inches, with a maximum spacing between borings of 75 feet. [AASHTO Manual on Subsurface Investigations 7.4.3.3 and 7.4.4.3]	Minimum 30 feet below invert unless rock or medium dense coarse-grained or very stiff fine-grained soils are encountered.

Exhibit 4.1 – Boring Depth and Spacing Requirements		
Area of Investigation	**Minimum Requirements for Test Borings**	**Minimum Depth of Test Borings**
Stormwater Management	Minimum one boring per Stormwater Management (SWM) control structure (such as weir or riser). [MDE Maryland Stormwater Design Manual Appendix D.1.]	Per MDE *Maryland Stormwater Design Manual*.
Shop Buildings & TPSSs	Minimum one boring per 2,500 square feet of building and two borings per substation.	Shallow Foundations – Minimum of 15 feet below estimated footing elevation or two times footing width for isolated footings or four times footing width for strip footings whichever is greater. Deep Foundations – Minimum of 20 feet below estimated pile or shaft tip elevation in soil or 10 feet into rock with recovery greater than 80 percent.
At-grade Stations	Minimum two borings per Station.	Minimum 20 feet below proposed or existing ground surface, whichever is deeper and 10 feet of core at shallow refusal locations.
Noise Walls	Minimum two borings per wall [AASHTO *Manual on Subsurface Investigations* 7.4.3.3] on spacing of 100 to 200 feet for walls greater than 100 LF.	Minimum 20 feet below estimated pile or shaft tip elevation in soil or 10 feet into rock.

In addition to the techniques described in the AASHTO *Manual on Subsurface Investigations*, Concessionaire's testing methods may include the Ko blade, Pre-bored Pressuremeter (ASTM D-4719), Electronic and Piezocone Testing (ASTM D-5778), Mechanical Cone Penetrometer (ASTM D-3441), and Dilatometer Test Probes (ASTM D-6635) in the subsurface investigations to aid in the development of in-situ soil parameters. Ko blade testing shall be in accordance with the manufacturers' recommended procedures and shall be submitted as part of the subsurface exploration program.

Concessionaire shall determine the coordinate location, Station, and offset from the design baseline, and ground surface elevation, for each boring and other test probes and show the information on the individual boring logs.

Visual/manual soil classification as reported on the boring logs shall be in accordance with ASTM D-2488. Description of all soil samples shall also include the AASHTO soil classification.

Concessionaire shall describe and classify rock in accordance with the Q-system or the geomechanics classification system (Rock Mass Ratingsystem). At a minimum, the rock descriptions shall include:

- the rock core run length;
- recovery;
- Rock Quality Designation;

- dip angles, spacing, and nature of discontinuities;
- rock type;
- hardness;
- strength; and
- weathering classification of each core.

Concessionaire shall prepare final boring and rock core logs using gINT software as supplied by Geotechnical Computer Applications, Inc. Owner will provide the electronic template for gINT.

The soils and rock samples obtained by Concessionaire for the supplemental subsurface investigation shall be the property of the Owner. Concessionaire shall deliver all samples to a designated location upon completion of construction. All soil and rock samples shall be stored by Concessionaire during Design Work and Construction Work and shall be available for inspection by Owner between the hours of 7:00 AM and 5:00 PM, Monday through Friday.

All SPT drilling equipment shall be calibrated within the three months prior to performing the Work. Concessionaire shall submit the Calibrated Efficiency of the Hammers for Information prior to performing the Work. Concessionaire shall update this Submittal every 12 months thereafter.

4.9 Laboratory Testing

Concessionaire shall select laboratory testing to adequately characterize the soil and rock, support the design parameters, and provide information for evaluation of design alternatives. Testing and methods will be dependent upon the materials encountered and may include, but shall not be limited to, the tests listed in AREMA and FHWA *Manual on Subsurface Investigations*. For facilities and structures that will be owned, operated, or maintained by Third Parties or Utility Owners, Concessionaire shall comply with the standards of the Third Party or Utility Owner in addition to the standards in this specification.

Concessionaire shall implement corrosion testing, including such tests as sulfate and chloride concentration, organic content, pH, and resistivity, using the general criteria of AASHTO.

Concessionaire's laboratory testing shall be performed by an AASHTO Materials Reference Laboratory (AMRL)-accredited laboratory, and the test methods shall be performed in accordance with the appropriate AASHTO or ASTM standards.

4.10 Design Requirements

4.10.1 Ground Strength and Deformation Parameters for Tunnels

Concessionaire shall estimate strength and deformation properties for soil and decomposed rock or saprolite from laboratory tests (e.g., triaxial tests, direct shear tests, consolidation tests) or in situ testing (e.g., cone penetrometers , dilatometers , pressuremeters , in situ jacking test, down-hole, cross-hole and surface geophysics, such as refraction microtremor or multichannel analysis of surface waves). Where such testing is not possible, strength and deformation parameters shall be based on correlations with SPT N-values and standard laboratory classification tests (e.g., Atterberg limits, grain size distribution).

Concessionaire shall estimate and develop design strength and deformation properties for intact rock on the basis of laboratory testing (e.g., uniaxial compression test, Brazilian tensile strength test). Rock mass strength and deformation properties shall be based on in situ pressuremeter or jacking tests, correlations with frequently used rock mass classification systems, such as, at a minimum, the Q-System, Rock Mass Rating, and geological strength index. Rock mass strength shall be based on Hoe-Brown empirical strength criterion.

Concessionaire shall determine orientation and spacing of rock joint sets from field investigation.

4.11 Summary of Submittals

Item	Section	Submittal	Action
1	4.4.1	Subsurface Exploration Plan	Review and Comment
2	4.4.2	Geotechnical Planning Report	Review and Comment
3	4.4.3	Geotechnical Engineering Report	Review and Comment
4	4.4.4	Foundation Design Report	Review and Comment
5	4.4.5	Geotechnical Tunnel Report	Review and Comment
6	4.5	Blasting Vibration Monitoring Plan	Review and Comment
7	4.5	Blasting Pre-Construction Surveys	Information
8	4.6	Protection of Existing Structures Plan	Review and Comment
9	4.6	Pre-Construction Surveys	Information
10	4.7	Tunneling Monitoring Plan	Review and Comment
11	4.7	Tunneling Pre-Construction Surveys	Information
12	4.8	Calibrated Efficiency of the Hammers	Information

5 ENVIRONMENTAL REQUIREMENTS

5.1 Overview

This Section describes the required environmental protection plans, SWM and Erosion and Sediment Control (ESC) procedures, environmental mitigation, and commitments.

5.2 Roles and Responsibilities

5.2.1 Owner's Responsibilities

Owner has provided Owner-Provided Approvals.

Owner will implement the stipulations of the Section 106 Programmatic Agreement to the extent that they are applicable to the Owner, with the exception of those Section 106 items listed under Part 2A, Section 5.2.2 of the Technical Provisions as Concessionaire responsibilities.

5.2.2 Concessionaire's Responsibilities

In addition to its obligations under Section 6.3.4 of the Agreement, Concessionaire shall:

- provide all necessary Governmental Approvals, or modified Governmental Approvals not specifically identified as Owner responsibility in Part 2A, Section 5.2.1 of the Technical Provisions;
- incorporate into the Final Design the stipulations contained and conditions in Governmental Approvals and Contract Documents;
- provide mitigation measures to offset unavoidable adverse environmental impacts to the extent in excess of that which Owner provided.
- implement the stipulations of the Section 106 Programmatic Agreement V.C (excepting C.1, which is already included in the Project);
- implement the stipulations of the Section 106 Programmatic Agreement V.D;
- implement the stipulations of the Section 106 Programmatic Agreement V.E;
- implement the stipulations of the Section 106 Programmatic Agreement V.F; and
- implement the stipulations of the Section 106 Programmatic Agreement V.G.

5.3 Governmental Approvals

5.3.1 Owner-Provided Approvals

Owner-Provided Approvals may require re-evaluation, amendment, or supplement as the Work progresses. Concessionaire shall identify which actions require additional environmental study and approval re-evaluation, amendment, or modification.

Concessionaire shall coordinate with Owner, FTA, and other Governmental Entities as necessary for Concessionaire to obtain amendments to Owner-Provided Approvals as part of the Work. Concessionaire shall prepare material as required to obtain the Amended Approvals and submit the Application for Amended Approval to the Owner for Review and Approval. Upon Owner's satisfaction with the material, Owner will submit the material to governmental agency for consideration.

5.3.2 Concessionaire-Provided Governmental Approvals

Concessionaire shall obtain all Governmental Approvals, other than Owner-Provided Approvals, necessary to complete the Work. Concessionaire shall submit Applications for Governmental Approvals to Owner for Review and Approval before submittal to the AHJ.

5.4 Comprehensive Environmental Protection Plan (CEPP)

Concessionaire shall develop and implement a CEPP, which shall be the overarching system by which Concessionaire shall ensure that commitments made during the environmental approval and permitting processes, and other environmental requirements, are carried forward and reflected, as appropriate, in the design and implemented throughout the Work. At a minimum, the CEPP shall contain the following elements:

- establish processes that Concessionaire will follow to manage and comply with Environmental Approvals, commitments, resource agency requirements, FTA requirements, Owner requirements, and laws;
- describe the processes that will be followed during the course of the Work to comply with those Environmental Approvals, mitigate the impacts and adopt measures to ensure compliance with all environmental legislations;
- component parts of the CEPP shall reflect in order of priority: impact identification, certain avoidance, minimization, and as a last resort, mitigation;
- commitment tracking system, which Concessionaire shall use to identify and track the responsibility and status of all Project commitments;
- identification and tracking of environmental compliance efforts, unresolved issues, noncompliance events, and the identified actions required and taken to make appropriate notifications and correct any such noncompliance event via a commitment tracking database;
- method and frequency for reporting commitment compliance to Owner;
- measures to be taken to ensure protection for the environment;
- the process to be implemented by Concessionaire to record and document the measures taken during the performance of the Work to avoid and minimize impacts on the environment;
- a goal of zero environmental violations during the performance of all Work activities; and
- detailed processes for rectifying violations in an appropriate and timely manner.

The CEPP and its component parts shall cover management of resources, compliance with regulation of and notifications to Owner regarding environmental resources, including at a minimum the following:

- Maryland Wild and Scenic Rivers Act, including fencing the work area, prohibiting activity outside the work area and securing MDNR compliance evaluation;
- well impacts;
- Endangered Species Act;
- Fish and Wildlife Coordination Act;
- wetlands and other water resources;

- floodplains;
- State-listed species;
- unregulated habitat;
- parks, recreational land, and open space, including Section 4(f) commitments;
- historic properties and archeological resources, including the Section 106 Programmatic Agreement;
- cultural resources;
- discovery of unknown historic or archaeological remains; and
- visual resources.

Component parts of the CEPP shall include, but are not limited to:

- Environmental Compliance and Mitigation Plan (ECMP);
- Environmental Protection Training Plan (EPTP);
- Hazardous Materials Management Plan (HMMP);
- Hazardous Materials Operations, Safety and Health Plan (HMOSHP);
- Compliance Action Plan (CAP);
- Standard Operating Procedures (SOP);
- Control of Odors and Dust (CODP); and
- Off Road Diesel Emission Plan (ORDEP).

Concessionaire shall incorporate all permanent environmental protection features into the Work at the earliest practicable time as required by the Contract Documents. Temporary environmental protection measures will be used to correct conditions that develop during Construction Work that were not foreseen during design; that are needed prior to installation of environmental protection features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the Project.

Concessionaire's attention is directed to the fact that temporary environmental protections may include control measures outside the Project ROW or Project Site where such work is necessary as a direct result of Project construction. Owner shall be kept advised of all such off-site control measures taken by the Concessionaire. This shall not relieve the Concessionaire of the basic responsibilities for such work.

In case of failure on the part of the Concessionaire to control erosion, pollution or siltation, Owner reserves the right to employ outside assistance or to use his own forces to provide the necessary corrective measures. All expenses incurred by Owner in the performance of such duties for the Concessionaire shall be withheld from monies becoming due to the Concessionaire.

Concessionaire shall submit the CEPP for Review and Approval within 90 calendar days after Financial Close. The CEPP shall be Approved before commencement of Construction Work.

5.4.1 Environmental Compliance and Mitigation Plan (ECMP)

The ECMP shall document and fully detail the following:

- compliance strategies and SOPs;

- document protocols, and methods to be used in accomplishing Work;
- monitoring, reporting, corrective actions, and adaptive management; and
- any mitigation required by Environmental Approvals and Concessionaire's approach to satisfying mitigation requirements, including mitigation requirements identified after completion of the ECMP and all relevant executive orders.

5.4.2 Environmental Protection Training Plan (EPTP)

The EPTP shall include methods and procedures to educate and train every non-administrative worker to, at a minimum:

- recognize the overall importance of environmental issues to constructing, operating, and maintaining a successful Project;
- recognize environmentally sensitive resources that may be encountered during the Work;
- avoid or take appropriate action to minimize environmental impacts arising from the Work;
- know the required actions, practices, and procedures regarding regulated resources;
- foster Concessionaire's management and supervisory personnel's attitude of commitment to the Project's environmental quality;
- convey to all workers Concessionaire's management commitment to the Project's environmental quality; and
- convey to all workers Owner's and Concessionaire's commitment to zero tolerance for violations.

The training shall, at a minimum, cover the following elements:

- erosion control measures – sequencing, implementation, and maintenance;
- maintaining approved LOD;
- tree and shrub protection;
- avoidance and minimization of impact to wetland areas, streams, or other water bodies;
- wildlife habitat protection;
- seasonal work restrictions – trees and waterways;
- pumping and dewatering operations;
- accidental discovery of archaeological material or human remains;
- impacts and consequences for departure from approved operating procedures;
- hazardous materials;
- no work zones; and
- historic properties.

Concessionaire shall not allow any non-administrative personnel to enter the Project ROW without completing the required training.

5.4.3 Hazardous Materials Management Plan (HMMP)

The HMMP shall include safe handling, storage, treatment and/or disposal of Hazardous Materials, whether encountered at or brought onto the Project ROW by Concessionaire, or by a Third Party. The HMMP shall include procedures compliant with all applicable Codes and Standards and include, at a minimum:

- technical details about sites having Hazardous Materials involvement, including the site description, site plan locating sources, and storage locations of Hazardous Materials, and inventory of Hazardous Materials present including amounts;
- for all chemicals to be used on the Project, Material Safety Data Sheets (MSDS), per OSHA requirements, for the Term;
- designated individuals responsible for implementation of the plan;
- procedures for ensuring that all applicable certifications, licenses, authorizations, and Governmental Approvals for personnel handling Hazardous Materials are current and valid through the duration of the Work;
- procedures for identifying and documenting potential contaminated sites which might impact Project development;
- assessment of the risk of release of Hazardous Materials into the ground, groundwater, or surface water of the property as a result of Concessionaire's Work;
- procedures for Hazardous Materials Management of known contaminated sites anticipated to impact construction;
- procedures for Hazardous Materials Management of unanticipated contaminated sites encountered during Construction Work;
- procedures for Hazardous Materials Management of contamination during the operations of the Project;
- provisions for appropriate storage and management or remediation of Hazardous Materials on Site for the Term;
- Hazardous Materials training module as an element of the EPTP component of the CEPP;
- procedures for preparing an Investigative Work Plan and Site Investigative Report in the event that Hazardous Materials are discovered during Construction Work, operations, or maintenance activities, including Owner's Review and Comment on such plans and reports; and
- identification and contact information for designated responsible individuals.

The HMMP shall require that all non-administrative personnel of Concessionaire handling Hazardous Materials be trained and certified at least to the minimum requirements established under the current guidelines of OSHA 1910.120 (HAZWOPER Training).

Owner shall have the right to direct alternative approaches or to undertake Hazardous Materials Management itself.

5.4.4 Hazardous Materials Operations, Safety and Health Plan (HMOSHP)

Concessionaire shall prepare, implement, manage, operate, and, as required, update a Hazardous Materials Operations, Safety, and Health Plan that complies with all applicable Law and Good Industry Practice, including at a minimum:

- procedures and contingency plans to meet the Resource Conservation and Recovery Act requirements in 40 CFR 262 for waste operations;
- risk identification and assessment, decontamination procedures, Emergency response procedures, training procedures for employees, personnel roles; lines of authority, training and communications; Emergency recognition and prevention; site security; evacuation routes and procedures; decontamination procedures; emergency medical treatment; and emergency alerting procedures;
- details of the training to be provided by Concessionaire for Owner staff required by their duties to visit the Project or facilities to be used in connection with the Project including, at a minimum, facilities for the production of materials or equipment;
- provisions for making all on-site workers aware of the potential Hazardous Materials to which they may be exposed, limiting Concessionaire, Contractors and other Site workers' exposure to Hazardous Materials and providing all necessary personal protection equipment to protect workers from exposure;
- requirement that the Concessionaire to provide any non-Concessionaire personnel who visit the Project with the appropriate personal protection equipment, full descriptions of Concessionaire's policies, plans, training programs, work site controls, and Incident Response plans to ensure the health and safety of personnel involved in the Project and the general public affected by the Project during the Term; and
- address procedures for immediately notifying Owner of all Incidents involving Hazardous Materials arising out of or in connection with the performance of the Work, whether on or adjacent to the Project.

5.4.5 Compliance Action Plan (CAP)

The CAP shall consist of a decision-making matrix which will define the triggers for initiating or re-initiating environmental compliance actions for construction and maintenance activities. For each trigger, the CAP will identify the appropriate type or level of environmental study, response, or other compliance action necessary to ensure the ongoing validity of Environmental Approvals and commitments. The CAP shall include but not be limited to:

- Concessionaire hierarchy for environmental management and compliance action team;
- determination of action thresholds and corresponding notification processes;
- description of resource allocation for compliance responses; and
- identification of specific at risk resources Project wide.

5.4.6 Standard Operating Procedures (SOP)

Concessionaire shall develop and implement SOPs for construction. SOPs for the following activities shall be developed and implemented, at a minimum:

- controlling dust during Construction Work;
- mitigating noise and vibration during Construction Work;
- mitigating light intrusion on adjacent properties;
- maintaining stream flow for bridge and culvert construction; and
- water quality monitoring.

5.4.7 Control of Odors and Dust Plan (CODP)

Concessionaire shall limit hazardous odors and nuisance odors encountered or created during Work on this Project, including odors associated with Site sanitation.

Concessionaire shall use dust control practices to:

- reduce wind erosion and dust;
- minimize deposition of dust and wind-transported soils into water bodies through run-off or wind action;
- reduce respiratory problems; and
- minimize low-visibility conditions caused by airborne dust.

Concessionaire shall maintain maximum opacity limits of 20 percent on site and 15 percent at the Project ROW boundary. Concessionaire shall document compliance by conducting regular monitoring, which is defined as daily or as reasonably requested by the Owner, in accordance with EPA standards and requirements. Concessionaire's opacity monitor shall be certified through an EPA approved opacity training and certification course.

Noncompliance with this performance specification shall require timely modification and/or mitigation of activities to bring the operation into compliance within two hours of discovery, or cessation of any and all operations in sufficiency to bring the overall operation into full compliance with opacity thresholds.

Dust control practices may include but are not limited to:

- limiting the area of exposed dust generation;
- application of mulch and vegetation-mulch or seed and mulch to protect exposed soil from wind erosion;
- establishment of vegetation;
- tilling or roughening surface using chisel-type plows spaced about 12 inches apart and plowing from the windward side of the site;
- irrigation with water until the surface is wet and no runoff occurs;
- placement of barriers such as solid board fences, snow fences, burlap fences, crate walls, and bales of hay at right angles to prevailing wind currents and at intervals of about 15 times the barrier height; and
- application of natural or organic tackifiers and soil stabilizers approved by MDE and used in conformance with MDE standards.

Asphalt and petroleum-based products shall not be used for dust abatement.

5.4.7.1 Control of Odors and Dust Incentive

Concessionaire shall report all failures to comply with the CODP, whether identified by Concessionaire or Owner, as part of the monthly progress report. Concessionaire shall rate the COPD performance on a monthly basis according to the following:

- Rating A. Up to 5 failures in a calendar month. All failures corrected within two hours of discovery.

- Rating B. 6 to 10 failures in a calendar month. All failures corrected within two hours of discovery.
- Rating C. 11 to 15 failures in a calendar month. All failures corrected within two hours of discovery.
- Rating D. 16 to 20 failures in a calendar month. All failures corrected within two hours of discovery.
- Rating F. 21 or more failures in a calendar month or any instance(s) of not correcting a failure within two hours of discovery in a calendar month.

Ratings shall only be made after commencement of construction.

5.4.8 Off-Road Diesel Emission Plan (ORDEP)

Concessionaire shall prepare an ORDEP to document compliance with the requirements.

Concessionaire shall submit a list prior to the start of construction and each quarter during Construction Work of the off-road 60+ HP diesel-powered construction equipment demonstrating compliance with the requirements, including, at a minimum, the following:

- equipment number, type, make, and Contractor/Supplier name;
- any emission control device make, model and EPA certification number; and
- type and source of fuel to be used.

The off-road 60+ HP diesel powered construction equipment fleet shall meet, as a minimum, the following EPA tiered percent usage requirements:

- EPA Tier 0: 0-10 percent use;
- EPA Tier 1: 0-60 percent use;
- EPA Tier 2: 20-90 percent use; and
- EPA Tier 3: 10-100 percent use.

The off-road 60+ HP diesel powered construction equipment fleet shall meet the requirements through one or more of the following methods:

- certification by the original equipment manufacturer;
- retrofit equipment that is included in the EPA Verified Retrofit Technology List; and
- clean fuels including low NOx and Particulate Matter emission diesel fuel.

All motor vehicles and/or construction equipment shall comply with all Law relative to exhaust emission controls and safety.

Idling of delivery, dump trucks, and other diesel-powered equipment shall be limited to three minutes.

Diesel powered exhausts shall not be located near fresh air intakes.

5.5 Stormwater Management

5.5.1 SWM Review Process

The Purple Line Sediment Control and Stormwater Management Program (SC/SMP) will provide Review and Approval of SWM design and construction pursuant to a delegated authority agreement with MDE. Review by AHJ shall be in accordance with the Third Party Agreement Requirements.

Concessionaire's SWM review process shall include, at a minimum, the following:

- SWM kickoff meeting between Concessionaire, SC/SMP Reviewers and Owner held after Financial Close. At a minimum Concessionaire's drainage design lead, erosion and sediment control design lead, Construction Manager, and erosion control manager shall attend the meeting. The purpose of the meeting will be to preview and discuss SWM concepts to be developed by Concessionaire, submission schedules proposed by Concessionaire, permitting and approval timeframes, submission requirements, and quality expectations;
- Concessionaire shall submit a Preliminary Stormwater Management Report for Review and Approval at Preliminary Design. The report shall address SWM for each location where discharge leaves the Limit of Disturbance;
- Concessionaire shall submit Final SWM Design Plan and Calculations for Review and Approval; and
- Concessionaire shall submit the SWM As-Built Certification Package for Review and Approval before the Revenue Service Availability Deadline.

Concessionaire shall anticipate multiple submissions and responses to obtain required SWM approvals.

5.5.2 Purple Line Project Water Quality Bank

Concessionaire shall tabulate the impervious surfaces created, modified, altered, or removed and mitigations performed, whether performed by Concessionaire or by Owner, for the Project. The Concessionaire shall also track the County and type (either on-site or off-site) in which each debit or credit occurred.

At all times throughout construction the Concessionaire shall show a zero or positive balance of impervious area treated on the tabulation.

At the conclusion of Construction Work, the Concessionaire's tabulation shall show all of the following:

- a zero or positive balance for the Project; and
- a zero or positive balance for each County.

The Project falls within the Washington Metropolitan Area subbasin (02-14-02).

5.5.3 Stormwater Management As-Built Certification

5.5.3.1 General

Concessionaire shall inspect SWM facilities during Construction Work and provide documentation to Owner certifying that facilities have been constructed as specified in the Contract Documents, including certification that the constructed SWM facilities meet the functionality as designed.

During Construction Work and upon completion of the final grade and stabilization at each SWM facility, Concessionaire shall survey each SWM facility, including contours, inflow and outflow ditches, limits of riprap, emergency spillway(s), outfall structure(s) (including elevations and dimensions at top, all orifices, weirs and openings), and all other pertinent features in and around the facility.

Elevation variance greater than three inches from approved plans shall be corrected by Concessionaire to meet the acceptable tolerance limits or Concessionaire shall provide computations for the volumes, discharges, stage-storage, freeboard, detention times, and other parameters to demonstrate that the SWM facility meets the designed parameters.

Concessionaire shall resurvey any corrected areas.

5.5.3.2 SWM As-Built Certification Package

The as-built certification package shall consist of, at a minimum:

- photographs;
- completed as-built checklists for each SWM facility;
- completed as-built certification forms for each SWM facility;
- material testing reports for any soil;
- green-line revision plans for SWM facilities that include as-built survey information;
- revised SWM computations;
- completed planting checklists;
- turf inspection data for SWM facilities and drainage conveyance areas (such as ditches and swales); and
- turf and plant inspector information.

The checklist for each SWM facility shall be completed in its entirety at the appropriate stages of Construction Work. The SWM as-built certification shall be signed and dated by the SWM inspector upon completion of all SWM facility checklists.

5.6 Erosion and Sediment Control (ESC)

5.6.1 ESC Review Process

The Purple Line Sediment and Stormwater Management Program will provide Review and Approval of ESC design and construction pursuant to a delegated authority agreement with MDE. Review by AHJ shall be in accordance with the Third Party Agreement Requirements.

Concessionaire’s ESC review process shall include, at a minimum, the following:

- ESC kickoff meeting between Concessionaire, SC/SMP Reviewers and Owner held after Financial Close. At a minimum Concessionaire’s staff responsible for drainage design, ESC design, and ESC installation and inspection, and Construction Manager shall attend the meeting. The purpose of the meeting will be to preview and discuss ESC concepts to be developed by Concessionaire, submission schedules proposed by Concessionaire, permitting and approval timeframes, submission requirements, and quality expectations;
- Concessionaire shall submit Inspection and Maintenance Protocols for ESC Devices for Review and Approval prior to any earth disturbance;
- Concessionaire shall submit ESC Report and Construction Plans for Review and Approval prior to any earth disturbance; and
- Concessionaire shall submit a completed Notice of Intent Form for Review and Approval in accordance with the NPDES General Permit for Construction Activities, and before any earth disturbance.

Concessionaire shall anticipate multiple submissions and responses to obtain required ESC approvals.

5.6.2 Inspection and Maintenance Protocols for ESC Devices

The Inspection and Maintenance Protocols for ESC Devices shall include, at a minimum:

- SOPs for inspection and maintenance of ESC devices;
- preemptive actions to address predicted severe weather events;
- response actions after severe weather events;
- response to sediment releases; and
- approach to stockpiling materials needed to perform emergency maintenance.

5.6.3 ESC Report

The ESC Report shall contain, but is not limited to, the following:

- drainage area maps to control devices for each phase;
- computations for sizing control devices;
- computations for rip rap sizing and outlet protection for temporary facilities and permanent storm drain outfall;
- plans and procedures for converting sediment control devices into SWM facilities; and
- identification of and placement of controls in sensitive areas.

5.6.4 ESC Construction Plans

ESC Construction Plans shall meet requirements of MDE's Maryland Stormwater Management and Erosion & Sediment Control Guidelines for State and Federal Projects and, at a minimum, the following:

- include detailed steps necessary to establish and maintain clear water diversions through or around any work area;
- coordinate with the Traffic Control Plan (TCP) phasing;
- apply best management practices for working in nontidal wetlands, wetland buffers, waterways, and 100-year floodplains;
- detail Concessionaire's method of maintaining clean ingress/egress into all access areas and prevention of sediment loss onto public roads; and
- include written ESC Sequence of Construction/Implementation Schedule including, at a minimum, the following for each earth disturbance area:
    - stages of earth disturbance;
    - sequence of construction, implementation, and maintenance of controls;
    - temporary and permanent stabilization, and the various stages of earth disturbance;
    - clearing and grubbing of areas necessary for installation of perimeter controls specified in the approved ESC Plan;
    - construction of perimeter controls as specified in the approved ESC Plan;

- remaining clearing and grubbing;
- roadway and Guideway grading (including off-site work);
- Utility installation and determination whether storm drains shall be used or blocked after construction;
- conversion of temporary sediment basins to permanent SWM facilities;
- final grading, landscaping, and stabilization; and
- removal of perimeter controls.

5.6.5 Not Used

5.6.6 ESC Compliance and Incentive

Concessionaire shall monitor ESC compliance with the CEPP.

Owner will provide Quality Assurance Oversight to ensure compliance with the approved ESC Construction Plans. The Owner will inspect for compliance with ESC Construction Plans on a regular basis and rate the Project on Form OOC-61 in accordance with the following:

- Rating A. The score is equal to or greater than 90.0;
- Rating B. The score is 89.9 to 80.0;
- Rating C. The score is 79.9 to 70.0. A ‘C’ rating indicates that the Project is in compliance with requirements; however, deficiencies are noted and shall be corrected. Owner will re-inspect the Project within 72 hours. Failure to achieve a ‘B’ rating upon re-inspection will result in the Project being rated as ‘D’;
- Rating D. The score is 69.9 to 60.0. A ‘D’ rating indicates that the Project is not in compliance with requirements. Immediately following a D rating, Concessionaire shall cease earthwork operations and focus all work efforts on correcting deficiencies. Owner will re-inspect the Project within 72 hours. Failure to achieve a ‘B’ rating upon re-inspection will result in the Project being rated as ‘F’;
- Rating F. The score is less than 60. An ‘F’ rating indicates that the Project is not in compliance with requirements. Concessionaire shall cease all construction activities not related to correcting ESC deficiencies. Owner will re-inspect the Project within 72 hours. Construction activities may not restart until a ‘B’ rating is achieved; and
- An ‘F’ rating will automatically apply if any one or more of the following conditions is met regardless of the score received:
  - Concessionaire has not obtained all appropriate permits and approvals for work in progress;
  - Concessionaire has not demarcated limits of disturbances, wetland and wetland buffers, floodplains, and tree protection areas;
  - Concessionaire is not proceeding according to the approved ESC plan and schedules; and
  - Concessionaire disregards deficiency correction requests.

When degradation to a resource is imminent, or if Concessionaire is unresponsive to direction to take corrective actions, Owner may implement corrective actions through a separate contract, and Concessionaire shall bear all costs associated with the corrective actions.

Ratings shall only be made after commencement of construction.

5.6.7 Severe Weather Event

When 3.0 inches or more of rainfall (or rainfall equivalent in the case of snow) within a 24-hour period occurs at the Project site Concessionaire shall maintain, repair, or replace any damaged erosion and sediment control devices within 48 hours or prior to the next rainfall event, whichever comes first.

5.7 Not Used

5.8 Environmental Mitigation

5.8.1 Owner-Provided Mitigation

Owner will provide the mitigation listed below:

- parkland replacement in sufficient quantity to mitigate parkland impacts based on the Record of Decision;
- off-site wetland mitigation in sufficient quantity to mitigate impacts to 0.52 acres of palustrine forested wetland and 0.25 acres of palustrine emergent wetland;
- off-site surface water (streams and other channels) mitigation in sufficient quantity to mitigate impacts to 1,342 linear feet of perennial stream, 3,841 linear feet of intermittent stream, 363 linear feet of ephemeral stream, and 0.11 acres of palustrine open water;
- 66 acres of off-site forest mitigation; and
- off-site impervious area water quality treatment in sufficient quantity to compensate for no more than 17.8 acres of impervious area water quality treatment deficit within Montgomery County.

Availability of Owner provided mitigation shall not be considered a substitute for avoidance and minimization of resource impacts, on-site water quality treatment, and on-site forest retention, afforestation and reforestation. Concessionaire shall avoid and minimize impacts to resources regulated by MDE and USACE as required by Law. Concessionaire shall retain existing forest on-site, enhance existing forest on-site, and exhaust on-site afforestation and reforestation opportunities to the satisfaction of MDNR as required by law. Concessionaire shall reduce impervious area and/or implement environmental site design to the maximum extent practicable prior to considering alternative management measures and shall include on-site structural BMP(s) from Chapter 3 of MDE’s 2000 Maryland Stormwater Design Manual Volumes I and II prior to utilization of off-site alternative management measures to meet impervious area water quality treatment requirements.

Purple Line Water Quality Bank credits for the Owner provided water quality mitigation, to the extent necessary based upon the Concessionaire's on-site water quality treatment, will be made available no earlier than twenty four months after Financial Close. An initial posting of not less than 5.00 acres of impervious area water quality treatment will be made. Additional 5.00 acres of impervious area water quality treatment will be posted by Owner to the Purple Line Water Quality Bank at the end of each successive twelve month period until the full extent of Owner provided off-site water quality mitigation has been provided or is necessary.

5.8.2 Mitigation Responsibilities of Concessionaire

Mitigation provided by Owner is limited to that listed in Part 2A, Section 5.8.1 of the Technical Provisions. Concessionaire shall be responsible for any additional mitigation required based on Concessionaire's design and construction of the Project.

5.8.3 Specific Required Mitigation

Concessionaire shall provide the following specific mitigation measures:

- Sligo Creek stream restoration — Concessionaire shall re-align Sligo Creek through the Wayne Avenue Bridge over Sligo Creek in conformance with the Sligo Creek Park Stream Realignment/tree protection drawing included in Book 5 Engineering Data using channel design techniques acceptable to Montgomery County M-NCPPC; and
- Long Branch Fish Passage - Concessionaire shall design and construct the Long Branch Stream Valley Park Culvert and adjacent stream restoration to provide fish passage to resident fish species during base flow condition. The base flow of approximately 0.31 cfs shall be verified by the Concessionaire. Fish passage criteria shall be based on providing adequate velocity and depth of water to allow passage of black-nosed dace. Black-nosed dace have a prolonged swimming speed of 30.87 cm/s to 46.12 cm/s (1.0 ft/s – 1.5 ft/s), maximum sustained swimming speed from 26.33 to 69.00 cm/s (0.9 ft/s – 2.3 ft/s), and require a minimum of 0.25 feet of water depth. Fish passage may require stream restoration design upstream and downstream of the culvert to accommodate stable plan form and profile with tie-in to existing channel geometry and geomorphic characteristics. Montgomery County M-NCPPC will design, furnish and install plantings and landscaping associated with stream restoration along Long Branch. Fish passage and stream restoration design shall be approved by Montgomery County M-NCPPC

5.9 Pest and Rodent Control

Concessionaire shall develop and implement a Pest and Rodent Control Plan within the Project ROW. The Pest and Rodent Control Plan shall, at a minimum:

- document preconstruction rodent and pest activity within the Project ROW and observable areas within 100 feet of the site; and
- provide pest management to eliminate rodent and pest activity within the Project ROW prior to and during Construction Work.

Concessionaire shall submit the Pest and Rodent Control Plan for Information prior to commencement of Construction Work.

5.10 Summary of Submittals

Item	Section	Submittal	Action
1	5.3.1	Application for Amended Approval	Review and Approval
2	5.3.2	Application for Governmental Approval	Review and Approval
3	5.4	CEPP	Review and Approval
4	5.5.1	Preliminary SWM Reports	Review and Approval
5	5.5.1	Final SWM Design Plans and Calculations	Review and Approval
6	5.5.1	SWM As-Built Certification Package	Review and Approval
7	5.6.1	Inspection and Maintenance Protocols for ESC Devices	Review and Approval
8	5.6.1	ESC Report and Construction Plans	Review and Approval
9	5.6.1	Notice of Intent Form	Review and Approval
10	5.9	Pest and Rodent Control Plan	Information

6 NOT USED

7 SYSTEM SAFETY

7.1 General Requirements and Responsibilities

Concessionaire shall design a safe light-rail transportation system in accordance with Federal, State, County, and local applicable Codes and Standards, and detect and avoid unsafe or vulnerable design solutions. Concessionaire shall identify unsafe conditions where systems and subsystems interface, and where overlapping design elements occur.

Concessionaire's system safety program shall eliminate or control critical and catastrophic safety hazards, and reduce Unacceptable Hazards/Risks through the application of Owner's risk criteria as defined in MTA's System Safety Program Plan (SSPP).

Concessionaire shall take corrective action to eliminate or control Unacceptable Hazards/Risks as defined by MTA's SSPP using the following approach to system safety, in the following order of precedence. Note that a combination or all of the following approaches may be used to mitigate or control hazards:

- design for minimum risk – Design to eliminate hazards through design selection. Concessionaire shall use fail-safe devices and principles of design, and incorporate high-reliability systems and components, and use of redundancy in hardware and software design;
- safety devices – Hazards that cannot be eliminated or controlled by design selection shall be controlled to an acceptable level of risk through the use of fixed, automatic, or other protective safety design features or devices. Safety devices shall be designed to permit limited and controlled operation. Throughout the Term, Concessionaire shall inspect and perform periodic functional checks of each safety device;
- warning devices – When neither design nor safety devices can effectively eliminate or control an identified hazard, Concessionaire shall provide a device to detect the hazardous condition and generate a warning signal to the OCC for subsequent corrective action by personnel; and
- procedures and training – When design selection, safety devices, and warning devices cannot effectively eliminate or control an identified hazard, Concessionaire shall use procedures and training to control the hazard. Concessionaire shall implement training, equipment, and procedures to reduce the probability of a hazardous event. System safety critical tasks, duties, and activities require training and certification of operations and maintenance personnel by nationally recognized certifying agencies acceptable to Owner.

7.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- "Rail Fixed Guideway Systems; State Safety Oversight." 49 CFR Part 659;
- Federal Transit Administration (FTA) Hazard Analysis Guidelines for Transit Projects;
- Federal Transit Administration (FTA) Circular FTA C 5800.1, Safety and Security Management Guidance for Major Capital Projects;
- Federal Transit Administration (FTA) Handbook for Safety and Security Certification;
- Maryland State Fire Prevention Code;
- MTA System Safety Program Plan (SSPP);

- NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems; and
- Purple Line Safety and Security Management Plan.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in 7.2.6 of the Agreement.

7.3 System Safety Program Plan (SSPP)

Owner's System Safety Program Plan is mandated by the Federal Transit Administration (FTA) through 49 CFR Part 659, and shall be the governing document for requirements, methodology, and implementation of system safety program.

7.4 System Safety Plan

Concessionaire shall submit the System Safety Plan for Review and Approval that documents the requirements, methodology, and implementation of system safety for the Project in accordance with the SSPP. Concessionaire shall update the System Safety Plan as required for significant issues and not less than annually. The initial submittal of the System Safety Plan shall be no later than 60 days after Financial Close.

The Concessionaire's System Safety Plan shall include, but not be limited to the following:

- task listing and time phasing of each task;
- organization and responsibilities of key personnel;
- procedures to accomplish system safety tasks, including, at a minimum:
    - hazard management program;
    - correct system safety deficiencies noted within Design Work;
    - evaluate system design and design changes;
    - conduct system safety analyses of Project systems, subsystems, and interfaces;
    - corrective action to address Unacceptable Hazards/Risks;
    - actions to reduce risks from Unacceptable Hazards/Risks;
    - cost-benefit analysis for elimination or acceptance of risk; and
    - internal safety audits.
- description of a data collection and feedback system to be used to establish requirements for redesign, design changes, and corrective actions; and
- description of training program for operations and maintenance personnel to provide information on system safety methods and procedures, protective devices, and emergency equipment, and provide input from safety analyses in the form of warnings and caution statements into the training program and into the operating and maintenance/service manuals, for systems, subsystems, equipment hardware, software, and firmware provided in the Contract Documents.

The validation of safety elements of the Project is governed by the Project-specific Safety and Security Certification Plan. The Project Safety and Security Certification Plan shall describe the procedures and methods used for attainment of safety-related elements required by the Contract Documents.

7.4.1 Concessionaire's Chief Safety Officer

Concessionaire shall provide a Chief Safety Officer having the primary responsibility for implementing and monitoring the goals and objectives established by the System Safety Plan and to meet the criteria for safety management systems. Responsibilities include oversight of Concessionaire project system safety during all project phases including design, construction, start-up, testing, and the initiation of revenue service through the Term of the project. The Concessionaire's Chief Safety Officer Responsibilities shall include, at a minimum:

- implementation and oversight of the Concessionaire's hazard management process;
- overseeing the Concessionaire's interface with local jurisdiction emergency responders, including emergency responder training and drills; and
- ensuring that Concessionaire personnel are trained in safety plans, procedures, and operations.

The Concessionaire's Chief Safety Officer shall also be responsible for Concessionaire safety audits, accident investigation and reporting, as well as reporting of safety and accident statistics to the Owner. The Chief Safety Officer and the Concessionaire's safety organization shall be independent from the staff and duties associated with the execution/production of the Work

7.4.2 Hazard Management Program

Concessionaire shall maintain a hazard management program throughout the Term. The hazard management program shall document Concessionaire's effort to eliminate, mitigate and control hazards that Concessionaire identifies during design, construction, testing, operations and maintenance of the Project. The hazard management program shall be described in the Concessionaire's System Safety Plan.

7.4.2.1 Safety Analysis

Concessionaire shall perform system safety analyses to identify safety hazards, assess their risk as a function of hazard severity and probability of occurrence, and apply the Owner risk criteria for hazard mitigation and resolution given in the Owner's SSPP.

Hazard severity and probability definitions shall be based on MTA's SSPP.

Concessionaire shall perform and document system safety analyses to identify potentially hazardous conditions as required to ensure that safety has been adequately considered. Concessionaire shall apply system safety analyses to:

- evaluate alternatives;
- evaluate and verify safety requirements of the systems, subsystems and assemblies for the systems under the scope of this Project;
- evaluate the operation/emergency procedures and training requirements; and
- provide visibility of relative safety and risk within system components.

Concessionaire shall perform safety analyses of systems, subsystems and functions to identify potential system safety hazards in System Elements, subsystems and assemblies, hardware and software and interfaces including at a minimum:

- System Elements and subsystems to be analyzed include but are not limited to those specified in the Certified Elements List (CEL) and Certified Items List (CIL);

- perform analyses of interfaces between each system and operating and maintenance personnel;
- perform analyses of interfaces between each system and other systems that directly interface with it; and
- perform analyses of potential human errors and fault conditions arising from operations and maintenance manuals.

Existing analyses and data that are properly documented and verifiable, and that present the material in a neat, concise and logical manner may be submitted for equipment and applications that are identical or manifestly similar.

The system safety analyses shall be an on-going function of the Concessionaire. Therefore, during the Design-Build Period, there will be multiple Submittals based on these analyses and the Concessionaire's schedule, including the Submittal Schedule, should reflect the time required to complete these analyses and include them as necessary for the Final Design, except as noted below.

Concessionaire shall submit system safety analyses described in Part 2A, Section 7.4.2.2 of the Technical Provisions for Review and Comment, except as noted for Review and Approval.

7.4.2.2 Types of System Safety Analyses

In performing the required analyses, the depth of detail shall be dictated by hardware and software components, functions and modules called for in the Final Design, identified critical items, and unresolved potential failures of Unacceptable Hazards/Risks. Concessionaire shall perform the following analyses, including, at a minimum:

- Preliminary Hazard Analysis - Concessionaire shall determine, evaluate and assess the hazards during Design Work. The PHA process shall include a workshop for each PHA including Concessionaire and Owner subject matter experts. A consensus shall be reached regarding the rating of hazard probability and severity, and risk. Concessionaire's Preliminary Hazard Analysis shall demonstrate that the Certifiable Elements and operational systems conform to the requirements of the Contract Documents and identified hazards have been either eliminated, or reduced to levels of risk acceptable to the Owner in accordance with Owner's SSPP. Design mitigation measures for hazards shall be verified as being included in the design at the end of Final Design. The PHA shall be initiated and updated throughout the Design Work and shall be submitted for Review and Approval for Final Design and be included in the Initial Baseline Schedule.
- Failure Modes and Effects Analysis - Concessionaire shall identify weaknesses in safety critical system hardware and software design, and to provide analysis of the modes and effects of failures whenever details are not established by historical records of equipment operation. The Failure Modes and Effects Analysis shall indicate circuit behavior, random component failures, electrical interference, and systematic component failures. The Failure Modes and Effects Analysis and reliability prediction shall be updated throughout Design Work and include the LRV and Operating System design.
- Software Failure Modes and Effects Analysis - Concessionaire shall determine and document the software failure modes and software errors in software-based logic that are likely to cause failure events. These events are classified according to their severity and criticality.

- Fault Tree Analysis– Concessionaire shall perform Fault Tree Analysis to investigate unresolved potential failures with Unacceptable Hazards/Risks. The Fault Tree Analysis shall evaluate the probability of item failure and combination of several item failures that result in a higher-level system failure. Fault Tree Analysis shall be updated throughout Design Work and shall include the LRV and operating system design.
- Event Tree Analysis – Concessionaire shall perform Event Tree Analysis to investigate any unresolved potential failures with Unacceptable Hazards/Risks. The purpose of Event Tree Analysis is to identify and quantify possible event outcomes following an initiating event. Event Tree Analysis shall be updated throughout Design Work and shall include the LRV and operating system design.
- Operating Hazard Analysis - Concessionaire shall identify and analyze hazards associated with personnel and procedures that occur during testing, training, operations, maintenance and emergencies. The Operating Hazards Analysis shall be initiated an updated throughout the Design-Build-Testing period and shall be included on the Initial Baseline Schedule. The final Operating Hazards Analysis shall be submitted for Review and Approval six months before the start of Trial Running.

7.4.2.3 Evaluating Hazards

For each identified hazard, Concessionaire shall establish hazard severity category, hazard probability ranking, and a combined hazard risk index reflecting the severity and probability ranking based on the hazard risk indices defined in Owner's SSPP.

Concessionaire shall apply risk assessment criteria to identified hazards based on the identified severity and probability of occurrence, to determine acceptance of the risk or the need for corrective action to further reduce the risk. The risk acceptance criteria shall conform to that defined in Owner’s SSPP.

Concessionaire shall analyze hazards that are identified as having an Unacceptable Hazards/Risks, using logic network analyses (such as fault tree) to determine effectiveness of corrective actions. Unacceptable Hazards/Risks shall be reduced to an acceptable level before design acceptance. Hazards or risks that are not Unacceptable Hazards/Risks shall be mitigated on a priority basis using cost-benefit considerations and shall be approved by the Owner.

Hazards identified as "acceptable with review" may be accepted by Owner in an "as-is" condition with no further corrective action. Alternatively, Owner may require Concessionaire to create operating and maintenance procedures for periodic tests and inspections of the subject item to ensure an acceptable level of safety is maintained over the life of the system.

7.4.2.4 Safety and Security Verification Tracking Log

Concessionaire shall maintain and update a Safety and Security Verification Tracking Log (SSVTL) throughout the duration of the Term to track safety-critical items identified during the system safety analyses as defined by Owner’s SSPP. The SSVTL shall track and document the certification process and outcome, and include, at a minimum:

- list of all certifiable elements;
- hazard analysis items;
- system safety and security requirements;
- criteria references;

- verification methods;
- compliance/noncompliance documentation;
- work around procedures; and
- closure status.

Concessionaire shall document any rationale in lieu of corrective action to mitigate a hazard. Concessionaire shall conduct special reviews of unresolved critical items on the SSVTL with Owner to determine disposition of the items.

Concessionaire shall submit the SSVTL for Review and Comment every 90 calendar days from Financial Close until the start of Revenue Service.

7.4.3 Safety Principles

The following safety principles, as modified from FTA's Hazard Analysis Guidelines for Transit Projects, shall be implemented by Concessionaire in the design and operational concepts of the systems, subsystems, functions, assemblies and interfaces, to the extent covered under Concessionaire's scope in the Contract Documents for the Project, within the dynamic environment of the Project Corridor:

- when the systems are operating normally there shall be no Unacceptable Hazard/Risks;
- systems design shall ensure successful operation under abnormal (failure recovery) and Emergency (e.g., derailment, fire/ smoke) conditions on the Guideway, and all safety analyses shall evaluate and ensure acceptable hazard risk under normal, abnormal (failure recovery), and Emergency conditions;
- safety of the systems in the normal automatic operating mode shall not depend on the correctness of actions or procedures used by operating personnel;
- there shall be no single-point failures or fault conditions in the system that can result in an Unacceptable Hazard/Risk, under normal, abnormal (failure recovery) or Emergency condition;
- if one failure combined with a second failure can cause an Unacceptable Hazard/Risk, the first failure shall be detected and the system shall achieve a known safe state before the second failure can occur;
- software faults shall not cause an Unacceptable Hazard/Risk under normal, abnormal (failure recovery), or Emergency conditions;
- Unacceptable Hazard/Risks shall be mitigated or eliminated by design; and
- maintenance activities required to preserve or achieve risk levels shall be performed. Personnel qualifications required to adequately implement these activities shall also be identified and tracked.

7.5 Fire/Life Safety and Security Committee (FLSSC)

The FLSSC serves as a liaison between the Owner and the external emergency response agencies. The FLSSC includes Owner and local emergency response agency representatives, and other local, State and Federal officials, as necessary. The FLSSC reviews, analyzes and directs activities related to the fire/life safety and security aspects of the Project and identifies the emergency response needs (such as training and drills) that are required to adequately respond to accidents/incidents that may occur during the Term. The FLSSC also provides expertise to facilitate the development and implementation of emergency responder training programs and activities, and Emergency operating procedures and plans.

In the interest of efficiency, the Owner has implemented two FLSSC sub-committees, one for Montgomery County and one for Prince George's County. In this way, the sub-committees can focus on local issues affecting their municipality. Common issues will be raised to the full Purple Line Project FLSSC.

Concessionaire shall participate in meetings of the FLSCC for both Prince George's County and Montgomery County as required for Concessionaire to meet the requirements of the Contract Documents.

7.6 Emergency Drills and Exercises

Concessionaire shall participate in the planning, co-ordination, and execution of tabletops, emergency drills and exercises with the Owner and Emergency Services to demonstrate project response to emergencies. Concessionaire shall participate in these drills and exercises during the pre-operational testing phases and through the project Term at least twice per year during the operations phase and as determined by the Owner and the local emergency response agencies.

7.7 Safety & Security Management Plan (SSMP)

Concessionaire shall submit the Safety and Security Management Plan for Review and Approval. Concessionaire shall address safety and security management for the Project from Financial Close to Revenue Service in accordance with FTA Circular C 5800.1, *Safety and Security Management Guidance for Major Capital Projects*. The SSMP shall be submitted at the same time as the PMP.

7.7.1 System Safety Criteria

System safety criteria shall be incorporated into the Design Work, Construction Work, and O&M Work. Safety criteria are dispersed throughout the technical provisions with respect to Stations, ROW, Traction Power, signals, yard and shops, Operations Control Centers, LRV, communications and operations.

Implement the approved criteria throughout all aspects of final design development, test, delivery, installation and maintenance. The criteria shall include requirements for the following:

- design safety: Employment of system safety techniques that optimize the design to minimize or control hazards identified by failure analyses. Coordination with reliability, maintainability and design engineers to avoid potential hazards resulting from complexity of design. Maintenance of standardization of design by use of proven standards of the railroad/ transit industry and applicable regulatory codes;
- potential failures: Ensure a single-point failure in a dynamic system will not result in an Unacceptable Hazard/Risk. Ensure elimination or minimization of the hazards by design, except in specific cases where high reliability, failsafe items may be used, based upon a properly documented past history of low failure rate, if approved by Owner after submission of the history of these items. Control of potential failures with hazards or risks that are not an Unacceptable Hazard/Risk through use of safety devices and approved operating or maintenance procedures;
- redundancy: Incorporation of redundant circuits and components in a coordinated system safety, reliability and maintainability engineering review to ascertain mutual agreement of system enhancement; and

- human factors: Prevent/minimize human error(s) when responding to field and operational conditions by eliminating the following: conflicting or ambiguous alarms and status indications; conflicting or ambiguous instructions; lengthy or complicated instructions; inherent design errors/problems; and unclear or incomplete supporting hardware and software documentation.

7.7.2 Safety and Security Certification Plan (SSCP)

The SSCP shall describe the process for the Project to achieve Safety and Security Certification. The Project will identify safety and security elements using various methods, including, at a minimum, previous experience, system safety analyses and security threat assessments. The purpose of the SSCP is to ensure that Project safety and security requirements are implemented by tracking them for application through all Project phases from Design through Revenue Service.

Concessionaire shall develop an SSCP in accordance with the FTA's Handbook for Safety and Security Certification, the Contract Documents, and that documents how the Concessionaire will achieve the following:

- Concessionaire shall prepare and submit for Review and Comment the Certifiable Elements List (CEL) that includes the significant Project elements that affect the safety and security of the Users, employees, Concessionaire staff, emergency responders and the general public. The CEL shall be submitted with the intermediate and final designs and be included on the Initial Baseline Schedule;
- Concessionaire shall prepare and submit for Review and Comment the Certifiable Items List (CIL) composed of the numerous items that make up the whole of the certifiable elements and require individual safety and security verification. The CIL shall be submitted with the intermediate and final designs and be included on the Initial Baseline Schedule;
- safety and security design criteria are developed to identify concerns appropriate for the Project;
- Concessionaire shall submit the Design Criteria Conformance Checklist for Review and Approval and be shown on the Submittal Schedule for final designs. Concessionaire shall identify and record the requirements generated from safety and security design criteria on such checklist. The format of the Checklist shall provide verification and compliance with the identified safety and security requirements;
- Concessionaire shall develop a Construction Specification Conformance Checklist to be used in coordination with the safety test plans. Concessionaire shall verify that the built facilities and systems incorporate the safety and security-related requirements of the Project. Concessionaire shall submit the Construction Specification Conformance Checklist for Review and Comment and be shown on the Submittal Schedule for construction/installation;
- Integration Tests are identified that need to be monitored for safety and security;
- training classes are provided to transit operations and maintenance staff that address safety, security and emergency preparedness;
- operations and maintenance manuals are provided to, or developed by, transit operations and maintenance staff;
- operations and maintenance staff are trained on O&M rules and procedures for the Project;

- public safety personnel (i.e., fire and police) are trained to manage their activities safely in the transit environment;
- emergency drills are conducted for identified transit emergencies that may occur on the Project;
- hazard and vulnerability identification and resolution are performed with tracking for resolution and/or acceptance throughout the Project;
- the Project Safety and Security Certificate of Conformance is issued to verify that the Project is safe and secure for Revenue Service;
- preparation and submission of the Safety and Security Certification Verification Report for Review and Approval; and
- the Project successfully complies with identified safety and security requirements.

Concessionaire shall submit the Safety and Security Certification Plan for Review and Approval within 120 days of Financial Close.

7.8 Safety Test Plans and Verification

Concessionaire shall verify that system safety requirements are met. A combination of analytical and test methods shall be utilized. Concessionaire shall integrate safety tests and verifications into the appropriate test plans developed in accordance with other sections of the Contract Documents for System Elements, subsystems and assemblies, hardware and software, and interfaces. Detailed test plans shall ensure:

- safety is adequately demonstrated;
- testing will be carried out in a safe manner; and
- any additional hazard introduced by testing procedures, instrumentation and test hardware is properly identified and minimized.

7.9 Railroad Worker Secondary Warning System

A system shall be provided to automatically notify maintenance personnel whenever a Train is approaching their location. The system shall be an advanced warning system that consists of devices that alert personnel on the tracks to oncoming LRVs, as well as alerting LRV operators to the presence of personnel on the tracks.

7.10 Safety Requirements – Fitness for Duty

Concessionaire personnel performing "Safety Sensitive Functions" shall be subject to drug and alcohol testing, which Concessionaire shall perform in accordance with applicable provisions of the Contract Documents and U.S. 49 CFR Parts 40, Procedures for Transportation Workplace Drug and Alcohol Testing Programs, and 655, Prevention of Alcohol Misuse and Prohibited Drug Use in Transit Operations.

7.11 Summary of Submittals

Item	Section	Submittal	Action
1	7.4	System Safety Plan	Review and Approval
2	7.7	Safety and Security Management Plan	Review and Approval
3	7.7.1	Safety and Security Design Criteria	Review and Approval
4	7.7.2	Safety and Security Certification Plan	Review and Approval
6	7.4.2.2	Preliminary Hazard Analysis	Review and Approval
7	7.4.2.2	Failure Modes and Effects Analysis	Review and Comment
8	7.4.2.2	Software Failure Modes and Effects Analysis	Review and Comment
9	7.4.2.2	Fault Tree Analysis	Review and Comment
10	7.4.2.2	Event Tree Analysis	Review and Comment
11	7.4.2.2	Operating Hazard Analysis	Review and Approval
12	7.7.2	Design Criteria Conformance Checklist	Review and Approval
13	7.4.2.4	Safety and Security Verification tracking Log	Review and Comment
14	7.7.2	Construction Specification Conformance Checklist	Review and Comment
15	7.7.2	Certifiable Elements List	Review and Comment
16	7.7.2	Certifiable Items List	Review and Comment
17	7.7.2	Safety and Security Certification Verification Report	Review and Approval

8 SYSTEM SECURITY

Concessionaire shall create and maintain a security vulnerability management process throughout the lifecycle of the Project. Concessionaire shall document security vulnerability management process efforts to eliminate, mitigate and control vulnerabilities that are identified during design, construction, testing, operations and maintenance of the Project.

8.1 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- Federal Transit Administration (FTA) Transit Agency Security and Emergency Management Protective Measures;
- MTA System Security and Emergency Preparedness Plan (SSEPP);
- Purple Line Safety and Security Management Plan;
- FTA, FTA-TRI-MA-26-7085-05, Transit Security Design Considerations;
- FTA, DOT-FTA-MA-26-5019-03-01, Public Transportation System Security and Emergency Preparedness Planning Guide;
- TSA/FTA, Security and Emergency Management Action Items for Transit Agencies;
- The Blue Ribbon Panel on Bridge and Tunnel Security, *Recommendations for Bridge and Tunnel Security*;
- Transit Security Working Group (TSWG), Contract Number N4175-05-R-4828, Final Report, *Bridge and Tunnel Report*;
- FTA-MA-90-5006-02-01/DOT-VNTSC-FTA-02-01, Handbook for Transit Safety and Security Certification;
- FTA Circular C 5800.1, Safety and Security Management Guidance for Major Capital Projects;
- DOT-FTA-MA-26-5005-00-01/DOT-VNTSC-FTA-00-01, Hazard Analysis Guidelines for Transit Projects;
- 49 CFR Part 659, Rail Fixed Guideway Systems, State Safety Oversight;
- 49 CFR Parts 12 and 1520, Protection of Sensitive Security Information;
- APTA, Recommended Practice APTA SS-SIS-RP-001-10, Crime Prevention through Environmental Design (CPTED) for Transit Facilities;
- APTA, Guidelines for Design of Rapid Transit Facilities;
- IESNA, IESNA G-1-03, Guideline on Security Lighting for People, Property, and Public Spaces; and
- IESNA, Recommended Practice IESNA RP-20, Lighting for Parking Facilities.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in 7.2.6 of the Agreement.

8.2 General Requirements and Responsibilities

Concessionaire shall be responsible for designing a secure system per applicable codes, standards and guidelines for detecting and/or avoiding vulnerable conditions that may be inherent in Concessionaire’s design solution and/or determined in a Threat and Vulnerability Assessment (TVA). Special attention to vulnerable conditions shall be given in areas where systems or subsystems interface, or where overlapping areas of design responsibility exist.

Concessionaire's system security program shall eliminate and/or control critical vulnerabilities or reduce security vulnerabilities through application of Owner's security risk acceptance criteria contained in the System Security and Emergency Preparedness Plan (SSEPP).

During consideration of precedence in the control of security vulnerabilities, Concessionaire shall consider human factors and limitations as a design constraint. Concessionaire shall take corrective action to eliminate or control security vulnerabilities using the following approach to system security:

- Concessionaire shall prepare and implement security strategies in accordance with the FTA document, The Public Transportation System Security and Emergency Preparedness Planning Guide;
- general application of security measures shall be supplemented by the Owner’s SSEPP and by TVAs;
- results of the TVAs shall be used to help determine risk mitigation and implementation priorities;
- Concessionaire shall prioritize security risks through TVAs and select sets of countermeasures for the Project that provides the best overall risk reduction; and
- Concessionaire shall incorporate TVA results as the design and threat assessments evolve.

8.3 Protection of Sensitive Security Information (SSI)

Concessionaire shall conform to 49 CFR Parts 15 and 1520 and shall categorize and protect SSI. Protecting SSI means restricting its distribution and controlling access to it.

SSI is defined in 49CFR 15.5. SSI may include, but is not limited to:

- Threat and Vulnerability Assessments;
- locations of security devices such as detectors, sensors, and barriers;
- non-routine security procedures and operations; and
- records of assessments, drills, or exercises that reveal system or security vulnerabilities.

Owner has established the Joint Security Group (JSG) as a committee for the Project to review documents that may be SSI. If Concessionaire knows or suspects that a document or other items may contain SSI, Concessionaire shall submit the document to Owner’s JSG to determine if Concessionaire’s Submittal meets Owner's SSI policy conditions. Determination of SSI will be in accordance with Owner SSI guidelines per Owner’s JSG. Concessionaire shall describe the methodology for controlling SSI in the Safety and Security Management Plan (SSMP) and shall be compliant with the Owner’s SSI policy.

Concessionaire shall not release certain other information regarding transit infrastructure, despite not constituting SSI. Concessionaire shall protect such other certain information consistent with the Maryland Public Information Act Manual, including at a minimum

- information relating to emergency procedures;
- infrastructure information;
- building plans;
- blueprints;
- schematic drawings;
- diagrams;
- hazard analyses;
- emergency ventilation systems;
- operational manuals; and
- other records.

8.4 Concessionaire's Security Plan

The Concessionaire's Security Plan (CSP) shall include but not be limited to the following elements:

- task listing and time phasing of each task;
- organization and responsibility of key personnel;
- procedures to accomplish the system security tasks, including provisions to:
    - correct system security deficiencies, including at a minimum vulnerabilities and security breaches noted during the Design Work, but not later than system design acceptance;
    - evaluate system design and design changes from the aspects of security threats and vulnerabilities;
    - conduct security TVAs of each critical asset of Concessionaire's scope of work, and their interfaces. Update the TVA during the construction, installation, testing and certification of the Project;
    - take immediate corrective actions to prevent personal injury or system damage when a Unacceptable Hazard/Risk is identified, and take action to reduce identified risk (defined as the combination of vulnerability severity and probability);
    - While unacceptable risk shall be immediately eliminated, designed-out and controlled to an acceptable level before design acceptance, undesirable risk shall be prioritized for corrective action based on cost-benefit considerations giving precedence to those vulnerabilities with the highest risk reduction potential with the most cost-effective mitigation measures;
    - implement security protections, system "hardening" changes, which are Concessionaire initiated and approved by Owner, and those initiated by the Owner, per Concessionaire's scope of Work and responsibility in accordance with the Contract Documents;
    - coordinate the activities of Concessionaire's system security plan and comply with the overall SSMP and Safety and Security Certification Plan (SSCP);
    - internal security audits; and

- o maintain system security during the O&M Period of the Project.

Validation of security elements of Project design shall be governed by Concessionaire's SSCP. The SSCP shall describe the procedures and methods that document attainment of security-related elements.

Concessionaire shall submit the Concessionaire's Security Plan for Review and Approval within 60 days after Financial Close.

8.5 Safety and Security Management Plan

Concessionaire's SSMP is described in Part 2A, Section 7 of the Technical Provisions.

8.6 Safety and Security Certification Plan

Concessionaire's SSCP is described in Part 2A, Section 7, of the Technical Provisions. The SSCP describes the process to verify that safety and security requirements have been incorporated into the design, construction, testing, and operation of the Project.

8.7 System Security Criteria (SSC)

Concessionaire's SSC shall be integrated into Project elements, including operations, maintenance and training. SSC are dispersed throughout the Contract Documents. These criteria are based on DHS and FTA security guidance documents and industry practice, including FTA's Transit Agency Security and Emergency Management Protective Measures. Concessionaire shall identify and implement the SSC throughout the Term including at a minimum: design, delivery, installation, testing, certification, operations and maintenance.

Concessionaire shall prepare and submit a Design Criteria Conformance Checklist. The checklist is described in described in Part 2A, Section 7 of the Technical Provisions.

Concessionaire shall prepare and submit a Construction Specification Conformance Checklist. The checklist is described in described in Part 2A, Section 7 of the Technical Provisions.

8.8 Security Analysis

Concessionaire's security analysis shall be conducted in accordance with the process outlined in Owner's SSEPP, mandated by FTA through 49 CFR Part 659, Rail Fixed Guideway Systems; State Safety Oversight.

The SSEPP shall be the governing document for requirements, methodology and implementation of the security analysis document itself. The SSEPP is marked as a SSI and is a controlled document. Concessionaire's security-cleared personnel shall contact Owner to obtain access rights and privileges.

Concessionaire shall perform a TVA for each Project critical asset, including element and subsystem interfaces. Concessionaire shall initiate his security analysis on the Owner-provided baseline TVA. Concessionaire's TVA will be conducted early during Design Work to identify security threats and vulnerabilities (weaknesses) in the Project System Elements and subsystems, assess their risk as a function of severity and probability of occurrence, and apply Owner risk acceptance criteria for security risk mitigation and resolution. The TVA shall be conducted in accordance with the FTA guide documents on security, except as modified herein. The TVA shall be updated by Concessionaire throughout Design Work, Construction Work, and certification of the Project. Concessionaire shall review the TVA and perform additional analyses in the event design elements change.

Categorization of severity, probability and risk acceptance of security threats and vulnerabilities:

- severity of a security vulnerability and the magnitude of the impact should a threat successfully exploit the vulnerability are rated in terms of their effects on people or property, similar to safety hazard severity;
- ease of a given threat to exploit a given vulnerability provides the probability of occurrence;
- combination of severity and probability ratings results in a risk rating (risk index) for a security vulnerability;
- Severity Categories I though IV used to categorize security vulnerability consequences shall be used for severity categorization in TVA per Owner's SSEPP;
- probability ratings A through E used for vulnerability probabilities will be qualitatively used to rank the likelihood of each security vulnerability; and
- Owner's SSEPP Hazard Risk Assessment Matrix and Acceptance Criteria shall be used in TVA to provide an Owner-approved measure for acceptance of risk and security risk resolution.

Concessionaire shall submit a TVA for Review and Approval that identifies security threats and vulnerabilities in the Project System Elements and subsystems, assesses their risks as a function of severity and probability of occurrence, and applies Owner's risk acceptance criteria for security risk mitigation and resolution. The TVA shall be initiated and updated throughout the Design Work and be included in the Initial Baseline Schedule. Concessionaire shall update the TVA throughout the design process and into construction, installation and testing of the Project.

Concessionaire shall maintain a compilation of security critical items identified during the TVA, in the Safety and Security Verification Tracking Log (SSVTL). The SSVTL shall be maintained and updated by Concessionaire throughout the Term. Security critical items shall consist of vulnerabilities with Unacceptable Hazards/Risks. The SSVTL is also used to track safety critical items and is described in Part 2A, Section 7 of the Technical Provisions.

8.9 Summary of Submittals

Item	Section	Submittal	Action
1	8.4	Concessionaire’s Security Plan	Review and Approval
2	8.12	Threat and Vulnerability Assessment	Review and Approval

9 SCHEDULE

This Section describes the schedule requirements for the Project.

9.1 Project Schedule

The purpose of the Project Schedule is to ensure that adequate planning, scheduling, and resource allocations occur to provide a reasonable and executable baseline work plan.

The types of Project Schedules are further described below and shall include:

- Initial Baseline Schedule
- Updated Initial Baseline Schedule
- Baseline Schedule
- Revised Baseline Schedule
- Project Schedule Updates
- Project Recovery Schedule

The Project Schedule shall be used for coordinating the Work, monitoring the progress of Work performed, identifying Work to be performed, and evaluating changes.

Concessionaire shall include in Project Schedules all required Owner, Third Party, and Utility activities and/or milestones. These shall include at a minimum ROW availability, review of submissions, and special inspections as detailed in the Technical Provisions and Agreement.

Concessionaire shall archive all approved Project Schedules.

9.1.1 Updated Initial Baseline Schedule

Concessionaire shall provide the first update to the Initial Baseline Schedule, submitted with the Proposal, for Review and Approval no later than 7 days after Financial Close.

9.1.2 Baseline Schedule

Concessionaire's Baseline Schedule shall be a detailed schedule for the Project from Financial Close through Final Completion.

The Baseline Schedule shall comply with all schedule requirements and be broken down into work packages and deliverables of reasonable duration for which progress can readily be reported and verified.

Concessionaire shall submit the Baseline Schedule for Review and Approval no later than 60 calendar days after Financial Close. Baseline Schedule shall be Approved before commencement of Construction Work.

9.1.3 Revised Baseline Schedule

Concessionaire shall revise the Baseline Schedule within seven calendar days for the following:

- revisions specifically previously approved by Owner;
- revisions requested in writing by Owner; and
- Delay event for which Owner grants Relief to Concessionaire;

Concessionaire shall submit the revised Baseline Schedule for Review and Approval. After Approval the revised Baseline Schedule shall become the Baseline Schedule.

9.1.4 Project Schedule Updates

Concessionaire shall produce Project Schedule Updates to reflect actual progress to date and to define future activities. The last day of the reporting period shall be the date used to calculate the schedule.

The Baseline Schedule shall be the basis for Project Schedule updates.

At no time shall Concessionaire continue to reflect an item of non-concurrence from Owner in the updates to the Project Schedule.

Project Schedule updates shall, at a minimum:

- depict activities that have started, are on-going, or have completed during the reporting period;
- show actual start and finish dates for activities;
- include value of work completed per the Work Breakdown Structure;
- depict remaining duration for on-going activities, with remaining duration based on the amount of time required to complete the work;
- modify activity relationships as necessary to correct out-of-sequence progress for on-going activities or to reflect Concessionaire's plan for completing remaining Work; and
- be accompanied by a narrative report, which shall:
    - identify the Baseline Schedule version;
    - provide a summary of and reasons for revisions;
    - identify milestones;
    - include started activities this period;
    - include completed activities this period;
    - include activities not started this period;
    - include activities not completed this period;
    - discuss critical resources;
    - describe the critical path;
    - identify near critical activities;
    - describe any pending Time Impact Analyses (TIA);
    - describe Project issues encountered; and
    - identify potential changes to Baseline Schedule.
- include the following as tables:
    - critical path;
    - added activities;
    - deleted activities;
    - added predecessors;
    - revised relationship lags;

- deleted predecessors;
- revised original durations;
- revised activity names;
- changed calendars;
- activities started this period;
- activities completed this period;
- near critical activities;
- activities not started this period;
- activities not completed this period; and
- activities started or completed in previous period.

Concessionaire shall submit monthly Project Schedule Updates for Review and Approval in coordination with the Progress Report.

9.1.5 Project Recovery Schedule

Whenever the Baseline Schedule shows any scheduled completion date having 90 days or more of negative float, Concessionaire shall prepare a Project Recovery Schedule. The Project Recovery Schedule submittals shall include a list of all activity changes and an accompanying narrative explaining the nature of the changes.

Concessionaire shall submit the Project Recovery Schedule for Review and Approval.

After Approval the Project Recovery Schedule shall become the Baseline Schedule.

9.2 Schedule Requirements

9.2.1 General

All Project Schedules shall comply with the Contract Documents, good planning and scheduling practices, and at a minimum:

- include all major activities of the Work in sufficient detail to enable Owner to monitor and evaluate design and construction progress from Financial Close to Revenue Service Availability;
- provide standalone schedules as required by the Third Party Agreements Requirements and Utility Owner Agreement Requirements;
- apply the critical path method of network calculation to generate the Baseline Schedule (the critical path shall be based on the longest network path through the Project) and prepare the Baseline Schedule using the precedence diagram method to establish relationships and interdependencies between the individual activities required to complete the Project. Total float criteria are not acceptable for identifying or representing the Critical Path. The scheduling software shall be configured to show the longest path in any schedule calculation and graphical representation. Concessionaire shall take care to distinguish between the Critical Path and near Critical Paths;
- identify and discuss Project overhead costs and Project-wide costs not applicable to a specific activity in the Baseline Schedule narrative;
- be resource-loaded;

- ensure that activity identification numbers, textual descriptions, and codes are consistently applied in the Baseline Schedule and are unique for each activity;
- divide all Work through Final Completion into activities with appropriate logic ties to show Concessionaire's overall approach to sequencing, include logical relationships between activities reflecting Concessionaire's actual intended sequence of Work, avoid open ends, and not use imposed constraint dates to begin or complete any activity unless such dates are specifically required in the Contract Documents or are mutually agreeable to the parties. The Project Schedule shall have a single start and a single completion point. Activities shall be used in lieu of lags where an activity is appropriate, i.e. use a concrete curing activity in lieu of a 7 or 28 day lag to achieve strength prior to a subsequent activity;
- avoid the use of non-typical relationships that cannot be shown to demonstrate a true dependency. Use of relationships and lags to position an activity at certain dates is not be permitted;
- depict the required coordination with and work to be performed by Utility Owners and Third Parties;
- show phasing of the Work as detailed in the plans, work to be performed by Contractors, procurement, fabrication, delivery, installation, testing of materials and equipment, commissioning of systems, and any long-lead time orders for major or significant materials and equipment;
- be cost-loaded to an activity-level consistent with the Schedule of Values, including direct costs used in the Schedule of Values, with the total cost loaded into the Project Schedule equal to the total of the Design-Build Contract Price. Level of effort cost loading shall not be used by the Concessionaire;
- identify regulatory Approvals required and the dates by which such Approvals are necessary; and
- incorporate the availability of Project ROW.

Project Schedules shall show the Project milestones for significant components of work that are critical to the start of key subsequent activities and will assist with managing the Project Schedule including at a minimum:

- Commercial Close;
- Financial Close;
- commencement of Design Work
- commencement of Construction Work;
- commencement of O&M Work;
- other milestones identified by Concessionaire and Owner, Third Party or Utility Owner reviews, approvals, and permits that may include key design submissions required prior to the start of fabrication, key permitting required for start of construction activities, completion of tunnel, major traffic changes, and other high priority items required for public relations needs;
- commencement of Integration Testing;
- commencement of Trial Running; and

- Revenue Service Availability Date.

Project Schedules shall use a Work Breakdown Structure that is well organized and based on a deliverable oriented methodology that:

- allocates all activities with an estimated cost/planned value; and
- is organized and cost distributed to address 100 percent of the Project scope at all levels of the WBS.

9.2.2 Software

The scheduling software employed by Concessionaire shall be compatible with Owner's scheduling software. Concessionaire's scheduling software shall have the capability to import and export data in the Primavera proprietary exchange format (.XER). Owner's scheduling software is the latest version of Primavera Project Management software. Any changes in scheduling software shall be mutually agreed upon by all parties.

9.2.3 Project Schedule Submission Requirements

Each submission of a Project Schedule shall include, at a minimum, the following:

- time-scaled logic diagram indicating the critical path, early start and early finish dates, total float, grouped by WBS, and sorted by early start and then total float;
- an electronic file of the Project Schedule in Primavera proprietary exchange format (XER) file format. Each submission shall have a unique file name to indicate the type and order of submission; and
- a narrative progress report of the Project Schedule. The narrative shall indicate, at a minimum, Concessionaire's plan of operation for meeting the interim milestones and the required Revenue Service Availability Deadline, an evaluation of the critical path, a discussion of Project-specific issues encountered since the last submission as such issues relate to the schedule, proposed solutions thereof, work calendars, constraints, delays experienced, and the status of any submitted or pending Time Impact Analyses, float consumption, documentation of any logic changes, duration changes, resource changes or other relevant changes. The report shall identify the Baseline Schedule in effect at the data date of the current update and the preceding Baseline Schedule Update for that period.

9.3 Not Used

9.4 Time Impact Analysis for Proposed Extensions of Time

The following shall apply if a Time Impact Analysis (TIA) is required:

- The TIA shall be based on the date on which the alleged Force Majeure Events or Relief Event is determined to have occurred, or, in the event of a proposed Change Order, the proposed date on which the implementation of such Change Order is to commence;
- The TIA shall show the current status of the Work using the most recent Project Schedule Update prior to the initiation of the events in question. The time computation of all affected activities shall be shown in the TIA along with a demonstration of steps used to mitigate impacts;
- Each TIA shall include a fragmentary network (fragnet) demonstrating how Concessionaire proposes to incorporate the impact into the most recent Project Schedule Update prior to the initiation of the events in question. A fragnet is defined as the sequence of new

activities and/or activity revisions, and logic relationships that are proposed to be added to the existing schedule to demonstrate the influence of impacts to the schedule. The fragnet is subject to the same requirements for activities including resource information for added scope and assignment of activity codes and assignment to the appropriate WBS structure, existing or amended. In the event of an alleged Relief Event or Force Majeure Event, Concessionaire shall demonstrate the calculation of its durations based on quantities, resource loading, and productivities for both the fragnet activities and the affected and impacted activities. The fragnet shall identify the predecessors to the new activities and demonstrate the impacts to successor activities. Concessionaire shall insert the fragnet into the most recent Project Schedule Update prior to the initiation of the alleged Relief Event or Force Majeure Event, run the schedule calculations, and submit the impacted schedule as required by the Contract Documents. Concessionaire shall include a narrative report describing the effects of new activities, resources and relationships to Contract Document milestones and the applicable Revenue Service Date with each TIA;

Concessionaire shall submit the Time Impact Analysis for Review and Approval. The TIA shall include an electronic file (in .XER file format) of the Project Schedule impact analysis.

Upon Approval Concessionaire shall incorporate the TIA into the next Baseline Schedule Update. Any TIA related to a Change shall be incorporated into, and attached to the applicable Change Order.

9.5 Summary of Submittals

Item	Section	Submittal	Action
1	9.1.1	Updated Initial Baseline Schedule	Review and Approval
2	9.1.2	Baseline Schedule	Review and Approval
3	9.1.3	Revisions to the Baseline Schedule	Review and Approval
4	9.1.4	Project Schedule Updates	Review and Approval
5	9.1.5	Project Recovery Schedules	Review and Approval
6	9.4	Time Impact Analysis	Review and Approval

10 SUBMITTALS

This Section describes the Submittal process and review procedures for all Concessionaire Submittals to Owner, Third Parties, and Utility Owners. In addition to the Design-Build Period, the requirements of this Section shall apply to all design and construction activities during the O&M Period.

10.1 General

The Owner and Concessionaire may modify and refine the Submittals, Submittal content, and review process required by the Contract Documents to provide for further efficiencies by mutual agreement, evidenced by a “no cost, no schedule change” Change Order.

The Owner, Concessionaire, and, under relevant Third Party Agreements or Utility Agreements, a Third Party or a Utility Owner may modify and refine the Submittals, Submittal content, and review process relating to the Agreement, the relevant Third Party Agreement or Utility Agreement, as applicable, required by the Contract Documents to provide for further efficiencies by mutual agreement, evidenced under the Agreement by a “no cost, no schedule change” Change Order, and, if applicable, as documented in the relevant Project Execution Plan.

10.2 Submittal Content

10.2.1 Technical Content

Part 2A, Section 3.6 of the Technical Provisions describes the use of Preliminary, Intermediate, and Final Submittal stages. Within the Technical Provisions, there are descriptions of what information shall be included with each Submittal. The Concessionaire may propose that different information be shifted into an earlier or later Submittal.

The Summary of Submittals table within sections of the Technical Provisions is for Concessionaire’s convenience only, and does not supersede any requirements pertaining to Submittals in the Contract Documents or imposed by the Third Parties, Utility Owners, or AHJ. Concessionaire shall comply with all requirements pertaining to Submittals specified in the Contract Documents.

The content of Submittals for Third Parties and Utilities shall be as required by the Third Party Agreements, Utility Agreements, and the respective Project Execution Plans.

10.2.2 Submittal Certification

With each Submittal, Concessionaire shall certify in writing that the Submittal meets the requirements of the Contract Documents and has been coordinated among all requirements of the Contract Documents including at a minimum Design Work, Construction Work, and O&M Work

For Final Design submittals (except for test results) the certification shall include signature of the Project Manager, and signatures recommending certification from authorized personnel of Concessionaire including at a minimum:

- Concessionaire’s Designer;
- Concessionaire’s Quality Program;
- Concessionaire’s builder;
- Concessionaire’s operations organization; and
- Concessionaire’s maintenance organization.

For all other Submittals (including test results), the certification shall include the signature of the Project Manager.

10.2.3 Quality Control Certification

Concessionaire shall control through the CQP a technical approval and certification system for every Submittal to the Owner, Utility Owner, and Third Party. Each Submittal shall contain a Quality Control certification.

10.2.4 Other Certifications

All Submittals shall contain any other certifications required by Codes and Standards, Law, Third Party Agreements, Utility Agreements, and Project Execution Plans.

10.2.5 Submittal Format

All Submittals shall be in the English language using U.S. customary units.

All Submittals shall be made in .PDF format, except where files are required by the Contract Documents, Third Party Agreements, Utility Agreements or Project Execution Plan to be delivered in a specific software format.

All plans and drawings shall be submitted true to scale as full size drawings for standard size paper.

A signed transmittal letter shall be included with each Submittal. The transmittal letter shall indicate the date of the transmittal, the type, stage where applicable, review type, entities to perform review, and review period for each entity.

In addition to the electronic copy of each Submittal, Concessionaire shall submit to Owner:

- two paper copies for Owner's records. For drawings, one paper copy shall be full size and one paper copy shall be half size. Paper drawing set submittals shall be screw bound. Other paper submittals shall be comb, spiral or wire bound; and
- paper copies or other formats in sufficient copies as required by the Third Party Agreement Requirements, Utility Agreements, or Project Execution Plans.

10.3 Submittal List

The Contract Documents specify the minimum required Submittals, types and content required by the Owner. Concessionaire shall identify any additional Submittals required by Concessionaire's Project Management Plan, Third Party Agreements, Utility Agreements, and the Project Execution Plans.

Concessionaire shall be responsible for identifying, scheduling and managing the Submittals necessary to meet the Project requirements.

Owner, Third Parties, and Utility Owners will not be obligated to meet review periods in Part 2A, Section 10.4.2 of the Technical Provisions and Article 5 of the Agreement for Submittals not in accordance with the Submittal List.

Concessionaire shall keep and maintain a list of all anticipated Submittals to Owner, Third Parties and Utility Owners. For each Submittal the list shall include:

- Submittal title;
- document control number;
- a brief description of the Submittal

- design stage per Part 2A, Section 3.6 of the Technical Provisions;
- the reviewing entity or entities (Owner, Third Parties, Utility Owners);
- the type of review for each reviewing entity per Part 2A, Section 10.4.4 of the Technical Provisions;
- the review period for each reviewing entity per Part 2A, Section 10.4.2 of the Technical Provisions and Section 5.1.3 of the Agreement;
- scheduled submission date;
- actual submission date;
- status of response(s) to the Submittal.

Concessionaire shall submit the Initial Submittal List for Review and Comment no more than 30 calendar days after Financial Close. The initial Submittal List shall be coordinated, to the extent possible, with the Initial Project Execution Plans required by Part 2A, Section 19.3 of the Technical Provisions.

Concessionaire shall submit the Final Submittal List for Review and Approval no later than 90 days after Financial Close.

Each month the Concessionaire shall submit an Updated Submittal List for Information in coordination with the Progress Report. The Updates Submittal List shall include revised scheduled submission dates, actual submission dates, and status of response(s) to the Submittal.

10.4 Submittal Process

The process described in this Part 2A, Section 10.4 of the Technical Provisions applies to all Submittals to Owner, Third Parties, and Utility Owners.

10.4.1 Transmittal

Submittals shall be made electronically via the Owner's project document control system. In the case of sample or mock up Submittals, the electronic Submittal shall contain information describing the location at which the sample or mock up Submittal can be examined.

Submittal will be returned to the Concessionaire without review if the requirements of Part 2A, Section 10 of the Technical Provisions and Section 5.1.2 of the Agreement have not been met.

Upon receipt from Concessionaire, Owner will be responsible for transmitting Submittals to the Third Parties and Utility Owners identified by Concessionaire as well as any other deemed necessary by Owner.

10.4.2 Review Period

Submittal review period(s) for each Submittal shall be determined based on the requirements of each entity (Owner, Third Party, and Utility Owner) performing review. If multiple entities are performing review for a single Submittal, this may result in differing length review periods for each entity, however all review periods during which the Owner is to provide review to the Concessionaire under Section 5.1.3 of the Agreement for a single submittal shall commence at the same time

The review periods shall be as specified in Section 5.1.3 of the Agreement.

Concessionaire may request expedited action as specified in Section 5.1.3.7 of the Agreement.

The Submittal review periods apply to initial Submittals and all resubmittals.

Submittals received complete in the document control system before 16:00 Project local time are considered received the same working day. Submittals received after 16:00 Project local time are considered received the next working day. Review period shall commence on the working day following receipt.

Review period shall end and response will be transmitted through the document control system by 16:00 Project local time.

10.4.3 Simultaneous Reviews

In accordance with Section 5.1.3.2 of the Agreement, Owner may extend the review period of simultaneous Submittals a reasonable period of time under any one or more of the following circumstances:

- Owner is in receipt of more than 20 simultaneous Submittals;
- Owner is in receipt of more than 5 simultaneous Submittals requiring review by a single design discipline; and

For Third Party and Utility Owner reviews, simultaneous submittals shall be limited in accordance with the relevant Third Party Agreement Requirements and Project Execution Plan.

10.4.4 Review Types

This Section describes the review types that Owner may perform. The Contract Documents identify the type of review that Owner may perform for each Submittal.

The Third Party Agreement Requirements and Project Execution Plans identify the review types that Third Parties and Utility Owners may perform for each Submittal.

When not otherwise specified in the Contract Documents, Third Party Agreement Requirements or Project Execution Plans, the review type shall be Review and Approval unless otherwise agreed to by Owner, Third Party or Utility Owner as applicable.

Under any review type, Owner, Third Parties, and Utility Owners may include and expressly identify comments for which Concessionaire is not obligated to provide a response.

10.4.4.1 Review and Approval

Owner will return the Submittal in one of the following manners:

- "Reviewed and Approved." Concessionaire may proceed to implementation of the Submittal or further development of the Design.
- "Reviewed and Approved with Comments." Subject to Section 10.4 of the Technical Provisions, Concessionaire shall document all comments received and the corresponding resolutions. Concessionaire shall incorporate comments into the next planned Submittal, or resubmit if no future Submittals are required.
- "Reviewed with Comments, Resubmit." Subject to Section 10.4 of the Technical Provisions, Concessionaire shall document all comments received and the corresponding resolutions. Concessionaire shall amend the Submittal in accordance with the comment resolutions and resubmit to Owner.

10.4.4.2 Review and Comment

Owner will return the Submittal in one of the following manners:

- "Reviewed with No Comments." Concessionaire may proceed to implementation of the Submittal or further development of the Design.
- "Reviewed with Comments, Resubmittal Not Required." Concessionaire shall be responsible for documenting all comments received and the corresponding resolutions. Concessionaire shall incorporate comments into the next planned Submittal or resubmit if no future Submittals are required.
- "Reviewed with Comments, Resubmit." Concessionaire shall be responsible for documenting all comments received and the corresponding resolutions. Concessionaire shall amend the Submittal in accordance with the comment resolutions and resubmit.

10.4.4.3 Information

Owner will acknowledge receipt of the Submittal via the document control system. There shall be no review period.

10.4.5 Submittal Response

Owner will provide Owner's written response through Owner's document control system in accordance with the defined review types and review periods. Owner's failure to provide review within the specified review period is handled under Sections 5.1.4 or 5.1.5 of the Agreement, as applicable.

Owner will provide Third Parties and Utility Owners written response through Owner's document control system in accordance with the defined review types and review periods as applicable to the relevant Third Party and Utility Owner. If any Third Party or Utility Owner fails to provide review within the specified review period, then the status of such Submittal shall be determined in accordance with the relevant Third Party Agreement Requirements, requirements under Owner Utility Agreements and relevant Project Execution Plans.

Owner will be responsible for coordinating the Submittal response with Third Parties and Utility Owners including but not limited to monitoring the review process and undertaking appropriate efforts to obtain timely responses from such Third Parties and Utility Owners. Concessionaire shall provide support to Owner, Third Parties and Utility Owners as necessary to support Third Party and Utility Owner reviews.

For submittals with multiple reviewing entities and differing review periods, Owner will provide relevant responses at the conclusion of each review period.

10.5 Concessionaire's Obligation to Coordinate

Concessionaire shall transmit to Owner any response or other correspondence received from Third Party or Utility Owner with respect to Submittals.

Concessionaire shall identify and resolve any conflicting comments and work with all parties to achieve resolution.

10.6 Amended Submittals

If Concessionaire determines that any Submittal previously provided to Owner, Third Party or Utility Owner is required to be amended or is identified to be outdated, incomplete, contain errors, or is no longer sufficient to cover Concessionaire's Work, Concessionaire shall revise the Submittal and submit for the same type of review as specified for the initial Submittal. The resubmittal shall identify specific changes made since the previous Submittal.

10.7 Summary of Submittals

Item	Section	Submittal	Action
1	10.2	Initial Submittal List	Review and Comment
2	10.2	Final Submittal List	Review and Approval
3	10.2	Updated Submittal List - Monthly	Information

11 PROGRESS REPORTS

This Section identifies the Progress Reports that Concessionaire shall provide during the Design-Build Period to document the progress of the Work. In addition to the Design-Build Period, the requirements of this Section shall apply to all design and construction activities during the O&M Period.

11.1 Not Used

11.2 Progress Report

Concessionaire shall submit a Progress Report for Information on a monthly basis. The Progress Report shall summarize progress over the past month, including, at a minimum:

- list of Contractors, count of personnel, and equipment at Project Site;
- design and engineering progress;
- issues adversely impacting the progress of the work;
- systems certification activities;
- significant material deliveries;
- high and low temperatures, general weather conditions, rain or snow amounts, and severe weather events;
- accidents;
- meetings and significant decisions;
- summary of special reports, and incident reports;
- stoppages and delays;
- summary of Concessionaire Quality Program activities including non-conforming design and Construction Work and corrective actions;
- summary of ratings for incentive programs;
- summary of liquidated damages occurrences;
- orders and requests of Authorities Having Jurisdiction (AHJ);
- Change Orders received and implemented;
- services connected and disconnected; and
- equipment or system tests and startups.

11.3 Not Used

11.4 Material Location Report

Concessionaire shall submit a Material Location Report for Information on a monthly basis. The report shall list major materials delivered to and stored at the Site. The list shall be cumulative, showing materials previously reported plus items recently delivered. The list shall include a statement of progress on and delivery dates for materials or items of equipment fabricated or stored away from the Site. The report shall indicate the following categories for stored materials:

- material stored prior to previous report and remaining in storage;

- material stored prior to previous report and since removed from storage; and
- material stored following previous report and remaining in storage.

11.5 Not Used

11.6 Occurrence Reports

Concessionaire shall submit an Occurrence Report for Information upon discovery of an occurrence including at a minimum Emergency, criminal activity, accident, injury, fire, infrastructure damage, safety and hazardous conditions, and negative public relations incidents. Concessionaire shall provide an immediate verbal notification to the Owner and shall submit a written report no later than 72 hours after discovery of the incident unless requested earlier by Owner. The report shall be a form prepared by Concessionaire and shall include a detailed description of the incident including name(s) of affected individual(s) and witnesses.

11.7 Special Reports

Concessionaire shall submit a Special Report for Information within one day after an event of an unusual and significant nature occurring at the Site, whether or not related directly to the Project. The report shall list the chain of events, persons participating, response by Concessionaire's personnel, evaluation of results or effects, and similar pertinent information. Advise Owner in advance when these events are known or predictable.

11.8 Summary of Submittals

Item	Section	Submittal	Action
1	11.2	Progress Reports	Information
2	11.4	Material Location Reports	Information
3	11.6	Occurrence Reports	Information
4	11.7	Special Reports	Information

12 PROJECT MEETINGS

The purpose of this Section is to describe the Project meeting process and required meetings during the Term. In addition to the Design-Build Period, the requirements of this Section shall apply to all design and construction activities during the O&M Period.

12.1 Purpose

Project meetings shall be held to enable orderly review with Owner during progress of the Work, and to provide for systematic discussion of items and issues.

12.2 Decision Authority

Concessionaire's personnel that attend and participate in Project meetings shall have all required authority to commit Concessionaire to decisions agreed upon at the Project meeting.

12.3 General Procedures

To the maximum extent practicable, Project meetings shall be held at the Project Management Office, Project Construction Management Office(s), or the MTA Transit Development & Delivery Office.

Meeting calendar, notifications and invitations shall be managed electronically by Concessionaire on a real-time basis.

Concessionaire shall provide agendas and meeting materials in advance of the meeting, lead and facilitate meetings, and distribute meeting minutes to all attendees within 72 hours of the meeting conclusion.

The meetings described in this Section do not represent all meetings necessary or required by the Contract Documents. The Owner may, with reasonable notice, require additional Project meetings at any time at no additional cost to the Owner.

12.4 Work Initiation Meetings

12.4.1 Project Work Initiation Meeting

Concessionaire shall hold the Project Work Initiation Meeting within 10 business days of Financial Close. At a minimum, the Key Personnel shall attend the meeting.

The Project Work Initiation Meeting shall address, at a minimum, the following:

- Project Management Plan including Key Personnel and organizational chart;
- Project Schedule;
- Concessionaire's approach to Design, Construction and O&M Work;
- Concessionaire's approach to Maintenance of Traffic;
- Concessionaire's approach to Third Party and Utility Owner coordination and approvals;
- Concessionaire's approach to LRV and systems design and procurement;
- Concessionaire's Project quality plans;
- Project ROW availability;
- Submittal procedures and document control and Record Documents;
- safety and emergency procedures;

- DBE, EEO, Insurance, and other requirements;
- payment and financial controls; and
- other topics as deemed necessary by Concessionaire or Owner.

12.4.2 Design Initiation Meeting

Concessionaire shall hold the Design Initiation Meeting within 60 calendar days of Financial Close. At a minimum, the Design Initiation Meeting shall address the following:

- Design management plan and organization chart;
- Concessionaire design work locations and logistics;
- Concessionaire's Submittals list, Reviews and schedule;
- Concessionaire's Design Quality Control;
- Owner plan for Review;
- Concessionaire's plan for Third Party or Utility Owner approvals and permits; and
- other topics as deemed necessary by Concessionaire or Owner.

12.4.3 Construction Initiation Meeting

Concessionaire shall hold the Construction Initiation Meeting a minimum of 90 calendar days before initiation of Construction. At a minimum, the Project Work Initiation Meeting shall address the following:

- major construction and field activities;
- Construction management and organization chart;
- Concessionaire's construction management plan;
- Concessionaire's construction offices and logistics;
- Concessionaire's schedule, staged construction plan and staging areas;
- Concessionaire's construction Quality Control;
- Owner plan for Quality Assurance Oversight;
- Concessionaire's plan to demarcate ROW;
- Concessionaire's CEPP;
- Concessionaire's Safety Plan and Emergency Plans;
- Concessionaire's Construction Security Plan;
- process for Record Documents; and
- payment and financial controls.

Concessionaire shall also hold Project Work Initiation Meeting with Third Parties and Utility Owners in accordance with the Third Party Agreement Requirements and Owner Utility Agreements.

12.4.4 Quality Work Initiation Meeting

Concessionaire shall hold a Quality Initiation Meeting within 15 business days following the Project Work Initiation Meeting. The meeting shall include discussion of all aspects of the Project Quality Control Plan, with a focus on implementation of the required processes.

12.4.5 Safety & Security Work Initiation Meeting

Concessionaire shall hold a Safety and Security Initiation Meeting within 45 calendar days following the Project Work Initiation Meeting and prior to commencing any Construction Work. The meeting shall include discussion of all aspects of the Safety and Security requirements, with a focus on implementation of the required processes and the CSHP.

12.4.6 Environmental Work Initiation Meeting

Concessionaire shall hold an Environmental Work Initiation Meeting within 15 business days following the Project Work Initiation Meeting. The meeting shall include discussion of all aspects of the Comprehensive Environmental Protection Program and processes required for design, permitting and construction of the Project.

12.4.7 Schedule Work Initiation Meeting

Concessionaire shall hold a Schedule Work Initiation Meeting within 15 business days following the Project Work Initiation Meeting. The meeting shall include discussion of the schedule requirements for the Project.

12.5 Regular Meetings

12.5.1 Progress Meetings

Concessionaire shall hold monthly progress meetings, including, at a minimum, the Project Manager, Project Design Manager, Project Construction Manager and Project Quality Manager, and Owner. Monthly progress meetings shall be held one week after Submittal of the monthly progress report. Discussion items shall include, as appropriate:

- Project Schedule, including progress for the past 30 days and 90-day look-ahead;
- quality update and issues;
- safety and security update and issues;
- Submittal and review process updates and issues;
- Project ROW availability updates and access issues;
- environmental reporting and issues;
- status of submitted and potential Change Orders, Relief Events, Force Majeure, Request for Changes, Owner Change and Directive Letters; and
- any other issues.

12.5.2 Not Used

12.5.3 Payment Request Review Meeting

Concessionaire shall hold Payment Request Review Meetings to review each of Concessionaire’s payment requests. The meeting shall be held no later than the week following the end of each billing period. Concessionaire shall provide the following information at the end of the billing period and prior to Payment Request Review Meetings:

- pencil-copy invoice;
- pencil-copy review checklist to document distribution of invoiced amounts to appropriate funding vehicles;
- updated Schedule of Values with updated values for current quantities or current percentage and current amount Invoiced;
- Project Schedule Update Narrative; and
- documentation confirming the percentage of earned value of work completed during the billing period;

12.6 Special Meetings

12.6.1 Change Order Meetings

As required, Concessionaire shall hold Change Order Meetings to discuss and resolve Change Orders, Relief Events, Force Majeure, Request for Changes, Owner Change and Directive Letters.

12.6.2 Functional Testing, Startup and Commissioning Meeting

Concessionaire shall hold a Functional Testing, Startup and Commissioning Meeting three months prior to the start of function testing. The meeting agenda shall include, at a minimum:

- detailed testing and commissioning plans and schedules;
- requirements and schedules for training of staff;
- requirements and schedules for O&M data;
- coordination and shutdown requirements;
- on-site witness testing by approval/regulatory agencies;
- protocol for certifications;
- sampling and analytical requirements and responsibilities; and
- SCADA integration and control.

12.7 Summary of Submittals

Item No.	Section No.	Submittal	Action
1	12.3	Project Meeting Schedule	Information
2	12.3	Meeting Agenda. Material and Minutes	Information

13 PUBLIC INFORMATION AND COMMUNICATIONS

This Section describes the responsibilities for public information and communications during the Term. In addition to the Design-Build Period, the requirements of this Section shall apply to all design and construction activities during the O&M Period.

13.1 General

Owner and Concessionaire are responsible for maintaining an open dialogue with the Users, businesses, communities, local groups and organizations, emergency responders, Third Parties, and Utility Owners surrounding the Project during the D&C Work with the objective of building a long-term relationship between Concessionaire and communities based on trust and respect.

All public information and communications materials, including the website, shall meet ADA requirements. All public information and communications materials shall be provided in both English and Spanish.

Concessionaire shall obtain permission from trademark owner for all uses of all trademarks, including SmartTrip® and CharmCard®.

13.2 Owner Responsibilities

13.2.1 General Owner Responsibilities

Owner will retain leadership of the Public Information and Communications Program from Financial Close to Final Completion. Owner's program activities will be designed to build upon previous communications and acknowledge the progression of the D&C Work. Owner will:

- lead preparation of the communication and public outreach plan;
- manage community outreach and public outreach using community outreach staff liaisons assigned to specific areas in the Corridor;
- serve as official spokesperson for the Project except for notifications regarding Construction Work, including road closures and detours;
- establish media protocols jointly with Concessionaire to provide clarity of responsibility for media comment on specific Project activities;
- print and distribute Project newsletters and press releases using content provided by the Concessionaire;
- develop and perform Project marketing activities, including development of a marketing outreach plan;
- develop and maintain the Project website and social media using content provided by the Concessionaire; and
- perform Quality Assurance of any information and communication activities performed by Concessionaire.

13.2.2 Communication and Public Outreach Plan

Owner will prepare the communication and public outreach plan with input from Concessionaire. The plan will:

- provide a framework for communication with the public;
- engage the community and local stakeholders during the D&C Work affording them the opportunity to provide input;

  - this engagement will include the use of neighborhood work groups as the primary forum for community engagement. Owner will hold regular neighborhood work group meetings as needed with the support and participation of the Concessionaire.
- facilitate a strong and enduring relationship with the public, the communities, businesses, third parties and other stakeholders within the Project catchment area during the Term;
- maximize public awareness of the benefits of the Project;
- educate the User on the use of the Project;
- take into account the Concessionaire's planned Work; and
- address the change in Concessionaire and Owner responsibilities for public information and communication when the Project enters the O&M Period.

13.3 Concessionaire Responsibilities

13.3.1 General Concessionaire Responsibilities

Concessionaire shall provide daily, on-going support to Owner in the implementation of the communication and public outreach plan from Financial Close to Final Completion. Such support may require work hours and work days to vary depending on Project requirements.

Concessionaire shall:

- provide a dedicated Concessionaire's spokesperson for the Project who will also serve as the Public Involvement Coordinator for Concessionaire's public information and communications tasks;
- inform local media and the public of scheduled Construction Work and its impacts including traffic congestion, road closures and detours;
- prepare responses for media inquiries in accordance with the communication and public outreach plan and provide support to Owner in responding to media inquires;
- provide a 24/7 construction hotline with information in English and Spanish;
- identify community liaisons to partner with Owner's community liaisons in providing daily coordination and communication with Users, stakeholders, businesses, and other interested parties regarding the Project. At least one community liaison fluent in Spanish shall be available at all times;
- provide formatted content for monthly Project newsletters ready for Owner Review and Approval and subsequent printing and distribution by Owner;
- support Owner's outreach and marketing activities by providing necessary materials and information for use in outreach efforts; such materials will include a graphical Project overview, plan of Work for the coming month, overall Project Schedule (on a quarterly basis), and updated Project photos;
- provide daily content for the Project website and social media developed and maintained by Owner;
- provide high-resolution construction progress photographs in electronic format at least monthly or at any time that a new significant activity commences. Monthly submissions shall include, at a minimum, ten new progress photos. In addition, Concessionaire shall facilitate requests and make arrangements for Owner to take additional photos on an as-

requested basis. Distinct from progress documentation photos, the purpose of photos is to facilitate public information via Project website(s), newsletters, and other such materials;

- developing, printing, and executing public notifications in accordance with Part 2A, Section 13.4 of the Technical Provisions;
- prioritizing community needs and concerns and ensuring they are effectively integrated into engineering and construction planning and execution as required; and
- participate in Owner-organized public forums, providing outreach and technical staff as necessary.

13.3.2 Innovative Outreach Strategies

Concessionaire shall develop and coordinate outreach approaches to adjacent communities and business. Such strategies may include but are not limited to vouchers for car washes because of significant construction dust or vouchers for hotels stays for local residents who experience extreme impacts from night construction.

13.3.3 Education Programs

Concessionaire shall develop a Public Education Program addressing the service, fare policy and operations, hours of service and emergency response features and systems. The program shall contain an LRT Safety Education component with particular emphasis on children and students. Concessionaire shall submit the Public Education Program for Review and Approval. Concessionaire shall support the Public Education Program implementation.

13.3.4 Business Outreach

Concessionaire shall seek to limit and mitigate business impacts during Construction Work of the Project. In development of content for the Project Website, Project Newsletters and other activities specified by the public outreach and communications plan, Concessionaire shall include construction impact information specific to businesses and promotion of local businesses. Concessionaire shall also provide signage regarding access and parking changes, and address reduced visibility of businesses by providing ‘Open for Business’ signage or similar efforts.

13.3.5 Communication Materials

All communications materials for consumption by the public, including at a minimum those required by this Section, shall be fully developed and quality reviewed by the Concessionaire. Concessionaire shall submit Communications Materials for Review and Approval no less than five business days prior to their use. Where such material is in response to an incident or emergency, Concessionaire shall coordinate with Owner to enable Owner to Review and Approve the communication in the time available.

Concessionaire shall not use Owner or Maryland logos, images and brands on any communication without the prior written approval of Owner.

13.4 Public Notifications

Concessionaire shall perform public notifications as required by the community and public outreach plan, for those activities shown in Exhibit 13.1, and for other activities identified as necessary by the Concessionaire and Owner.

As appropriate for the situation, public notifications include, but are not limited to email notifications, phone calls, personal visits, dynamic message signs, static signs, flyer postings and door-to-door delivery of written notices or door hangers.

Concessionaire shall also notify Third Parties and Utility Owners as required for these entities to implement their own notification processes.

Concessionaire shall submit Public Notifications for Review and Approval. After Approval, Concessionaire shall print public notifications. Owner and Concessionaire shall work jointly to distribute.

Exhibit 13.1 Notifications

Notice	Requirement
Lane Closure	Depending on the scope and duration of the closure, written notices shall be posted in advance of planned Closures at intermediate intersections/junctions with United States (U.S.), State, or local highways and roads in accordance with the TMP.
Critical Utility Shut-off/Diversion	Written notice to appropriate parties at least 72 hours, or greater if required by the Utility Owner, in advance of shut-off and, as applicable, diversions.
Business/Commercial Utility Shutdown	Written notification of Utility shutdown or diversion for businesses and commercial property at least 72 hours, or greater if required by Utility Owner, in advance of shutdown.
Residential Utility Shutdown	Written notification of Utility shutdown or diversion for residential property 72 hours, or greater if required by Utility Owner, in advance of shut-down.
Road and Driveway Closures	Written notice and personal contact a maximum of 60 days but not less than 30 days in advance of closures.
Commencement of Work	Written notification of commencement of work in an area a maximum of 60 days but not less than 30 days in advance of the operation or activity.
Evening/Night Work	Written notification of any work scheduled between 7:00 p.m. and 7:00 a.m. at least 48 hours in advance of the operation or activity.
Weekend Work	Written notification of any work scheduled between 12 midnight on Friday to 7 a.m. on Monday at least 72 hours in advance of the operation or activity.
Blasting or Pile Driving	Written notification of any blasting or pile driving work scheduled at least 72 hours in advance of the operation or activity.

13.4.1 Public Notification Incentive

Concessionaire shall report all public notification that did not occur in accordance with Exhibit 13.1, whether identified by Concessionaire or Owner, as part of the monthly progress report. Concessionaire shall rate the performance for public notifications on a monthly basis in accordance with the following:

- Rating A. Up to zero missed public notifications in a calendar month;
- Rating B. One missed public notification in a calendar month. All public notification requirements complied with within two hours of discovery;
- Rating C. 2 to 3 missed public notifications in a calendar month. All public notification requirements complied with within two hours of discovery;
- Rating D. 3 to 5 missed public notifications in a calendar month. All public notification requirements complied within two hours of discovery; and
- Rating F. 6 or more missed public notifications in a calendar month or any instance(s) of failing to resolve a missed public notification within two hours of discovery in a calendar month.

Ratings shall only be made after commencement of Construction Work.

13.5 Project Identification Signage

Concessionaire shall provide, erect, and maintain Project Identification Signs placed at:

- the western and eastern terminus of the Project;
- the following intersections of the Project with US or State highways: MD 185; MD 29; MD 320 (at Arliss Road); MD 320 (at MD 193); at MD 650; MD 212; at MD 193 and Adelphi Rd; at US 1; at MD 201 and MD 410; at MD 295;and at MD 450;
- Concessionaire's main office and all field offices; and
- up to 10 additional locations as designated by Owner.

The signs shall meet FTA project signage requirements and shall include the name of the Project, Project hotline number, Project website address and Project logo. Concessionaire shall submit a sample Project Identification Sign for Review and Comment. Concessionaire shall install signs within one week of commencing Construction Work.

13.6 Project Tours

From time to time, representatives of peer transit agencies, community-based organizations, elected officials, and others may wish to tour the Site. Concessionaire shall accommodate Project tours bearing in mind both the need for positive community engagement and the safe and timely prosecution of the Work.

13.7 Summary of Submittals

Item	Section	Submittal	Action
1	13.3.3	Public Education Program	Review and Approval
2	13.3.5	Communications Material	Review and Approval
3	13.4	Public Notifications	Review and Approval
4	13.5	Project Identification Sign	Review and Approval

14 CONCESSIONAIRE'S QUALITY PROGRAM

This Section defines the responsibilities of Concessionaire in the management of quality in all phases of the Work during the Term, including the activities of Contractors and Suppliers. In addition to the Design-Build Period, the requirements of this Section shall apply to all design and construction activities during the O&M Period.

14.1 CONCESSIONAIRE'S QUALITY PROGRAM (CQP) REQUIREMENTS

Concessionaire shall implement and maintain an effective quality program to manage, control, document, and ensure that the Work complies with the requirements of the Contract Documents. Concessionaire shall submit Concessionaire's Quality Program for Review and Approval within 30 calendar days after Financial Close. CQP shall be approved before commencement of Construction Work.

The CQP shall contain all processes and procedures necessary to ensure complete quality assurance and quality control for all major activity categories: design; materials; equipment; testing; construction; start-up; coordination; workmanship; fabrication; operations; maintenance; and, document control for both on-Site and off-Site Work by Concessionaire (including Contractors, Suppliers, laboratories and consultants). Separate volumes addressing Design, Construction and Operations/Maintenance shall be produced which shall comprise the CQP. This Technical Provision addresses the Design and Construction volume of the CQP; Part 3 of the Technical Provisions contains the requirements for the Operations/Maintenance volumes of the CQP.

The processes and procedures established in the CQP shall be ISO 9001:2008-compliant.

The CQP shall address, at a minimum, the 15 elements identified in the *FTA-PA-27-5194-12.1*, *The FTA Quality Management System Guidelines.* The CQP shall include an organization chart showing names, titles, responsibilities, authority, and the interrelationship between those involved in managing and directing the Quality Program. Concessionaire's Quality Program Manager (QPM) shall be responsible for overseeing the overall quality program and the preparation, implementation and update of the CQP for Concessionaire, including management, design and construction. The CQP shall establish a "quality program team" which shall be distinct and separate from the design and construction production organization. The quality program team shall report directly to the QPM.

As work progresses, Concessionaire shall update the CQP to reflect current conditions. Concessionaire and/or the Owner may identify the need for revisions to the CQP. Concessionaire shall submit any revisions or updates to the CQP for Review and Approval within 30 calendar days after the identification of the need for a revision. In addition, Concessionaire shall submit its CQP for Review and Approval on or immediately prior to the anniversary of the initial submittal of the CQP. Concessionaire shall submit a conformed CQP with revisions highlighted. Revisions to the CQP shall be approved by the QPM prior to Submittal for approval to the Owner.

The following subsections are all elements of the CQP and should be specifically addressed therein.

14.1.1 Management Responsibility

Concessionaire shall define and document a quality policy that includes objectives for each specific project and shall communicate, implement, and maintain that policy at all levels of its organization. Concessionaire shall have a published statement of its commitment to quality and the organization's quality objectives. It shall explain the Concessionaire's commitment to quality relative to the Project, shall be made known to all staff, and shall be included in the CQP. The policy statement within the CQP shall be signed by the Project Manager.

14.1.2 Documented Quality Management System (QMS)

Concessionaire shall establish and maintain a documented QMS to ensure Project quality objectives are satisfied. The QMS requirements shall extend to Concessionaire's entire organization.

The QMS shall either contain or reference the procedures and documentation critical to quality and shall define policies, goals and objectives of the organization and organizational interfaces. Concessionaire shall prepare documented procedures consistent with the requirements of the Contract Documents and the Concessionaire's stated quality policy. These procedures may include both standard procedures and those developed specifically for use on this Project.

The procedures shall define the interface between the quality organization and the design and construction groups of Concessionaire and shall be written with the intent of gaining employee understanding of the system.

The procedures and instructions shall contain a statement of their purpose and scope, and shall contain any references to appropriate codes, standards, or specifications. In developing the quality procedures and instructions, consideration shall be given to identifying and acquiring any inspection equipment, skills, or special quality processes needed to ensure quality performance. Where new techniques are being proposed for construction or manufacturing, adequate time shall be allowed to develop appropriate quality procedures and instruction for the new techniques and to train the personnel who will be using these new techniques. The procedures and instructions shall contain formats for the quality records needed to ensure that the procedures and instructions are followed and documentation requirements are understood.

14.1.3 Design Control

It shall be Concessionaire's sole responsibility to provide Design Documents in accordance with the Contract Documents and Concessionaire's Design Quality Plan (CDQP). Review of Concessionaire's Design Documents by the MTA shall not relieve Concessionaire of the responsibility to meet all requirements of the Contract Documents.

During the development of Concessionaire's design criteria and CDQP, the designer shall insert quality control provisions and references to the Project's CQP. Furthermore, Concessionaire shall establish and maintain procedures in the CQP to control and verify the design of the Project in order to ensure that the design criteria, other specified requirements, and requirements of the applicable Governmental Entities, Third Parties, and Utilities are met. Design Control includes ensuring that the design requirements are understood, planning and scheduling the design interfaces and the design verification activities, executing the design verification activities, and controlling design changes through Project completion.

Design control shall be applied to computer programs, design tables and all other products that provide analytical results which are used to develop or check designs.

Concessionaire shall establish and include in the CDQP procedures on how design changes are to be initiated, reviewed, approved, implemented and recorded in accordance with the Technical Provisions in order to control configuration management, and shall include the identification of persons authorized to approve design changes. An approved CDQP is required before submittal of any Design Documents can be made.

14.1.4 Document Control

Procedures for control of Project documents shall be established and maintained. The document control measures shall ensure that all relevant documents are current and readily available. Electronic document distribution and management shall be managed in the same manner as hard copy distribution and management.

The Project documents shall include, at a minimum: contracts, plans, specifications, permits, master drawing lists or equivalent documents, critical procedures and work instructions, quality system manuals, Quality plans and data (e.g., computer databases, computer files).

Concessionaire shall establish and maintain documented procedures to control the Project documents and implement procedures to ensure that the Work is fit for its intended functions and uses. Use of a master list or equivalent document control procedure identifying the current revision status of Project documents shall be established and be readily available to preclude the use of invalid and/or obsolete documents.

Concessionaire shall establish and maintain documented procedures to control the process for Project document review, resolution of comments and establishment of approval authority.

This control shall ensure that:

- pertinent issues of appropriate Project documents are available at all locations where operations essential to the effective functioning of the quality system are performed; and
- invalid and/or obsolete Project documents are promptly protected against unintended use.

Changes to Project documents and data shall be reviewed and approved by the same internal authority that performed the original review and approval, unless specifically designated otherwise. If this is not possible then the designated approval authority shall have adequate background and experience upon which to base the decision. The designated functions/organizations shall have access to relevant project documents upon which to base their review and approval.

14.1.5 Purchasing

Concessionaire shall ensure that purchased services or products conform to Concessionaire’s specified requirements. Concessionaire shall require suppliers to have quality programs consistent with Concessionaire’s use of such products of service in the Work meeting the requirements of the Technical Provisions.

Procurement shall be controlled through processes established in the CQP covering such activities as procurement document control, supplier/sub-supplier selection/qualification, supplier quality survey, pre-award quality surveys, supplier quality approval, source/vendor surveillance, source/vendor inspection, release for shipment, and receiving inspection.

14.1.5.1 Not Used

14.1.5.2 Control of Owner Supplied Items

Concessionaire shall establish and maintain documented procedures for the control of verification, storage and maintenance of Owner-supplied items provided for incorporation into the Project or for related activities. When such items are encountered, documented procedures shall be submitted as part of the CQP which detail the receipt/acceptance, storage, maintenance and preservation of these items.

14.1.6 Product Identification and Traceability

Measures shall be established and maintained for identifying and controlling items of production (batch, materials, parts, and components) to prevent the use of incorrect or defective items and to ensure that only correct and acceptable items are used or installed. Concessionaire shall establish and maintain documented procedures for identifying product from receipt and during all stages of production, delivery and installation for all products incorporated as part of the Purple Line System.

The filing and retrieval of operating manuals, certificates of compliance and/or analysis, inspection status and nonconforming product shall be traceable to the items. Records shall be kept that identify the installed location of the product.

14.1.7 Process Control

Concessionaire shall identify and plan the production and installation processes that directly affect quality and shall ensure these processes are performed under controlled conditions. Special processes, including at a minimum welding, nondestructive testing, and heat treatment, the results of which cannot be directly verified by subsequent inspection and testing of the product, shall be continuously monitored to ensure the quality of the final product. Concessionaire shall also ensure that any activities related to the requirements are monitored and controlled by identifying any relevant provisions of the Contract Documents and determining a method to verify that they are met.

Documentation of the processes may be in the form of a narrative, flow chart or control points.

14.1.8 Inspection and Testing

Inspection and testing procedures shall be planned and executed as necessary to verify quality. Procedures shall be specified, implemented, with the results documented for receiving incoming products for final inspection, verification and testing. Testing shall be included, in the CQP, including references to required certifications, testing procedures, frequency and location, requirements for witnessing of tests, and where factory inspection and/or testing is recommended prior to shipping.

Concessionaire shall be responsible to perform all quality control and quality assurance related inspection and testing under the Contract Documents. The required certifications, inspections and testing, and the records to be established shall be detailed in the CQP.

14.1.9 Inspection, Measuring, and Test Equipment

Inspection, measuring, and test equipment (including test software) necessary to carry out inspection and testing shall be identified, controlled, calibrated, and maintained in order to demonstrate the conformance of work to the specified requirements. Provisions shall be made for recalibration of such equipment in a timely manner and these provisions shall be documented in the CQP. Concessionaire shall provide a Schedule of Testing Equipment as part of the CQP identifying all equipment that needs periodic and regularly scheduled recalibration including date of initial calibration, schedule for recalibrations, and current calibration status. This schedule shall be audited by Concessionaire's Quality Assurance personnel on an appropriate frequency.

Concessionaire's testing equipment shall be calibrated prior to its use on the Project. Inspection, measuring, and test equipment shall be used in a manner that ensures that the measurement uncertainty is known and is consistent with the required measurement capability. Records of calibrations shall be maintained as a Quality Record.

14.1.10 Inspection and Test Status

A means shall be provided as part of the CQP for identifying the inspection and test status of work during production and installation. The purpose of this is to ensure that only work that has passed the CQP-required inspections and tests are accepted.

The inspection and test status shall be identified by suitable means, which indicate the conformance or nonconformance of the work with regard to the inspections and tests performed. The identification of inspection and test status shall be maintained, as defined in the CQP, throughout production, installation, and servicing to ensure that all work has passed the required inspections and tests.

14.1.11 Nonconformance

Procedures shall be established and maintained as part of the CQP to ensure that Nonconforming Work is not inadvertently used, installed or allowed to remain in place. Nonconforming Work shall be identified, documented, and evaluated to determine appropriate disposition.

14.1.12 Corrective Action

Corrective action procedures shall be established, documented, and maintained as part of the CQP. These include procedures for investigation of the root cause of nonconforming work and the corrective action needed to correct the nonconformance, prevent recurrence, and procedures for analysis to detect and eliminate potential causes of nonconforming work. Concessionaire's QA personnel shall verify that the corrective action has been accomplished to the satisfaction of the Owner. Concessionaire shall also determine preventive action to eliminate the causes of potential nonconformances in order to prevent their occurrence. This also includes implementing and recording changes in procedures resulting from preventive action, corrective action, and continual improvement initiatives.

14.1.13 Quality Records

Procedures shall be established and maintained as part of the CQP by Concessionaire for Quality Records, both hard copy and electronic. These procedures shall identify which records shall be kept, responsibility for production and collection, and responsibility for indexing, filing, storage, maintenance, and disposition of Quality Records.

Quality Records shall be maintained to demonstrate conformance to specified requirements and the effective operation of the quality system. Concessionaire shall provide records necessary to provide objective evidence of contract review, procedure compliance, design review (when applicable), training, and completion and acceptance of inspection and testing, and to provide traceability of equipment or items to document.

All Quality Records shall be legible and shall be stored and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss. .

Quality Records shall be made available to the Owner in accordance with the requirements of the Contract Documents. Retention periods and the storage medium of such records shall be established in accordance with the requirements of the Contract Documents.

14.1.14 Quality Audits

A Quality Audit program shall be established by Concessionaire and documented in the CQP to ensure that the elements of the QMS are functioning as intended. Concessionaire shall establish and maintain documented procedures for planning and implementing a comprehensive program of scheduled and unscheduled Quality Audits to verify whether quality activities and related results comply with planned outcomes and to determine the effectiveness of the quality system.

Quality Audits shall be conducted on a planned and scheduled basis, consistent with the importance of the activities being performed, no less frequently than every 12 months. Quality Audits shall be initiated early enough in the life of the activity to assure effective Quality Control during all phases. The Quality Audits shall include Project management, testing, and technical work activities.

Format and content of Concessionaire's Quality Audit checklists, audit finding reports, and audit schedule shall be reviewed by Owner. A quarterly report shall be provided to Owner for Information.

The results of the Quality Audits shall be recorded and brought to the attention of the personnel having responsibility in the area audited. The management personnel responsible for the area shall take timely corrective action on deficiencies found during the Quality Audit.

The personnel conducting a Quality Audit shall be independent of those having direct responsibility for the activity being audited. Auditor qualifications shall be established and documented by Concessionaire, with qualification records maintained as quality records.

Records of audits shall be maintained by Concessionaire. Concessionaire must make available all quality records such that the Owner can conduct an audit of Concessionaire's quality practices and adherence to the CQP.

14.1.15 Training

Concessionaire shall establish and maintain procedures as part of the CQP for identifying the training needs of and provide for the training of all personnel performing activities affecting quality on the CQP and on the project's quality assurance and quality control strategies. The CQP shall also detail criteria for determining which aspects of the Work affect quality**.**

Personnel performing specific assigned tasks shall be certified on the basis of appropriate education, training and/or experience, as required. Appropriate records of training and certifications shall be maintained.

Concessionaire shall establish documented procedures and records to ensure that the tasks are performed only by qualified persons. These shall be developed through training and/or the recorded accumulation of experience, with systematic reviews of their competence at determined levels, and before any deployment of new roles. Training shall focus on improving competency and skill for those performing activities that impact quality.

14.2 GENERAL REQUIREMENTS FOR CONCESSIONAIRE'S DESIGN QUALITY PLAN (CDQP)

Concessionaire shall submit Concessionaire's Design Quality Plan for Review and Approval. No design shall commence until the CDQP is approved.

14.2.1 Design Documentation

14.2.1.1 Progress Tracking

Concessionaire shall include engineering and design progress and changes in its Project Schedule, including work on any design changes.

14.2.1.2 Monthly CDQP Report

The Design QA Manager shall submit a monthly CDQP Report for Information at the same time as the monthly Progress Report that includes the following:

- summary of reviews conducted;
- Nonconforming Work and current status and/or disposition (based on design nonconformance log); and
- List of design Submittals(s) from Concessionaire and status.

14.2.1.3 CDQP Final Design Report

Upon completion of the final design for each design package (as determined by Concessionaire), the Design QA Manager shall notify Concessionaire, with a copy to the Owner, of any outstanding monitoring report issues or unresolved review comments in the CDQP Final Design Report. The CDQP Final Design Report shall be submitted with the relevant Final Design Submittal.

14.2.1.4 Quantity Estimates

To facilitate the determination of QAO sampling and testing requirements, Concessionaire shall provide quantity estimates for the Work. The quantity estimates shall be in units that facilitate sampling and testing, i.e. United States customary units unless otherwise specified by Owner. Concessionaire shall submit Quantity Estimates for Information 15 business days prior to commencement of the construction activity.

14.2.1.5 CADD Standards

CADD formatting for Design and As-Built Plans shall conform to the MTA Drawing and CADD Standards, except where required otherwise by the Third Party Agreement Requirements or Owner Utility Agreements.

14.2.2 Quality Records

The Design QA Manager shall prepare and submit monitoring reports to the Owner of all design issues and review comments resulting from the scheduled and additional checks and reviews.

Concessionaire shall maintain an auditable record of all CDQP procedures, reviews and checks. An independent auditor shall be able to determine and verify by reviewing documentation if all procedures included in the CDQP have been followed.

Concessionaire shall develop, implement, and maintain a log of design Nonconformance Reports and/or notices indicating the dates issued, the reasons for the nonconformance, the status of the item, and ultimately the manner of resolution and the date of resolution.

14.2.3 Design Quality Assurance Manager

Concessionaire shall provide a Design QA Manager. Concessionaire’s Design QA Manager shall assess and evaluate Concessionaire’s design QC activities in order to certify to the QPM and to the Owner that the design QC activities comply with the CDQP and Contract Requirements.

Concessionaire shall ensure that the Design QA Manager carries out all of their duties expressed and implied in the Contract Documents.

The Design QA Manager shall have QA responsibilities related to the following:

- design of permanent and major temporary elements;

- changes in design of permanent elements; and
- As-Built Plans.

The Design QA Manager shall also perform the following activities:

- identify and report non-conformities/noncompliance;
- track, monitor, and report on status of outstanding Design Nonconformance Reports;
- supply DQCP Monthly Report; and
- submit specified certificates (permanent elements and major temporary elements).

14.2.3.1 Checking by the Lead Design Firm

The requirement that Concessionaire engage and use a Design QA Manager shall not relieve the Lead Design Firm from responsibility for all the checks and reviews of the work that is actually being designed. Documentation of the checking by the Lead Design Firm must be maintained as Quality Records as discussed in Part 2A, Section 14.2.2 of the Technical Provisions.

14.2.4 Staffing Levels

The actual size of the field/site quality staff shall reflect the complexity, needs, shifts, and composition of QC and QA activities consistent with work in progress.

Concessionaire’s quality staff shall consist of experienced staff in sufficient numbers to adequately perform the duties required by the CDQP. The CQP shall include a training procedure for the quality staff that clearly defines the education, previous experience and training requirements for this Project. The training procedure shall include the evaluation of each candidate’s knowledge of the CQP, including the CDQP. All staff shall be evaluated for conformance to the training requirements and shall be confirmed as meeting the requirements of the training program by the QPM. The quality staff shall be independent organizationally from those responsible for performing the Work to ensure that the quality staff are not involved in the review of work that they perform.

The CDQP shall identify administrative and clerical support for the maintenance and management of records and documents pertinent to Concessionaire’s quality activities. Concessionaire’s quality staffing schedule shall be updated as necessary throughout Design Work to reflect staffing requirements to perform the work set forth in the CDQP.

14.3 GENERAL REQUIREMENTS FOR CONCESSIONAIRE’S CONSTRUCTION QUALITY PLAN (CCQP)

14.3.1 General

Concessionaire shall submit Concessionaire’s Construction Quality Plan (CCQP) for Review and Approval. No construction shall commence until CCQP is approved. The Owner, in its Quality Assurance Oversight (QAO) role will conduct verification oversight inspections, audits, sampling and testing, and Independent Assurance.

The CCQP shall certify that procurement, shipping, handling, fabrication, installation, cleaning, inspection, construction, testing, storage, examination, repair, maintenance, and required modifications of all materials, equipment, and elements of the work will comply with the requirements of the Contract Documents and that all materials incorporated in the work and all equipment and all elements of the work will perform satisfactorily for the purpose intended.

Concessionaire shall submit Planned Construction Activity Reports bi-weekly for Information. The planned construction activities shall include all planned construction activities, including fabrication, for the previous two weeks and the following four weeks. The first two weeks of look ahead will be detailed and the second two weeks may be more general. For activities occurring a distance greater than 100 miles from the Project area, such as fabrication, Concessionaire shall give the Owner at least 21 calendar days of notice of planned Work.

14.3.2 Concessionaire's Construction Quality Organization

14.3.2.1 Construction Quality Organization

Concessionaire shall establish a construction-quality organization to oversee, manage, certify, and perform construction quality activities. Quality staff shall be responsible for management and scheduling all quality inspection, sampling, and testing of all items of Construction Work.

14.3.2.2 Construction QC Manager (CQCM)

Concessionaire shall assign an on-site CQCM, who shall report to the QPM.

Concessionaire's CQCM shall be responsible for overall management and supervision of Concessionaire's construction QC staff.

Concessionaire's CQCM shall be responsible for coordinating the schedules of Concessionaire's Construction QC inspectors, testers and samplers with Concessionaire's construction activities.

14.3.2.3 Staffing Levels

The actual size of the field/site staff shall reflect the complexity, needs, shifts, and composition of Quality activities consistent with Work in progress.

Concessionaire's quality staff shall consist of experienced; Quality Control Inspectors, Quality Control (QC) Engineers, Quality Assurance (QA) Engineers, QA Auditors and others in sufficient numbers to adequately perform the duties required by the CCQP. Concessionaire's quality personnel shall report to the CQCM. The CQP shall include a training procedure for the quality staff that clearly defines the education, previous experience and training requirements for this Project. The training procedure shall include the evaluation of each candidate's knowledge of the CQP, including the CCQP. All staff shall be evaluated for conformance to the training requirements and shall be certified to perform the necessary quality activities. The quality staff shall be independent from those responsible for performing the work.

The CCQP shall identify administrative and clerical support for the maintenance and management of records and documents pertinent to Concessionaire's quality activities. Concessionaire's quality staffing schedule shall be updated as necessary throughout Construction Work to reflect staffing requirements to perform the work set forth in the CCQP.

14.3.2.4 Laboratories and Testing

Laboratory testing shall be conducted by laboratories, retained by Concessionaire, that comply with the requirements for FTA certification for applicable tests. Laboratories shall be accredited by the AASHTO Material Reference Laboratory, the Concrete Cement Reference Laboratory, the National Precast Concrete Association for precasters, the Prestressed Concrete Institute, American Association for Laboratory Accreditation, and/or the National Voluntary Laboratory Accreditation Program as appropriate, and approved by the Owner, for the work to be constructed.

Compliant satellite locations (field laboratories) of these laboratories conforming to the specifications described in this Section 14.3.2.4 may be used. The equipment in the satellite laboratories shall be certified at the start of work and annually thereafter, and subject to Owner audit. Certification shall be performed by an independent accredited laboratory inspector.

The laboratory shall have written policies and procedures to assure portable and satellite laboratories performing testing activities on the Project are capable of providing testing services in compliance with the test methods described by the laboratories listed in the first paragraph of this Section 14.3.2.4. The policy and procedures shall address inspection and calibration of testing equipment as well as a correlation-testing program between the accredited laboratory and portable or satellite facilities.

The Owner reserves the right to verify laboratory testing procedures and techniques and to check testing equipment for compliance with specified standards.

The Owner also reserves the right to witness any testing and to verify compliance of the testing procedures, techniques and results.

14.3.2.5 Competence

If a concern arises as to the performance of any of the organization's individuals, Owner will give notice to the Concessionaire. The Owner reserves the right to investigate any such concern. If this investigation substantiates the concern, a corrective action shall be implemented by Concessionaire in accordance with CQP or procedures established by the Owner, as part of the Work.

14.3.3 Construction Control

The CCQP shall contain procedures and policies to detect and prevent the reoccurrence of non-conforming Work.

14.3.4 Material Certifications

Concessionaire shall submit a Sources of Supply and Item Material Types Report for Information according to the follow schedule:

- within 30 calendar days after Financial Close to the extent information is known;
- for materials not initially identified or changes to the initial source provided, the source of supply shall be provided as soon as known and no less than 30 calendar days prior to delivery to the Project.

Documentary evidence that materials and equipment conform to the requirements of the Contract Documents shall be available at the Site prior to installation or use of such materials and equipment. This documentary evidence shall be retained at the site and shall be sufficient to identify the specific requirements, such as, Working Plans, codes, standards, or Technical Provisions, are fulfilled by the purchased materials and equipment. Substitution of specified materials shall not occur without prior approval by Concessionaire's Engineer of Record. Failure to acquire prior substitution approval will result in the issuance of a Nonconformance Report. Additionally, a copy of all documentary evidence that materials and equipment conform to the requirements of the Contract Documents shall be provided to the Owner, or its representative, at the same time Concessionaire receives such documentary evidence. The effectiveness of the QC by Concessionaire's own forces and Contractors shall be assessed by Concessionaire and the QC Engineers at intervals consistent with the importance, complexity, and quantity of the product or services. The Owner reserves the right to audit and review these documents at any time.

Concessionaire shall submit prior to the Revenue Service Availability Date a Source of Supply Certificate of Compliance signed by Concessionaire's Project Manager and Construction QC Manager indicating that all material incorporated into the Project conforms to the requirements of the Contract Documents.

14.3.5 Process Control

Concessionaire shall establish and maintain documented procedures in the CCQP to control all key processes associated with construction as described in Section 14.1.7.

14.3.5.1 Quality Check Points

Concessionaire shall establish Quality Check Points (QCPs) at reasonable stages of the construction progress that ensures work is performed in accordance with the approved designs, the CQP including the CCQP, and within the requirements of the Contract Documents. As work is accomplished, Concessionaire's Construction Manager, representative from the Quality Control staff, and appropriate engineer shall meet with the Owner to review documentation and procedures for quality control including, at a minimum: material certifications, daily inspection records, material testing results, survey results, permits, and material placement records. Concessionaire's QC staff shall coordinate with Owner to ensure that QCP's are accomplished timely so the work is not delayed. Notification to the Owner that a QCP has been reached while work is still being performed or not allowing adequate time to complete the QCP review and opportunity for adjustments will result in the issuance of a Nonconformance Report.

At a minimum QCPs shall be established at the initiation of each stage of construction. Concessionaire will identify all QCPs prior to commencing Construction Work on a design package.

14.4 QUALITY ASSURANCE OVERSIGHT

14.4.1 Owner QA Oversight

Quality Assurance Oversight (QAO) will be performed by the Owner.

The Owner will periodically audit aspects of Concessionaire's work. The audits, and subsequent feedback to Concessionaire's Quality Program Manager are intended to assess the adequacy of Concessionaire's QC and QA plans, including frequency of testing and adherence to the requirements of the Contract Documents.

Owner observations will be identified either as conforming or non-conforming to related requirements of the Contract Documents. Observations, conformances, and nonconformances may be presented to Concessionaire through QAO Assessment Reports. Concessionaire shall be required to respond to all nonconformances. An Owner-reported nonconformance will be closed by the Owner upon verification of a resolution of the issue acceptable to the Owner in accordance with the requirements of the Contract Documents.

14.4.2 Independent Assurance

Verification sampling and testing may be performed by the Owner on samples that are taken independently of the Concessionaire's quality control and/or quality assurance samples.

Additionally, the Owner may periodically provide independent assurance to evaluate the quality sampling and testing.

14.5 Summary of Submittals

Item	Section	Submittal	Action
1	14.1	Concessionaire Quality Program	Review and Approval
2	14.2	Concessionaire's Design Quality Plan	Review and Approval
3	14.2.1.2	Monthly CDQP Report	Information
4	14.2.1.4	Quantity Estimates	Information
5	14.3	Concessionaire's Construction Quality Plan	Review and Approval
6	14.3.1	Planned Construction Activities	Information
7	14.3.4	Sources of Supply and Item Material Types Report	Information

15 CONSTRUCTION SAFETY REQUIREMENTS

Concessionaire shall maintain a safe work environment at all times. Concessionaire shall create and maintain a safe work environment during Construction Work. This Section defines the requirements Concessionaire shall follow to create and maintain the safe work environment. Concessionaire's safe work environment is applicable to all on-site Concessionaire and non-Concessionaire personnel.

15.1 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American National Standards Institute (ANSI)
    - B30.5 - Mobile and Locomotive Cranes
    - B30.9 – Slings
    - Z49.1 - Safety in Welding and Cutting
    - Z87.1 - Occupation and Education Eye and Face Protection
    - Z89.1 - Requirements for Industrial Head Protection
- Factory Mutual
- National Fire Protection Association (NFPA)
    - 70 - National Electrical Code (NEC)
    - 704 - Identification of the Fire Hazards of Materials for Emergency Response (Hazard Warning System - NFR Diamond)
- Underwriters Laboratory (UL)
- American Conference of Governmental Industrial Hygienists
- Compressed Gas Association
- Building Code of cities and counties
- Maryland State Fire Prevention Code
- Maryland Building Code
- Code of Federal Regulations :
    - 29 CFR 1900.1200 – Labor
    - 29 CFR 1910 - Occupational Safety and Health Administration (OSHA)
    - 29 CFR 1926 - Safety and Health Regulations for Construction
    - 36 CFR 1911, Appendix A - ADA Accessibility Guidelines for Buildings and Facilities
- Maryland Department of the Environment (MDE)
- Maryland Transit Administration Safety Regulations
- Maryland Transit Administration System Safety Program Plan
- Maryland Transit Administration Accident/Incident Investigation Guide

- Maryland Transit Administration Accident/Incident Investigation Handbook
- Maryland Occupational Safety and Health (MOSH)
- U.S. Environmental Protection Administration

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in 7.2.6 of the Agreement.

15.2 Safety – General Requirements and Responsibilities

Safety of individuals, whether a passenger, Owner personnel and Concessionaire personnel who Work, visit or use the Purple Line System, are the primary responsibility of Concessionaire.

Concessionaire shall comply with this Section and provisions of the Occupational Safety and Health Administration , the U.S. Environmental Protection Agency, Maryland Department of Environment, the Maryland State Fire Protection Code, Maryland Building Codes, the Maryland Occupational Safety and Health, MTA "System Safety Program Plan," and all other applicable rules and regulations of the Authorities Having Jurisdiction (AHJ's).

Concessionaire shall permit inspection without delay and at any reasonable time on any premises where the work is being performed by Owner, Federal or State inspector authorized to investigate compliance with the contract and above mentioned Federal and State statutes and regulations. The Concessionaire shall correct any violations found to existing during such inspection within a reasonable time after the issuance of any citation, unless Concessionaire contests the validity thereof through the appropriate administrative and judicial process.

Concessionaire shall, throughout the Term, participate as a primary and active member of the *Purple Line Fire/Life Safety & Security Committee* which shall require Concessionaire to meet with representatives of Owner, AHJ's and Emergency Responders to identify and resolve issues arising from construction and operation of the Project.

Should an incident arise that involves a person and/or vehicle with the Purple Line System, Concessionaire shall manage the incident through standard protocol in accordance with the MTA's Accident/Incident Investigation Standard Operating Procedure (SOP) and Concessionaire's Safety & Health Plan/Hazard Communication Program.

Concessionaire shall maintain an indexed MSDS book of all hazardous materials to be stored and incorporated into or used in the Work, including an MTA MSDS evaluation form. The MSDS shall be readily available whenever required, in a convenient location and in close proximity to where the material is stored.

Prior to any excavation, Concessionaire shall contact "Miss Utility" of Maryland (http://www.missutility.net/maryland/). Concessionaire shall provide notice at least two full business days prior to the day they plan to start Work. The day of the call to "Miss Utility" is not counted as one of these days. The "Miss Utility" number in Maryland is 1-800-257-7777.

Concessionaire's Safety Engineer, Concessionaire's Safety Supervisor, and/or a designated safety representative shall be onsite whenever Work is performed.

Concessionaire shall post construction information; including maps showing locations where pedestrian, bicycle, and/or wheelchair access may be difficult during Construction Work. Locations of and directions to nearby hospitals and emergency care facilities shall also be included on maps. Emergency numbers for fire, police, and emergency response shall also be posted. The information shall be posted on a construction site information board at all entrances to the site.

15.3 Concessionaire's Safety Engineer (CSE)

The CSE's sole responsibility shall be the management of all Concessionaire construction safety matters.

Concessionaire shall certify in writing to Owner stating that the CSE and the Concessionaire's safety organization is independent from the Concessionaire's organization responsible for the actual work.

The CSE shall maintain a master Safety Log for all Site safety matters. All safety related activities including safety deficiencies and corrective actions taken at each work site shall be included in the Log. Individual work site safety logs shall be signed daily by the CSE, Safety Supervisor, and/or a designated safety representative on each shift. The daily Logs shall be maintained on site and be available for Owner's use and inspection. The master Safety Log shall be maintained by the CSE and be available for Owner's use and inspection.

In the event of an unsafe condition, the CSE shall order the Work to be stopped and the unsafe condition immediately corrected.

Concessionaire shall provide continuous safety coverage during the performance of the Work by the CSE or designated representative. The CSE or designated representative shall be easily identified on the Site by hardhat markings or other means.

15.4 Concessionaire Safety & Health Plan

Concessionaire shall develop and maintain a Project specific *Concessionaire Safety & Health Plan (CSHP). The CSHP Document shall de*fine the management, organization and strategy to provide work site safety. The CSHP shall define the personnel responsible for developing and delivering safe Work practices. The CSHP shall be in accordance with MTA's *Contractor Safety and Health Plan Guidelines.*

*Concessionaire's CSHP shall be or*ganized into sections including, at a minimum, the following:

- Table of contents listing all Sections and Exhibits, inclusive of page number.
- Safety Policy Statement signed by an Officer of Concessionaire.
- Concessionaire's Organization Chart indicating personnel responsible for implementing the CSHP, inclusive of their duties and responsibilities. The Organization Chart shall show the reporting relationship and integration of the CSE with all personnel, including senior level managers who are responsible for implementing the OSHA required Accident Prevention Program and the Hazard Communication Program.
- Comprehensive Description of the Project.
- Description of CSE responsibilities, including the safety responsibilities of Concessionaire's Project Management Team, Safety Supervisor(s) and Competent Persons. Competent Persons shall be as defined by OSHA.

In addition to the Owner's *Contractor Safety and Health Plan Guidelines*, the Concessionaire's CSHP shall include the construction hazard procedures and controls as listed in the FTA Project and Construction Management Guidelines.Concessionaire shall submit the CSHP for Review and Comment within 90 calendar days after Financial Close and before commencement of Construction Work.

15.4.1 Safety Orientation Program

The Safety Orientation Program is Concessionaire's written detailed plan and training program for the safety orientation of employees. Concessionaire's Safety Orientation Program shall include, at a minimum:

- Concessionaire Safety and Health Plan;
- applicable safety rules and regulations; and
- responsibility of each employee to formally acknowledge receipt of safety rules, safety orientation and training prior to performing or being assigned duties on the Project.

The Safety Orientation Program shall cover the applicable construction hazards addressed by OSHA safety regulations and training described in 29CFR Part 1910, Occupational Safety and Health Standards and 29CFR Part 1926, Safety and Health Regulations for Construction.

Topics for the Safety Orientation Program include, at a minimum:

- emergency preparedness and response plan and drill;
- specific site hazards and safe working methods;
- review of hazardous materials communication program (MSDS);
- track safety training for work on or adjacent to tracks or energized rails (initial two-year certification and subsequent two-year recertification required);
- personal protective equipment and safety procedures;
- fire prevention;
- location of first aid and medical facilities; and
- operating track / energized OCS.

15.4.2 Management of Safety Documents

Concessionaire shall maintain compliance records and provide for their retention for a period of six years beyond the end of the Term. The types of compliance records shall include, at a minimum:

- minutes of safety meetings, inclusive of attendee sign-in sheets;
- training records including schedule for refresher training and plans for Safety Briefing subject matter;
- Safety Engineer's and Safety Supervisor's daily logs;
- accident records including OSHA Form 300, Log of Work-Related Injuries and Illnesses, accident investigation reports and C-2s for Concessionaire; and
- permit log consisting of:
    - description of permit;
    - permit number;
    - date Issued;
    - date of expiration; and
    - new employee orientation.

All compliance records and logs, as well as all reference documents shall be kept available (i.e., in Concessionaire's Project Office) for Owner's use and inspection. Copies of compliance records and reference documents shall be provided to Owner upon request.

15.4.3 Daily Safety Audit Checklist

Concessionaire shall prepare a Daily Safety Audit Checklist, identified in the Owner CSHP as Form 110, including at a minimum:

- header stating: Title of Contract and Contract Number, Date, Time of shift, Work area(s) inspected, and Weather conditions;
- entry for each safety deficiency that includes: Location, severity and nature of deficiency, Time noted, Names of persons and firms that were notified* of the deficiency including time notified; and Time and nature of corrective action(s);
- Notification shall include at a minimum the parties exposed to the safety hazard;
- entry for each deficiency not corrected on the prior shift's Daily Safety Report until the deficiency is corrected;
- notation of each accident, incident, or injury reported including name of injured party or affected property owner; time of accident, incident, or injury, and description of accident, incident, or injury; and
- printed name and signature of person completing the report.

15.4.4 Environmental and Hazardous Material Response Plan

Concessionaire shall develop an Environmental and Hazardous Material Response Plan in accordance with OSHA Parts 1910 and 1926. The Environmental and Hazardous Material Response Plan shall include at a minimum:

- identification of potential environmental accidents and emergencies associated with site-specific construction activities;
- response procedures to construction site environmental accidents and emergencies and for the prevention and mitigation of the environmental impacts that may be associated with them; and
- annual reviews and revisions of the Emergency Preparedness and Response Plan, in particular after the occurrence of environmental accident and emergency.

15.4.5 Emergency Action Plan

Concessionaire shall create an Emergency Action Plan in accordance with OSHA 1926.35 that addresses, at a minimum:

- fire, excavation collapse, tunnel collapse and flooding;
- weather events.
- Utility damage;
- ventilation for underground Work areas; and
- equipment movement accidents.

15.5 Safe Work Plan (SWP)

A Safe Work Plan (SWP), Activity Hazard Analysis (AHA), and SWP summary is a written work plan, which identifies the tasks to be completed, including access/egress and setup/breakdown under all expected environmental conditions. Also included is the method of work for completing these tasks, associated work hazards, and the corresponding equipment and methods that will be used to prevent loss for all Work.

The SWP, AHA, and SWP summary document shall provide Owner with a defined plan of action for identified hazards and comprehensive prevention methods for exposures to workers, the public, and property. SWPs and AHAs shall address all foreseeable exposures to employees, the public, and property for all the Work. The SWP and AHA shall be used as basis for coordination items and safety planning discussions in the construction management process.

Concessionaire shall submit the SWP, AHA, and SWP summary for Review and Comment for each Work activity seven days prior to the start of the activity. Owner may request at any time a presentation by the CSE or CSS to explain how the plan will be effectively implemented.

The basis for the SWP and AHA shall be:

- 29 CFR Part 1926 – Safety and Health Regulations for Construction;
- Applicable regulations of the Maryland Department of the Environment and other environmental regulatory authorities;
- Applicable MTA Safety Rules and Regulations, including those in Concessionaire Safety and Health Plan Guidelines;
- Construction-related standards from:
    - American National Standards Institute (ANSI);
    - National Fire Protection Association (NFPA); and
    - American Conference of Governmental Industrial Hygienists.

Absence of an applicable standard or regulation shall not limit Concessionaire's obligation to provide the appropriate controls within a SWP and AHA.

The SWP and AHA Document shall be structured to correlate with Concessionaire's Project Schedule. Each work item on Concessionaire's Project Schedule shall be identified and described in the SWP and AHA with corresponding sub areas or tasks.

The following headings shall be used for the SWP and AHA:

- PRIMARY WORK ACTIVITY: Describe scope of Work;
- TASK / SUB ACTIVITY DESCRIPTION(S);
- EQUIPMENT AND METHOD OF CONSTRUCTION: List major equipment that will be used and how it will perform the task or subtask activity;
- TRAINING REQUIREMENTS;
- INSPECTION REQUIREMENTS;
- HAZARD DESCRIPTION: Describe each foreseeable hazard present as a result of task or subtask activity;
- SAFETY CONTROLS/LOSS PREVENTION: Describe controls and procedures that will be implemented to reduce or eliminate each foreseeable hazard described above; reference

attachments as necessary. When controls are compliance based, such as for confined space entry, all applicable compliance information shall be submitted or appropriately referenced. Of particular concern, are training items that shall be used to educate employees to the exposures through the Tool Box meeting process, which is held to discuss the hazard, requires identification. More formal training (such as offsite, confined space, and trenching competent person) shall be listed and documentation referenced or provided. Reinforcing training shall be included in the plan to be given at regular intervals;

Priority shall be given to the following methods of controlling hazards:

- elimination of the hazard;
- engineering controls;
- provision of personal protective equipment; and
- management controls/training, such as a safety monitor for fall exposures.

Work proceeding while a CSHP is not in place shall have the SWP and AHA include Emergency Preparedness and Response Plan, Fitness for Duty requirements and Safety Deficiencies Consequences.

15.6 Accident Reporting and Investigation

Concessionaire shall develop an Accident/Incident Investigation Plan per APTA Standard for Rail Transit Accident/Incident Investigation (APTA RT-S-OP-002-02) to address procedures for accident/incident investigation. Concessionaire shall use Owner’s accident classification and reporting categories described in Owner’s SSPP, Accident/Incident Investigation Guide and Accident/Incident Investigation Handbook.

An accident investigation decision chart for identifying root causes to prevent recurrences shall be included. Concessionaire shall review, and if necessary, revise the CSHP based on the occurrence of serious accidents or incidents (near misses) and upon any changes in Work conditions, or as required by Owner.

Concessionaire shall submit Incident Investigation Reports for Information according to the following schedule:

- provide verbal notification immediately for all accidents involving personal injury and damage to property;
- submit the MTA "Incident Investigation Report" (Form 102, CSHP Guidelines) no later than 24 hours following each accident; and
- provide verbal notification only of near misses and any corrective action being taken.

In the event of a serious accident as defined in the CSHP Concessionaire shall convene an investigative meeting for the purpose of determining the cause of the accident and actions to be taken by Concessionaire to prevent a recurrence of such accidents. Concessionaire shall notify Owner of the investigation meeting in sufficient time to allow Owner to notify the Owner's Safety group, and others who may attend the meeting.

15.7 Construction Safety Report

Concessionaire shall submit a Construction Safety Report for Information on a monthly basis. The Construction Safety Report shall contain summary data for the previous month and Project total data including, at a minimum:

- number of first aid cases;

- number of recordable cases;
- number of lost time cases;
- number of days lost; and
- total man-hours worked.

15.8 Unsafe Conditions

An Unsafe Condition is a condition that gives rise to the imminent possibility of serious injury to workers or the public, of serious damage to property or the environment, or of affecting the safe movement of trains. When an Unsafe Condition exists at the Site, Work shall be stopped in the affected area until the condition is corrected.

If Concessionaire does not take corrective action immediately, or within the time period specified by Owner, Owner reserves the right to take whatever action is required to correct the Unsafe Condition. A Stop Work Order may be imposed by Owner for specific Work activities when site conditions exist that are determined by the Owner to be immediately dangerous to life and health. In addition, actions perceived by Owner to be in flagrant disregard to accepted SWP's and AHA's will be cause for such actions to be taken, including, at a minimum:

- workers who have not attended the Owner's one-day Track Safety Training, working on or near the Project ROW;
- no Approved CSE or CSS on-site;
- no Approved SWP and AHA; and
- no Traction Power safety measures when working around Traction Power.

A safety stand-down involving all Concessionaire personnel may be instituted by Owner under the circumstances including, at a minimum:

- recurring deficiencies revealed via trend analyses;
- two or more serious accidents or near misses; and
- flagrant disregard to comply with prescribed safety management procedures.

15.9 Fitness for Duty

Concessionaire shall ensure fitness for duty of all personnel when they report for Work and throughout the day per the Owner's SSPP and CSHP guidelines.

Should a worker be found to demonstrate incapacity because of drugs or the use of alcohol, the Concessionaire shall immediately and permanently remove the worker from the Project.

15.10 Employee Conduct

Owner reserves the right to refuse access to the Project Site or require immediate removal from the Project Site of any individual violating or alleged to have violated site safety regulations. Concessionaire agrees to hold the Owner and the State of Maryland harmless for taking such actions.

15.11 Safety Training

An interpreter shall be provided to interpret the contents of all safety training for any non-English speaking employee(s). Concessionaire shall provide a written translation of all safety-related instructions on the Site into each native non-English language for each employee where English is not their native language.

Safety training is required per OSHA Parts 1910 and 1926, including at a minimum the following sections.

15.11.1 Safety Orientation

All Concessionaire personnel on the Project site shall have attended the Safety Orientation Program per the CSHP.

15.11.2 Just in Time Safety Training

Concessional shall provide just in time safety training one week or less before any primary Work activity is to be performed for the first time by Concessionaire. These sessions shall include:

- presentation of approved SWP and AHA;
- step-by-step analysis of the Work's hazards and all hazard control methods; and
- review of MSDS forms for all materials/products to be used for these tasks, discussing personal protective equipment, handling precautions, first aid and emergency responses.

Additional just in time safety training sessions shall be provided to Concessionaire's new personnel before the personnel begin work at the Site. If existing personnel who have received just in time safety training are switched to a different task the personnel shall be trained for the new task before they are permitted to begin the work.

15.11.3 Safety Toolbox Meetings

Toolbox meetings shall be held at the start of each week, per the Owner's CSHP, to instruct all employees in safety precautions applicable to that week's Work hazards. Prior to start of such Work, a walkthrough of each work site shall be conducted to point out hazardous locations and conditions.

15.11.4 Safety Walk-Thru

Concessionaire shall hold a monthly Safety Walk-Thru attended by Concessionaire and Owner. The CSE shall bring all active (look-back and look-ahead Schedules) SWP, AHAs, and MSDS on the walk-through, for reference. The walk-thru shall include a visit to the PMO where the CSE shall have available for review the daily safety log and other safety related records. Owner shall record the activities and observations that were noted during the walk-thru, including listing all those in attendance.

During the walk-through, the effective implementation of all appropriate SWP and AHAs will be reviewed with safety issues and findings identified, including review of the Owner's Safety deficiencies affecting the Site safety; and

During the meeting immediately after the walkthrough, the observations will be reviewed and corrective actions identified. Also, outstanding findings identified in the interim between walk-throughs will be addressed.

15.12 Summary of Submittals

Item	Section	Submittal	Action
1	15.4	Concessionaire’s Safety & Health Plan	Review and Comment
2	15.5	SWP, AHA and SWP Summary	Review and Comment
3	15.6	Incident Investigation Reports	Information
4	15.7	Construction Safety Report	Information

16 CONSTRUCTION SECURITY REQUIREMENTS

This Section described the security requirements during Construction Work.

16.1 Overview

Concessionaire shall secure and maintain the Site in a secure manner at all times. Concessionaire shall be solely responsible for all damage and the restoration of damaged property resulting from illegal trespass.

16.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- FTA, FTA-TRI-MA-26-7085-05, Transit Security Design Considerations;
- FTA, DOT-FTA-MA-26-5019-03-01, Public Transportation System Security and Emergency Preparedness Planning Guide;
- FTA, Transit Agency Security and Emergency Management Protective Measures;
- TSA/FTA, Security and Emergency Management Action Items for Transit Agencies;
- The Blue Ribbon Panel on Bridge and Tunnel Security, Recommendations for Bridge and Tunnel Security; and
- Transit Security Working Group (TSWG), Contract Number N4175-05-R-4828, Final Report, Bridge and Tunnel Report.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in 7.2.6 of the Agreement.

16.3 Site Security Plan (SSP)

Concessionaire shall develop and maintain a Project specific Site Security Plan (SSP*)*. The SSP Document shall define the management, organization and strategy to provide Site security. The SSP shall define the personnel responsible for developing and delivering security related Work practices. The SSP shall be in accordance with the Owner's System Security Emergency Preparedness Plan (SSEPP)*.*

Concessionaire shall submit the SSP for Review and Comment within 120 calendar days after Financial Close and before commencing Construction Work.

16.3.1 SSP Content

The SSP shall include, at a minimum, the following:

- table of contents;
- intent and purpose policy statement with approving official's name and signature;
- sensitive security information;
- Project security organizational chart;
- approval of security plan;

- exceptions to security plan;
- references;
- emergency action plan and emergency contacts;
- security risk analysis of site, including crime data for proximity areas of construction site;
- work zone/site diagram of construction site boundaries;
- site working hours;
- site access control;
- procedures for controlling delivery vehicles;
- physical security, where provided, including at a minimum:
    - perimeter, including fencing and lighting;
    - site signage, including language to deter trespassers; and
    - on-site and boundary lighting.
- equipment security (inventory, controls);
- incident reporting;
- evacuation plan, route, and rally points;
- police department protocols;
- explosives handling, storage, and transport policy;
- trash/recycling removal;
- trailers and temporary buildings;
- storage containers;
- motorized equipment security, including fuel tanks, fuel storage, and batteries;
- surveillance, where provided, to include video surveillance and security guard service;
- security awareness training;
- security progress reporting; and
- site audits, reporting and follow-up.

Concessionaire's SSP shall be applicable to Concessionaire personnel, visitors, guests, delivery personnel, Contractors, and sub-contractors.

16.3.2 SSP Security Risk Analysis

Concessionaire shall complete a security risk analysis of the Project construction site(s), prepare findings, and include risk mitigation recommendations.

Concessionaire's SSP security risk analysis shall be based on the Owner's System Security Emergency Preparedness Plan (SSEPP) wherein the report identifies threats, vulnerabilities and mitigations. The SSP shall include the requirements of this Section, Federal, State, and local laws, regulations, and requirements of the Contract Documents.

Concessionaire's Site areas include, but are not limited to, Stations, below-grade Station excavations, alignment retaining walls, Guideways, Operations and Maintenance Facilities (OMFs), underpasses, bridges and tunnels. Each of these environments presents a serious security risk and Concessionaire is responsible to take preemptive measures to preclude unauthorized access to these areas at all times. Concessionaire's SSP shall identify and include security risk mitigation for these areas.

16.4 Security Requirements

Concessionaire shall manage and secure perimeter of construction site(s) and temporary office facilities in accordance with the SSP.

Concessionaire shall prepare a Site Access Roster annotated with time and/or personnel restrictions. The Site Access Roster shall be updated when changes in personnel with site access occur. Concessionaire shall submit the Site Access Roster for Information within 24 hours of request by Owner.

Owner shall have 24-hour, seven-day per week access to be exercised at the Owner's discretion.

16.5 Coordination Requirements

Concessionaire shall coordinate law enforcement emergency protocols and provide emergency contact information. Concessionaire shall provide and maintain similar information with all appropriate agencies and Utility Owners to ensure:

- provisions for documented procedures in response to emergencies, incident reports, and assistance calls;
- appropriate patrol of environment external to the construction site(s), including storage and laydown yards; and
- provision of criminal investigative support.

In the event of a security incident, Concessionaire shall contact law enforcement for immediate response and then inform Owner.

16.6 Identification

Concessionaire personnel shall carry and clearly display a visible photo ID badge at all times.

All Concessionaire personnel shall be responsible to report unknown or unidentified personnel to the site security supervisor when observed within the Construction site(s).

16.7 Summary of Submittals

Item	Section	Submittal	Action
1	16.3	Site Security Plan (SSP)	Review and Comment
2	16.4	Site Access Roster	Information

17 WORK RESTRICTIONS

This Section specifies work restrictions that Concessionaire shall comply with in the prosecution of the Work. The Third Party Agreement Requirements and Owner Utility Agreements contain additional restrictions.

17.1 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- ANSI S1.4;
- FHWA-PD-96-046 Measurement of Highway-Related Noise; and
- FTA Transit Noise and Vibration Impact Assessment;
- ISO 9533;
- MOSH regulations;
- OSHA 29CFR; and
- SAE J994.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

17.2 Construction Work Hours

Concessionaire shall comply with work hour restrictions, if any, in the Third Party Agreement Requirements and Owner Utility Agreements for applicable Work.

17.3 Construction Noise Requirements

To minimize the potential disruption of daily human activity from construction related noise Concessionaire shall implement a construction noise control strategy program including, at a minimum, the following:

- a construction noise control, monitoring and mitigation plan in accordance with Part 2A, Section 17.3.1 of the Technical Provisions;
- implement all practicable noise attenuation measures to minimize construction noise regardless of whether noise levels are below maximum construction noise levels required by Part 2A, Section 17.4 of the Technical Provisions;
- implement special precautions and noise abatement measures to reduce public exposure to construction noise; and
- perform work in such a manner to prevent and minimize nuisance conditions such as noise that exhibits a specific audile frequency or tone (such as unmaintained equipment or brake squeal) or impact noise.

Noncompliance with construction noise requirements shall require modification and/or additional mitigation by Concessionaire to bring the operation into full compliance. Noncompliance with the maximum construction noise levels in Part 2A, Section 17.4 of the Technical Provisions shall require immediate modification and/or additional mitigation by Concessionaire to bring the operation into full compliance.

Concessionaire shall submit a Noise Control, Monitoring, and Mitigation Plan for Review and Comment prior to commencement of Construction Work.

The plan shall be in compliance with the Contract Documents, including Third Party Agreement Requirements, for each device or activity employed by Concessionaire.

The Noise Control, Monitoring and Mitigation Plan shall include, at a minimum, the following:

- daily noise measurement plan;
- description of the anticipated construction activities including construction equipment locations;
- inventory of construction equipment and associated noise levels;
- construction noise commitments;
- noise sensitive locations/receptors;
- noise monitoring locations;
- type of noise measurement devices;
- noise monitoring methods, frequency, and procedures that shall be used, including both stationary and hand held noise/portable meter measurements in accordance with Part 2A, Sections 17.3.2 and 17.3.3 of the Technical Provisions;
- maximum noise levels for various areas and activities in accordance with Part 2A, Section 17.4 of the Technical Provisions;
- planned and potential construction noise waiver requests in accordance with Part 2A, Section 17.4.2 of the Technical Provisions;
- description of noise reduction measures to be used in accordance with Part 2A, Section 17.3.1 of the Technical Provisions;
- data reporting method that shall be used;
- complaint response procedures; and
- noise mitigation training program for all field-worker supervisory personnel. Supervisors shall field-train all field workers to minimize construction noise.

17.3.1.1 Construction Noise Reduction Measures

All construction equipment shall have sound deadening/noise suppression devices and/or materials and shall incorporate noise attenuation features and as listed below:

- comply with Maryland Transportation Code §22-402(c)(3) for idling vehicles;
- back-up alarms shall be either audible self-adjusting back-up alarms or manual adjustable alarms. Backup alarms required for all vehicles entering the construction site shall be in compliance with OSHA approved Regulations, 29CFR Part 1926, Subpart “O”, 1926.601.b.4 and 1926.602.a.9. Installation and use of alarms shall be consistent with the performance requirements of the current revisions of SAE J994, J1446 and OSHA regulations;
- impact and drilling equipment such as pile drivers, jackhammers, hoe rams, core drills, direct push soil probes (e.g. Geoprobe), and rock drills shall be equipped with a muffler;
- slamming of dump truck tail gates shall be prohibited;

- earthmoving and stationary equipment shall be noise attenuated;
- silencers on air intakes and air exhaust of equipment;
- mitigate noise from construction devices with internal combustion engines by ensuring that the engine doors are kept closed, and by using noise-insulating material mounted on the engine housing that does not interfere with the manufacturer guidelines and by operating the device at lower engine speeds to the maximum extent possible;
- operate equipment to minimize banging, clattering, buzzing, and other annoying types of noises;
- provide shields, acoustic fabric, soundproof housings or other physical barriers to restrict the transmission of noise;
- jackhammers shall be equipped with elongated effective muffler casing or bellows;
- alternative methods to hoe ramming concrete, including hydraulic jacks or chemical splitting, shall be considered;
- hoe rams shall be the smallest and quietest necessary. A noise shroud enclosure shall be wrapped around the head (i.e. chisel) of the hoe ram;
- auger drill rigs shall be equipped with well-maintained and effective mufflers. All moving parts shall be well lubricated to avoid unnecessary noise squeaking parts. Debris from the drill bit shall be removed without quick twisting, jerking, or hammering the bit;
- street plates shall be properly installed minimize vehicular tire impact on the plate and minimize noise; and
- use the local power grid to reduce the use of generators.

17.3.1.2 Construction Noise Monitoring

Concessionaire's Noise Control, Monitoring and Mitigation Plan shall include daily measurements for above ground noise generating activities. In addition, Concessionaire shall conduct measurements upon request by Owner and upon receipt of a noise complaint.

The time period for each noise measurement shall be 20 minutes. All measurements shall be performed using the A-weighting network and the "RMS fast" setting of the sound level meter.

The measurement microphone shall be fitted with an appropriate windscreen, shall be located 5 feet above the ground, and shall be at least 5 feet away from the nearest acoustically-reflective surface. Monitoring shall measure sound levels at the closest point adjacent to the site of the Project in use by public while Work is in progress.

Noise monitoring performed during precipitation or when wind speeds are greater than 15 mph shall be conducted in such a manner as to negate the acoustic effects of rain and high winds.

17.3.1.3 Construction Noise Monitoring Equipment

All noise measurements shall be performed with an instrument that is in compliance with the criteria for a Type 1 (Precision) or Type 2 (General Purpose) Sound Level Meter as defined in the current revision of ANSI Standard S1.4. The sound level meter shall be capable of measuring dBA noise levels in compliance with the requirements of Section 17.4.1 and displaying L_{eq} and L_{max} over 20-minute intervals in the field without the need for post-processing of data.

The sound level meter and the acoustic calibrator shall be calibrated and certified prior to commencing construction and every two years thereafter by the manufacturer or other independent certified acoustical laboratory. The sound level meter shall be field calibrated using an acoustic calibrator, according to the manufacturer's specifications, prior to and after each measurement.

Concessionaire shall submit a Noise Meter Laboratory Calibration Certificate for Information prior to performing any noise level monitoring, following subsequent calibrations, and upon completion of any repairs to the Noise Meter.

17.3.2 Construction Noise Report

Concessionaire shall submit a Construction Noise Report for Information on a monthly basis. Reports shall include, but not be limited to:

- location plan of the construction area, operating equipment, and receptors;
- construction and other noise generating activities occurring while performing the noise measurements shall be noted;
- daily field logs, site, noise measurement summary tables, and complaint responses; and
- noise reduction measures implemented, the effectiveness of implemented reduction measures, and additional measures to be implemented.

17.4 Maximum Construction Noise Levels

Except as allowed by Part 2A, Sections 17.4.1 and 17.4.2 of the Technical Provisions, the maximum construction noise level for the Project Site, as measured in accordance with Part 2A, Section 17.3 of the Technical Provisions, shall be the more stringent of that provided in the Third Party Agreement Requirements and as stated in Exhibit 17.1.

Exhibit 17.1 Maximum (Lmax) Construction Noise Levels in dBA

	Monday - Friday		Weekends / Holidays	
	Residential Zone	**Non-Residential Zone**	**Residential Zone**	**Non-Residential Zone**
7:00am to 9:00am	85	85	55*	62*
9:00am to 7:00pm	85	85	65*	67*
7:00pm to 10:00pm	65*	67*	65*	67*
10:00pm to 7:00am	55*	62*	55*	62*

* - or ambient, whichever is higher

17.4.1 Construction Noise Exceptions

The maximum construction noise levels in Part 2A, Section 17.4 of the Technical Provisions shall not apply to:

- pile driving operations performed Monday through Friday between 8am and 5pm.

Concessionaire's Noise Control, Monitoring, and Mitigation Plan shall contain justification for exceeding the maximum construction noise levels in Part 2A, Section 17.4 of the Technical Provisions for the following areas:

- Plymouth Ave Tunnel;
- within the Silver Spring Transit Center;
- Spring Street Bridge;
- 16th Street Bridge; and
- between Colesville Road and the intersection of Ramsey Ave and Bonifant Street.

Justification submitted for these areas shall contain the same information as required by Part 2A, Section 17.4.2 of the Technical Provisions and shall address any Third Party Agreement Requirements.

17.4.2 Construction Noise Waivers

Concessionaire may submit Noise Waiver requests for Review and Approval. Noise Waivers shall be reserved for those Construction Work activities that cannot meet maximum construction noise levels despite making all reasonable efforts in accordance with Part 2A, Section 17.3 of the Technical Provisions. Noise Waiver requests shall contain, at a minimum, the following information:

- type of construction activity;
- location of construction activity and impacted receptors;
- existing and proposed noise contour maps;
- work hours and calendar days for proposed noise waiver;
- noise mitigation measures to be used;
- exhibit showing the proposed noise levels as they relate to the contractually required noise levels; and
- any other information justifying issuance of a waiver.

Noise waivers, if approved, shall not exceed a period of 30 days. Concessionaire may request two renewal periods of up to 30 days each, after which time a new noise waiver request shall be required.

17.5 Vibration

Concessionaire shall identify and implement appropriate measures to minimize the potential for vibration during Construction Work and operation of the Project.

Concessionaire shall conduct construction activities such that the maximum ground borne vibration in any direction does not exceed 0.2 in/sec Peak Particle Velocity for building categories I, II, III and 0.12 in/sec PPV for building category IV. Building categories shall be as defined by FTA-VA-90-1003-06 Transit Noise and Vibration Assessment.

17.5.1 Design Requirements and Documents

Concessionaire shall perform site-specific assessment of those areas that the FEIS identifies as having potential vibration impacts and develop appropriate mitigation measures.

Concessionaire shall analyze vibration-sensitive buildings on the UMD-College Park campus in accordance with the Third Party Agreement Requirements.

When suitable vibration reduction cannot be achieved, Concessionaire shall consider the temporary or permanent relocation of vibration sensitive receptors.

17.5.2 Construction Requirements

Concessionaire shall submit a Vibration Control, Monitoring, and Mitigation Plan for Review and Comment prior to commencement of Construction Work. Concessionaire shall implement control measures to minimize the potential for vibration impacts.

17.5.3 Construction Vibration Report

Concessionaire shall submit a Construction Vibration Report for Information on a monthly basis. Reports shall include, but not be limited to:

- location plan of the construction area, operating equipment, and receptors;
- construction and other vibration generating activities occurring while performing the noise measurements shall be noted;
- daily field logs, site, noise measurement summary tables, and complaint responses; and
- vibration reduction measures implemented, the effectiveness of implemented reduction measures, and additional measures to be implemented.

17.6 Noise and Vibration Incentive

Concessionaire shall report all failures to comply with Sections 17.3, 17.4 and 17.5, whether identified by Concessionaire or Owner, as part of the monthly progress report. Concessionaire shall rate the performance for public notifications on a monthly basis in accordance with the following:

- Rating A. Up to 5 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating B. 6 to 10 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating C. 11 to 15 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating D. 16 to 20 failures in a calendar month. All failures resolved within two hours of discovery; and
- Rating F. 21 or more failures in a calendar month or any instance(s) of not correcting a failure within two hours of discovery in a calendar month.

Ratings shall only be made after commencement of construction.

17.7 Utility Restrictions

Concessionaire shall take suitable precaution to prevent damage to underground or overhead public utility structures.

Utilities may impose seasonal or other restrictions on Utility Work. Concessionaire shall coordinate with the Utility to determine restrictions and incorporate the restrictions into the Project Schedule.

17.8 Load Restrictions

Concessionaire shall identify and comply with all State and local requirements pertaining to speed, size and weight of motor vehicles. Concessionaire shall take into account any and all posted bridges, the crossing of which might be contemplated by work on the Project. No loads in excess of posted limits will be allowed unless the required permits are obtained from the appropriate State and local governmental agencies.

Concessionaire shall consider possible detrimental effects of construction activities on retaining walls, pipe culverts, arches, forms for concrete work as well as construction existing prior to this Project.

Owner shall have the right to limit passage of heavy equipment (plus loads) when such passage or usage is causing apparent or visible damage to embankments, paving, structures or any other property.

17.9 Public Convenience and Safety

Equipment and/or materials stored upon the Site shall be placed so as to cause a minimum of obstruction to the public.

Existing facilities planned to be removed, but which might be of service to the public during Construction Work are not to be disturbed until other and adequate provisions are made. Existing mailboxes shall be maintained or reset in positions accessible to the public and to mail deliveries during Construction Work and subsequent to construction in their final locations in a satisfactory condition.

Fire hydrants on or adjacent to the Site shall be kept accessible to fire apparatus at all times, and no material or obstruction shall be placed within 15 feet of any such hydrant. All footways, gutters, sewer inlets and portions of the Project adjoining the work under construction shall not be obstructed more than is absolutely necessary.

17.10 Preservation and Restoration of Property

Concessionaire shall not enter upon public or private property outside of the Project ROW for any purpose without obtaining permission. Concessionaire shall be responsible for the preservation of all public and private property, trees, monuments, signs and markers and fences thereon, and shall use every precaution necessary to prevent damage or injury thereto.

Concessionaire shall be responsible for all damage or injury to property of any character during the prosecution of the Work, resulting from any act, omission, neglect or misconduct in his manner or method of executing said Work, or at any time due to defective Work or materials, and said responsibility shall not be released until the Work shall have been completed and accepted. When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect or misconduct in the execution of the Work or in consequence of the nonexecution thereof on the part of the Concessionaire, he shall restore, at his own expense, such property to a condition similar to, or equal to, that existing before such damage or injury, in an acceptable manner. In case of the failure on the part of the Concessionaire to restore such property or make good such damage or injury, Owner may, upon 48 hours notice, proceed to repair, rebuild or otherwise restore such property as may be deemed necessary and the cost thereof will be deducted from any monies due or which may become due the Concessionaire under this Agreement.

17.11 Columbia Country Club

Concessionaire may use the one year license granted by Columbia Country Club, as shown on the right of way plans in Book 4 Contract Drawings, for the limited purpose of constructing and using a temporary construction access road (20 foot maximum width) on, over, and across the licensed area, ingress and egress of vehicles, and for the storage and staging of construction vehicles, materials and equipment. This license shall terminate upon completion of construction adjacent to the license area or after one year from commencement of use, whichever is sooner. Prior to termination, Concessionaire shall remove the access road completely and restore the license area as nearly as possible to its previous condition.

Concessionaire shall sequence the Work such that Columbia Country Club golf course shall remain open for course play throughout Construction Work. Concessionaire shall provide written notification to Owner and Columbia County Club no less than 90 days prior to commencing work adjacent to or within right of way, easement, or license area acquired from Columbia Country Club. Upon such written notice, Columbia Country Club will endeavor to relocate course play, including the 14th green, outside of the right of way, easement and license area.

17.12 Long Branch Local Park

If specific Construction Work in the Long Branch Stream Valley Park necessitates Construction Work or access through Long Branch Local Park, Concessionaire shall avoid affecting park access and parking within Long Branch Local Park during June and July to minimize operational impacts to Long Branch Community Center.

17.13 Brookville Depot

Concessionaire shall provide temporary replacement parking prior to displacing the current parking area at the Brookville Depot. At no point shall access to the Brookville Depot by MCDOT staff or contractors be limited during Construction Work. Access to the MCDOT Highway Services compound, including the administration building, salt storage areas, leaf storage areas, and equipment storage area shall be available at all times.

17.14 Property Access Restrictions

Owner is providing limited duration temporary construction easements for the specific properties noted in Exhibit 17.2 below. Concessionaire shall complete all Construction Work that reduces available parking within the subject temporary construction easement areas within the maximum construction duration noted in Exhibit 17.2. The maximum construction durations shall commence on the date when Concessionaire starts any Construction Work on the applicable property that reduces available parking. Maximum Construction Duration shall be measured continuously from the date of commencement and shall not stop and start each time Concessionaire starts or stops Construction Work.

Construction shall be phased and coordinated to minimize impacts to parking and access and in accordance with the Contract Documents. Concessionaire shall notify and coordinate with the property owner and current occupant (if different) a maximum of 60 days, but not less than 30 days, before commencement of Construction Work within the temporary construction easement.

Exhibit 17.2 – Property Access Restrictions

MTA Item	Plat No.	Property Description	Maximum Construction Duration affecting parking	Notes
01390	59200	Bethesda-Chevy Chase Association Racquet Club LP, 4400 Montgomery Ave.	16 Weeks	
01406	59210	Round Hill Apartments LLC, 2823 Terrace Dr	16 Weeks	
01408	59211	Washington Suburban Sanitary Commission, 2501 Lyttonsville Rd	16 Weeks	
01419	59215	Bradford Place LLC, 8600 16th Street	16 Weeks	
01414	59217	Summit Building LLC, 8555 16th Street	4 Weeks	
01418	59218	Falkland Road Residential LLC, 1545 North Falkland Lane	16 Weeks	
01634	59222	PFA-A Silver Spring, LC, 833 Wayne Ave	16 Weeks	
01631	59222	801 Wayne Ave Ltd Partnership, 801 Wayne Ave	16 Weeks	
01560	59223	Loreto, James A, 711 Wayne Ave	16 Weeks	
01641	59227	M-NCPPC, Wayne Ave	16 Weeks	
01593	59227	Old Dominion Associates, 8800 Manchester Rd	4 Weeks	
01612	59228	Wayne Manchester Ltd Partnership, 25 E Wayne Ave	16 Weeks	
01638	59229	Creative Development Corp. (Kenwood House) 95 E. Wayne Ave	4 weeks	Concessionaire shall maintain use of parking lot driveway during construction of water main.
02087	59229	Borchers, James W & N L, 8807 Plymouth St	4 Weeks	
01613	59229	Ellman, Martin, 8809 Plymouth St	4 Weeks	
01494	59232	Piney Spring LLC, 8528 Piney Branch Rd	16 Weeks	

MTA Item	Plat No.	Property Description	Maximum Construction Duration affecting parking	Notes
01511 01512 01513	59232	Ejra Inc, 8533 Piney Branch Rd	16 Weeks	
01510	59232	Fleitas LLC, 8547 Piney Branch Rd	16 Weeks	
01632	59231 to 59233	Flower Branch Apts LLC, 8648 Piney Branch Rd.	4 Weeks	
01493	59232	Goodacre Associates, 8619 Piney Branch Rd	16 Weeks	
01502	59233	Foxhall Assoc Ltd Partnership, 8700 Barron St	16 Weeks	
01500	59234	Hernandez, Moises H & C A, 8716 Piney Branch Rd	16 Weeks	
01633	59234	Angkor Thom Inc, 649 E University Blvd	4 Weeks	
01630	59234	Latino Management LLC, 701 E University Blvd	16 Weeks	
01653	59236	Montgomery County, 734 E University Blvd	16 Weeks	
01650	59236, 59237	University Manor Apts. Ltd Partnership, 820 E University Blvd	4 Weeks	
01654	59237	VICSN I LLC, 831 E University Blvd	16 Weeks	
01659	59238	Takoma Park Station LLC, 925 E. University Blvd	16 Weeks	
01660	59238	Horning, Carol F, 949 E University Blvd	16 Weeks	
01791	59238	University Assocs. Ltd. Partnership, 1001 Merrimac Dr	16 Weeks	
01758	59238	University Assocs. Ltd. Partnership, 1020 University Blvd	4 Weeks	
01716	59238, 59239	Langley Gardens Apts. Ltd. Partnership, 1032 University Blvd	4 Weeks	
01694	59239	Saul Subsidiary I Ltd. Partnership, 1101 E University Blvd	16 Weeks	

MTA Item	Plat No.	Property Description	Maximum Construction Duration affecting parking	Notes
01695	59239, 59240	Saul Subsidiary I Ltd. Partnership, 1167 E University Blvd	16 Weeks	
01710	59240	Langley Park Plaza Inc, 8011 New Hampshire Ave	16 Weeks	
01700	59240	Walgreen Co, 7663 New Hampshire Ave	16 Weeks	
01733	59240	McCormick-Goodhart ,Nita E Etal Tr, 1348 University Blvd	4 Weeks	
02250	59240	Walgreen Co, 1329 E University Blvd	16 Weeks	
01707	59240, 59241	Unilang Park Assoc. Ltd, 1335 E University Blvd	4 Weeks	
01711	59241	La Union Center, LLC, 1401 University Blvd	16 Weeks	
01798	59241, 59242	Shellhorn Langley LLC, 1425 University Blvd	4 Weeks	
01741	59242	Neyesh Properties, 1500 University Blvd	4Weeks	
01752	59242	Insurance USA, LLC, 1600 University Blvd	4 Weeks	
01734	59242	Bazar La Chiquita LLC, 1606 University Blvd	4 Weeks	
01783	59242	Hechinger Plaza Limited Partnership, 1535 University Blvd	4 Weeks	
01762	59242	Pep Boys-Manny, Moe & Jack, 1804 University Blvd	4 Weeks	
01763	59242, 59243	Melhi, Ravinder K, 1810 University Blvd	16 Weeks	
01784	59242	UPOB LLC, 1511 University Blvd	16 Weeks	
01785	59243	UPOB LLC, 1835 University Blvd	16 Weeks	
01777	59243	Third C E W Properties Inc, 2001 University Blvd	4 Weeks	
01737	59243, 59244	Sandelman, Sanford Trust Of Esue Trst, 2010 University Blvd	4 Weeks	Driveway shall not be closed for construction simultaneously with 2020 University Blvd. driveway.

MTA Item	Plat No.	Property Description	Maximum Construction Duration affecting parking	Notes
01738	59244	Calla LLC, 2020 University Blvd	4 Weeks	Driveway shall not be closed for construction simultaneously with 2020 University Blvd. driveway.
01793	59243	Riggs Plaza Shop Center Ltd. Partnership, 2065 University Blvd	4 Weeks	Both driveways shall not be closed simultaneously for construction.
01792	59244	Kim,Jiun U & Jin S, 2074 University Blvd	4 Weeks	
01713	59244	University Blvd Ltd. Partnership, 2200 University Blvd	8 Weeks	
01776	59244	2204 University Boulevard LLC, 2204 University Blvd	16 Weeks	
01788	59244, 59245	University City LLC, 2213 University Blvd	4 Weeks	
01753	59244	Kramer,Rona E Trustee, 2208 East University Blvd	4 Weeks	Complete Work without disruption to drive-thru exit lane operations.
01715	59244, 59245	P K LLC, 2210 University Blvd	16 Weeks	
01795	59245	Leon, Leroy V, 2216 University Blvd	16 Weeks	
01796	59245	Fairview Hampshire LLLP, 2220 University Blvd	16 Weeks	
01720	59245	2277 University Blvd LLC, 2277 University Blvd	4 Weeks	
01730	59245, 59246	Park, Je B & Mee Y, 2301 University Blvd	4 Weeks	
01725	59246	McDonalds Real Estate Co, 2306 University Blvd	4 Weeks	
01770	59246	Clements, Adrian & Shirley A, 2311 University Blvd	4 Weeks	
01755	59246	EBC Properties LLC, 2340 University Blvd	4 Weeks	
01775	59246	Difranco, Carmine & Giuliana, 2344 University Blvd	4 Weeks	

MTA Item	Plat No.	Property Description	Maximum Construction Duration affecting parking	Notes
01754	59246, 59247	Adelphi Center LLC, 2520 University Blvd	16 Weeks	
01750	59247, 59248	M-NCPPC, University Ln	16 Weeks	
01771	59248, 59249	State Of Maryland (Leased), 3424 Tulane Dr	8 Weeks	
01832	59322, 59323	American Center For Physics Inc, River Road	4 Weeks	
01943	59326, 59327	Atlantic Korean American Presbyterian Church Inc, 6410 Kenilworth Ave	8 Weeks	
01873	59327	Coopersmith Md Properties LLC, 6408 Kenilworth Ave	4 Weeks	
01955	59327, 59328	Rinaldis Riverdale Bowl LLC, 6322 Kenilworth Ave	16 Weeks	
01932	59328 & 59331	Maine Properties Inc, 6250 Kenilworth Ave	16 Weeks	
01907	59331	Papadopoulos, Eleftherios M Etal, 5416 Quesada Rd	4 Weeks	
01977	59330	Trager, Maraline A, 6210 Kenilworth Ave	16 Weeks	
01923	59332	McDonalds Corp, 6106 57Th Ave	16 Weeks	
01973	59333	Suburban Trust Co, 5710 Riverdale Rd	16 Weeks	
01949	59334	Roman Catholic ArchBishop Of Wash, 5811 Riverdale Rd	8 Weeks	Do not disrupt church and school operations and bus access during the school year. Pedestrian and vehicular access from Riverdale Road shall be maintained at all times.
01849	59335	Refreshing Spring Church of God I C, 6201 Riverdale Rd	16 Weeks	
01877	59338	Ivory Investment LLC, 6611 Riverdale Rd	16 Weeks	
01855	59339	Prince Georges County, 6700 Riverdale Rd	16 Weeks	
01879	59339	DGV Apartments LLC, 6739 & 6747 Riverdale Rd	4 Weeks	

MTA Item	Plat No.	Property Description	Maximum Construction Duration affecting parking	Notes
02000	59346, 59347	County Center Joint Venture, 7520 Annapolis Rd	16 Weeks	Complete parking circulation improvements prior to initiating retaining wall construction.
02026	59347	Berman Sanford Z, Chesapeake Road	16 Weeks	
02027	59349	Chesapeake Landing LLC, 7501 Buchanan St	16 Weeks	

17.15 Summary of Submittals

Item	Section	Submittal	Action
1	17.3	Noise Control, Monitoring, and Mitigation Plan	Review and Comment
2	17.3.1.3	Noise Meter Laboratory Calibration Certificate	Information
3	17.3.2	Construction Noise Report	Information
4	17.4.2	Noise Waiver	Review and Approval
5	17.5.2	Vibration Control, Monitoring, and Mitigation Plan	Review and Comment
6	17.5.3	Construction Vibration Report	Information

18 THIRD PARTY COORDINATION

Concessionaire shall provide coordination of the Work with previously identified Third Parties and any other third party per the requirements of the Contract Documents and as indicated herein.

18.1 General Requirements

Except as otherwise required by the Contract Documents, Concessionaire shall coordinate directly with each third party entity to identify, collaborate and resolve all items and issues that impact the Project in a timely manner. Concessionaire shall invite Owner to participate in third party coordination.

Concessionaire shall coordinate and resolve all third party items and issues throughout the Term, whether or not:

- the Owner has had previous discussion with a third party;
- the Owner has executed an agreement and/or a memorandum of understanding with a third party; or
- the Owner has or has not identified a third party.

18.2 Third Party Coordination Work Plan

Concessionaire's Third Party Coordination Work Plan shall include, but not be limited to, the following:

- a Third Party Coordination Manager is assigned exclusively to the Project and functioning as the primary contact between Concessionaire and the third party;
- the Third Party Coordination Manager role and responsibility shall remain active and in force until Final Completion;
- identification of each third party, by contact, type, schedule to closure, and resolution status;
- identification of the party responsible for the design, construction, inspection, acceptance and cost of the Work in accordance with the Contract Documents;
- notification to Owner of requested betterments;
- monthly third party-specific coordination meetings from Financial Close to Final Completion including Concessionaire and the third party;
- creation, maintenance and update on a monthly basis of a report of third party coordination activities; and
- establishment of Concessionaire’s design and construction procedures, processes and schedule for third party Work and methodology for ensuring that all third party Work is completed in accordance with the Third Party Coordination Work Plan.

Concessionaire shall submit the Third Party Coordination Work Plan for Review and Comment within 30 calendar days of Financial Close.

18.3 Project Execution Plan

In connection with any Third Party Agreement and for Montgomery County Public Schools, Concessionaire shall prepare a Project Execution Plan in accordance with the requirements of Section 19.3 of the Technical Provisions.

18.4 Summary of Submittals

Item	Section	Submittal	Action
1	18.2	Third Party Coordination Work Plan	Review and Comment

19 UTILITY COORDINATION

Concessionaire shall provide Utility coordination of the Work in accordance with the Contract Documents.

19.1 General Requirements

Concessionaire shall coordinate directly with all Utility Owners to identify and confirm Utility locations, potential conflicts and relocations necessary for the Project.

Concessionaire's obligation to coordinate Utilities is applicable to all Utilities impacted by the Project, whether or not:

- Owner has had previous discussion with a Utility Owner;
- Owner has entered into a Utility Agreement with the affected Utility Owner;
- Owner has identified the existing Utility on a Utility composite map; and
- the Utility was installed before, during or after construction and during the Term.

Concessionaire may enter into agreements with Utility Owners in accordance with the Agreement. Concessionaire shall submit any Concessionaire Utility Agreements for Review and Comment before execution.

19.2 Utility Coordination Work Plan

Concessionaire's Utility Coordination Work Plan shall include, at a minimum:

- a Utility Coordination Manager assigned exclusively to the Project as the main point of contact for Utility Owners and Owner until the start of Revenue Service; The position requires overseeing all the Utility Work so that is it coordinated with each Utility Owner, and Owner;
- preliminary identification of Utility Work necessary for the Project;
- identification of the party responsible for the design, construction, inspection, acceptance and cost of the Utility Work in accordance with the Contract Documents;
- verification that all post-construction Utilities are capable of providing service at least equal to that offered by the pre-construction Utility unless the Utility Owner has specified a lesser replacement;
- Submittal, Review, and Approval processes for Owner and Utility Owners as required by the Contract Documents and Owner Utility Agreements;
- notification and a process for obtaining Owner Approval of requested Betterments;
- monthly Utility specific coordination meetings beginning 30 calendar days after Financial Close and continuing until the start of Revenue Service. Meetings shall include Concessionaire, Utility Owners, and Owner. Concessionaire shall prepare and distribute meeting agendas, minutes, and attendance records;
- creation, maintenance and update on a monthly basis of the Project Utility composite map showing all the existing and proposed Utility alignments;
- establishment of Concessionaire's design and construction procedures, processes and schedule for adjusting Utilities;

- a process for emergency work that includes timely status updates and coordination with the Utility Owner and Owner for issue resolution;
- a methodology for ensuring that all Utility Work is completed in accordance with the Utility Coordination Work Plan; and
- creation, maintenance, and update on a monthly basis a Utility Relocation Schedule.

Concessionaire shall submit the Utility Coordination Work Plan for Review and Comment within 30 calendar days of Financial Close.

19.3 Project Execution Plan

Concessionaire shall prepare a Project Execution Plan for each Utility Owner, Third Party, and for Montgomery County Public Schools. Owner, Concessionaire and the relevant Utility Owner or Third Party (including, for purposes of this Section 19.3 and Section 19.4, Montgomery County Public Schools) shall agree upon a Final Project Execution Plan with respect to the Utility Work or the Third Party Work. For purposes of this Section 19.3, “Utility Work” includes performance of any Betterments for a Utility Owner and “Third Party Work” includes performance of additional improvements sought by Third Party.

Concessionaire shall submit each Initial Project Execution Plan for Review and Comment in accordance with the following schedule:

- WMATA – no later than 30 days after Financial Close;
- Montgomery County – no later than 30 days after Financial Close;
- University of Maryland – no later than 45 days after Financial Close;
- Prince George’s County – no later than 45 days after Financial Close;
- Potomac Electric Power Company – no later than 60 days after Financial Close;
- Washington Suburban Sanitary Commission – no later than 60 days after Financial Close;
- Verizon – no later than 60 days after Financial Close;
- Washington Gas – no later than 60 days after Financial Close;
- Montgomery County Public Schools – no later than 90 days after Financial Close;
- Maryland-National Capital Park & Planning Commission (with regard to its Montgomery County jurisdiction) – no later than 90 days after Financial Close;
- Maryland-National Capital Park & Planning Commission (with regard to its Prince George’s County jurisdiction) – no later than 90 days after Financial Close; and
- Zayo Group, LLC – no later than 90 days after Financial Close.

Each Initial Project Execution Plan will be reviewed only by Owner and not the relevant Third Party or Utility Owner.

Concessionaire shall address comments on the Initial Project Execution Plan and submit a Draft Project Execution Plan(s) for Review and Comment. Owner will coordinate review by the relevant Utility Owner, Third Party or Montgomery County Public Schools.

Upon resolution of all comments, Concessionaire shall submit each final Project Execution Plan for Review and Approval.

Each Project Execution Plan shall be approved by the earliest of (a) the date upon which the applicable Utility Agreement or Third Party Agreement specifies, if any, and (b) 15 Business Days prior to commencing any construction work that is subject to the Project Execution Plan.

19.3.1.1 Project Execution Plan Content

The primary purpose of the Project Execution Plan shall be to give greater detail to the work to be performed within the scope of the Utility Agreement or Third Party Agreement. The Project Execution Plan shall contain, at a minimum:

- detailed procedures not otherwise enumerated in the Utility Agreement or Third Party Agreement for the Utility Work, Third Party Work, inspection, and acceptance of facilities or other work to be owned by the Utility Owner or Third Party upon completion;
- detailed procedures for submittals in accordance with the Third Party Agreement, Utility Agreement, and other submittal requirements of the Contract Documents;
- the Submittal list as related to the Third Party or Utility Owner, which shall be coordinated and updated from time-to-time as may be necessary to match the Submittal list required by Part 2A, Section 10.3 of the Technical Provisions.
- Concessionaire's approved Baseline Schedule, in accordance with Part 2A, Section 9.1.2 of the Technical Provisions relevant to scope of Utility Work or Third Party Work;
- standards, responsibilities and procedures for design and review of the Utility Work or Third Party Work;
- standards, responsibilities and procedures for performance of the Utility Work or Third Party Work;
- standards, responsibilities and procedures for any inspection, testing and acceptance of facilities or other work required prior to acceptance (including, with respect to Utility Owners, placement of facilities into service);
- standards, responsibilities and procedures for quality assurance and quality control of the Utility Work or Third Party Work;
- the scope and timeline for development of operations and maintenance procedures necessary for Utility Work or Third Party Work, if any; and
- any information, plan or procedure specifically called for in the Utility Agreement or Third Party Agreement, as applicable.

The Project Execution Plan may neither expand the responsibilities nor diminish the rights of the Concessionaire under the Agreement, Contract Documents, or the applicable Utility Agreement or Third Party Agreement.

Refer to Section 7.6.6 of the Agreement for provisions with respect to negotiation and payment for Betterments.

19.4 Summary of Submittals

Item	Section	Submittal	Action
1	19.1	Concessionaire Utility Agreements	Review and Comment
2	19.2	Utility Coordination Work Plan	Review and Comment
3	19.3	Initial Project Execution Plans	Review and Comment
4	19.3	Draft Project Execution Plans	Review and Comment
5	19.3	Project Execution Plans	Review and Approval

20 MAINTENANCE OF TRAFFIC

This Section contains the requirements for developing and implementing a comprehensive Transportation Management Plan (TMP). Construction access and mobility, and lane closure restrictions and permitting requirements are also included.

20.1 Overview

Concessionaire shall design and implement Maintenance of Traffic (MOT) for work areas in accordance with the Contract Documents and the following general requirements:

- provide for the safe and efficient passage of all forms of traffic including at a minimum pedestrians, bicycles, and vehicular traffic through and around construction zones throughout construction of the Project, while maintaining safety and accessibility for all workers on the Project;
- minimize adverse impacts on residents, businesses and all road users;
- provide traffic analysis of all MOT phases to ensure acceptable mobility, capacity, queues, delays, and progression throughout the Project area;
- develop and coordinate MOT and incident management activities with the Maryland State Police, Owner Police, local law enforcement, and other Emergency Services to ensure public safety and emergency response times are not compromised;
- provide for the safe passage of Trains through grade crossings, street intersections and shared traffic lanes prior to Revenue Service Availability Date;
- provide and maintain in passable condition such temporary access, roads and bridges as may be necessary to accommodate traffic diverted from the Project under construction, or using the Project under construction; and
- provide and maintain in a safe condition temporary approaches to, and crossings of the Project.

20.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- AASHTO, A Policy on Geometric Design of Highways and Streets;
- AASHTO, Highway Safety Design and Operations Guide;
- AASHTO, Roadside Design Guide;
- ATSSA, Quality Standards for Work Zone Traffic Control Devices;
- FHWA, Manual for Assessing Safety Hardware;
- FHWA, Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD);
- FHWA, NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features;
- FHWA, NCHRP Report 553, Crashworthy Work Zone Traffic Control Devices;
- MCDOT, Guidelines for Temporary Traffic Control Plan Preparation;
- MDSHA, Bicycle Policy and Design Guidelines;

- MDSHA, Standard Specifications for Construction and Materials;
- MDSHA, Supplemental Special Provisions & Special Provision Inserts;
- MDSHA, Accessibility Policy and Guidelines for Pedestrian Facilities along State Highways;
- MDSHA, Book of Standards for Highway and Incidental Structures;
- MDSHA, Flagger Policy at Signalized Intersections;
- MDSHA, Functional Guidelines for Portable Changeable Message Signs;
- MDSHA, Guidance on Maintenance of Traffic Alternatives Analysis;
- MDSHA, Guidelines for Late Lane Merge Concept;
- MDSHA, High Visibility Apparel Policy;
- MDSHA, List of Qualified Removable Preformed Pavement Marking Material for Maintenance of Traffic;
- MDSHA, Maryland Manual on Uniform Traffic Control Devices for Streets and Highways (MDMUTCD);
- MDSHA, Maryland State Police Criteria for Use in Work Zones and Interagency Agreement between SHA and Maryland State Police;
- MDSHA, NCHRP Report 350, Implementation Schedule;
- MDSHA, Office of Materials and Technology, Qualified Products List;
- MDSHA, Office of Traffic and Safety, Qualified Products List for Temporary Traffic Control Devices and Miscellaneous Items;
- MDSHA, Roadway Delineation Policy;
- MDSHA, Standard Sign Book;
- MDSHA, Standard Specifications for Construction and Materials;
- MDSHA, Temporary Traffic Barrier Policy;
- MDSHA, Transportation Management Plans: Guidelines for Development, Implementation and Evaluation;
- MDSHA, Work Zone Lane Closure Analysis Guidelines;
- MDSHA, Work Zone on 65/60 MPH Roadways;
- MDSHA, Work Zone Safety and Mobility Policy;
- MDSHA, Work Zone Safety Tool Box;
- M-NCPPC, Local Area Transportation Review and Transportation Policy Area Review Guidelines
- US Department of Justice (DOJ), ADA Standards for Accessible Design; and
- US DOJ, Americans with Disability Act Accessibility Guidelines.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

20.3 Transportation Management Plan

Concessionaire shall develop and implement a comprehensive Transportation Management Plan (TMP) detailing the process of how mobility and safety will be maintained throughout Design Work and Construction Work.

The TMP shall identify the type of traffic control required for the Project, identify and evaluate work zone impacts, and develop work zone impact management strategies to mitigate those impacts through the use of:

- transportation operations strategies to better manage the transportation system;
- Traffic Control Plans (TCP) to provide site-specific MOT solutions;
- public information and outreach strategies to communicate with the public and Project stakeholders throughout construction; and
- Strategies to mitigate the loss of small business patronage and adverse impacts to small business operations due to street and lane closures.

Concessionaire shall prepare the TMP in a report format, with numbered and dated pages, with tracked and logged revisions as necessary to update the report for design and construction activities.

Concessionaire shall submit the TMP for Review and Comment at the Preliminary Design stage and prior to commencing any Construction Work. The TMP may be prepared for logical geographic segments or phases of the project. A TMP shall be prepared specifically for the Silver Spring Parking District.

The TMP is anticipated to be a living document. Concessionaire shall submit TMP Revisions for Review and Comment, or as required by the Third Party Agreement Requirements Review and Approval.

The TMP shall include, at a minimum, the chapters as described in the sections below.

20.3.1 Administrative

The administrative section of the TMP shall include, at a minimum:

- Introduction (including a cover page and table of contents);
- log sheet indicating all changes to the TMP by date, type of action, affected pages;
- Executive Summary;
- TMP Teams, Roles, Responsibilities and Contact Information;
- Project Description (including goals and constraints);
- Existing Conditions (such as traffic and crash data, roadway characteristics).

20.3.2 Work Zone Impacts Assessment

Concessionaire shall identify MOT related issues anticipated due to the Project; review and evaluate alternative MOT concepts to address those issues; select and analyze proposed construction phasing; and, identify the work zone impacts associated with the selected phasing. Concessionaire shall provide the following, at a minimum, in the work zone impacts assessment:

- Red Flag Summary – per MDSHA Maintenance of Traffic Red Flag Summary requirements;
- Maintenance of Traffic Alternative Analysis (MOTAA) – per *MDSHA Guidance on Maintenance of Traffic Alternative Analysis (MOTAA)* requirements. Concessionaire shall provide a recommended work zone option in each MOTAA report, and shall seek concurrence from the Owner on the recommendation prior to proceeding with detailed MOT design or construction;
- High-Level Construction/MOT Phasing – conceptual plans and durations to serve as the basis for site-specific TCP;
- Work Zone Traffic Analysis – Concessionaire shall use the year 2020 No-Build Conditions Wiring Diagrams provided in Book 4 Contract Drawings to analyze all proposed MOT phases in accordance with the methods, tools and allowable mobility thresholds provided in the MDSHA *Work Zone Lane Closure Analysis Guidelines* document. The work zone traffic analysis shall include, at a minimum:
    - Traffic and Travel Characteristics at the Project Location – a summary of traffic and travel characteristics in the Project area including recurring congestion issues, non-recurring congestion issues (such as Emergency Services pre-emptions/operations, special event traffic issues, weather related delays, potential for incident related traffic congestion), heavy vehicle volumes, high pedestrian and bicycle traffic, directional traffic, vehicular or pedestrian accident frequency, on and off street parking availability, and recreational or seasonal traffic issues;
    - Traffic Analysis Strategies – a brief description on how the expected traffic conditions during Construction Work were determined including source and date of traffic data, traffic reduction factors or other parameters assumed for the calculations;
    - ITS Analysis Strategies - Identify Areas Where Existing ITS or Traffic Monitoring May Be Used;
    - Measures of Effectiveness – identify the measures of effectiveness including at a minimum capacity, volume, queue, travel time, diversion rates, safety, and adequacy of detour routes.;
    - Analysis Tool Selection Methodology and Justification – identify the traffic analysis tools used including a summary of the criteria used to select the most appropriate tool;
    - Mobility Implications of Construction Approaches – identify construction approaches that have the potential to impact mobility during the Project including, at a minimum, lack of shoulders requiring incident management strategies, doing work at night to reduce traffic delays, or traffic capacity and management issues that may exist on a proposed detour route;
    - Analysis Results – compare existing and construction traffic conditions and operations, with and without work zone impact management strategies (where included). Detour route analysis shall be included where detours will be used. Traffic analysis shall address in a quantitative manner the impacts on:
        - Access for residences, businesses, and non-Emergency Services;
        - Access for pedestrians, bicyclists and persons with disabilities;

- Emergency Services impacts (fire, ambulance, police, hospitals);
- Safety;
- Adequacy of detour routes;
- Intersection traffic control (such as signal timing and signage);
- Heavy vehicle traffic (including over-height, over-weight vehicles);
- Transit operations (such as bus stops, school buses, other transit operations); and
- Seasonal impacts (such as summer travel).

- Safety Issues - identify pre-existing and potential Construction Work safety issues and evaluate safety implications of proposed construction approaches;
- Community Impacts – identify community, business and residential impacts and related issues, including accessibility concerns, coordination issues, business access relocation, work impacting residential driveway access, detour related mobility impacts, construction noise concerns, and pedestrian and bicycle related impacts;
- Coordination with Other Projects – identify any adjacent or overlapping projects and include the combined impacts of these projects and the Purple Line Project in the required analyses.

20.3.3 Work Zone Impacts Management Strategies

Concessionaire shall develop work zone impacts management strategies in accordance with the requirements of the MDSHA *Summary of Work Zone Impact Management Strategies* document and the following requirements, including at a minimum:

- Site-specific TCP for each major phase of construction that requires diversion of traffic. TCP for the initial phases of construction shall be included in the TMP Submittal at the Preliminary Design stage. TCP for subsequent phases of construction shall be submitted at Intermediate and Final Design for Review and Comment. Concessionaire shall include the following components in each TCP:
  - detailed sequence of construction notes, separated by work zone activities and construction activities;
  - locations of signs, drums, cones, barricades, PVMS boards, concrete barriers and all other temporary traffic control devices, along with device size, messaging, spacing, frequency and other pertinent information necessary to provide a complete and compliant traffic control setup;
  - specific sign messages with sign sizes, spacing or referenced distances for all temporary signs;
  - MDMUTCD sign designations for standard signs;
  - sign fabrication details for all non-standard signs (i.e. those signs not included in MDMUTCD);
  - pavement marking details including size, material, color, location, spacing (for discontinuous marking) and lane widths;
  - flagger locations and signage;

  - detailed design of all temporary roadways, including pavement markings, roadside barriers and other appurtenances required to complete the work. All temporary roadways shall be designed for the assigned posted speed;
  - temporary signing, traffic signal, and lighting plans, as required;
  - all temporary traffic control devices necessary to safely and efficiently construct a particular portion of the Work; and
  - contact information of emergency responders.
- Concessionaire shall also submit the following along with each TCP package:
  - traffic analysis for each MOT phase; and
  - traffic signal timing plans for temporary and existing traffic signals (if changed).
- Transportation Operations Strategies;
- Public Information and Outreach Strategies;
- Strategies to mitigate the loss of small business patronage and adverse impacts to small business operations (business access, customer parking, loading/unloading, customer pick-up/drop-off, etc.) due to street and lane closures.

20.3.4 Contingency Plan

Concessionaire shall develop a contingency plan that specifies actions that will be taken to minimize traffic impacts should unexpected events (such as unforeseen traffic demand or inclement weather) occur in the work zone. The Contingency Plan shall include but it is not limited to the following:

- information that clearly defines trigger points which require lane closure lifting (i.e., inclement weather, length of traffic queue exceed thresholds);
- decision tree with clearly defined lines of communication and authority;
- specific duties of all participants during lane closure operations, such as coordination with Police; and
- standby equipment to be provided by Concessionaire and availability of Concessionaire's personnel for callout.

20.3.5 Traffic Incident Management Plan

Concessionaire shall develop a Traffic Incident Management Plan for accidents and other incidents occurring within the Project limits. The Traffic Incident Management Plan shall include, but is not limited to, accident prevention strategies, emergency procedures, reporting requirements, and mitigation strategies. Concessionaire shall provide immediate response to emergencies by trained personnel from an incident response team in accordance with the Contract Documents. Immediately following the initiation of actions necessary for the security of people and property, Concessionaire shall coordinate with the Owner on the investigation of an accident and incident. Concessionaire shall provide documentation to the Owner with details on:

- cause of disruption (i.e., whether construction oriented or not);
- actions being taken to alleviate the problem;
- responsible party for the actions; and
- anticipated duration of the disruption.

Concessionaire shall cooperate with Emergency Services in their response to accidents, fires, spills, or other emergencies in any area affected by the Project, including those on the construction site and on open traffic lanes effected by the result of any Concessionaire's activities.

For all accidents, crashes, or other incidents that occur within the work zone, Concessionaire shall submit the MDSHA Work Zone Accident / Incident Report for Information within 10 days of the accident, crash or other incident.

Concessionaire shall coordinate with Emergency Services regarding emergency access to and in the Corridor, and establish procedures for coordinating with emergency service providers during an incident.

Concessionaire shall establish and manage an emergency response telephone tree. All appropriate Emergency Services shall be included on this telephone tree for immediate response in the event of an emergency. The telephone tree shall be divided into areas of expertise so the appropriate agencies or personnel are called for specific emergency situations.

20.3.6 TMP Implementation and Monitoring Plan

Concessionaire shall prepare a TMP implementation and monitoring plan that defines processes to ensure that the TMP and all associated plans and elements are developed and implemented efficiently and correctly.

20.4 Maintenance of Traffic Requirements

20.4.1 General Requirements

Concessionaire shall implement all MOT on the Project in accordance with the TMP, AHJ requirements, and the following:

- design TCP and implement MOT setups using the greater of prevailing travel speed, posted speed, or design speed to determine buffer and taper lengths, clear zone distances, attenuator arrangements, and other temporary traffic control elements;
- utilize temporary raised pavement markers to supplement all temporary pavement markings;
- comply with drainage requirements on all active roadways and shoulders;
- unless otherwise agreed by the property owner, maintain access to all businesses, residences, local streets and private driveways at all times, including all temporary approaches and crossings of and intersections with roads and streets;
- consider any special access needs of property owners and tenants, such as business hours, delivery schedules and circulation patterns;
- maintain all existing pedestrian and bicycle access at all times. Whenever an existing pedestrian or bicycle access route in the public right of way is obstructed, an alternate route shall be provided. The alternate route shall be ADA compliant and may be either an existing facility or a new temporary or permanent facility constructed by Concessionaire. Existing roadways and directly adjacent sidewalks with grades steeper than ADA requirements shall not require reconstruction to reduce the grade.
- Notwithstanding the above, the Concessionaire shall not be responsible for the construction or maintenance of the alternate detour route for the interim Capital Crescent Trail. The construction and maintenance work for the alternate interim Capital Crescent Trail detour route will be performed by Montgomery County for the duration of the design and construction period.

20.4.2 Schools and Public Transportation Agencies

Concessionaire shall coordinate with local schools, appropriate board of education, and public transportation agencies for both city and local counties to maintain bus, private vehicle, and pedestrian access to educational facilities and public transportation services in the area.

20.4.3 Detour Routes

Where complete roadways or ramp closures are allowed by the Contract Documents or approved as part of the TMP, detour routes shall be required. All complete or directional roadway closures (for any period of time) and associated detour routes shall be subject to Review and Approval by the Owner and AHJ. Proposed detour routes, including traffic and operations impacts shall be included in the TCP and evaluated during the design review process.

Detouring traffic onto lesser classification roadways is prohibited unless approved by Owner and AHJ.

20.4.4 Motorist Guidance

Concessionaire shall provide positive guidance and signage to motorists who are diverted around or traveling through the construction areas.

At least seven calendar days before a road closure or major change in the roadway configuration or travel pattern, Concessionaire shall utilize Portable Variable Message Signs (PVMS) warning motorists of the pending changes. PVMS shall remain in place at least five but not more than seven calendar days after a major change in the roadway configuration or travel pattern.

In the event that PVMS messages not included in the TCP or TMP are required, Concessionaire shall submit PVMS Messages for Review and Comment a minimum of seven calendar days before implementation.

20.4.5 Construction Access and Mobility Plan

Concessionaire shall develop a Construction Access and Mobility Plan depicting all haul routes and access points on scaled drawings. Concessionaire shall submit the Construction Access and Mobility Plan for Review and Comment before commencement of Construction Work.

Deliveries and hauling to and from the Project shall be confined to the Project ROW and performed by means of designated haul routes along the Project alignment.

Concessionaire shall not use local streets through residential neighborhoods for access to the Project except for work located on the local roadway. Concessionaire shall access the Project to and from the following routes:

- MD 355 – Wisconsin Avenue;
- Reed Street – from the east via MD 355 and Woodmont Ave.;
- MD 410 (Bethesda) – East-West Highway;
- MD 185 – Connecticut Avenue;
- Apple Avenue, via 2nd Avenue and Colesville Road;
- Jones Bridge Road from the west via MD 185;
- Lyttonsville Place from the south via MD410, Grubb Road / Lyttonsville Road ;
- Brookville Road from the south via MD 410, Grubb Road, Lyttonsville Road, Lyttonsville Place;

- Stewart Avenue from the south via MD 410, Grubb Road, Lyttonsville Road, Lyttonsville Place, Brookville Road;
- Talbot Road from the south via MD 410, Grubb Road, Lyttonsville Road, Lyttonsville Place, Brookville Road;
- MD 390 – 16th Street;
- US 29 – Georgia Avenue;
- Wayne Avenue from the west via US 29;
- Flower Avenue from the south via MD 320;
- MD 320 – Piney Branch Road;
- MD 193 – University Blvd;
- MD 195 – Carroll Avenue;
- MD 650 – New Hampshire Avenue;
- MD 212 – Riggs Road;
- Adelphi Road from the north via MD 650, from the west via MD 193 / MD 193B;
- MD 193B – Campus Drive;
- Campus Drive from the west via MD 193 / MD 193B;
- University of Maryland Campus (West) from the west via MD 193 / President Drive;
- University of Maryland Campus (East) from the west via US 1;
- US 1 – Baltimore Avenue;
- Paint Branch Pkwy from the south via MD 201 (or from the north via US 1);
- MD 201 – Kenilworth Avenue;
- MD 410 – East West Hwy / Riverdale Rd (Riverdale Park);
- MD 295 – Baltimore Washington Pkwy (Posted No-Trucks);
- MD 410 - Veterans Pkwy;
- MD 450 – Annapolis Road;
- Ellin Road from the west via MD 410; and
- US 50 – John Hanson Highway.

Concessionaire shall not use new final surface paving as a haul route.

Concessionaire shall provide designated parking areas for Concessionaire use. Concessionaire shall not park on residential streets.

20.4.6 Construction Crossings

Concessionaire's TMP shall address the need for construction traffic to cross roadways that intersect the Project. Construction Crossings shall meet AHJ and the following requirements at a minimum:

- crossings shall be within the Project ROW;

- mobility thresholds shall be maintained;
- flagging procedures and/or temporary traffic signals shall be required in accordance with the TMP; and
- at-grade crossings are restricted as shown in Exhibit 20.1 below.

Exhibit 20.1 - Roadway Crossing Schedule Restrictions		
Roadway	**Day of the Week**	**Time of Day**
Stewart Avenue	Mon. – Fri.	7:00 AM – 9:00 AM 4:00 PM – 8:00 PM
MD 193	Mon. – Fri.	6:00 AM – 8:30 AM 4:00 PM – 8:00 PM
US 1	Mon. – Fri.	7:00 AM – 9:00 AM 4:00 PM – 7:00 PM

20.5 Construction

20.5.1 Pre-Traffic Switch Meeting

Concessionaire shall arrange and host a pre-traffic switch meeting with the Owner, AHJ and all affected agencies at least two weeks prior to switching traffic (i.e. changing the traffic patterns as a result of proceeding from one phase of the TCP to another) on any roadway.

For significant traffic switches (such as road openings or closings), Concessionaire and the Owner shall agree in advance on the timing of the pre-traffic switch meeting to allow for adequate planning, public outreach and coordination. All traffic switch materials including, at a minimum, sign overlay panels, temporary signs, and sign supports shall be verified to be on-site at the time of the pre-traffic switch meeting; otherwise, the Owner will postpone the planned traffic switch at no additional cost to Owner.

20.5.2 Temporary Signing Compliance

Temporary signing that is not in compliance with the MDMUTCD or Category 1 of the MDSHA *Book of Standards* shall be corrected within 24 hours, unless the sign is a critical regulatory or warning sign, in which case the sign shall be corrected as soon as possible and no later than six hours from discovery. If the deficiency is caused by an accident, the required timeframe begins when access to the area is available.

20.5.3 Field Verification of Traffic Operations

Concessionaire shall be responsible for monitoring queues and delays during maintenance of traffic operations. If the required mobility thresholds are exceeded, Concessionaire shall modify the TCP or implement one or more work zone impact management strategies from the TMP to reduce the queues and delays below the required mobility threshold levels.

20.5.4 Traffic Control Device Inspections

Concessionaire's Traffic Manager and his designees shall perform regular inspections for all daily activities of the Project and direct corrections as necessary.

Concessionaire shall conduct inspections and ratings of temporary traffic controls using the electronic version of MDSHA's Work Zone Traffic Control Inspection / Rating Report. Temporary traffic controls shall be inspected upon installation and weekly thereafter. Owner also retains the right to perform periodic inspections and ratings.

Concessionaire shall correct temporary traffic control deficiencies based on the criticality of the deficiency, but in all cases within 48 hours for ratings of A or B, 4 hours for C, and immediately for D and F.

Temporary traffic control ratings of D or F shall be subject to Temporary Traffic Control Liquidated Damages until a rating of B is achieved.

20.5.5 Other Requirements

Concessionaire shall contact and notify the AHJ 30 minutes prior to initiating any lane closure and after removing the lane closure.

When closing or opening a lane on freeways, expressways, and roadways with posted speed equal to or greater than 55 MPH, a work vehicle shall be closely followed by a protection vehicle during installation and removal of temporary traffic control devices. The protection vehicle shall consist of a work vehicle with approved flashing lights, a truck mounted attenuator with support structure designed for attaching the system to the work vehicle, and arrow panel (arrow mode for multilane roadways and caution mode on two-lane, two-way roadways). The work vehicle size and method of attachment shall be as specified in the truck mounted attenuator manufacturer's specification as tested under NCHRP Test Level 3.

When a temporary lane or shoulder closure is in effect, work shall begin within one hour after the lane is closed. Any delay greater than one hour with no work in progress shall require Concessionaire to remove the lane closure at no additional cost to the Owner. Concessionaire's Traffic Manager shall attend Concessionaire's pre-construction and pre-paving meetings and shall discuss the TCP and any procedures to be implemented for closing lanes or shoulders.

Workers and equipment, including temporary traffic control devices needed for setting up a lane closure or restriction, are prohibited in the lane or shoulder to be closed or restricted before the time permitted in the MOT restrictions, unless otherwise directed by the Owner.

Temporary traffic control devices to be used for lane or shoulder closures may be placed on the shoulder of the roadway by workers no earlier than 30 minutes prior to the actual time the lane/shoulder closure or restriction is permitted. When temporary traffic control devices are being installed, all work vehicles involved in the installation shall display flashing lights that provide 360-degree visibility of the vehicles. These lights shall remain on until the full installation of temporary traffic control devices is complete. Temporary traffic signs may be displayed to traffic at this time.

Workers shall not enter a lane open to traffic. Workers may be present on shoulders to prepare the lane closure set up no earlier than 30 minutes prior to actual time the lane/shoulder closure or restriction is permitted. During preparation for the lane closure, all work vehicles present at the site and involved in the installation of the lane closure or restriction shall display flashing lights that provide 360-degree visibility of the vehicles. These lights shall remain on until the full implementation of the road closure or restriction is complete.

All temporary lane or shoulder closures shall be restored at the end of the closure period. Prior to opening the closed lane or shoulder, Concessionaire shall clear the lane or shoulder of all material, equipment, and debris.

20.5.6 Lane and Shoulder Closure Request

Concessionaire shall obtain necessary lane and shoulder closure permits from the AHJ. Concessionaire shall submit a Lane Closure Request Form for Review and Comment. The appropriate type of closure and required advance notice is as follows in Exhibit 20.2.

Exhibit 20.2 – Advance Notification for Closures by Type		
Type of Closure	**Minimum Advance Notice (Calendar Days)**	**Maximum Advance Notice (Calendar Days)**
1	30 Days	45 Days
2	10 Days	21 Days
3	5 Days	14 Days
4	3 Days	14 Days

Type 1 – Planned closures of an arterial or local street, traffic switches, new ramp openings, or changed traffic patterns.
Type 2 – closure(s) that would have significant impact on traffic, such as temporarily stopping traffic completely (traffic drags); closing 2 or more lanes; closing an exit or entrance ramp at freeway interchanges; or, flagging operations.
Type 3 – closure(s) that would have minor or no impact on the flow of traffic, such as closing one lane on a three-lane freeway during off-peak hours.
Type 4 – closure(s) that would close a shoulder (right or left) on a freeway or ramp.

For Type 1 closures, Concessionaire shall make provisions in the TCP for local traffic to access properties and businesses at all times on the closed arterial or local street.

Type 1 and 2 closures will require extensive media and stakeholder notification effort and coordination among various local and State agencies. Concessionaire shall assist with all notification and coordination efforts.

All advanced notification time periods exclude weekend and holidays.

Temporary lane shifts to an opposing direction of travel lanes may be necessary in order to maintain the minimum number of lanes to satisfy the AHJ permit and obtain the necessary travel lanes and shoulders in each direction required.

20.6 MOT Restrictions

Except in cases of Long Term Closures or with the approval of the AHJ, lane or shoulder closures are not permitted on the days indicated below, or on the work day preceding and following these days:

- New Year’s Day, January 1;
- Presidential Inauguration Day;
- Good Friday;
- Easter weekend;
- Memorial Day, the last Monday in May;

- Independence Day, July 4;
- Labor Day, the first Monday in September;
- Thanksgiving Day, the fourth Thursday in November; and
- Christmas Day, December 25.

20.6.1 Closures

Nothing in this section shall restrict the Concessionaire from requesting from Owner and AHJ differing Short Term Lane and Shoulder Closures, Long Term Lane and Shoulder Closures, and alternate work hours. Any such request shall be subject to the approval of the AHJ.

20.6.1.1 Short Term Lane and Shoulder Closures

Short Term Lane and Shoulder closures are those temporary closures which do not extend beyond a single continuous work session, such as a work day, an overnight period or a weekend and are easily removed in the case of an emergency. Allowable Short Term Lane and Shoulder Closures are provided in Exhibit 20.3.

Shoulders directly adjacent to a closed lane shall also be closed.

Concessionaire shall restore full traffic capacity in accordance with the lane and shoulder closure restriction or liquidated damages will be assessed in accordance with Exhibit 11 of the Agreement.

20.6.1.2 Long Term Lane and Shoulder Closures

Long Term Lane and Shoulder Closures are defined as those closures extending across multiple work sessions longer than a work day, overnight period or a weekend. Long Term Lane and Shoulder Closures shall only be used when work is actively taking place or is reasonably planned to take place. Shoulders directly adjacent to a closed lane shall also be closed.

The following Long Term Lane and Shoulder Closures are allowed:

- Riverdale Road: The existing right-most eastbound lane from Kenilworth Avenue to where it currently ends approaching 61st Place may be closed.
- Riverdale Road: The eastbound shoulder from 61st Place to Eastpine Drive maybe closed.
- Veterans Parkway: The right-most eastbound through lane from Riverdale Road to west of Annapolis Road may be closed. The right-most eastbound lane from Annapolis Road to Ellin Road may be closed.
- University Boulevard (MD 193) : One lane in each direction along the portions of MD 193 that are currently comprised of three through lanes in each direction may be closed, consistent with the final post-construction configuration of MD 193;
- Kenilworth Ave (MD 201): One lane southbound may be closed.
- Colesville Road (MD 384): One lane southbound and one lane northbound may be closed.
- 16th Street (MD 390): One lane southbound may be closed.
- Baltimore-Washington Parkway (MD 295): One shoulder northbound and one shoulder southbound may be closed. Concessionaire shall construct the Project across MD 295 so as not to hinder emergency response and incident management. Concessionaire shall maintain full access to and from any existing MD 295 emergency crossovers between the

northbound and southbound roadways. Concessionaire shall construct the Project along MD 295 so that the existing left shoulder is not reduced in width and remains open at all times. Concessionaire shall provide twelve (12) foot wide thru lanes along MD 295 and all ramp movements at all times.

- Spring Street: One lane in each direction may be closed.
- Bonifant Street: Bonifant Street may be reduced to one lane, one-way at the start of construction, consistent with the final condition. One lane eastbound on Bonifant Street east of Georgia Avenue shall be maintained at all times. One lane of traffic between Dixon Avenue and Fenton Street shall be maintained at all times. Bonifant Street west of Dixon Avenue shall not be closed at the same time as Ripifant Street. Pedestrian access shall be maintained throughout the closures to vehicular traffic.
- Wayne Ave: Concessionaire shall maintain one lane of traffic in each direction on Wayne Avenue during all stages of MOT, except for temporary lane closures as specified in Exhibit 20.3. Concessionaire shall maintain access to all homes and off-street parking along Wayne Avenue during all stages of MOT unless otherwise agreed to in writing with the property owner. Concessionaire shall design MOT plans to minimize impacts to turning movements along Wayne Avenue during Construction Work..
- Arliss Street: Arliss Street may be closed as required for construction of the tunnel and transitway provided that access is maintained to the Giant Shopping Center, the Arliss Knolls Townhouse Parking Lot and the Flower Branch Apartment Parking Lot. The Walden Road intersection may be closed provided an approved detour is implemented.
- Paint Branch Parkway: Complete closure of Paint Branch Parkway is permitted Monday thru Friday, 6:30 pm to 5:30 am, and weekends from 6:30 pm on Friday to 5:30 am on Monday, provided access must be maintained to the College Park Metro station garage and the Maryland Fire and Rescue Institute (MFRI). Paint Branch Parkway may not be closed during Other Events shown in Part 2B, Section 20.6.2 of the Technical Provisions. Pedestrian movements must also be maintained along Paint Branch Parkway. A vehicular detour route shall be signed directing traffic to use River Road, MD 410 and US 1.
- Elin Road: Complete closure of Elin Road is permitted provided that access must be maintained to the Metro station bus loop and Kiss and Ride, the IRS driveway, the PEPCO substation, Hanson Oaks Drive, and Emmerson Place. Pedestrian movements must also be maintained between Hanson Oaks Drive and the Metro station; and
- Elm Street: Elm Street may be closed to through traffic directly adjacent to the Apex Building for construction of the Project, including Utility Adjustments. Continuous egress must be maintained for the Elm Street exit of the parking garage for 7316 Wisconsin Avenue. Continuous access must be maintained for the Bethesda Row Cinema and parking east of the intersection of Elm Street and Woodmont Avenue.

20.6.1.3 Long-Term Closure Median Openings and Intersections

Long Term Closure of the median openings and intersections in this section must be performed sequentially.

Long Term Closure of the median opening is permitted at:

- MD 193 at Seek Lane;
- MD 193 at Lebanon Street;

- MD 193 at 14th Avenue; and
- MD 193 at Guilford Road, except that such closure is not permitted until double left turn lanes are opened on westbound MD 193 at southbound MD 212.

Long Term Closure at the following intersections is permitted.

- Quesada Road may be closed at MD 201 to facilitate intersection Construction Work; and
- Quintana Road may be closed at MD 201 to facilitate intersection Construction Work.

20.6.2 Other Events

Lane closures are not permitted between and including New Hampshire Avenue (MD 650) and Kenilworth Avenue (MD 201) on days of University of Maryland home football games and other events as determined by the Owner and the Third Party Agreement Requirements.

Concessionaire shall schedule construction to avoid impacts to the annual Hispanic Festival. No temporary lane closures will be permitted on University Boulevard between MD 650 and US 1 during the weekend of the festival.

20.6.3 Bridge Closures

The Lyttonsville Place Bridge may not be closed while the Talbot Avenue Bridge is closed. The Talbot Avenue Bridge may be closed during its replacement. The Lyttonsville Place Bridge may be closed for up to six months, which must include the months of June, July and August, subject to extension in accordance with Exhibit 11 of the Agreement.

The Spring Street Bridge may be fully closed as follows:

- at any time between Friday at 7:00 PM and Monday at 7:00 AM; or
- for up to four months, subject to Concessionaire developing and obtaining approval from the AHJ for a plan to mitigate cut through traffic on 2nd Avenue. This closure is subject to extension in accordance with Exhibit 11 of the Agreement.

20.6.4 Other Restrictions

Concessionaire shall maintain access to at least two of three entrances/exits to the Bonifant-Dixon parking garages at all times. Concessionaire shall maintain access to the Silver Spring Transit Center at all times. Concessionaire shall maintain access to either parking lot #29 or #38 at all times during the posted operating hours for parking meters.

Eastpine Drive, 63rd Avenue and the entrance to Refreshing Springs shall remain open until the completion of the realignment of Mustang Drive and the activation of the new signal at Mustang Drive. Thereafter, two points of public points of access shall be maintained for the community at all times.

While Northwest Branch Trail may be temporarily detoured from the eastern to western side of West Park Drive, Concessionaire shall maintain full access to the trail, park and all facilities through Construction Work.

Concessionaire shall maintain access to the service road along MD 193 east of Guilford Road during all stages of MOT and Construction Work.

20.7 Access and Mobility Incentive

The incentive shall be based on compliance with the following requirements:

- Part 2A, Section 20.4.5 of the Technical Provisions;
- except as otherwise provided herein, maintain access to all businesses, residences, local streets and private driveways at all times, including all temporary approaches and crossings of and intersections with roads and streets;
- except as otherwise provided herein, maintain all existing pedestrian and bicycle access at all times. Whenever an existing pedestrian or bicycle access route in the public right of way is obstructed, an alternate route shall be provided. The alternate route shall be ADA compliant and may be either an existing facility or a new temporary or permanent facility constructed by Concessionaire.

Concessionaire shall report all failures to comply with the above State requirements, whether identified by Concessionaire or Owner, as part of the monthly progress report. Concessionaire shall rate the performance for access and mobility on a monthly basis in accordance with the following:

- Rating A. Up to 5 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating B. 6 to 10 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating C. 11 to 15 failures in a calendar month. All failures resolved within two hours of discovery
- Rating D. 16 to 20 failures in a calendar month. All failures resolved within two hours of discovery; and
- Rating F. 21 or more failures in a calendar month or any instance(s) of not correcting a failure within two hours of discovery in a calendar month.

Ratings shall only be made after commencement of construction.

20.8 Summary of Submittals

Item	Section	Submittal	Action
1	20.3	Transportation Management Plan	Review and Comment
2	20.3.3	Traffic Control Plans - Intermediate	Review and Comment
3	20.3.3	Traffic Control Plans - Final	Review and Comment
4	20.3.5	MDSHA Work Zone Accident / Incident Report	Information
5	20.4.5	Construction Access and Mobility Plan	Review and Comment

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
I. US 1 – Baltimore Avenue (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 8:00 PM
	1/0	Fri. - Sun	8:00 PM Fri. - 8:00 PM Sun.
	1/0	Sun. - Thurs	8:00 PM - 7:00 AM Next Day
Southbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 8:00 PM
	1/0	Fri. - Sun	8:00 PM Fri. - 8:00 PM Sun.
	1/0	Sun. - Thurs	8:00 PM - 7:00 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
II. US 29 – Georgia Avenue(Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 3:00 PM
	0/0	Mon. - Fri.	3:00 PM - 8:00 PM
	2/0	Mon. - Sun.	12:00 AM - 05:00 AM
	1/0	Fri. - Sun	8:00 PM Fri. - 8:00 PM Sun.
	1/0	Sun. - Thurs	8:00 PM - 7:00 AM Next Day
Southbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 8:00 PM
	2/0	Mon. - Sun.	12:00 AM - 05:00 AM
	1/0	Fri. - Sun	8:00 PM Fri. - 8:00 PM Sun.
	1/0	Sun. - Thurs	8:00 PM - 7:00 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
III. US 50 – Ramps to / from MD 410 East West Hwy / Veterans Pkwy (Expressway)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Ramps Only	0/0	Sun. – Sat.	None

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
IV. MD 185 – Connecticut Avenue (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. - Fri.	7:00 AM -8:00 AM
	1/0	Mon. - Fri.	8:00 AM - 3:00 PM
	0/0	Mon. - Fri.	3:00 PM - 7:00 PM
	2/0	Mon. – Sun.	12:00 AM - 05:00 AM
	1/0	Fri. - Sun	7:00 PM Fri. - 700 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
Southbound	0/0	Mon. - Fri.	6:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 3:00 PM
	0/0	Mon. - Fri.	3:00 PM - 7:00 PM
	2/0	Mon. - Sun.	12:00 AM - 05:00 AM
	1/0	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 6:00 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
V. MD 193 – University Blvd (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	6:30 AM -8:30 AM
	1/0	Mon. - Fri.	8:30 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	2/0 (*)	Mon. - Sun.	11:30 PM - 05:30 AM Next Day
	1/0	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 6:30 AM Next Day
	- Closures as noted above are in addition to the permanent closure of one lane in each direction per Part 2B, Section 20.6.1.2 of the Technical Provisions. - (*) Lane closure requires flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
VI. MD 195 – Carroll Avenue (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	6:30 AM -8:30 AM
	1/0(*)	Mon. - Fri.	8:30 AM - 4:00 PM
	0/1	Mon. - Fri.	8:30 AM - 4:00 PM
	0/0	Mon. - Fri.	3:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	0/1	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 6:30 AM Next Day
	0/1	Sun. - Thurs	7:00 PM - 6:30 AM Next Day
	- (*) Lane closure requires flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
VII. MD 201 – Kenilworth Avenue (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 4:00 PM
	0/1	Mon. – Fri.	9:00 AM – 4:00 PM
	0/0	Mon. – Fri.	4:00 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	0/1	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	0/1	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
Southbound	1/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 4:00 PM
	0/0	Mon. – Fri.	4:00 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	- Closures as noted above are in addition to the permanent closure of one southbound lane in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions.		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
VIII. MD 212 – Riggs Road (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. – Fri.	6:30 AM -8:30 AM
	1/0(*)	Mon. – Fri.	8:30 AM - 4:00 PM
	0/0	Mon. – Fri.	4:00 PM - 7:00 PM
	2/0(*)	Mon. – Fri.	11:30 PM - 05:30 AM Next Day
	1/0(*)	Fri. – Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. – Thurs	7:00 PM - 6:30 AM Next Day
	- (*) Lane closure requires flagging operation north of MD 193		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
IX. MD 320 – Piney Branch Road (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 4:00 PM
	0/0	Mon. – Fri.	4:00 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
Southbound	0/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 4:00 PM
	0/0	Mon. – Fri.	4:00 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
X. MD 384 – Colesville Road (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 3:00 PM
	0/0	Mon. – Fri.	3:00 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	- Closure noted above is in addition to single long-term lane closure Part 2B, Section 20.6.1.2 of the Technical Provisions..		
Southbound	0/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 3:00 PM
	1/0	Mon. – Fri.	3:00 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	- Closure noted above is in addition to single long-term lane closure in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions.		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
XI. MD 390 – 16th Street (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	0/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 3:30 PM
	0/0	Mon. – Fri.	3:30 PM – 7:00 PM
	2/0	Mon. – Fri.	12:00 AM – 05:00 AM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
Southbound	0/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 3:30 PM
	0/0	Mon. – Fri.	3:30 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	- Closure noted above is in addition to single long-term lane closure in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions.		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
XII. MD 410 East – West Hwy / Riverdale Road (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Eastbound	1/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 3:30 PM
	0/0	Mon. – Fri.	3:30 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	- Closure noted above is in addition to the closure of one eastbound lane between MD 201 and 61st Place in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions.		
Westbound	0/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0	Mon. – Fri.	9:00 AM – 3:30 PM
	1/0	Mon. – Fri.	3:30 PM – 7:00 PM
	1/0	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0	Sun. – Thurs	7:00 PM – 7:00 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
XIII. MD 410 – East – West Hwy / Veterans Pkwy (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 3:30 PM
	0/1	Mon. - Fri.	9:00 AM - 3:30 PM
	0/0	Mon. - Fri.	3:30 PM - 7:00 PM
	1/0	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	0/1	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	0/1	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
Southbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 3:30 PM
	0/1	Mon. - Fri.	9:00 AM - 3:30 PM
	0/0	Mon. - Fri.	3:30 PM - 7:00 PM
	2/0(*)	Mon. – Sun.	12:00 AM – 5:00 AM
	1/0	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	0/1	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	0/1	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- Closure noted above is in addition to single long-term lane or shoulder closure. - (*) Applies only to three lane sections		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
XIV. MD 450 – Annapolis Road (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 6:00 PM
	2/0	Mon. - Fri.	12:00 AM - 05:00 AM
	1/0	Fri. - Sun	6:00 PM Fri. - 6:00 PM Sun.
	1/0	Sun. - Thurs	6:00 PM - 7:00 AM Next Day
Southbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 6:00 PM
	2/0	Mon. - Fri.	12:00 AM - 05:00 AM
	1/0	Fri. - Sun	6:00 PM Fri. - 6:00 PM Sun.
	1/0	Sun. - Thurs	6:00 PM - 7:00 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
State Highway Administration			
XV. MD 650 – New Hampshire Avenue (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	1/0	Mon. - Fri.	6:30 AM -8:30 AM
	1/0	Mon. - Fri.	8:30 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	2/0 (*)	Mon. - Sun.	11:30 PM - 05:30 AM Next Day
	1/0	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 6:30 AM Next Day
Southbound	0/0	Mon. - Fri.	6:30 AM -8:30 AM
	1/0	Mon. - Fri.	8:30 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	2/0 (*)	Mon. - Sun.	11:30 PM - 05:30 AM Next Day
	1/0	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0	Sun. - Thurs	7:00 PM - 6:30 AM Next Day

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
National Park Service			
XVI. MD 295 – Baltimore Washington Parkway (Freeway)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Sun.	5:00 AM -11:00 PM
	1/1	Mon - Sun.	11:00 PM – 5:00 AM Next Day
	- Closure noted above is in addition to single long-term shoulder closure in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions..		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XVII. Jones Mill Road (Arterial), Jones Bridge Road (Arterial) & Sligo Creek Parkway (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- (*) Lane closure require flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XVIII. Brookville Road (Arterial) & Lyttonsville Place (Other)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 3:00 PM
	0/0	Mon. - Fri.	3:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- (*) Lane closure require flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XIX. Stewart Avenue (Other)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	1/0(*)	Mon. – Sun.	24 hrs/day
	- (*) Lane closure require flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XX. Spring Street (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Northbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 3:00 PM
	0/1	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	0/1	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	0/1	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- (*) Lane closure require flagging operation		
Southbound	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	8:00 PM Fri. - 8:00 PM Sun.
	1/0(*)	Sun. - Thurs	8:00 PM - 7:00 AM Next Day
	- Closure noted above is in addition to single long-term lane closure in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions. - (*) Lane closure require flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XXI. Wayne Avenue(Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 3:30 PM
	0/0	Mon. - Fri.	3:30 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- Closure noted above is in addition to single long-term lane closure between Fenton Street and Sligo Creek Parkway in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions. - (*) Lane closures require flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XXII. Fenton Street (Arterial), Cedar Street (Arterial) & Dale Drive (Arterial)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 3:30 PM
	0/0	Mon. - Fri.	3:30 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- (*) Lane closures require flagging operation		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XXIII. Arliss Street (Other)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 3:00 PM
	0/0	Mon. - Fri.	3:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- (*) Lane closures require flagging operation - Closures noted above are in addition to closing Arliss Street for tunnel construction in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions.		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Montgomery County			
XXIV. Other Roadways			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Varies	0/0	Mon. - Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. - Fri.	9:00 AM - 4:00 PM
	0/0	Mon. - Fri.	4:00 PM - 7:00 PM
	1/0(*)	Fri. - Sun	7:00 PM Fri. - 7:00 PM Sun.
	1/0(*)	Sun. - Thurs	7:00 PM - 7:00 AM Next Day
	- (*) Lane closures require flagging operation		
Listing of Other Roadways	Barron Street	Bayfield Street	Bradford Road
	Dixon Avenue	Cloverfield Road	Dartmouth Avenue
	Garland Avenue	Flower Avenue	Forston Street
	Manchester Road	Gilbert Street	Greenbrier Drive
	Navahoe Drive	Mansfield Road	Merrimac Drive
	Plymouth Street	Newdale Road	Pershing Drive
	Springvale Street	Reading Road	Seek Lane
	Michigan Ave (**)	Walden Road	Ramsey Avenue
	4th Avenue(***)	Talbot Ave (**)	Lanier Drive (**)
		Greenwood Rd	
	- (**) Lane Closures shown are exclusive of periods of Talbot Avenue Bridge Closure in accordance with Part 2B, 20.6.3 of the Technical Provisions. - (***)Lane Closures shown are exclusive of periods of single lane, single direction in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions.		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Prince George County			
XXV. Paint Branch Pkwy (Arterial) & Ellin Road (Other)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. – Fri.	6:00 AM -9:00 AM
	1/0(*)	Mon. – Fri.	9:00 AM – 3:00 PM
	0/0	Mon. – Fri.	3:00 PM – 7:00 PM
	1/0(*)	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0(*)	Sun. – Thurs	7:00 PM – 6:00 AM Next Day
	- Closures shown are in addition to long-term closure in accordance with Part 2B, Section 20.6.1.2 of the Technical Provisions. - (*) Lane closures require flagging operation if during long-term closure of two lanes of traffic.		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

<table>
<tr><th colspan="4">Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule</th></tr>
<tr><th colspan="4">Prince George County</th></tr>
<tr><th colspan="4">XXVI. River Road – (Arterial)</th></tr>
<tr><th>Direction</th><th># Lane(s)/Shoulder Can Be Closed</th><th>Day of the Week</th><th>Closure Period (Time of Day)</th></tr>
<tr><td rowspan="6">Both</td><td>0/0</td><td>Mon. – Fri.</td><td>7:00 AM -9:00 AM</td></tr>
<tr><td>1/0</td><td>Mon. – Fri.</td><td>9:00 AM – 3:00 PM</td></tr>
<tr><td>0/0</td><td>Mon. – Fri.</td><td>4:00 PM – 6:00 PM</td></tr>
<tr><td>1/0</td><td>Fri. – Sun</td><td>6:00 PM Fri. – 6:00 PM Sun.</td></tr>
<tr><td>1/0</td><td>Sun. – Thurs</td><td>6:00 PM – 7:00 AM Next Day</td></tr>
<tr><td colspan="3"></td></tr>
</table>

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

<table>
<tr><th colspan="4">Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule</th></tr>
<tr><th colspan="4">Prince George County</th></tr>
<tr><th colspan="4">XXVII. Adelphi Road (Arterial)</th></tr>
<tr><th>Direction</th><th># Lane(s)/Shoulder Can Be Closed</th><th>Day of the Week</th><th>Closure Period (Time of Day)</th></tr>
<tr><td rowspan="7">Northbound</td><td>0/0</td><td>Mon. – Fri.</td><td>7:00 AM -9:00 AM</td></tr>
<tr><td>1/0</td><td>Mon. – Fri.</td><td>9:00 AM – 3:00 PM</td></tr>
<tr><td>0/0</td><td>Mon. – Fri.</td><td>3:00 PM – 7:00 PM</td></tr>
<tr><td>2/0</td><td>Mon. – Fri.</td><td>12:00 AM – 05:00 AM</td></tr>
<tr><td>1/0</td><td>Fri. – Sun</td><td>7:00 PM Fri. – 7:00 PM Sun.</td></tr>
<tr><td>1/0</td><td>Sun. – Thurs</td><td>7:00 PM – 7:00 AM Next Day</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="6">Southbound</td><td>0/0</td><td>Mon. – Fri.</td><td>7:00 AM -9:00 AM</td></tr>
<tr><td>1/0</td><td>Mon. – Fri.</td><td>9:00 AM – 3:00 PM</td></tr>
<tr><td>0/0</td><td>Mon. – Fri.</td><td>3:00 PM – 7:00 PM</td></tr>
<tr><td>1/0</td><td>Fri. – Sun</td><td>7:00 PM Fri. – 7:00 PM Sun.</td></tr>
<tr><td>1/0</td><td>Sun. – Thurs</td><td>7:00 PM – 7:00 AM Next Day</td></tr>
<tr><td colspan="3"></td></tr>
</table>

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

Exhibit 20.3 – Temporary Lane or Shoulder Closure Schedule			
Prince George County			
XXVIII. Other Roadways (Other)			
Direction	**# Lane(s)/Shoulder Can Be Closed**	**Day of the Week**	**Closure Period (Time of Day)**
Both	0/0	Mon. – Fri.	7:00 AM -9:00 AM
	1/0(*)	Mon. – Fri.	9:00 AM – 3:00 PM
	0/0	Mon. – Fri.	3:00 PM – 7:00 PM
	1/0(*)	Fri. – Sun	7:00 PM Fri. – 7:00 PM Sun.
	1/0(*)	Sun. – Thurs	7:00 PM – 7:00 AM Next Day
	- (*) Lane closures require flagging operation		
Listing of Other Roadways	14th Avenue	15th Avenue	23rd Avenue
	24th Avenue East	24th Avenue West	25th Avenue
	61st Place	62nd Avenue	62nd Place
	66th Avenue	67th Avenue	67th Court
	Anne Street	Edwards Place	Emerson Place
	Guilford Road	Haig Drive	Hanson Oak Drive
	Lebanon Street	MFRI Entrance	Rittenhouse Street
	Patterson Street	Phelps Road	Tuckerman Street
	Rivertech Court	Temple Street	West Park Drive
	Tulane Drive	University Research Court	Campus Drive (**)
	- (**) Between Adelphi Road and Mowatt Lane		

Note: For any case, shoulder shall also be closed when the lane closure is directly adjacent to the shoulder.

21 TEMPORARY UTILITIES

This Section identifies the requirements for temporary utilities.

21.1 Functional Requirements

Concessionaire shall provide all temporary utility systems, services, connections and disconnections necessary to perform the Work, including maintenance of utility service to adjacent properties and utility service necessary for Owner staff to perform Project related functions.

Concessionaire shall submit Temporary Utility Designs for Information at least 10 days prior to performing the Work.

Concessionaire shall coordinate with all parties as necessary to provide temporary utilities, subject to the restrictions of Third Party Agreement Requirements and Owner Utility Agreements.

Concessionaire shall disconnect and remove all unnecessary temporary connections as the Work progresses.

Upon disconnection of the temporary services, Concessionaire shall restore to original condition all disturbed areas and facilities not otherwise being improved as part of the Project.

21.2 Summary of Submittals

Item	Section	Submittal	Action
1	21.1	Temporary Utility Designs	Information

22 TEMPORARY FACILITIES

This Section defines the requirements for temporary Project office facilities.

22.1 Overview

Concessionaire shall establish a Project Management Office (PMO) from which to administer the design and construction of the Project. Concessionaire shall also establish no less than one Project Construction Management Offices (PCMOs) for purposes of construction administration and inspection.

Owner will co-locate with Concessionaire at the PMO and each PCMO. Concessionaire shall provide temporary facilities for Owner at the PMO and PCMOs in accordance with the Contract Documents.

22.2 PMO and PCMO General Requirements

Concessionaire shall provide and manage fully outfitted, furnished and networked office space for Concessionaire and Owner use including at a minimum insurance, lease agreements, Utility connections, Utility service, internet service, maintenance, janitorial, security and other services necessary to provide the required temporary facilities.

Concessionaire shall provide parking facilities sufficient for the number of Concessionaire and Owner personnel assigned to the location plus visitor parking.

Concessionaire shall be responsible for loss to Owner and visitor property as a result of fire, theft, malicious acts, and other human activity or related causes at the PMO and PCMOs.

All fixtures, equipment, systems, and appurtenances furnished by Concessionaire for use by Owner shall return to Concessionaire as Concessionaire's property no more than 45 calendar days after Final Completion.

22.3 Project Management Office Requirements

Concessionaire shall provide a PMO which is class B office space within a one-half mile radius of the Project. Concessionaire space shall be determined by Concessionaire. Owner and shared space shall be according to the following schedule:

Space	Quantity	Minimum Size (SF)
Office (Owner)	10	120
Workstation Cubicle (Owner)	15	72
Conference Room (Shared)	4	384
Conference Room (Owner)	1	192
File and Storage Room (Owner)	1	500
Network Server Room (Owner)	1	
Reproduction/Mail Room (Shared)	1	
Kitchen (Shared)	1	
Washroom (Shared)	1	

Concessionaire shall provide PMO Site and Floor Plans for Review and Comment no less than 30 calendar days prior to occupancy. Concessionaire shall commence occupancy and Owner shall have ability to commence occupancy of the PMO no later than 60 calendar days after Financial Close. PMO shall be available for Owner's occupancy and use up to 45 calendar days after Final Completion.

22.4 Project Construction Management Office requirements

Concessionaire shall provide a minimum of one PCMO meeting, at a minimum, the following:

- Concessionaire space as determined by Concessionaire. Owner and Shared space according to the following schedule:

Space	Quantity	Minimum Size (SF)
Office (Owner)	6	100
Workstation Cubicle (Owner)	8	64
Conference Room (Shared)	2	250
File Room (Shared)	1	240
Storage Room (Shared)	1	100
Kitchen (Shared)	1	
Washroom (Shared)	1	

- Separate, secured, storage suitable for Owner's nuclear density gauges.

Concessionaire shall provide PCMO Site and Floor Plans for Review and Comment no less than 30 days prior to occupancy. Concessionaire shall commence occupancy and Owner shall have ability to commence occupancy of the PCMO no later than 30 calendar days before commencement of Construction Work in the geographic area that the PCMO will service. PCMO shall be available for Owner's occupancy and use up to 45 calendar days after Final Completion.

22.5 Systems and Equipment

Concessionaire shall provide Owner continuous access and maintain, at a minimum, the following systems and equipment at the PMO and each PCMO location:

- High-speed internet connection with minimum 45 Mbps download/10Mbps upload with static IP address;
- Network connected color printer/scanner/copier/fax, minimum 600 dpi and 60 pages per minute, staple, duplex and paper handling up to 11"x17";
- Telephone system for each office, desk, cubicle and conference room including remotely accessible voicemail; and
- computer network wiring for each office, desk and conference room to support Owner-provided file server (for Owner's dedicated use) and all other networked devices.

22.6 Summary of Submittals

Item	Section	Submittal	Action
1	22.3	PMO Site and floor plans	Review and Comment
2	22.4	PCMO Site and floor plans	Review and Comment

23 SURVEY AND LAYOUT

This Section includes requirements for land survey units, datum, controls, and monumentation.

23.1 Overview

The Owner will provide Project control, surveys and mapping as Reference Documents. Concessionaire shall determine the suitability of the Reference Documents for use on the Project and shall provide any revisions, corrections, or additional land survey or mapping that is required to perform the work required by the Contract Documents.

The preliminary engineering drawings provided as Reference Documents are based on a high level aerial survey that was conducted in 2007. As horizontal and vertical control were being established and field verification surveys being conducted, it was observed that the high level aerial survey was not prepared at a sufficient accuracy to support Final Design. Therefore, a low level, high accuracy aerial survey was conducted in February 2013. The cross sections provided as Reference Documents in the “2013 Survey Comparison” package depict the results from both surveys. Existing topography for the high level survey is shown in black and existing topography for the low level, high accuracy survey in red. Concessionaire shall perform all land surveying and mapping under the direction of a Maryland Registered Professional Land Surveyor or Property Line Surveyor.

Concessionaire shall be responsible for preparing and securing all applications, permits, access rights, permissions, approvals or otherwise necessary for property access prior to carrying out survey work. Concessionaire shall provide copies of Property Access Permission for Information before performing the survey work.

Concessionaire shall protect carefully from disturbances or damages all land monuments and property marks until Concessionaire has recorded their location. Concessionaire shall replace such monuments and marks upon completion of construction.

23.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- Annotated Code of Maryland (COMAR) Title 09 Department of Labor, Licensing and Regulation, Subtitle 13, Board for Professional Land Surveyors, Chapter 06, Minimum Standards of Practice;
- Federal Geodetic Control Committee, Geometric Geodetic Accuracy Standards and Specifications for Using GPS and Relative Positioning Techniques, August 1989;
- Federal Geodetic Control Committee, Standards and Specifications for Geodetic Control Networks, August 1, 1984;
- Federal Geographic Data Committee – Federal Geodetic Control Subcommittee, *Geospatial Positioning Accuracy Standards, Part 1: Reporting Methodology*, document FGDC-STD-007.1-1998;
- Federal Geographic Data Committee – Federal Geodetic Control Subcommittee, *Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic Networks*, document FGDC-STD-007.2-1998;
- Federal Geographic Data Committee – Federal Geodetic Control Subcommittee, *Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy*, document FGDC-STD-007.3-1998;

- Federal Geodetic Control Subcommittee, Specifications and Procedures to Incorporate Electronic Digital / Bar-Code Leveling Systems, FGCSVERT (ver. 4.1 5/27/2004)
- National Geodetic Survey (NGS), User Guidelines for Single Base Real Time GNSS Positioning, Version 2.1, August 2011;
- Maryland State Highway Administration (MDSHA), Division of Plats & Surveys, *Survey Field Procedures Manual*, Revised and Edited November 2001; and
- MDSHA Integrated Design System CAD Standards Committee, *Microstation V8 Computer Aided Design (CAD) Standards Manual*, July 2004.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

23.3 Datum and Units

Except where specified otherwise by Third Party standards, Owner Utility Agreements or Third Party Agreement Requirements Concessionaire shall perform all land survey and mapping in accordance with the following:

- Units: U.S. Survey Feet;
- Horizontal Datum: Maryland Coordinate System, North American Datum 1983/1991 adjustment (NAD 83/91); and
- Vertical Datum: North American Vertical Datum 1988 adjustment (NAVD88).

23.4 Control Requirements

23.4.1 Horizontal Accuracy Requirements

23.4.1.1 Primary Control

Concessionaire shall establish primary control by either Global Navigation Satellite System (GNSS) methods or conventional traversing methods. Concessionaire shall tie primary control to NAD 83/91 static monuments, published either by the National Geodetic Survey (NGS) or Maryland State Highway Administration (MDSHA).

Concessionaire shall survey the primary control network to an accuracy standard of 1 centimeter of positional tolerance as described in the Federal Geodetic Control Subcommittee – Federal Geographic Data Committee's *Geospatial Positioning Accuracy Standards, Parts, 1, 2, and 3*, document FGDC-STD-007.1, .2, and .3-1998.

Concessionaire shall not use real time kinematic or real time network surveys for establishment of primary control. Concessionaire shall not use the NGS's Online Positioning User System as a means for determining GNSS positions.

23.4.1.2 Secondary Control

Concessionaire shall establish secondary control to control the mapping of the Project Corridors. Secondary control shall be tied to and connect the primary control. Secondary control shall be established using GNSS or conventional traversing methods.

The secondary control shall be surveyed to an accuracy standard of 2 centimeters of positional tolerance as described in the Federal Geographic Data Committee – Federal Geodetic Control

Subcommittee's *Geospatial Positioning Accuracy Standards, Part 1: Reporting Methodology*, document FGDC-STD-007.1-1998, and *Part 2: Standards for Geodetic Networks*, document FGDC-STD-007.2-1998.

Real time kinematic surveys meeting the Class RT1 specifications as detailed in the NGS *User Guidelines for Single Base Real Time GNSS Positioning, Version 2.1* (August 2011) are acceptable for the establishment of secondary control. Real time network surveys shall not be used for the establishment of secondary control. Concessionaire shall not use the NGS's Online Positioning User System as a means for determining GNSS positions.

23.4.1.3 Supplemental Control

Concessionaire shall establish supplemental control for the purpose of gathering design-related data, and metes and bounds surveys.

The supplemental control shall be tied to either the secondary control networks or the primary control networks, or a combination of both, and shall be surveyed to an accuracy standard of 2 centimeters plus 50 parts per million of positional tolerance.

Real time kinematic surveys meeting the Class RT1 specifications as detailed in the NGS *User Guidelines for Single Base Real Time GNSS Positioning, Version 2.1* (August 2011) are acceptable for the establishment of secondary control. Real time network surveys shall not be used for the establishment of secondary control. Concessionaire shall not use the NGS's Online Positioning User System as a means for determining GNSS positions.

23.4.2 Vertical Accuracy Requirements

Concessionaire shall establish vertical control as defined by the Federal Geodetic Control Committee's report *Standards and Specifications for Geodetic Control Networks (*August 1, 1984), as supplemented by *Federal Geodetic Control Subcommittee Specifications and Procedures to Incorporate Electronic Digital/Bar-Code Leveling Systems* (FGCSVERT, ver. 4.1, May 27, 2004).

Concessionaire shall establish Primary control and secondary control networks by digital leveling with the use of an invar rod or by differential leveling using the three-wire method. Primary and secondary control shall be established to an accuracy of Second Order, Class 1.

Supplemental Control networks shall be established to an accuracy of Third Order.

GNSS survey shall not be used for the establishment of vertical control.

23.4.3 Permanent Control Monuments

Concessionaire shall place permanent control monuments in accordance with the following:

- monuments shall be brass monument discs permanently anchored in concrete;
- Concessionaire shall place a minimum of three monuments within each one-mile increment along the Project Corridor; and
- Concessionaire shall set monuments in a way so as to minimize the chances of being disturbed or destroyed during Construction Work. Disturbed or destroyed monuments shall be replaced within 7 calendar days. Each monument must be visible to the next monument before and after construction. Concessionaire shall not set monuments in roadways.

23.4.4 Control Survey Field Books and Records

Concessionaire shall obtain necessary survey books from MDSHA Plats and Surveys Division.

Concessionaire shall reference each monument to at least three permanent, physical features to remain during Construction Work. Concessionaire shall prepare detailed sketches showing the monument and reference ties, as well as the general physical location.

Concessionaire shall record all horizontal and vertical control work, including angles, distances, adjusted coordinates, levels, elevations, and references, in a field book supplied by MDSHA. Concessionaire shall catalog copies of their horizontal and vertical control adjustment files and final adjusted coordinates and elevations.

Concessionaire shall submit Control Survey Field Books and Records for Information within 14 calendar days of completion of the control establishment.

23.5 ROW and Permanent Easement Surveys

Concessionaire shall perform right of way and easement surveys and stakeout as necessary to prosecute the work.

Upon request from the Owner or property owner abutting the Project ROW, Concessionaire shall stake out the Project ROW and easements at the abutting property within 14 calendar days.

23.5.1 ROW and Permanent Easement Monuments

Concessionaire shall place permanent monuments to define the Project ROW and permanent easement in accordance with the following:

- Concessionaire shall place brass discs stamped with “MTA ROW” permanently anchored in concrete at 2,000-foot intervals along the Project Corridor. Where the monument falls near a control station (P.C., P.T., P.R.C., P.C.C), that monument shall be placed at that station;
- Concessionaire shall place rebar and caps in between the brass disc concrete monuments in such a way that there is an approximate 1,000-foot interval between monumentation. Rebar shall be a minimum of ½ in diameter and 18” long. Cap shall be 2 ½” in diameter, made of a metal material and stamped with “MTA ROW”; and
- Concessionaire shall set monuments in a way so as to minimize the chances of being disturbed or destroyed during Construction Work. Disturbed or destroyed monuments shall be replaced within seven calendar days.

23.5.2 ROW and Permanent Easement Field Books and Records

Concessionaire shall record all ROW and permanent easement monument stakeout, including traverse used, stakeout computations with angles and distances, and references sketches, in a MDSHA supplied field book.

Concessionaire shall submit ROW and Permanent Easement Field Books and Records for Information within 30 calendar days of the monument stakeout.

23.6 Summary of Submittals

Item	Section	Submittal	Action
1	23.1	Property Access Permission	Information
2	23.4.4	Control Survey Field Books and Records	Information
3	23.5.2	ROW and Permanent Easement Field Books and Records	Information

24 CLEANING

The Section outlines the requirements to keep a clean and orderly Site free of waste material.

24.1 Codes and Standards

The Concessionaire shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- 29 CFR 1910 - Occupational Safety and Health Administration (OSHA); and
- 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA).

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

24.2 Waste Material

Concessionaire shall maintain the Site in a clean and neat condition, clear and free of waste, trash, rubbish and debris.

Waste material shall not remain on the Site or adjoining streets, and shall immediately be removed by Concessionaire. Concessionaire shall clean and keep clean all roadways, sidewalks and other public areas in which the Work is to be done. Protect such areas against unauthorized dumping of waste material by others and remove such material promptly.

Concrete mixing trucks shall not be washed on local streets, nor shall the waste material from the washing out of concrete mixing trucks and grouting operations be discharged to any sewer manhole, catch basin, sewer or street.

Rubbish (such as bottles, cans, paper, and wrappers) shall be placed into rodent-proof, tightly covered, plastic-lined trashcans located in each work area.

All work areas shall be protected against unauthorized dumping of waste material by others.

Refuse or debris that spills or blows from a container shall be immediately cleaned up.

Concessionaire shall prevent waste from entering into storm or sanitary sewers.

24.3 Not Used

24.4 Public Roadway Cleaning

Concessionaire shall prevent dirt and debris transfer from the leaving the Site and from spilling onto public roadways, sidewalk, paths, and trails within the Site. Dirt and debris transferred to paved surfaces shall be cleaned up immediately.

All public roadways and walkways adjacent to the Work of the Project, including those within the Site, shall be cleaned daily. Dry sweeping is prohibited.

24.5 Cleaning Incentive

Concessionaire shall report all failures to comply with Part 2A, Section 24.2 and 24.4 of the Technical Provisions, whether identified by Concessionaire or Owner, as part of the monthly progress report. Concessionaire shall rate the performance for cleaning on a monthly basis in accordance with the following:

- Rating A. Up to 5 failures in a calendar month. All failures resolved within two hours of discovery;

- Rating B. 6 to 10 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating C. 11 to 15 failures in a calendar month. All failures resolved within two hours of discovery;
- Rating D. 16 to 20 failures in a calendar month. All failures resolved within two hours of discovery; and
- Rating F. 21 or more failures in a calendar month or any instance(s) of not correcting a failure within two hours of discovery in a calendar month.

Ratings shall only be made after commencement of construction.

25 TRAINING

This Section specifies the requirements relating to the training required by the Contract Documents.

25.1 Requirements

Concessionaire shall establish and maintain documented procedures for identifying training needs and provide for the training of all personnel performing activities affecting safety or quality. Personnel performing specific assigned tasks shall be qualified on the basis of appropriate education, training and/or experience, as required. Appropriate records of training shall be maintained.

Concessionaire shall establish documented procedures and records to ensure that the skills and professional judgment of their personnel are developed appropriately for their intended roles, through training and/or the recorded accumulation of experience; with systematic reviews of their competence at determined levels, and before any deployment of new roles.

Training shall focus on improving competency and skill for those performing activities that materially impact safety or quality.

All qualification and training records shall be considered quality records and shall be maintained accordingly.

Project personnel shall be trained in all the special Project procedures applicable to their work.

Craft journeymen with special skills need not be trained for activities affecting quality but their competency shall be verified and a record maintained of the verification. They shall be trained for Project safety.

Concessionaire shall provide Project specific training for Owner personnel as required for Owner personnel to perform their designated work functions. Owner will designate all Owner personnel who need to receive training no less than 14 days prior to the scheduled training, including training required for full access to the site. For any Owner personnel training required to support the activities in Part 2C, Sections 3 and 4, Owner will designate such personnel no less than 30 days prior to the scheduled start of such training.

26 RECORD DOCUMENTS

This Section describes the requirements for Record Documents, including record retention.

26.1 Overview

Concessionaire shall establish and maintain documented procedures to control and produce Release for Construction Documents and Record Documents for all documents and data that relate to the requirements of this Project including, at a minimum contracts, plans, specifications, permits, master drawing lists or equivalent documents, critical procedures and work instructions, quality system manuals, Project quality plans and data (e.g. computer data bases, computer files).

26.2 Document Control

Concessionaire shall review and approve for adequacy by authorized personnel all documents and data prior to issue. A master list or equivalent document-control procedure identifying the current revision status of documents shall be established and be readily available to preclude the use of invalid and/or obsolete documents.

Document control shall ensure that:

- pertinent issues of appropriate documents are available to Concessionaire, Owner, Utility Owners, and Third Parties ; and
- invalid and/or obsolete documents are promptly removed from all points of issue or use, or otherwise assured against unintended use.

26.3 Document and Data Changes

Concessionaire shall identify the process for the initiation, review, and approval of all document changes prior to issuance of those changes.

Changes to documents and data shall be reviewed and approved by the same authority that performed review and approval, unless specifically designated otherwise. If this is not possible, then the designated authority shall have adequate background and experience upon which to base the decision. The designated authority shall have access to pertinent background information upon which to base their review and approval.

26.4 Record Documents

Record Documents shall reflect the actual conditions and location of Work as constructed and installed, including drawings, specifications, and related documentation such as reports.

Drawings that are part of the Record Documents shall be produced in the same manner, scale and size as the original drawings. Concessionaire shall electronically modify all drawings to record actual construction where it varies from the Release from Construction drawings and Shop Drawings.

Record Documents shall be produced in format that is acceptable to the AHJ.

26.5 Record Document Requirements for Revenue Service

Concessionaire shall submit Design and Construction Record Documents for Information prior to entering Revenue Service.

26.6 Summary of Submittals

Item	Section	Submittal	Action
1	26.5	Record Documents	Information

27 RIGHT OF WAY

This Section describes the process for Concessionaire to manage and maintain the Right of Way and to request revisions to the Project ROW.

Right of Way information shown on the plats and/or deeds shall supersede any similar information shown on the Right of Way Drawings/Right of Way Plans included in Book 4 Contract Drawings.

27.1 Right of Way Management, Maintenance and Demolition

Concessionaire shall manage and maintain all property, whether occupied or not, within the Project ROW upon acquisition of the property by Owner. Concessionaire shall protect the property from vandalism, theft and unauthorized use. Concessionaire shall be responsible for demolition and disposal of existing structures including at a minimum pre-demolition hazardous materials inspections, removal and disposal of foundations, footings, slabs, buildings, above and below grade utilities, and utility structures. Utility connections shall be abandoned at the property boundary and in accordance with the applicable Utility company standard.

Concessionaire shall remove underground storage tanks from the following properties:

- 8550 Piney Branch Road (MTA Item No. 1495) – 3 tanks
- 6111 Kenilworth Avenue (MTA Item No. 1911) – 3 tanks
- 6631 Riverdale Road (MTA Item No. 1878) – 4 tanks

Removal shall be in accordance with Law and the Contract Documents including at a minimum the MDE Oil Control Program.

27.1.1 Falkland Apartments

Concessionaire shall coordinate with the Falkland Apartments owner and demolish the 6 end apartment units in each complex as shown in the Book 4 Contract Drawings. Work shall include new end walls, including at a minimum stud walls, façade, insulation, utility services and finishes. Concessionaire shall salvage, clean and reuse the existing brick façade for the new end walls. Demolition shall also include coordination and relocation of all utilities including at a minimum hot, cold and returning cold water lines, and capping of an existing abandoned steam pipe.

27.1.2 Apex and Air Rights Buildings

Concessionaire shall survey all mechanical, electrical, plumbing and fire protection systems, including HVAC intake and exhaust, which are within or adjacent to the Project ROW and identify impacts to the systems regarding accessibility, air quality, code compliance or functionality caused by the Project. Concessionaire shall coordinate with the building owners and make code compliant modifications to the building systems to eliminate the impacts.

27.1.3 Creative Development Corp. (Kenwood House)

Concessionaire shall not, at any time, reduce the number of parking spaces at Kenwood House.

27.2 Request for Additional Properties or Other Temporary Interests

In accordance with Section 7.5 of the Agreement, if Concessionaire wishes Owner to obtain Additional Properties or other interests in real property for the Project, Concessionaire shall submit a Request for Additional Properties for Review and Approval including, at a minimum, the following elements:

- Concessionaire's justification for acquisition;
- proposed use for the property;

- new or revised surveys, legal descriptions, Project ROW maps, and proposed Project ROW plat revisions; and
- estimated property cost of each acquisition.

Owner is not obligated to approve any such request. If Owner agrees to undertake the acquisition Owner will be responsible for:

- providing an estimated property acquisition schedule;
- acquisition, negotiations and relocation activities; and
- advising the Concessionaire of any changes to the Concessionaire's estimate cost.

If Owner agrees to undertake the acquisition Concessionaire shall be responsible for:

- performing all necessary activities required to complete the acquisition of the property including environmental studies, reports, permitting and public involvement activities;
- coordinating and resolving of any and all impacts with Utility Owners, Third Parties or other stakeholders;
- reimbursing Owner's costs in accordance with Section 7.5.2 of the Agreement; and
- all delays associated with the acquisition in accordance with Section 7.5.2 of the Agreement.

27.3 Replacement of Private Property Features

Concessionaire shall replace in kind existing sidewalks, fences, handrails, and structural retaining walls (where a nominal slope 2:1 or flatter will not adequately support finished grade) on private property when such features are displaced by construction.

27.4 Summary of Submittals

Item	Section	Submittal	Action
1	27.2	Request for Additional Properties	Review and Approval

This page not used.

PART 2B, DESIGN BUILD TECHNICAL REQUIREMENTS

1 CIVIL, STREETS, AND ROADWAYS

1.1 Overview

This Section identifies requirements for streets, roadways, sidewalks, trail connections, shared use paths, bikeways, intersections, embankment, parking lots, and pavement design.

1.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- AASHTO, A Policy on Geometric Design of Highways and Streets
    - MDSHA roadways shall be provided in accordance with the 2001 version
- AASHTO, Roadside Design Guide
- AASHTO, Guide for the Development of Bicycle Facilities
- AASHTO, Guide for the Planning, Design, and Operation of Pedestrian Facilities
- AASHTO, Guide for Park-and-Ride Facilities
- AASHTO, Guide for Design of Pavement Structures
- MDSHA, Book of Standards for Highway and Incidental Structures
- MDSHA, Standard Specifications for Construction and Materials
- MDSHA, Supplemental Specifications and Provisions
- MDSHA, Bicycle Policy and Design Guidelines
- MDSHA, Accessibility Policy & Guidelines for Pedestrian Facilities along State Highways
- MDSHA, Guidelines for Traffic Barrier Placement and End Treatment Design
- MDSHA, Maryland Manual on Uniform Traffic Control Devices (MDMUTCD)
- MDSHA, Pavement Design Guide
- MDSHA, TC 3.10 Pavement Performance Specification
- MDSHA, Standard Specifications for Subsurface Explorations
- ADA, ADA Standards for Accessible Design
- FHWA, Manual on Uniform Traffic Control Devices (MUTCD)
- FHWA, Geotechnical Engineering Circular No. 5 – Evaluation of Soil and Rock Properties
- FHWA, Geotechnical Engineering Circular No. 6 – Shallow Foundations
- FHWA, Geotechnical Instrumentation
- FHWA, Ground Improvement Technical Summaries Volumes I and II
- MCDOT, Design Standards
- MCDOT, Road Code
- PGDPW&T, Specifications and Standards for Roadways and Bridges
- Prince George's County, "The County Code"

- WMATA, Station Site and Access Planning Manual
- MDE, Maryland Standards and Specifications for Soil Erosion and Sediment Control
- NCHRP Report 529
- MDE Maryland Stormwater Design Manual
- NCHRP Web Document 65 (Project 24-11)

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

1.3 Functional Requirements

Concessionaire shall provide all street and roadway elements in accordance with, at a minimum, the following functional requirements:

- integrate the proposed LRT elements into the existing roadway network;
- meet or exceed the lane configuration shown on the 2020 Build and 2040 Build Wiring Diagrams;
- maintain access to private properties; and
- provide pedestrian and bicycle facilities.

All elements that will not be maintained by Concessionaire shall be provided in accordance with the requirements of the Authority Having Jurisdiction (AHJ).

To the extent that the following jurisdictions do not have published standards and requirements, facilities constructed for these jurisdictions shall use the following requirements:

- Town of Riverdale — Use Prince George's County requirements for facilities owned by the Town of Riverdale Park; and
- University of Maryland — Use MDSHA requirements.

1.4 Design Requirements

1.4.1 Roadway Geometry

Roadway alignments shall be designed for the AASHTO functional classifications and design speeds specified in Exhibit 1.1 – Roadway Design Data. For roadway functional classifications and design speeds not specified in Exhibit 1.1, Concessionaire shall determine the required functional classification, posted speed and design speed and submit Proposed Roadway Design Data for Review and Approval prior to commencing Design Work.

Concessionaire shall design the alignment of streets, roadways and trails in accordance with all requirements of the Contract Documents and to be within the following ranges of the alignments shown in the Book 4 Contract Drawings:

- horizontal alignments: range of five feet left and right of the horizontal alignment shown on the Book 4 Contract Drawings.

Roadway vertical alignments on existing cross streets and side streets shall meet current requirements of the AHJ or at a minimum match the existing vertical alignment of the roadway. Roadway vertical alignments for the mainline roadways shall meet requirements of the AHJ.

Roadway vertical alignments for MDSHA roadways shall have a minimum of 0.5% percent roadway grade except within vertical curves. The presence of roadway lighting shall not reduce the requirements for vertical sight distance on sag curves along MDSHA roadways.

Design speeds for vertical alignments on roadway legs approaching stop sign controlled intersections may be reduced by a maximum of 20 mph from the roadway design speed at the intersection.

Concessionaire shall provide clear zones and horizontal clearances to obstructions in accordance with AASHTO or AHJ requirements, whichever is more restrictive. Bridge abutments or associated non-traversable slopes or piers, excluding median piers, shall be located outside the clear zone. Where Project ROW is not sufficient to allow use of clear zones, protection shall be in accordance with AASHTO or AHJ requirements, whichever is stricter. Concessionaire shall provide vertical clearances in accordance with the requirements of AASHTO or the AHJ for the facility being crossed, whichever is more restrictive.

Exhibit 1.1 – Roadway Design Data

Road Name	Functional Classification	Design Speed	LIMITS OF ROADWAYS		EB/ NB	WB / SB
		MPH	Begin	End	Min. Lanes	Min. Lanes
Newdale Road	Residential	25	End of Newdale Rd	Connecticut Avenue	1	1
Jones Mill Road	Primary Residential	30	West Coquelin Terrace	Susanna Lane	1	1
Lyttonsville Place	Minor Arterial	30	Lyttonsville Road	Brookville Road	1	1
Stewart Avenue	Industrial	25	Brookville Road	End of Stewart Avenue	1	1
Talbot Avenue	Secondary Residential	25	Michigan Avenue	4th Avenue	1	1
4th Avenue	Residential	25	Hanover Street	Grace Church Road	1	1
Spring Street	Arterial	30	16th Street	2nd Avenue	1	1
Bonifant St	Business District	30	Ramsey Avenue	Georgia Avenue	-	1
Bonifant St	Business District	30	Georgia Avenue	Fenton Street	2	-
Wayne Avenue	Arterial	30	Fenton Street	Sligo Creek Parkway	2	2
Wayne Avenue	Arterial	30	Sligo Creek Parkway	Plymouth Tunnel	1	2
Wayne Avenue	Primary Residential	30	Plymouth Tunnel	North of Manchester Place	1	1
Arliss Street	Business District	30	Flower Avenue	MD 320 (Piney Branch Rd)	1	1

Road Name	Functional Classification	Design Speed MPH	LIMITS OF ROADWAYS Begin	End	EB/ NB Min. Lanes	WB / SB Min. Lanes
MD 320 (Piney Branch Road)	Urban Minor Arterial	35	Arliss Street	MD 193 (University Blvd)	2	2
MD 193 (University Boulevard)	Urban Other Principal Arterial (OPA)	40	MD 320 (Piney Branch Road)	West Park Drive	2	2
MD 193 (University Boulevard)	Urban OPA	50	West Park Drive	Adelphi Road	2	2
Campus Drive	N/A	30	MD 193 (University Blvd)	East of Presidential Drive	2	2
Presidential Drive	N/A	30	Campus Drive	Valley Lane	1/2	1/2
Union Drive	N/A	30	Valley Lane	Union Lane	1	1
Union Lane	N/A	30	Campus Drive	Limits of Work	1	1
Campus Drive	N/A	30	Union/Library Lane	Regents Drive	1	2
Regents Drive - South	N/A	30	Campus Drive	Limits of Work	1	1
Regents Drive - North	N/A	30	Campus Drive	Limits of Work	1	1
Campus Drive	N/A	30	Regents Drive	Limits of Work	1/2	1
Rossborough Lane	N/A	25	BL Construction Armory	US 1	2	1
Rossborough Lane	N/A	30	US 1	Paint Branch Parkway	1	1
Paint Branch Parkway	Urban 4-Lane Collector	40	Limits of Work	Rossborough Lane	2	2
Paint Branch Parkway	Urban 4-Lane Collector	40	Rossborough Lane	College Park Metro/Limits	2	2
River Road	Urban 4-Lane Collector	40	American Center for Physics Entrance	Kenilworth Avenue	2	2
MD 201 (Kenilworth Avenue)	Urban OPA	45	Limits of Work	MD 410 (East West Hwy)	2	2
MD 201 (Kenilworth Avenue)	Urban OPA	45	MD 410 (East West Hwy)	Limits of Work	2	2
Quesada Road Connector	Urban Secondary Residential	20	MD 201 (Kenilworth Avenue)	Quesada Road	1	1

Road Name	Functional Classification	Design Speed	LIMITS OF ROADWAYS		EB/ NB	WB / SB
		MPH	Begin	End	Min. Lanes	Min. Lanes
Quesada Road	Urban Secondary Residential	30	MD 201 (Kenilworth Avenue)	Limits of Work	1	1
MD 410 (Riverdale Road)	Urban OPA	45	East of 61st Street	MD 410 (Veterans Parkway)	2	2
Mustang Drive	Urban Secondary Residential	30	MD 410 (Riverdale Road)	South of Patterson Street	1	1
MD 410 (Veterans Parkway)	Urban OPA	50	MD 410 (Riverdale Road)	Ellin Road	2	2
Ellin Road	Urban 4-Lane Collector	35	MD 410 (Veterans Parkway)	New Carrolton Metro	2	2

1.4.2 Typical Section

Travel lanes, shoulders, bicycle lanes, parking lanes and other typical section elements shall be provided in accordance with the following:

- requirements and exhibits shown of this Section;
- requirements of the AHJ; and
- as required to meet the level of service requirements.

The width of travel lanes, shoulders, bicycle lanes, and parking lanes shall meet the standards of the AHJ or, if not specified, AASHTO.

MDSHA roadways shall have a minimum lane width of 11 feet. Where adjacent to combination curb and gutter, minimum lane width shall not include the gutter pan. Where adjacent to curb, minimum lane width shall be 12 feet.

In addition to the above, shared LRT/vehicular lane widths shall be a minimum width of 12 feet.

1.4.3 Superelevation and Cross Slopes

1.4.3.1 New or Reconstructed Roadways

Vehicular travel lane normal cross slopes and superelevation shall be provided in accordance with the requirements of the AHJ.

Shared LRT/vehicular travel lanes cross slopes shall:

- meet the requirements of AHJ when feasible for the LRT system;
- meet a minimum of 0.5 percent cross slope (expect where in transition); and
- shall not exceed the maximum superelevation as required for the LRT system.

Concessionaire shall correct deficient cross slopes or superelevation on existing roadways being reconstructed to accommodate LRT.

The maximum cross slope break between travel lanes shall be 4 percent. The maximum shoulder rollover shall be 7 percent.

1.4.3.2 Resurfacing

Concessionaire may match existing cross slopes when resurfacing (or milling and resurfacing) existing roadways that are not reconstructed provided there are no existing drainage or safety issues and the cross slope is a minimum of 1.5 percent in the appropriate direction.

1.4.4 Access to Public and Private Property, Streets, and Roads

Concessionaire shall provide property access points to streets, service roads, parking lots, businesses, and driveways as it exists today except as shown in Exhibit 1.2 or as required by the Third Party Agreement Requirements. New or modified access points shall consider design vehicle turning movements appropriate for the parcel land use.

Exhibit 1.2 – Access Changes

Street/Entrance	Relocate/ Modify	Cul-de-sac	Remove Access
Campanaro Property Access Drive	X		
Silver Spring International Middle School/ Sligo Creek Elementary School	X		
Entrance to Wayne Manchester Towers	X		
Entrance to Flower Branch Apartments	X		
Plymouth Street Residential Entrance	X		
Entrance Driveway to Long Branch Community Center	X		
Giant Property “WRIT” Entrance from Arliss Street	X		
Entrance to Takoma/Langley Shopping Center From MD 193 (University Boulevard)	X		
Exxon Gas Station entrance from MD 193 (University Boulevard)	X [1]		
Forest 24 Hour Laundromat Entrance from MD 193 (University Boulevard)			X
Family Dollar Entrance from MD 193 (University Boulevard)			X
Citgo Gas Station Entrance from MD 193 (University Boulevard)	X		
Valley Dollar Entrance from 23rd Avenue	X		
Entrances to and from Graduate Hills Parking	X		
University Baptist Church Access Road from Campus Drive (EB)	X		
Parking Lot Entrances with University of Maryland	X		

Street/Entrance	Relocate/ Modify	Cul-de-sac	Remove Access
Union Drive	X		
American Center for Physics Entrance Road from River Road	X		
Quesada Road Connector	X		
Patterson Street		X	
Refreshing Springs Church of God Entrance from MD 410 (Riverdale Road)			X
Refreshing Springs Church of God Entrance from Mustang Drive	X		
Mustang Drive	X		
63rd Avenue		X	
Eastpine Drive	X		
Eastpines Entrance from MD 410 (Riverdale Road)			X
Eastpines Entrance from 67th Avenue	X		
Maryland National Capital Park Police Headquarters Entrance from MD 410 (Riverdale Road)	X		
67th Place		X	
Glenridge Center Entrance from MD 410 (Veterans Parkway)	X		

[1] Relocate entrance to Edwards Place.

1.4.5 Limits of Roadway and Street Work

Concessionaire shall identify the necessary limits of Work on roadways and streets to meet the requirements of the Project. The localized limit of Work shall conform to the following:

- widening or reconstruction of any portion of a roadway shall require that the entire roadway width be, at a minimum, resurfaced within the longitudinal limits of the widening or reconstruction;
- addition of sidewalks outside an existing roadway or curb and gutter replacement shall not require that the existing road be resurfaced;
- Concessionaire shall resurface the entire width of a roadway after any portion of the roadway has been subject to eradication of permanent or temporary pavement markings for a longitudinal distance of 10 feet beyond the last eradicated marking; and

1.4.6 Shared Use Paths and Bikeways

Concessionaire shall replace or improve existing shared use paths and other bikeways within the Project ROW in accordance with requirements of the AHJ. Trails shall be included as a type of shared use paths.

Concessionaire shall provide new shared use paths and other bikeways at the locations specified in the Exhibit 1.3 below. Concessionaire shall provide new bike facilities in accordance with the requirements of the AHJ except as noted below.

- the Capital Crescent Trail (CCT) shall be designed with a minimum paved path width of 12 feet and minimum two foot shoulders where Project ROW allows:
- all ramp access to the CCT shall meet the turning radius of a standard Montgomery County all-terrain vehicle;
- trail crossings under the LRT shall have a minimum 18 mph design speed. Horizontal curve sight distance shall meet a minimum 18 mph; and
- Concessionaire shall provide bollards in place of other barriers at the top of cut retaining walls adjacent to parking lots or loading areas.
- the Green Trail shall be designed with a paved path width of 8 feet and a buffer width of 5 feet from back of curb to edge of paved path:
- no buffer shall be provided for the ROW limits of the property at 801 Wayne Avenue. The trail shall be 9 feet in paved width at this location.
- Where sufficient Project ROW is available all legs of MDSHA roadways at intersections shall include bike accommodations within the curb returns at the intersections; and
- Concessionaire shall provide trail connections at the locations specified in Exhibit 1.4.

Exhibit 1.3 – Bike Facilities

Road Name	LIMITS OF BIKE FACILITIES		WB (LT)	EB (RT)	Bike Lane	Shared Lane	Off Road Path
	Begin	End					
Capital Crescent Trail	Elm Street Park	South of Pearl Street		X			X
Capital Crescent Trail	South of Pearl Street	North of Rock Creek	X				X
Capital Crescent Trail	North of Rock Creek	Talbot Avenue		X			X
Capital Crescent Trail	Talbot Avenue	North of Colesville Road	X				X
Jones Mill Road	W. Coquelin Terrace	Susanna Lane	X	X	X		
Spring Street	16th Street	2nd Avenue	X	X		X	
Wayne Avenue (Green Trail)	East of Fenton Street	Sligo Creek Parkway	X				X
MD 320 (Piney Branch Rd)	Greenwood Avenue	Arliss Street	X	X	X		
MD 320 (Piney Branch Rd)	Arliss Street	MD 193 (University Blvd)	X	X	X		
MD 193 (University Blvd)	MD 320 (Piney Branch Rd)	West of Adelphi Road	X	X	X		
MD 212 (Riggs Rd)	Limits of Work east of MD 193	Limits of Work west of MD 193	X	X	X		
MD 193 (University Blvd)	West of Adelphi Road	Adelphi Road	X	X	X		
Campus Drive	MD 193 (University Blvd)	Presidential Drive	X	X	X		
Presidential Drive	Campus Drive	Library Lane		X			X
Campus Drive	Library Lane	Regents Drive		X			X
Rossborough Lane	Parking Lot	US 1		X			X
MD 201 (Kenilworth Ave)	River Road	MD 410 (East West Hwy)	X	X	X		
MD 410 (Riverdale Road)	61st Place	64th Avenue	X	X	X		
MD 410 (Veterans Parkway)	MD 410 (Riverdale Rd)	Ellin Road		X	X		

Exhibit 1.4 – Trail Connections

Trail Connection Name	LIMITS OF TRAIL CONNECTIONS		Ramp Connection	Stair	Under LRT
	Begin	End			
Bethesda Sidewalk	Bethesda Platform	East of Pearl Street	X		
Elm Street Park	Elm Street Park	Capital Crescent Trail	X		
Pearl Street	Pearl Street	Capital Crescent Trail	X		
Lynn Drive	Lynn Drive	Capital Crescent Trail			X
East West Hwy	Montgomery Ave	Capital Crescent Trail	X	X	
Sleaford Road	Kentbury Drive	East West Highway		X	X
Kentbury Drive	Kentbury Drive	Capital Crescent Trail	X		
Newdale Road	Newdale Road	Capital Crescent Trail	X		
Connecticut Avenue Stair	Capital Crescent Trail	Connecticut Avenue		X	
Georgetown Branch Trail	Capital Crescent Trail	Kansas Avenue	X		
Jones Mill Road	Jones Mill Road	Capital Crescent Trail	X	X	
Rock Creek Park	Rock Creek Trail	Capital Crescent Trail	X		
Grubb Road	Grubb Road	Capital Crescent Trail	X		
Lyttonsville Place	Lyttonsville Platform	Lyttonsville Place	X	X	
Michigan Avenue	Capital Crescent Trail	Michigan Avenue	X		
Lyttonsville Road	Lyttonsville Road	Capital Crescent Trail	X		
16th Street Trail	16th Street	Capital Crescent Trail	X	X	
MD 390 (16th Street*)	16th Street Entrance to Woodside Platform	Summit Hills Apartment Homes	X	X	
Spring Street	Capital Crescent Trail	Spring Street		X	
Spring Street	Capital Crescent Trail	2nd Avenue	X		
Apple Avenue	Capital Crescent Trail	Apple Avenue	X		
Northeast Branch at River Road	Kenilworth Avenue	Under bridge over Northeast Branch	X		

*Trail connection width shall be minimum 5 feet

1.4.7 Sidewalks

Concessionaire shall provide new sidewalks at the locations specified in Exhibit 1.5 below and at locations necessary to safely and efficiently move pedestrians to and from the LRT Stations according to the Codes and Standards and requirements of the AHJ.

Buffer requirements shall be designed according to the requirements of the AHJ. MDSHA roadways shall have a minimum 3 foot buffer where feasible.

Concessionaire shall replace or improve existing sidewalks within the Project ROW in accordance with requirements of the AHJ and shall adhere to the same requirements as new sidewalks. Pedestrian refuge areas shall be designed at all marked crossings of divided roadways where a median is proposed. The minimum width of cut-through median and island openings measured between face of curb of one direction of travel to face of curb of the opposing direction of travel, shall be 6 feet. The cut-through width shall be the same as the complete width of the crosswalk.

Exhibit 1.5 – Sidewalks

Road Name	LIMITS OF SIDEWALKS		WB/SB (LT)	EB/NB (RT)
	Begin	End		
MD 410 (East West Highway)	Montgomery Avenue	Bridge over CCT & Tracks		X
Newdale Road	West End of New Dale Road	Connecticut Avenue		X
Jones Mill Road	W. Coquelin Terrace	Tones Bridge Road	X	X
Brookville Road	West of Lyttonsville Garage Entrance	East of Lyttonsville Place		X
Lyttonsville Place	Lyttonsville Road	Brookville Road	X	X
Stewart Avenue	Brookville Road	Campanaro Access Driveway	X	
Stewart Avenue	Brookville Road	Purple Line Alignment		X
4th Avenue	Hanover Street	Talbot Avenue		X
4th Avenue	Talbot Avenue	Grace Church Road	X	
MD 390 (16th Street)	8600 Luxury Rentals Parking Lot	Access Road to Woodside Platform	X	
Spring Street	14th Street	East of Tracks	X	X
Bonifant Street	Ripifant Road	Parking Garage		X
Bonifant Street	Parking Garage	Georgia Avenue		X
Bonifant Street	Ramsey Avenue	Georgia Avenue	X	
Wayne Avenue	Fenton Street	Manchester Place Station		X
Wayne Avenue	West of Sligo Creek Parkway	Manchester Place	X	
Arliss Street*	Flower Avenue	Piney Branch Road	X	X
MD 320 (Piney Branch Road)	Greenwood Avenue	East of University Boulevard	X	X

Road Name	LIMITS OF SIDEWALKS		WB/SB (LT)	EB/NB (RT)
	Begin	End		
MD 193 (University Boulevard)	North of Piney Branch Road	West of Adelphi Road	X	X
Campus Drive	University Boulevard	East of Presidential Drive	X	X
Presidential Drive	Campus Drive	Valley Lane	X	X
Union Drive	Valley Lane	Library Lane	X	X
Campus Drive	Library Lane	Regents Drive	X	X
Regents Drive	South of Campus Drive	North of Campus Drive	X	X
Campus Drive	Library Lane	Rossbourgh Lane	X	X
Rossborough Lane	Campus Drive	West of Paint Branch Parkway	X	X
Paint Branch Parkway	North of Rossborourgh Lane	South of College Avenue		X
River Road	Under Bridge over Northeast Branch	MD 201 (Kenilworth Avenue)		X
MD 201 (Kenilworth Avenue)	Tuckerman Street	South of MD 410 (East-West Hwy)	X	X
Quesada Road Connector	MD 201 (Kenilworth Avenue)	West of MD 201 (Kenilworth Avenue)	X	
Quesada Road	MD 201 (Kenilworth Avenue)	West of 54th Place	X	
Mustang Drive	MD 410 (Riverdale Road)	South of Patterson Street	X	X
MD 410 (Riverdale Road)	61st Place	Baltimore/Washington Parkway		X
MD 410 (Riverdale Road)	BW Parkway	MD 410 Veterans Parkway	X	X
67^{th} Place	67th Place cul-de-sac	Beacon Heights Platform	X	
Chesapeake Sidewalk	West of MD 410 (Veterans Parkway)	Chesapeake Landing Apartments	X	
Ellin Road	MD 410 (Veterans Parkway)	Emerson Place		X
Ellin Road	Emerson Place	New Carrolton Station	X*	X

*Sidewalk shall be 8 foot minimum

1.4.8 Sidewalk Curb Ramps

Concessionaire shall provide sidewalk curb ramps, to include cut-through (curb-cut) openings in accordance with the Codes and Standards and requirements of the AHJ and the following:

- sidewalk curb ramps within the Project ROW and/or limit of work, whichever is greater, shall be analyzed for ADA compliance and deficient sidewalk curb ramps shall be replaced;

- when any one leg of an intersection is impacted by the Project, all legs of the intersection shall be analyzed and any deficient sidewalk curb ramps replaced; and
- curb-cuts at street crossings shall be the full width of the path or sidewalk approaching.

1.4.9 Bus Stops, Shelters and Loading Zones

Concessionaire shall submit Bus Stop Relocation Plans for Review and Comment for any relocation of existing bus stops, bus bays or shelters. Bus stops, bus bays, and shelters shall be provided in accordance with the requirements of the AHJ.

1.4.10 Curbs, Medians, and Islands

Concessionaire shall provide eight inch combination curb and gutter meeting AHJ or, where not specified by the AHJ, MDSHA standards along all new, widened, or reconstructed streets or access roads to be maintained by Concessionaire except where Environmental Site Design (ESD) practices require open sections for sheet flow into the facilities.

Concessionaire shall provide 6 inch combination curb and gutter meeting AHJ or, where not specified by the AHJ, MDSHA standards where curb and gutter is adjacent to a parking lane.

Concessionaire shall provide eight inch high concrete curb or combination curb and gutter around the perimeter and around islands of all new or reconstructed parking lots to be maintained by Concessionaire.

Concessionaire shall provide curbs along other roadways, Park & Rides, Kiss & Rides, or other facilities in accordance with the appropriate AHJ Codes and Standards.

Curb and combination curb and gutter, other than those used for Station Platforms, shall not be located within the dynamic envelope of the LRV.

Concessionaire shall provide monolithic medians and channelizing or splitter islands as needed to safely and effectively move vehicles through the Corridor and intersections. Hardscape medians shall be provided when median width is less than six feet.

Asphalt curb shall not be used on this Project. Vertical curb of any type shall not be used on MDSHA roadways with a posted speed greater than 40 mph.

1.4.11 Parking

Concessionaire shall provide on street parking as required by Exhibit 1.6.

Concessionaire shall reconstruct existing parking lots impacted by the Project to match the existing total number of parking spaces except as noted in Exhibit 1.7 or as required by the Third Party Agreement Requirements.

Exhibit 1.6 – On Street Parking

Road Name	LIMITS OF ON STREET PARKING		WB/SB (LT)	EB/NB (RT)	Permanent Parking	Off-Peak Parking
	Begin	End				
Lyttonsville Place	Lyttonsville Road	Lyttonsville Place Bridge	X	X	X	
Stewart Avenue	Brookville Road	Limits of Work	X	X	X	
Spring Street	16th Street	2nd Avenue	X	X	X	
Bonifant St	Georgia Avenue	West of Fenton St.		X	X	
Bonifant St	100’ West of Fenton St.	Fenton Street	X		X	
Bonifant St	West of Fenton St.	Fenton Street	X		X	
Wayne Avenue	Cedar Street	Dale Drive	X	X		X
Wayne Avenue	Dale Drive	International Middle School (Lower Lot Entrance)		X		X
Wayne Avenue	International Middle School (Lower Lot Entrance)	East of Mansfield Road	X	X		X
Wayne Avenue	East of Mansfield Road	Sligo Creek Parkway	X			X
Wayne Avenue	Sligo Creek Parkway	South of Manchester Place Station (Apartment Entrance)	X	X		X
MD 193 (University Boulevard)	200’ West of Bayfield Street	100’ East of Bayfield Street	X		X	
MD 193 (University Boulevard)	MD 195 Carroll Ave	Lebanon Street	X		X	
MD 193 (University Boulevard)	Guilford Road	Phelps Road		X	X	
MD 193 (University Boulevard)	24th Avenue (South)	West Park Drive		X	X	
MD 193 (University Boulevard)	200’ West of Temple Street	300’ East of Tulane Drive	X		X	
MD 201 (Kenilworth Ave)	Rittenhouse Street	Patterson Street		X	X	

Exhibit 1.7 – Parking Lots

Parking Lot Description	Maximum Existing Spaces Permanently Impacted	Minimum Replacement Spaces Required
Bradford Place LLC, 8600 16th Street	19	1
Summit Building LLC, 8555 Sixteenth St	38	18
Falkland Partners LLC, 1545 North Falkland Lane	45	16
Montgomery County, 1100 Bonifant St.	25	0
Loreto, James A, 711 Wayne Ave.	1	0
Board of Education, 313 Wayne Ave., Silver Spring International Middle School	(Book 4 Contract Drawings)	
M-NCPPC, Wayne Ave., Sligo Cabin Park	(Book 4 Contract Drawings) 0	
B Franklin Kahn Et Al Trus, 8750 Arliss St.	70	0
Fleitas LLC, 8547 Piney Branch Rd.	6	0
Flower Branch Apts LLC, 8648 Piney Branch Rd.	34	24
Maryland National Capital Park &, 720 E University Blvd.	10	0
University Manor Apartments LTD Partnership, 820 E University Blvd.	7	0
Saul Subsidiary I Ltd Part, 1101 E University Blvd.	5	2
Saul Subsidiary I Ltd Part, 1167 E University Blvd.	16	10
Langley Park Plaza Inc., 8011 New Hampshire Ave.	26	0
La Union Center, LLC, 1401 University Blvd.	15	0
Neyesh Properties, 1500 University Blvd.	34	7
Insurance USA, LLC, 1600 University Blvd.	1	0
Bazar La Chiquita LLC, 1606 University Blvd.	2	0
Hechinger Plaza Limited Partnership, 1535 University Blvd.	15	0
Pep Boys-Manny, Moe & Jack, 1804 University Blvd.	14	0
Melhi, Ravinder K, 1810 University Blvd.	13	0
Upob LLC, 1511 University Blvd.	7	0
Sandelman, Sanford Trst FF Esue Trst, 2010 University Blvd.	17	0

Parking Lot Description	Maximum Existing Spaces Permanently Impacted	Minimum Replacement Spaces Required
Calla LLC, 2020 University Blvd.	11	0
Kim, Jiun U & Jin S, 2074 University Blvd.	7	0
University Blvd Ltd Partnership, 2200 University Blvd.	10	0
2204 University Boulevard LLC, 2204 University Blvd.	10	0
Kramer, Rona E Trustee, 2208 East University Blvd.	5	0
P K LLC, 2210 University Blvd.	1	0
Leon, Leroy V, 2216 University Blvd.	6	0
McDonalds Real Estate Co, 2306 University Blvd.	12	6
EBC Properties LLC, 2340 University Blvd.	7	0
Adelphi Center LLC, 2520 University Blvd.	9	0
State of Maryland (Leased), 3424 Tulane Dr., Graduate Hills Apartments	30	19
Campus Drive, Lot 3	(Per Third Party Agreement Requirements)	
Presidential Drive, Lot 1d	(Per Third Party Agreement Requirements)	
Presidential Drive, Lot 1b	(Per Third Party Agreement Requirements)	
Presidential Drive, Lot JJ3 & Lot Z	(Per Third Party Agreement Requirements)	
Campus Lot C1	(Per Third Party Agreement Requirements)	
Atlantic Kor Amer Pres Ch Inc., 6410 Kenilworth Ave.	19	0
Coopersmith MD Properties LLC, 6408 Kenilworth Ave.	1	0
Rinaldis Riverdale Bowl LLC, 6322 Kenilworth Ave.	3	0
Maine Properties Inc., 6250 Kenilworth Ave.	48	0
Papadopoulos, Eleftherios M Etal, 5416 Quesada Rd.	2	0
Trager, Maraline A., 6210 Kenilworth Ave.	20	0
McDonalds Corp, 6106 57th Ave.	6	0
Suburban Trust Co., 5710 Riverdale Rd.	8	0

Parking Lot Description	Maximum Existing Spaces Permanently Impacted	Minimum Replacement Spaces Required
Roman Catholic Arch of Wash, 5811 Riverdale Rd., St. Bernard’s	2	0
Ivory Investment LLC, 6611 Riverdale Rd.	18	18
Prince Georges County, 6700 Riverdale Rd., M-NCPPC Park Police	41	0
DGV Apartments LLC, 6739 & 6747 Riverdale Rd.	3	0
County Center Joint Venture, 7520 Annapolis Rd.	99	17
Berman, Sanford Z., Chesapeake Road	11	0

1.4.12 Roadside Barriers

Use of any type of roadside barrier shall be minimized to the extent practicable through removal of obstacles and selection of appropriate side slopes. Where clear zone requirements cannot be met, Concessionaire shall provide roadside barriers in accordance with AASHTO requirements.

Any existing roadside barriers within the Project limits shall be evaluated for removal. If the barrier cannot be removed but meets current standards it may remain in place. If the barrier does not meet current standards, it shall be upgraded or replaced by Concessionaire.

Sand filled barrels shall not be used as permanent end treatments on the Project.

1.4.13 Median Barriers

Traffic barrier w-beam shall be used where median barrier is required. If w-beam median barrier standards cannot be met, concrete median barrier shall be used.

Sand filled barrels shall not be used as permanent end treatments on the Project.

1.4.14 Other Requirements

Concessionaire shall realign the existing entrance road to the Long Branch Community Center to be directly across from Barron Street, forming the fourth leg of the intersection with MD 320 (Piney Branch Road) in accordance with M-NCPPC and in general accordance with the drawing ‘Long Branch Community Center Relocated Access’ as shown in the Preliminary Engineering Plans Update Plate contained in Book 5 Engineering Data.

Concessionaire shall reconstruct the Sligo Cabin Park parking lot to be in general conformance with the ‘Sligo Cabin Park Parking Lot Concept’ plan as shown in the PE Plans Update Plate contained in Book 5 Engineering Data.

The parking lot and associated facilities shall be reconstructed as shown in the Book 4 Contract Drawings. Demolition and removal of the existing parking lot and associated facilities and reconstruction of the parking lot and associated facilities which impact parking, ingress or egress to school facilities shall be limited to a summer work window when school and/or teachers are not in session. The summer work window shall be limited to the period between June 15th and August 15th. Specific work activities may be performed during periods outside the summer work window, such as clearing, final fine grading, landscaping, finishing work for retaining walls, installation of final hot mix asphalt surface courses provided that the specific work activities do not impact parking and ingress or egress to school facilities.

The Concessionaire shall be required to coordinate all construction activities with Montgomery County Public Schools including submission of a Project Execution Plan in accordance with Part 2A, Sections 18.3 and 19.3 of the Technical Provisions.

At College Park Metro, Concessionaire shall provide a seven bay bus loop with bus access from River Road in accordance with WMATA requirements and in general accordance with the drawing 'College Park Metro Station Alternate Civil Site Plan' provided as a Reference Document.

At new Carrollton Metro, Concessionaire shall provide the following in accordance with WMATA requirements and in general accordance with the drawings "New Carrollton Station Concept Site Layout" included in Reference Documents:

- bus loop with a minimum of eight bus bays;
- kiss and ride with a minimum capacity of 23 vehicles;
- taxi stand with a minimum capacity of 14 vehicles; and
- general parking with a minimum capacity of 231 vehicles.

MDSHA has plans to construct improvements to US Route 1 / Rossborough Lane in the vicinity of the Project. Draft final review plans for these MDSHA improvements are provided as Reference Documents. Concessionaire shall design and construct the Project to match all improvements planned by MDSHA from Sta. 7156+50 to Sta. 7159+00 US 1 (Baltimore Ave), including the number of lanes, pavement widths, curb lines, pedestrian facilities, and so forth. Elements constructed by the Concessionaire shall taper to meet existing elements outside of the limits specified above. Concessionaire shall not be responsible for constructing median islands on US Route 1.

1.4.15 Roadway Design Submittals

Concessionaire shall submit Roadway Plans for Review and Comment at Preliminary and Final Design, including, at a minimum, the following elements:

- geometry control and data sheets for roadway, shared use path, and trail connection baselines;
- roadway plan sheets – including at a minimum the following elements: bikeways, sidewalks, trails, trail connections, sidewalk curb ramps, bus loading zones, curbs, medians, islands, barriers, parking lots, and limits of roadway work;
- vertical alignment sheets for streets and roadways, shared use paths, and trail connections;
- intersection detail sheets – including at a minimum the following elements: curb ramps, curb return stakeout charts, islands, medians, sidewalk stakeout charts;
- typical section sheets including roadway and pedestrian elements;
- pavement detail sheets;
- superelevation data sheets;
- miscellaneous detail sheets to show non-standard details or additional details as required;
- cross sections at even 50 foot stations, at driveways, and at other critical locations; and

- design calculations for all proposed and temporary alignments including at a minimum:
    - horizontal sight distance;
    - vertical sight distance;
    - intersection sight distance;
    - intersection geometrics including items such as curb radii and stakeouts,.;
    - superelevation calculations;
    - clear zone calculations; and
    - guardrail length of need.

1.5 Slopes and Earth Embankments

Slopes and Embankments shall be provided in accordance with Part 2B, Section 1.5.1 of the Technical Provisions and the following:

- MDSHA owned facilities – in accordance the MDSHA Geotechnical Performance Specification for Purple Line provided in Book 5 Engineering Data;
- Third Party owned facilities – In accordance with the standards and requirements of the Third Party. In the absence of requirements issued by the Third Party, Part 2B, Section 1.5.2 of the Technical Provisions shall be used; and
- all others – In accordance with Part 2B, Section 1.5.2 of the Technical Provisions.

1.5.1 General Requirements

Concessionaire shall analyze the effect of embankment, LRT and other surcharge loads on existing and proposed Utilities, structures and other facilities. Concessionaire shall mitigate impacts through redesign to avoid impacts, protection of utilities, structure or facilities, replacement of utilities, structure or other facilities, or as required by the Contract Documents including Third Party Agreement Requirements and Utility Agreements.

Concessionaire shall perform settlement monitoring for any embankment expected to settle more than four inches.

In addition to those requirements established herein, slopes and earth embankments shall meet all MDE requirements.

1.5.2 Design Requirements

The maximum allowable cut and fill slope shall be 2(H):1(V) unless treatments such as reinforced soil slopes, soil nails or rock fill in accordance with AREMA are used to support a steeper slope.

Reinforced soil slopes shall be provided using procedures and considerations of reinforced soil slopes in accordance with FHWA-NHI-10-024 and 025, *Geotechnical Engineering Circular No. 11 – Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Volumes I and II*, and the requirements of the Contract Documents. Concessionaire shall submit calculations as part of the Geotechnical Engineering Report demonstrating that required long-term and short-term factors of safety can be achieved.

For slopes greater than or equal to 20 feet in height, slopes placed over material that classifies as A-7, A-6, A-5, A-4, or organic material and other slopes as needed. Concessionaire shall provide slope stability evaluations using limit equilibrium techniques and settlement estimates in the Geotechnical Engineering Report.

Concessionaire shall provide permanent slopes for a minimum calculated safety factor of 1.5 in the static condition and 1.2 in the dynamic (earthquake) condition if the slopes support a structure and a minimum safety factor of 1.3 in the static condition and 1.1 in the dynamic (earthquake) condition if the slopes do not support a structure. Bridge abutments and wing walls within 30 feet of abutments shall be considered to support a structure. For pond embankments and other slopes likely to be subjected to rapid draw down conditions, Concessionaire shall provide stability analyses for the rapid drawdown condition with a minimum factor of safety of 1.1 for all slopes where rapid drawdown conditions may occur.

Concessionaire may provide alternative embankment materials for reducing loads and settlements. Concessionaire shall submit alternate embankment materials as part of the Geotechnical Engineering Report, documenting that alternative materials used are designed in accordance with current practices and procedures, and comply with all environmental compliance requirements set forth in the Contract Documents, Governmental Approvals, and applicable Environmental Laws. Concessionaires Design Work and Construction Work shall comply with NCHRP Report 529 - *Guideline and Recommended Standard for Geofoam Applications in Highway Embankments,* NCHRP Web Document 65 (Project 24-11) - *Geofoam Applications in the Design and Construction of Highway Embankments, and* NCHRP 597 *Development of a Recommended Practice for Use of Controlled Low-Strength Material in Highway Construction.* Geotechnical analyses of the stability of soil and rock fill slopes shall be performed in general accordance with the guidelines in AREMA. Geotechnical analyses of soil and rock cut slopes shall be performed in general accordance with the requirements of AREMA to assess stability. Design shall address the potential effects of water including, at a minimum, seepage, erosion, infiltration, and deterioration or loss of soil resistance due to pre-existing slickensides, local climatic and construction conditions. Benches, ditches, catchment zones, and drainage and erosion control provisions shall be incorporated into the design of slopes to control seepage and slough. The maximum slope height between benches and bench dimensions shall be as per MDE requirements.

1.6 Pavement

Pavement for MDSHA owned roadways shall use the pavement sections specified by MDSHA Pavement Sections for Purple Line provided in Book 5 Engineering Data or if not specified therein shall be designed by Concessionaire in accordance with Section 1.6.1. Concessionaire may submit an Alternate Pavement Design for Review and Approval.

Pavement for Montgomery County and Prince Georges County owner roadways shall be selected from the standard pavement designs included in the County Codes and Standards. Concessionaire may submit an Alternate Pavement Design for Review and Approval.

Concessionaire shall design private driveways and access roads to non-public facilities to be selected from the appropriate MDSHA, Prince Georges County or Montgomery County standard paving section for entrances or driveway. If the existing pavement cross section offers greater Design Life, then the existing cross section shall be used. Concessionaire may submit an Alternate Pavement Design for Review and Approval.

Concessionaire shall design all other pavement in accordance with Section 1.6.1.

Alternate pavement designs, if used, shall be in accordance with Section 1.6.1.

Concessionaire’s pavement selections, designs, or alternate pavement design shall be in accordance with the above and the following:

- for resurfacing or widening reconstruction, Concessionaire shall select rigid vs. flexible pavement to match the existing roadway material;

- bus-specific areas shall only be rigid pavement;
- the Capital Crescent Trail surface shall be non-permeable flexible pavement, except that permeable flexible pavement may be used between station 44+92 and 73+67. The Capital Crescent Trail across structures shall be concrete; and
- embedded track lanes not intended to be shared with vehicular traffic shall have a clear demarcation in pavement texture to reinforce the restriction of vehicles other than the LRT in those lanes.

Concessionaire shall submit all pavement selections, designs or alternate designs for Review and Approval as part of the Geotechnical Engineering Report before Final Design.

1.6.1 Pavement Design

All pavement design shall be performed in accordance with MDSHA Pavement Design and Construction Performance Specification for Purple Line (included in Book 5 Engineering Data), MDSHA Pavement Sections for Purple Line (included in Book 5 Engineering Data) and the following requirements.

The pavement design life shall be 25 years unless otherwise specified by AHJ requirements

Equivalent Single Axle Load (ESAL) information not provided in Book 5 Engineering Data, shall be developed by the Concessionaire.

Subgrade design values shall be based on an evaluation of laboratory test results such as California bearing ratio, falling weight deflectometer, or M_r tests. If subgrade improvement techniques such as lime stabilization or soil cement are used, the design shall be based on laboratory testing.

1.6.2 Paving Limits

The limits of milling and resurfacing for roadways intersecting the Project shall extend beyond the curb return or to the limits of Construction Work required to tie into existing pavement, whichever is greater.

1.6.3 Underdrain

Concessionaire shall provide pavement underdrains according to location, minimum size, cleanout spacing, and outfall spacing requirements required by the AHJ. A cleanout shall be provided for each 90-degree bend and for each two 45-degree bends. Underdrains shall be either PVC or non-reinforced concrete pipe.

1.7 Materials and Equipment

Roadway materials including at a minimum sidewalk, curb, combination curb and gutter, curb ramps, monolithic medians, islands, detectable warning surfaces, fences, and barriers for new and reconstructed facilities shall conform to the requirements of the AHJ and the Third Party Agreement Requirements.

1.7.1 Pavements

Asphalt, concrete, and subbase materials shall conform to the municipal codes and design manuals for the AHJ, including at a minimum MDSHA Standard Specifications for Construction and Materials and MDSHA Pavement Design and Construction Special Provision for Purple Line, included in Book 5 Engineering Data.

Superpave mixes may be selected that allow for the use of WMA.

1.7.2 Borrow

Soil and aggregate borrow materials and compaction shall meet the requirements of MDSHA Standard Specifications for Construction and Materials and MDSHA Pavement Design and Construction Special Provision for Purple Line, included in Book 5 Engineering Data.

Borrow for SWM facilities shall be in accordance with MDE specifications.

Lightweight fill materials consisting of Expanded Poly Styrene, lightweight foamed concrete fill or lightweight aggregate may be used provided that applicable testing is performed in accordance with AASHTO standards, NCHRP Report 529, Web Document 65, ACI guidelines and the Contract Documents.

1.7.3 Geosynthetics

Concessionaire shall specify geosynthetics in accordance with AREMA Section 1, Part 10, using design procedures in accordance with FHWA-HI-95-038, *Geosynthetic Design and Construction Guidelines Participant Notebook*.

Uses of geosynthetics not addressed in AREMA including at a minimum pavement interlayers, separation, drainage, modular block walls, reinforced soil slopes reinforcement, and filtration, shall be designed in accordance with FHWA-HI-95-038, *Geosynthetic Design and Construction Guidelines Participant Notebook*.

Geosynthetics on roadways shall be designed in accordance with the applicable MDSHA Codes and Standards and MDSHA Pavement Design and Construction Special Provision for Purple Line, included in Book 5 Engineering Data.

1.8 Construction Requirements

1.8.1 Pavements

1.8.1.1 Roadway Pavement - New, Reconstruction and Rehabilitation

Pavement shall be constructed in accordance with the MDSHA Standard Specifications for Construction and Materials and the MDSHA Pavement Design and Construction Performance Specification for Purple Line, included in Book 5 Engineering Data.

Existing pavements interrupted by LRT construction shall be either neatly saw cut or, as in the case of rigid pavements, replaced to the nearest existing longitudinal and transverse joint. Saw cuts shall be full depth. Saw cut lines or pavement joints shall not be visible on the pavement surface.

During Construction Work, Concessionaire shall perform subgrade verification testing such as, calibrated Dynamic Cone Penetrometer in accordance with ASTM D 6951, or falling weight deflectometer testing to verify design assumptions.

1.9 Summary of Submittals

Item	Section	Submittal	Action
1	1.4.1	Proposed Roadway Design Data	Review and Approval
2	1.4.9	Bus Stop Relocation Plans	Review and Comment
3	1.4.15	Roadway Plans – Preliminary	Review and Comment
4	1.4.15	Roadway Plan Plans - Final	Review and Comment

2 TRACKWORK

This Section includes requirements for track alignment, physical clearances alongside the track, and trackwork materials.

2.1 Functional Requirements

2.1.1 General

All mainline and yard track geometry shall be compatible with the capabilities of the Light Rail Vehicles and all rail mounted maintenance equipment.

The Project shall use a railway track vehicle guidance system consisting of flanged steel wheels riding on steel rails. Standard track gauge of 4’ 8 ½” shall be used. Rails shall be supported and constrained by crossties and rail fastenings in ballasted track and direct fixation rail fasteners on tracks not within streets. Tracks within streets shall be embedded in a concrete slab so as to be suitable to share the lane with rubber-tired vehicles.

The track and special trackwork shall be capable of providing horizontal and vertical guidance as well as providing a solid base to withstand the wheel loading from the LRVs and rail-mounted maintenance vehicles. The track and special trackwork shall be capable of providing sufficient electrical conductivity for the return current to the TPSSs.

2.1.1.1 Ballasted Track

Tracks shall be constructed as conventional crosstie ballasted track except where a different trackform is required by the Contract Documents.

Ballasted track shall include rail-supporting crossties with integral rail fastenings, bedded in and supported by ballast, which in turn is supported by subballast and a prepared subgrade. The overall ballasted track section shall incorporate facilities for proper drainage. Drainage shall ordinarily be conventional open ditches except in areas of constrained ROW where a curbed ballast section with underdrains may be used.

2.1.1.2 Direct Fixation Track

Where direct fixation track is required it shall be configured with adjustable plate-type direct fixation rail fasteners supported on concrete plinths. Plinths shall be anchored to a underlying track slab, bridge deck or tunnel invert.

2.1.1.3 Embedded Track

Where embedded track is required the rails shall be encased in a full depth concrete slab that incorporates all elements of the track system. The top of the concrete shall provide for joint use of the Guideway by rubber tired vehicles except for locations where vehicles can be excluded.

2.1.1.4 Green Track

If provided by Concessionaire, green track shall be configured as for direct fixation track with the rails and rail fastening system standing proud of the turf. The design of green track shall be supportive of the growth of vegetation as specified elsewhere in these Technical Provisions. Vegetation shall not be permitted to interfere with the mechanical and electrical functions of the track system. Concessionaire shall consider the need to provide a pathway in green track sections to permit track inspection to proceed without damaging plantings. Any such pathway shall be pervious.

2.1.1.5 Trackform Requirements

At locations noted below, Concessionaire shall provide the following trackform:

- Embedded track shall be used between Regents Drive and US Route 1.

2.1.2 Track Alignment

The alignment of the Purple Line System main line tracks shall be such as to provide a comfortable ride to Users at speeds that are consistent with the operating requirements and LRV requirements as set forth in the Contract Documents.

Concessionaire shall design the alignment of tracks in accordance with all requirements of the Contract Documents and to be within the following ranges of the alignments shown in the Book 4 Contract Drawings:

- horizontal alignments: range of 5 feet left and right of the horizontal alignment shown in the Book 4 Contract Drawings.

2.1.2.1 Track Alignment Requirements

At locations noted below, Concessionaire shall provide the following track alignment:

- at Bethesda, the trail tracks west of the Station Platforms shall not extend more than 100 feet west into Woodmont Plaza from the face of the existing Apex Building;
- the terminal crossover tracks adjacent to the Bethesda Station shall be located under the existing buildings;
- at the Silver Spring Library, between Track No. 1 Stations 347+72 and 352+41, the horizontal and vertical alignment, typical section, Platformand other items are fixed. Concessionaire's design must fit within the envelope agreed upon as part of the coordination with Montgomery County on the library construction; and
- at New Carrollton Station, Concessionaire's design at the tail tracks shall not preclude future extensions of the Purple Line System.

2.1.3 Trackwork Hardware

The hardware and construction details used on the trackwork shall be designed to support the operating requirements and match the needs of the LRV proposed. Concessionaire shall provide trackwork component and assemblies that are based on existing, service proven technology, have a record of performance satisfactory to the Owner, and are available from a minimum of three domestic suppliers of materials which meet Buy America requirements.

2.1.4 Environmental Conditions

The trackwork shall be suitable for the Project's environmental conditions, including, at a minimum, winter weather. Components shall be resistant to the effects of heavy salt and deicing chemicals, cold temperatures, heavy snow falls, icing conditions, and the potential for frost heaving conditions. The trackwork shall not be susceptible to damage from snow plowing.

2.1.5 Stray Current

Concessionaire shall address in detail the approach to controlling stray Traction Power current so as to protect Purple Line System structures, adjacent structures, and underground Utilities from the corrosive effect of stray current. The design shall include measures to minimize the housekeeping and maintenance effort necessary to maintain a satisfactory level of electrical isolation.

2.1.6 Noise and Vibration

Concessionaire's trackwork shall address in detail the approach to controlling noise and vibration to the levels required by the Contract Documents. These measures shall include, but not be limited to:

- consideration of the noise and vibration due to track alignment, including at a minimum sharp curvature;
- use of acoustic attenuation materials in the track structure;
- rail lubrication and the use of friction modifiers, whether by use of trackside devices or car-borne equipment; and
- rail grinding, both as measures to deter the development of rail corrugations and the use of asymmetrical grinding patterns to facilitate vehicle steering.

Concessionaire shall refer to the Third Party Agreement Requirements for information concerning vibration within the UMD Campus.

Concessionaire shall perform studies as required, design and construct the trackwork as may be necessary to meet the noise and vibration objectives stipulated in the FEIS, the ROD, and the Third Party Agreements. Concessionaire shall take other actions as may be required to mitigate the effects of noise and vibration on the community at indicated locations.

2.1.7 Railroad Tracks

Any relocation or realignment of non-Project owned railroad tracks and associated infrastructure and systems that is necessary to construct the Project shall be provided by Concessionaire in accordance with the standards of the railroad involved.

2.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American Railway Engineering and Maintenance of Way Association (AREMA), Manual for Railway Engineering;
- AREMA, Portfolio of Trackwork Plans;
- Transit Cooperative Research Program (TCRP) Report 155, Track Design Handbook for Light Rail Transit, Second Edition;
- TCRP Report 17, Integration of Light Rail Transit into City Streets;
- TCRP Report 23, Wheel/Rail Noise Control Manual;
- TCRP Report 69, Light Rail Service: Pedestrian and Vehicular Safety;
- TCRP Report 71: Track Related Research (seven volumes to date);
- TCRP Report 137, Improving Pedestrian and Motorist Safety Along Light Rail Alignments;
- TCRP Research Results Digest, 82, Use of Guard/Girder/Restraining Rails;
- TCRP Research Results Digest 79, Design of Track Transitions;
- 49CFR213 - Track Safety Standard of the US Department of Transportation, Federal Railroad Administration, as applicable;

- Salient regulations and guidance as issued by or as may be issued by the US Department of Transportation, Federal Transit Administration; and
- APTA RT-FS -S -002-02 - Standard for Rail Transit Track Inspection and Maintenance.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

2.3 Design Requirements

2.3.1 Acceptable Design Parameters

This Technical Provision calls out acceptable minimum and acceptable maximum parameters for various elements of the track alignment. Examples are minimum radius curves and maximum gradients. Concessionaire shall, in all cases, strive to use parameters that are more generous and less severe than the stated acceptable values.

The Book 4 Contract Drawings and Reference Documents show some track alignment parameters that contravene the acceptable maximums and acceptable minimums recited in this Section. Exhibit 2.1 provides specific locations were Design Waivers shall be considered pre-approved and Design Waivers are not required.

Exhibit 2.1 Track Alignment Design Waivers						
No.	**Curve Designation / Location**	**Approximate Station Limits**		**Description of Variance (Sub-Acceptable)**	**Acceptable Limit**	**Design Waiver Value**
		Start	**End**			
	Length of Horizontal Tangents					
H1	CN 1 234.1 to CN 1 245.1	TRK 1 234+00	TRK 1 245+00	Minimum Length of Horizontal Tangent not achieved.	100'	99'
H2	CN 1 333.1 to CN 1 335.1	TRK 1 333+00	TRK 1 335+00	Minimum Length of Horizontal Tangent not achieved.	100'	51'
H3	CN 1 340.1 to CN 1 342.1	TRK 1 340+00	TRK 1 342+00	Minimum Length of Horizontal Tangent not achieved.	100'	82'
H4	CN 1 366.1 to CN 1 370.1	TRK 1 367+62	TRK 1 368+17	Minimum Length of Horizontal Tangent not achieved.	100'	54.4'
H5	CN 1 388.1 to CN 1 391.1	TRK 1 389+59	TRK 1 390+43	Minimum Length of Horizontal Tangent not achieved.	100'	83.4'
H6	CN 1 391.1 & CN 1 394.1	TRK 1 392+41	TRK 1 393+07	Minimum Length of Horizontal Tangent not achieved.	100'	66'
H7	CN 1 400.1 & CN 1 407.1	TRK 1 404+94	TRK 1 405+65	Minimum Length of Horizontal Tangent not achieved.	100'	71'
H8	CN 1 455.1 to CN 1 460.1	TRK 1 456+96	457+84	Minimum Length of Horizontal Tangent not achieved.	100'	88'
H9	CN 1 760.1 to CN 2 764.1	TRK 1 761+15	TRK 1 761+97	Minimum Length of Horizontal Tangent not achieved.	100'	81.77'
H10	CN 1 922.1 to CN 1 926.1	TRK 1 923+29	924+21	Minimum Length of Horizontal Tangent not achieved.	100'	92'
H11	CN 2 333.1 to CN 2 335.1	TRK 2 333+00	TRK 2 335+00	Minimum Length of Horizontal Tangent not achieved.	100'	51'
H12	CN 2 340.1 to CN 2 342.1	TRK 2 340+00	TRK 2 342+00	Minimum Length of Horizontal Tangent not achieved.	100'	89'
H13	CN 2 366.1 to CN 2 370.1	TRK 2 367+59	TRK 2 368+14	Minimum Length of Horizontal Tangent not achieved.	100'	55'
H14	CN 2 384.1 to CN 2 388.1	TRK 2 385+44	TRK 2 386+39	Minimum Length of Horizontal Tangent not achieved.	100'	92.6'
H15	CN 2 388.1 to CN 2 391.1	TRK 2 389+53	TRK 2 390+38	Minimum Length of Horizontal Tangent not achieved.	100'	84.9'
H16	CN 2 391.1 & CN 2 394.1	TRK 2 392+34	TRK 2 393+09	Minimum Length of Horizontal Tangent not achieved.	100'	75.4'
H17	CN 2 394.1 & CN 2 401.1	TRK 2 396+14	TRK 2 397+05	Minimum Length of Horizontal Tangent not achieved.	100'	91.1'
H18	CN 2 401.1 & CN 2 407.1	TRK 2 404+80	TRK 2 405+34	Minimum Length of Horizontal Tangent not achieved.	100'	54.4'
H19	CN 2 648.1 to CN 2 652.1	TRK 2 650+21	650+89	Minimum Length of Horizontal Tangent not achieved.	100'	68'

Exhibit 2.1 Track Alignment Design Waivers						
No.	**Curve Designation / Location**	**Approximate Station Limits**		**Description of Variance (Sub-Acceptable)**	**Acceptable Limit**	**Design Waiver Value**
		Start	**End**			
H20	CN 2 760.1 to CN 2 764.1	TRK 2 761+15	TRK 2 761+97	Minimum Length of Horizontal Tangent not achieved.	100'	80.04'
H21	CN 2 950.1 to CN 2 953.1	TRK 2 951+20	951+87	Minimum Length of Horizontal Tangent not achieved.	100'	67'
Horizontal Curve Radius						
H22	CN 1 717.1	TRK 1 717+00		Minimum Curve radius for Ballasted Track not achieved.	500'	354'
H23	CN 2 717.1	TRK 2 717+00		Minimum Curve radius for Ballasted Track not achieved.	500'	354'
H24	CN 1 333.1	TRK 1 333+00		Minimum Curve radius for DF Track not achieved.	300'	170'
H25	CN 2 333.1	TRK 2 333+00		Minimum Curve radius for DF Track not achieved.	300'	142'
H26	CN 1 785.1	TRK 1 783+08	TRK 1 787+72	Minimum Curve radius for DF Track on a bridge structure not achieved.	300'	218.55'
H27	CN 2 785.1	TRK 2 783+08	TRK 2 787+72	Minimum Curve radius for DF Track on a bridge structure not achieved.	300'	205'
Superelevation						
H30	CN 1 342.1	TRK 1 342+00		Negative Actual Superelevation applied to curve.	0"	-1
H31	CN 1 370.1	TRK 1 368+17	TRK 1 372+07	Maximum Equilibrium Superelevation (Eq) exceeded.	6.5"	6.513"
H32	CN 1 370.1	TRK 1 368+17	TRK 1 372+07	Maximum Unbalanced Superelevation (Eu) exceeded.	3"	3.138"
H33	CN 1 394.1	TRK 1 393+07	TRK 1 395+10	Maximum Unbalanced Superelevation (Eu) exceeded.	3"	3.367"
H34	CN 1 490.1	TRK 1 490+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H35	CN 1 517.1	TRK 1 517+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H36	CN 1 623.1	TRK 1 623+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H37	CN 1 658.1	TRK 1 658+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H38	CN 1 682.1	TRK 1 682+00		Maximum Unbalanced Superelevation (Eu) exceeded.	3"	4.46"
H39	CN 1 843.1	TRK 1 843+00		Maximum Unbalanced Superelevation (Eu) exceeded.	3"	3.36"

Exhibit 2.1 Track Alignment Design Waivers						
No.	**Curve Designation / Location**	**Approximate Station Limits**		**Description of Variance (Sub-Acceptable)**	**Acceptable Limit**	**Design Waiver Value**
		Start	**End**			
H40	CN 2 342.1	TRK 2 342+00		Negative Actual Superelevation applied to curve.	0"	-1
H41	CN 2 401.1	TRK 2 397+05	TRK 2 400+21	Maximum equilibrium superelevation (Eq) exceeded.	6.5"	6.875"
H42	CN 2 401.1	TRK 2 397+05	TRK 2 400+21	Maximum Unbalanced Superelevation (Eu) exceeded.	3"	3.625"
H43	CN 2 611.1	TRK 2 611+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H44	CN 2 611.2	TRK 2 611+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H45	CN 2 631.1	TRK 2 631+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H46	CN 2 677.1	TRK 2 677+00		Negative Actual Superelevation applied to curve.	0"	-1.125"
H47	CN 2 844.1	TRK 2 844+00		Maximum Unbalanced Superelevation (Eu) exceeded.	3"	3.34"
Horizontal Track Alignment at Station Platform						
H48	CN 1 103.1 Bethesda Platform	TRK 1 103+00		Horizontal Tangent Track through the entire length of Platform was not achieved.	Tangent	R = 1548.78' Ea = 0" Eu < 1"
H48 A	CN 2 103.1 Bethesda Platform	TRK 2 103+33	TRK 2 103+39	Bethesda Platform: TRK 2 has a 500' radius curve 45.36' from the end of the Platform, spiral is 5.36' from Platform; the Platform is also on a curve (See H48)	52'	5.36'
H49	Silver Spring Library Platform	TRK 1 349+62	TRK 1 352+11	The minimum length of horizontal tangents beyond the end of the Platform to the nearest horizontal curves was not achieved.	52'	22' / 27'
H50	CN 2 103.1, Bethesda Platform	TRK 2 103+00		Horizontal Tangent Track through the entire length of Platform was not achieved.	Tangent	R = 1577.50' Ea = 0" Eu < 1"
H51	Silver Spring Library Platform	TRK 2 349+62	TRK 2 352+11	The minimum length of horizontal tangents beyond the end of the Platform to the nearest horizontal curves was not achieved.	52'	24' / 34'

2.3.2 Design Speeds

Concessionaire shall provide a track and Guideway system that accommodates design speeds for track segments as are required to meet the Project operating requirements.

2.3.3 Horizontal Track Alignment

The horizontal alignment of mainline tracks shall be composed of a series of tangents joined together by spiraled circular curves. Owner will consider Design Waivers for use of simple circular curves only for constrained circumstances. Superelevation shall be used to maximize running speeds, where possible.

2.3.3.1 Length of Horizontal Alignment Segments

The acceptable minimum length in feet of tangents and circular curves (exclusive of spiral length) in mainline tracks shall be three times the design speed in miles per hour. Acceptable minimum spiral lengths shall conform to criteria recited elsewhere in this Section.

2.3.3.2 Lateral Track Location Within Mixed Traffic Lanes

Track location within mixed-traffic lanes shall be offset to one side of the traffic lane whenever possible to minimize the potential for motorists to ride the rails. Track location in mixed-traffic lanes shall be such that Station Platforms do not encroach into traffic lanes.

2.3.3.3 Tangents Along and Adjacent to Station Platforms

With the sole exception of the Bethesda Station, track through Station Platforms shall be horizontally tangent. Full compliance with ADAAG is required at all LRV doors at all Stations. The tangent length from the end of a Station Platform to the beginning of any adjoining horizontal curve or spiral shall be coordinated with the vehicle and architectural design so as to insure that the vehicle does not strike the Platform edge.

2.3.3.4 Curves

Circular curves shall be defined by the arc definition of curvature and shall be expressed by their radius, measured in feet. Track alignment in curves shall be designed so as to match the following parameters:

- lateral acceleration: acceptable maximum = 0.10g; and
- lateral jerk rate: acceptable maximum = 0.03g/s.

The values above shall be as measured at the car floor and are inclusive of the dynamic response of the vehicle suspension system. They are not inclusive of the vehicle response to track irregularities resulting from construction and maintenance tolerances.

Curves shall use the largest radius possible consistent with functional design. The acceptable minimum radius for mainline tracks is as follows:

- mainline ballasted acceptable minimum: 500 feet;
- direct fixation, tunnel and bridge segment acceptable minimum: 300 feet; and
- embedded, direct fixation, green track acceptable minimum: 100 feet.

The acceptable minimum radius for yard and service tracks is as follows:

- acceptable minimum: 100 feet.

2.3.3.5 Track Superelevation

Mainline track shall be provided with superelevation in order to provide a comfortable ride at the design speed without resorting to excessively large curvature radii.

The acceptable maximum values for actual and unbalanced superelevation shall be as follows:

- acceptable maximum actual superelevation (E_a):
  - o main line track in exclusive Guideway: 4 inches;
  - o embedded track in mixed traffic: maximum allowed by the roadway design criteria and not to exceed 3½ inches; and
  - o yard and auxiliary Tracks: 1 inch.
- unbalanced superelevation (E_u) for all trackforms:
  - o acceptable maximum: 3 inches.

Owner will consider a Design Waiver for the use of an E_u greater than the acceptable maximum only under constrained circumstances. If Concessionaire desires to exceed E_u = 3 inches in the main track, Concessionaire shall verify the normal operating roll of Concessionaire's LRV and demonstrate that the acceptable maximum value of lateral acceleration experienced by the Users, including the induced effects of vehicle roll, will not be exceeded.

Negative superelevation, i.e. the inner rail of the curve is higher than the outer rail shall require a Design Waiver and shall not be greater than one inch. Negative superelevation shall only be considered for use in embedded track in a mixed traffic lane where conformance to a crowned pavement surface is necessary. If authorized, the value of negative superelevation shall be deducted from the acceptable value of unbalanced superelevation for determination of maximum allowable Train speed.

2.3.3.6 Variation in Train Operating Speed

In any variable-speed curve, the acceptable maximum unbalanced superelevation experienced by riders anywhere within all cars throughout the full length of the Train shall be 3.0 inches.

2.3.3.7 Special Trackwork

Horizontal track geometry shall be such as to permit the use of special trackwork of conventional design based on AREMA design principles. Turnouts shall be on horizontally tangent track.

- mainline track alignment shall be horizontally tangent for a distance of not less than 25 feet ahead of the point of switch through to a point not less than 25 feet beyond the heel joint of the frog; and
- yard track alignment shall be horizontally tangent for a distance of not less than 10 feet ahead of the point of switch through to a point not less than 10 feet beyond the heel joint of the frog.

If ballasted tracks are horizontally curved in the zone beyond the frog, Concessionaire shall provide switch ties of special design to accommodate the curvature.

Special trackwork shall be located away from locations where pedestrians will cross the tracks and vice versa.

2.3.3.8 Transition Spirals

Spiral transition curves shall be used to develop the superelevation of the track and limit the lateral acceleration during the horizontal transition of an LRV as it enters a curve.

2.3.3.9 Track Twist

At locations where one rail is rising or falling relative to the other, in either tangent or curved track, slope length shall consider the response of the LRV suspension system to the rotation. Analysis shall also consider twist due to deteriorated track surface due to ordinary wear and tear and construction and maintenance tolerances.

2.3.4 Vertical Track Alignment

Vertical alignment shall be composed of constant grade tangent segments connected by parabolic curves having a constant rate of change in grade. For areas where the track centers vary, a separate track profile shall be provided.

2.3.4.1 Maximum and Minimum Profile Grades

The minimum length of vertical tangents, in feet, between points of vertical curvature shall be either three times the Train speed in miles per hour or 100 feet, whichever is greater.

2.3.4.1.1 Mainline Tracks

Mainline tracks shall conform to the maximum gradients and lengths of grades:

- acceptable limits:
  - 5.00 percent, unlimited length;
  - 5.01 percent, not longer than 3,500 feet; and
  - 7.00 percent, not longer than 1,500 feet, subject to the restrictions of 2.3.4.1.2 concerning ballasted track.
- Maximum lengths of gradients between 5.01 percent and 7.00 percent shall be interpolated.

For purposes of evaluating compliance with maximum lengths of gradient only:

- length of grade shall be calculated between the points of vertical intersection, ignoring the vertical curves; and
- profile gradient shall be adjusted upward at the rate of 0.04 percent per degree of horizontal curvature for any horizontal curve which falls with limits of vertical grade. No actual curve compensation is required except as may be required to achieve compliance with this article.

For continuous but undulating grades that include multiple gradient segments, such as 6.17 percent for 500 feet followed by 3.28 percent for 218 feet followed by 6.93 percent for 397 feet, Concessionaire shall calculate both:

- gradient and length of each individual segment; and
- weighted average gradient over the entire run.

Both grade and length conditions shall fall within the acceptable limits.

There is no minimum requirement for track gradient provided that stormwater drainage can be assured. In embedded track segments with track gradient less than 2.0 percent, the Basis of Design Report required by this Section shall specifically address and demonstrate that the flangeways will drain and remain clear of stormwater, snow and ice.

2.3.4.1.2 Ballasted Track on Steep Grades

Ballasted track grades steeper than 6.0 percent shall not be used.

2.3.4.1.3 Special Trackwork

Special trackwork in ballasted track shall be located on vertical tangents between a point not less than 50 feet ahead of the point of switch through to the last long tie. In rigid trackforms, the track shall be tangent between a point not less than 50 feet ahead of the point of switch and a point 50 feet beyond the heel joint of the frog. Track gradients through ballasted special trackwork shall not exceed an acceptable maximum of 4.0 percent. Track gradients through special trackwork in rigid trackforms shall not exceed an acceptable maximum of 5.0 percent.

2.3.4.1.4 Passenger Platforms

With the sole exception of the Campus Center Station at the University of Maryland, track through Stations shall be on a straight gradient. ADAAG compliance at all vehicle doors is mandatory.

2.3.4.1.5 At-Grade Crossings

Where the track intersects public streets and private driveways the track grade shall not exceed 5.0 percent.

2.3.4.2 Yard

Yard lead and storage tracks shall not exceed the following grades:

- maximum acceptable grade for yard lead tracks: 4.0 percent; and
- maximum acceptable grade for storage tracks: 0.5 percent.

There is no minimum gradient requirement for yard tracks provided that stormwater drainage can be assured.

Tracks within the shop building shall be level except that the first 20 feet inside of exterior doors shall be sloped slightly downward (approximately 1.0 percent) toward the exterior so that stormwater coming in open doorways drains properly.

2.3.4.3 Vertical Curves

Vertical curves, defined by parabolic curves having a constant rate of change in grade, shall be required when the difference in grades is greater than 0.05 percent. Both sag and crest vertical curves shall have the maximum reasonable length. Vertical broken-back curves and short horizontal curves at sags and crests of vertical curves shall be justified in the BODR.

2.3.4.3.1 Acceptable Length of Vertical Curve

The acceptable minimum length of vertical curve in mainline track for both sag and crest conditions shall be determined by the following formula (but shall be not less than 200 feet):

- $LVC = 100 (G_1-G_2)$

Where:

- LVC = length of vertical curve in feet; and
- (G_1-G_2) = algebraic difference in grades (in percent) approaching and leaving curve

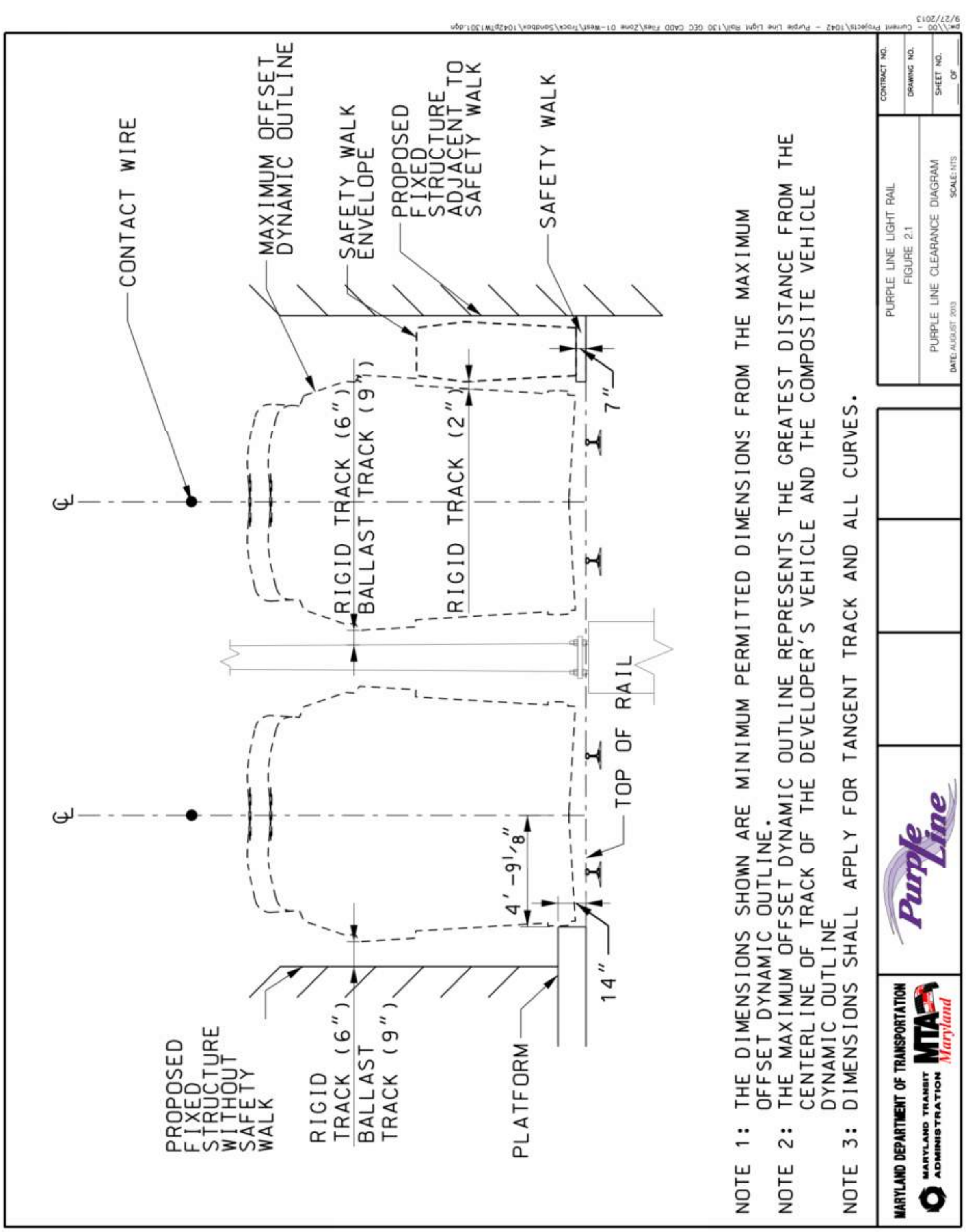
2.3.5 Clearances and Track Centers

So as to allow for running clearance and construction and maintenance tolerances of both the track and wayside structures, clearances between the dynamic envelope of the LRV shall be not less than those given on Exhibit 2.2 Purple Line Clearance Diagram. Detailed requirements for clearances and track centers shall be prepared as part of Concessionaire's Track Alignment and Trackwork Design Criteria. Application of the design criteria for clearances shall be addressed in the BODR.

Where they are required, the overall clearances shall include space for walkways to be used as emergency egress and maintenance activities. Except for extremely short locations such as catenary poles and signal masts, locations where clearances are insufficient for personnel to safely stand during passage of a Train shall be clearly marked with prominent signage.

Clearances shall give due consideration to the requirements of maintenance of way vehicles and any loads that they are designed to carry.

Exhibit 2.2


CONTACT WIRE
MAXIMUM OFFSET DYNAMIC OUTLINE
SAFETY WALK ENVELOPE
PROPOSED FIXED STRUCTURE ADJACENT TO SAFETY WALK
SAFETY WALK
PROPOSED FIXED STRUCTURE WITHOUT SAFETY WALK
RIGID TRACK (6")
BALLAST TRACK (9")
RIGID TRACK (2")
PLATFORM
TOP OF RAIL
14"
7"
4'-9 1/8"
NOTE 1: THE DIMENSIONS SHOWN ARE MINIMUM PERMITTED DIMENSIONS FROM THE MAXIMUM OFFSET DYNAMIC OUTLINE.
NOTE 2: THE MAXIMUM OFFSET DYNAMIC OUTLINE REPRESENTS THE GREATEST DISTANCE FROM THE CENTERLINE OF TRACK OF THE DEVELOPER'S VEHICLE AND THE COMPOSITE VEHICLE DYNAMIC OUTLINE
NOTE 3: DIMENSIONS SHALL APPLY FOR TANGENT TRACK AND ALL CURVES.
MARYLAND DEPARTMENT OF TRANSPORTATION
MARYLAND TRANSIT ADMINISTRATION
PURPLE LINE LIGHT RAIL
FIGURE 2.1
PURPLE LINE CLEARANCE DIAGRAM
DATE: AUGUST 2013
SCALE: NTS
CONTRACT NO.
DRAWING NO.
SHEET NO.
OF

2.4 Design Submittals

2.4.1 Track Alignment and Trackwork Design Criteria Report

Concessionaire shall prepare a comprehensive Track Alignment and Trackwork Design Criteria Report document fully addressing and explaining how Concessionaire proposes to design the system to meet the requirements of the Contract Documents. The written text shall be supplemented by figures, tables, and standard detail drawings.

Each article within the design criteria report shall include an explanation of how it addresses specific requirements of this Technical Provision and the requirements of other provisions of the Contract Documents.

Concessionaire shall address, at a minimum, the following elements:

- horizontal track alignment:
    - curves, including minimum radii and lengths;
    - track superelevation, and transition spirals, including underbalance, lateral acceleration, jerk rate and vehicle roll, ratio of actual superelevation to underbalance, method of addressing variations in Train operating speed, and track twist;
    - Station Platforms, including consideration of minimum tangent lengths through and beyond Station and limitations on horizontally curved Platforms, all demonstrating coordination with the architectural design and the design of the vehicle;
    - horizontal track alignment limitations due to special trackwork, including achievement of reliable vehicle tracking through switches and frogs;.
    - minimum lengths of horizontal geometric segments based on ride comfort limits; and
    - criteria for design of compound curves, reverse curves and double reverse curves.
- vertical track alignment:
    - tangent Grades, including maximum and minimum gradients, limitations at Station Platforms and special trackwork, limitations due to trackform, limitations at locations shared with or intersecting with rubber tired traffic, and gradients approaching and within yards and maintenance facilities, all demonstrating coordination with other affected design disciplines including at a minimum architecture and vehicles;
    - vertical curves including minimum lengths of vertical curves based on both ride comfort and vehicle limitations;
    - criteria for compound and reverse vertical curves;
    - minimum lengths of vertical geometric segments (both tangents and curves) based on ride comfort and vehicle mechanical limits as appropriate; and
    - limits on combined vertical and horizontal curvature based on both ride comfort and the limitations of the light rail vehicle.
- vehicle clearances, including the vehicle dynamic envelope, clearances to wayside objects, safety evacuation paths, and other trains, running clearances, assumptions concerning construction tolerances for wayside objects, assumptions concerning extreme condition construction and maintenance tolerances on the track, allowances for

maintenance and safety walkways, effects of curvature and superelevation, and other clearance allowances. Vehicle clearances for the required prototype LRV as well as the LRV selected by Concessionaire shall be provided;

- minimum track centers for various types of track construction and OCS configurations;
- classification of tracks (such as primary track or secondary track) and the type(s) of trackform to be employed in each based on use, Train speed, and other salient factors;
- description of each trackform (such as ballasted track, direct fixation track, embedded track, green track (if used), shop track, special trackwork in each trackform as applicable); and
- trackwork configurations and materials:
  - track gauge, including salient factors of vehicle wheel profile and gauge, rail cant;
  - flangeway widths, depths and shape to be employed in special trackwork, restraining rail, embedded track and both roadway and pedestrian crossings;
  - track construction and maintenance tolerances goals;
  - types of track construction to be employed and the standard details of each;
  - rail section(s) to be employed including metallurgy, rail welding and precurving of rail in sharp radius curves;
  - restraining rail for use in sharp radius curves, including details of how it will be applied in different trackforms;
  - emergency guardrail for bridges and other appropriate locations including details of how it will be applied in different trackforms;
  - crossties for ballasted track, including design and spacing requirements;
  - direct fixation rail fasteners for plain direct fixation track and green track (if used) including design and spacing requirements;
  - embedded track details and hardware;
  - trackwork details for maintenance shops such as maintenance pits and appurtenances, including transitions between different types of track construction and rail sections;
  - special trackwork for various trackforms including application criteria, design and fabrication details, designs of switches, frogs, and appurtenances including coordination with the Train control system concerning switch machines and related systems;
  - track appurtenances including at a minimum insulated joint bars for various trackforms, derails, end-of-track buffers and bumpers, rail lubrication systems, railway/highway at-grade crossing surface hardware, rail expansion joints for embedded track bridges and sharply curved direct fixation track bridges;
  - details for approach slabs and other arrangements for transitioning between trackforms with different values of vertical stiffness;
  - methods of electrically isolating the track in all trackforms, including special trackwork so as to prevent corrosion due to stray Traction Power current; and
  - coordination and interfaces with other systems and facilities.

Concessionaire shall submit the Track Alignment and Trackwork Design Criteria Report for Review and Comment prior to submission of Preliminary Design.

2.4.2 Basis of Design Report

Concessionaire's Basis of Design Report for Trackwork shall document the design process, complement the drawings and specifications, and provide the information used to prepare the design, including at a minimum the following elements:

- assumptions, design philosophy, coordination, integration of the design, and validation of compliance with the performance requirements;
- the design criteria used and any approved Design Waivers;
- document the designer's assumptions concerning material choices with respect to construction and construction produces, highlighting instances where non-conventional construction is proposed;
- explanation of the anticipated construction means and methods; and
- appendices including at a minimum:
  - design calculations;
  - documentation of interdisciplinary coordination;
  - records of coordination with Owner; and
  - approved Design Waivers.

With respect to construction and construction products, the BODR shall document the designer's assumptions concerning material choices, highlighting instances where non-conventional construction is proposed. An explanation shall also be given of the anticipated construction means and methods. This part of the BODR shall include records of collaboration between Concessionaire's designers and constructors.

Concessionaire shall submit the BODR for Trackwork with each submission of Track Alignment and Trackwork Design Plans.

2.4.3 Track Alignment and Trackwork Design Plans

Concessionaire shall submit Track Alignment and Trackwork Design Plans for Review and Comment at Preliminary and Final Design.

2.5 Equipment & Materials Requirements

2.5.1 Ballast, Subballast and Subbase

In areas of ballasted track construction, Concessionaire shall provide a subballast and ballast structure that has been engineered in accordance with AREMA requirements.

Sub-ballast for track bed shall consist of a uniform layer of densely graded aggregate placed over the entire width of the subgrade, following the profile and cross section of the subgrade. The sub-ballast shall be graded to promote drainage of stormwater runoff away from the track bed section. Except in cases where the AREMA requirements indicate that additional thickness is required, the acceptable minimum depth of the sub-ballast shall be 8 inches measured from top of subgrade to top of sub-ballast.

Ballast shall consist of hard granite or traprock in accordance with AREMA requirements. Except in cases where the AREMA requirements indicate that additional thickness is required, the acceptable minimum depth of ballast beneath the crossties at any point shall be 10 inches.

Concessionaire shall provide ballast curb for ballasted track sections as required.

In areas of embedded track, green track (if used) and direct fixation track at grade, the track slab shall be underlain by a layer of subbase material as indicated in Part 2B, Section 1 of the Technical Provisions.

2.5.2 Running Rail

Concessionaire shall use new steel tee rail conforming to AREMA *Manual for Railway Engineering.*

2.5.2.1 Continuous Welded Rail

With the exception of insulated rail joints, the adjoining ends of all running rails shall be welded. Flash-butt welding shall be used to produce rail strings of the longest lengths feasible for storage, handling, and installation. Each such flash-butt welded string shall then be thermite field-welded to form Continuous Welded Rail (CWR).

The track design on structures shall consider the need for high, low or zero longitudinal restraint rail fastenings and/or rail expansion joints.

2.5.2.2 Pre-Curved Rail

Concessionaire shall use pre-curved rail sections for curves and special trackwork with radii less than or equal to 300 feet.

2.5.3 Curved Track

Curved tracks in main line and yard track shall be equipped with restraining rail in accordance with the criteria noted below.

2.5.3.1 Restraining Rail Application Criteria

Sharply curved mainline tracks with centerline radii of 500 feet or less shall have restraining rail adjacent to the inside running rail of the curve. Curved mainline track with a centerline radius of less than 125 feet shall have restraining rail on both running rails.

For yard tracks, restraining rail shall be provided along the inside running rail on curves of radius 300 feet or less along high traffic volume tracks including yard leads, ladder tracks, loop tracks, car wash tracks and storage tracks. For purposes of this requirement, high volume is defined as more than four movements per operating day. Tracks with four or fewer movements per day may use restraining rail at Concessionaire’s discretion.

2.5.3.2 Restraining Rail Flangeway Dimensional Criteria

Appropriate flangeways widths and track gauge for tracks equipped with restraining rail shall be determined in accordance with TCRP Report 155, Chapter 4, assuming shared contact.

The top of restraining rail shall normally be set ¼ inch above the top of inside running rail. In crosswalks and similar intersections between a track and an accessible pedestrian path, the top of the restraining rail shall be set flush with the top of the running rail. The restraining rail shall not be lower than the running rail.

Restraining rail in embedded track and at any pedestrian crossing shall be configured with a solid floor in the bottom of the flangeway so that the flangeway is not more than 1 ¾ inches deep, measured from the top of the running rail.

2.5.3.3 Restraining Rail Configuration and Fabrication Requirements

Restraining rail shall be fabricated from a steel section with sufficient strength to serve the purpose. Examples are vertically mounted 115RE rail, CEN 33C1 check rail mounted on chairs, and strap guardrail. It is not mandatory to use the same restraining rail detail at all locations. Restraining rail for curves of radius 300 feet and less shall be precurved.

Ends of restraining rails shall be flared so as to smoothly intercept vehicle flanges without excessive jolts at the designated track speed for that location.

Restraining rail shall project not less than 10 feet, plus the length of the end flares, into the adjoining tangent track.

2.5.4 Emergency Guardrail

Emergency guardrail shall be used to limit the lateral excursion of a derailed LRV along open track locations as recited below:

- bridges and aerial structures;
- retained fill sections where the wall is closer than 15 feet to the centerline of track and/or higher than three feet;
- embankments greater than 10 feet in height or with side slopes steeper than 1 vertical to 3 horizontal; and
- adjacent to piers of overhead structures that are located closer than 15 feet to the centerline of the LRT track.

Emergency guardrail shall be installed inside of the running rail on the side of the track opposite the identified hazard.

Emergency guardrail shall extend a minimum of 100 feet ahead of the beginning of the area to be protected, and 50 feet beyond the end of the protected structure or area on the departure end. Emergency guardrail extension limits may be reduced to half of the established distances where track speed is 20 mph or less.

Lateral position of the emergency guardrail shall be coordinated with the design of the LRV trucks.

The top of emergency guardrail shall be located between ½ inch and 1-inch below the top of the running rail.

Emergency guardrail shall have end sections that curve smoothly toward the track centerline, extending a minimum of 15 feet beyond the defined limits.

Details of emergency guardrail shall be developed by Concessionaire, but in all cases it shall be designed to sustain derailment loadings and securely anchored to the underlying crossties or track slab.

Emergency guardrail is not required in embedded track. The use of isolated segments of embedded track for the purpose of avoiding the requirements of this Article is not permitted.

2.5.5 Ballasted Track Crossties

2.5.5.1 Crosstie Material

Crossties and turnout ties (switch ties) used in ballasted track for the Project shall be new, designed and manufactured in accordance with AREMA *Manual for Railway Engineering*, Chapter 30, “Ties.”

2.5.5.2 Crosstie Spacing

Crosstie spacing shall be determined in accordance with AREMA design principles with consideration of the live loadings, the bearing area of the crosstie, and the bearing capacity of the underlying ballast, subballast and subgrade materials and lateral stability of the track against lateral loadings due to Train loadings and thermal stress in the rails.

2.5.6 Rail Fastening Systems

The rails and special trackwork shall be supported and restrained by rail fastening systems. Rail fastening systems shall incorporate components to provide the electrical isolation necessary for Train Control Systems and Traction Power stray current mitigation. If not provided elsewhere within the track structure, rail-fastening systems shall incorporate components to attenuate vibrations.

2.5.7 Special Trackwork

2.5.7.1 Ballasted Special Trackwork

Ballasted special trackwork for mainline and yard tracks shall use new switch ties with elastic rail fastening clips. Switch points for ballasted track turnouts shall be split-switch type with floating heel blocks, meeting the requirements of AREMA *Portfolio of Trackwork Plans*.

2.5.7.2 Embedded Special Trackwork

Every effort shall be made to avoid locating special trackwork in areas of embedded track. Where embedded special trackwork is unavoidable, it shall be configured in a manner suitable for the service environment, including accommodation of rubber tired traffic. Switch components shall be designed for use in trafficked areas and recesses or voids in embedded switches shall incorporate both positive drainage and accommodations for inspection, servicing and cleaning. Embedded switches shall incorporate heating elements for winter operation.

2.5.7.3 Direct Fixation Special Trackwork

Direct fixation special trackwork shall be of similar design to ballasted special trackwork, except, instead of crossties, it shall be anchored to concrete plinths using standard and special design direct fixation fasteners.

2.5.7.4 Special Trackwork in Green Track

If used, special trackwork in a green track zone it shall be configured:

- as for direct fixation track, modified as necessary to meet the objectives of green track; or
- as embedded special trackwork.

2.5.8 Derails

Derails shall be provided at entrances and exits of yards so as to prevent an out-of-control Train from proceeding out onto main track. Yard throat derails shall be a split switch design. See Part 2B, Section 7 of the Technical Provisions for additional requirements for derails on out-of-service tracks within the shop facility and the adjacent yard.

2.5.9 End-of-Track Bumpers and Buffers

End-of-track devices shall be installed at stub-ended tracks to engage the anti-climber of any out-of-control LRV and decelerate it to a complete stop. Deceleration rate shall be not more than 1.0g.

The type of end-of-track device selected for each individual track shall consider the type and mass of equipment using the track, the possible presence or absence of Users and the possible impact speed. Fixed bumpers and wheel stops shall be used only on tracks that are never used by light rail vehicles.

2.5.10 Rail Expansion Joints

On any bridges and sharply curved aerial structures where slippage of the continuously welded rail through rail fasteners as a means of accommodating structural expansion/contraction cannot be assured, provide rail expansion joint assemblies of suitable design.

2.5.11 Grade Crossings

At-grade crossings of highways, local streets, service roads and pedestrian paths shall be designed in accordance with the following:

- AREMA *Manual for Railway Engineering*, Chapter 5, Track;
- MUTCD;
- TCRP Report 155 – Track Design Handbook for Light Rail Transit;
- applicable State and local traffic control manuals;
- grade crossing systems shall incorporate measures to control stray currents in accordance with the requirements of Book 2B, Section 20 and also provide acoustic isolation as may be necessary;
- intersections of roadway and or path crossings along embedded track sections shall use the same embedded track design as is used on either side of the grade crossing;
- intersections of roadway and or path crossings along ballasted track sections shall use either cast-in-place concrete crossings, or precast concrete panels the width to be limited to the width of the roadway and or path; and
- flangeway widths shall comply with ADAAG and shall be not greater than 1 ¾ inches deep.

2.5.12 Electrical Continuity and Stray Current Control

Electrical continuity of the track is essential to ensure negative return of Traction Power to the substation and to facilitate track signals (where provided). Concessionaire shall identify appropriate locations for electrical bonding with due consideration of the needs of Traction Power and Train Control Systems. This includes standard cross-bonding as well as special bonding requirements at special trackwork.

2.6 Construction Requirements

2.6.1 Relocated CSXT Spur

Concessionaire shall design the relocated CSXT Spur. Concessionaire shall construct the following elements of the Relocated CSXT Spur (Storage Track):

- remove and dispose of the existing storage track to within 150' of the point of switch on the mainline;
- perform grading for the relocated storage track;
- furnish and install subballast for the relocated storage track;
- furnish and install fencing as required by the Contract Documents.

CSXT will furnish and install the ballasted track.

2.6.2 Construction Specifications

Concessionaire shall develop detailed trackwork specifications for the procurement of trackwork materials and for the construction of trackwork and related appurtenances. At a minimum, distinct construction specification sections shall be developed for the following topics:

- general trackwork construction (including laying of CWR);
- ballasted track construction;
- direct fixation track construction;
- embedded track construction;
- green track construction (if used);
- shop track construction;
- special trackwork construction;
- rail welding (both shop welding and field welding);
- subballast;
- ballast;
- crossties and switchties;
- procurement of rail fastenings systems for ballasted, embedded and green track (if used);
- procurement of direct fixation rail fasteners;
- procurement of running rail;
- procurement of special trackwork (including shop-curved rail and restraining rail);
- trackwork appurtenances (including all miscellaneous trackwork materials such as insulated joints, rail lubricators, bumpers and other end-of-track devices, rail expansion joints, Guideway drainage systems not otherwise addressed in civil construction specifications);
- highway and pedestrian crossing surfaces and approaches; and
- track-to-earth electrical isolation testing.

2.7 Summary of Submittals

Item	Section	Submittal	Action
1	2.4.1	Track Alignment and Trackwork Design Criteria	Review and Comment
2	2.4.3	Track Alignment and Trackwork Design Plans - Preliminary	Review and Comment
3	2.4.3	Track Alignment and Trackwork Design Plans - Final	Review and Comment

3 STRUCTURES

3.1 Overview

Structures designed as part of the Project shall comply with these structural design provisions. If a Concessionaire's Design Documents are found to have special conditions that are outside the parameters identified in the Contract Documents, Concessionaire shall determine the applicable technical sources for the design to be used and obtain Owner approval. Concessionaire's Design Work shall comply with applicable local, State, and Federal regulations and codes. It shall be Concessionaire's responsibility to obtain clarification for any unresolved or perceived ambiguity prior to proceeding with Design Work or Construction Work.

The minimum design life of permanent bridges, aerial structures, and other structures designed in accordance with AASHTO shall be 75 years. Maintenance issues shall be controlled through design in order to achieve this design life.

Reference Part 2B, Section 3.4.13 and Part 2B, Section 7 of the Technical Provisions for additional design life requirements.

3.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets;
- AASHTO, AASHTO Guide Specifications for Seismic Isolation Design, Second Edition;
- AASHTO, LRFD Bridge Construction Specifications;
- AASHTO, LRFD Bridge Design Specifications;
- AASHTO, LRFD Guide Specification for Design of Pedestrian Bridges;
- AASHTO, Manual for Bridge Evaluation;
- AASHTO, R 8-96, Standard Recommended Practice for Evaluation of Transportation-Related Earthborne Vibrations;
- AASHTO, Standard Specifications for Highway Bridges, Seventeenth Edition, 2002, with current interim specifications;
- AASHTO, Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals;
- American Concrete Institute (ACI), ACI 207, Guide to Mass Concrete;
- ACI, ACI 318, Building Code Requirements for Reinforced Concrete
- ACI, ACI 358.1R-92, Analysis and Design of Reinforced Concrete Guideway Structures, 1992;
- ACI, ACI 506R - Guide to Shotcrete;
- ACI, ACI 530, Building Code Requirements and Specification for Masonry Structures and Related Commentaries;
- ACI, ACI 562-12, Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings (an ACI Provisional Standard);

- American Institute of Steel Construction (AISC), Steel Construction Manual, Specification for Structural Steel Buildings;
- AISC, Seismic Design Manual;
- AISC, Steel Construction Manual;
- American Railway Engineering and Maintenance-of-Way Association (AREMA), Manual for Railway Engineering;
- ASTM International (ASTM) Standards;
- American Welding Society (AWS) Standards;
- Applied Technology Council , ATC-32, Improved Seismic Design Criteria for California Bridges: Provisional Recommendations, 1996;
- ASCE/SEI Standard 7, Minimum Design Loads for Buildings and Other Structures;
- Code of Federal Regulations, 23 CFR Part 650.2, National Bridge Inspection Standards;
- Comite Euro-International De Beton - Federation Internationale De La Preconstrainte Model Code for Concrete Structures, 1990;
- FHWA-IF-03-017, Geotechnical Engineering Circular No. 7 – Soil Nail Walls;
- FHWA HIF-07-039, Geotechnical Engineering Circular No. 8 – Design and Construction of Continuous Flight Auger Piles;
- FHWA-IF-99-015, Geotechnical Engineering Circular No. 4 – Ground Anchors and Anchored Systems;
- FHWA RD-82-046, Tiebacks, Executive Summary;
- FHWA RD-82-047, Tiebacks;
- FHWA-RD-89-93, Soil Nailing for Stabilization of Highway Slopes and Excavations;
- FHWA-SA-93-068, Soil Nailing Field Inspectors Manual;
- FHWA-SA-96-069, Manual for Design and Construction Monitoring of Soil Nail Walls, 1997;
- FHWA-SA-96-071, Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Design and Construction Guidelines, 1996;
- Idriss, I. M. and Sun, J. I., A Computer Program for Conducting Equivalent Linear Seismic Response Analyses of Horizontally Layered Soil Deposits, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California at Davis, 1992;
- International Code Council (ICC), International Building Code (IBC);
- ICC, International Existing Building Code ;
- Maryland Building Performance Standards;
- MDSHA, Sound Barrier Policy;
- MDSHA, Structural Design Performance Specification, dated 6/08/2014;
- MDSHA, Standard Specifications for Construction and Materials;

- MDSHA, Structural Standards Manual Vol. 1 and 2, including:
- Standard No. BR-SS(5.02)-76-55, Protective Barrier for Portion of Bridge over Electrified Railroad with F-Shape Parapet; and
- Standard No. BR-SS(3.05)-75-25, Anti-Climb Shield for Chain Link Safety Fences Types I and II.
- Maryland Transit Administration (MTA), Design Development Manual;
- MTA, Facilities Inspection Manual;
- MTA, Inspection of MTA Buildings;
- Montgomery County, Highway Noise Abatement Policy;
- Multidisciplinary Center for Earthquake Engineering Research (MCEER), MCEER-98-0005, Screening Guide for Rapid Assessment of Liquefaction Hazard to Highway Bridges;
- National Center for Earthquake Engineering Research (NCEER), NCEER-97-0022, Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils;
- National Cooperative Highway Research Program (NCHRP), Report 350, Devices in Work Zones;
- NCHRP, Report 663, Design of Roadside Barrier Systems Placed on MSE Retaining Walls;
- National Forest Products Association (NFPA), National Design Specification for Wood Construction ;
- National Fire and Protection Association (NFPA), NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems;
- Occupational Safety and Health Administration (OSHA) Standards;
- Parsons Brinckerhoff, Monograph 7, Seismic Design of Tunnels – A Simple State of the Art Approach;
- Parsons Brinckerhoff, Monograph 25, An Innovative Method for Assessing Tunneling – Induced Risks to Adjacent Structures;
- Portland Cement Association (PCA), Engineering Mass Concrete Structures;
- PCA, PCA Thickness Design for Concrete Highway and Street Pavements;
- Post Tensioning Institute, Recommendations for Prestressed Soil and Rock Anchors;
- Precast Concrete Institute (PCI), PCI Design Handbook: Precast and Prestressed Concrete;
- Transit Cooperative Research Program (TCRP), Report 155, Track Design Handbook for Light Rail Transit;
- U.S. Access Board, Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines;
- U.S. Army Corps of Engineers, EM 1110-2-2901, Tunnels and Shafts in Rock;
- U.S. Bureau of Mines (USBM), RI 8507, Structure Response Damage Produced by Ground Vibration from Surface Mine Blasting;

- U.S. Department of Transportation (DOT), Americans with Disabilities Act (ADA) Accessible Transportation Facilities;
- U.S. DOT, Americans with Disabilities Act (ADA) Standards for Transportation Facilities;
- U.S. DOT, Americans with Disabilities Act (ADA) Guidelines for Buildings and Facilities;
- U.S. DOT, FHWA, Lateral Support Systems & Underpinning, Vols. I, II, III, FHWARD 75-128, -129, and -130;
- U.S. DOT, FHWA, Geotechnical Engineering Circular No. 4: Ground Anchors and Anchored Systems, FHWA-IF-99-015
- U.S. DOT, FHWA, Geotechnical Engineering Circular No. 5: Evaluation of Soil and Rock Properties, FHWA-IF-02-034;
- Wang, J., Seismic Design of Tunnels – A Simple State-of-the-Art Design Approach, Monograph 7, 1991 William Barclay Parsons Fellowship, Parsons Brinckerhoff, 1993;
- Washington Metropolitan Area Transit Authority (WMATA), Adjacent Construction Project Manual;
- WMATA, Standard Technical Specifications;
- WMATA, Manual of Design Criteria for Maintaining and Continued Operation of Facilities and Systems;
- WMATA, Directive and Standard Drawings;
- Youd, T. L., Screening Guide for Rapid Assessment of Liquefaction Hazard to Highway Bridges, MCEER-98-0005, MCEER, 1998; and
- Youd, T. L., and Idriss, I. M., Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, NCEER-97-0022, NCEER, 1997.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

3.3 Functional Requirements

3.3.1 Design Codes

When proposed structures are within influence zones of property owned by agencies other than Owner, including other railroad tracks and buildings, Concessionaire shall adhere to the property owner's requirements for adjacent work.

3.3.2 Tunnels

Concessionaire shall design tunnel geometry for both tangent and curved alignments with consideration of construction tolerances such that it will accommodate all system components outside the LRV dynamic envelope.

3.3.3 Ancillary Structures

Concessionaire shall develop ancillary structure geometry to accommodate all clearances required for installation, removal, and replacement of all mechanical and electrical systems to be housed internally, along with adequate space for maintenance and repair access. Within ancillary structures, all systems shall be installed outside the space reserved for maintenance and repair access.

3.3.4 Shafts and Underground Stations

Concessionaire shall develop shaft and Underground Station geometry to accommodate all clearances required for access/egress and installation, removal, and replacement of all mechanical and electrical systems to be housed internally, along with adequate space for maintenance and repair access. All systems shall be installed outside the space reserved for maintenance and repair access.

3.3.5 Watertightness of Underground Structures

3.3.5.1 Qualitative Criteria

Waterproofing of underground structures shall be in conformance with Section 422 of MDSHA's Standard Specifications for Construction and Materials. Qualitative criteria shall apply upon completion of Construction Work. The determination of Owner shall govern in the evaluation of these criteria. Concessionaire shall be required to perform all remedial work necessary to render structures in compliance with the following criteria:

- spaces occupied by operating personnel on a daily or frequent basis and spaces containing moisture or humidity-sensitive electrical and mechanical equipment shall be dry. For purposes of this test, dry means that no moisture is visible on the inside face of the structure and that blotting paper applied to the inside face shall not absorb moisture;
- other spaces shall be generally dry. For purposes of this test, generally dry means that a dry hand applied to the inner surface does not feel surface moisture, or blotting paper applied to the surface experiences only minor moisture absorption; and
- tunnels may be generally moist within the limits specified herein. For purposes of this test, generally moist means that blotting paper applied to the inner surface will absorb moisture, but dripping water is not present.

3.3.5.2 Quantitative Criteria

Water infiltration shall not exceed the limits in Table 3.1.

Table 3.1 – Water Infiltration Limits

Structure Type	Permissible Infiltration*
Ancillary Structures, Underground Stations and Shafts	.001 gal/sq. ft/day
Tunnels	0.002 gal/sq. ft/day

*Note: Permissible infiltration is measured through the structure, assuming undrained structures.

Local infiltration shall be limited to 0.25 gallons per day for 10 square feet of area.

No water ingress shall cause entry of soil particles into ancillary structures, Underground Stations, shafts or tunnels.

3.4 Design Requirements

3.4.1 Design Method

3.4.1.1 New Structures

The components of new structures shall be designed as a system in accordance with the following:

- For bridges that support LRT loading with or without influence from highway and/or pedestrian loading, the design shall be conducted in accordance with the applicable LRT load combinations specified herein and AASHTO *LRFD Bridge Design Specifications*, with interim specifications. When AASHTO LRFD is not applicable, the AREMA *Manual for Railway Engineering* shall be used;
- The limit states described in AASHTO LRFD shall be investigated for the design and analysis of bridge components. At a minimum, permanent deformations under overloads, live load deflections, and fatigue characteristics under service loadings shall be investigated. Concessionaire must also complete constructability checks in accordance with AASHTO LRFD;
- The LRFD method shall be used for the design of all components of segmental concrete bridges and post-tensioned concrete bridges;
- AREMA shall be used for the design of thru-girder bridges;
- Bridges shall be rated for both inventory and operating conditions using all applicable Train consists and work trains. For bridges where highway and/or pedestrian loads are also present, the rating shall include the HL-93 truck, permit loads, Maryland legal loads, pedestrian loads, and any local jurisdiction requirements, such as fire trucks and school buses. The controlling load rating values shall be provided on the plans. Ratings shall be provided for structures based on the method of design used;
- Drainage structures and buried structures, such as culverts, subjected to LRT, highway, and/or pedestrian loads shall be designed in accordance with AASHTO LRFD. Pipe culverts shall be designed in accordance with AASHTO LRFD regardless of whether or not they are influenced by LRT, highway, and/or pedestrian loading;
- Drainage structures and buried structures, such as culverts (except for pipe culverts), not subjected to LRT loads and without the influence of highway and/or pedestrian loads shall be designed in accordance with applicable criteria;
- For building structures that support LRT loading, applicable loads shall be applied to the structure;
- For building structures not subjected to LRT loading, as well as the structural components located above the portion of a structure subjected to LRT loading, the International Code Council's *International Building Code* (IBC) shall be used, unless the AHJ has other requirements;
- For steel structures subjected to LRT, railroad, or highway loading, excluding bridges, drainage structures, and buried structures, *Steel Construction Manual, Specification for Structural Steel for Buildings* of the American Institute of Steel Construction (AISC) shall be used;
- For concrete, reinforced concrete, precast concrete, and prestressed and post-tensioned concrete structures subjected to LRT, railroad, or highway loading, excluding bridges,

drainage structures, and buried structures, the *Building Code Requirements for Reinforced Concrete* of the American Concrete Institute (ACI 318) shall be used;

- The use of timber shall be prohibited in the design of structures that support or retain LRT loading. Timber shall only be used for ancillary structures. For timber structures other than structures subjected to LRT or highway loading, the *National Design Specification for Wood Construction* , by the National Forest Products Association (NFPA), shall be followed. Timber structures with spans over 20 feet in length shall not be allowed for permanent structures;
- Earth retention structures that are railroad-owned or which retain railroad tracks shall be designed in accordance with criteria prescribed in AREMA Chapter 8, Part 5, as supplemented by criteria of the railroad owner;
- Earth retention structures that are owned by local governments or other owners shall be designed in accordance with criteria specified by each owner;
- Earth retention structures retaining or influenced by any combination of LRT, highway, and pedestrian loads shall be designed in accordance with AASHTO LRFD. The loads shall be combined in accordance with Section 3.4.2;
- Earth retention structures that retain building loads and are not subjected to LRT loading shall be designed in accordance with ICC's *IBC* or *International Residential Code (IRC)*, as applicable;
- The deck system, except for temporary structures, over Underground Stations shall be designed and rated as a bridge structure in accordance with the Contract Documents;
- Underground structures shall be modeled and shall take into account the stiffness of the surrounding material; and
- Noise walls shall be designed in accordance with the AHJ requirements. If the AHJ has no requirements, Maryland State Highway Administration's (MDSHA) *Sound Barrier Standards* shall be used.

3.4.1.2 Existing Structures

The components of existing structures shall be analyzed as a system in accordance with the following:

- Components of existing structures, including bridges, buildings, and earth retaining structures, shall be checked for their capacities using the same design methodology for which they were designed. If the original design methodology is unknown, bridge and earth retaining structures shall be checked for their capacities in accordance with AASHTO's *Standard Specifications for Highway Bridges*, with the addition of applicable LRT loading. For building structures, if the original design methodology is unknown, AISC and ACI 318, as applicable, shall be used to check the structural capacity of the existing structure;
- Underground structures shall be modeled and analyzed, taking into account the stiffness of the surrounding soil;
- Load ratings shall be performed for bridges, for both inventory and operating conditions, using all applicable Train consists and work trains. For bridges where highway and/or pedestrian loads are also present, the rating shall include the HL-93 truck, permit loads, Maryland legal loads, pedestrian loads, and any local jurisdiction requirements, such as

fire trucks. The controlling load rating values shall be provided on the plans. Load ratings shall be provided for bridges based on the method of design for which the structure was originally designed. If the original design methodology is unknown, structures shall be rated in accordance with AASHTO;

- Repairs and strengthening, if required, shall also be designed in accordance with the same design methodology for which the structure was designed. If the original method of design is unknown, repairs and strengthening design shall be completed in accordance with the same methodology as outlined in the first bullet of this Section; and
- Concessionaire shall analyze the integrity and capacity of existing culverts, pipes and structures proposed to be reused under and adjacent to the alignment.

3.4.1.3 Facilities Retained by Third Parties and Utility Owners

Facilities owned by entities other than Owner shall be designed based on the design criteria of the AHJ. Units of measurement used for the design of, and plans for, modifications to any facilities owned by entities other than Owner shall be compatible with the units used in their original design or as specified by the AHJ.

3.4.2 Loads and Forces

Structures or parts of structures subject to LRT loadings shall be designed to withstand the loads and forces, at a minimum, defined herein. Sections 3.4.2.1 through 3.4.2.19 provide unfactored loads to be combined as defined in Sections 3.4.2.20 through 3.4.2.22, as applicable, based on the guidance provided in Section 3.4.1. These include loads due to the following:

- Dead load (DL);
- Live load (LL);
- Derailment load (DR);
- Impact (I);
- Centrifugal force (CF);
- Rolling force (RF);
- Hunting force (HF);
- Longitudinal force (LF);
- Earth pressure (E);
- Hydrostatic pressure and buoyancy (B);
- Wind load on structure (W);
- Wind load on live load (WL);
- Stream flow pressure and flooding (WA or SF);
- Shrinkage and creep forces (S);
- Thermal force (T);
- Force effect due to temperature gradient (TG);
- Force effect due to uniform temperature (TU);

- Ice pressure (ICE);
- System loads (SL);
- Rail break load (RB).
- Differential settlement (DS);
- Earthquake force (EQ); and
- Snow load (SN).

The loading criteria to which structures are designed shall appear on the structural drawings. Concrete placing sequence shall be indicated on the plans or in the supplementary conditions. Elements shall be checked for loads induced by the concrete placing sequence. Construction loads shall be accounted for in the design.

3.4.2.1 Dead Load (DL)

Dead load (DL) forces applied to structures and bridges supporting LRT shall consist of the actual weight of the structure including the basic supporting girders, beams, deck, floors, permanently installed trackwork, electrification, catenary support, canopies, elevators, escalators, stairways, environmental enclosures, Platforms, safety walks, fences, light/signal poles, pipes, conduits, cables, Utilities, and other permanent fixtures. DL shall include DC, DD, and DW for AASHTO LRFD load combinations.

Trackwork, appurtenances, and secondary elements supported by the structure and added after construction of the basic structure shall be considered as superimposed dead load. In areas of tie-and-ballast construction, the weight of rails, fastenings, ties, and ballast shall also be considered as superimposed dead load.

Dead load forces applied to structures not supporting LRT shall consist of the actual weight of the structure, including beams, girders, decks, floors, walls, walkways, railings, lights, pipes, conduits, cables, Utilities, mechanical systems, and other permanent fixtures.

Any items supported by the structure, but added after construction of the basic structure, shall be considered as superimposed dead load.

The following dead loads shall apply to maintenance and storage facilities:

- An additional 25 pounds per square foot (psf), unfactored, shall be included in the design of mezzanines and elevated walkways.
- In addition to dead load, the roof framing system shall include an unfactored design dead load of 10 psf for miscellaneous Utilities supported from the framing system.

Additional dead loads shall be applied as follows:

- An additional 15 psf, unfactored, shall be included in the design where bridge decks and/or floor slabs are supported by steel forms that remain in place.
- An additional 25 psf, unfactored, to account for a (new) future-wearing surface shall be included in the design where bridge decks and/or floor slabs carry highway traffic.

The structure shall be designed in a manner to sustain dead load stresses at all times without reduction, except as required by applicable load combinations. Dead load shall be computed from the weights of the materials composing the structure and its permanent fixtures.

3.4.2.2 Live Load (LL)

Live load (LL) shall consist of any non-permanent loads, including the weight of machinery, equipment, stored materials, persons, LRVs, work trains or other moving objects, and loads due to maintenance operations.

3.4.2.2.1 Buildings and Structures Owned by Owner – Unfactored Loads

- Floors, except as listed below or unless otherwise directed in Section 3.4.2.2.18, shall be designed for a minimum live load of 250 psf, regardless of the intended use of the space.
- Electrical equipment rooms, service rooms, storage space, and machinery rooms shall be designed for a uniform load of 250 psf, to be increased if storage or machinery loads dictate.
- Elevator rails, and potential buffers for cabs and/or counterweights, shall account for the live loads of the elevator.
- Where applicable, loads due to the presence of LRVs shall be applied in accordance with this Section of design provisions.
- Any live loads not listed shall conform to the requirements of the IBC.

3.4.2.2.2 LRV Design Loading

Concessionaire shall use all applicable Train consists, whichever produces the critical design loading, for structural design. The weight with AW4.00 loading plus a safety margin of 2,500 pounds to reflect a worst case full vehicle shall be used for structural design. An imbalance between power trucks shall also be accounted for in the design as determined by Concessionaire. LRV wheel loads shall be distributed as follows:

- **Fixed rail structures** – Where a wheel load is transmitted to a slab through rail mountings placed directly on the slab, the wheel load shall be assumed to be uniformly distributed on the slab over a 3-foot length of rail and a 1-foot 2-inch width normal to the rail and centered at the rail. In addition, the slab shall be designed to support the derailment load as defined in Section 3.4.2.3. The effective distribution width (E) of the derailment load shall be as outlined below.

  For deck between supports:

  $$E = 0.58S \leq 3.0 \text{ feet} \quad \text{(Equation 3-1)}$$

  Where:

  S = Span length between center lines of support.

  For cantilever deck:

  Moment: $$E = 2.5 \text{ feet} + 0.2X \quad \text{(Equation 3-2)}$$

  Diagonal Tension: $$E = 4t \quad \text{(Equation 3-3)}$$

  Where:

  X = Distance from load to point of support.

  t = Thickness of deck.

- **Ballasted deck structures** – The live load distribution for ballasted decks supported by transverse steel floor beams or longitudinal steel beams or girders shall be in conformance with AREMA Chapter 15 Section 1.3.4.2, “Ballasted Deck Structures.” The live load distribution for ballasted decks supported by concrete structures shall be in conformance with AREMA Chapter 8 Section 2.2.3(c) Live Load (2), (3), and (4).

3.4.2.2.3 Crane Car and Work Train Design Loading

The crane car and work trains shall be assumed to occupy a single LRT track while the other LRT track is empty. For mixed-traffic bridges, lanes without LRT tracks shall be assumed to carry highway live loads.

3.4.2.2.4 Locomotive Design Loading

The locomotive shall be assumed to be pulling a full Train consist (AW2.00 loading) on a single LRT track. The other LRT track shall be assumed to be operating under normal conditions.

3.4.2.2.5 Reduction in Load Intensity

For structures carrying LRT loads only, a track shall be considered as a traffic lane in referencing applicable sections of AASHTO LRFD Article 3.6.1 or AASHTO Article 3.12 as applicable.

For highway bridges supporting LRT loads, the following shall be used to determine the number of traffic lanes:

- If lanes are shared use (i.e., LRVs share a lane with highway vehicles), the live load shall be determined by the controlling case between:
  - Case 1 – Treating lanes as highway lanes and applying applicable multiple presence factors per AASHTO LRFD Article 3.6.1 or AASHTO Article 3.12.
  - Case 2 – Treating highway-only lane(s) with applicable multiple presence factors per the references in Case 1, above, and treating shared use lane(s) as LRT lane(s) with no reduction in load intensity.
- If lanes are dedicated use (i.e., LRVs will never share a lane with highway vehicles), the live load shall be determined in accordance with Case 2, above.

3.4.2.2.6 Highway Bridges not Supporting LRT Loads

For highway bridges not supporting LRT loads, live loads shall be determined in accordance with AASHTO LRFD or AASHTO as applicable.

3.4.2.2.7 Underground Stations

Underground Stations having less than 8 feet of earth cover shall be designed for the more severe of the two cases, as follows:

- Case 1 – If the depth of backfill cover is less than or equal to 2 feet, roadway live loads shall be distributed according to AASHTO LRFD or AASHTO as applicable.
- If the depth of backfill cover is greater than 2 feet, distribution of roadway vehicle wheel loads through earth fills may be based on the following: Use a graduated uniform live load distributed over a square area with sides equal to 1.75 times the depth of fill in select granular backfill or equal to the depth of fill in other cases. Where such areas overlap due to several wheels, the total load shall be uniformly distributed over the area.
- Case 2 – Assume a future backfill cover of 8 feet plus a uniform live load of 300 psf.

Underground Stations having greater than 8 feet of earth cover shall be designed for the load due to the depth of cover plus a uniform live load of 300 psf.

3.4.2.2.8 Pedestrian Bridges and Other Pedestrian Areas

Pedestrian bridges, pedestrian ramps, mezzanines, passenger Platforms, and other pedestrian areas associated with an LRT Station or with direct access to a mezzanine or Platform shall be designed for an unfactored uniform live load of 150 pounds per square foot. This load applies to primary supporting members including beams, girders, trusses, and arches with no load reduction permitted. Pedestrian bridges and other pedestrian structures not associated with a Station Platform or mezzanine shall have a live load in accordance with AASHTO *LRFD Guide Specification for Design of Pedestrian Bridges*, as applicable, with no load reduction permitted. This load applies to primary supporting members, including beams, girders, trusses, and arches with no load reduction permitted. Secondary members shall be designed for an unfactored live load of 90 psf with no reduction permitted.

Pedestrian bridges shall be designed for an occasional single maintenance vehicle load provided vehicular access is not physically prevented. The following loads for AASHTO Standard H-Truck shall be used: 10,000 pounds (H-5 Truck) for clear deck width from 6 feet to 10 feet, and 20,000 pounds (H-10 Truck) for clear deck width over 10 feet. Deck widths of less than 6 feet need not be designed for a maintenance vehicle load.

3.4.2.2.9 Concrete Track Slab

Concrete track slabs shall be designed to carry applicable loads as listed in Section 3.4.2.

The slab thickness and reinforcement provided shall be adequate to resist longitudinal bending stresses due to:

- Dynamic wheel loads, including impact, as described in Section 3.4.2.4.
- The maximum authorized live loads if freight traffic is anticipated.
- Warping stresses caused by temperature differentials between the top and bottom of the slab.
- Thermal stresses.
- Shipping and handling stresses.

3.4.2.2.10 Fixed Ladders

Ladders shall be designed, at a minimum, to sustain loads as required by Occupational Safety and Health Administration (OSHA) standards, IBC, and ASCE/SEI Standard 7.

3.4.2.2.11 Railings – Unfactored Loads

Railing shall be designed for the following loads:

- Railings on Station Platforms and mezzanines – Railings at these locations shall be designed for the simultaneous application of a horizontal load of 150 plf and a vertical load of 100 plf at the top.
- Handrails and top rails of guards other than on Station Platforms and mezzanines
    - Uniform load of 50 plf applied in any direction.
    - Concentrated load of 200 pounds applied in any direction.

    - Uniform and concentrated loads need not be assumed to act concurrently.
    - All handrails/top rails of guards shall have adequate attachment devices and supports to transfer loads to the structure.
- Intermediate rails, balusters, and infill panels.
    - Horizontally applied normal load of 50 pounds on an area not to exceed 1 square foot, including opening and space between rails.
    - This load and other loads need not be assumed to act concurrently.
    - Intermediate rails, balusters, and infill panels shall have adequate attachment devices and supports to transfer load to the structure.
- Parapets – The force applied to the parapet for design shall be taken as the more stringent of the following loads.
    - Uniform load of 50 plf applied in any direction at the top of the parapet.
    - Concentrated load of 200 pounds applied in any direction at the top of the parapet.
    - Derailment load if structure carries LRVs and is not protected by emergency guardrails.
    - TL-1 loading criteria in accordance with AASHTO LRFD Article 13.7.2 if structure is a pedestrian bridge.
    - TL-4 loading criteria in accordance with AASHTO LRFD Article 13.7.2 if structure retains highway loading, with the exception of the B/W Parkway Bridges over the LRT and Riverdale Road which shall have an FHWA-approved TL-3 barrier specific for the B/W Parkway.
    - Uniform, concentrated, derailment, TL-1 and TL-4 loads need not be assumed to act concurrently.

3.4.2.2.12 Safety Walks

Safety walkways shall be designed for a minimum uniform live load of 85 psf on the walkway area, or a minimum concentrated load of 300 pounds.

3.4.2.2.13 Sidewalks

Sidewalk loads on pedestrian bridges shall be in accordance with Section 3.4.2.2.8 and in accordance with AASHTO LRFD for highway bridges.

3.4.2.2.14 Ballast Curbs

The face of ballast curbs shall be designed for a horizontal force of 500 plf.

3.4.2.2.15 Grates over Vent Shafts

Steel grates over vent shafts shall be designed based on their locations. If subject to pedestrian and vehicular live load, grates shall be designed for the applicable wheel load. At a minimum, an unfactored load of 150 psf shall be applied to the grate and the frame of the grate. Air pressure loads due to ventilation and moving trains shall be accounted for in the design.

3.4.2.2.16 Bridge Cranes

Bridge crane design, including gravity, longitudinal forces, transverse forces and impact loading shall be in accordance with IBC and ASCE/SEI Standard 7.

3.4.2.2.17 Stairways

Stairways shall be designed for a uniform load of 100 psf or a concentrated load of 300 pounds on the center of stair treads, whichever controls.

3.4.2.2.18 Maintenance and Storage Facilities

In addition to applicable loading above, the following minimum loads shall be used for maintenance and storage facilities, and may be increased depending on specific conditions and activities at any given maintenance facility.

- Shop tracks (embedded rail or posted rail, or any turntables or hoisting equipment that LRVs will pass over) shall be designed to support the weight of all applicable Train consists of the empty car plus AW3.00 load without any overstress, or the rescue locomotive, whichever is greater.
- Shop floor areas that can be accessed from the exterior by highway vehicles shall be designed to support an H-20 AASHTO highway truck loading.
- Shop floor areas that can be accessed by forklift-type vehicles shall be designed to support a forklift single-axle loading (wheels 4 feet on center) of 12 kips.
- Shop floor areas within 10 feet of the center of a shop embedded rail track shall be designed to support a portable jack loading on the slab of 20 kips applied over a bearing area of 2 feet by 2 feet.
- LRV repair areas shall be designed for a uniform floor live loading of 250 psf. This floor loading shall not be combined with vehicle, forklift, or jack loadings.
- All LRV component repair areas shall be designed for a uniform floor live loading of 250 psf. This floor loading shall not be combined with vehicle or forklift loadings.
- Parts or component storage areas shall be designed for a minimum floor loading of 250 psf. High bay storage areas (any storage system extending higher than 10 feet above the floor) shall be designed for a minimum floor loading of 500 psf. An analysis of the rack system shall be made to document the final floor design loading in storage areas using rack systems. Aisles adjacent to storage racks shall be designed to support forklift loadings but the forklift loading shall not be combined with the minimum floor loading.
- Office, locker, toilet, training, and conference rooms, and other support type areas, shall be designed for a minimum floor loading of 100 psf.
- Work platforms shall be designed for a minimum live load of 125 psf. Operational studies of work platform use shall be made and the platform designed for concentrated loads from pallet jacks, dollies, or components if maintenance operations dictate such a loading.
- Mezzanine areas in maintenance and storage facilities that are not LRV component repair areas or storage areas shall be designed for a live load of 80 psf minimum. Mezzanine level areas that are LRV component repair areas or storage areas shall be designed for a minimum floor live load of 250 psf.

- Pit columns and the floors leading to the pits shall be designed for the LRV, work train, crane car, and locomotive. At a minimum, 250 psf shall be applied to these components.
- Based on shop material handling requirements, structural framing shall be incorporated into the building framing system to support the crane and monorail loadings including gravity, impact, lateral, and longitudinal loadings based on ASCE/SEI Standard 7.

3.4.2.3 Derailment Load (DR)

Potential derailment load (DR) effects shall be accounted for in the design. In the absence of actual crash test data or the results of a detailed dynamic crash/impact analysis, the load effect of a derailment event shall be accounted for by applying concurrently vertical and horizontal (transverse) forces to the supporting structure as outlined in Sections 3.4.2.3.1 and 3.4.2.3.2.

When checking any component of tunnel, superstructure or substructure that supports two or more tracks, only one Train on one track shall be considered to have derailed, with the other track(s) being empty.

Elements of the structure shall be checked assuming simultaneous application of derailed wheel loads. The reduction of positive moment in continuous slabs due to derailed wheel loads in adjacent spans shall not be allowed.

The derailment load shall be applied to elements of the superstructure and to those elements of the substructure as required by Section 3.4.2.4.

3.4.2.3.1 Vertical DR

The vertical DR of LRV shall consist of the LRV's maximum wheel load multiplied by an impact factor. An impact factor of 100 percent shall be used for deck and tunnel slab design (multiply wheel load by 2.0) and an impact factor of 33 percent shall be used for girder and applicable substructure design (multiply wheel load by 1.33). The derailment impact shall be applied to any two adjacent axles within a single truck assembly at a time, and the normal impact factor shall be used for all other axles, as defined in Section 3.4.2.4, which produces the critical loading condition for the structure.

Lateral vehicle excursion shall vary from 4 inches minimum to 36 inches maximum for tangent track and curved track with a radius greater than 5,000 feet. For track with smaller radii, the maximum excursion shall be adjusted so that the derailed wheel flange is located 8 inches from the rail traffic face of the nearest barrier, if any, or the edge of deck. In any case, for track protected by emergency guardrail, maximum excursion shall be limited to that allowed by the placement of the guardrail plus 6-inches.

For derailment events that will cause LRV's wheels to bear directly on the structure slab, the wheel load distribution on the slab shall be established using a rational method.

3.4.2.3.2 Horizontal DR

The horizontal load shall be equal to 10 percent of the LRV or work train weight, distributed proportionately along the length of the Train in accordance with the axle load distribution, acting perpendicular (transverse) to the track alignment at an elevation of 42 inches above the top of the low rail.

For cross-sections and tunnels having clearance between LRV dynamic envelope and barrier, wall, or obstruction of 6 inches to 36 inches, with maximum vehicle speeds of 60 mph and not protected by emergency guardrail, the force applied to the barrier, wall, or obstruction due to horizontal DRs shall be taken as 40 percent of a single vehicle weight acting 24 inches above top of rail and normal to the barrier, wall, or obstruction for a distance of 10 feet along the wall. Barriers, walls, and obstructions farther than 36 inches clear from vehicles need not be designed for this increased force.

For tracks protected by emergency guardrail with a barrier, wall, or obstruction within 18 inches of the LRV static envelope, the barrier, wall, or obstruction shall be designed to resist the increased force as defined in the above paragraph and the emergency guardrail need not be designed to resist derailment forces. For tracks protected by emergency guardrail with a wall or obstruction greater than 18 inches from the static envelope of the LRV, the emergency guardrail shall be designed for the increased force as mentioned in the above paragraph and the barrier, wall, or obstruction need not be designed to resist derailment forces.

For tracks carried by a tunnel, bridge or retained by a retaining wall, in the absence of emergency guardrails, a barrier with a minimum thickness of 1 foot shall be designed to resist this force.

3.4.2.3.3 Collision Force

Piers and abutments for bridges carrying LRVs over vehicular roadways shall be designed for the collision forces specified in AASHTO LRFD or shall be protected by a crash wall.

3.4.2.4 Impact Load (IM or I)

Impact loads for highway bridges not supporting LRT loading shall meet the requirements of AASHTO LRFD (IM) or AASHTO (I) as applicable. Impact considerations for bridges supporting LRT loading shall meet the following requirements:

- Impact shall be applied to the superstructure and to those members of the structure that extend down to the top of footings. The portion above the ground line of concrete or steel piles rigidly connected to the superstructure, as in rigid frame or continuous design, shall be included. The portion of the piles rigidly connected to the superstructure shall be designed for impact. Impact shall not be considered for retaining walls, piles, footings, and service walks, nor shall it be considered for culverts and buried structures having a cover of 3 feet or more.

Vertical impact for bridges shall be accounted for in the design as follows:

- Impact force for the design of deck joints subject to LRVs, with or without the influence of highway vehicles, shall be I = 75 percent.
- Impact force for the design of the fatigue and fracture limit state to other components except deck joints subject to LRVs, with or without the influence of highway vehicles, shall be I = 15 percent of the total live load.
- Under other limit states, as defined in Sections 3.4.2.20 through 3.4.2.22, for components other than deck joints subject to LRVs, with or without the influence of highway vehicles, impact force shall be I = 33 percent of the total live load.
- These constant vertical impact factors apply where the unloaded natural frequency of the first mode of vibration of the span is not less than 2.5 hertz. The minimum unloaded natural frequency of the first mode of vibration of the span shall be 2.5 hertz unless a special dynamic analysis is conducted in accordance with Section 3.4.5.2.
- For impact requirements for steel thru-girder bridges, refer to Section 3.4.6.1.6.

Impact shall not be considered for stairways, mezzanines, Station Platforms, or other pedestrian areas. This also excludes impact from being applied to H-10 and H-5 trucks on pedestrian bridges.

3.4.2.5 Centrifugal Force (CE or CF)

Structures carrying curved track alignments shall be designed for a horizontal radial force as described in AASHTO LRFD Article 3.6.3 (CE) or AASHTO Article 3.10 (CF), as applicable. Centrifugal force shall be applied 5 feet above the top of the low rail on tracks.

3.4.2.6 Rolling Force (RF)

A force equal to 10 percent of the LRV loading per track shall be applied downwards on one rail and upwards on the other, on all tracks. The rolling force shall be considered in a similar fashion as a longitudinal force. For the rolling force on steel thru-girder bridges, refer to Section 3.4.6.1.6.

3.4.2.7 Hunting (or Nosing) Force (HF)

A transverse horizontal force equal to 10 percent of the LRV weight, without impact, shall be applied at the top of the low rail in either transverse direction. This force, known as the hunting or nosing force, shall be equally distributed to the individual axles of the LRV. If this force and centrifugal forces act simultaneously, only the larger of the two shall be considered. The HF shall only be applied to one track of a tangent dual-track structure.

3.4.2.8 Longitudinal Force (LF)

A longitudinal force equal to 15 percent of the LRV loading, without impact, per track shall be applied 5 feet above the top of the low rail on all tracks. Acceleration and deceleration forces where there is more than one track shall be accounted for in the design.

For double track substructures, a minimum of three longitudinal loading cases shall be considered:

- Case 1, Single Track Loaded – One Train accelerating/decelerating.
- Case 2, Both Tracks Loaded – One Train accelerating, one decelerating. Longitudinal forces acting in the same direction.
- Case 3, Both Tracks Loaded – Both Trains accelerating/decelerating. Longitudinal forces acting in opposite directions.

50 percent of this force may be assumed to be transferred beyond the structure limits when tie-and-ballast tracks with continuously welded or bolted rails spanning the entire structure are used.

3.4.2.9 Earth Pressure (EV, EH, ES or E)

When highway and/or LRV traffic can come within a horizontal distance from the top of the structure equal to one-half its height, the pressure shall have added to it a live load surcharge. Surcharge loads on structures caused by LRV traffic and other loads shall be superimposed to the direct loads per AREMA guidelines. The surcharge due to the track loading shall be taken as uniformly distributed on the surface of the ballast below the tie, over a width equal to the tie length. With increased depth of the ballast structure, above top of retaining walls, the additional load distribution may be performed per AREMA Part 05-Section 5.3.1. Lateral earth pressures due to LRV traffic shall be computed using the elastic solutions (Boussinesq Equation) outlined in Section 20.3.2.2 of AREMA Part-20.

The zone of influence for dead loads and live loads, including LRT loading, shall be considered in computing earth pressures on both new and existing structures. The zone of influence is defined as a line projected downward at a 45-degree angle from the edge of the foundation or from the edge of the LRT tie.

Cut-and-cover underground structures, except for Underground Stations, shall be designed for a minimum cover depth of 8 feet. If the actual cover depth is greater than 8 feet, the actual cover depth shall be used. For Underground Stations refer to Section 3.4.2.2.7.

For underground structures, including Underground Stations, where full hydrostatic pressure below the groundwater table is used as a design load, a submerged unit weight of soil shall be used. The downward force of the soil above the structure resisting flotation shall not be taken greater than 110 pcf for dry soil and 48 pcf for submerged soil.

3.4.2.10 Hydrostatic Pressure and Buoyancy (B)

All substructure units shall be designed to resist buoyancy.

3.4.2.11 Wind Load on Structure (WS or W)

Bridge structures shall be designed to withstand wind loads of uniform pressure acting upon the superstructure, substructure, and live loads.

The effect of wind loads must be accounted for when pouring the deck.

Where photovoltaic panels are provided or are to be considered for future installation, the uplift force due to wind on the panels shall be included. Uplift on the panels shall be designed as cladding in accordance with ASCE/SEI Standard 7.

3.4.2.11.1 Wind Load on Superstructure

Wind loads on the superstructure shall be developed in accordance with AASHTO LRFD Article 3.8 or AASHTO Article 3.15, as applicable. Both horizontal and vertical wind load shall be included.

Wind load on the catenary support system shall be included in the design of both superstructure and substructure elements.

3.4.2.11.2 Wind Load on Substructure

The substructure shall be designed to withstand the preceding loads applied to the superstructure as they are transmitted to the substructure. In addition, a horizontal load of 40 psf shall be applied simultaneously at the centroid of the substructure area in accordance with AASHTO LRFD Article 3.8.1.2.3 or AASHTO Article 3.15.2, as applicable.

3.4.2.12 Wind Load on Live Load (WL)

Design shall include a transverse horizontal wind load (WL) and a longitudinal horizontal WL for the entire length of track supported by the element being designed. The values of these WLs shall be determined in accordance with AASHTO LRFD Article 3.8.1.3 or AASHTO Article 3.22.1, as applicable, except as modified herein. The transverse load shall be applied to the Train as concentrated loads at the axle locations, in a plane 7 feet above the top of the low rail and normal to the track. The longitudinal force shall be applied to the rails and superstructure as a uniformly distributed load in a horizontal plane 7 feet above the top of the low rail. Both forces shall be applied simultaneously.

These loads apply to the design of substructure elements supporting a single track. For the design of substructure elements supporting two tracks, these loads shall be decreased by 30 percent when both tracks are loaded.

3.4.2.13 Stream Flow Pressure and Flooding (WA or SF)

Design of the structures shall make an allowance for stream flow and flood loading as required by the particular type of structure and the conditions affecting each location. Anticipated flood elevations shall be determined by a study of official flood records, or if not available Concessionaire shall develop appropriate flood models. Stream flow pressure and flooding forces shall be included in the design of bridges where applicable. Piers and other portions of structures that are subject to flood forces shall be designed in accordance with sound engineering practice. The requirements outlined in AASHTO LRFD Article 3.7 or AASHTO Article 3.18 shall be used as a guide, as applicable.

3.4.2.14 Thermal Force (TU and TG, T)

3.4.2.14.1 Temperature Changes

Provision shall be made for stresses and deformations resulting from temperature changes as follows (60°F shall be considered setting or neutral temperature for concrete and steel; 100°F for rail):

- Concrete:
    - Temperature rise: 30°F.
    - Temperature fall: 40°F.
- Steel:
    - Temperature rise: 60°F.
    - Temperature fall: 60°F.
- Rail:
    - Temperature rise: 40°F
    - Temperature fall: 110°F

3.4.2.14.2 Thermal Effect

For positive temperature gradient, AASHTO LRFD Article 3.12.3 shall be implemented considering Zone 3 in AASHTO LRFD Table 3.12.3-1. Negative temperature values shall be obtained by multiplying the specified positive values by (-0.3) for plain concrete decks and (-0.2) for asphalt overlay.

In lieu of Project-specific information, the load factor for temperature gradient may be taken as:

- 0.0 for strength and extreme event limit states.
- 1.0 for service limit state when live load is not present.
- 0.5 for service limit state when live load is present.

For direct fixation track, provision shall be made for transverse and longitudinal forces due to temperature variations in the rail. These forces shall be applied in a horizontal plane at the top of the low rail as follows:

- Radial (Transverse) Force – For equal adjacent spans, the transverse force per span of structure per rail shall be determined by the following formula:

$$T = EA\alpha * \Delta T * (L/R) \quad \text{(Equation 3-4)}$$

Where: T = Transverse temperature force per span of structure per rail, pound.

E = Young's Modulus of rail, psi.

A = Rail cross-sectional area, inches^2.

α = Coefficient of expansion of rail, inch/inch/°F.

ΔT = Temperature differential, °F.

L = Span length along curve, feet.

R = Curve radius, feet.

For unequal adjacent spans, L shall be taken as the average of the span lengths. The transverse force must be resolved into components parallel and perpendicular to the pier at each rail fastener and then summed.

- Longitudinal Force – The maximum longitudinal force, T, per structure per rail shall be determined by the following formula:

$$T = 0.65 \times P \times L \quad \text{(Equation 3-5)}$$

Where: P = Vertical clamping force of rail fastener per linear foot, determined by the following formula:

$$P = 2 \text{ X } F_{clip} / S_{ties} \quad \text{(Equation 3-6)}$$

Where: F_{clip} = Clip toe resistance per rail clip, pounds.

S_{ties} = Spacing of the rail ties per fastener, feet.

L = Average span length of two adjacent spans, feet. For curved track, L is measured along the curve.

Note: The actual force, T, may be less than the maximum determined from the above equation and can be determined by performing rail-structure interaction analysis in accordance with TCRP Report 155, *Track Design Handbook for Light Rail Transit*.

Whenever CWR is terminated, any movement of the rail end must be restricted. CWR shall not be terminated on the structure.

Thermal forces resulting from the temperature variations in the overhead power distribution system shall be accounted for. Concessionaire shall account for temperature changes in the final lining design for tunnels.

3.4.2.14.3 Trackwork

Consideration shall be given to the thermal force interaction between the structural components and the trackwork system. Refer to TCRP Report 155, *Track Design Handbook for Light Rail Transit*, and Part 2B, Section 2 of the Technical Provisions for guidance on the interactions that must be considered for design. The maximum stress allowed in the rails for fixed track sections due to rail-structure interaction shall be 13,000 psi in compression or tension.

The temperature range specified in Section 3.4.2.14.1 for rail structures shall apply.

3.4.2.15 Ice Pressure (IC or ICE)

Ice forces on piers shall be selected with regard to site conditions and the mode of ice action to be expected. The following modes shall be considered:

- Dynamic loads due to moving ice sheets and ice floes carried by streamflow, wind, or currents;
- Static loads due to thermal movements of continuous stationary ice-sheets on large bodies of water;
- Static pressure resulting from ice-jams; and
- Static uplift or vertical loads resulting from adhering ice in waters of fluctuating level.

Where ice may be anticipated, the thickness of ice and height at which it applies shall be determined by investigation at the site of the structure, and its effects on the structure shall be determined following the suitable group loading combinations outlined in AASHTO LRFD.

Provision for the applicable dynamic and static forces due to ice pressure on the structure shall be made in accordance with AASHTO LRFD Article 3.9 or AASHTO Article 3.18, as applicable.

For ice pressure on overhead catenary support structures, reference Part 2B, Section 15 of the Technical Provisions.

3.4.2.16 System Loads (SL)

Design shall include loads and forces produced by the system-wide elements, such as electrification, signalization, and communication equipment.

3.4.2.17 Rail Break Load (RB)

Rail break loads shall be determined as outlined in TCRP Report 155, *Track Design Handbook for Light Rail Transit*, and Part 2B, Section 2 of the Technical Provisions. For design of direct-fixation tracks, the following assumptions shall be made:

- Only one rail on the structure can break at a time.
- The maximum allowable longitudinal gap in a rail due to a rail break shall be 2 inches. The minimum rail fastener spacing shall be 27 inches.

The structure shall be designed to include horizontal forces at the fixed bearing due to the summation of the longitudinal restraint of each rail fastener. The structure shall also be designed to include a twisting moment in a horizontal plane at the height of the low rail due to opposing directions of the forces in the broken and unbroken rails.

Apply a longitudinal rail break force on the maximum temperature differential in the rail to each abutment. Apply this force only in combination with the lateral earth pressure acting on the abutment.

3.4.2.18 Earthquake Force (EQ)

Structures shall be designed to resist forces induced by earthquake motions. Earthquake forces shall be calculated in accordance with the applicable design codes. These forces shall be combined with other loads and forces to which structures may be subjected to form a loading combination group, as appropriate.

Provision for the applicable dynamic forces due to earthquake on the bridge structures shall be made in accordance with AASHTO LRFD Article 3.10 or AASHTO Article 3.21, as applicable.

Provision for the applicable dynamic forces due to earthquake on building structures shall be made in accordance with the IBC.

A dynamic analysis is required for structures supporting the LRT and Aerial Stations. At a minimum, a linear static analysis shall be completed for all other structures. A higher order analysis may be completed at Concessionaire's discretion.

Refer to Section 3.4.19 for additional requirements and for seismic provisions for underground structures.

3.4.2.19 Snow Load (SN)

The snow load on building structures shall be applied in accordance with the IBC. SN on bridges and culverts supporting LRV loading shall be 25 psf except for locations where LRVs run in non-dedicated ROW (i.e., where LRT and highway vehicles operate in mixed-traffic alignments).

3.4.2.20 Load and Resistance Factor Design (LRFD)

In addition to the loads specified in Section 3.4.2, applicable loadings specified in AASHTO LRFD Article 3, "Loads and Load Factors," shall be included in the design. The load modifier, a factor accounting for ductility, redundancy, and bridge operational importance, shall be as follows:

Bridges shall be designed for specified limit states as described in AASHTO LRFD Article 1.3. Each component and connection of the structure shall satisfy the following equation for limit states:

$$\Sigma \eta_i \gamma_i Q_i \leq \varphi R_n \quad \text{(Equation 3-7)}$$

Where: η_i = Load modifier factor which is a function of ductility factor η_D, redundancy factor η_R, and importance factor η_I.

γ_i = Load factor from AASHTO LRFD Table 3.4.1-1 of the Governing Specifications.

Q_i = Force effect determined from structural analysis.

R_n = Nominal resistance determined per AASHTO LRFD.

φ = Resistance factor determined per AASHTO LRFD.

Ductility factor η_D, redundancy factor η_R, and importance factor η_I shall be determined as follows:

- Ductility factor η_D = 1.0 for structures. Non-ductile components and connections shall not be used.
- Redundancy factor η_R = 1.0, except for when components and connections are found to be fracture critical and/or non-redundant, use η_R = 1.05. Where feasible, Concessionaire is encouraged to design alternate load paths for members. Importance factor η_I as follows:
    - o η_I = 0.95 for bridges that meet ALL of the following criteria:
        - length less than 50 feet;
        - design Average Daily Traffic less than 500;
        - detour less than 10 miles or capability of erecting a temporary crossing in less than two days; and

        - not carrying LRVs.
- η_I = 1.05 for bridges that meet ANY of the following criteria:
    - total bridge construction cost exceeds $20 million;
    - design Average Daily Traffic greater than 50,000;
    - detour length greater than 50 miles; and
    - carrying LRVs.
- η_I = 1.00 for all other bridges.

The loading combinations specified in AASHTO LRFD Table 3.4.1-1 shall be modified as follows in Table 3.2 – Modified Load and Resistance Factor Limit States

Table 3.2 – Modified Load and Resistance Factor Limit States

Load Combination Limit State	CR DC DD DW EH EV ES SH SL SN	CF I HF RF LF LL IM CE BR PL LS	B SF WA	W WS	WL	TU	TG	SE	EQ	Use one of these at a time. ICE	DR	CT	CV	RB
STRENGTH I (unless noted)	γ_p	1.75	1.00	-	-	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-	1.20
STRENGTH II	γ_p	1.35	1.00	-	-	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-	1.20
STRENGTH III	γ_p	-	1.00	1.40	-	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-	1.20
STRENGTH IV EH, EV, ES, DW, DC ONLY	γ_p 1.50	-	1.00	-	-	0.50/1.20	-	-	-	-	-	-	-	1.20
STRENGTH V	γ_p	1.35	1.00	0.40	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-	1.20
EXTREME EVENT I	γ_p	γ_{EQ}	1.00	-	-	-	-	-	1.00	-	-	-	-	1.00
EXTREME EVENT II	γ_p	0.50	1.00	-	-	-	-	-	-	1.00	1.00	1.00	1.00	1.00
SERVICE I	1.00	1.00	1.00	0.30	1.00	1.00/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-	1.20
SERVICE II	1.00	1.30	1.00	-	-	1.00/1.20	-	-	-	-	-	-	-	1.20
SERVICE III	1.00	0.80	1.00	-	-	1.00/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-	1.20
SERVICE IV	1.00	-	1.00	0.70	-	1.00/1.20	-	1.00	-	-	-	-	-	1.20
FATIGUE I - II, IM, & CE ONLY	-	1.50	-	-	-	-	-	-	-	-	-	-	-	-
FATIGUE II - II, IM, & CE ONLY	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-

Where:

- DR = Derailment load.
- RF = Rolling force.
- LF = Longitudinal force.

- HF = Hunting force.
- RB = Rail break.
- SL = System loads.
- EV = Vertical earth pressure.
- EH = Horizontal earth pressure.
- CF = Centrifugal force due to LRT.
- I = Impact.

Other loads are as defined in AASHTO LRFD Article 3.3.2.

Unless directed otherwise, Concessionaire shall assume γ_{EQ} = 1.00.

The Strength II load case shall be evaluated for locomotive and work train design loadings as defined in Sections 3.4.2.2.3 and 3.4.2.2.4. In addition, the following combination shall be investigated at the service limit state for segmental bridges:

- DC + DW + EH + EV + ES + WA + CR + SH + TG + EL + SL

Construction loads and construction loading combinations for the service limit state and the strength limit state shall follow AASHTO LRFD Article 3.4.2.

For underground Stations, in addition to the load combinations cited above, the following load cases shall be analyzed for the design of underground structures. Maximum and minimum values of load factors shall be according to AASHTO Table 3.4.1-2:

- Case 1 – Full vertical load and full horizontal earth pressure and water pressure, using maximum load factors on loads.
- Case 2 – Full vertical load and minimum horizontal load. Maximum load factors are applied to vertical loads, and minimum load factors are applied to horizontal earth and water pressures.
- Case 3 – Minimum vertical loads, with maximum horizontal loads on one side and minimum horizontal load on the other. The hydrostatic load may be assumed to be balanced on both sides of the section. Maximum load factors shall be applied to the maximum loads and minimum load factors shall be applied to the minimum loads.
- Case 4 – Maximum vertical loads, with maximum horizontal loads on one side and minimum horizontal load on the other. The hydrostatic load may be assumed to be balanced on both sides of the section. Maximum load factors shall be applied to the maximum loads, and minimum load factors shall be applied to the minimum loads.
- Cases 5 & 6 – These cases apply the maximum and minimum horizontal loads to the opposite sides as Cases 3 and 4, where sections are not symmetric.

In the corresponding service state load cases, load factors of 1.0 apply.

3.4.2.21 Strength Design (Load Factor) Requirements (for Existing Structures)

The minimum strength required for structural members and their connections to existing structures supporting the LRT loads shall be computed from the most critical group in following list:

- Group I = 1.3(β_D*DL + 1.67(LL + I + RF + HF) + CF + β_E*E + B + SF + SL).

- Group IB = 1.3(β_D*DL + LL + I + RF + HF + CF + β_E*E + B + SF + SL).
- Group II = 1.3(β_D*DL + β_E*E + B + SF + W + S + T + SL).
- Group III = 1.3(β_D*DL + LL + I + RF + HF + CF + β_E*E + B + SF + 0.3W + WL + LF + SL).
- Group IV = 1.25(β_D*DL + LL + I + RF + HF + CF + β_E*E + B + SF + 0.3W + WL + LF + T + SL + S + RB).
- Group V = 1.3(β_D*DL + CF + β_E*E + B + SF + LF + W + S + T + 0.85DR + SL).
- Group VI = 1.3(β_D*DL + LL + I + CF+ β_E*E + B + SF+ 0.3W + WL + LF +S + T + 0.85RB + SL).
- Group VII = 1.3(β_D*DL + β_E*E + B + SF + EQ + SL).
- Group VIII = 1.3(β_D*DL + LL + I + RF + HF + CF + β_E*E + B + SF + ICE + SL).
- Group IX = 1.2(β_D*DL + β_E*E + B + SF + W + ICE + SL).

Where:

- β_D = Dead load coefficient in accordance with AASHTO Article 3.22.1.
- β_E = Earth pressure coefficient in accordance with AASHTO Article 3.22.1.
- DL = Dead load.
- LL = Live load.
- DR = Derailment load.
- I = Impact.
- CF = Centrifugal force.
- RF = Rolling force.
- HF= Hunting force.
- LF = Longitudinal forces.
- E = Earth pressure.
- B = Hydrostatic pressure and buoyancy.
- W = Wind load on structure.
- WL = Wind load on live load.
- SF = Stream flow pressure.
- S = Shrinkage and creep forces.
- T = Thermal force (radial and longitudinal).
- ICE = Ice pressure.
- SL = System loads.
- RB = Rail break.
- EQ = Earthquake force.

- And where live load shall be the locomotive and work trains, as defined in Sections 3.4.2.2.3 and 3.4.2.2.4 for Group IB.

3.4.2.22 Service Load (Allowable Stress) Design Requirements (for Existing Structures and Thru-Girder Bridges)

For design of substructure components of existing structures and thru-girder bridges supporting LRT loading and requiring service load (allowable stress) analysis, loads to the substructure components shall be computed from the most critical group in Table 3.3.

Table 3.3 – Loads to Substructure Components

Group Loading			Allowable Basic Unit Stress
Group I	=	DL + LL + I + RF + HF + CF + E + B + SF + SL	100%
Group IB	=	DL + LL** + I + RF + HF + CF + E + B + SF + SL	***
Group II	=	DL + E + B + SF + W + S + T + SL	140%
Group III	=	DL + LL + I + RF + HF + CF + E + B + SF + 0.3W + WL + LF + SL	125%
Group IV	=	DL + LL + I + RF + HF + CF + E + B + SF + 0.3W + WL + LF + S + T + SL + RB	133%
Group V	=	DL + CF + E + B + SF + LF + W + S + T + 0.85DR + SL.	125%
Group VI	=	DL + LL + I + CF+ E + B + SF + 0.3W + WL + LF + S + T+ RB + SL	140%
Group VII	=	DL + E + B + SF + EQ + SL	133%
Group VIII	=	DL + LL + I + RF + HF + CF + E + B + SF + ICE + SL	140%
Group IX	=	DL + E + B +SF + W + ICE + SL	150%

** For Group IB, LL shall be the locomotive and work trains as defined in Sections 3.4.2.2.3 and 3.4.2.2.4.

$$\text{*** Percentage} = \frac{\text{Maximum Unit Stress (Operating Rating)}}{\text{Allowable Basic Unit Stress}} \times 100$$

3.4.2.23 Design Requirements for Tunnels

Concessionaire shall prepare detailed design memoranda for each underground structure. At a minimum, these memoranda shall cover, but not be limited to, the following:

- tunnel, ancillary structure, and shaft configuration;
- Codes and Standards;
- references;
- LRV dynamic clearance envelope;

- type of excavation and, if mined, the number and size of excavation sequences and proposed excavation methods;
- groundwater control during excavation including treatment and disposal. Concessionaire shall investigate existence of well, septic, and geo-thermal HVAC systems that may be impacted by de-watering. Concessionaire shall mitigate for any such impacts by , modifying existing systems, rebuilding damaged systems, or constructing comparable replacement systems to maintain the complete and proper functionality of affected systems;
- design loads, including dead loads, roadway loads, vertical and horizontal earth pressures, water pressures, surcharge loads, and air pressures;
- load combinations;
- lining design (temporary, initial and permanent support) including pre-excavation support methods, installation sequence, anticipated convergence and shotcrete properties;
- tunnel face stability design;
- ground characteristics, strength and deformation parameters;
- ground settlement analysis and impact on existing structures, facilities and Utilities within the zone of influence of the tunnel;
- effects to adjacent structures of lowering the ground water;
- tunnel portal initial ground support design;
- waterproofing, including type of membrane and properties;
- logistics and requirements involved with the tunnel construction staging and site access including at a minimum the following:
    - outlining the staging of construction I and coordinating with the Project Schedule;
    - identifying the number and type of equipment required;
    - identifying the area to start the tunnel excavation and mucking operations;
    - identifying areas for stockpiling materials such as shotcrete/concrete batch plant and steel sets;
    - estimating the number of truck loads required to haul away the excavated material and haul in required materials;
    - Identifying truck routes to an approved dumping site; and
    - Identifying areas for treatment of construction water and discharge locations.
- settlement analysis due to tunneling simulating the effects of tunneling and dewatering to compute ground surface settlements for a predetermined width on either side of the tunnel centerline. The surface settlements shall be used to evaluate the impact of tunneling on the building structures, roadways and Utilities located on either side of the tunnel.

3.4.2.23.1 Tunnel and Ancillary Structures

The following definitions apply:

- Sequential Excavation Method - An open face tunneling method applicable to a wide range of ground conditions, ranging from soft ground to rock. The method involves sequential excavation of the tunnel in short sections, while concurrently installing initial support to provide immediate support to the ground behind the advancing face. The method is also known as the New Austrian Tunneling Method.

- Initial Support – Ground support elements that are installed concurrently with excavation. These elements are considered long-term support used in conjunction with additional ground support elements (Secondary Support). Initial Support design shall include full consideration for long-term ground loads. Welded wire fabric or steel fibers shall be used on the applied shotcrete layer.
- Secondary Support – Ground support elements that are installed subsequent to installation of Initial Support and are considered long-term support acting in conjunction with Initial Support.
- Temporary Support – Ground support elements that are installed concurrently with excavation. These elements are considered short-term support until Permanent Support is installed. The structural capacity of Temporary Support shall not be considered for permanent conditions.
- Permanent Support – Ground support elements that are installed subsequent to excavation which are considered long-term support, and which operate independently of Temporary Support.

Initial or Temporary Support shall be installed in a phased manner concurrently with excavation. Concessionaire shall determine any restrictions on the shotcrete application system and include such restrictions in the Contract Documents.

3.4.3 Design Methodology

The design of mined tunnels shall use empirical methods, ground stress-strain methods, force equilibrium methods, and structural methods. The procedure shall establish upper and lower solution boundaries that can be adjusted to account for additional investigation and testing.

The methods for the Initial Support design shall be empirical, stress-strain, and force equilibrium. The methods for Permanent Support design analyses shall be stress-strain and structural. The results of these types of analyses shall be integrated for the final design of the initial and permanent linings.

3.4.3.1 Empirical Methods

Empirical design methods, such as the Norwegian Geotechnical Institute's Q system shall be used to assess general support requirements with appropriate modifications to suit site specific conditions For multiple drift excavation, three dimensional excavations, irregular cavern shapes and areas of rock cover (equivalent to less than one-third the span of the excavation) the empirical analysis shall be verified by stress-strain methods.

The ground support shall be sufficient to support all of the stages and the full excavation.

3.4.3.2 Stress-Strain Methods

The stress-strain analysis shall determine ground stresses, loadings, and displacements around the cavern under all conditions of excavation sequencing. The analysis shall account for factors that influence the loads on the excavation. The analysis shall include relevant safety factors and the allowable ground movements. The method shall use numerical analysis with fully verified software.

The stress-strain method shall account for three-dimensional effects of excavation progress and the timing of support installation by allowing for release of ground stress prior to installation of support.

3.4.3.3 Force Equilibrium Methods

Force equilibrium methods shall be used for analysis of Initial Support. The analysis shall use the joint geometry information established. The force equilibrium method shall determine the size, location, weight, and shape of blocks that may feasibly fall out of the cavern crown or walls by the action of gravity.

The initial lining shall be designed to stabilize the rock blocks and soil areas that are unstable, including the maximum wedge. The calculated shotcrete thickness shall be verified by stress – strain methods.

Force equilibrium methods shall not be used for free displacement boundary conditions, crown bending ("beam effect"), and displacements of neighboring joints.

3.4.3.4 Structural Methods

Structural methods shall be applied in structural analysis of initial or final linings.

The loads used in the structural analysis shall be established by the empirical, ground stress-strain, or force equilibrium method.

The passive resistance provided to the liner shall be modeled by spring stiffness that shall account for deformation, compressibility of the waterproofing membrane, concrete shrinkage, and blast damage.

3.4.4 Type and Excavation

Depending on opening size and ground conditions, mined tunnels may be excavated full-face or using a series of phased excavations of smaller geometry than the full cross-section. Initial Support ground reinforcement elements and Temporary Support ground reinforcement elements do not require corrosion protection.

3.4.4.1 Design Loads for Tunnels

Loads used for the design of tunnels and underground ancillary structures shall be according to previous provisions of this Section, with the exception of dead load, roadway loading, and other loads described in this subsection. Refer to Section 3.4.19 for seismic requirements.

3.4.4.1.1 Dead Load

Dead load (DL) shall consist of the weight of the basic structures and the weight of secondary elements permanently supported by the structure. Dead load shall include miscellaneous loads of any system or facility that shall apply a permanent load on the structure.

The design unit weight of earth, both above and below the groundwater table, shall not be less than 130 pcf (buoyant weight 68 pcf). When dead weight is used to calculate a tunnel's resistance to flotation, a unit weight of not more than 110 pcf (buoyant weight 48 pcf) shall be used for the backfill placed over the structure. In cases where the full hydrostatic pressure below the groundwater table is used as a design load, a submerged design unit weight of not less than 68 pcf shall be used for the earth below the groundwater table.

3.4.4.1.2 Roadway Loading

All underground structures having less than 8 feet of earth cover shall be designed for the most severe of the following conditions:

- **Ground Cover Depth Less Than 2 Feet** – Roadway live loads shall be distributed according to AASHTO Specifications.
- **Ground Cover Depth Greater Than 2 Feet** – Distribution of wheel loads through earth fills may be based on a graduated uniform live load distributed over a square area with sides taken as 1.75 times the depth of fill in select granular backfill, or equal to the depth of fill in all other cases. Where such areas overlap due to several wheels, the total load shall be uniformly distributed over the area.
- **Assumed Ground Cover** – Roadway loading shall be determined based on an assumed future ground cover of 8 feet plus a uniform live load of 300 psf.

3.4.4.1.3 Other Loads

The following list of load types shall also apply:

- Ground pressures for design of tunnels and underground ancillary structures in soil, mixed-face, and rock shall be established for specific areas.
- Air pressures due to ventilation and moving trains shall be established.

3.4.4.2 Load Combinations for Tunnels

3.4.4.2.1 Initial or Temporary Support

Surcharge loads (ES), vertical earth pressures (EV), horizontal earth pressures (EH), and water pressures (WA) shall be defined in design memoranda.

The factored loads to be used in Strength Design (Load Factor) in accordance with ACI 318 shall be calculated according to Equation 3-8.

Design Load = 1.4(DL+EV+ES) + 1.7LL + 1.7EH[+1.4WA](1) (Equation 3-8)

(1) Add water pressure if temporary lining includes impermeable covering of full excavation perimeter or perimeter above invert. Impermeable coverings include shotcrete with a thickness of greater than 4 inches or precast concrete segments with gaskets.

3.4.4.2.2 Secondary or Permanent Support

The controlling forces and displacements in the design of linings consisting of combined Initial Support and Secondary Support or independently functioning Permanent Support linings shall result from the following load cases:

Case I: 1.4(DL+EV+ES) + 1.7LL + 1.7EH + 1.4WA (Equation 3-9)

Case II: 1.4(DL+EV+ES) + 1.7LL + 1.7WA (Equation 3-10)

Case III: 1.4(DL+EV+ES) + 1.7LL + 1.7EH (Equation 3-11)

Service 1: 1.0(DL+EV+ES) + 1.0LL + 1.0EH+1.0WA (Equation 3-12)

Extreme: 1.0(DL+EV+ES)+1.0EH+1.0WA+1.0EQ (Equation 3-13)

3.4.4.2.3 Safety Factors for Tunnel, Ancillary Structure and Shaft Design

The design of the lining shall be performed using the load factors in Sections 3.4.4.2.1 and 3.4.4.2.2 and the strength reduction factors in ACI 318. Strength reduction factors for shotcrete shall be in accordance with ACI 506.

3.4.4.3 Lining Design for Tunnels

3.4.4.3.1 Vertical Ground Pressure (EV + ES)

When the depth of cover is less than or equal to 3 times the final excavated width of the structure, tunnels in soil and mixed-face conditions shall be designed for a vertical ground pressure equal to full overburden pressure plus the surcharge (EV + ES). For greater depths of ground cover, reduced ground pressures due to arching may be used. Justification for such reduced ground pressures must be provided in design memoranda.

For lesser depth of cover, vertical ground pressures for tunnels in rock may be based on numerical analyses.

All underground structures shall be designed for the actual cover depth or for an assumed minimum cover depth of 8 feet when the actual cover depth is less than 8 feet. Deeper tunnels may consider reductions in overburden pressure due to arching effects, subject to the limitations described in Section 3.4.4.1.2.

Vertical ground pressure shall be included in design memoranda.

3.4.4.3.2 Horizontal Ground Pressure (EH)

Horizontal ground pressure for tunnels in soil shall be determined from at-rest earth pressure theory. Horizontal ground pressure for mixed-face tunnel profiles in soil or residual soil and partially to completely weathered and decomposed rock shall also be determined from at-rest earth pressure theory. For tunnels in rock and for mixed-face tunnel profiles in moderately weathered to unweathered rock, the horizontal ground pressure shall range between 0 ksf and the lateral confining pressure for a factor of safety of 1.

Horizontal ground pressure shall be included in design memoranda.

3.4.4.3.3 Water Pressure (WA)

The estimated high and low ranges of the groundwater table during the service life of the structure shall be used to determine the water pressure for design. Structures with undrained linings shall be designed for hydrostatic pressure.

3.4.4.3.4 Design Ground Pressures and Water Pressures

Specific design memoranda for each underground structure shall contain ground pressure and water pressure to be used for design, as well as necessary ground strength and deformation parameters.

3.4.4.3.5 Mined Tunnel and Ancillary Structure Initial or Temporary Support Design

For each ground condition and each specific section with that ground condition, Initial or Temporary Support lining for the final excavated dimension shall be based on the information contained in the relevant design memorandum.

After designing Initial or Temporary Support for the final excavated dimensions, alternative excavation sequences shall be studied using two-dimensional geotechnical modeling software such as FLAC, PLAXIS, and PHASE2 for soil and mixed-face mined tunnels. For rock mined tunnels, Initial or Temporary Support for each excavation stage shall be designed using UNWEDGE and sequential excavation shall be modeled using UDEC. The number of excavation steps and size of excavation for each step shall be varied to optimize excavation behavior and ground response. Time-dependent strength gain of shotcrete shall be considered in the analyses.

For all cases of numerical modeling, the convergence-confinement concept shall be applied either via supporting calculations or appropriate assumptions in order to assess the stress relaxation experienced in the surrounding rock mass before the support is installed and becomes effective. Expected surface settlements for relatively shallow excavations shall be determined. Parametric studies with variable stress relaxation values shall be performed to assess displacement dependency upon relaxation. It should be noted that each software package identified above handles such simulations differently. Therefore, Concessionaire shall verify the suitability of the software package to the process and ground conditions being modeled.

Locations which experience transition from one ground condition to another have maximum potential for uncontrolled ground loss. Therefore, three-dimensional modeling shall be performed at representative sections of these locations, which shall be identified in the appropriate design memoranda. The modeling shall include simulation of the effects of any ground treatment(s) and pre-reinforcement. Modeling shall be based on assumed lead-lag relationships of excavation steps. Lead-lag relationships shall be modified as required to control ground loss.

3.4.4.3.6 Mined Tunnel and Ancillary Structure Secondary or Permanent Support Design

Initial Support installed with shotcrete thicknesses greater than 6 inches may be considered part of the final lining. Secondary and Permanent Support sections shall be analyzed using conventional beam-element methods to resist the loads contained in the design memoranda.

3.4.4.3.7 Shaft Initial or Temporary Support Design

If the Initial or Temporary Support of a shaft excavation through soil is impermeable, the shaft shall be designed to resist groundwater loads and temporary horizontal earth loads. Evaluation of the temporary horizontal loads shall account for the length of time that the excavation will be open before the Secondary or Permanent Support lining is constructed.

Initial or Temporary Support of circular or oval shafts may consist of ring beams and lagging, rings formed of secant piles or slurry walls, or shotcrete in combination with ground reinforcement and/or lattice girders. Ground reinforcement installed as part of Initial Support, as defined in Section 3.4.2.23.1, shall require corrosion protection. Ground reinforcement installed as part of Temporary Support shall not require corrosion protection. Non-circular or oval shaft excavations shall be supported by systems such as soldier pile and lagging, secant piles, or slurry walls, which may be either braced or tied back.

3.4.4.3.8 Shaft Secondary or Permanent Support Design

Shaft Secondary or Permanent Support shall be designed to resist long-term horizontal earth loads and hydrostatic pressures imposed by groundwater. Secondary and Permanent Support shall be concrete and shall be placed in a manner to meet infiltration limits. The final structure shall be designed to a nominal ovaling deformation of 0.005D. In addition, the structure shall resist horizontal surcharges from loads applied at the tunnel surface and accommodate racking due to seismic loads or any unbalanced horizontal loads. Racking deformations shall not exceed 0.005H, where H is the depth of the shaft structure.

3.4.4.3.9 Waterproofing

Mined tunnels shall be designed with full membrane waterproofing supplemented by drains and sumps installed to collect intended seepage water. A water proofing membrane coupled with a geotextile drainage mat placed against the Initial Support shall be designed so that water can flow laterally outside of the membrane. The circumferential seal shall fully connect with the mined structure end seals, which in turn will connect with tunnel seals.

Due to the presence of the waterproofing membrane, the shear strength of the contact between the initial and final lining shall be taken as zero.

3.4.4.4 Ground Improvement

Evaluate the need for ground improvement as required to control excavation stability, seepage, and to control ground movements to protect adjacent structures and Utilities from damage. Design and employ ground improvement as required.

3.4.4.5 Underpinning

Evaluate the need for underpinning to support adjacent structures and Utilities from damage. Design and employ underpinning as required.

3.4.4.6 Management of Construction Vibrations and Air Overpressure

Develop and implement a program to monitor and control construction vibrations and air overpressures.

Air overpressures shall not exceed 0.013 psi (130 dB, based on linear weighting), or as required based on applicable regulations and ordinances.

Ground-borne vibrations shall be monitored and controlled based on PPV . Maximum PPV at the nearest structure shall not exceed the frequency-based maximum PPV criteria for plaster structures presented in USBM Publication RI 8507 (1980).

3.4.5 Additional Design Considerations

3.4.5.1 Structure Deformations and Settlements

Structure deformations, including foundation settlement, shall be considered not only for their effect on structural behavior, but also for their effect on trackwork.

3.4.5.2 Vibration

To limit potential dynamic interaction between the superstructure and LRVs, bridges shall be designed so that the unloaded natural frequency of the first mode of flexural vibration of each simple span is not less than 2.5 hertz. Further, in a series of three consecutive simple spans, no more than one span shall have a first mode frequency less than 3.0 hertz. Continuous span bridges shall not have a first mode frequency less than 3.0 hertz.

Concessionaire may find that compliance with these criteria necessitates the inefficient use of certain materials, particularly where girders are made of structural steel and span lengths are relatively long.

A special dynamic analysis shall be performed for any bridge or for superstructures having a first mode of vertical vibration less than 2.5 hertz or for the condition when more than one span in a series of three consecutive spans has the first mode of vibration less than 3.0 hertz. To assure passenger comfort, the vehicle amplitude of the vehicle-structure dynamic response shall be limited to 0.05g, where g is the acceleration of gravity.

Where such a finding is made, the proposed design shall be discussed with Owner to determine, for that particular instance, whether a lower natural frequency may be acceptable as a Deviation.

The special analysis shall model the proposed structure and the transit vehicle. The analysis shall contain a sufficient number of degrees of freedom to allow modeling of the structure, vehicle truck spacing, vehicle primary suspension, and the car body. It shall make provision for the placement of the vehicle on the structure in various locations to model the passage of the transit vehicle. When the exact configuration of the vehicle or the structure is not known, the analysis shall assume a reasonable range of parameters and shall model combinations of those parameters as deemed appropriate.

That special dynamic analysis shall also be used to determine whether impact in excess of the 33% limit is warranted.

For pedestrian bridge vibration requirements, see Section 3.4.5.8.

3.4.5.3 Deflection

Live load deflection limits shall be in accordance with IBC, AASHTO LRFD, and AASHTO, as applicable, except for multi-girder structures subjected to LRT loading. Live load deflections of multi-girder structures subject to LRT loading shall be as follows:

- Girders of simple spans shall be designed so that deflections due to service live load plus impact shall not exceed 1/1,000 of the span length.
- Girders of continuous spans shall be designed so that deflections due to service live load plus impact shall not exceed 1/1,000 of the length between points of contraflexure.
- Deflection of cantilever arms due to service live load plus impact shall be limited to 1/375 of the cantilever arm length.
- Maintenance and storage facilities shall meet the following requirements:
    - Structural floor slabs (as opposed to slabs on-grade) at vehicle repair areas, LRV component repair areas, parts or component storage areas, and areas adjacent to storage areas, including areas subject to forklift loads, shall be in compliance with a deflection criteria of span over 600 (L/600).
    - Office, locker, toilet, training, and conference rooms, and other support-type areas, shall be in compliance with a deflection criteria of span over 600 (L/600).

The span-to-depth ratio limit per AASHTO LRFD shall be met for bridge structures designed per AASHTO LRFD.

For pedestrian bridge deflection requirements, reference Section 3.4.5.8.

3.4.5.4 Structure Skew Angle

Unless the local governing jurisdiction has a more stringent limit for the maximum skew angle, the following limits shall be adhered to for design of structures supporting any combination of LRT, highway, and pedestrian loading:

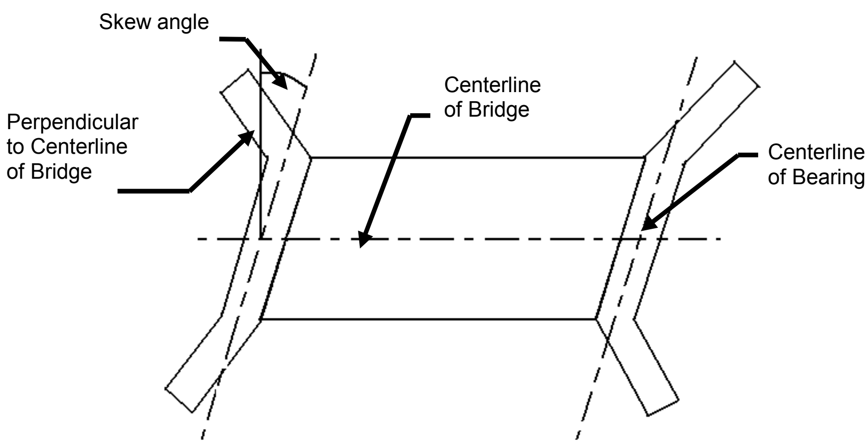
- For integral abutments, the maximum skew angle varies linearly from 30° for 100-foot spans to 20° for 300-foot spans. For integral abutment spans less than 100 feet, the skew angle shall not exceed 30°. For integral abutment spans greater than 300 feet, the skew angle shall not exceed 20°.

- The maximum skew angle for concrete slab and box beam bridges shall be 15°.
- For other structures not listed above, the maximum skew angle shall be 30°.

The use of a skew angle greater than the above limits requires the approval of the jurisdiction with ownership of the structure.

Fastener spacing on skewed bridges (greater than 10°) shall be coordinated to ensure that the fasteners are sufficiently supported on each side of the deck joints.

Figure 3.1 – Skew Angle



3.4.5.5 Fatigue

Consideration shall be given to the effect of change of stress levels caused by passage of LRVs over structures. The design life of the structure shall be 75 years. Over the life of the structure, the fatigue capacity shall be estimated using procedures outlined in AASHTO LRFD and AREMA Chapter 8, Part 27. The $ADTT_{SL}$ shall be 500 for LRVs. $ADTT_{SL}$ for highway vehicles shall be determined by the governing jurisdiction.

In addition to all primary structural members, all diaphragm and cross frame connections to primary structural members for LRT bridges shall be designed for fatigue.

3.4.5.6 Uplift

Provision shall be made for adequate attachment of the superstructure to the substructure should any combination of loading produce uplift at any support. Where dead load, earth pressure, or any other loadings tend to reduce the uplift effect, the corresponding load factors shall be taken as 0.9 for DL, 0.75 for E, and 1.0 for other loadings.

3.4.5.7 Jacking

End diaphragms and/or girders shall be designed for a jacking force equal to 110 percent of the end reaction due to dead load. Provisions for jacking for bearing maintenance and/or replacement shall be included in the design and plan preparation.

3.4.5.8 Pedestrian Bridge Requirements

The fundamental frequency of the pedestrian bridge without live load shall be greater than 3.0 hertz (Hz). If the fundamental frequency cannot satisfy this limitation, or if the second harmonic is a concern, a dynamic performance evaluation shall be made.

In lieu of such an evaluation, the pedestrian bridge shall be proportioned so that the fundamental frequency (*f*, Hz) is greater than:

- $f \geq 2.86 * \ln(180 / W)$ (Equation 3-14a)
- $W \geq 180e^{(-0.35f)}$ (Equation 3-14b)

Where W = the weight of the supported structure including only dead load (kips) and f = the fundamental frequency in the vertical direction (Hz).

Deflection of pedestrian bridges shall be in accordance with AASHTO's LRFD Guide Specification for Design of Pedestrian Bridges.

Pedestrian bridges shall have railings and parapets in conformance with Sections 3.4.2.2.11, 3.4.5.9, and 3.4.6.2.

Design and construction of the pedestrian bridge superstructure shall be in accordance with current requirements of the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG).

3.4.5.9 Not Used

3.4.5.10 Elevators and Escalators

Structural design for elevator and escalator systems and the structure to support these shall conform to the following Codes and Standards:

- Elevators and escalators included in any facility supporting the LRT system shall be in conformance with the U.S. DOT's *Americans with Disabilities Act (ADA) Standards for Transportation Facilities*.
- Structural members, elements, and components subject to dynamic loads from elevators shall be designed for impact loads and deflection limits prescribed by ASME A17.1.
- Elevators, escalators, and hoistway systems shall satisfy seismic design requirements for nonstructural components defined by ASCE/SEI Standard 7.

Concessionaire's structural design shall provide adequate support for rail bracket support points, machine-mount support points, deflector sheave mount points, and buffer reaction points (cab and/or counterweights).

3.4.6 Bridge and Transportation Structures

3.4.6.1 Structural Steel Design

3.4.6.1.1 Design Codes

Structural steel and composite concrete-steel flexural members for LRT bridges shall conform to the requirements of this Section and the design codes and loading as specified in Sections 3.4.1 and 3.4.2, respectively, unless specified otherwise herein.

3.4.6.1.2 Material and Painting Requirements

Consideration shall be limited to the types of structural steel listed in Section 3.5.

The steel superstructure elements of non-weathering steel bridges shall be painted in their entirety, including at a minimum steel beams, girders, bearing assemblies, trusses, floor beams, stringers, bracing, and support brackets. This does not include substructure elements, railings, sign structures, Utilities, or light poles.

ASTM A588 weathering steel for bridges shall be selectively painted. Areas to be painted include entire fascia girder and structural steel within the first 10 feet on each side of supports. At bolted field splices, 12 inches beyond the longest splice plate on each side of each splice shall be painted. More extensive painting requirements may be dictated by the AHJ of the bridge. On dual structures, the entire median fascia girder of each bridge shall be painted.

Bridge deck joints shall be painted on the outside, top, and inside surfaces of the parapets. Areas of bridge deck joints that will be exposed in the finished structure shall be painted as well, both above and below the seal.

Concessionaire shall coordinate final paint color with Owner of respective structure.

3.4.6.1.3 Minimum Sizes for Members and Welds

Primary fabricated structural steel members, such as stringer flanges and webs, cross frames for curved girders and LRT bridges, floor beams, truss members, splice plates, stiffeners, connection plates in the bridge superstructure shall have a minimum thickness of ½ inch.

Secondary fabricated structural steel members, such as wind bracing and diaphragms, in the bridge superstructure shall have a minimum thickness of ⅜ inch.

The minimum thickness criteria apply to rolled sections as well as built-up members.

The only exception to the minimum thickness requirement shall be for filler plates at splices.

Other minimum size criteria are as follows:

- Girder flange width: 12 inches;
- Girder flange thickness: 1 inch;
- Flange plates shall have a width-to-thickness ratio of b_f / $t_f \leq 12$;
- Weld size: 5/16 inch (except for seal welds); and
- Stiffener width: to nearest ½ inch and approximately ½ inch less than the distance from the face of web to the edge of the flange, but not over 10 times the stiffener thickness for Grade 50 steel or 12 times the stiffener thickness for Grade 36 steel.

3.4.6.1.4 Connections

Shop connections shall be welded. Welding shall be in accordance with the applicable code or specifications of the American Welding Society.

Field connections shall be designed for high-strength bolts. High-strength bolts shall be ASTM A325 or A490 bolts of the appropriate type.

3.4.6.1.5 Fracture Critical Members (FCMs)

Concessionaire shall obtain written approval from Owner for the use of FCMs for each bridge on a case-by-case basis. Concessionaire shall provide internal redundant load paths for FCMs.

Welds for bridges carrying LRVs which contain FCMs shall be designed and tested in accordance with AWS D1.5 as modified by AREMA Chapter 15, Section 1.14. Concessionaire shall call out all FCMs on the plans.

3.4.6.1.6 Thru-Girder Bridges

The following layout requirements shall apply for thru-girder bridges:

- For bridges on curves, the girders, abutments, and piers shall be located with reference to chords.
- An emergency ballast safety walk shall be provided along the interior face, LRT Guideway side, of each girder measured 2 feet off of the edge of the knee braces at the level of the ballast walking surface. One emergency ballast safety walk is required per track.
- Thru-girder bridges that require a pedestrian walkway in addition to the emergency safety walk shall support the walkway with steel brackets that are connected to the outside of the girder. Walkways shall have a minimum clear width of 5 feet.

The following design loads shall be used for thru-girder bridges:

- Thru-girder bridges shall be designed for applicable live loads specified in Sections 3.4.2 and 3.4.5. Loads for thru-girder bridges shall be combined per the specifications in Section 3.4.2.22.
- The distribution of live load shall be in conformance with AREMA Chapter 15, Section 1.3.4.
- In computing the dead load of the structure, include the weight of an additional 6 inches of ballast to allow for future track surfacing.
- Impact shall be computed in conformance with AREMA Chapter 15, Section 1.3.5, but shall not be less than 30 percent of the total LRV loading. Application of impact shall be in conformance with Section 3.4.2.4.
- Rolling force (RF) shall be computed in conformance with AREMA Chapter 15, Section 1.3.5(d).

The superstructure of thru-girder bridges shall meet the following requirements:

- The thickness of the steel deck plate shall be in accordance with Table 3.44.

Table 3.4 – Steel Deck Plate Thicknesses

Plate Thickness	Max Clear Distance between Floor Beams
½ inch	1 foot, 6 inches
⅝ inch	2 feet, 0 inches
¾ inch	2 feet, 4 inches

- The steel deck plates shall be shop welded with a pair of 5/16-inch continuous fillet welds to each floor beam or deck beam. Deck units shall be shop assembled with two or three beams per unit. Deck plates are not permitted to overhang the beam when these units are fabricated.
- The closing deck plate between adjacent deck units shall be fillet welded to the beams with continuous 5/16-inch fillet welds at each beam. After the deck plates are welded to the beam, fill the space between the deck plates along the joint with Portland cement concrete.
- For welded plate girders, no more than two flange section transitions shall be permitted.
- Intermediate stiffeners shall consist of two angles, one on each side of the web, and shall be bolted to the web. End-bearing stiffeners may be plates or angles, welded or bolted.
- The bottom lateral bracing system, if required by AREMA, shall be bolted to the girders.
- Continuous spans shall not be permitted.
- Floor beam brackets (or knee braces) shall be weldments that are bolted to the top flange of floor beams and to vertical stiffeners on the girder. The slope of the bracket shall be 4 inches in 12 inches (4H/12V), where possible.
- Intermediate floor beams shall frame into the girder web using double connection angles and high strength steel bolts. At brackets or at other locations where there is an intermediate stiffener, the stiffener on the inside of the girder shall be terminated a minimum of 1 inch above the top of the floor beam.
- End floor beams shall frame into the end stiffeners, where possible, given the skew angle and the spacing of girders. An additional connection angle shall be provided where welded stiffener plates are used. If end floor beams are unable to be framed into the girders, consideration shall be given to supporting the end floor beam, and required number of intermediate floor beams, on the substructure beam seat. The bearing devices for the floor beams supported by the substructure beam seats shall be capable of permitting rotation and translation in the longitudinal and transverse directions, where required.
- The end floor beams and connections or girder extensions past the bearings shall be designed such that the bridge can be jacked up by placing jacks under the end floor beams or girder extensions, whichever is most practical. Jacking stiffeners shall be provided at jacking points.
- Thru-girder spans are limited to single and double-track bridges only.
- Refer to AREMA Chapter 15, Section 1.3.13 for fatigue design of superstructure elements.
- Steel members shall be painted. If ASTM A588 weathering steel is used, refer to Section 3.4.6.1.2 for painting requirements.

The following deflection requirements shall apply:

- Floor beams of thru-girder bridges shall meet the deflection criteria limit for live load plus impact of L/640.
- Lateral deflection shall be limited as described in AREMA Chapter 15, Section 1.2.5.
- Girders shall meet the requirements of Section 3.4.5.3.

3.4.6.1.7 Box Girder and Tub Girder Bridges

The minimum sizes of members for new structures shall conform to the requirements of Article 6.11.2 of AASHTO LRFD. The provisions of Article 6.11 of AASHTO LRFD shall be met for the design of box girder and tub girder bridges.

Diaphragms, cross frames, access holes, and lateral bracing shall be provided in box girders as prescribed in Article 6.7 of AASHTO LRFD. The design of these elements must include the construction sequence and applicable constructability checks.

Steel-concrete composite box girders shall be designed and analyzed by rigorous analytical methods with due regard to torsion and other stresses imposed when the rails do not lie in the plane of the webs. Thorough analysis shall be made of the lateral distribution of LRT loads.

Box members do not need to be constructed to be airtight, but shall be designed to be closed to the elements to inhibit water and moisture to the interior. Crevices shall be sealed with a sealant.

Drain holes shall be provided to prevent accumulation of water inside of the sections.

The interior of the boxes shall be painted white to facilitate inspection.

The inside of the boxes shall be lit in accordance with the requirements of Section 3.4.17.2.

The box or tub girder system must be checked against the constructability requirements of Section 3.4.6.1.13.

3.4.6.1.8 Truss Bridges

Trusses shall be designed in accordance with Article 6.14.2 of AASHTO LRFD.

The minimum member sizes shall meet the requirements for member types as prescribed in AASHTO LRFD.

In addition to the requirements of the AASHTO LRFD, unless approved by Owner and effectively connected to both flanges, the lateral bracing of compression chords shall be as deep as the chords. In addition to the shear from lateral forces, the lateral bracing of the compression chords of trusses and the flanges of deck girders shall be proportioned for a transverse shear in any panel equal to 2.5 percent of the axial stress in both members in that panel. Girders shall be cambered to compensate for dead load deflections and for any vertical curvature required by profile grade.

Design details shall minimize the potential for crevice corrosions. Critical members and connections shall be sized for consideration of sacrificial material thickness due to corrosion in accordance with the design life of the structure.

3.4.6.1.9 Multi-Girder Bridges

Rolled beams and built-up plate girder bridge typical sections that carry more than one track shall have a minimum of two beams/girders, one for each rail. Therefore, on a double-track system, four beams/girders shall be used. For single track systems a minimum of three girders shall be used.

For shared use or highway bridges the number of girders and girder spacing shall be coordinated with Owner and/or the AHJ.

The exterior girders shall not be designed for less capacity than the interior girders.

The bridge system must be checked for constructability requirements in accordance with Section 3.4.6.1.13.

The following deflection requirements shall apply to multi-girder bridges:

- Dead Load Camber – Girders of all spans shall be cambered for dead load deflection plus vertical curve correction. The camber tolerance is 0 inches (i.e., nothing) under to ¾ inch over.
- Live Load Deflections – See Section 3.4.5.3.

3.4.6.1.10 Rigid-Frame Structures

Rigid frame-type structures shall be designed in accordance with AASHTO LRFD.

For the purpose of determining the theoretical span length of a beam or girder, monolithic with its support, the support point shall be either the centerline of the supporting element or a point one half of the depth of the beam (measured at the face of support) inward from the face of said support, whichever gives the lesser span. When the width of the monolithic supporting member is more than twice the depth of the beam or girder, the portion of the beam over the support shall be considered as infinitely rigid, and the frame shall be designed accordingly.

3.4.6.1.11 Diaphragms and Cross Frames

The diaphragms and cross frames of LRT bridges shall be designed as primary members to resist the transverse forces due to the lateral distribution of the LRT loads as described in Section 3.4.2. Diaphragm and cross frame connections to girders shall be designed for fatigue loading as described in Section 3.4.5.5.

Refer to AASHTO LRFD or AASHTO, as applicable per Section 3.4.1 for additional requirements for spacing, size, and connections of diaphragms and cross frames.

3.4.6.1.12 Station Platform Structures

Aerial Platforms shall be designed as bridge-type structures. The design shall be in conformance with the applicable codes and load conditions as described in Section 3.4.1 and Section 3.4.2.

Reactions due to loads applied to canopies shall be included.

3.4.6.1.13 Constructability Checks

The requirements of AASHTO LRFD Article 6.10.3 must be met for all stages of construction. The loads for construction shall be factored in accordance with AASHTO LRFD Article 3.4.2. For deflection, load factors shall be taken equal to 1.0.

Sections in positive flexure that are composite in the final condition but non-composite during Construction Work shall be investigated during the various stages of the deck placement. The effect of overhang concrete and brackets, screed, walkways, formwork, and wind loads on the pouring sequence must be checked.

3.4.6.2 Reinforced and Prestressed Concrete Design

3.4.6.2.1 Design Codes

Reinforced and prestressed concrete members for LRT bridges shall conform to the requirements of this Section and the design codes and loading as specified in Sections 3.4.1 and 3.4.2, respectively, unless other specified herein.

3.4.6.2.2 Reinforcing Steel

Moderate exposure conditions shall be used to determine reinforcement distribution requirements.

Reinforcing bar details shall be as per ACI 318 and ACI 315.

3.4.6.2.3 Pretensioning and Post-Tensioning Steel

Refer to AASHTO LRFD for further explanation of parameters.

The minimum center-to-center spacing of pretensioning steel shall be 2 inches.

Post-tensioning strands shall be designed assuming the following parameters:

- Apparent modulus of elasticity: 28,500 ksi.
- Friction coefficient: 0.25 per radian.
- Wobble coefficient: 0.0002 per foot (internal ducts).
- Anchor set: 0.375 inches.

Bar tendons (high-strength threaded bars) shall be designed assuming the following parameters:

- Friction coefficient: 0.30 per radian.
- Wobble coefficient: 0.0002 per foot.
- Anchor set: 0.063 inches.

3.4.6.2.4 Clear Cover

Clear cover requirements shall be as follows:

- Reinforced Concrete – Clear cover shall be 2 inches unless otherwise noted. Clear cover in the bottom and sides of footings shall be 3 inches. For bridge decks using steel forms which remain in place, clear cover in the bottom of deck slabs shall be 1 inch to the top of corrugations. Clear cover in the top of deck slabs and culvert top slabs used as a riding surface shall be 2½ inches.
- Precast Concrete – Clear cover shall be 1½ inches for precast elements except segmental concrete construction, defined below.
- Segmental Concrete Construction – Clear cover for the superstructure shall be as follows:
    - Top riding surface: 2 inches.
    - Outside face of webs: 2 inches.
    - Other locations: 1½ inches.

3.4.6.2.5 Concrete Design

Unbonded and ungrouted prestressing steel shall not be used.

The compressive strength of concrete at the time of initial prestressing shall be a minimum of 80 percent of the 28-day compressive strength.

Requirements for tension stresses are as follows:

- In plain concrete, the extreme fiber tensile stress shall not exceed $0.21f_r$ under service loads, where f_r is the modulus of rupture ($f_r = 7.5\sqrt{f'_c}$ for normal weight concrete).

- In reinforced concrete, the concrete section shall resist no tension stresses. The tension stresses shall be resisted by the tension steel.
- In prestressed concrete, longitudinal tension stresses shall satisfy AASHTO LRFD Article 5.9.4.

3.4.6.2.6 Post-Tensioning Systems

The following requirements shall apply for post-tensioning systems:

- Post-tensioning shall be in accordance with AASHTO LRFD.
- Post-tensioning systems do not need to be designed for fatigue.
- Anchorage systems must be tested and accepted prior to approval.
- The additional local zone reinforcement required to resist bursting and splitting stresses at the proposed anchorage system locations shall be determined.
- After post-tensioning and anchoring have been completed and accepted, the ducts shall be grouted.

3.4.6.2.7 Shrinkage and Temperature Crack Control

The design of shrinkage and temperature reinforcement, and contraction joints, shall be as follows:

- Shrinkage and Temperature Reinforcement – Shrinkage and temperature reinforcement for above-ground concrete structures shall be designed per the requirement of AASHTO LRFD 5.10.8 or AASHTO 8.20, as applicable.
- For concrete walls, slabs, and footings less than 48 inches thick and resting directly against earth, minimum temperature and shrinkage reinforcement shall be 0.15 percent of the gross concrete area. For members larger than 48 inches thick, the temperature and shrinkage reinforcement requirements shall be in accordance with the crack control measures as recommended by AASHTO LRFD 5.10.8 or AASHTO 8.20, as applicable. For crack control, the maximum bar spacing shall be 18 inches on center.
- Contraction Joints – To control shrinkage stresses in concrete slabs and walls and to minimize cracking, a unit length of 30 feet or less between contraction joints shall be preferred. For units longer than 30 feet between contraction joints, the construction procedures and requirements for temperature and shrinkage reinforcement shall be in accordance with the crack control measures as recommended by ACI 318.
- Expansion Joints - To control shrinkage stresses in concrete walls and to minimize cracking, a unit length of 90 feet or less between expansion joints shall be incorporated into the design.

3.4.6.2.8 Segmental Concrete Construction

The following design provisions apply to the design of precast or cast-in-place segmental post-tensioned concrete bridges. The design shall satisfy the requirements of AASHTO LRFD Article 5.14.2, “Segmental Construction.” Wherever applicable, other sections of these structural design provisions shall apply.

- Specifications – For items not specifically addressed below or in AASHTO LRFD, consult the applicable guideline or standard.

- Notation – Unless otherwise indicated, the notations used in these criteria correspond to the notations contained in AASHTO LRFD. Other codes are specified where necessary.
- Shrinkage and Creep – Creep and shrinkage strains shall be determined using the provisions in Chapter 2 of Comite Euro-International De Beton - Federation Internationale De La Preconstrainte Model Code for Concrete Structures, 1990. Moment redistribution in a continuous structure shall be considered for the effect of shrinkage and creep. Resulting stresses shall be calculated assuming a realistic construction sequence submitted to Owner.
- Prestressing – AASHTO LRFD Articles 5.9 and 5.10 shall be referenced. The structure shall be designed for both initial and final prestressing forces. The design shall satisfy the following criteria:
    - Box girder deck slabs shall be transversely post-tensioned.
    - If draped tendons are used in the deck slab, consideration shall be given to the final location of the center of gravity of the strands within the duct. Critical eccentricities over the web and at the centerline of the box shall be reduced by ¼ inch from the theoretical value to account for construction tolerances.
    - The effect of structural indeterminacy shall be examined.
    - In the design of horizontally curved bridges, special consideration shall be given to the effect of the lateral force component of the curved tendons using the provisions in AASHTO LRFD Article 5.10.4.3. When a tendon curves in two planes, the in-plane and out-of-plane forces shall be added as vectors.
    - If the fundamental natural frequency of the tendons is in the range of 0.8 to 1.2 times that of the bridge, excessive vibrations of external post-tensioning tendons may occur. Unless a vibration analysis indicates otherwise, the unsupported length of external tendons shall not exceed 25 feet.

3.4.6.2.8.1 Allowable Stresses

Concrete Allowable Stresses:

- Concrete allowable stresses, in the transverse and longitudinal directions, under temporary construction loads at the service limit state shall follow AASHTO LRFD Article 5.14.2.3.3; and
- Concrete allowable stresses for permanent loading conditions shall satisfy AASHTO LRFD Article 5.9.4.

Prestressing Allowable Stresses:

- For low-relaxation prestressing tendons:
    - Maximum jacking stress: 0.8 f_{pu} but not to exceed 0.90 f_{py}.;
    - At anchorage after anchoring: 0.70 f_{pu}.;
    - At other locations after anchoring: 0.74 f_{pu}.; and
    - At service limit state after losses: 0.80 f_{py}.
- For prestressing bars:
    - Maximum jacking stress: 0.72 f_{pu} (0.9 f_{py});

- At anchorage after anchoring: 0.70 f_{pu} ; and
- At service limit state after losses: 0.80 f_{py}.

3.4.6.2.8.2 Box Girder Proportions

The box girder cross-section dimensions shall satisfy the requirements of AASHTO LRFD Article 5.14.2.3.10. The overall dimension of the box girder cross-section shall not be less than that required to limit the live load plus impact deflection, calculated using the gross section moment of inertia and the secant modulus of elasticity, to 1/1,000 of the span.

See the commentary of AASHTO LRFD Article 5.14.2.3.10d for determining girder depth and web spacing.

Segment weight shall be suitable for construction and erection equipment.

3.4.6.2.8.3 Analysis Method and Mathematical Computer Modeling

Analysis of segmental bridges shall follow the guidelines outlined in AASHTO LRFD Article 4.6.2.9. Elastic analysis and beam theory may be used to determine design moments, shears, and deflections.

The analysis shall be conducted in both the transverse and longitudinal directions. The effect of secondary moment due to prestressing shall be included in stress calculations at the service limit state. At the strength limit state, the secondary force effects induced by prestressing, with a load factor of 1.0, shall be added algebraically to the force effects due to other factored loads.

The effective flange width for box girders shall be based on AASHTO LRFD Article 4.6.2.6. The capacity of the cross-section at the strength limit state shall be determined by considering the full compression flange width effect. Shear lag shall be considered for service load stress calculations.

Mathematical models shall include loads, geometry, material behavior, and response characteristics of the structure foundation and soil-structure interaction. The computer model shall verify the anticipated structural behavior and must include the construction stages suggested for the Project. It must also account for the final status of the bridge under service loads, as well as the effect of time-dependent factors such as creep, shrinkage, and prestressing losses.

3.4.6.2.8.4 Design Method

All applicable limit states including, but not necessarily limited to, strength, extreme events, service, and fatigue shall be satisfied in accordance with these design provisions and the AASHTO LRFD specifications. The service limit state shall cover at a minimum cracking, deformations, deflections, and concrete stresses.

For the strength limit state, the resistance factors shall follow AASHTO LRFD Article 5.5.4.2. The structure as a whole shall be proportioned to resist collapse due to extreme events specified in AASHTO LRFD Table 3.4.1-1 as may be appropriate to its site and use.

The deck shall be designed per AASHTO LRFD Article 9.7.6, “Deck Slabs in Segmental Construction.”

3.4.6.2.8.5 Shear and Torsion

AASHTO LRFD Article 5.8.6 shall be applied for shear and torsion design.

Checks for principal tensile stresses shall be performed in accordance with AASHTO LRFD Article 5.8.5 as a method of preventing cracking under service load conditions.

3.4.6.2.8.6 Total Web Reinforcement

The total web reinforcement shall be designed in consideration of the combined effects of vertical shear and torsion and transverse web bending per AASHTO LRFD Article 5.8.1.5.

3.4.6.2.8.7 Segmental Construction Joints

Joints in precast segmental bridges shall be either cast-in-place closures or match cast.

Cast-in-place concrete joints and epoxy joints between precast units shall be considered as Type A joints. Dry joints considered as Type B joints are not permitted.

The resistance factors of joints in flexure and shear shall follow that of AASHTO LRFD Table 5.5.4.2.2-1.

For Type A joints, auxiliary bonded reinforcement through the joint may be provided at a stress of 0.5 fy to carry the allowable tensile force in accordance with AASHTO LRFD Tables 5.9.4.1.2-1 and 5.9.4.2.2-1.

The concrete strength of the cast-in-place closures shall not be less than that of the precast concrete. The width of the closure shall permit the development of the reinforcement in the joint or coupling of the tendons ducts, if used.

3.4.6.2.8.8 Shear Keys

The total depth of web shear keys shall be 75 percent of the section depth and its width shall be at least 75 percent of the web thickness in accordance with AASHTO Article 5.14.2.4.2.

Alignment keys on the top and bottom slab shall also be provided to correct the alignment of the two match-cast segments being erected.

Shear and alignment keys shall not both be located in the tendon duct zones.

3.4.6.2.8.9 Erection Schedule and Construction

The method of construction assumed for the design shall be shown in the Design Documents. Temporary supports required prior to the time when the structure, or its components, is capable of supporting itself and subsequently applied loads, shall be clearly shown in the Design Documents.

A typical erection schedule and anticipated construction system shall be incorporated into the Design Documents in an outlined schematic form. The assumed erection loads, along with time of application and removal of erection loads, shall be clearly stated in the plans.

3.4.6.2.8.10 Construction Data Elevations and Camber Curve

Construction data elevations shall be based on the vertical and horizontal geometry. Camber curves shall be calculated based on the assumed erection loads and schedule used in the design, as well as the assumed construction sequence. Camber curve data shall be provided at the centerline of the box.

3.4.6.2.8.11 Integrated Drawings

Design Documents shall be prepared in accordance with AASHTO LRFD Article 5.14.2.3.9. Congested areas of post-tensioned concrete shall be shown on integrated drawings with an assumed post-tensioning system.

Such areas include, but are not necessarily limited to, anchorage zones, areas containing embedded items for the assumed post-tensioning system, areas where post-tensioning ducts deviate both in the vertical and transverse directions, and other highly congested areas.

Integrated drawings utilizing the assumed system shall be detailed to show reinforcing and post-tensioning steel in complete three-dimensional (3-D) drawings.

3.4.6.2.8.12 Segmental Box Drainage

For segmental concrete construction, 2½-inch diameter drainage holes shall be provided at the low side of each segment.

3.4.6.2.9 Multi-Girder Bridges

Shapes such as spread boxes, T-beams, double-Ts, and slab structures may be considered for use in bridge projects, provided the beams satisfy applicable design criteria. Exterior girders shall not be designed for less capacity than the interior girders.

3.4.6.2.10 Rigid-Frame Structures

For the purpose of determining the theoretical span length of a beam or girder, monolithic with its support, the support point shall be either the centerline of the supporting element or a point one half of the depth of the beam (measured at the face of support) inward from the face of said support, whichever gives the lesser span. When the width of the monolithic supporting member is more than twice the depth of the beam or girder, the portion of the beam over the support shall be considered as infinitely rigid and the frame shall be designed accordingly**.**

3.4.6.2.11 Culverts and Buried Structures

Culverts and other buried structures carrying LRT loads shall be designed to carry applicable loads from Section 3.4.2, in accordance with AREMA Chapter 8, Parts 10 and 16. References to track loading within AREMA Chapter 8 shall consider the LRT loads as described within this provision.

3.4.6.2.12 Approach Transitions

A transition from a bridge deck to the rail section off of the bridge shall be provided at the approach to bridge structures.

Approach slabs shall be provided at the approaches to bridge structures carrying only LRVs where the approach and bridge both support the same track system, either direct-fixation track, embedded track, ballasted track, or different trackforms. Approach slabs shall also be provided for bridges with the combination of light rail and highway vehicles where required by the local governing jurisdiction. If the bridge is designed with an integral abutment, regardless of the loading on the bridge, an approach slab supported by a sleeper slab shall be provided. At the end of the approach slab, a biaxial geogrid transition for an integral abutment shall be provided to strengthen the soil. The biaxial geogrid shall be designed in accordance with Part 2A, Section 4 of the Technical Provisions.

The approach slab shall be constructed on a minimum of 1 foot of sub-ballast extending 2 feet beyond the sides of the approach slab.

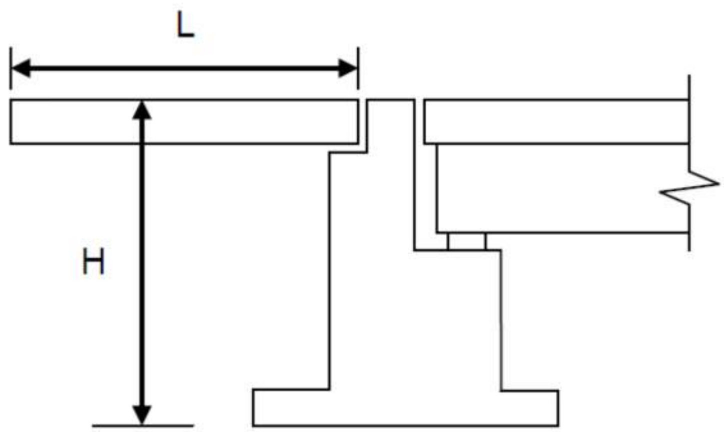
The approach slab shall have a minimum length of 20 feet and a maximum length of 25 feet, measured along the centerline of the bridge. Ideally, the length of the approach slab shall equal the height of the bridge abutment. As shown in Figure 3.2, the dimension “L” equals the dimension “H,” as far as is reasonable and possible. The width of the approach slab shall be the same as the width of the bridge. The width of the pedestrian rail or curb does not need to be included in the width of the approach slab.

The end of the approach slab shall be perpendicular to the track centerline. The effects due to skew shall be accounted for.

The approach slab shall be designed to support the maximum moment and shear for applicable loadings as described in Section 3.4.2. The slab shall span from the abutment backwall to the sleeper slab without taking into account any bearing resistance of the fill below the approach slab. Differential settlement across approach slabs shall be less than 1/2 inch and accounted for in the design. If necessary to meet this requirement, ground improvement techniques to the approach embankment subgrade may be implemented.

To reduce water in embankment fills at bridge abutments, an underdrain system shall be designed beneath the approach slabs. Drains on the bridge deck shall be located to minimize the amount of water flowing across joints.

Figure 3.2 – Approach Slab Length



3.4.6.2.13 Sleeper Slabs

Sleeper slabs shall be provided to support approach slabs at an integral abutment. The sleeper slab shall be designed to resist applicable loads, as outlined in Section 3.4.2.

3.4.6.2.14 Moment Slabs

Moment slabs shall be provided at MSE walls supporting LRT and/or highway and/or pedestrian loads. Moment slabs shall be designed in accordance with NCHRP *Report 663, Design of Roadside Barrier Systems Placed on MSE Retaining Walls*, to resist all loads as described in Section 3.4.2, including derailment where emergency guardrails are not provided and vehicular collision loads, as applicable. The applicable vehicular collision load shall be determined by the local jurisdiction.

The moment slabs must be designed for shear resistance without the use of shear stirrup reinforcement. Moment slabs shall be a minimum of 20 feet long between contraction or expansion joints.

3.4.6.2.15 Integral Abutments

Integral abutments shall be designed to support the maximum moment and shear due to all applicable load combinations as described in Section 3.4.2.

3.4.6.2.16 Slabs-on-Grade

Structural slabs shall be designed to handle the maximum moment and shear due to all loading that may be potentially placed upon them as described in Section 3.4.2. For slabs in areas handling pedestrian loading and snow loads only, design shall include HS-15 truck loading (as defined in AASHTO) at a minimum. Reinforcing in areas exposed to weather and de-icing chemicals shall have galvanized or epoxy coated reinforcement.

A designed graded aggregate base shall be placed beneath the slab-on-grade. This material shall extend a minimum of 2 feet beyond the sides of the slab. The modulus of subgrade reaction will be based on the specific soil information for the site and shall be adjusted to account for the size of the track slab.

3.4.6.2.17 Station Platforms

Aerial Platforms shall be designed as bridge-type structures. The design shall be in conformance with the applicable codes and load conditions as described in this provision.

The reactions due to the loads applied to the canopies shall be included.

3.4.6.2.18 Shrinkage and Creep

Stresses and movements resulting from concrete shrinkage and creep shall be considered in the design and included in all load combinations. The shrinkage coefficient shall be assumed to be 0.0002 inches per inch for both prestressed and reinforced concrete. To minimize creep problems the average prestressing compression stress after losses shall not exceed 1,000 psi.

3.4.6.2.19 Bridge Deck Overhangs

The maximum bridge deck overhang width permitted for multi-girder bridges shall be less than the following:

- the depth of the exterior beam;
- 40 percent of the spacing of the beams; and
- 4 feet.

Reference Section 3.4.6.2.8 for bridge deck overhang widths for segmental construction.

For Station overhangs subject to pedestrian loads, the maximum overhang shall be designed to accommodate all loads described in Section 3.4.2, as applicable. The overhang must be checked for vibration and deflection for bridges in accordance with Section 3.4.5.

3.4.6.2.20 Shear Keys

Shear keys shall be provided to resist shear forces between two adjacent but separate concrete cast-in-place pours. Adjacent pre-cast concrete units shall be doweled and grouted together with a shear key.

See Section 3.4.6.2.8 for specific requirements for the shear keys for segmental construction.

3.4.6.2.21 Parapets and Concrete Barriers

Two conduits, each 3 inches in diameter, shall be provided in all parapets and concrete barriers along both sides of a structure.

Slipforming shall be considered for the construction of parapets and concrete barriers.

Parapets shall have a minimum height of 42 inches above low rail.

3.4.6.2.22 Chamfer

The exposed edges of all reinforced concrete structures shall be chamfered ¾ inch.

3.4.6.2.23 Camber and Dead Load Deflections

All girders of all spans shall be cambered for dead load deflection. The camber tolerance is 0 inches (i.e., nothing) under to ¾ inch over.

The total long term predicted camber growth less deflection due to full dead load shall be limited to 1/2,000 of the span length.

3.4.6.2.24 Mass Concrete

Structural mass concrete is defined as any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking. A placement of structural concrete with a minimum dimension equal to or greater than 4 feet shall be considered mass concrete. Similar considerations shall be given to other concrete placements that do not meet this minimum dimension but contain Type III cement, accelerating admixtures, or cementitious materials in excess of 660 pounds per cubic yard of concrete. Consideration shall also be given to placements that trap heat. Mass concrete shall be designed such that the structure can be poured to minimize cracking.

Admixtures may be used to improve concrete workability and to aid in air entrapment. High-early-strength cement, calcium chloride, and accelerating-type admixtures shall not be used. Ground granulated blast furnace slag or fly ash may be used in the mix to reduce the heat of hydration. Slag or fly ash may be used as a cementitious replacement material for cement up to a maximum limit of 50 percent by weight of total cementitious material in the mix. Refer to AASHTO *LRFD Bridge Construction Specifications* Section 8.4 for additional information. Slag and/or fly ash shall be from single sources approved by Owner and shall be compatible with the type of cement used and thoroughly blended in the mix. Refer to Section 3.5.22 for restrictions on the use of fly ash.

Temperature monitoring shall be implemented during Construction Work. A mass concrete control plan shall be submitted to Owner for review and approval prior to placement of any concrete.

3.4.6.3 Foundations

Bridge and transportation structure foundations may be either shallow or deep. All applicable loads and combinations as listed in Section 3.4.2 shall apply.

Concessionaire's foundation systems shall accommodate the site constraints and shall accommodate the ultimate configuration, as well as any interim configuration required. Concessionaire shall confirm that the strength and serviceability requirements of the foundation are satisfied through engineering analyses and load testing. The performance of the foundation (i.e., settlement, lateral movement and any end-condition restraints) shall not adversely impact any existing Structure. Concessionaire shall determine allowable settlements and deflections based on AREMA, AASHTO and IBC codes and engineering analysis.

Concessionaire's safety factors and resistance factors shall adhere to the applicable AREMA, AASHTO and IBC codes.

Concessionaire shall not use timber piles or auger cast piles for any bridge, retaining wall, culvert or underpass foundation supporting LRT or highway loading. Drilled shaft resistance factors for drilled shafts shall not be used for auger cast piles. Concessionaire shall design auger cast piles in accordance with FHWA HIF-07-039, Geotechnical Engineering Circular No. 8 – Design and Construction of Continuous Flight Auger Piles.

Foundation designs shall consider and document the scour elevations and shall consider the effects of the extreme event earthquake for the local vicinity.

Deep concrete foundations shall be reinforced for their full length. Reinforcement shall be in accordance with the AASHTO LRFD or AASHTO.

When new foundations are to be constructed adjacent to existing foundations, Concessionaire must adhere to the requirements of adjacent work and also account for loading influences.

3.4.6.4 Bearing Design

The bearing and any additional plates shall be designed so that the combined system is stiff enough to prevent distortions of the bearing which would impair its proper functioning, and the stresses imposed on the supporting structure.

All girders shall be positively located on their supporting bearings by a connection which can resist the longitudinal and transverse forces which may be imposed on it.

Bearings shall be designed for girder lengthening and rotation due to all possible loading conditions.

Guides and restraints shall be used to prevent and/or limit movement in one or more directions.

Expansion bearings shall be able to accommodate the full anticipated longitudinal movement plus an allowance for construction tolerances. The minimum construction tolerance shall be ½ inch for every 100 feet of span length, but not less than a total of 1 inch.

The bearings must be accessible for inspection and replacement.

Potential uplift at the bearings must be investigated for all construction stages.

3.4.6.4.1 Bearing Components

Sole plates shall have a minimum thickness of 1 inch. Masonry plates shall be positively secured to their supports by bolting or welding.

If the inclination of the underside of the girder to the horizontal exceeds 0.01 radian, a tapered sole plate shall be used in order to provide a level load surface to be placed on the bearing. This requirement shall be met under full dead load at the mean annual temperature for the structure site.

Anchor bolts shall have a minimum diameter of 1¼ inches. Anchor bolt holes in pedestals, masonry plates, or sole plates shall be ⅜ inch larger in diameter than the bolts. Anchor bolts/rods shall extend a minimum of 12 inches into masonry substructures. Anchor bolts/rods shall be swedged or threaded. Anchor bolts shall extend through the sole plate when they will not impede bearing function.

Anchor bolts shall be designed for bending over their length between the sole plate and the masonry plate. The bending induced in the anchor bolt may be reduced if shear blocks are used to reduce the moment arm. Anchorage to concrete shall be designed in accordance with ACI 318, Appendix D.

At least 6 inches of cover shall be provided between anchor bolts and the closest edge of the concrete.

Reinforcement shall be provided for pedestals greater than 3 inches high.

Concessionaire shall include a 1/8-inch thick preformed fabric pad in accordance with Section 910.02.03 of MDSHA's *Standard Specifications for Construction and Materials* beneath the masonry plate.

3.4.6.4.2 Elastomeric Bearings

All elastomeric bearings shall be steel reinforced. Steel reinforcement shall be a minimum of 0.0598 inch (16 gauge) thick and shall be stainless steel Type 304. The design of elastomeric bearings for bridges carrying LRVs shall be in accordance with Method A of AASHTO LRFD. The design of all elastomeric bearings shall consider provisions for seismic, compressive stress, compressive deflection, shear deformation, rotational capacity, stability, reinforcement strength, and anchorage.

The elastomer shall have a shear modulus between 0.08 and 0.175 ksi and a maximum nominal hardness of 60 durometer. All other material properties shall be in accordance with AASHTO LRFD Section 14, "Bearings."

When some combination of loads exist that causes a shear force greater than one-fifth of the simultaneously occurring or minimum vertical compressive force, whichever is smaller, the pad shall be secured against horizontal movement to ensure that the bearing does not "walk out" from under the girder. If the elastomeric pad is vulcanized to the sole and masonry plates, this requirement is not applicable.

Uplift forces for elastomeric bearing pads shall not be permitted.

Polytetrafluorethylene (PTFE) bearings shall be in accordance with AASHTO LRFD. The PTFE self-lubricating bearing element shall be composed of 100 percent virgin (unfilled) PTFE polymer, bonded to a rigid confining substrate. The substrate shall limit the flow (elongation) of the PTFE to not more than 0.009 inch under a load of 2,000 pounds for 15 minutes at 78 degrees Fahrenheit for a 2 inch-by-3 inch test sample. The virgin (unfilled) PTFE shall have a thickness not less than 1/32 inch. The properties of the PTFE shall conform to the requirements of Table 3.5.

Table 3.5 – PTFE Properties		
Requirements	Test Method	Value
Hardness at 78°F (26°C)	ASTM D2240	50 to 65 Durometer D
Tensile Strength	ASTM D1457	2,800 psi (20 MPa) (minimum average)
Elongation	ASTM D1457	200% (minimum average)
Deformation under load at 78° F (26 °C), 2,000 psi (14 MPa), 1/2 x 1/2 x 1/32 in. (13 by 13 by 1 mm)	ASTM D621	4% (maximum)
Specific Gravity	ASTM D792	2.14 to 2.21

3.4.6.4.3 Spherical Bearings

All spherical bearings shall consist of two metal parts with matching curved surfaces and a low-friction sliding interface, and shall be in accordance with AASHTO LRFD Article 14.7.3. The sliding surfaces may consist of PTFE or bronze or copper alloys in accordance with AASHTO LRFD Articles 14.7.2 and 14.7.7.

Guide bars shall be provided for guided expansion bearings. The length of the guide bars shall be set based on a thermal movement due to a 60-degree change in temperature, a 1 inch construction tolerance, and 1 inch clear distance from the end of the concave plate to the end of the guide bar.

3.4.6.4.4 Disc Bearings

Disc bearings shall consist of a polyether urethane elastomeric structural element (disc) confined by upper and lower external steel load plates. Disc expansion bearings may also include a flat sliding surface to allow for horizontal movement.

The confining elements of the lower external steel load plate may be integrated into an appropriately designed masonry plate or may be designed as separate elements with the lower load plate bolted or welded to the masonry plate.

For fixed disc bearings without a flat sliding surface, the confining elements of the upper external steel load plate may be integrated into an appropriately designed sole plate or may be designed as separate elements with the upper load plate bolted or welded to the sole plate. For expansion disc bearings with a flat sliding surface, the confining elements of the upper external steel load plate may be integrated into an appropriately designed base plate that also supports the sliding element.

Disc bearings shall be equipped with a shear restriction mechanism to prevent movement of the disc.

Disc bearings shall adequately provide for the thermal expansion and contraction, rotation, camber changes, and creep and shrinkage of structural members.

3.4.6.5 Joints

Joints shall be provided in accordance with local jurisdictions.

The use of joints on Owner bridges and aerial structures shall be minimized. When feasible, compression seals are preferred. If larger movements are to be accommodated, finger joints are preferred. Joints do not have to be similar at all locations on a bridge (i.e., a finger joint may be used at one abutment and a compression seal at the other).

3.4.7 Cut-and-Cover Underground Structures

This Section includes additional requirements for the design of underground structures, except for mined tunnel linings and shafts. The components of the excavation system are:

- Excavation support wall
- Bracing system – When buildings or adjacent property lines are in close proximity to the excavation, ground anchors shall not be used. Mixed wale-and-strut and wale-and-ground-anchor systems may be used.

Rock bolts may be installed in excavation sidewalls for cut-and-cover excavations that locally extend into rock. The proximity of property lines shall be considered when designing rock bolts.

Retained excavations, which are open excavations with a continuous concrete invert, that connect at-grade LRT facilities to underground structures of various types defined herein, are considered to be underground structures for purposes of these Contract Documents.

3.4.7.1 Loads for Design of Cut-and-Cover Underground Structures

Loads used for the design of underground structures shall be the same as for all other structures, except as noted below. The structural drawings shall include plans showing the design loads.

Structures shall be modeled taking into account the stiffness of the surrounding material.

- Dead Load (DL)– The DL shall consist of the weight of the basic structure and weight of the secondary elements permanently supported by the structure. For cut-and-cover structures, dead load shall include the weight of earth cover supported by the roof of the structure and acting as a simple gravity load.
    - All cut-and-cover underground structures shall be designed for the actual cover depth or for an assumed minimum cover depth of 8 feet when actual cover depth is less than 8 feet.
    - Dead load shall include miscellaneous loads of any system or facility that shall apply a permanent load on the structure.
- Live Loads – Refer to Section 3.4.2.2 for live loads.
- Railings – Refer to Section 3.4.2.2 for railing loads.
- Curbs – A horizontal force of 500 plf shall be applied at the top of curbs on permanent structures.
- Lateral earth pressure
- Water pressure
- Surcharge loads – Surcharge loads shall be as established in Section 3.4.2.9.
- Air pressure due to ventilation

- Air pressure due to moving Trains
- Seismic Loads – Seismic design shall be in accordance with the seismic requirements provided in Section 3.4.19.

3.4.7.2 Load Combinations for Design of Cut-and-Cover Underground Structures

In addition to the load combinations cited elsewhere in this Section for the design of all Project structures, the load cases outlined for Underground Stations in Section 3.3.2.20 shall be analyzed for the design of underground structures. Maximum and minimum values of the load factors shall be in accordance with AASHTO Table 3.4.1-2.

3.4.7.3 Buoyancy

A minimum factor of safety against flotation of 1.0 shall be provided, with a factor of 0.9 applied to resisting permanently acting dead loads. The weight of backfill over the structure within vertical planes extending up from the outside faces of the structure may be taken to resist flotation. Friction against foundation elements may be included.

3.4.8 Earth Retaining Structures

This Section outlines provisions for the design of abutments, wingwalls, retaining walls, and other earth retention structures. The requirements specific to the cut-and-cover underground structures shall be in accordance with Section 3.4.7.

3.4.8.1 Computation of Applied Forces

Computation of applied forces shall be in accordance with Section 3.4.2.9 of these criteria and supplemented by AREMA Chapter 8, Section 5.3, “Computation of Applied Forces;” AASHTO LRFD Article 11 “Abutments, Piers and Walls;” AASHTO Article 5 “Retaining Walls;” IBC Article 1807; or IRC Article 404.

Global stability of all retaining walls shall be evaluated based on classical slope stability analysis. The external stability of all retaining walls shall be evaluated based on bearing capacity, overturning, and sliding.

Internal stability and compound stability (where the critical failure surface passes through the reinforcement) of MSE walls shall be evaluated.

Retaining wall layout shall address slope maintenance above and below the wall. The ends of the retaining wall shall be buried or returned into the retained fill or cut. Any residual wall batter shall be into the fill.

A fence or railing with a minimum height of 42 inches above a standing surface shall be provided at the top of walls 30 inches or greater.

3.4.8.2 Type

Segmental retaining walls, modular block walls, gravity walls and timber walls, including bin walls, concrete or timber crib walls, and gabion walls, shall not be permitted to retain LRT, railroad, highway or waterway loadings and may only be used as secondary walls with Owner approval. Recycled material walls shall not be permitted for permanent retaining walls.

The design and installation of proprietary earth retaining structures must be reviewed and approved by Owner.

3.4.8.3 Design Requirements

Retaining walls shall be designed in accordance with the applicable standards and references outlined. Retaining walls must be designed to withstand earth and hydrostatic pressures, including any live load surcharge and the dead weight of the wall.

For retaining structures constructed immediately adjacent to the LRT Guideway, Concessionaire must determine if the structure is within the soil pressure zone of influence due to the LRV loading. If applicable, the surcharge load shall be included. Any adjacent surface elements (such as Traction Power mast supports) that may exert a surcharge loading on the retaining structure must also be considered.

For retaining structures supporting WMATA, CSXT Railroad, Amtrak, existing buildings or other significant structures, Concessionaire must determine if the proposed earth retaining structure is within the soil pressure influence zone due to the existing element(s). If applicable, the surcharge loads shall be included.

Design and construction shall consider surface and subsurface drainage. A drainage system shall be provided to intercept or prevent surface water from entering behind walls, and mitigate the build-up of hydrostatic pressure. Both the water pressure and the lateral soil pressure must be considered in the design. Waterproofing and dampproofing shall be applied in accordance with Section 422 of MDSHA's Standard Specifications for Construction and Materials.

All retaining wall components, not owned and maintained by others, shall remain within Project ROW.

The design of all wall systems must consider the constructability of the system.

3.4.8.4 Characteristics of Permanent Retaining Walls

3.4.8.4.1 Primary Walls Retaining LRT, Railroad, and/or Highway

The following types of retaining walls may be used as primary walls for LRT, railroad, and/or highway loads.

- Mechanically Stabilized Earth (MSE) Walls – MSE walls shall be in accordance withPart 2A, Section 4 of the Technical Provisions. MSE wall designs shall include site-specific corrosion protection/prevention measures. Concessionaire shall address the potential for accelerated corrosion or deterioration of structural elements of MSE walls due to the relatively high permeability of roadbeds and the potential for precipitation, other potentially corrosive substances infiltrating the roadbed, and stray currents.
- Cast-in-Place Concrete Walls – Construction joint spacing shall accommodate differential settlement.
- Top-Down Walls – Cantilever sheet pile walls and cantilever soldier pile and lagging walls may be used when top-down construction is warranted. Cantilever sheet pile walls shall have a maximum exposed height of 10 feet. Cantilever soldier pile and lagging walls may be taller but shall be checked for deflection. Lagging shall consist of horizontal sheet piling or precast concrete panels. Lagging shall not consist of timber. Permanent top-down walls shall have a layer of concrete facing that is a minimum of 8 inches thick. Shotcrete shall not be used for final finish facings. Refer to Exhibit 3.11 for finish requirements.
  - Soldier pile and lagging walls may be designed using tie-backs and anchors. Tie-back wall design and construction shall conform to FHWA RD-82-046, FHWA RD-82-047, and FHWA-IF-99-015. Anchors shall be encapsulated with plastic

sheathing. Proof load tests and verification (performance) tests for anchors shall be provided in accordance with the specified FHWA guidelines.

    - Concessionaire shall analyze cut walls in accordance with AASHTO LRFD based upon the guidelines for analyses set forth in FHWA design manuals. Other external load requirements shall be taken into consideration, along with the potential for high at-rest (Ko) conditions imposed by over-consolidated soils.

- Modular and Soil Nail Walls – Modular walls shall not be used as the primary retaining walls for LRT or railroad tracks, or highways. Soil nail walls shall not be used as the primary retaining walls for LRT or railroad tracks but may be used for retaining highway sections or cuts above LRT/railroad tracks if structural facings are provided.
    - Modular walls shall not be used when a crash wall is required in areas encroaching on the horizontal clearance envelope of the LRV.
- Tie-Backs – All tie-backs, where permitted, must remain in Project ROW or within permanent subsurface easements.

3.4.8.4.2 Secondary Walls Retaining Earth, Buildings, and/or Pedestrian Traffic

In addition to the wall types listed in Section 3.4.8.4.1, above, the following types of retaining walls may be used for secondary retaining walls, such as park-n-ride and LRT Stations:

- Modular Walls – Modular walls shall be in accordance with Part 2A, Section 4 of the Technical Provisions. Where allowed, modular wall height shall not exceed 15 feet, and a mechanical connection to the wall facing for soil reinforcement shall be provided; friction connections relying on gravity alone are not acceptable. Concessionaire shall design modular block walls in accordance with either NCMA Design Manual for Segmental Retaining Walls or AASHTO. Backfill requirements shall be in accordance with AASHTO Soil Groups A-1, A-2-4, and A-2-6. If the material in the reinforcement zone contains more than 12-percent passing the #200 sieve-size, a separate drainage system shall be used.
- Soil Nail Walls – Soil nail walls may be used when top-down construction is warranted. Soil nail walls shall not be used if groundwater seepage may be a problem. Design and construction shall conform to FHWA-RD-89-93, FHWA-SA-93-068, FHWA-SA-96-069, and FHWA-IF-03-017. Load testing for nails shall be provided in accordance with these FHWA guidelines. Soil nail walls shall have a minimum temporary facing thickness of 4 inches and a minimum permanent facing thickness of 8 inches. Shotcrete shall not be used for final finish facings.
- Gravity Walls – Gravity walls, including bin walls, concrete or timber crib walls, and gabion walls, shall not be permitted without Owner approval.

3.4.8.5 Deflection Limits

The overall horizontal deflection at the top of top-down secondary retaining walls shall be limited to H/100 or 2 inches, whichever is less at the head (top) of the wall. The overall horizontal deflection at the top of top-down primary retaining walls shall be limited to 1 inch at the head (top) of the wall. The effects of wall movements on adjacent facilities shall be considered in the development of the wall design. Retaining wall deflections shall not detract from the serviceability, usefulness, or aesthetics of the walls or any structures or facilities supported by the wall.

This deflection shall be accounted for when determining the clearance between the LRV and the track.

The deflection of single shaft and pole foundations shall be checked and compared against the ultimate fixity location.

3.4.8.6 Vibrations

The potential effects of vibrations created during the construction of any retaining walls or foundation elements shall be considered. Vibrations shall be mitigated so as to not inflict damage upon any nearby structures. USBM RI 8507 and AASHTO R 8-96 shall be consulted when establishing vibration limits.

3.4.8.7 Characteristics of Temporary Retaining Walls

Characteristics of temporary retaining walls shall be in accordance with Section 3.4.8.4 except that timber lagging shall be acceptable. Deflection limits shall be as specified in Section 3.4.8.5.

3.4.8.8 Form Liner

A minimum cover of 2 inches from the maximum relief to the reinforcement shall be required for all form liners.

3.4.9 Noise Walls

All components of noise walls shall be designed in accordance with the prevailing design code as outlined in Section 3.4.1 The foundation design shall correspond to the same prevailing design code as used for the noise wall components.

If the noise wall is structure-mounted, the service load reactions obtained at the base of the noise wall shall be factored in accordance with AASHTO LRFD load combinations and shall be applied to the structure.

3.4.9.1 Setback and Spatial Requirements

Setback and spatial requirements for noise walls shall be as follows:

- The setback of proposed noise walls must meet the clearance and ROW requirements of Section 3.4.12;
- All noise wall components shall remain within the ROW;
- Where ROW constraints allow, noise walls shall be setback a minimum of 10 feet from the ROW line to allow for maintenance; and
- Noise walls shall be located as outlined in the Contract Documents.

3.4.9.2 Types of Walls

Noise walls shall be designed and detailed utilizing the MDSHA *Noise Barrier Standard Drawings*, or an approved proprietary noise barrier system, and the design of noise wall elements shall be in accordance with AASHTO *LRFD Bridge Design Specifications*. In addition, the following requirements shall apply:

- Wooden noise walls shall not be permitted;
- Noise wall systems shall have a minimum sound transmission coefficient of 25;
- The maximum height for a proposed noise wall shall be 34 feet above the finished ground line. Bridge-mounted heights greater than 12 feet above the bridge deck require Owner approval;

- Post type and design shall be compatible with the panel design in terms of texture, color, acoustical profile, and scale;
- A single type of post shall be used for the entire length of noise walls. Posts on bridges shall not be connected to the vertical faces of parapets; rather, the parapet shall be widened to allow for mounting; and
- Consistent post spacing shall be used for the entire length of noise walls. Where consistent post spacing is not possible, Concessionaire shall provide the illusion that the spacing of posts is equal through the use of false posts and special double-wide panels.

3.4.9.3 Foundations

Design shall conform to the standards set forth in this Section and shall be based upon any one of three MDSHA standard barrier detail post spacings (12, 16, or 20 feet) using 30- to 36-inch drilled shaft diameters for panel heights up to 24 feet and 36 to 48-inch diameters for panels over 24 feet in height. Maximum theoretical deflection at the head of drilled shafts shall be limited to 1 inch using the design methodology described in this Section. Sloping ground conditions shall be considered in the evaluation of noise wall foundations.

Where the foundation will be supported on an embankment, after an embankment is built, the embankment materials may be tested using SPT soil borings, physical property testing of Shelby tube samples, or other in-situ testing probes to determine the properties of the embankment material. These engineering parameters may be used to design the depth and size of noise wall drilled shaft foundations. Design shall consider both vertical and lateral loads.

3.4.9.4 Loads

The following loads, at a minimum, shall be considered in the design of noise walls:

- Dead Loads – The dead loads include the weight of the noise wall system. The loads of the sound barrier components shall be applied through their respective centers of gravity.
- All retaining walls and ground-mounted noise walls which are higher than 24 feet shall be designed for the additional dead load moment caused by a 2-degree rotation of the panels and posts at the top of the retaining wall or ground-mount system.
- Derailment Loads – For noise walls adjacent to LRT or railroad tracks without emergency guardrail, the noise wall components shall be designed for the derailment load.
- Wind Loads – Wind loads on noise walls shall be determined based on AASTHO's *LRFD Bridge Design Specifications.*
- Seismic Loads – If earthquake loads are to be considered for the design of the structure to which the noise wall is attached, the same seismic provisions shall apply to the noise wall. If the noise wall is independent of any other structures, refer to Section 3.4.2.18 for earthquake loads.
- Earth Loads – Horizontal earth pressure loading shall be in accordance with Section 3.4.2.9.
- Traffic Loads – Traffic loads need not be applied to a noise wall system unless the noise wall is combined with the concrete traffic barrier. The foundation system for a combined noise wall and concrete traffic barrier shall not be less than that required for the concrete traffic barrier alone.

- Bridge Loads – When a noise wall is on a bridge traffic barrier, the loads from the noise wall, as specified in this Section must be transferred to the superstructure and substructure of the bridge.

3.4.10 Crash Walls

3.4.10.1 LRV Collision with Structures

Abutments, piers, or other structure support elements located within a distance of 25 feet to the centerline of a rail transit track shall be protected by a reinforced concrete crash wall. The provisions of this Section need not be considered for structures if they are protected by any of the following:

- An embankment.
- A structurally independent, crashworthy, ground-mounted, 6-foot-high barrier or wall, located within 10 feet of the component being protected.
- A 42-inch high crashworthy barrier located more than 10 feet from the component being protected.
- Where LRVs are restrained by emergency guardrail or direct fixation containment walls.
- A reinforced concrete crash wall shall be provided between the LRT and CSXT in locations where the centerline of LRT is within 50 feet of the centerline of the closest CSXT track.

3.4.10.2 Crash Wall Requirements

Crash walls located adjacent to existing or proposed structures shall meet the following requirements:

- Adjacent to existing structures – Piers and other structural support elements supporting structures over LRT or CSXT with a clear distance of 25 feet or less from the centerline of track shall be of heavy construction or shall be protected by a reinforced concrete crash wall. Crash walls shall be designed in accordance with AREMA Chapter 8, Section 2.1.5. Reference AREMA Chapter 8, Section 2.1.5c for the requirements of piers defined as being of heavy construction.
- Adjacent to proposed structures – All new structure support elements supporting structures over LRT or CSXT with a clear distance of 25 feet or less from the centerline of track shall be of heavy construction. Reference AREMA Chapter 8, Section 2.1.5c for the requirements of piers defined as heavy construction.

3.4.10.3 Highway Vehicle Collision with Structures Supporting LRT

Abutments, piers, and other structure support elements supporting LRT over a vehicular roadway shall be protected from vehicular impact if they are within the roadway clear zone as defined by AASHTO's *A Policy on Geometric Design of Highways and Streets*. Collision shall be addressed by either providing structural resistance or by redirecting or absorbing the collision load. Where the design choice is to redirect or absorb the collision load, the structure shall be protected by a minimum 54-inch barrier wall crash tested for a minimum of a Test Level 5 impact load as described in NCHRP *Report 350*. When the design choice is to provide structural resistance, the substructure units shall be designed for the appropriate collision forces.

3.4.11 Sign Structures, Digital Message Systems, Traffic Signals, Overhead Catenary Supports, and Luminaires

3.4.11.1 Structures

Sign structures, digital message systems , traffic signals, and luminaires shall be designed in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. The sign importance factor shall be taken as 1.0.

3.4.11.1.1 Overhead Elements

Overhead Contact System (OCS) pole locations and design shall be coordinated with track designs and all other Utilities in the Project vicinity.

OCS poles may be used as joint-use lighting or signal poles to support traffic signals, LRT signals, signs, and luminaires only if approved by the AHJ. The calculations for the pole loading shall therefore include forces induced by these other elements. These poles shall support low-profile catenary and/or single contact wire configurations as well as simple catenary configuration as required.

All poles, except those on existing overpasses or underground garage structures, shall be installed on cast-in-place reinforced concrete foundations by means of embedded anchor bolts. On existing structures, the poles shall be mounted with anchor bolts installed through the existing structure.

3.4.11.1.2 Structure/Bridge-Mounted Elements

The forces induced into the structure and/or bridge from a mounted sign structure shall be included in the analysis and/or design of the structure and/or bridge components. On proposed structures, the factored load combinations for the reactions shall be developed in accordance with these design provisions and AASHTO LRFD.

On existing structures, the poles shall be supported by means of anchor bolts installed through the deck or cast into piers. The factored load combinations of the service reactions shall be developed in accordance with these design provisions, AASHTO, and AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

3.4.11.2 Pole Foundations

OCS pole foundations shall be designed in accordance with Part 2B, Section 15 of the Technical Provisions and the following provisions.

Foundations shall be designed to limit the total effect of foundation rotation and pole deflection at the top of the foundation as listed below:

- Horizontal deflection limit at top of foundation: 0.50 inch.
- Rotation limit at top of shaft foundation [Δ/D]: 0.30 percent (wind only).
- Rotation limit at top of shaft foundation [Δ/D]: 2.0 percent (total load).

Where Δ is the drilled shaft head deflection and D is the diameter of the drilled shaft.

Pole foundations and guy anchor foundations shall be designed using p-y techniques to estimate the lateral foundation deflection. Sloping ground conditions shall be considered in the evaluation of pole foundations.

Concessionaire shall use FHWA Drilled shafts FHWA-IF-99-025, *Drilled Shafts: Construction Procedures and Design Methods* to design drilled shaft foundations.

Where the foundation will be supported on an embankment, after an embankment is built, the embankment materials may be tested using SPT soil borings, physical property testing of Shelby tube samples, or other in-situ testing probes to determine the properties of the embankment material. Design shall consider both vertical and lateral loads.

Grouted rock anchors may be used for overhead catenary system foundations when rock is encountered close to the ground surface. Design of grouted rock anchors shall be in accordance with FHWA-IF-99-015, *Geotechnical Engineering Circular No. 4 – Ground Anchors and Anchored Systems*.

3.4.11.3 Base Plates

The minimum base plate thickness shall be equivalent to the anchor bolt diameter. For overhead sign structures, the minimum base plate thickness shall be 2 inches or the anchor bolt diameter, whichever is greater. No grout shall be installed beneath the base plates.

3.4.11.4 Cantilever Signs

The arms of cantilevered signs shall be quad-chord trusses made of steel. No single-chord mast arms shall be used.

3.4.11.5 Fatigue Design

The design of these structures shall incorporate the fatigue requirements of AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

3.4.12 Clearances and Geometry

3.4.12.1 Vertical Clearance

The following vertical clearances apply to the entire usable roadway or travel area, including shoulders.

The actual computed vertical clearance shall be shown for each bridge on the Project; the point of minimum vertical clearance shall be shown in the general plan, and the location and actual vertical clearance shall be shown in the elevation view. Should a bridge cross more than one roadway (e.g., two-directional traffic), the actual vertical clearance shall be shown for each roadway.

All vertical and horizontal clearances shall be verified with the appropriate authorities at the time of final design.

3.4.12.1.1 Bridges over Highways

Bridges carrying roadways, railroad tracks, or LRVs over existing roadways shall meet the following minimum vertical clearance criteria set by the AHJ of the facility.

- Montgomery and Prince George’s Counties:
    - For all bridges (except pedestrian bridges) over interstate, U.S., or State highways, the minimum design vertical clearance shall be 16 feet 9 inches, which provides for 16 feet of absolute minimum clearance and 9 inches of future surfacing; and

- For all bridges (except pedestrian bridges) over county roads, local roads, and streets, the minimum design vertical clearance shall be 15 feet, which provides for 14 feet 6 inches of absolute minimum clearance and 6 inches of future surfacing.

The legal maximum height of a vehicle in Maryland is 13 feet 6 inches; temporary reductions in clearances during Construction Work may be required, but in no case shall they be less than 14 feet 6 inches. When a temporary reduction in clearance provides less than 16 feet for bridges over interstate, U.S., or State highways, or 14 feet 6 inches for bridges over city/county roads, local roads, or streets, the work area shall be signed to indicate reduced clearance caused by construction and Concessionaire shall get written approval from Owner. Concessionaire shall also coordinate and obtain approval from the AHJ of the roadway whenever reduced clearances for construction are required.

3.4.12.1.2 Bridges over CSXT/AMTRAK

Structures carrying roadways, railway tracks, or LRVs over existing railway tracks shall meet the following minimum vertical clearance criteria set by the AHJ of the facility.

For all bridges over CSXT, AMTRAK, or other similar facilities, the minimum vertical clearance shall be 23 feet. All vertical clearances shall be coordinated with the railroad.

3.4.12.1.3 Bridges over WMATA

For all bridges carrying LRVs and roadways over existing WMATA tracks, a minimum vertical clearance of 15 feet shall be maintained between top of existing rail and the bottom of the proposed structure.

3.4.12.1.4 Bridges over LRT

- Bridges carrying roadways, railway tracks, LRT tracks, or other overhead obstructions over proposed LRT tracks shall meet the minimum vertical clearance criteria as outlined in Part 2B, Section 15 of the Technical Provisions. Clear distances between the lowest element of an overhead bridge and the messenger or contact wires shall be in accordance with Part 2B, Section 15 of the Technical Provisions and AREMA Chapter 33, Section 2.2.5.

Contact wires shall not be connected to the bridge under any circumstances without proper insulators and an agreement with the appropriate governing authorities, owners, and stakeholders of the structures.

3.4.12.1.5 Bridges over Pedestrian Paths

Bridges carrying roadways, railway tracks, or LRVs over proposed or existing pedestrian paths shall provide a minimum vertical clearance of 10 feet unless otherwise approved by Owner.

3.4.12.1.6 Pedestrian Bridges

For pedestrian bridges over roadways, railroad tracks, or LRT tracks, the clearances specified in these sections, Section 3.4.12.1.1 through 3.4.12.1.54, above shall be increased by 1 foot.

3.4.12.1.7 Bridges over Non-Transportation Structures

A minimum vertical clearance of 10 feet shall be provided between the bottom of a proposed LRT bridge structure and the top of a structure not providing a means of transportation, such as a building, shaft, or canopy.

3.4.12.1.8 Bridges over Waterways

The clearance of a structure over a non-navigable waterway is dependent upon a hydraulic analysis. The minimum freeboard provided shall be 1 foot between the bottom of the structure and the design stormwater surface elevation. The clearance of a structure over a navigable waterway shall be coordinated with the agency having jurisdiction.

3.4.12.2 Horizontal Clearances and Tolerances

All structures shall take into account the required horizontal clearances and tolerances as described in Part 2B, Section 2 of the Technical Provisions.

Concessionaire shall determine required horizontal clearances specific to the maintenance and storage facilities.

3.4.13 Building Structures

3.4.13.1 Design Codes

This Section shall apply to the structural design of all elements of buildings, Stations, and shop facilities. These elements shall be designed in accordance with the IBC except as noted within this Section.

In the case of Platforms subjected to LRT loading, all structural elements above the Platform and not subjected to LRT loading shall be designed in accordance with this Section. All structural elements below and including the Platform shall be designed as a bridge. All load combinations with LRT loading shall be per Section 3.4.2 of these design provisions.

3.4.13.2 Building Frame Types

Structures constructed below-ground shall be limited to the use of cast-in-place or precast concrete materials. Refer to the IBC and ACI 318 for design provisions, as applicable.

Structures constructed above ground may be of cast-in-place concrete, precast concrete, prestressed concrete, steel, or cold-formed steel. For design provisions, refer to the IBC, ACI 318, and AISC's *Steel Construction Manual*, as applicable.

- Masonry – Unless the element is isolated from the structure so that vertical and lateral forces are not imparted on the element, masonry shall be designed as reinforced.
    - Shear walls shall be of running bond construction only; stacked bond construction shall not be permitted.
- Bolted connections – Compressible washer-type direct-tension indicators or twist-off type tension-control bolts shall be provided at all bolted connections.
- Cold-formed steel, light frame construction – The compression flanges of all wall studs in bending shall be stiffened or partially stiffened. Unstiffened compression flanges shall not be permitted. All strap bracing shall be anchored to solid blocking.
    - Wall stud assemblies shall be constructed such that the studs are firmly placed into the track prior to attachment. No gaps shall exist between the wall stud and the attached track.
    - Connections between cold-formed steel members shall be with screw fasteners or by welding. Pneumatic nailing is permitted only for the connection of cold-formed members to other materials.

- Cold-formed steel members exposed to spray from salt, salt water, or brackish water shall be galvanized per ASTM A653 G90, and all fasteners shall be corrosion-resistant.

3.4.13.3 LRT Stations

Shelters shall be fixed to a Platform slab or a concrete slab on-grade.

Platform slabs and slabs on-grade shall be designed for pedestrian live load in addition to all possible dead loads as listed in Section 3.4.2. The minimum slab thickness shall be 8 inches, or as required to resist all applicable loads. The geotechnical site conditions shall be considered in accordance with Part2A, Section 4 of the Technical Provisions.

3.4.13.4 LRT Aerial Stations

The natural frequency of the unloaded Platform shall not be less than 2.0 cycles per second. The calculated live load deflection shall be limited to the maximum of 1 inch or deflection limits as specified in Section 3.4.5.3.

If a Station is located on an aerial structure segment and the Platform is supported independently from the track, structural deflections must be analyzed to ensure that the vertical distance from the Platform surface to the LRV car floor remains compliant with ADAAG regulations. Noncompliance may occur if the LRV is loaded to AW3.00 but the Platform is empty, or if the LRV is empty (AW0) and the Platform is crush-loaded.

Concessionaire may find that compliance with the above criteria necessitates the inefficient use of certain materials, particularly where the girders are made of structural steel and the span lengths are relatively long. For such structures, a special dynamic analysis may be conducted to understand the effects of the deflection. Where such a finding is made, the proposed design shall be discussed with Owner to determine, for that particular instance, whether a lower natural frequency and/or a higher deflection limit may be acceptable. For better control of shrinkage stresses and to minimize cracking in monolithically poured concrete slabs and walls in the long linear Platform structure, contraction joints shall be provided at a spacing not exceeding 30 feet or the width of the element, whichever is less. The reinforcing steel shall be designed to handle the calculated stresses.

To ensure serviceability and durability, permanent deformations under dead load, live load deflections, and fatigue characteristics under service loadings shall be investigated.

Where shelters are to be provided at LRT Aerial Stations, the shelters shall be in accordance with Section 3.4.13.3.

3.4.13.5 Parking Garage Facilities

Parking garages shall be designed in accordance Section 3.4.13.1 and may be prestressed, precast, or cast-in-place concrete structures, either above or below ground.

3.4.13.6 Stairways

Stairways shall be provided in accordance with Part 2B, Section 8 of the Technical Provisions. Stairways and their structural support systems shall be designed in accordance with Section 3.4.13.1.

Stair nosings and treads shall require minimal maintenance and shall be in accordance with Part 2B, Section 8 of the Technical Provisions.

3.4.13.7 Emergency Stairways

Emergency stairways shall be provided in accordance with Part 2B, Section 8, of the Technical Provisions. All emergency stairways and their structural support systems shall be designed in accordance with Section 3.4.13.1.

3.4.13.8 Access Hatch

The dead load of the access hatch shall be included in the structural design of the facility. Access hatches for exterior locations, such as roofs and slabs, shall have a lift-assistance mechanism; the preferred system is a compression spring enclosed in a telescopic tube with a hold-open arm and a grip handle release.

3.4.13.9 Ventilation Shafts

Shafts shall be designed to use the minimum number of bends and elbows and to avoid sudden transitions in the shaft cross-section. Turning vanes may be used in order to reduce pressure loads. Obstructions in the fan shaft passages shall be streamlined where required.

3.4.13.10 Shop Considerations

The following shop elements shall meet the requirements herein.

3.4.13.10.1 Bridge Crane

The support system for the bridge crane shall be integrated into the building structure where possible. If additional columns are required to support the bridge crane, the columns shall be located so as to reduce the impact on the work space within the shop.

3.4.13.10.2 Floor Design

The floor slab supporting all equipment within the shop shall be designed with consistent reinforcing to support the equipment loads in accordance with the requirements of Section 3.4.2. In order to accommodate future modifications to the shop, localized reinforcement for specific machinery shall not be permitted.

Expansion joints shall be minimized within work bays near the proposed locations of the LRVs' axles in order to accommodate rolling equipment for maintenance and repair. Additional reinforcement shall be provided, as necessary, to compensate for larger areas between expansion joints.

3.4.13.10.3 Work Bay Elevated Platforms

The work bay elevated platforms shall be designed as mezzanine structures for maintenance and storage facilities in accordance with Section 3.4.2.

The work bay elevated platforms may be permitted to be suspended from the structure, but must be braced against horizontal sway.

The work bay elevated area shall be free of columns to support the work bay platforms. The structural support of the work bay elevated platforms shall be designed to minimize the impact of the structure to the work bays.

3.4.13.10.4 Apron Slabs

Apron slabs shall be provided at the entrances to all shop facilities for each track entering or exiting the facility. Apron slabs shall have a maximum length of 50 feet along the length of the track and a minimum length of 25 feet. The slabs shall be reinforced concrete and shall be designed using the loads and combinations, as applicable, provided in Section 3.4.2 of these provisions. The minimum slab depth shall be 12 inches.

The rails shall be constructed on a concrete sub-slab or mud slab which is embedded into the apron slab. The sub-slab or mud slab shall be integrally connected to the apron slab using doweled reinforcement.

Aggregate shall be placed beneath the apron slab. The minimum depth of aggregate shall be 6 inches

3.4.13.10.5 Pits

The pits in the shop facilities shall be designed to accommodate all equipment and machinery loads anticipated at that location. Minimum loads are provided in Section 3.4.2.

The pit floor shall be designed such that the bottom slab is reinforced uniformly throughout as a two-way slab; no local reinforcement for specific equipment loads shall be permitted.

The walls of the pit shall be designed to resist all loads, including ladders (as necessary), equipment, and live loads placed adjacent to the pit in the work bay. In addition, design shall also include all earth pressure loads.

3.4.13.10.6 Utilities

To the greatest extent possible, all Utilities shall be surface-mounted to structural elements. The structural elements shall be designed to accommodate this preference where feasible.

3.4.13.10.7 Above-Grade Floor Construction

All above-grade floor construction shall consist of concrete, normal-weight or lightweight, and a composite metal deck

3.4.13.10.8 Roof Construction

All roof construction for maintenance and storage facilities shall be galvanized metal roof decking unless a study or specific loading requirement necessitates an alternate type of roof construction.

3.4.13.11 Foundations

Building foundations may be either shallow or deep. Foundation design shall be in accordance with Part 2A, Section 4 of the Technical Provisions and shall consider all applicable loads and combinations.

Deep concrete foundations shall be reinforced for their full lengths.

Where applicable, foundation design shall include a scour analysis.

3.4.13.12 Miscellaneous Considerations

3.4.13.12.1 Mezzanines

Mezzanines, except for work bay elevated platforms in maintenance facilities, shall be allowed only per Owner approval and shall be designed in accordance with these design provisions.

3.4.13.12.2 Shrinkage and Temperature Crack Control

Temperature and shrinkage reinforcement for above-ground concrete structures shall be designed as per the requirements of ACI 318, Articles 7.12, 10.5, and 14.3.

For concrete walls, slabs and footings less than 48 inches thick and resting directly against earth, minimum temperature and shrinkage reinforcement shall be 0.15 percent of the gross concrete area. For members larger than 48 inches thick, the temperature and shrinkage reinforcement requirements shall be in accordance with the crack control measures as recommended by ACI 318. For crack control, the maximum bar spacing shall be 18 inches on-center.

To control shrinkage stresses and minimize cracking in all concrete slabs and walls, a unit length of 30 feet or less between contraction joints shall be preferred. For units longer than 30 feet between contraction joints, the construction procedures and requirements for temperature and shrinkage reinforcement shall be in accordance with the crack control measures as recommended by ACI 318. Expansion joints shall be incorporated into the design per IBC and ACI requirements.

3.4.13.13 Facade Elements

All facade elements shall be designed for minimal maintenance over the course of the design life.

- Glazing – Glazing shall be designed to withstand all horizontal and vertical loads applied to it. The connection of the glazing to the structure shall be designed to require minimal maintenance.
- Curtain Walls – Curtain wall systems shall be designed to resist all horizontal and vertical loads to which they are subjected, including the horizontal and/or shear forces due to hanging or attaching the system to the structure, and due to the anticipated expansion of the system.
- Curtain walls shall create a watertight and airtight building envelope.
- Cladding and Veneer – All cladding materials shall be fixed to the structural envelope of the building.
- Masonry Veneer Base – Masonry veneer shall be placed on a shelf angle or a foundation ledge that is lower than the base of the steel stud wall by at least 4 inches. The width of the shelf angle or foundation ledge shall be at least two-thirds of the veneer thickness plus the minimum air space, and shall include the width of the masonry veneer and the cavity. The thickness of the angle or ledge shall be at least ½ inch. The steel shelf angle shall be hot-dip galvanized structural steel with gaps for thermal expansion and contraction between segments. The deflection at the end of the horizontal leg shall be limited to 1/16 inch.

3.4.13.14 Underground Stations

Except for mined tunnel linings and shafts, Underground Stations shall consist of an excavation support wall, a bracing system, and a decking system. The decking system shall be designed in accordance with Section 3.4.6.

Where there is a portion of a continuous box structure without restraint on one side, such as at entrances from at-grade track to Underground Stations, a horizontal sway shall be assumed and the horizontal slabs shall be investigated for their capacity to transfer load by diaphragm from the portion of the structure with unbalanced load to the restrained end of the structure. The capacity of the soil at the ends of the structure shall also be investigated to determine whether it provides sufficient passive resistance to sustain the loads being transferred thereto.

3.4.14 Drainage Systems

3.4.14.1 Fixed Rail Concrete Decks

For drainage purposes, the top surface of direct fixation and embedded rail concrete decks shall have a minimum transverse and longitudinal slope of 0.5 percent. Deck drains shall collect water and pipe down to an external discharge system or into a positive drainage system. Deck drainage for direct fixation track systems shall be designed so that the water conveyed along the deck is a maximum of 2 inches below the top of the plinth at the prescribed design storm.

For embedded rail track systems, the runoff crossing the deck will be interrupted by the rails and end up traveling longitudinally along the deck in the rail trough. A drainage system needs to be developed to periodically capture this runoff along the rails.

For waterproofing purposes, the concrete bridge deck slab shall be protected with a linseed oil protective coating in conformance with 902.12 of MDSHA's *Standard Specifications for Construction and Materials*.

Scupper design shall accommodate all applicable forces and shall be designed in accordance with AASHTO LRFD or AASHTO, as applicable.

3.4.14.2 Ballasted Decks

For drainage purposes, the top surface of waterproofing protection shall have a transverse slope of 1 inch per foot with a crown under the centerline of each track. An underlayment with a minimum thickness of 3½ inches of Portland cement concrete with welded wire fabric shall be used to provide the required slope on precast concrete decks. Underlayments shall be in accordance with the requirements of AREMA Chapter 8, Section 29.

The top surface of waterproofing protection shall have a minimum longitudinal slope of 0.5 percent. For precast concrete decks and steel or concrete decks that are level or slope less than 0.5 percent, an underlayment with a minimum thickness of 3½ inches of Portland cement concrete with welded wire fabric shall be used to provide the required longitudinal slope.

For waterproofing purposes, longitudinal half-round deck drains and pans shall be used between tracks and at ballast retainers or concrete-encased communication ducts to collect discharge. Deck drains and bottom pans shall be 12 gauge, galvanized, and bituminous-coated.

All ballasted bridge decks shall be waterproofed using membrane waterproofing. Waterproofing or dampproofing shall be applied to the entire surface of deck and inside faces of parapets or curbs. Materials and construction shall be in accordance with AREMA Chapter 8, Section 29, plus the following requirements.

- Use 3/32-inch thick butyl rubber membrane waterproofing conforming to the requirements of AREMA Chapter 8, Section 29.9.5, on the entire deck and ballast retainers.
- No. 3 tongue-and-groove splices, as shown in AREMA Chapter 8, Figure 8-29-3, shall be used for splicing the butyl rubber membrane.

- Two layers of asphaltic panels, conforming to AREMA Chapter 8, Section 29.10.3, with a total thickness not less than 1 inch, placed with staggered joints, and set in a compatible adhesive, shall be used to protect the butyl rubber membrane on deck and ballast retainers. Ballast shall be placed as soon as practicable following placement of the panels to prevent distortion from sunlight. Edges and protrusions of panels are to be coated in accordance with AREMA Chapter 8, Section 29.14.4.4.

3.4.14.3 Platform Drainage

The cross slope of passenger Platforms shall comply with ADA requirements and shall not exceed 2 percent. Consideration shall be given to construction tolerances in the development of the cross slope for passenger Platforms. Side Platforms shall slope away from the track, allowing water to run off the Platform and onto other surfaces.

3.4.14.4 Station Drainage

The cross slopes provided to facilitate proper drainage of all Station components subject to stormwater runoff shall comply with all ADA requirements, with consideration of construction tolerances.

For situations where down-ramps or stairways end near a below-grade entranceway, drains shall be installed in front of the entranceway doors.

All drainage cavities shall have clean-out provisions.

3.4.14.5 Drainage Structures

Drainage structures shall be designed in accordance with Sections 3.4.1 for all applicable loads as described in Section 3.4.2.

3.4.15 Support of Excavation Structures

Design Documents shall cover traffic diversions, mandatory restrictions, and necessary construction staging approved by public authorities and Utility companies as applicable. Accepted locations for construction access ramps, or any other construction facility that affects the work, shall also be indicated.

Detailed design for the temporary decking, sheeting, and bracing shall be prepared by Concessionaire.

All temporary work and excavations within influence zones of non-Owner property, including other railroad tracks and buildings, shall be designed in accordance with the AHJ’s specifications.

If traffic with a barrier is present within 6 feet of the near face of a temporary wall, or if a traffic barrier, temporary or permanent, is within 4 feet of the near face of a temporary wall, the traffic barrier shall have a positive connection to the wall. Additionally, the wall shall be designed for the TL-2 criteria as specified in AASHTO LRFD Article 13.7.2 unless otherwise directed by Owner.

Owner and/or other applicable jurisdictions shall decide on a case-by-case basis whether temporary structures shall remain in place. If desired by the local jurisdiction, all materials for both above and below ground temporary structures shall be removed.

Where sheeting is to be left in place, Concessionaire shall coordinate with all Utility Owners in the area. Within Project ROW, all sheeting that is to be left in place shall be cut-off a minimum of 1 foot below the subballast. Where subballast is not used, the sheeting which is to remain shall be cut off a minimum of 1 foot below finished grade. Temporary structures left in place shall be grounded.

3.4.16 Modifications to Existing Structures

3.4.16.1 Inspection and Analysis

Existing structures intended for use as part of the proposed LRT system shall be inspected, analyzed, and rehabilitated or modified in accordance with the provisions stipulated by these design provisions and all applicable codes. All modifications shall include structural materials that are noncombustible.

Any existing buildings, bridges, or other miscellaneous structures shall be surveyed to verify that they are adequate to support the intended function. Prior to initiating final design for each existing structure, an in-depth inspection to the extent allowed by Owner shall be performed to determine the condition and geometry of the structure.

In general, inspections shall follow the guidelines presented in MTA's *Facilities Inspection Manual*, FHWA's *National Bridge Inspection Standards*, and AASHTO's *Manual for Bridge Evaluation*, as applicable. Inspections shall include the following:

- Establish the material properties of the primary structural elements. Laboratory testing techniques shall be used as necessary.
- Assess the condition of the load-carrying members and identify any structural deficiencies.
- Determine the foundation system of the structure using as-built drawings, exploratory test pits, or any other generally accepted methods of making a reliable determination.
- Evaluate the hydraulic requirements of any waterway crossings and inspect the existing foundations for scour.
- Survey for any hazardous material and document the findings.

The actual condition of the structural elements as determined from the in-depth inspections shall be used to calculate the load-carrying capacity of the existing structures. The results of this structural analysis shall be used in conjunction with information gathered during the in-depth inspections to determine the feasibility of using the existing structure for LRT operations.

Structures that are possible candidates for rehabilitation shall be modified and retrofitted in accordance with these provisions and must be able to support all loads and forces as described in Section 3.4.2. Proposed materials must meet the requirements of the Contract Documents

Standards for the inspection and evaluation of existing building structures include ACI 562-12, *Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings* (an ACI Provisional Standard), and Appendix 5 of AISC's *Specification for Structural Steel Buildings*. If a structure cannot be brought to compliance with current codes because of conflicting legal requirements, e.g. historic designation, the provisions of the International Existing Building Code shall be applied.

3.4.16.2 Overhead Contact System (OCS) Attachments to Existing Structures

Where OCS attachments or foundations are required at existing structures along the LRT alignment, the attachments shall be coordinated with the appropriate Third Party.

A structural analysis shall be completed at each location where an attachment or foundation is required to verify that the OCS attachment and foundation are secure and safe. Grounding provisions at each location shall be added or confirmed to ensure that the supporting structure is effectively grounded. Unless clearance limitations or the along-track length of the structure requires an attachment, no attachments shall be made to underpass structures.

Except where the structure's span is greater than the allowable OCS span, foundations for OCS shall not be located on overpass structures or decks. Existing traffic, lighting, and power poles shall not be used to support OCS elements. New support poles are preferred for making attachments rather than using existing buildings, but in some locations attachments to existing buildings may be required due to clearance restrictions

3.4.17 Inspection Access

3.4.17.1 Buildings

Consideration shall be given to future inspections during the design of buildings included within the scope of the Project. In particular, access into interior partitions and behind exterior cladding shall be considered and provided.

3.4.17.2 Bridges and Transportation Structures

Bridges and related transportation structures shall be inspected in accordance with MTA's *Inspection Manual*, the *National Bridge Inspection Standards* published by FHWA, and AASHTO's *Manual for Bridge Evaluation*, as applicable.

All bridge superstructures, joints, and bearings shall be made accessible for long-term inspection and shall be designed and detailed for ease of replacement. Superstructures consisting of I-girders with exposed cross frames shall be made accessible with walkways, ladders, or by use of a snooper. In the design of the bridge, consideration shall be given to catenary poles and other obstructions that may be on the structure, as well as traffic, environmentally sensitive areas, and streams that may restrict access to the bridge for inspectors.

Box girders shall be made accessible for interior inspection. An access opening shall be provided at each end of the bridge and in each span. Maximum access opening spacing shall be 250 feet. Access openings shall not be located directly over traffic lanes, railroads, or waterways. Access opening doors shall have latches both inside and outside and shall swing into the box girder. Access openings shall be located midway between stems and shall be located no closer than 4 feet to a column or bent to facilitate the removal of form lumber. Locate access openings at least 8 feet off the ground to prevent or deter unauthorized entry into the box. Fall protection shall be provided inside the box around each access opening. Box girders shall be protected from access by vermin. The interior of all box girder bridges shall be lit, and electrical receptacles, at a maximum spacing of 50 feet, shall be provided inside for use by bridge inspection personnel.

3.4.18 Emergency Guardrail

Emergency guardrail shall be used to restrain the lateral movement of a derailed LRV, where the consequences of a derailment may be particularly catastrophic. Refer to Part 2B, Section 2 of the Technical Provisions for locations requiring emergency guardrail.

3.4.19 Seismic Design

3.4.19.1 Introduction

The seismic design criteria for structures are established in this Section. These criteria apply to viaduct structures/bridges, cut-and-cover tunnels and Stations, tunnels, retaining walls, U-section structures, surface buildings, miscellaneous permanent structures, and nonstructural components and equipment.

This Section has been written to address the general seismic design conditions that apply to the Project. Where there are cases of special designs encountered that are not specifically covered in this Section, Concessionaire shall determine the proper technical source and develop the proper procedure for the design.

3.4.19.1.1 Design Policies and Objectives

From the seismic design standpoint, Project structures are broadly divided into three categories: underground structures, bridges, and surface buildings. A two-level earthquake hazard design approach shall be conducted for underground structures and the design procedures and requirements are specified in this Section.

The two earthquake hazard levels to be accounted for in the design of underground structures are the Operating Design Earthquake and the Maximum Design Earthquake.

The Operating Design Earthquake (ODE) is defined as an earthquake event that has a return period of 500 years. There shall be no interruption in rail service during or after the ODE. When subjected to the ODE, the structure shall be designed to respond in an elastic manner. There shall be no collapse and no damage to primary structural elements. Only minimal damage to secondary structural elements shall be permitted, and such damage shall be minor and easily repairable. The structure shall remain fully operational immediately after the earthquake.

The Maximum Design Earthquake (MDE) is defined as an earthquake event that has a return period of 2,500 years. When subjected to the MDE, it is acceptable that the structures behave in an inelastic manner without collapse, and that structural damage is limited to elements that are easily accessible and can be readily repaired. The structure shall be designed with adequate strength and ductility to survive loads and deformations imposed on the structure during the MDE, thereby preventing structure collapse and maintaining life safety.

Seismic design of surface building structures and/or non-building surface structures/facilities that will be used to house the railroad system components shall meet the requirements of the current IBC (International Building Code) and Maryland Building Performance Standards (MBPS). All buildings and permanent non-building surface structures shall be designed with a seismic importance factor of 1.50 (per ASCE/SEI Standard 7).

Nonstructural components (including architectural components) and their attachments, and the attachments for permanent equipment (including mechanical/electrical and fire protection systems) supported by a structure, shall be designed in accordance with the procedure outlined in ASCE/SEI Standard 7.

Seismic design of bridges/elevated viaducts shall meet the requirements of current AASHTO LRFD Bridge Design Specifications and the relevant portions of the AREMA Manual.

3.4.19.2 Design Response Spectra for Underground Structures

Horizontal acceleration design response spectra (for 5 percent damping) for seismic design of the underground structures representing MDE and ODE shall be derived based on the ground motion parameters (for Site Class B, Soft Rock) established by the U.S. Geological Survey (USGS) seismic hazard maps. The procedures included in AASHTO LRFD shall be used to establish a design response spectrum based on the USGS parameters. To develop design response spectrum for various site classes other than Site Class B, site factors included in AASHTO LRFD or IBC shall be used.

The earthquake magnitudes for MDE and ODE shall be established based on the USGS deaggregation data.

The site classes shall be established using one or more of the following three methods:

- C_s Method – Mean shear wave velocity (C_s) for the top 100 feet.
- N Method – Mean standard penetration testing blow count (N) for the top 100 feet.
- S_u Method – Mean undrained shear strength, S_u, for cohesive soil layers (PI > 20) in the top 100 feet, and N_{ch} for cohesionless soil layers (PI < 20) in the top 100 feet. If the S_u and N_{ch} criteria differ, select the softer site class (e.g., use Site Class E instead of D).

Site class parameters C_s, N, N_{ch}, and S_u shall be determined in the upper 100 feet of the site soil. Profiles containing distinctly different soil layers shall be subdivided into those layers designated by a number that ranges from 1 to n in the upper 100 feet.

3.4.19.3 Underground Structures

The general procedure for seismic design of underground structures shall be based primarily on the ground deformation approach specified herein. The structures shall be designed to accommodate the deformations imposed by the ground. The analysis of the structure response can be conducted first by ignoring the stiffness of the structure, leading to a conservative estimate of the ground deformations. In cases where the structure is stiff relative to the surrounding soil, the effects of soil-structure interaction shall be taken into account.

3.4.19.3.1 Reinforced Concrete Box Structures

Reinforced concrete box (rectangular) structures include cut-and-cover structures and Underground Stations that behave in a similar manner to a rectangular structure during earthquake shaking. Design details for the seismic design of the reinforced concrete box structures shall be in accordance with the provisions of the ACI 318.

Seismic design of the transverse cross-section of a reinforced concrete box structure shall consider two loading components: the racking deformations due to the vertically propagating shear wave and inertia forces due to vertical seismic motions.

In addition, the material strains of the main structural members shall be checked not to exceed the allowable values for both MDE and ODE-level design.

3.4.19.3.2 Tunnels in Soil

For tunnels constructed in soils, the maximum free-field ground shear strains shall be developed based on in-situ shear wave velocity of the soils encountered at the tunnel elevations. The shear wave velocity or the shear modulus values shall be reduced in the analysis to account for the strain-level-dependent soil softening effects during the earthquake excitations. In addition, due to the lower stiffness of soils (compared to that of the rock), the effect of soil-structure interaction may be an important factor, and, therefore, shall be considered in the tunnel lining evaluation. In the absence of measured data, shear wave velocity estimated based on empirical correlation with SPT data or laboratory measured undrained shear strength (for cohesive soils) may be used for preliminary assessment.

3.4.19.3.3 Tunnels in Mixed-Face Ground

A structural model capable of simulating soil-structure interaction shall be used to evaluate tunnel sections within mixed-face ground conditions.

The seismic ovaling deformation shall be combined with deformations resulting from non-seismic loads. For the ODE-level design, the lining shall be designed to respond in an elastic manner with no ductility demand. The material strains of the lining shall be checked not to exceed 0.001 for concrete and 0.002 for steel. For the MDE-level design, inelastic deformations shall be permitted.

The material strains of the lining shall be checked not to exceed 0.002 for concrete and 0.006 for steel. For the MDE-level design, the concrete strain may be allowed to exceed 0.002 but not to exceed 0.004 if the strain is caused predominantly by flexure.

The lining shall also be designed to satisfy the strength requirements for the ODE-level design. The internal forces, EQ, associated with the seismic ovaling deformation ΔD_{EQ} shall be derived by elastic analysis using the effective I_c value. The loading combination shall be as follows:

$$\text{Group Load} = 1.0\ [DL + LL + B + E + EQ] \qquad \text{(Equation 3-15)}$$

Where:

- DL = Dead load.
- LL = Live load.
- B = Hydrostatic pressure and buoyancy.
- E = Static soil/rock pressure on lining.
- EQ = Elastic seismic force due to seismic ovaling deformation, ΔD_{EQ}.

3.4.19.3.4 Axial and Curvature Deformations

The tunnel lining shall be designed to accommodate seismic strains caused by axial and curvature deformations of the ground. The strains due to combined axial and curvature deformations shall be estimated by combining the longitudinal strains generated by axial and bending strains.

The horizontally traveling shear wave velocity, $C_{s,H}$, shall correspond to the seismic shear wave propagation through the deeper rocks rather than to that of the shallower soils where the tunnel may be located. The angle of wave propagation, θ, shall be the value that maximizes the combined axial strains.

For the ODE-level design, the longitudinal strains, ε_{EQ}, due to the axial and curvature deformations shall be checked not to exceed 0.001 for concrete and 0.002 for steel. For the MDE-level design, the allowable material strains are 0.002 for concrete and 0.006 for steel.

3.4.19.4 Retaining Wall Structures / U-Section Structures

For conventional reinforced concrete retaining walls and U-Sections, seismic loads expressed in terms of dynamic earth pressures, as outlined in AASHTO LRFD Specifications and FHWA Publication No. FHWA HI-99-012, shall be followed. Special considerations shall be directed to the yielding/non-yielding nature of the walls in determining the dynamic earth pressures. For retaining walls that are allowed to accommodate some limited deformations, depending on their functioning requirements during MDE and ODE, the dynamic earth pressures may be reduced by selecting a design seismic coefficient lower than the peak ground acceleration value (expressed in terms of percent gravity, g). Peak ground accelerations associated with these seismic site classes shall be used for design of the retaining wall structures.

3.4.19.5 Bridges/Viaduct Structures

Seismic design of bridges/elevated viaducts shall meet the requirements of current AASHTO LRFD Bridge Design Specifications and the relevant portions of the AREMA Manual.

3.4.19.6 Surface Building Structures

Seismic design of surface building structures and/or non-building surface structures/facilities that will be used to house the railroad system components shall meet the requirements of the IBC, ASCE/SEI Standard 7, and Maryland Building Performance Standards (MBPS).

3.4.19.7 Non-Structural Components and Equipment

Permanent nonstructural components (including architectural components) and their attachments, and the attachments for permanent equipment (including mechanical/electrical systems) supported by a structure shall be designed in accordance with the International Building Code. The components shall be considered to have the same Seismic Use Group Category as that of the structure to which they are attached. The horizontal acceleration response spectra corresponding to the seismic site classes for these structures shall be used for seismic design of the permanent nonstructural components and their attachments.

3.4.19.8 Other Seismic Considerations

Liquefaction and liquefaction related ground instability shall be evaluated at relevant locations along the Project alignments. Empirical procedures based on cone penetrometer data or SPT blowcounts may be used (MCEER, 1997). An initial screening study (MCEER, 1998) shall be conducted, followed by more refined analyses and an evaluation of its impact to the proposed facility. Special attention shall be paid to loose fill and alluvium at the Project Site. The effects of liquefaction on the design of the tunnels as well as underground structures shall be thoroughly investigated. These effects shall include, but not be limited to, the following:

- Loss of bearing capacity and ground settlements.
- Increased lateral pressures and buoyancy forces on underground structure walls.

If the liquefaction impact analyses yield unacceptable performance of the structures, mitigation measures shall be incorporated into the design.

3.5 Equipment and Material Requirements

All materials required for building applications which are not listed below shall conform to the IBC and the applicable specifications and codes.

All materials required for bridge applications which are not listed below shall conform to Section 900 of MDSHA's *Standard Specifications for Construction and Materials*, as well as the applicable specifications and codes.

3.5.1 Cements

The following requirements shall apply to the use of Portland cement.

- Type I Portland cement shall ordinarily be specified;
- Type II Portland cement shall be specified for concrete construction where soils or groundwater conditions require moderate sulfate resistance and moderate heat of hydration, or where required by a geotechnical or corrosion engineer; and
- Type III Portland cement may be specified for concrete mix design requiring a high early strength, except where soil conditions make the use of Type II necessary. Shrinkage compensation cement may be used only if approved by Owner.

3.5.2 Foundation Materials

An appropriate foundation type shall be selected based on site borings and a foundation analysis of the loads to be supported and the acceptable settlements.

- Structural steel for steel H-piles for structures supporting LRT loads shall conform to ASTM A 709, Grade 50;
- Structural steel for steel pipe piles shall conform to ASTM A 252, Grade 3. Pipes shall have the entire void filled with gravel or concrete;
- Concrete for precast concrete piles shall be in accordance with Section 900 of MDSHA *Standard Specifications for Construction and Materials*;
- Reinforcement steel for precast concrete piles shall conform to ASTM A 615 Grade 60;
- Drilled shaft concrete and reinforcement shall be in accordance with Section 900 of MDSHA *Standard Specifications for Construction and Materials*;
- Micropiles shall be in accordance with FHWA-NHI-05-039, Micropile Design and Construction Reference Manual and AASHTO LRFD Bridge Design Specifications;
- Spread footing concrete shall be in accordance with Section 900 of MDSHA *Standard Specifications for Construction and Materials*;
- Subfoundation concrete shall be in accordance with Section 900 of MDSHA *Standard Specifications for Construction and Materials*; and
- Concrete for cast-in-place piles shall be in accordance with Section 900 of MDSHA *Standard Specifications for Construction and Materials.*

3.5.3 Structural Steel

Structural steel shall conform to the following requirements:

- Structural steel for building elements shall conform to the following:
    - Wide-flange shapes: ASTM A992;
    - HSS members: ASTM A500, Grade B;
    - Open-web joists: Any of the following, depending on the series, manufacturer, depth, span, and strength requirements:
    - ASTM A36;
    - ASTM A242;
    - ASTM A529, Grade 50;
    - ASTM A572, Grades 42 and 50;
    - ASTM A588, Grade 50;
    - ASTM A606;
    - ASTM A1008; and
    - ASTM A1011.
- All other members: ASTM A36.

- Structural steel for primary bridge members shall conform to ASTM A709, Grade 50, 50W or ASTM A588, Grade 50, 50W. If Grade 50 is not available for primary members, such as rolled shapes used in curved steel girder cross frames, Grade 36 shall be permitted;
- Structural steel for secondary bridge members shall conform to ASTM A709, Grade 36 or Grade 50, or ASTM A588, Grade 36 or Grade 50;
- Structural steel for maintenance and storage facility building frames shall be of the types listed above for structural steel buildings, but shall be a minimum of Grade 50;
- The toughness of structural steel for bridge members shall be T2 for non-fracture-critical members or F2 for FCMs;
- The use of ASTM A588 steel shall not be used in areas where the steel may be exposed to de-icing salts;
- High performance steels (Grade 70) shall be investigated for special situations for bridge applications and used with approval by Owner;
- Except for LRT bridges all railings and handrails shall consist of stainless steel conforming to ASTM A312 Grade TP321;
- Structural Steel for railings on LRT bridges shall consist of ASTM A709, Grade 36 or Grade 50, or ASTM A588, Grade 36 or Grade 50;
- Structural tubing for railings shall be in accordance with ASTM A500 Grade B, ASTM A618 or A501;
- Unless used in conjunction with weathering steel, all bolts, washers, and nuts for bridge applications shall conform to ASTM A325 or A490 and shall be galvanized in accordance with ASTM A153. Where bolts, washers, and nuts are used in conjunction with weathering steel for bridge applications, the bolts, washers, and nuts shall conform to ASTM A325, Type 3. Washers and nuts shall conform to ASTM A563 and F436, Type 3, respectively;
- Bolts, washers, and nuts for building applications shall conform to ASTM A307 or A325;
- Anchor bolts for bridge applications shall conform to ASTM A709 or ASTM F1554 and shall be galvanized in accordance with ASTM A153;
- Anchor bolts for traffic signals, highway lighting, and signs shall conform to Section 909.08 of MDSHA's *Standard Specifications for Construction and Materials*;
- Paint system for non-weathering and weathering steel on bridges shall conform to Paint System B as prescribed in Section 912.05 of MDSHA's *Standard Specifications for Construction and Materials*;
- Paint system for steel on building applications shall meet the finish requirements of Part 2B, Section 8 of the Technical Provisions; and
- Structural steel for bearing plates in bridge applications shall conform to ASTM A709, Grade 36 or Grade 50.

3.5.4 Additional Types of Steel

Additional types of steel not listed in Section 3.5.3, above, shall meet the following requirements:

- Cold-formed steel shall be in accordance with ASTM A500;
- Galvanized metal roof deck steel shall be in accordance with ASTM A653; and

- Steel for composite floor systems shall be galvanized and shall be in accordance with ASTM A653.

3.5.5 Concrete

Concrete for building structures shall have the following minimum 28-day cylinder compressive strength (f'_c) specified in the Contract Documents:

- Concrete topping for the composite metal deck of maintenance and storage facilities: (f'_c) = 4,000 psi lightweight concrete.
- Concrete topping on interior metal deck: (f'_c) = 3,000 psi.
- Concrete for maintenance and storage basement and underground applications: (f'_c) = 4,000 psi.
- All other concrete: (f'_c) = 4,000 psi.

The minimum 28-day cylinder compressive strength (f'_c) for non-segmental prestressed concrete for bridge applications shall be 7,500 psi. The maximum 28-day compressive strength (f'_c) for non-segmental prestressed concrete for bridge applications shall be 10,000 psi.

The minimum 28-day cylinder compressive strength (f'_c) for cast-in-place segmental and precast (including cast in place joints) segmental concrete construction for bridge applications shall be 6,500 psi. The maximum 28-day compressive strength (f'_c) for segmental prestressed concrete for bridge applications shall be 10,000 psi.

All prestressed and post-tensioned concrete for bridge applications shall have a corrosion inhibitor admixture added to the mix design.

Concrete for bridge applications shall have a minimum 28-day compressive strength (f'_c) as follows:

- Overlays for prestressed beam bridges: (f'_c) = 4,000 psi.
- Bridge deck, parapets, abutment backwalls, approach slabs, and parapet portions of wingwalls(except as mentioned above): (f'_c) = 4,500 psi.
- Bridge substructure: (f'_c) = 3,500 psi.
- Grade beams and slabs on-grade: (f'_c) = 4,500 psi.

If slip forming is used for concrete parapet or median construction on a bridge, concrete shall have a minimum 28-day compressive strength (f'_c) of 4,500 psi with a maximum slump of 1 inch, measured at the placement point as the concrete is charged into the slip form machine. Crushed stone meeting ASTM M43, size number 7, shall be used for the coarse aggregate. The coarse aggregate shall be proportioned to be 63 percent of the total aggregate in the mix.

Concessionaire may request approval from Owner for the use of lightweight and heavyweight concrete. If approved, the concrete material shall be in accordance with Section 902 of MDSHA's *Standard Specifications for Construction and Materials*.

All other concrete for bridge and transportation applications shall be in accordance with Section 902 of MDSHA's *Standard Specifications for Construction and Materials*. The concrete compressive strength required shall be provided in the Design Documents.

Cast-in-place concrete for buildings, bridge, and transportation applications shall be designed assuming a lower compressive strength (f'_c) than specified in the Concessionaire's Design

Documents. The values presented in Table 3.6 represent value that shall be specified in the Concessionaire's Design Documents:

Table 3.6 – Concrete Compressive Strength

Design Value	Design Document Value
2,500 psi	3,000 psi
3,000 psi	3,500 psi
4,000 psi	4,500 psi

An effort shall be made to minimize variability of color in concrete elements adjacent to each other and exposed to public view. The method of achieving this, and the limits of construction within which this provision applies, shall be coordinated with architects, landscape architects, urban planners, and the local jurisdiction on a case-by-case basis.

To facilitate proper moisture control of a slab-on-grade to meet the moisture limits of water-based adhesives and durability during Construction Work, a vapor retarder with a minimum thickness of 10 millimeters and a maximum permeance rating of 0.04 perm. shall be used. Where moisture is a critical issue under the floor covering and a vapor barrier is required, the maximum permeance rating shall be reduced to 0.01 perm.

A permanent moisture barrier shall be provided beneath concrete slabs constructed at-grade for enclosed buildings and inverts of tunnels and other subterranean enclosures. The moisture barrier shall meet the requirements in Table 3.7.

Table 3.7 – Moisture Barrier Requirements

Test Property	Test Method	Specification Limits
Grab Tensile Strength, lb/in. at 12 in./minute rate of loading, min	D5034	70
Pliability, 180° bend, 1 in. mandrel at 20°F	D146	Unaffected
Resistance to Puncture, lb min	E154 (square mounting frame method)	40
Permeance, perm (kg/Pa · s · m2), max	E96, Method B	0.1
Weight, oz/yd^2 min	D3776	40

A non-metallic dust-on surface hardener and sealer shall be used on all slabs on-grade in the maintenance areas of the maintenance and storage facilities. The aggregate shall not consist of crushed or fractured aggregate particles, but shall be the natural configuration. All components of the surface hardener shall be formulated and processed under stringent quality control.

3.5.6 Reinforcing Steel

All reinforcing steel for building applications, including maintenance and storage facilities, shall conform to ASTM A615 Grade 60.

All welded wire mesh for building applications shall conform to ASTM A185.

All reinforcing steel for bridge and transportation applications, including roadways and maintenance and storage non-building applications, shall conform to Section 908.01 as prescribed in MDSHA's *Standard Specifications for Construction and Materials*. Alternate forms of reinforcement such as stainless steel reinforcement and Glass Fiber Reinforcement requires written approval by Owner.

Welded wire fabric for bridge and transportation applications, including roadways and yard and shop non-building applications, shall conform to Section 908.05 as prescribed in MDSHA's *Standard Specifications for Construction and Materials*. Galvanized welded wire fabric in conformance with Section 908.07 as prescribed in MDSHA's *Standard Specifications for Construction and Materials* may be used in slabs on-grade or pedestrian bridge decks in lieu of epoxy coated reinforcement.

Galvanized coating for fabric, ties, and connecting wire shall be at least 0.8 oz/ft^2 when tested per ASTM A90.

Epoxy-coated reinforcing steel shall conform to Section 917.02 as prescribed in MDSHA's *Standard Specifications for Construction and Materials* and shall be coordinated with the requirements of Part 2B, Section 20 of the Technical Provisions. Epoxy-coated reinforcing steel shall be used at the following locations unless otherwise directed by Part 2B, Section 20 of the Technical Provisions:

- Deck slabs.
- Approach slabs.
- Moment slabs.
- Barriers and parapets.
- Bearing seat pads under bridge deck roadway joints.
- All concrete superstructure/railway elements.
- Abutment backwalls.
- Abutment bearing seat areas.
- Pier caps under bridge deck roadway joints.
- End post and parapet portion of wingwalls.
- Portions of retaining walls, piers, abutments, and noise wall components located within 10 feet of the outside edge of the shoulder of any nearby roadway or areas where de-icing salts are used, measured vertically and/or horizontally.
- Top mat of the top slab including truss bars and any reinforcement extending into the top of the top slab for box culverts with less than 1 feet 6 inches of cover.

3.5.7 Pretensioning Steel

Prestressing steel shall be 0.5 inch or 0.6 inch-diameter low-relaxation strands conforming to ASTM A416 Grade 270.

3.5.8 Post-Tensioning Steel

Post-tensioning steel strand tendons shall be 0.5 or 0.6 inch-diameter low-relaxation strands conforming to ASTM A416 Grade 270, including the following requirements:

- Ultimate strength of prestressing steel (f_{pu}): 270 ksi.
- Yield stress (f_{py}) may be taken as $0.9f_{pu}$ = 243 ksi.
- Apparent modulus of elasticity: 28,500 ksi.

Post-tensioned parallel wires shall conform to ASTM A421. Bar tendons (high strength threaded bars) shall conform to ASTM A722 Grade 150, including the following requirements:

- Ultimate strength of bar (fpu): 150 ksi.
- Yield stress (fpy) may be taken as 0.8fpu = 120 ksi.
- Modulus of elasticity: 30,000 ksi.

3.5.9 Fiberglass Reinforced Polymers

Fiberglass reinforced polymers shall be preformed sheets and shall conform to the specifications in Table 3.8.

Table 3.8 – Fiberglass Reinforced Polymer Requirements

Property	Test Method	Specification Limits
Density, g/cm, min	D 792	1.25
Absorption, % max	D 570	1
Tensile Strength, average of five specimens in both the transverse and longitudinal direction, psi min	D 638	10,000
Thickness, in.	—	3/16
Thickness Tolerance, in.	—	+1/16, -0
Color No.	In accordance with Section 8 of the Technical Provisions	TBD

3.5.10 Not Used

3.5.11 Steel Stay-in-Place Forms

Steel forms which remain in place shall be fabricated from steel conforming to Section 909.11 of MDSHA's *Standard Specifications for Construction and Materials.* The minimum thickness of the steel stay-in-place forms shall be 0.0359 inch.

3.5.12 Timber

Structural timber elements of all permanent and temporary structures shall meet the material requirements of AASHTO M168. Concessionaire shall furnish certification as required within MTA's Standard Specifications.

3.5.13 Fire Protection

When working adjacent to, or within, WMATA ROW, WMATA's Adjacent Construction Project Manual shall be followed for specific requirements for temporary works. When working adjacent to property owned by an entity other than Owner, including other railroad tracks and buildings, fire protection shall be in accordance with the AHJ's specifications.

3.5.14 Waterproofing and Dampproofing

Materials for waterproofing and dampproofing applications shall be in accordance with Section 913 of MDSHA's Standard Specifications for Construction and Materials. Water stops shall be in accordance with Section 911.08 of MDSHA's Standard Specifications for Construction and Materials.

3.5.15 Grating

All grating for personnel walkways and vent shaft covers shall be made of steel in accordance with these provisions with slip resistant grit finish. Fiberglass reinforced plastic is not permitted for use.

3.5.16 Utilities

Allowable materials for utility applications shall be in accordance with Part 2B, Section 6 of the Technical Provisions.

3.5.17 Backfill

Materials used for backfill, including lightweight backfill, shall be in accordance with Part 2A, Section 4 of the Technical Provisions. .

Backfill placed below the ground grid elevation for TPSSs shall be of the lowest resistivity available.

Reinforced fill materials for MSE walls shall be MDSHA No. 57 stone. Select backfill in accordance with the specifications in Exhibit 2, Section 5 of the Agreement may be used for MSE walls whose anticipated owner is MTA as identified in Exhibit 3.11 of the Technical Provisions. Reinforced fill and retained fill materials consisting of Expanded Poly Styrene, lightweight foamed concrete fill or lightweight aggregate may be used provided that applicable testing is performed in accordance with AASHTO standards, NCHRP Report 529, Web Document 65 and the Contract Documents.

3.5.18 Ventilation Shafts

Air passages shall be constructed of smooth concrete or stainless steel sheet metal duct work.

3.5.19 Geofoam

Geofoam material shall conform to the requirements of ASTM D6817.

3.5.20 High-Strength Geotextile

High-strength geotextile fabric shall conform to the requirements of Section 921.09 of MDSHA's *Standard Specifications for Construction and Materials.*

3.5.21 Additional Materials Provisions for Tunnels

The following requirements shall apply to materials used in the design and construction of mined tunnels and shafts:

- Cast-in-Place Concrete: 28-day Compressive Strength: 5,000 psi.
- Shotcrete: 28-day Compressive Strength: 5,000 psi.
- Shotcrete Reinforcement: ASTM A82, ASTM A185, ASTM A496, ASTM A497, ASTM A615, ASTM A706, ASTM A820.
- Reinforcing Steel: ASTM A615 or ASTM A706, Grade 75.
- Lattice Girders: Minimum Tensile Strength: 80 ksi; Minimum Yield Strength: 70 ksi.
- Rock Reinforcement: ASTM A615 or ASTM A706, Grade 75.
- Rock Reinforcement End Hardware: ASTM A436; ASTM A563.
- Rock Reinforcement Bearing Plates: ASTM A36.
- Soil and Rock Anchors: ASTM A416; ASTM A722.

3.5.22 Fly Ash

Fly ash shall conform to the requirements of ASTM C618. The use of fly ash or other material that supports the flow of current is prohibited in any application where stray currents may be present. Owner must approve the use of fly ash in any application.

3.6 Construction Requirements

The provisions in this Section 3.6 set forth specific requirements for the facilities and structures noted.

Concessionaire shall coordinate the design and aesthetics of all bridges, retaining walls, noise walls, and structures with the AHJ. For the convenience of Concessionaire, a list of anticipated structures required for the Project is provided as Exhibit 3.10, 3.11 and 3.12 at the end of this Section. Therein reference is made to aesthetic treatments. Refer to Section 3.7.

The dimensions provided in this Section shall be considered a minimum and may need to be adjusted in Final Design based upon roadway design, traffic design, MOT and other factors. For MOT restrictions at specific locations refer to Part 2A, Section 20 of the Technical Provisions. All load testing data; pile driving records; drilled shaft inspection reports, field California bearing ratio verification testing; subgrade inspection reports; vibration, deformation, settlement, and other instrument monitoring reports; and any foundation performance and integrity testing shall be verified for their accuracy, validity and correctness.

Concessionaire shall submit Test Pile Reports for Information no later than 5 working days after driving test piles. The Test Pile Reports shall contain, as applicable:

- wave equation;
- high strain Dynamic Testing;
- signal matching reports;
- shaft integrity;
- static load Test Reports.

Concessionaire shall notify Owner at least 14 calendar days prior to performing any pre-production foundation installation activities.

3.6.1 Bethesda South Entrance and Terminal Station

The Bethesda South Entrance, including but not necessarily limited to, high speed elevators between Elm Street, the Purple Line System and WMATA Metrorail Red Line, emergency stairs, service rooms at WMATA Red Line Mezzanine and Machine-Room Levels, service rooms at Purple Line Level, ventilation shaft, stairs between Purple Line System and Elm Street, and extension of the pedestrian passageway at Red Line Mezzanine Level shall be designed and constructed in accordance with WMATA standards. Concessionaire shall coordinate design and construction with WMATA and Montgomery County. Machine room-less elevators shall not be permitted. Design and construction shall be in accordance with WMATA Standard Technical Specifications, WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities and Systems, WMATA Directive and Standard Drawings and the WMATA Adjacent Construction Project Manual.

All sanitary, groundwater and stormwater systems for the Bethesda South Entrance shall comply with WMATA and WSSC requirements.

Concessionaire shall coordinate design of Terminal Station with Montgomery County DOT, M-NCPPC and owners of Apex Building. Concessionaire shall coordinate design and location of ventilation towers and associated ventilation plenums with Federal Realty (Woodmont Plaza), M-NCPPC, owners of Apex Building and owners of Air Rights Building.

3.6.2 Montgomery County-Owned Structures

Except as modified herein design of the structures carrying highway traffic, including hydrology and hydraulics to size the opening of the bridge if applicable, shall be performed in accordance with MDSHA Structural Performance Specification. The use of fracture critical members for bridges carrying highway traffic is not permitted.

3.6.3 Capital Crescent Trail

The riding/walking surface on all bridges carrying the Capital Crescent Trail shall be concrete. The riding/walking surface shall be smooth and all joints shall be flush.

All bridges carrying highway traffic over the Capital Crescent Trail shall have lighting installed between the beams to illuminate the trail as described in Part 2B, Section 9 of the Technical Provisions.

The bridge carrying the trail over the LRT at the Air Rights Building to connect the Capital Crescent Trail to Elm Street Urban Park shall have a clear width of 14’0” and be either a bow string or tied arch bridge. A clear protective barrier shall be installed on both sides of the bridge over the OCS and extend from Elm Street Urban Park to a point east of Pearl Street where the barrier is no longer required for OCS protection.

The trail connection from Elm Street Urban Park to the proposed Capital Crescent Trail at the Air Rights Building shall be reconstructed with an ADA compliant connection. The location and design of the trail connection shall be coordinated with Montgomery County DOT and M-NCPPC Montgomery County Department of Parks. The surface of the trail from the Pearl Street connection to Elm Street Park shall be concrete.

Design of walls adjacent to and under the Air Rights Building shall be consistent with the proposed redevelopment of the Air Rights Building, minimizing visual impacts to Elm Street Urban Park. The design of the walls shall be coordinated with M-NCPPC Montgomery County Department of Parks and Montgomery County DOT.

3.6.4 Wisconsin Avenue Bridge over Purple Line (MD SHA Bridge No. 150500)

Retaining walls are anticipated to be constructed under the existing bridge to provide additional horizontal clearance for the Purple Line System and pedestrian walkway. The existing bridge abutments are supported on piles. Care shall be taken in placing temporary support of excavation to avoid conflicts with the existing piles. No tiebacks attached to the existing abutments will be allowed. The proposed modifications shall not hinder or limit accessibility for inspecting or maintaining the existing bridge. A sprinkler system shall be installed under the bridge to ensure the temperature of the superstructure never exceeds 500 degrees Fahrenheit. The Concessionaire shall coordinate with the Montgomery County Fire Marshall and MD SHA on the installation of this system. Structural connections for the sprinkler system and OCS shall not overstress any exiting bridge element. The Concessionaire shall blast clean and paint the entire steel superstructure in accordance with Maryland Standard Specification Section 436 following the requirements for Paint System C. The Concessionaire shall follow the MDSHA Structural Performance Specification for any modifications required to MDSHA Bridge No. 1501500.

3.6.5 Lynn Drive Underpass

A concrete arch culvert shall be provided under the LRT and CCT with a minimum clear width of 14’0” and minimum clear height of 10’0” and shall accommodate a trail clearance envelope of 12’0” wide and 9’0” high. The underpass shall be built with knock-out panels at entry and exit.

3.6.6 Sleaford Road Pedestrian Underpass

The existing adjacent drainage culvert and sanitary sewer shall be replaced with reinforced concrete pipe.

A concrete arch culvert shall be provided under the LRT and CCT with a minimum clear width of 14’0” and clear height of 10’0”. The underpass shall be along the Sleaford Road right-of-way with a connection to Kentbury Drive. Stair access shall be provided to the CCT at the Sleaford Road right-of-way. A switchback connection is not permitted in this location. ADA access shall be at the Kentbury Drive trail access point. The profile of the trail connection shall provide drainage away from the underpass.

3.6.7 Columbia Country Club

Two (2) golf cart underpasses shall be provided in the Columbia Country Club. The west underpass shall have a minimum clear width of 12’0” and clear height of 8’0”; the east underpass shall have a minimum clear width of 14’0” and a clear height of 10’0”.

3.6.8 Chevy Chase Lakes Development

A minimum 40’0” wide opening shall be provided for a future roadway connection under the LRT and Capital Crescent Trail at the Chevy Chase Lakes Development east of Connecticut Avenue. The location and vertical clearance shall be coordinated with Montgomery County and the property developer. Concessionaire shall coordinate design with the approved Sector Plan.

3.6.9 Coquelin Run Culverts

At Coquelin Run, two separate concrete arch structures, one for the stream and one for a future trail, shall be provided. The opening for the future trail shall have a minimum clear opening of 14’0" wide and 10’0" high and provide a clearance envelope of 10’0" wide and 9’0" high. The future trail structure shall be built with knock-out panels at entry and exit until such time that the trail is constructed.

3.6.10 Connecticut Avenue Bridges

The Purple Line System and Capital Crescent Trail shall span over Connecticut Avenue; an at-grade crossing will not be permitted. The Purple Line System and Capital Crescent Trail over Connecticut Avenue shall be carried on separate superstructures. The Capital Crescent Trail Bridge shall be a tied arch bridge as shown in Exhibit 1. The aesthetics of the two bridges shall be coordinated with M-NCPPC and Montgomery County DOT. The bridge carrying the CCT shall have a minimum clear width of 16’0”.

Exhibit 3.1 - Tied Arch Bridge for CCT Bridge over Connecticut Avenue

3.6.11 Jones Mill Road Bridge over Purple Line System and Trail

Except as modified herein design shall be performed in accordance with the MDSHA Structural Performance Specification. Abutments shall be designed assuming frozen bearings and for redundant tiebacks. The finish on the inside of the parapet walls on the Jones Mill Road Bridge shall match the color and finish as that on the Stony Brook Bridge. Solid, clear protective barriers, 6-foot high, shall be installed on the parapets over the OCS for the entire length of the bridge with anti-climb shields per MDSHA Standard BR-SS (3.05)-75-25. The bridge geometrics shall be determined based upon adjacent roadway design and a connection to the CCT provided and coordinated with Montgomery County DOT.

3.6.12 Rock Creek Bridges and Trail

All construction activities in the Rock Creek Park and Stream Valley area must be contained within County-owned transportation right-of-way including temporary construction easements. The Purple Line System and Capital Crescent Trail over Rock Creek shall be carried on separate superstructures. The Capital Crescent Trail Bridge shall be at a lower profile than the LRT Bridge to provide a view shed north and south of the park. A minimum window of 6’0” high x 130’0" wide shall be provided between the top surface of the deck of the Capital Crescent Trail Bridge and the underside of the superstructure of the LRT Bridge. The bridge carrying the Capital Crescent Trail over Rock Creek shall be a tri-chord, parabolic vierendeel truss as shown in Exhibit 3.2 and include a certified bridge inspection safety cable on the underside of the deck. The deck width shall vary parabolically from 16’0” at the abutments to 20’0” at midspan. Concessionaire shall coordinate the design and aesthetics with M-NCPPC and the National Capital Planning Commission, and the design and aesthetics shall be Approved by Owner. Both bridges shall be comprised of a single span; no permanent construction units will be permitted in the floodplain of Rock Creek. Both superstructures shall be composed of painted structural steel. Access to the LRT bridge abutments shall be provided from a path off of the CCT.

Concessionaire shall construct an ADA compliant connection between the Capital Crescent Trail and Rock Creek Trail on the north side of the transitway and trail fully within the County-owned transportation right-of-way. The design of the trail connection shall be coordinated with M-NCPPC Montgomery County Department of Parks and Montgomery County DOT. The trail connection shall consist of a switchback design and retaining walls utilized to reduce impacts and maximum planting areas.

The existing Rock Creek Trail shall be raised on an elevated wooden boardwalk out of the two-year floodplain as shown in Exhibits 3, 4 and 5. All work shall be contained within County-owned transportation right-of-way. Concessionaire shall coordinate with M-NCPPC on trail configuration and limits.

Rock Creek Trail shall be detoured, as necessary, and remain open during Construction Work of the LRT and Capital Crescent Trail Bridges over Rock Creek. Concessionaire shall provide trail user protection from overhead work to allow users access through the construction site to the maximum extent practical.

Minimum, selective tree clearing in and adjacent to Rock Creek Park shall be conducted. All work must be coordinated with M-NCCPC. Replanting and restoration shall occur within County-owned right-of-way to the maximum extent practical. No SWM or drainage structures shall be constructed within Rock Creek Stream Valley Park.

The existing pre-fabricated trusses carrying the Capital Crescent Trail over Rock Creek shall be protected, salvaged and transported, and unloaded to Montgomery County DOT to a location to be stipulated.

There shall be no heavy construction access from the Rock Creek Trail; only personnel can use the trail for access.

Exhibit 3.2 - Vierendeel Truss for CCT Bridge

Rock Creek Trail Boardwalk Exhibits

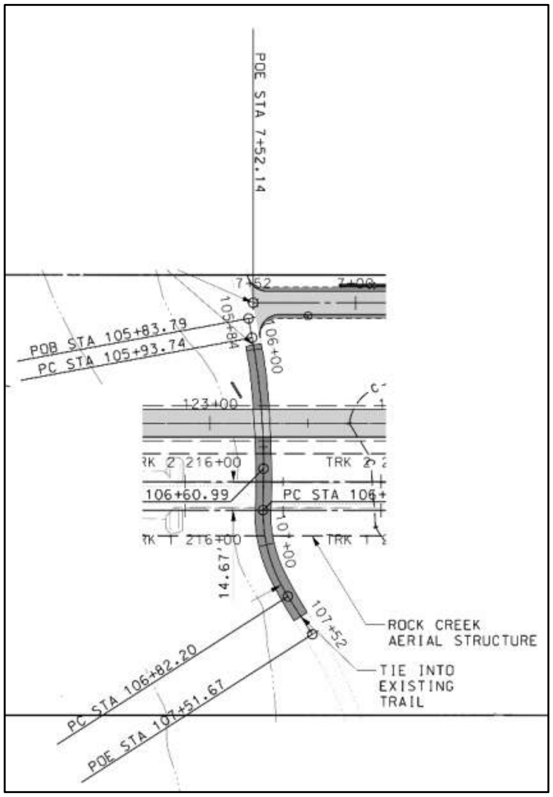


Exhibit 3.3: Alignment

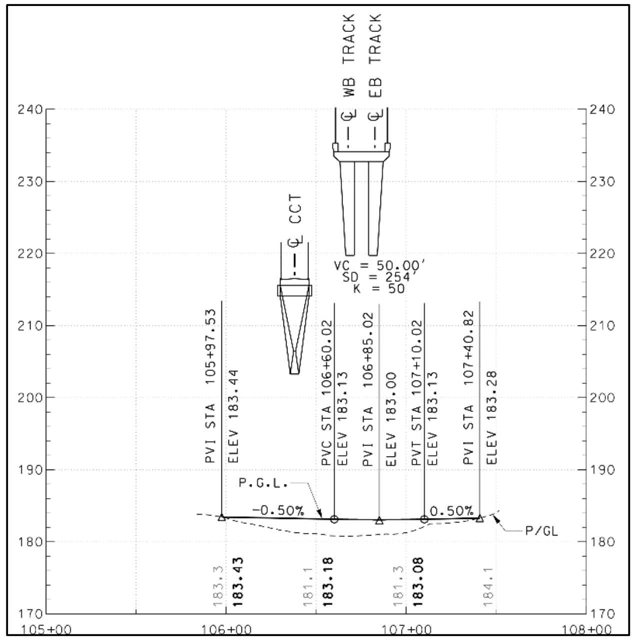


Exhibit 3.4: Profile

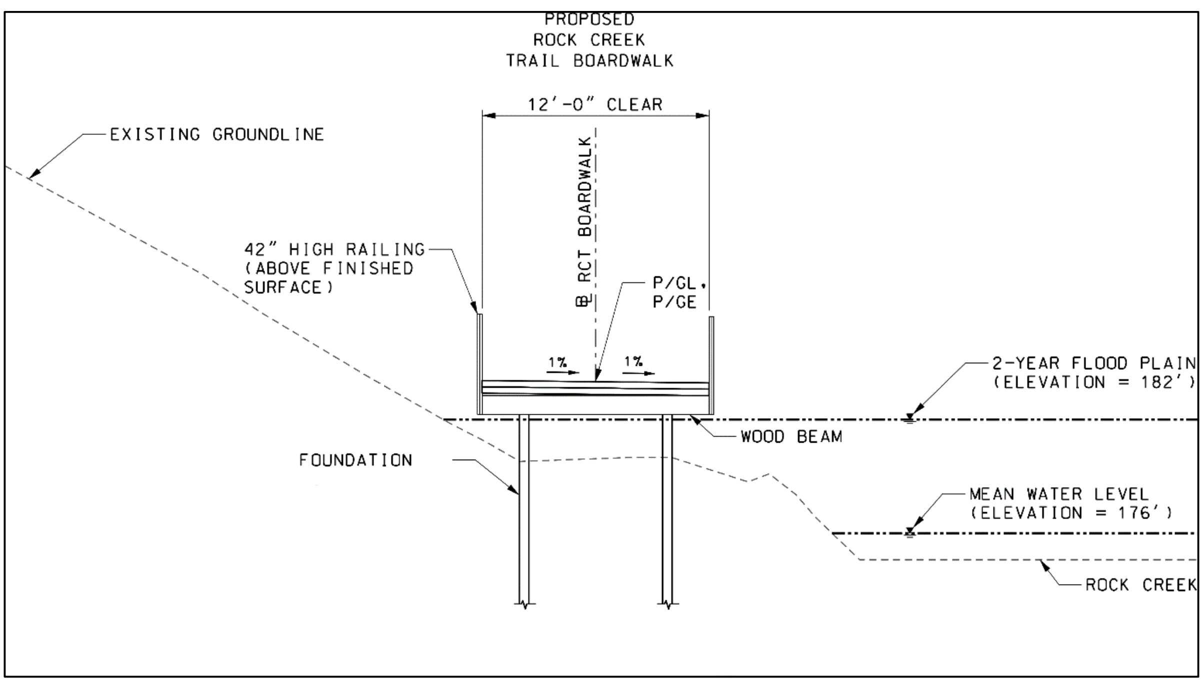


Exhibit 3.5: Section

3.6.13 CCT Underpass East of Rock Creek Bridges

The CCT underpass east of the Rock Creek Bridges and west of Lyttonsville shall provide a minimum clear width of 16’0” (12’0" wide path and a 2’0" shoulder on each side) and clear height of 12’0”. Dimensions shall be increased if required to meet sight distance requirements.

3.6.14 Not Used

3.6.15 Lyttonsville Place Bridge over Purple Line System and Trail

Except as modified herein design shall be performed in accordance with MDSHA Structural Performance Specification. Solid, clear protective barriers. 6 feet high, shall be used on both sides of the bridge on the parapets over the OCS wires for the entire length of the bridge with anti-climb shields per MDSHA Standard BR-SS(3.05)-75-25. In addition to normal areas requiring painting, if weathering steel is the chosen material for the superstructure, all girders for the span over the CCT shall be painted.

Provisions for kiss-and-ride drop-off shall be provided on both sides of the bridge.

The clear deck width shall be 48’0” curb-to-curb. A 12’8” sidewalk shall be constructed on the north side and a 5’8” sidewalk on the south side.

3.6.16 Talbot Avenue Bridge over Purple Line System and CSXT

Work for the retaining walls and proposed bridge shall be coordinated with Montgomery County DOT and Montgomery County Public Schools. Heavy construction of the bridge abutments and retaining walls adjacent to the Rosemary Hills Elementary School shall be limited to summer months.

Solid, clear protective barriers, 6-foot high, shall be used on approach retaining walls and on both sides of the bridge on the parapets over the OCS wires for the entire length of the bridge with anti-climb shields per MDSHA Standard BR-SS(3.05)-75-25.

The clear deck width of the proposed bridge shall be 28’0”. A 12’8” sidewalk shall be constructed on the west side of the bridge.

3.6.17 16th Street Bridge over Purple Line System, CCT, CSXT and WMATA (MD SHA Bridge No. 1508900)

It is anticipated that the existing abutment will be underpinned to support the proposed Purple Line System. The Concessionaire shall verify the locations and limits of the existing substructure units and coordinate the final design with MDSHA. Care shall be taken not to undermine the existing substructure when constructing the proposed retaining walls underneath the bridge. A protective barrier shall be installed over the OCS in accordance with MDSHA requirements and standards for barrier over an electrified railroad. The proposed modifications to the bridge shall not hinder or limit accessibility for inspecting or maintaining the existing bridge. The Concessionaire shall follow the MDSHA Structural Performance Specification for any modifications required to MDSHA Bridge No. 1508900.

3.6.18 Spring Street Bridge over Purple Line System, CCT, CSXT and WMATA

The typical section and striping shall be coordinated with Montgomery County. Aesthetic treatment is required on both the inside and outside faces of the parapet walls and a solid, clear protective barrier, 6-foot high, shall be utilized on the parapets over the OCS wires for the full bridge length with anti-climb shields per MDSHA Standard BR-SS(3.05)-75-25. The superstructure shall be composed of prestressed concrete beams.

The clear deck width shall be 24’0” curb-to-curb, each side of the median. A 5’8” sidewalk shall be provided on each side of the bridge. A 4’0” wide, aesthetic raised median shall be provided between travel lanes with a fence mounted to the median. The median and fence should extend along the median of Spring Street between the intersections with 16th Street and 2nd Avenue and have similar aesthetics to that as installed along Randolph Road between the intersections with Selfridge Road and Veirs Mill Road.

3.6.19 LRT and CCT Bridges at Silver Spring Transit Center

The bridge carrying the CCT adjacent to the Silver Spring Transit Center shall have a clear width of 14’0” and 10’6” clear height.

CSXT, WMATA and MARC service and egress shall be maintained at all times.

All formwork for substructure and superstructure elements shall meet CSXT clearance requirements.

Only one lane in each direction of Colesville Road may be closed at a time.

The Purple Line Mezzanine Connection shall be constructed to include a connection to WMATA.

Structural steel over the plaza shall be painted; weathering steel shall not be permitted.

The Metropolitan Branch Trail shall be included with the Plaza Level design and be ADA compliant.

A special wind study for the elevated Station shall be conducted.

3.6.20 Silver Spring International Middle School Retaining Walls

Work for the retaining walls shall be coordinated with Montgomery County DOT and Montgomery County Public Schools. Heavy construction of the retaining walls and parking lot adjacent to the Silver Spring International Middle School shall be limited to summer months.

3.6.21 Wayne Avenue Bridge over Sligo Creek

Concessionaire shall maintain pedestrian traffic at all times. The aesthetics on the parapets and three-strand open rail shall be coordinated with Owner and Montgomery County. Corrosion resistance reinforcing, either ASTM A1035 or stainless steel, shall be utilized for the bridge superstructure including deck, parapets, end posts, cheekwalls, bearing pedestals and beam seats. The superstructure shall be composed of prestressed concrete beams.

An 8’9” sidewalk shall be provided on the north side of the bridge and a 6’9” sidewalk on the south side. Lane widths shall be determined based upon adjacent roadway approach design.

Guardrails, bridge parapets and railings, signs and other existing structures on Wayne Avenue and Sligo Creek Parkway shall be replaced with new structures, where appropriate. Any new structures shall match existing elements throughout the park, including aesthetics on the parapets and three-strand open rail.

Concessionaire shall consider that this bridge and location is located within the 10 year flood plain. Concessionaire shall take appropriate precautions when designing foundations for the bridge, anchor wires and OCS poles as well as design of System Elements including, at a minimum, ductbanks, manholes and Utilities.

3.6.22 Retaining Walls Adjacent to Manchester Place Station

A solid, clear protective barrier, 6-foot high, shall be utilized on the full length of walls over the OCS wires.

3.6.23 Plymouth Tunnel

As referenced from the eastbound track, the portion of tunnel between Stations 411+41.46 and 421+61.94 shall not be an open cut tunnel. A solid, clear protective barrier, 6-foot high, shall be utilized on the full length of portal walls adjacent to and over the OCS wires.

3.6.24 Long Branch Stream Valley Park Culvert (MDSHA Small Structure No. 15045X0)

The existing culvert that conveys Long Branch Stream beneath Piney Branch Road shall be lengthened and a new parallel box culvert shall be constructed. The existing lengthened culvert shall be used to mitigate frequent flooding. The size of the new culvert required to handle base flow and provide fish passage shall be determined by the Concessionaire. The headwalls and wing walls associated with the proposed culvert extension shall be raised to accommodate a future sidewalk widening to 10'0" without impacting the extended culvert. The new culvert, the culvert extension, wingwalls, and headwalls shall be cast-in-place concrete. The Concessionaire shall complete a full condition inspection of the existing culvert and submit the inspection findings to MDSHA Office of Structures for review and make any repairs as directed by MDSHA. All design on this structure, including hydrology and hydraulics to size the opening of the culvert, shall be performed in accordance with MDSHA Structural Performance Specification.

3.6.25 Northwest Branch Stream Valley Park

A retaining wall shall be constructed near the eastern end of an existing drainage ditch located directly east of West Park Drive on the north side of University Boulevard to maintain the ditch and avoid disturbance of the embankment that supports an existing pond, located to the north of the proposed wall. Areas that are impacted as a result of SWM upgrades shall be returned to MNCPPC when construction is completed.

3.6.26 University Blvd Bridge over Northwest Branch (MDSHA Bridge No. 1601800)

Only the bridges carrying vehicular traffic will be owned and maintained by MDSHA. The Concessionaire shall replace this bridge with three separate and independent structures with joints between both the superstructures and substructures. The two highway bridges carrying northbound and southbound MD 193 traffic shall each provide a 1'0" offset to the median adjacent to the LRT, two 11'0" travel lanes, a 5'0" bicycle lane, and a minimum 5'8" sidewalk. The sidewalk along the northbound MD 193 Bridge will vary between 7'9" on the west end and 8'11" on the east end. Pedestrian traffic must be maintained at all times for both sidewalks during Construction Work. The minimum width of the pedestrian path during Construction Work shall be 4'6". Both steel and concrete options for superstructures will be allowed. All design for the vehicular structure, including hydrology and hydraulics to size the opening of the bridge, shall be performed in accordance with MDSHA Structural Performance Specification.

3.6.27 Anacostia LRT Bridge over Northeast Branch

A minimum of 10'0" horizontal clearance shall be maintained between the existing bridge and the proposed bridge and a minimum vertical clearance of 8'0" maintained over existing trails. Aesthetics of the bridge shall be coordinated with M-NCCPC.

3.6.28 Kenilworth Avenue Aerial

The Purple Line System shall be grade-separated over the intersection of Kenilworth Avenue and East West Highway (MD 410). A clear span shall be placed over the intersection and all substructure units located to accommodate a future widening, one lane at 12'0", of MD 410 in the westbound direction and sight distances. Concessionaire shall coordinate with MDSHA on pier locations and sight distances.

3.6.29 Riverdale Park Station

The Riverdale Park Station shall be elevated. Structural support shall be developed by the Concessionaire.

Exhibit 3.6 – Not Used

Exhibit 3.7 – Not Used

Exhibit 3.8 – Not Used

3.6.30 Baltimore-Washington Parkway over Purple Line System and Riverdale Road

MOT shall be coordinated with the NPS to avoid impacts to trees and an archaeological site in the median, as illustrated in the FEIS. Protected resources shall be identified and marked in the field prior to construction activities. Two lanes of traffic in each direction on Baltimore-Washington Parkway shall be maintained during all stages of construction.

Permanent replacement bridges shall be constructed and include similar arch design as the existing bridge structures. The clear roadway width of the new bridges shall match the existing. The new structures shall be on the same horizontal alignment as the existing. The new bridges shall include horizontal arched protection shields above the transitway OCS wires and the design of the shields shall be coordinated with the NPS. The shape of the shields shall match the arch of the bridge superstructure, blending in visually as vehicles approach the bridge on Riverdale Road. The shields shall not extend above the bridge railings so as to maintain views from the Parkway.

Stone removed from the existing wingwalls shall be salvaged and reused on the face of the proposed wingwalls. If additional stone is required, it shall be selected in consultation with the NPS to match the existing.

Catenary wires shall be attached to the bridges to minimize the number of poles throughout the Park. Location and details shall be coordinated with the NPS.

Concessionaire shall reference *Baltimore-Washington Parkway Design Elements, February 1984* for additional design requirements.

3.6.31 Noise Walls

Between the Bethesda Terminal Station and Jones Mill Road, noise walls or retaining walls shall be placed adjacent to residential areas. The height of the noise wall or retaining wall shall not be less than 4’0” above top of rail if adjacent to LRT and 4’0" above walking surface if adjacent to the CCT. If the noise wall also functions as a safety fence, the height shall meet that required for safety and security. Noise walls or retaining walls are required where shown in Exhibit 3.12.

3.6.32 Bonifant Garage 5/55

It is anticipated an existing circulation bridge at the 3rd Level over Bonifant Street will be demolished to accommodate the LRT profile. A new bridge shall be provided between existing column lines 10 and 11 at the 2nd Level and the clear width shall be 22’0". A 1" isolation joint shall be provided between the existing parking structures and the new bridge.

Solid, clear protective barriers, 6-foot high, shall be used on both sides of the bridge on the parapets over the OCS wires for the entire length of the bridge with anti-climb shields per MDSHA Standard BR-SS(3.05)-75-25.

3.7 Structure Aesthetics

3.7.1 General

In addition to the finishes specified in Part 2B, Section 3.6 of the Technical Requirements, Concessionaire shall provide architectural treatment on structures as specified in Exhibits 3.10, 3.11, and 3.12 and the Contract Drawings. Concessionaire shall apply form release agents, form stripping methods, patching materials, and construction procedures that are mutually compatible with the specified surface finish and concrete stain. If the geometric layout of a structure is changed by Concessionaire during design, the resulting effects on the aesthetic details shall be included in the Submittals.

Finishes are organized into groups of similar texture and/or type as follows:

- Group 1 – Masonry Finishes
    - Brick
    - Royalite
    - Rustic Ashlar
    - New England Dry Stack
    - Random Cut Stone
    - Segmental Retaining Wall Split Face
- Group 2 – Coarse Textured Finishes
    - Exposed aggregate concrete
    - Fuzzy Rake
    - Fractured Fin
- Group 3 – Fine Textured Finishes
    - Sandblast Finishes
    - Fractured Granite
    - Random Slate
- Group 4 – Plain Architectural Finishes
    - Smooth-rubbed Finish

Concessionaire shall provide architectural finishes as set forth in Exhibits 3.10, 3.11 and 3.12, and other Contract Documents as applicable. In cases where the Contract Documents specify a finish group, Owner will consult with stakeholders as required, select a finish within the specified family, and advise Concessionaire accordingly. Concessionaire shall provide the Owner selected finish.

Concessionaire's Project Schedule shall identify the dates by which Owner must inform Concessionaire of Owner selected finishes.

Owner will consult with and obtain input from others regarding architectural finishes for Structures. Concessionaire shall support this effort by attending meetings, furnishing data and providing presentation materials as requested by Owner in accordance with Part 2A, Section 13.3 of the Technical Requirements .

3.7.1.1 Form Liner

Form liners shall be oriented level and plumb and shall not follow the profile of the roadway, track, trail or proposed grade.

The form liner shall attach easily to the forming system, and shall not compress more than 0.021 feet when poured vertically at a rate of 10 ft/hr. The liners shall be capable of withstanding anticipated concrete pour pressures without leakage causing physical or visual defects. The liners shall be removable without causing concrete surface deterioration or weakness in the substrate.

Concessionaire shall carefully blend form liner butt joints into the approved pattern and finish of the final concrete surface. There shall be no visible vertical or horizontal seams or conspicuous form marks created by butt joining form liners. The finished texture, pattern, and color shall conform to the approved sample panel, and shall be continuous without visual disruption.

Concessionaire shall prior to each pour, clean the form liners to be free of build up and visually inspect each liner for blemishes and tears. Concessionaire shall make repairs in accordance with the manufacturer’s recommendations and at no change in the appearance of the final product.

Concessionaire shall securely attach form liners to forms in accordance with the manufacturer’s recommendations and with less than a 1/4 inch seam.

When form or wall ties are used that result in a portion of the tie permanently embedded in the concrete, submit the type of form ties for approval by Owner prior to use in this work.

The release agent shall be compatible with the surface finish and concrete stain to be applied. Concessionaire shall apply the release agent in accordance to the manufacturer’s recommendations.

3.7.1.2 Concrete Stain

The color of the concrete stain shall conform to Federal Standard 595, for the Color No. specified. The coloring agent shall be a penetrating stain mix, compatible color finish designed for exterior application on new or old concrete with field evidence of resistance to moisture, alkali, acid, mildew, mold and fungus discoloration or degradation. The coloring agent shall be breathable, allowing moisture and vapor transmission. Concessionaire shall select concrete stain from a list of prequalified concrete stains that is maintained by the MDSHA Office of Materials Technology. Unless otherwise specified, apply two coats of concrete stain in accordance with the manufacturer’s recommendations.

When the concrete is at least 28 days old, Concessionaire shall pressure wash surfaces to be stained with a pressure washer set at 3000 psi to remove laitance. Hold the fan nozzle perpendicular to the surface at a distance of 1 to 2 ft. Abrasive blasting is prohibited. The completed surface shall be free of blemishes, discolorations, surface voids, and conspicuous form marks.

3.7.1.3 Expansion Joint Material

Expansion joint material shall be finished so as to visually continue the simulated stone/brick pattern or other specified finishes, uninterrupted. Include a sample of the colored expansion joint material in the sample panel.

3.7.1.4 Sample Panels

The Concessionaire shall construct a sample panel for each form liner type specified and for each concrete stain color specified using approved form lining materials and surface coloring for Review and Approval. Concessionaire shall use the same formwork including form or wall ties proposed for use and concrete placement for the sample panel as that used for the finished structure.

The form liner and concrete stain used for each sample panel shall produce the same pattern and surface coloring that is intended for use on the finished structure. When the finished structure will contain vertical or horizontal form liner seams/joints, the sample panel shall include the same seams/joints. The sample panel shall be unreinforced concrete cast in the same position (vertically or horizontally) as will be the finished product to determine the surface texture resulting by use of the form liner. The minimum size of concrete sample panel shall be 6 inches thick, 4 feet wide, and 4 feet high.

The approved sample panels shall remain on the Site as a basis for comparison.

3.7.1.4.1 Sample Panel Photographs

The Concessionaire shall provide MTA digital photographs of the sample panel as part of the Submittal. The photographs will be used by Owner in evaluating the acceptance of the finish, but will not replace or supersede the delivery of sample panels as required. MTA reserves the right to make an on-site inspection at any time or to request additional photographs. Concessionaire shall submit additional photographs depicting the relief and colors, provided that the additional photographs conform to the requirements in this section.

Concessionaire shall use a digital camera with a minimum resolution of 3.1 megapixels, and take all photographs without the use of the camera’s zoom features. All all photographs will be taken with the camera’s line of sight being approximately perpendicular on the horizontal to the surface of the sample panel regardless of the orientation of the sunlight and taking multiple photographs with variations in the angle of the sunlight shinning on the sample panel in approximately 15 degree increments and be free of shadows from the camera and other foreign objects. The camera may be required to be plus or minus perpendicular to accomplish this requirement when the sun is shining on the sample panel at a 90 degree angle.

The Concessionaire shall take photographs so that the top and bottom of the sample panel take up the full top and bottom of the camera’s view screen without the use of the zoom feature. Concessionaire shall place a card adjacent to the sample panel in each photograph identifying the supplier, the casting date for each panel; and a 1 x 6 in. black bar, a ruler, or other means of showing scale that is legible when viewing the photograph.

Concessionaire shall certify that all all photographs submitted as part of the Review and Approval of the sample panel and were made directly from the digital camera’s memory device at the time of the inspection with no enhancement or modifications. The certification submitted by Concessionaire with the photographs shall contain the following information:

- casting date;
- contract number;
- description of the sample with file names for each sample;
- number of images sent;
- date and time the images were shot;

- panel serial numbers, or other identifying markings; and
- certification that the panel has not been used on a previous project, that the panel is uniquely marked. .

3.7.1.5 Uniformity

Due to the large size and scope of the Project, the Concessionaire shall ensure that the same manufacturer's form liner or concrete stain is used by all Contractors at all locations for each type of specified architectural treatment. When exposed aggregate is specified as the architectural treatment, the same coarse aggregate shall be used in the production of these elements.

3.7.2 Random Cut Stone

Random cut stone form liner pattern shall have concrete stain finishes replicating a real, random cut stone pattern. The form liner pattern shall comply with the following dimensional ranges for individual stones:

- individual stone lengths of 2' to 6' and heights of 24";
- dimension of form liner reveal from the outermost face of stone to the inside face of the grout joint shall be a maximum of 1"; and
- width of the grout pattern joints between individual stones shall be 3/8" to 1".

Concessionaire shall provide three different form liner patterns with a minimize size of 32 ft^2. The pattern shall have the capability of being turned 180 degrees to result in a minimum of six different pattern combinations. Individual patterns shall not be repeated side by side. Provide a combination of liner patterns that prohibit long continuous horizontal or vertical grout pattern joint lines occurring on the finished exposed surface.

The concrete stain color shall be light gray and be subject to approval by the MTA. The concrete stain colors shall include a light gray base color, a range of four shades of gray from 20 to 80 percent gray highlight colors to achieve a finished look that will simulate natural stone. The specified color range shall vary within the cool gray range from light to medium base colors with dark gray highlights. Use a minimum of seven shades of gray to simulate the natural stone.

3.7.3 New England Dry Stack

A New England dry stack form liner pattern shall have a concrete stain finished replicating a real, dry stack stone pattern. The form liner pattern shall comply with the following dimensional ranges for individual stones:

- individual stone lengths and heights from 3" to 24";
- dimension of form liner reveal from the outermost face of stone to the inside face of the grout joint shall be ½" to 1 3/8"; and
- width of the grout pattern joints between individual stones shall be 3/8" to 2".

Concessionaire shall provide two different form liner patterns with a minimize size of 16 ft^2. The pattern shall have the capability of being turned 180 degrees to result in a minimum of four different pattern combinations. Individual patterns shall not be repeated side by side. Provide a combination of liner patterns that prohibit long continuous horizontal or vertical grout pattern joint lines occurring on the finished exposed surface.

The concrete stain colors shall include a base color, a surface color, and two highlight colors to achieve a finished look that will simulate natural stone. Apply the base color, which may be sprayed, to the entire surface (stones and grout pattern joints). Apply the surface color to 80 percent of the surface of simulated stones (front face and edges). Apply each highlight color to 2 to 5 percent of the surface of the simulated stones (front face only). Apply the surface and highlight colors to the front face of the simulated stones using a sponge; however, the surface color shall be applied to the edges of the simulated stones by brush. Do not apply the surface and highlight to the grout pattern joints.

3.7.4 Royalite Dry Stack

A royalite dry stack form liner pattern shall have a concrete stain finished replicating a real, dry stack stone pattern. The form liner pattern shall comply with the following dimensional ranges for individual stones:

- individual stone lengths and heights from 3” to 16”;
- dimension of form liner reveal from the outermost face of stone to the inside face of the grout joint shall be 1 ¼” to 2 ¼”; and
- width of the grout pattern joints between individual stones shall be 3/8” to 2”.

Concessionaire shall provide two different form liner patterns with a minimize size of 16 ft^2. The pattern shall have the capability of being turned 180 degrees to result in a minimum of four different pattern combinations. Individual patterns shall not be repeated side by side. Provide a combination of liner patterns that prohibit long continuous horizontal or vertical grout pattern joint lines occurring on the finished exposed surface.

The concrete stain colors shall include a base color, a surface color, and two highlight colors to achieve a finished look that will simulate natural stone. Apply the base color, which may be sprayed, to the entire surface (stones and grout pattern joints). Apply the surface color to 80 percent of the surface of simulated stones (front face and edges). Apply each highlight color to 2 to 5 percent of the surface of the simulated stones (front face only). Apply the surface and highlight colors to the front face of the simulated stones using a sponge; however, the surface color shall be applied to the edges of the simulated stones by brush. Do not apply the surface and highlight to the grout pattern joints.

3.7.5 Running Bond Used Brick

A running bond used brick form liner pattern or stamped pattern shall have a concrete stain finish replicating a real brick constructed in a running bond pattern. The form liner and stamped pattern shall comply with the following dimensional ranges for joints:

- dimension of form liner reveal from the outermost face of brick to the inside face of the grout joint shall be ½” with a plus 1/8” tolerance; and
- width of the grout pattern joints between individual bricks shall be 3/8” with a plus 1/8” tolerance.

When used for noise walls, the Concessionaire has the option of providing a stamped brick finish on one side of the panel. At least one side of the panel shall have a form liner finish. When a stamped finish is used, the stamped side shall be on the side of the wall facing away from the LRT.

Concessionaire shall place all form tie holes in the grout pattern joints. The ties shall be designed so that all material in the device to a depth of at least 1” behind the concrete face (bottom of grout pattern joint) can be disengaged and removed without spalling or damaging the concrete.

Concessionaire shall finish the tie holes in accordance with standard concrete practices and ensure that all patching material matches the color and appearance of the cast concrete surface.

The approved sample panel shall be the basis for determining the appropriate color/stain application.

3.7.5.1 Defects and Tolerances

Concessionaire shall place concrete in a manner so that there are no cold joints. Concessionaire shall conform to the following tolerances with each panel:

- simulated brick dimensional tolerance - Variations from specified nominal dimensions for the length, height, and thickness shall be plus 0, minus 1/16 in.
- simulated brick installation tolerances - Installation tolerances for precast concrete panels with brick finish:
  - maximum variation in alignment of horizontal or vertical mortar joints shall be ¼" in 10', noncumulative;
  - maximum offset in plane of adjacent form liner units shall be 1/16"; and
  - maximum misalignment between adjacent form liner units shall be 3/64".

3.7.6 Fractured Granite and Random Slate Textured Finish

A fractured granite and random slate textured finish form liner pattern shall have a concrete stain finished replicating either a fractured granite or random slate. The textured finish shall be consistent from edge to edge of form liner. The textured finish shall have an approximate depth of 3/8".

3.7.7 Fractured Fin

A fractured fin form liner pattern shall have a concrete stain finish replicating a fractured fin surface. The fractured fin pattern shall run in the vertical direction unless stated otherwise. The fractured fin relief shall run parallel to the lines of the structure as opposed to being level or plumb. The form liner pattern shall comply with the following dimensional ranges:

- fin spacing shall be from 1 ½" to 3";
- relief or depth of grooves shall be ¾" to 1"; and
- width of projecting fins or ribs shall be as wide as or wider than grooves or depressions between ribs.

Where specified the fractured fin surface shall have a concrete stain applied.

Where not specified, a concrete stain is not required. The Concessionaire shall protect the fractured fin surface throughout construction from stains, discoloration, chips, cracks, etc., as the surface will be the finish surface of the structure.

3.7.8 Railings

Refer to Exhibit 3.13 for railing requirements at LRT and Capital Crescent Trail Bridges.

3.8 Design Submittals

3.8.1 Structures Design Submittals

Concessionaire shall submit Structures Design for Review and Comment at Preliminary, Intermediate and Final Design. Concessionaire may elect to submit structures individually or in groups of similar type. Content of the Submittals shall be in accordance with the following sections.

3.8.1.1 Preliminary Design Submittal

The Preliminary Design Submittals shall include, at a minimum:

- type selection reports (Basis of Design);
- preliminary general arrangement drawings;
- preliminary tunnel reports;
- preliminary foundation reports;
- preliminary hydraulic reports;
- preliminary aesthetic treatment proposals; and
- verification of consistency with components already constructed or to be constructed.

3.8.1.2 Intermediate Design Submittal

The Intermediate Design Submittal shall include, at a minimum:

- updates to the preliminary Submittal as applicable;
- plans;
- specifications;
- technical memos;
- studies; and
- calculations.

3.8.1.3 Final Design Submittal

The Final Design Submittal shall include, at a minimum:

- updates to the Intermediate Design Submittal as applicable;
- independent design check reports on bridge and tunnel structures;
- mass concrete control plan as applicable;
- fracture critical fabrication and inspection control plan; and
- final Structures Computations Report.

3.8.2 Final Structure Computations Report

Concessionaire shall submit a Final Structures Computations Report shall be a complete set of computations, including computer input/output, for the final geometry, structure hydrology and hydraulics (where required), and structural design/analysis for the designed elements of each structure as well as the rating and rating files. Ratings for non-Owner structures shall be in accordance with the AHJ requirements. This record submission shall comprise of complete documentation for the design work.

3.8.3 Structure Inventory

Concessionaire shall provide all the necessary input for Owner's inspection database system. The input data shall be provided in the inspection report described in Part 3, Section 5.1.2 of the Technical Provisions. Concessionaire will be provided the opportunity to review the database results prior to their finalization.

Concessionaire shall submit the Structure inventory for Information upon completion of construction of each structure.

3.8.4 Numbering of Structures

The final structure numbering system will be provided by Owner for each permanent bridge, noise barrier, retaining wall, culvert, and catenary pole. Concessionaire shall provide markers that are four inches square, precast concrete at each permanent structure extending 2'6" minimum above finished ground. Edges of markers shall be chamfered ½" and reinforced.

For structures that will be owned by others the AHJ will provide direction regarding the numbering system and disposition of markers.

3.9 Summary of Submittals

Item	Section	Submittal	Action
1	3.4.6.2.24	Mass Concrete Control Plan	Review and Approval
2	3.6	Test Pile Reports	Information
3	3.7.1.4	Sample Panels	Review and Approval
4	3.7.1.4.1	Sample Panel Photographs	Information
5	3.8.1	Structures Design Submittal - Preliminary	Review and Comment
6	3.8.1	Structures Design Submittal - Intermediate	Review and Comment
7	3.8.1	Structures Design Submittal - Final	Review and Comment
8	3.8.2	Final Structures Computations Report	Information
9	3.8.3	Structure Inventory	Information

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Exhibit 3.10 Structures: Bridges, Culverts and Vertical Circulation

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
1	Apex Building Modifications	1	Montgomery County Building owner	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings	
2	Bethesda South Entrance Project	1	Montgomery County, Building owner, WMATA	WMATA	WMATA/ Concessionaire	See Book 4 Contact Drawings architectural drawings	
3	Wisconsin Avenue Bridge	1	Montgomery County, SHA	SHA	SHA	4	Paint beams, concrete and fencing in Fed. Color No. 36231
4	Air Rights Building Modifications	1	Montgomery County, Building owner	Building owner	Building owner	4	All concrete, steel and plenum surfaces shall be painted Fed. Color No. 36231
5	East Fan Plant beneath Air Rights Parking Garage	1	Montgomery County, Building owner	MTA	Concessionaire	4	All wall surfaces shall be painted Fed Color No. 36231 except south side adjacent to Elm Street Park shall be medium Ironspot masonry veneer color #77 by Endicott with stainless steel louvers

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
6	CCT Pedestrian Bridge at Bethesda Station including south approach retaining walls	12	Montgomery County	Montgomery County	Montgomery County	3	Substructure shall be stained fractured granite finish with plain coping Structural steel paint color shall be Fed. Color No. 30109
7	Lynn Drive Underpass	1	Montgomery County	MTA	Concessionaire	1	Headwall and wing walls: Stained coursed random cut stone (keyed).
8	Sleaford Road Pedestrian Underpass	1	Montgomery County	MTA	Concessionaire	1	Headwall and wing walls: Stained coursed random cut stone (keyed).
9	Columbia Country Club Underpasses	1	MTA, Columbia County Club	MTA	Concessionaire	1	East and West underpass south headwalls, West underpass wingwalls III & IV and East underpass wingwalls I & II: Stained New England dry stack with plain coping. East and West underpass north headwalls and West underpass wingwalls I & II: Split face masonry
10	Connecticut Avenue Aerial	1	SHA	MTA	Concessionaire	1	Stained brick with plain coping and pilasters Structural steel shall be painted Fed. Color No. 34064

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
11	Connecticut Avenue Pedestrian Bridge	12	SHA, Montgomery County	Montgomery County	Montgomery County	1	Stained brick with plain coping and pilasters Structural steel shall be painted Fed. Color No. 34064
12	Connecticut Avenue Vertical Structures	1	SHA, Montgomery County	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings	
13	Chevy Chase Lakes Development Road B-1 Pedestrian Bridge	12	Chevy Chase Lakes Developer, Montgomery County	Montgomery County	Montgomery County	1	Stained brick with plain coping and pilasters
14	Chevy Chase Lakes Development Road B-1 Aerial	1	Chevy Chase Lakes Developer, Montgomery County	MTA	Concessionaire	1	Stained brick with plain coping and pilasters
15	Coquelin Run Culvert & Underpass	1	Montgomery County	MTA	Concessionaire	4	Culvert surface and wingwalls: Plain sealed concrete - no stain

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
16	Jones Mill Road Highway Bridge	1	Montgomery County	MTA	Montgomery County - Snow removal from road only; Concessionaire - Everything else	1 & 3	Inside parapets: To match color and finish of Stoneybrook Bridge Outside parapets: Fractured granite stained finish Abutments at Jones Mill: Stained rustic ashlar with plain coping and pilasters.
17	Rock Creek Aerial	1	Montgomery County, National Capital Planning Commission, M-NCPPC	MTA	Concessionaire	3	See Technical Provisions for signature structure requirements and railing aesthetics. Abutments: Fractured granite stained finish Structural steel paint color shall be Fed Color No. 30109
18	Rock Creek Pedestrian Bridge	12	Montgomery County, National Capital Planning Commission, M-NCPPC	Montgomery County	Montgomery County	3	See Technical Provisions for signature structure requirements and railing aesthetics. Abutments: Fractured granite stained finish Structural steel paint color shall be Fed Color No. 30109

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
19	CCT Underpass West of Lyttonsville	1	Montgomery County	MTA	Concessionaire	1 & 4	Headwalls: Stained rustic ashlar finish with plain coping Underpass: Plain sealed concrete finish stained
20	Lyttonsville Place Highway Bridge	1	Montgomery County	MTA	Montgomery County - Snow removal from road only; Concessionaire - Everything else	3 & 4	Inside and outside of parapets: Fractured granite stained finish Piers: Plain sealed concrete – no stain Both abutments: Fractured granite stained finish with plain coping All to be coordinated with Lyttonsville Yard and operations building. Structural steel paint color shall be Fed Color No. 36231
21	Lyttonsville Yard Building & Parking Deck	10	Montgomery County	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings, Technical Provisions and coordinate with Lyttonsville Place Highway Bridge.	

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
22	Talbot Avenue Highway Bridge	2	Montgomery County, CSXT, Rosemary Hills Elem. School	Montgomery County	Montgomery County; Concessionaire – clear protective barrier	1, 3 & 4	Inside and outside of parapets: Stained rustic ashlar finish with plain coping Pier: Horizontal plain concrete banding Abutments: Stained fractured granite with plain concrete pilasters and coping. Structural steel paint color shall be Fed Color No. 36231.
23	Spring Street Highway Bridge	2	Montgomery County, CSXT, WMATA	Montgomery County	Montgomery County; Concessionaire – clear protective barrier	1 & 4	Inside and outside of parapets, and median: Rustic ashlar stained finish with plain coping North abutment: Stained coursed random cut stone (keyed) with plain coping and pilasters Pier: Horizontal plain concrete banding

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
24	CCT Pedestrian Bridge at Silver Spring Transit Center	12	Montgomery County, CSXT, WMATA, MARC	Montgomery County	Montgomery County	3	West abutment: Fractured granite finish stained Structural Steel Paint Color shall be Fed Color No. 36231 Piers: coordinate with Book 4 Contact Drawings SSTC architectural drawings
25	Silver Spring Transit Center Aerial	2	Montgomery County, CSXT, WMATA, MARC	MTA	Concessionaire	4	Abutments: Plain concrete finish with sealant or stain with plain concrete coping. See Book 4 Contract Drawings architectural drawings for details on bridge, piers, Station, canopy, and railing. Also see Technical Provisions. All site walls to have a textured stained finish to match existing site wall textures.
26	Silver Spring Transit Center Vertical Structures	2	Montgomery County, CSXT, WMATA, MARC	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings	

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
27	Bonifant Street Garage	2	Montgomery County; Montgomery County Parking Facilities Management	Montgomery County Parking Facilities	Montgomery County Parking Facilities	Parapets shall match existing Bonifant garage architectural panels and parapets in texture and color.	
28	Silver Spring Library Station	3	Montgomery County	MTA	Concessionaire & Montgomery County	To be coordinated with the County. See Book 4 Contact Drawings architectural drawings	
29	Wayne Avenue Highway Bridge	3	Montgomery County, M-NCPPC	MTA	Concessionaire	1 & 3	Abutment, wingwalls and both faces of end posts: Royalite in brown and tan stain palette with plain concrete pilasters and stepped coping with fractured granite finish
30	Plymouth Tunnel including East Portal Retaining Walls	4	Montgomery County	MTA	Concessionaire	4	Plain concrete finish with sealant. See Book 4 Contact Drawings architectural drawings
31	Manchester Station including West Portal Retaining Walls	4	Montgomery County	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings	
32	Long Branch Stream Culvert Extension	5	SHA, M-NCPPC	SHA	SHA	4	Plain concrete finish – no stain

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
33	Northwest Branch & University Boulevard Highway Bridge	6	SHA, Prince George's County M-NCPPC	SHA - Roadway Bridges; MTA - LRT Bridge	Shared between SHA and Concessionaire	1	Inside and outside of parapets: Stained rustic ashlar finish with plain coping Abutments, wingwalls, retaining walls and piers: Stained coursed random cut stone (keyed) with plain coping. To be coordinated with Prince George's County M-NCPPC.
34	CSXT Bridge over Paint Branch Parkway	8	Prince George's County, CSXT	Prince George's County	Concessionaire		N/A
35	College Park Metro Bus Loop Existing Box Culvert	8	WMATA, Prince George's County	WMATA	WMATA	4	Plain sealed concrete finish – no stain
36	72" RCP South of College Park Metro Station	8	Prince George's County, WMATA	MTA	Concessionaire	4	Plain sealed concrete finish – no stain
37	Anacostia River Aerial	8	Prince George's County M-NCPPC, Prince George's County	MTA	Concessionaire	Match existing bridge over NE Branch in size, color, and texture of finish for abutments and pier. Structural steel paint color shall be Fed Color No. 30109	

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment	
38	Kenilworth Avenue Aerial	8	SHA, Prince George's County, City of Riverdale	MTA	Concessionaire	2	North abutment: Plain sealed concrete Horizontal fractured fin finish on insets of piers – no stain See Book 4 Contact Drawings architectural drawings for additional finishes of Station and structural railing Structural steel paint color shall be Fed Color No. 36231
39	Kenilworth Avenue Vertical Structures	8	SHA, Prince George's County, City of Riverdale	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings for additional finishes of Station and structural railing Structural steel paint color shall be Fed Color No. 36231	
40	B/W Parkway Highway Bridges	8	NPS, Prince George’s County M-NCPPC	NPS	NPS	Real stone finish on abutments and wingwalls; existing stone shall be salvaged for reuse. See Technical Provisions for additional required treatments.	
41	B/W Parkway Temporary Bridges	8	NPS, Prince George’s County M-NCPPC	MTA	Concessionaire	N/A	

#	Structure Description (Bridges, Culverts & Vertical Circulation)	Zone	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment
42	Glenridge Shop Building	11	Prince George's County M-NCPPC, Prince George's County	MTA	Concessionaire	See Operations and Maintenance Facilities Technical Provisions.
43	New Carrollton Bridge Modifications, Elevator Towers, Stair Towers and Extension of Pedestrian Tunnel	9	WMATA, Amtrak, MARC, GSA, Prince George's County	MTA, WMATA, GSA	Refer to Maintenance Delineation Drawings in Book 5	See Book 4 Contact Drawings architectural drawings and WMATA Third Party Requirements

Exhibit 3.11 Structures: Retaining Walls

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
1	Wall on N side of LRT under Apex Building	1N	Building owner	MTA	Concessionaire	See Book 4 Contact Drawings architectural drawings		N/A	
2	Wall on N side of LRT under Wisconsin Ave Bridge	1N1	Building owners; SHA	MTA	Concessionaire	4	Plain architectural finish	N/A	
3	Wall on S side of LRT under Wisconsin Ave Bridge	1N2	Building owners; SHA	MTA	Concessionaire	4	Plain architectural finish	N/A	
4	North side of CCT at west end of Bethesda CCT Bridge	TE0	Building owner	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
5	South side of CCT at west end of Bethesda CCT Bridge	TE1	Building owner	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
6	North side of CCT starting @ end of Bethesda CCT Bridge	TE2	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
7	North side of Bethesda Sidewalk starting @ Bethesda Tunnel	TE3	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping		
8	North side of LRT starting @ end of Bethesda CCT Bridge	TE4	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
9	North side of CCT between Bethesda & EW Hwy	TF0	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
10	South side of LRT between Bethesda & EW Hwy	1Z0	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
11	South side of LRT on the southeast side of the EW Highway Bridge	1Z1	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping	N/A	
12	North side of CCT on west side of EW Highway Bridge	TF1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
13	Between LRT and CCT on west side of EW Hwy	TF3	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with horizontal band to match existing pier for Bridge No. 15058	N/A	
14	South side of Connection between S.W. side of EW Hwy and CCT	TF4	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish	N/A	
15	North side of Connection between S.W. side of EW Hwy and CCT	TF5	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
16	Stairs from Northeast side of EW Hwy and CCT	TG	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish
17	North side of CCT on East side of EW Hwy Bridge	TG0	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish
18	Between LRT & CCT on east side of EW Hwy Bridge	TG2	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with horizontal band and plain coping to match existing pier for Bridge No.15058	N/A	
19	South side of LRT East of EW Hwy Bridge	1C0	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with horizontal band and plain coping to match existing pier for ridge No.15058	N/A	
20	South side of LRT West of Sleaford Underpass	1C1	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
21	North side of CCT West of Sleaford Underpass	TG1	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
22	Stairs from Northwest side of Sleaford Pedestrian Path & CCT	TG	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish
23	North side of CCT East of Sleaford Underpass	TG3	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
24	South side of LRT East of Sleaford Underpass	1C2	Montgomery County	MTA	Concessionaire	N/A		4	Stained coursed random cut stone (keyed) with plain coping
25	North side of CCT west of Columbia Country Club	TG4	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
26	South side of LRT throughout Columbia Country Club	1H	Montgomery County, Columbia Country Club	MTA	Concessionaire	4	Plain architectural finish with plain coping	4	Plain architectural finish with plain coping
27	North side of CCT on west side of Columbia Country Club	TJ0	Montgomery County, Columbia Country Club	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
28	North side of CCT at West Golf Cart Underpass	TJ1	Montgomery County, Columbia Country Club	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
29	North side of CCT at East Golf Cart Underpass	TJ2	Montgomery County, Columbia Country Club	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
30	Segmental Retaining Walls on north side of West Golf Cart Underpass	1J2, 1J3, 1J4	Montgomery County, Columbia Country Club	MTA	Concessionaire	1	1J3 and 1J4: Split face masonry; texture, style, and color to be coordinated with Columbia Country Club	1	1J2: Split face masonry; texture, style, and color to be coordinated with Columbia Country Club
31	Segmental Retaining Walls on north side of East Golf Cart Underpass	1J5, 1J6, 1J7	Montgomery County, Columbia Country Club	MTA	Concessionaire	N/A		1	Split face masonry; texture, style, and color to be coordinated with Columbia Country Club
32	North side of CCT on west side of Connecticut Avenue Bridge	1F0	Montgomery County	MTA	Concessionaire	2	Noise Wall finish on Purple Line System and CCT side – stained fuzzy rake with plain coping – stained	4	Plain architectural finish with plain pilasters and coping Noise Wall finish on residential side - flat concrete finish with recessed panel – sealant or stain TBD

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
33	South side of LRT on west side of Connecticut Avenue Bridge	1F0	Montgomery County	MTA	Concessionaire	2 & 4	Plain architectural finish Noise Wall finish on Purple Line System and CCT side – stained fuzzy rake with plain coping – stained	4	Plain architectural finish with plain pilasters and coping Noise Wall finish on residential side - flat concrete finish with recessed panel – sealant or stain TBD
34	South side of LRT at Chevy Chase Lakes Station	1R	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain pilasters and coping
35	North side of CCT between Connecticut Ave Bridge and Chevy Chase Lakes Development Road B-1 Pedestrian Bridge	TH1	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain pilasters and coping
36	North side of CCT on east side of Chevy Chase Lakes Development Road B-1 Pedestrian Bridge	TH2	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain pilasters and coping

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
37	South side of LRT on east side of Chevy Chase Lakes Development Road B-1 Aerial	1F1	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain pilasters and coping
38	North side of CCT on west side of Coquelin Run Culvert	TH3	Montgomery County	Montgomery County	Montgomery County			4	Plain architectural finish with plain coping
39	South side of LRT on west side of Coquelin Run Culvert	1F2	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping	N/A	
40	North side of CCT on west side of Coquelin Run Culvert	TH4	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping		
41	North side of CCT at Coquelin Run Culvert	TH5	Montgomery County	Montgomery County	Montgomery County			4	Plain architectural finish with plain coping
42	South side of LRT at Coquelin Run Culvert	1F3	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
43	North side of CCT between Coquelin Run Culv. & Jones Mill	TK0	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
44	South side of LRT between Coquelin Run Culv. & Jones Mill	1G0	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain pilasters and coping	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
45	South side of LRT between Coquelin Run Culv. & Jones Mill	1G1	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain pilasters and coping	N/A	
46	South side of LRT west side of Jones Mill	1G2	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain pilasters and coping	N/A	
47	North side of CCT west of Jones Mill	TK1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain pilasters and coping	N/A	
48	Between LRT and CCT on west side, below and east side of Jones Mill	TK2	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping	N/A	
49	Ramp from Northeast side of Jones Mill to CCT	TL0	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
50	North side of Stairs and CCT from Northeast side of Jones Mill to CCT	TL1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain pilasters and coping	N/A	
51	North side of CCT East side of Jones Mill	TL2	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain pilasters and coping	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
52	North side of CCT between Jones Mill and Rock Creek	TL3	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish, no pilasters, plain coping
53	Between LRT and CCT west of Rock Creek	TL4	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish, no pilasters, plain coping
54	South side of LRT East side of Jones Mill Road	1Q0	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain pilasters and coping	N/A	
55	South side of LRT between Jones Mill & Rock Creek	1Q1	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain pilasters and coping	N/A	
56	North side of CCT west side of CCT Underpass	TN2	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish, no pilasters, plain coping
57	Rock Creek Pedestrian Connection	TN1	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish, no pilasters, plain coping
58	Rock Creek Pedestrian Connection	TN0	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish, no pilasters, plain coping

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
59	North side of LRT between Rock Creek LRT Bridge & CCT Underpass	1U0	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish, no pilasters, plain coping
60	South side of LRT west side of CCT Underpass	1U1	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish, no pilasters, plain coping
61	South side of LRT (Between LRT & CCT) East side of CCT Underpass	1U2	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish, no pilasters, plain coping
62	South side of CCT East side of CCT Underpass	TP	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	4	Plain architectural finish, no pilasters, plain coping
63	East side of Grubb Rd Connection continuing to south side of CCT	TQ0	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping	N/A	
64	North side of LRT & Shop Tracks between Wall 1U1 and Lyttonsville Yard	1U3	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish, no pilasters, plain coping
65	North side of LRT on West side of Lyttonsville Yard	1V	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping and parapet	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
66	South side of CCT on West side of Lyttonsville Yard	TQ1	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
67	North side of Yard Track 1 west side of Parking Garage	LC	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping Coordinate with OCS building and Lyttonsville Bridge	N/A	
68	North side of Yard Track 1 north side of Parking Garage	LC	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping Coordinate with OCS building and Lyttonsville Bridge	N/A	
69	South side of Brookville Road East of Lyttonsville Place	2H0	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping to coordinate with Lyttonsville Bridge and OCS building	N/A	
70	South side of connection ramp on East side of Lyttonsville Place Bridge	TR0	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish to be coordinated with potential green screen.

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
71	Wall between CCT & Connection ramp on East side of Lyttonsville Place Bridge	TR0	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping - See Book 4 Contact Drawings architectural drawings	N/A	
72	East side of Lyttonsville Place on South side of Bridge	N/A	Claridge House Property Owner; Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping (side of wall facing Claridge House Property)
73	South side of LRT East of Stewart Ave	2J0	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
74	North side of LRT East of Stewart Ave	2J1	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping	N/A	
75	CSXT Corridor Crash Wall	2U	CSXT	MTA	Concessionaire	4	Plain concrete. Crash wall at Woodside Station shall be coordinated with Station aesthetics and finish requirements. See Book 4 Contact Drawings architectural drawings	4	Plain architectural finish

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
76	South side of LRT along Talbot Ave	2K	Montgomery County	MTA	Concessionaire	1 & 4	Outside parapet: Stained rustic ashlar Wall: Plain architectural finish plain concrete pilaster; plain coping	1	Inside parapet: Stained rustic ashlar
77	South side of Talbot Ave. between Lanier Drive and the Talbot Ave Bridge	2R	Montgomery County	MTA	Concessionaire	N/A		1 & 4	Outside parapets: Stained rustic ashlar finish Wall: Plain architectural finish, no pilasters, plain coping
78	South side of CCT East of Talbot Ave Bridge	TT	Montgomery County	Montgomery County	Montgomery County	1 & 4	Parapet: Stained rustic ashlar Wall: Plain architectural finish with plain coping	N/A	
79	Concrete U-Wall along CCT East of Talbot	TU0	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	4	Plain architectural finish, no pilasters, plain coping
80	Concrete U-Wall along CCT Ramp to Lyttonsville Road	TU1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	4	Plain architectural finish, no pilasters, plain coping

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
81	North Side of CCT East of Lyttonsville Road Ramp	TU2	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish, no pilasters, plain coping
82	South side of CCT west side and below 16th St	TV	Montgomery County; SHA	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	N/A	
83	South side of LRT between Talbot & 16th Street	2L	Montgomery County; Apartment Building owner; SHA	MTA	Concessionaire	4	Plain architectural finish	4	Plain architectural finish
84	North side of CCT East side of 16th St Bridge	TW0	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with plain coping		
85	Stairs between northeast side of 16th St & CCT	TW1	Montgomery County; SHA	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	4	Plain architectural finish, no pilasters, plain coping

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
86	Northeast 16th St. ramp connection to the CCT	TW2	Montgomery County; SHA; WMATA	Montgomery County	Montgomery County	N/A		4	Stained rustic ashlar, no pilasters, plain coping
87	North side of CCT East side of 16th St	TW3	Montgomery County	Montgomery County	Montgomery County	N/A		4	Stained rustic ashlar, no pilasters, plain coping
88	Southwest side of 16th St behind proposed sidewalk	2S0	SHA, Montgomery County	Montgomery County	Montgomery County	N/A		1 & 4	Inside and outside of parapet: Stained rustic ashlar with plain coping Wall: Plain architectural finish with plain coping
89	Ramp & Stairwell from Summit Hills Apt to 16th St	2S1	SHA, Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping
90	Ramp & Stairwell from Southeast side of 16th St to Woodside Station	2M0	SHA, Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
91	South side of LRT East of 16th St	2M1	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain coping		

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
92	South side of LRT west, below and to the east of Spring St	2M3	Montgomery County	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping	N/A	
93	North side of CCT west side of Spring St	TW4	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish, no pilasters, plain coping
94	Stairs between northeast side of Spring St & CCT	N/A	Montgomery County	Montgomery County	Montgomery County	See Spring Street Bridge		N/A	
95	East side of Ramp Connection from Northeast side of Spring St to CCT	TY1	Montgomery County	Montgomery County	Montgomery County	N/A		4	Plain architectural finish with plain coping, no pilasters
96	South side of CCT between west side of Spring Wall TZ2	TZ1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish no pilasters, plain coping	N/A	
97	CCT U - Wall from Spring St Connection to Apple Ave Connection	TZ2	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	4	Plain architectural finish, no pilasters, plain coping
98	South side of CCT from Wall TZ2 to Wall TZ4	TZ3	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping		

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
99	CCT U - Wall from Apple Ave Connection to SSTC CCT Ped Bridge	TZ4	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish, no pilasters, plain coping	4	Plain architectural finish, no pilasters, plain coping
100	South side of LRT east side of Spring	2N	Montgomery County; Office Building	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
101	South side of LRT west side of SSTC	2A	Montgomery County; Falklands Development	MTA	Concessionaire	N/A		4	Plain architectural finish with sealant or stain and plain coping; to be coordinated with SSTC.
102	North side of LRT west side of SSTC	2A	Montgomery County; CSXT	MTA	Concessionaire	N/A		4	Plain architectural finish with sealant or stain and plain coping; to be coordinated with SSTC.
103	North side of LRT East side of SSTC	2A	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with sealant or stain and plain coping; to be coordinated with SSTC.

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
104	South side of LRT East side of SSTC	2A	Montgomery County	MTA	Concessionaire	N/A		4	Plain architectural finish with sealant or stain and plain coping; to be coordinated with SSTC.
105	Wayne Ave Retaining Wall	3E	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with stepped coping	N/A	
106	Wayne Ave Retaining Wall	3G	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish with stepped coping	N/A	
107	Silver Spring International Middle School Parking Lot - Wall F1	3F1	Montgomery County; School	MTA	Concessionaire	1 & 4	Plain architectural finish with fractured granite finish on barrier face	3	Fractured granite finish on barrier face
108	Silver Spring International Middle School Parking Lot - Wall F2	3F2	Montgomery County; School	MTA	Concessionaire	3 & 4	Plain architectural finish with fractured granite finish on barrier face	3	Fractured granite finish on barrier face
109	Silver Spring International Middle School Parking Lot - Wall F3	3F3	Montgomery County; School	MTA	Concessionaire	3 & 4	Plain architectural finish with fractured granite finish on barrier face	3	Fractured granite finish on barrier face
110	North side of Wayne Ave at Mansfield Rd	3H	Montgomery County	Montgomery County	Montgomery County	3 & 4	Plain architectural finish with fractured granite finish on barrier face	4	Plain stained concrete on barrier face

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
111	North side of Wayne Ave east of Sligo Creek Parkway	3J	Montgomery County	Montgomery County	Montgomery County	3 & 4	Plain architectural finish with stepped coping with fractured granite finish	N/A	
112	Northwest corner of Kenwood House Parking Lot	4K	Property owner	Property owner	Property owner	3 & 4	Plain architectural finish with fractured granite finish on barrier face	3	Fractured granite finish on barrier face
113	North side of Arliss St. on South side of Apartment Parking Lot	5D1	Montgomery County; Apartment Building. owner	Montgomery County	Montgomery County	N/A		4	Plain architectural finish
114	East side of Arliss St. at Apartment Parking Lot	5D2	Montgomery County; Apartment Building. owner	Montgomery County	Montgomery County	N/A		4	Plain architectural finish
115	South side of Arliss St from shopping plaza driveway to Piney Branch Rd	5E1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish	N/A	
116	South side of Arliss St from shopping plaza driveway to Piney Branch Rd	5E2	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
117	South side of Piney Branch East of Barron St	5F1	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish	N/A	
118	South side of Piney Branch East of Barron St	5F2	Montgomery County	Montgomery County	Montgomery County	4	Plain architectural finish	N/A	
119	South Side of Univ. Blvd at MD 650	6D	SHA	SHA	SHA	1	Running bond used brick, stained to match existing wall with brick coping to match existing shape and size of existing wall	N/A	
120	North side of LRT in center of University Blvd	6N	SHA	MTA	Concessionaire	N/A		3	Fractured granite stained finish with plain coping to be coordinated with University Blvd bridge colors.
121	South side of LRT in center of University Blvd	6P	SHA	MTA	Concessionaire	N/A		3	Fractured granite stained finish with plain coping to be coordinated with University Blvd bridge colors.
122	West side of LRT at College Park Metro	8M	WMATA	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
123	East side of LRT south of College Park Metro	8U	WMATA	MTA	Concessionaire	N/A		4	Plain architectural finish with plain concrete pilasters and coping
124	West side of LRT at College Park Metro Physics Ellipse	8N		MTA	Concessionaire	4	Plain architectural finish with plain coping	N/A	
125	South Side of M Square Station	8A		MTA	Concessionaire	N/A		3	Fractured granite stained finish to be coordinated with architectural aesthetics of Station.
126	South side of LRT on West side of Anacostia Bridge	8X		MTA	Concessionaire	N/A		Match existing bridge aesthetics over NE Branch in size, color, and texture for abutments and pier.	
127	East side of LRT on North side of Kenilworth Bridge	8C	SHA	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping. To be coordinated with Riverdale Park Station. Same finish to be used for structures 8C & 8D.

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)	Aesthetic Treatment on side of wall away from LRT (Group and Description)	
128	West side of LRT on North side of Kenilworth Bridge	8C	SHA	MTA	Concessionaire	N/A	4	Plain architectural finishwith plain coping. To be coordinated with Riverdale Park Station. Same finish to be used for structures 8C & 8D.
129	North side of LRT on East side of Kenilworth Bridge	8D	SHA	MTA	Concessionaire	N/A	4	Plain architectural finish with plain coping. To be coordinated with Riverdale Park Station. Same finish to be used for structures 8C & 8D.
130	South side of LRT on East side of Kenilworth Bridge	8D	SHA	MTA	Concessionaire	N/A	4	Plain architectural finish with plain coping. To be coordinated with Riverdale Park Station. Same finish to be used for structures 8C & 8D.
131	South side of LRT on West side of Mustang Drive	8V	SHA	MTA	Concessionaire		4	Plain architectural finish with plain coping.

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
132	Temporary Walls at BW Pkwy	8Z	NPS			N/A		N/A	
133	South side of Beacon Heights Station	8W		MTA	Concessionaire	3	Fractured granite stained finish with plain coping to be coordinated with Beacon Heights Station.	N/A	
134	South side of LRT along Veterans Parkway East of Riverdale Rd	9D	SHA	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping. Natural stone palette.	N/A	
135	South side of LRT along Veterans Parkway East of Riverdale Rd	9E	SHA	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping.	4	Plain architectural finish with plain coping
136	North side of LRT along Veterans Parkway West side of Glenridge Yard	9F	SHA	MTA	Concessionaire	N/A		4	Plain architectural finish with plain concrete pilasters and coping.
137	South side of LRT along Veterans Parkway at Glenridge Yard	9W	SHA	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping.	N/A	

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
138	West side of Glenridge Yard and Shop	GD	Prince George's County M-NCPPC	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping; to be coordinated with the architectural requirements of Glenridge Yard & Shop.
139	South and East side of Glenridge Yard	GD	Prince George's County M-NCPPC	MTA	Concessionaire	4	Plain architectural finish with plain coping; to be coordinated with the architectural requirements of Glenridge Yard & Shop.	N/A	
140	South side of LRT along Veterans Parkway at Glenridge Yard	9X	SHA	MTA	Concessionaire	4	Plain architectural finish and coping.	N/A	
141	North side of LRT along Veterans Parkway East side of Glenridge Yard	9G	SHA	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping.	N/A	
142	South side of LRT along Veterans Parkway west of Annapolis Rd	9H	SHA	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping.

#	Retaining Wall Location	Zone - Structure Code	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment on LRT side of wall (Group and Description)		Aesthetic Treatment on side of wall away from LRT (Group and Description)	
143	South side of LRT along Veterans Parkway East of Annapolis Rd	9K	SHA	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping.
144	North side of LRT along Veterans Parkway East of Annapolis Rd	9L	SHA	MTA	Concessionaire	N/A		4	Plain architectural finish with plain coping
145	Wall on North Side of LRT along Ellin Road ending at Emerson Pl.	9P	Prince George's County	MTA	Concessionaire	4	Plain architectural finish with plain concrete pilasters and coping	N/A	
146	New Carrollton Walls	9C1	WMATA	MTA	Concessionaire	N/A		To be coordinated with Book 4 Contact Drawings architectural drawings and WMATA Third Party Requirements	
147	New Carrollton Walls	9C2	WMATA	MTA	Concessionaire	N/A		To be coordinated with Book 4 Contact Drawings architectural drawings and WMATA Third Party Requirements	
148	New Carrollton Walls	9C3	WMATA	MTA	Concessionaire	To be coordinated Book 4 Contact Drawings architectural drawings and WMATA Third Party Requirements		N/A	

Exhibit 3.12 Structures: Ground Mounted Noise Walls

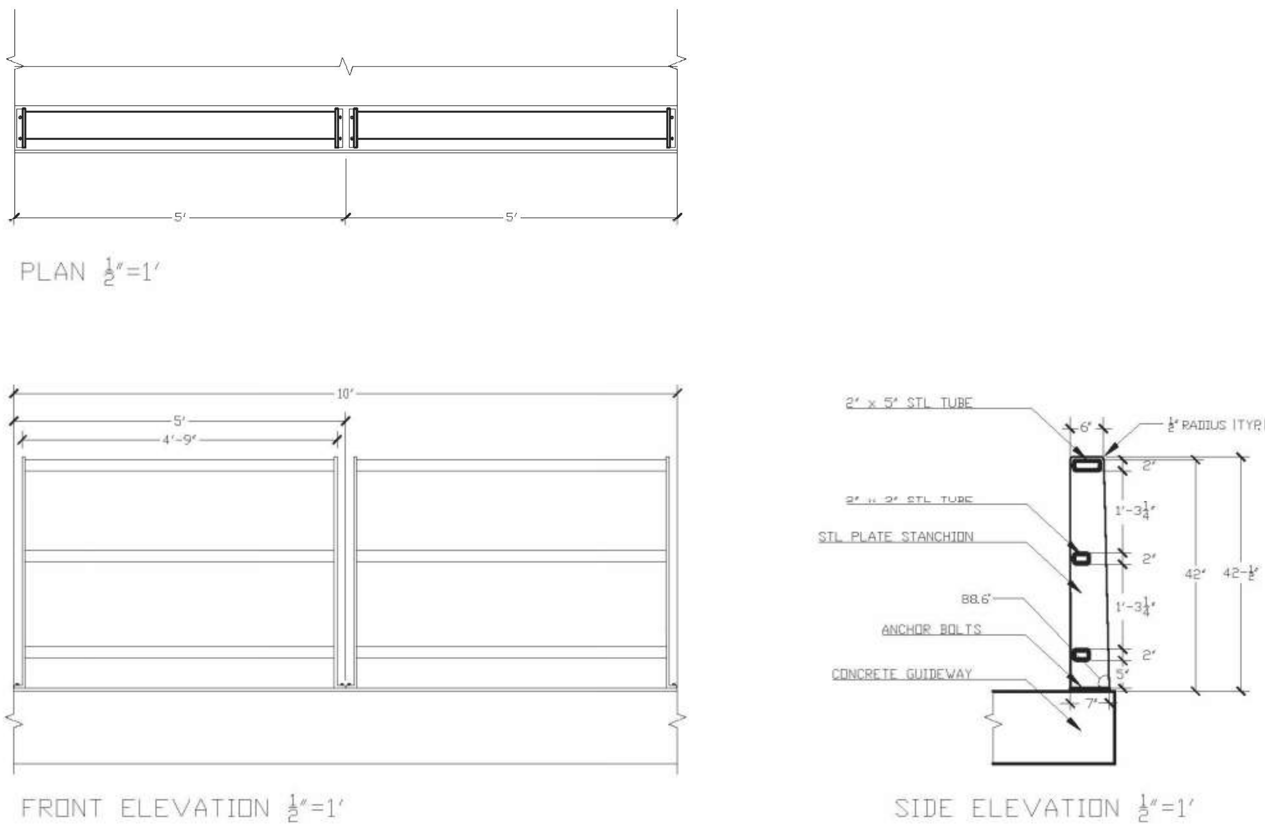
#	Ground Mounted Noise Walls Wall Location	Zone - Structure Code	Wall starting station	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment (Group and Description)	
1	South side of LRT East of Bethesda Tunnel	NW1A	TRK 1 112+09	Montgomery County	MTA	Concessionaire	1 & 2	Residential side: Stained rustic ashlar, plain coping LRT side: Stained fuzzy rake finish, stained plain coping
2	South side of LRT west of CCC	NW1B	TRK 1 136+03	Montgomery County	MTA	Concessionaire	1 & 2	Residential side: Stained rustic ashlar, plain coping LRT side: Stained fuzzy rake finish, stained plain coping
3	South side of LRT on East side of CCC	NW1C	TRK 1 158+78	Montgomery County	MTA	Concessionaire	2	Residential side: Exposed aggregate, plain coping LRT side: Stained fuzzy rake finish, stained plain coping
4	South side of LRT East of Connecticut Avenue	NW1D	TRK 1 177+20	Montgomery County	MTA	Concessionaire	1, 2 & 4	Residential side: 1) Up to start of RW 1F2: Stained flat concrete finish with recessed panel, plain coping 2) From RW 1F2 to end of NW1D: Stained rustic ashlar finish, plain coping LRT side: Stained fuzzy rake finish, stained plain coping

#	Ground Mounted Noise Walls Wall Location	Zone - Structure Code	Wall starting station	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment (Group and Description)	
5	South side of LRT West of Rock Creek	NW1E	TRK 1 212+22	Montgomery County, M-NCPPC	MTA	Concessionaire	1 & 2	Park side: Stained rustic ashlar, plain coping LRT side: Stained fuzzy rake finish, stained plain coping
6	North side of CCT East of Bethesda Tunnel	NWTA	CCT 16+99	Montgomery County	MTA	Concessionaire	2 & 4	Residential side: Stained fuzzy rake finish, stained plain coping LRT side: Flat stained finish, no coping
7	North side of CCT between Bethesda & EW Hwy	NWTB	CCT 21+50	Montgomery County	MTA	Concessionaire	2 & 4	Residential side: Stained fuzzy rake finish, stained plain coping LRT side: Flat stained finish, no coping
8	North side of CCT east of EW Hwy	NWTD	CCT 33+51	Montgomery County	MTA	Concessionaire	1, 2 & 3	Residential side: Stained rustic ashlar, plain coping LRT side: Stained fuzzy rake finish with stained plain coping alternating with fractured granite stained finish and stained plain coping

#	Ground Mounted Noise Walls Wall Location	Zone - Structure Code	Wall starting station	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment (Group and Description)	
9	North side of CCT at Sleaford Underpass	NWTE	CCT 37+96	Montgomery County	MTA	Concessionaire	1, 2 & 3	Residential side: Stained rustic ashlar, plain coping LRT side: Stained fuzzy rake finish alternating with fractured granite stained finish and stained plain coping
10	North side of CCT west of Columbia Country Club	NWTF	CCT 43+59	Montgomery County	MTA	Concessionaire	2 & 4	Residential side: Stained fuzzy rake finish with stained plain coping LRT side: Flat stained finish, no coping
11	North side of CCT west of Columbia Country Club	NWTG	CCT 45+08	Montgomery County	MTA	Concessionaire	2 & 4	Residential side: Stained fuzzy rake finish with stained plain coping LRT side: Flat stained finish, no coping
12	North side of CCT through the Columbia Country Club	NWTH	CCT 48+20	Montgomery County, Columbia Country Club	MTA	Concessionaire	2, 3 & 4	Residential side: Exposed aggregate, plain coping LRT side: Flat stained finish alternating with random slate finish, no coping

#	Ground Mounted Noise Walls Wall Location	Zone - Structure Code	Wall starting station	Required Coordination with Outside Agencies	Anticipated Owner	Maintained By	Aesthetic Treatment (Group and Description)	
13	North side of CCT East of Developer Road Bridge	NWTJ	CCT 79+91	Montgomery County	MTA	Concessionaire	2, 3 & 4	Residential side: Stained flat concrete finish with recessed panel, plain coping LRT side: Stained fuzzy rake with stained plain coping alternating with fractured granite finish with stained plain coping
14	North side of CCT at Coquelin Run Culvert	NWTK	CCT 96+35	Montgomery County	MTA	Concessionaire	1 & 4	Residential side of noise wall: Stained rustic ashlar finish, plain coping LRT side: Flat stained finish, no coping
15	North side of CCT east of Coquelin Run	NWTL	CCT 103+25	Montgomery County	MTA	Concessionaire	2	Residential side: exposed aggregate, plain coping LRT side: Stained fuzzy rake, stained plain coping
16	North side of LRT between Jones Mill Road and Rock Creek	NWTN	TRK 1 210+14	Montgomery County	MTA	Concessionaire	2 & 4	LRT side: Stained fuzzy rake with stained plain coping Trail side: Flat stained finish, no coping

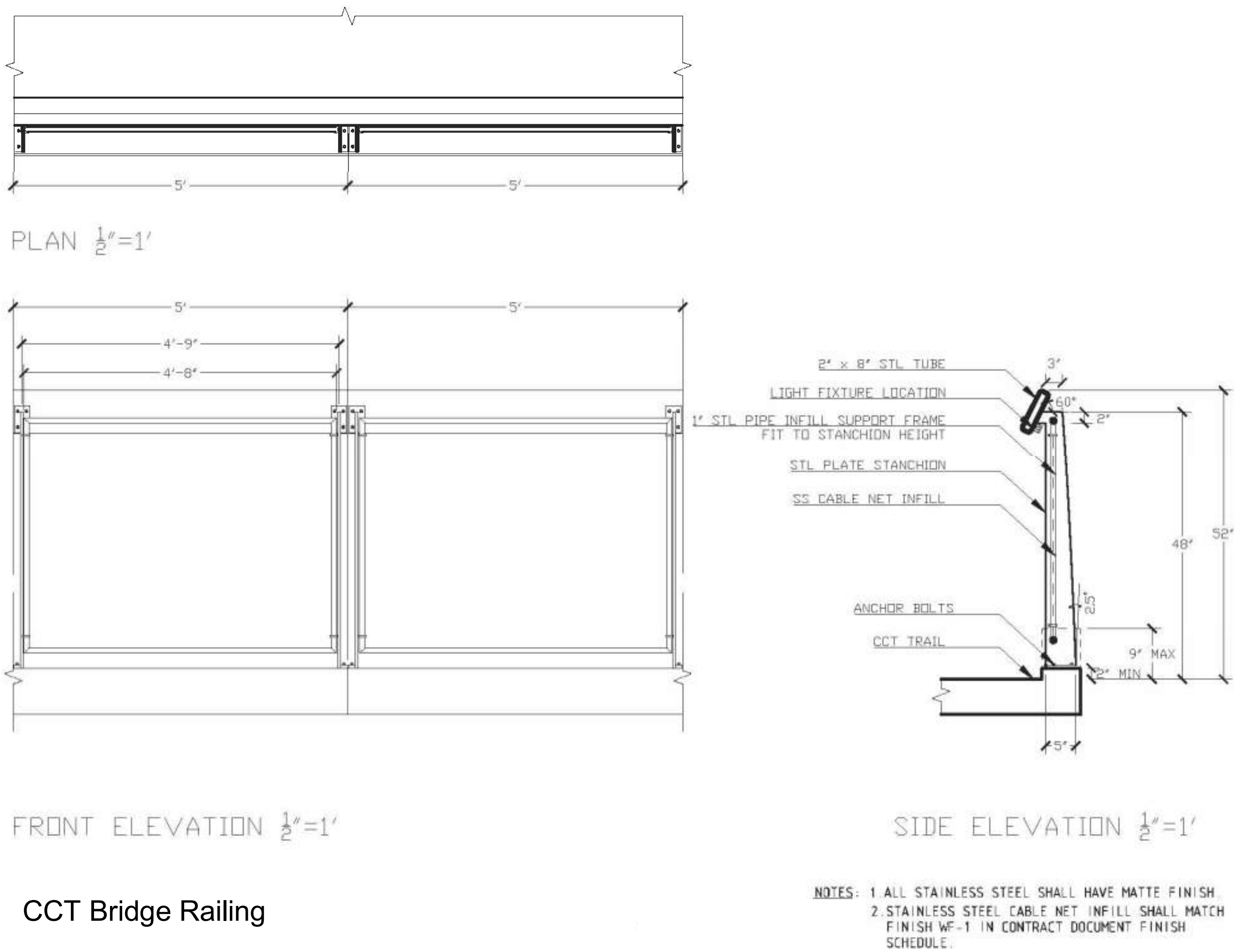
Exhibit 3.13 Railing Requirements at LRT and Capital Crescent Trail Bridges



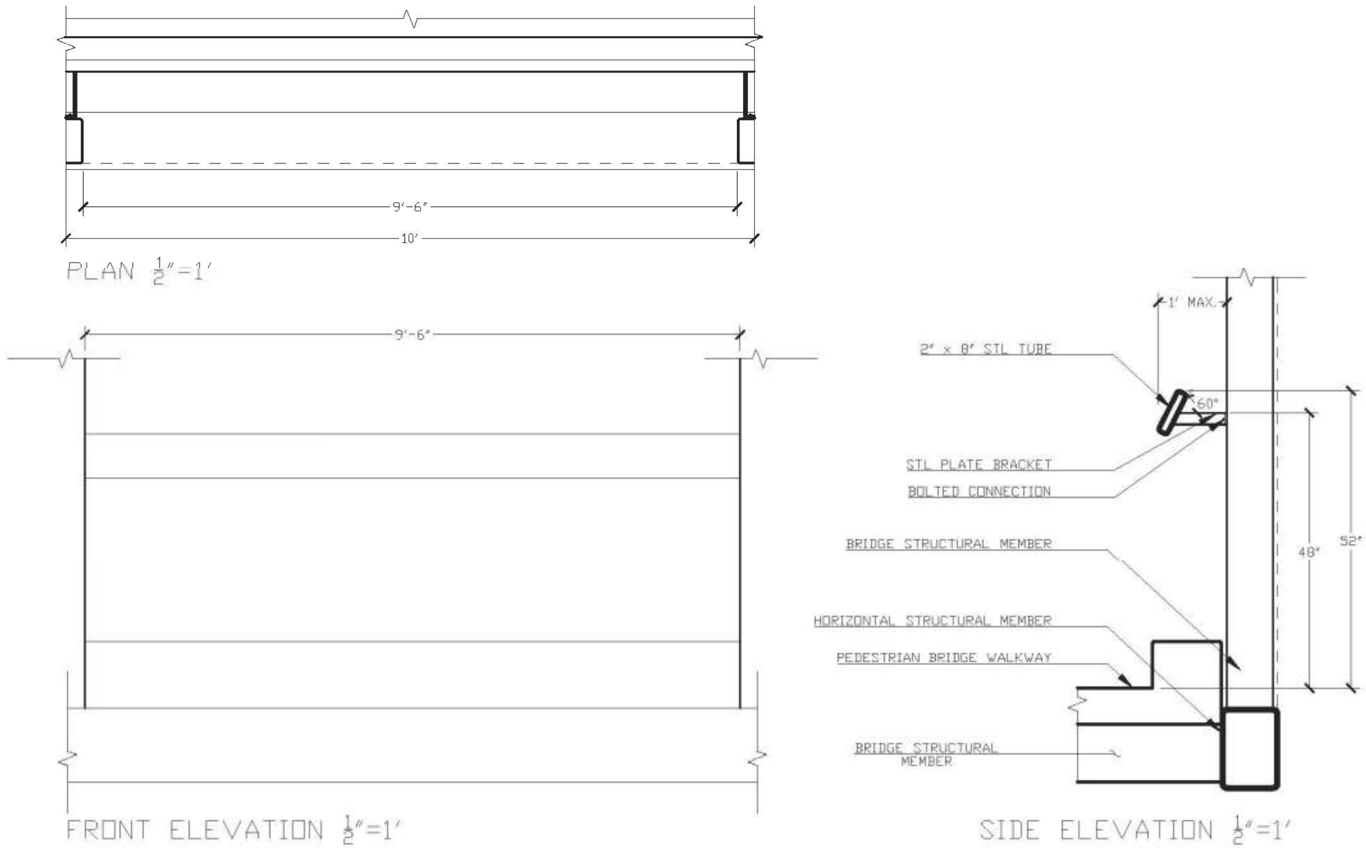
LRT Bridge Railing

CONNECTICUT AVENUE, CHEVY CHASE LAKES
DEVELOPER ROAD, ROCK CREEK, SSTC, RIVER ROAD,
KENILWORTH AVENUE

NOTE: ALL STAINLESS STEEL SHALL HAVE MATTE FINISH.



CCT Bridge Railing



Rub Rail to Structure Connection

CONNECTICUT AVENUE PEDESTRIAN BRIDGE

NOTE: ALL STAINLESS STEEL SHALL HAVE MATTE FINISH.

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4 DRAINAGE

This Section describes the surface drainage and SWM requirements for the Project.

4.1 General Requirements

Concessionaire shall provide drainage and SWM meeting the requirements of the AHJ. For MTA facilities, or where the AHJ does not have requirements, Concessionaire shall meet MD SHA requirements.

Existing drainage elements within the Project shall be inspected and assessed for capacity, outfall stability, system condition, remaining service life and other parameters with respect to the requirements of the Contract Documents. Concessionaire may retain existing drainage elements meeting the requirements of the Contract Documents, rehabilitate existing drainage elements to meet the requirements of the Contract Documents, or replace existing drainage elements.

4.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- Annotated Code of Maryland, Environment Article, Title 4, Subtitle 1, “Sediment Control”;
- Annotated Code of Maryland, Environment Article, Title 4, Subtitle 2, “Stormwater Management”;
- FHWA, “HEC-24, Highway Stormwater Pump Station Design”;
- FHWA, “HEC-26, Culvert Design for Aquatic Organism Passage”;
- FHWA, “HEC-15, Design of Roadside Channels with Flexible Linings”;
- Maryland Department of the Environment , “Maryland Stormwater Management and Erosion & Sediment Control Guidelines for State and Federal Projects”;
- Maryland Department of the Environment “Maryland’s Waterway Construction Guidelines”;
- Maryland Department of the Environment, “Stormwater Design Guidance – Addressing Quantity Control Requirements”;
- Maryland Department of the Environment, “2000 Maryland Stormwater Design Manual, Volumes I and II”;
- Maryland Department of the Environment, “2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control”;
- Maryland Department of the Environment, “Clarification on Grass Swale Design for State and Federal Project”;
- Maryland Department of the Environment, “Environmental Site Design (ESD) Process & Computations”;
- Maryland Department of the Environment, “Environmental Site Design (ESD) Redevelopment Examples”;
- Maryland Department of the Environment, “Facts About Maryland’s Stormwater Program & Proprietary Practices;
- Maryland Department of the Environment, “Sediment and Stormwater Procedures Manual for State & Federal Projects”;

- Maryland Department of the Environment, “Stormwater Design Guidance – Submerged Gravel Wetlands”;
- Maryland Department of the Environment, “Stormwater Design Guidance – Rainwater Harvesting”;
- Maryland Department of the Environment, “Stormwater Design Guidance – Solar Panel Installations”;
- Maryland Department of the Environment, “Stormwater Design Guidance – Addressing Quantity Control Requirements”;
- Maryland Department of the Environment, “Stormwater Management (SWM) Concept Design for State and Federal Projects”;
- Maryland Department of Environment, “Stormwater Management Site Design and Innovative Technology”;
- Maryland Department of the Environment, “Surface Storage Volume Tables for Bioretention and Bioswales”;
- Maryland Department of the Environment, “Water Quality Summary Sheet – May 2013 Draft”;
- Maryland Department of the Environment, “Maryland’s Waterway Construciton Guidelines”;
- Maryland Department of Transportation, “Guidelines for Development Adjacent to State Highways”;
- Maryland Department of Transportation, “Highway Drainage Manual”;
- Maryland Department of Transportation, “Book of Standards – For Highway & Incidental Structures;
- Maryland State Highway Administration, “Stormwater Management Site Development Criteria”;
- Montgomery County, “Montgomery County Stormwater Management Facility Guidelines”;
- Montgomery County Code, Chapter 19, “Stormwater Management”;
- Montgomery County Department of Transportation, “Design Standards”;
- Montgomery County Department of Transportation, “Drainage Design Criteria”;
- Maryland Transit Administration, “Definition of Terms used in the Water Quality Banking Summary Sheet for Red Line/Purple Line”;
- Natural Resources Conservation Service, “Pond Code MD-378”;
- Prince George’s County Code, Subtitle 4, Division 4, “Stormwater”;
- Prince George’s County Department of Public Works, “Stormwater Best Management Practices Inspection Manual”;
- Prince George’s County Department of Public Works, “Stormwater Management Design Manual”;
- Prince George’s Soil Conservation District, “Soil Erosion & Sediment Control – Pond Safety Reference Manual”;

- Regulation COMAR 26.08.02.10, “Water Quality Certification”;
- Regulation COMAR 26.08.04, “Permits”;
- Regulation COMAR 26.17.01, “Erosion and Sediment Control”;
- Regulation COMAR 26.17.012, “Stormwater Management”;
- Regulations COMAR 26.27.04 “Construction on Nontidal Waters and Floodplains”; and
- University of Maryland, Facilities Management, “Design Criteria/Facility Standards.”

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

4.3 Surface Drainage

4.3.1 General Requirements

Concessionaire shall provide surface drainage conveyances including at a minimum open channels, inlets, closed storm drainage systems, cross culverts, bridges over water and entrance driveway pipes in accordance with the requirements of the Contract Documents and the AHJ, whichever is more restrictive. If the AHJ does not have requirements, the requirements of MD SHA shall be considered to be the requirements of the AHJ.

All drainage shall be provided in accordance with the following:

- Concessionaire shall investigate existing systems and include in the Project the design and construction of the drainage system to include repair and/or replacement of unstable or deteriorating outfalls, inlets, manholes, cross culverts or pipes, or other drainage structures, as well as replacement of all existing brick drainage structure regardless of condition with the Project limits. Concessionaire shall compile inspection reports and submit for concurrence from the AHJ. Include photographs and a written report describing the structural integrity of the drainage structure. Replace or repair all existing pipes and drainage structures failing to meet structural integrity or hydraulic requirements. Concessionaire shall also include the repair of existing outfalls and replacement of adversely sloped and level (zero gradient) pipes to remove adverse slopes and provide positive drainage. Concessionaire shall not request waivers or variances from MDE’s Channel Protection Volume (Cp_v) requirements unless a stable outfall is documented;
- Concessionaire shall clean all existing and new pipes and drainage structures to be free of debris and sediment at conclusion of construction;
- Concessionaire shall remove all existing pipes and drainage structures that will not be used in the final design or abandon by filling with flowable backfill;
- Concessionaire shall provide positive drainage flow in all open and closed systems;
- Concessionaire shall not trap water on any surface. If during design or construction an area of the Project is identified as not having positive drainage in pre-construction conditions, Concessionaire shall provide adequate measures to ensure positive drainage after construction;
- Concessionaire shall show all relevant existing and proposed utilities on storm drain and culvert profiles; and

- Concessionaire shall maintain, at a minimum, the existing drainage conditions throughout construction, including interim construction operations (e.g. construction of asphalt berms to divert flow from base course paving to storm drains in closed sections).

4.3.2 Cross Culverts

Concessionaire shall provide cross culverts to provide conveyance of the 50-year storm frequency or AHJ requirements, whichever is greater, and the following:

- 50-year storm elevation shall be below the top of sub-ballast;
- 100-year storm elevation shall be below bottom of rail, and a minimum of 1 foot below TPSS floor, Station head house entrances, tunnel portal thresholds;
- 100-year storm headwater pool at new culverts or new bridges over water shall remain within the Project ROW or permanent easements;
- 100-year storm headwater pool at existing, replacement, or extended culverts and bridges over water shall be at or below the pre-construction 100-year storm headwater pool elevation;
- discharges for cross culverts and bridges over water shall be calculated using USDA, NRCS TR-55 and TR-20 hydrology models unless the drainage area exceeds 200 acres in which case GISHydro may also be used;
- design culvert outfalls to the HDM Design Guidelines and HEC-14; and
- floodplain hydraulic modeling shall be performed using HEC-RAS.

Where fish passage is required, culverts less than 72 inches in diameter shall be constructed with inverts depressed a minimum of one foot below the stream inverts. Culverts 72 inches or greater and box culverts (excluding those not for the purpose of hydraulic crossings) shall be constructed with inverts depressed a minimum of two feet below the stream invert. The effects of invert depression on culvert hydraulic performance shall be incorporated into the design.

4.3.3 Storm Drains

Concessionaire shall provide storm drain systems to provide conveyance of the 10-year storm frequency or AHJ requirements, whichever is greater, and the following:

- bottom of rail shall be above the hydraulic gradient for the 100-year storm; and
- use the rational method if method is not specified by the AHJ.

Concessionaire shall provide closed system storm drains in accordance with Contract Documents and the following minimum requirements:

- inlet spread for the 10-year storm (except 2-year storm for MDSHA facilities) shall be limited to edge of rail or portion of traveled lane required by the AHJ;
- small pipe structures to be owned by SHA shall be reinforced concrete;
- drainage structure shall be AHJ Standards wherever feasible. Concessionaire shall design modified or special structures as necessary;
- written approval from the AHJ is required prior to conversion of existing drainage structures into junction boxes within roadways;
- no breaks in curb, such as curb cuts, are allowed for drainage purposes;

- drainage structures shall be provided at changes in pipe slope, alignment, and size, and at the intersections of multiple pipes;
- manhole spacing in track sections shall be 300-feet maximum;
- horizontal clearance from LRT facilities shall be the same as that required for Utilities;
- vertical clearance from LRT facilities shall be the same as that required for Utilities, except where the vertical clearance would require either reconstruction or replacement of existing storm drains beyond the Project ROW; and
- new storm drains crossing Guideways shall be reinforced concrete pipe, conforming to ASTM C76, Class V, Wall B or C, with gasketed joints.

Concessionaire shall provide open channel drainage in accordance with the Contract Documents and the following minimum requirements:

- capacity, freeboard, and channel bed stability requirements for post-construction conditions shall be according to AHJ requirements;
- design ditch linings using HEC-15 “Design of Roadside Channels with Flexible Linings”’;
- soil stabilization matting is preferred over rip rap:
  - Type A matting is used in ditches where shear stress is less than 1.75 psf or for slope protection;
  - Type B matting is used in ditches where shear stresses are between 1.75 and 3.0 psf; and
  - Type C matting is used in conjunction with Type B matting where shear stresses are between 3.0 and 7.0 psf.
- Concrete lined ditch and concrete slope or channel protection shall not be used unless prior approval is received from the AHJ;
- top of sub-ballast shall be above the ditch conveyance elevation for a 50-year storm; and
- open channel lining shall be designed to withstand the velocity and extend above the limits of the 10-year storm.

Concessionaire shall replace structurally deficient existing facilities within the Project ROW using, at a minimum, the hydraulic equivalent, and shall design facilities in accordance with criteria established by the AHJ.

Relocation of existing facilities required to accommodate construction of the Project shall use, at a minimum, the hydraulic equivalent, and shall be designed in accordance with criteria established by the AHJ.

4.3.4 Not Used

4.3.5 Other Requirements

If Concessionaire includes work on the existing 48-inch storm drain crossing of Parcel 884 – Maryland National Capital Park and Planning Commission, Concessionaire shall replace and/or restore existing athletic facilities and appurtenances impacted to pre-existing or better conditions immediately upon completion of the work. Work on storm drain, if required, shall not be initiated until after end of the academic year for Silver Spring International Middle School and shall be completed prior to the beginning of the subsequent academic year.

The stormwater conveyance system serving the existing stormwater pumping station in the vicinity of Track 1 Sta. 684+50, Left may be designed to maintain 25-year HGL below bottom of rail in lieu of 100-year HGL as required by Part 2B, Section 4.3.3 of the Technical Provisions.

Top of rail in the vicinity of the Northwest Branch stream crossing by University Boulevard, between 25th Avenue and Lake Manor may be designed to maintain the 10-year Design High Water below bottom of rail in lieu of 100-Year Design High Water as required by part 2B, Section 4.3.2 of the Technical Provisions.

The stormwater conveyance system in the vicinity of the Northwest Branch stream crossing by University Boulevard, between 25th Avenue and Lake Manor may be designed to maintain the 10-year HGL below bottom of rail in lieu of 100-year HGL as required by Part 2B, Section 4.3.3 of the Technical Provisions.

4.3.6 Required Surface Drainage Plan Submissions

Concessionaire shall submit Surface Drainage Report and Design for Review and Comment at Preliminary and Final design. Plan contents shall be according to the requirements of the AHJ.

The Surface Drainage Report shall include all drainage design computations performed according to the AHJ criteria, drainage area mapping and schematics necessary to complete the design of the stormwater conveyances for the project.

All drainage computations shall be performed using the appropriate design charts as required by the AHJ and shall include clear references for all tables and charts used.

Culvert Analysis reports, when necessary for Waterway Construction Permit Review and Approval, shall be included as an attachment to the Surface Drainage Report and shall follow the format described below.

4.3.6.1 Surface Drainage Report Contents

The report shall include, but not be limited to the following:

- storm sewer design computations including schematics, inlet drainage area maps, spacing, capacity, spread, hydraulic gradients, and structural design for non-standard drainage structures;
- culvert analysis including 2, 10, 25 and 100 year frequency storms and design storms;
- ditch computations and drainage area maps for ditch capacity, freeboard and lining stability;
- evaluation of outfall stability, and outfall protection design;
- any deviations from the guidelines and AHJ approvals for the deviations;
- culvert service life verification;
- for proposed tie-in to existing storm drain systems, the hydraulic gradient shall be calculated through the existing system and extended into the proposed system; and
- inspection documentation and evaluation of existing drainage structures, storm drains and culverts not being replaced.

4.4 Stormwater Management

4.4.1 SWM General

Concessionaire shall provide storm water management in accordance with the requirements of the MDE's *2000 Maryland Stormwater Design Manual, Volumes I and II* and subsequent supplements and/or changes and *Maryland Stormwater Management and Erosion & Sediment Control Guidelines for State and Federal Projects, Sediment and Stormwater Procedures for State and Federal Projects,* and the following:

- Third Party Agreement Requirements;
- provide the best fit facility given the site context;
- alternative surfaces, non-structural practices and micro-scale practices shall be provided when feasible;
- structural practices shall be provided only when demonstrated that alternative surfaces, non-structural practices and micro-scale practices are not feasible;
- low maintenance practices shall be provided when feasible;
- suitable access or access roads shall be provided considering site condition, the frequency with which access is required and types of equipment needed to perform maintenance or rehabilitation; and
- Concessionaire shall not locate underground water quality and water quantity facilities within the travel lane of any MDSHA maintained roadway.

4.4.2 Surface SWM

Concessionaire shall provide SWM in accordance with the Contract Documents and the following minimum requirements:

- linear SWM in fill/embankment greater than 5 feet in height shall have impervious liners or subsurface drainage controls at some depth below the topsoil to allow vegetative growth but prevent infiltration of surface water into fill material;
- new SWM ponds, constructed wetlands, wet swales or modified existing facilities shall be located a minimum distance of 15 feet from any edge of pavement or track subballast measured from the 2-year water surface elevation limit; and
- Concessionaire shall coordinate storm water management facility detailing throughout the Project Facility types, outfall structure designs, detailing, colors planting palettes, landforms, surface area shapes and fencing (where required) shall be consistent.

SWM embankment shall be provided in accordance with the following:

- SWM embankment material is required to conform to NRCS Pond Code MD-378. Embankment clay core and cut-off trench shall conform to A-2-7, A-7-2, A-4-7, A-7-4, or A-7. Maximum particle size shall be three inches;
- SWM embankments shall be planted:
  - o with herbaceous plants or turf grass;
  - o woody material shall not be planted on SWM embankments within 15 feet of the toe of SWM embankments or within 25 feet of facility outfall structures; and

  - a minimum 15-foot clear zone shall be provided within the Project right-of-way at the toe of SWM embankments to allow for maintaining the required woody vegetation free zone.

- filter drainage diaphragms shall be used for embankment seepage control in place of anti-seep collars within the SWMt embankment when classified as embankment ponds;
- maximum grade allowed for side slopes at SWM facilities shall not exceed three horizontal to one vertical (3:1).
- SWM riser structures shall be provided in accordance with the following:
  - structure shall be reinforced concrete, either cast in place or precast as one unit;
  - set structure into embankment or place so they are easily accessed for maintenance and are visually unobtrusive;
  - structures that are visible to the surrounding community shall have an integral color admixture applied to the concrete mixture. A sandblast finish shall be applied to the completed, colored drainage structures. The admixture shall be a colored, water reducing, admixture containing no calcium chloride with coloring agents that are limeproof and UV resistant. The admixture shall conform to C979, C494 and M194. The color shall meet Federal Standard 595B. The manufacturer shall choose from the following colors: 30277, 30145, and 30219. The same color shall be used throughout the Project; and
  - open tops on outfall structures shall not be acceptable.

SWM pipe systems shall be provided in accordance with the following:

- pipe outfall systems shall be reinforced concrete meeting ASTM C-361; and
- low flow, perforated pipes shall meet AASHTO M-304 or M-352 and have slotted perforation and shall be wrapped with galvanized wire mesh. Pipes extending into ponds shall be anchored against flotation.

Trash Racks on SWM risers shall be provided in accordance with the following:

- flat-fronted cages that stand away from and completely enclose the riser opening(s);
- ends of steel rods shall be attached to a frame that attaches to the structure;
- similar detailing shall be used for all openings and structures on the Project; and
- trash racks shall be hot-dipped galvanized steel, M 111-80.

Adequate access to surface SWM facilities for maintenance shall be provided. Ensure that each part of the facilities is accessible by the equipment needed to maintain or rehabilitate the facility.

Fencing of SWM facilities, when required by the AHJ, shall meet the requirements of the AHJ and the following requirements:

- fence fabric, aesthetics and height shall match that specified for a pedestrian barrier; and
- a 12-foot wide double gate matching the adjacent fence in aesthetics shall be provided where fencing is used at maintenance access points for vehicular traffic. The location of the gate shall allow an SU vehicle to stop at the gate without impeding roadway traffic flow. The gate shall include an exterior grade padlock. Owner and AHJ shall be supplied with a minimum of two keys for each padlock.

Vehicular access to stormwater management facilities without fencing shall meet the following requirements:

- a 12-foot wide double gate shall be provided at the driveway apron from the adjacent roadway. The location of the gate shall allow an AASHTO single unit vehicle to stop at the gate without impeding roadway traffic flow. The gate shall include an exterior grade padlock and Owner shall be supplied with a minimum of two keys for each padlock.

4.4.3 Underground SWM

Underground SWM provided by Concessionaire shall meet, at a minimum, the following requirements:

- Underground SWM structures, detention pipes, manholes and other access structures shall not be within the roadway paving section;
- Concessionaire shall address groundwater recharge (Re_v), water quality volume (WQ_v), Channel Protection Volume (Cp_v) and Overbank Flood Protection Volume (Q_p) as required;
- Concessionaire shall provide safe, stable, long term maintenance access to each underground SWM facility from roadways including sufficient room to safely park a vehicle outside the traffic lanes;
- Concessionaire shall consider filter media design life/maintenance frequency and maintenance difficulty for underground SWM including water quality facilities. All water quality devices, proprietary or otherwise must either be included in the *2000 Maryland Stormwater Design Manual, Volumes I and II* or shall be approved by the AHJ and MDE in writing;
- underground SWM structural elements, including pipes shall have a minimum required service life of 50 years;
- whenever any of the structural elements are under a roadway, or extend more than 10 feet below the surface, the minimum required service life is 100 years; and
- underground SWM requiring vacuum truck maintenance access shall require that no point within each separate chamber of the facility be more than 100 feet from an access point.

4.4.4 SWM Reports

The Concessionaire shall perform engineering computations and/or analysis and maintain all backup data. Concessionaire shall submit Stormwater Management Reports, including drainage reports, geotechnical report and field inspections reports, computations, and maps for Review and Approval.

The SWM report shall contain the following:

- a thorough discussion explaining the extent of improvements at each outfall and the proposed quantitative and qualitative control methods of SWM, including reasons why other methods were not selected;
- an explanation of hydrologic/hydraulic analysis methodologies used. Final supporting computations, maps, schematics, cross-sections, details and computer outputs shall be included for each outfall location;
- outfall stability analysis, including photographs of each outfall and receiving channel;
- computations for riprap sizing and outlet protection;

- maps and schematics clearly showing the location of subareas, structures, existing land use, time of concentration paths, soil types and SWM facilities;
- pond summary sheets;
- BMP identification forms with BMP numbers indicated. The Concessionaire shall define or obtain BMP numbers from the AHJ as applicable to final ownership of all Project SWM facilities.

4.5 Summary of Submittals

Item	Section	Submittal	Action
1	4.3.6	Drainage Design - Preliminary	Review and Comment
2	4.3.6	Drainage Design - Final	Review and Comment
3	4.4.4	Stormwater Management Reports	Review and Approval

5 TRAFFIC

This Section describes the requirements for traffic analysis and traffic control devices.

5.1 Overview

Concessionaire shall perform traffic analysis for roadway, intersection and highway-LRT crossing operations to verify proposed designs meet or exceed the required traffic operations.

Concessionaire shall provide all Traffic Control Devices (TCD) for the Project, including, at a minimum, pavement markings, delineation, signing, traffic signals, traffic control cabinets and wire, systemization, gates, and flashing light signals.

Concessionaire shall provide other Project elements, including lighting and Intelligent Transportation Systems (ITS).

Concessionaire shall design all TCD and other Project elements in accordance with the Codes and Standards of the AHJ.

5.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards, including, at a minimum, the following:

General

- AASHTO, Roadside Design Guide;
- AASHTO, Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals;
- AASHTO, Highway Safety Design and Operations Guide;
- AASHTO, Guide for the Planning, Design, and Operation of Pedestrian Facilities;
- AASHTO, A Policy on Geometric Design of Highways and Streets;
- FHWA, Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD);
- FHWA, National Cooperative Highway Research Program (NCHRP) Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features;
- FHWA, Manual for Assessing Safety Hardware;
- FHWA, NCHRP Report 672, Roundabouts: An Informational Guide;
- IEEE, National Electrical Safety Code;
- ITE, Traffic Engineering Handbook;
- MDSHA, Standard Specifications for Construction and Materials;
- MDSHA, Maryland Manual on Uniform Traffic Control Devices for Streets and Highways (MDMUTCD);
- MDSHA, Standard Office of Traffic and Safety Shelf Typicals;
- MDSHA, Book of Standards for Highway and Incidental Structures;
- MDSHA, Specifications for Consulting Engineer's Services, Volume II, Section VIII;
- MDSHA, Office of Traffic and Safety, Traffic Engineering Design Division, Traffic Control Devices Design Manual;

- MDSHA, Roundabout Traffic Design Guidelines;
- MDSHA, Accessibility Policy & Guidelines for Pedestrian Facilities along State Highways;
- MDSHA, Roadway Delineation Policy;
- MDSHA, Bicycle Policy and Design Guidelines;
- MDSHA, Microstation V8 CAD Standards Manual;
- MDSHA, Traffic Engineering Design Division Design Checklist;
- MDSHA, Office of Traffic and Safety, Traffic Control Device Application Guidelines;
- MDSHA, Office of Traffic and Safety, Qualified Products List;
- MDSHA, Office of Materials Technology, Qualified Products List;
- MDSHA, Office of Traffic and Safety, Shelf Specifications;
- M-NCPPC, Local Area Transportation Review and Transportation Policy Area Review Guidelines
- NACTO, Urban Bikeway Design Guide;
- NFPA, National Electrical Code, NFPA 70;
- NFPA, NFPA 502, Standard for Road Tunnels, Bridges, and Other Limited Access Highways;
- State of Maryland, Maryland High Voltage Line Act;
- State of Maryland, Maryland Vehicle Law;
- US DOJ, ADA Standards for Accessible Design; and
- US DOJ, Americans with Disability Act Accessibility Guidelines (ADAAG).

Traffic Analysis

- FHWA, NCHRP 572, Roundabouts in the United States;
- ITE, Manual of Transportation Engineering Studies;
- MDSHA, Office of Traffic and Safety, Procedures for Intersections Memorandum (Queuing Analysis Methodology);
- MDSHA, SHA Policy for Determining Yellow Timing at Intersections;
- MDSHA, Traffic Signal Timing Guidelines & Training Manual; and
- TRB, Highway Capacity Manual.

Signing, Pavement Markings, Traffic Signals

- FHWA, Standard Highway Signs;
- FHWA, Standard Alphabets for Highway Signs;
- MDSHA, List of Qualified Permanent Pavement Markings;
- MDSHA, List of Qualified Loop Sealants;
- MDSHA, List of Qualified Detectable Warning Surfaces;

- MDSHA, Standard Sign Book;
- MDSHA, Line Striping Material Selection Policy;
- MDSHA, Accessible Pedestrian Signals – Design and Installation Guidelines;
- MDSHA, Guidelines for Application of Rumble Strips and Rumble Stripes;
- MDSHA, Bicycle Policy and Design Guidelines;
- MCDOT, Sign Shop Signing Standards and Procedures Manual
- MDSHA, Street Name Sign Policy, Procedures and Guidelines;
- MDSHA, Traffic Signal Design Guide;
- MDSHA, Guidelines for Using Edge Line Extensions & Yield Lines;
- MDSHA, Alternate Merge Guidelines;
- MDSHA, Application & Design Guidelines For Shoulder Bypass Lanes
- MDSHA, Guidelines for Traffic Barrier Placement and End Treatment Design
- NATCO, Urban Bikeway Design Guide;
- PGDPWT, Specifications and Standards for Roadways and Bridges; and
- ASTM, #E 2177-01, Test Method for Measuring the Coefficient of Retroflected Luminance of Pavement Markings in a Standard Condition of Wetness.

Highway, Intersection, Pedestrian and Sign Lighting

- AASHTO, Roadway Lighting Design Guide;
- IESNA, DG-5-94, Recommended Lighting for Walkways and Class 1 Bikeways;
- IESNA, G-1-03, Guideline on Security Lighting for People, Property, and Public Spaces;
- IESNA, RP-8-00, American National Standard Practice for Roadway Lighting;
- IESNA, RP-19-01, Roadway Sign Lighting;
- IESNA, RP-20-98, Lighting for Parking Facilities;
- IESNA, RP-22-11, American National Standard Practice for Tunnel Lighting;
- MDSHA Lighting Guidelines and Traffic Control Devices Design Manual;
- MDSHA, Office of Traffic and Safety Lighting Guidelines, dated July 2013;
- MDSHA Technical Design Standards;
- MCDOT, Streetlight Installation Guidelines, and
- MCDOT, Streetlight Specifications.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

5.3 Functional Requirements

Concessionaire shall integrate the Project within the existing transportation system and shall minimize impacts to non-LRT modes of travel while maintaining safe and efficient operations.

Concessionaire shall use opening year 2020 traffic volumes and lane configurations as shown in the 2020 Build Conditions Wiring Diagrams provided in Book 5 Engineering Data for all calculations and analysis required by this Section.

Concessionaire shall provide for projected traffic operations equal to or better than required traffic operations for the design year 2040, as shown in the 2040 Build Conditions Wiring Diagrams provided in Book 5 Engineering Data.

Proposed traffic signalization shown on the 2040 Build Conditions Wiring Diagrams Contract Drawings shall be considered the minimum configuration.

5.3.1 Concept of Operations for Traffic Operations System

Concessionaire shall develop and update as required a Traffic Operations System Concept of Operations for signal systems for LRT, vehicular, bicycle and pedestrian traffic. The Traffic Operations System Concept of Operations shall identify and communicate the overall quantitative and qualitative characteristics of the systems, including traffic signal operations, ITS, CCTV, applicable TCD operations, communications, Transit Signal Priority and Preemption (TSPP); and systems maintenance, operation and monitoring. The Traffic Operations System Concept of Operations shall be coordinated with and acceptable to all affected Third Parties.

Concessionaire shall use a Systems Engineering approach to:

- identify all stakeholders and Third Parties;
- identify constraints;
- define Project goals and objectives, including documenting changes in goals with each revision;
- elicit needs from all stakeholders and Third Parties (or in future years, validate that needs are unchanged);
- resolve conflicting needs, prioritize needs, and complete a gap analysis;
- determine functional and performance requirements;
- identify data protocol for communications with each Traffic Management Center and the control, status and alarm functions;
- define design parameters;
- define implementation approach;
- determine if implementation matches needs; and
- document process and results.

The Traffic Operations System Concept of Operations Report shall include, at a minimum, the following elements:

- Project scope;
- referenced documents;

- operational description;
- operational needs;
- system overview;
- operational and support environment;
- operational scenarios;
- maintenance needs; and
- next steps.

Proposed traffic signalization shown on the 2020 Build and 2040 Build Conditions Wiring Diagrams in Book 5 Engineering Data shall be considered the minimum configuration. Concessionaire shall include all crossings within the Project limits in the report.

An initial Traffic Operations System Concept of Operations for the Project has been developed and is included within the Reference Documents.

Concessionaire shall submit the Traffic Operations System Concept of Operations Report for Review and Comment at Preliminary Design, Final Design, and the conclusion of Trial Running.

5.4 Traffic Operations Analysis

5.4.1 Analysis Techniques and Software

Concessionaire shall use the following analysis techniques and software for the Project:

- Highway Capacity Manual / Highway Capacity Software shall be used to analyze signalized intersections, unsignalized intersections, freeway mainlines, ramp junctions (merge and diverge locations), and weaving sections for opening and design year conditions. As part of relevant Submittals, Concessionaire shall provide a summary of results on a wiring diagram, including both the Level of Service (LOS) and the volume-to-capacity (V/C) ratio as appropriate, and electronic calculation files;
- Synchro/SimTraffic shall be used to analyze Corridor operations along Corridors consisting of multiple intersections. Timing plans shall consider Corridor-wide cycle lengths and appropriate offsets. Analysis shall take into consideration channelized islands, curb ramps, sidewalks, bike lanes and trails. Concessionaire shall also use Synchro/SimTraffic to establish traffic signal phasing and timing at isolated intersections;
- VISSIM shall be used to analyze conditions for arterial and freeway operations (i.e. Corridor analysis). This shall be in addition to the Highway Capacity Manual / Highway Capacity Software and Synchro / SimTraffic requirements. VISSIM shall also be used for analyzing operations in locations where TSPP or complex LRT phasing is necessary;
- aaSIDRA shall be used to complete operational analyses of roundabouts with the Environmental Factor set to 1.2. Volumes shall be checked against the capacity thresholds outlined in NCHRP 572, Roundabouts in the United States;
- Queuing Analysis Technique shall be used to determine the appropriate length of left- and right-turn bays. Queue lengths for through lane(s) and turn lane(s) shall be calculated using the MDSHA Queuing Analysis methodology as outlined in the MDSHA Office of Traffic and Safety Capacity/Queuing Analysis Procedures for Intersections memorandum;

- SHA's Critical Lane Volume methodology shall be used for traffic operations analysis; and
- Concessionaire shall complete a pedestrian impact statement in accordance with M-NCPPC, Local Area Transportation Review and Transportation Policy Area Review Guidelines. Pedestrian Impact Statement shall include evaluation of all at-grade segments and ingress/egress from all Stations. The Concessionaire is encouraged to develop and submit the report in logical segments, rather than a single report covering the entire corridor.

5.4.2 Preliminary Traffic Operations and Engineering Design Analysis

Concessionaire shall prepare a Preliminary Traffic Operations and Engineering Design Analysis Report to demonstrate that Concessionaire's design meets the minimum traffic operations as shown in the design year 2040 Build Conditions Wiring Diagram, proposed designs and subsequent submittals for the Project to conform to AHJ standards. The required analysis for the proposed Project shall include, at a minimum, the following:

- computations to provide capacity (V/C ratio, LOS and delay) computations for 2020 Build Conditions for all intersections and roadway segments. This information shall be displayed in the same format as shown in the design year 2040 Build Condition Wiring Diagram. This information shall be included within the Preliminary and Final Traffic Operations Design and Engineering Analysis Report Submittal;
- evaluation and analysis of new or modified ITS components and systems;
- conduct Traffic Signal Warrant Analyses for all intersections as shown in the opening year 2020 Build Conditions Wiring Diagrams including all LRT grade crossings . The Traffic Signal Warrant Analyses will specify warrants evaluated and consideration given to safety, operations, delay and available gaps in traffic resulting from adjacent signalized intersections;
- provide Signal Timing Evaluation forms showing existing signal timings and phasing (if applicable), proposed signal timings and phasing including clearance (yellow change) interval calculations, LOS, delay computation for overall intersection, and by approach, including any failing movements, queuing for each approach (95th percentile) and any blocked movements;
- preliminary findings of the Traffic Evaluation Report for LRT Grade Crossings;
- final intersection analysis using Synchro software;
- Corridor analysis using VISSIM software to review Corridor-wide operations of the proposed Project for both 2020 Build and 2040 Build conditions;
- comparison of the anticipated operational speed and design speed for each segment of roadway in tabular form;
- comparison of the anticipated operational speed of vehicles and LRT speed in tabular form;
- final utility locations, including sources of system needs and utility clearances; and
- any changes proposed by Concessionaire to the information as provided in opening 2020 and design year 2040 Build Conditions Wiring Diagrams. Concessionaire proposed changes shall be shown on revised wiring diagrams clearly labeled as "Concessionaire Proposed Changes" in separate figures using the same format as the opening year 2020

and design year 2040 Build Condition Wiring Diagrams provided in the Book 5 Engineering Data.

Concessionaire shall submit the Preliminary Traffic Operations and Engineering Design Analysis Report for Review and Approval at Preliminary Design.

5.4.3 Final Traffic Operations and Engineering Design Analysis

Concessionaire's Final Traffic Operations and Engineering Design Analysis Report shall demonstrate that Concessionaire's design is in conformance with all applicable Project requirements. The required analysis for the proposed Project shall include, at a minimum, the following:

- complete listing of all comments and documented responses with final resolution from the Preliminary Traffic Operations and Engineering Design Analysis review;
- listing of all new or modified traffic signal interconnection and equipment;
- listing of all new or modified ITS components, systems and equipment;
- final opening year 2020 and design year 2040 Build Conditions Wiring Diagrams denoting all changes from the original drawings as shown in Book 5 Engineering Data. Changes shall be clearly labeled as "Concessionaire Proposed Changes";
- final Traffic Signal Warrant Analyses for all intersections as shown in the opening year 2020 Build Conditions Wiring Diagrams including all LRT grade crossings to determine if signalization and other TCD is required for the opening year 2020 . The Traffic Signal Warrant Analyses shall specify warrants evaluated and consideration given to safety, operations, delay and available gaps in traffic resulting from adjacent signalized intersections. These analyses shall be included in the Design Request Forms;
- final Signal Timing Evaluation forms. These analyses shall be included in the Design Request Forms;
- final findings and recommendations of the Traffic Evaluation Report for LRT Grade Crossings;
- final Corridor analysis using VISSIM software to review Corridor-wide operations of the proposed Project;
- final comparison of the anticipated operational speed and design speed for each segment of roadway in tabular form; and
- final comparison of the anticipated operational speed of vehicles and LRT speed in tabular form.

Concessionaire shall submit the Final Traffic Operations and Engineering Design Analysis Report for Review and Approval at Intermediate Design.

5.4.3.1 Traffic Evaluation Report for LRT Grade Crossings

Concessionaire shall justify the selection and application of pavement markings, signing, traffic signals, lighting, ITS, gates, flashers, and other TCD at LRT grade crossings throughout the Project. The Traffic Evaluation Report shall be prepared separately but be included within the Preliminary and Final Traffic Operations and Engineering Design Analysis reports. Concessionaire shall include, at a minimum, the following information in the Traffic Evaluation Report:

- existing data:
    - documentation and collection of known conditions at the crossing location;
    - identification of land-use and traffic generators;
    - vehicular traffic count data;
    - pedestrian and bicyclist count data;
    - crash history and related safety analysis for the three most recent years as of time of report preparation; and
    - speed studies to determine prevailing vehicular speeds.
- proposed data:
    - planned operating speeds for LRT and roadway; and
    - projected traffic volume data for opening and design years.
- traffic analysis:
    - signal warrant analyses;
    - capacity analysis including overall LOS, failing movements, delay, queuing for each approach, and blocked movements;
    - operational improvements to mitigate concerns identified during the capacity analysis;
    - recommendations for device selection and application at LRT grade crossings:
    - proposed traffic control and other device types and locations; and
    - removal and/or modification of existing traffic control or other devices due to addition of LRT.

5.5 Design Requests Forms

Upon resolution of comments on the Final Traffic Operations and Design Analysis, Concessionaire shall initiate all new or proposed changes to traffic signals and TCDs by Submittal of Design Request forms to the appropriate AHJ:

- MDSHA and Prince George's County, use MDSHA Office of Traffic and SafetyTraffic Control Device Design Request form; and
- Montgomery County, use MCDOT Traffic Engineering and Operations Division's Traffic Control Device Design Request form.

For traffic signals (including Intersection Control Beacons and Hazard Identification Beacons), Concessionaire shall provide all necessary traffic operations, signal phasing and timing evaluations, and signal warrant analyses to justify their installation, modification, or removal. AHJ will implement signal timing and may use the Concessionaires proposed design or develop an alternate timing.

Concessionaire shall submit Design Request Forms and Supporting Documentation for Review and Approval following Final Traffic Operations and Design Analysis.

5.6 Pavement Markings

Concessionaire shall provide pavement markings in accordance with the Codes and Standards of the AHJ and the following:

- single longitudinal pavement marking lines shall be 5 inches wide;
- double width lines shall be 10 inches wide;
- preformed 10 inch wide lines shall be one continuous 10 inch wide material
- stop lines shall be 24 inches wide.
- crosswalk lines shall be 12 inches wide except crosswalks on Montgomery County roadways shall be Ladder Bar Style with 16” to 24” Ladder Bars and 20” to 36” Spaces. Refer to MCDOT Standard Crosswalk Pavement Markings; and
- Concessionaire shall select pavement marking material in accordance with Exhibit 5.1.

Exhibit 5.1 – Roadway Pavement Markings

Category	Roadway Type	Line Striping Material		
		center lines	lane lines	edge lines
Portland Cement Concrete (PCC) (Including Bridge Decks)				
1	Interstate Highway / Freeway / Expressway	------	Contrast PPPRP with RPM	PPPRP **
2	Highway (other than Interstate / Freeway / Expressway) AADT ≥ 50,000	PPPRP with RPM	Contrast PPPRP with RPM	PPPRP
3	Highway (other than Interstate / Freeway / Expressway) AADT < 50,000	PPPRP with RPM	Contrast PPPRP with RPM	PPPRP
Hot Mix Asphalt				
1	Interstate Highway / Freeway / Expressway	------	PPPRP with RPM	PPPRP
2	Highway (other than Interstate / Freeway / Expressway) AADT ≥ 50,000	PPPRP with RPM	PPPRP with RPM	PPPRP
3	Highway (other than Interstate / Freeway / Expressway) AADT < 50,000	Durable with RPM	Durable with RPM	Durable
4	2-Lane 2-Way Roadway AADT ≥ 30,000	Durable	------	Durable
5	2-Lane 2-Way Roadway AADT < 30,000	Paint	------	Paint
RPM – snowplowable raised pavement markers; PPPRP – permanent preformed patterned retro-reflective pavement markings; Durable – includes thermoplastics, patterned profiled thermoplastics (wet tape), or epoxy.				
** Note: Contrast Markings shall be utilized for the right edge (white) lines. The left edge (yellow) lines shall not utilize contrast markings.				
All transverse pavement markings such as yield symbols, shark's teeth, crosswalks, stop lines, as well as arrows, letters, and other symbols shall be heat-applied permanent preformed thermoplastic, except on concrete surfaces. On concrete surfaces, all transverse pavement markings shall be PPPRP.				

Concessionaire shall show proposed pavement markings on the same plan sheets as Project signing. Plans shall show color, size, location, and material type of pavement markings within the limits of work. Plans shall clearly identify locations where pavement markings change color, width, or material. Vehicular and bicycle lanes shall be dimensioned based on typical sections for the Project. Dimensions shall be included for each change in the highway typical section. The width of each vehicular travel lane shall be specified at least two times on each plan sheet, as well as wherever a change in travel lane width occurs.

5.7 Signing

Concessionaire shall provide, at a minimum, all guide, supplemental, route markers, and regulatory and warning signs required for this Project and as may be required by the AHJ.

Signing plans shall include all signing that is affected by the Project, including signs outside the limits of construction of the Project, whether existing or proposed.

Concessionaire shall modify or remove all signing that is affected by the Project and is no longer appropriate or pertinent.

Concessionaire shall upgrade all existing signing that does not meet Project requirements to meet Project requirements.

Concessionaire shall provide signing for roadways where existing access is being modified by the Project.

For all existing signing removed by Concessionaire, Concessionaire shall return the signing to the AHJ or if directed by the AHJ dispose of the signing.

5.7.1 Design of Sign Panels and Sign Supports

Concessionaire shall coordinate the design of proposed sign locations with all proposed roadside equipment and features to assure proper clearances and adequate sight distance.

For all existing signs that are to remain or be modified for the Project, Concessionaire shall provide testing that signs meet retro-reflectivity requirements. Existing sign retroreflectivity shall be verified by the use of a portable hand held retroreflectometer. These devices shall be of the annular type as specified in ASTM E1709. The devices shall be properly calibrated per the manufacturer's recommendations. Certification of calibration shall be provided to the AHJ upon request. When performing retroreflectometer readings, Concessionaire shall follow the procedures outlined in ASTM E1709 and the equipment manufacturer's recommendations.

The messages, fonts, font sizes, arrows, shields, colors, borders, and type of supports for the overhead and ground-mounted signs shall be designed and constructed according to the MD MUTCD and applicable AHJ design manual.

Fluorescent yellow background sheeting shall be used for all yellow traffic signs.

Fluorescent yellow-green shall be used for all school signs.

Clearview font shall be used for all positive contrast signs.

When a sign contains more than one background color, the signs shall have two separate borders corresponding to each background color where the background colors meet. If the background colors utilize the same border color, then only one border is necessary where the background colors meet.

Concessionaire shall provide street name signs at all highway-LRT crossings, including at-grade and grade separated crossings. Concessionaire shall install blade type street names signs on opposing corners of all intersections. Additionally, Concessionaire shall install overhead signage on all traffic signal mast arms. All existing advanced street name signage shall be replaced. No additional advanced street name signage is required on MCDOT roadways.

All proprietary logos will be provided by the Owner. Concessionaire shall identify the proprietary logos required as part of the preliminary design submission.

Concessionaire shall follow the manufacturer's recommendations and the MDSHA ground mounted steel post breakaway system selection process for selecting the appropriate breakaway system and accompanying steel posts for ground-mounted signs requiring steel supports. 100 mph wind speed shall be used for design. The structure design life shall be a 10-year recurrence interval for ground-mounted signs using breakaway steel supports. All steel posts except for W6X9 wide flange steel I-beams shall have at least 7 feet of clearance between posts (inside of post to inside of post).

Extruded signs and steel breakaway posts will not be allowed on MCDOT roadways without prior written approval of MCDOT. Concessionaire shall use 2" square steel posts on MCDOT roadways wherever possible.

Signs over 32 square feet shall be designed using steel supports. Signs shall not be supported on bridge overpass structures or banded to Utility poles, street lighting poles, and overhead sign structure uprights unless approved by the AHJ.

Signs and sign supports shall be located either outside the clear zone or behind roadside barriers unless those signs are installed on breakaway supports.

5.7.2 Aesthetic Guidelines

Concessionaire shall provide signs, and sign supports that conform to the aesthetic guidelines for the Project.

Concessionaire shall use galvanized steel "U" channel posts for sign supports for all ground mounted signs smaller than 32 square feet to be installed on Prince George's County roadways.

5.7.3 Signing Plans

Plans shall show the proposed message, MDMUTCD, or MUTCD sign designation (if applicable), size and location of all guide, supplemental, route marker assemblies, and regulatory and warning signs.

Plans shall also show the location, messages and sizes of all existing signs including those to be removed, modified or relocated.

Concessionaire shall provide a note for each sign and sign structure shown on the signing plans to denote ownership and maintenance responsibility.

Concessionaire shall use the pertinent AHJ standard signing plan sheet format to document signing details.

Signing Plans shall include pavement markings.

Concessionaire shall submit Signing and Pavement Marking Plans for Review and Comment at Intermediate Design and Final Design.

5.8 Traffic Signal Design

Concessionaire shall provide all traffic signals using mast arms. Location and number of signal poles and mast arms shall comply with the standard design practices of the AHJ. Color of mast arms and poles shall match existing. Coatings shall be per standards of the AHJ.

Concessionaire shall provide the necessary roadway lighting for signalized intersections. Design of signal pole mounted lighting shall be coordinated with adjacent existing and/or proposed roadway lighting. Electrical cables for intersection lighting shall be energized directly from the metered service pedestal for the traffic signal and shall not pass through the signal cabinet. LED Roadway luminaires shall be used for lighting installed on traffic signal equipment. LED vehicular and pedestrian traffic signal heads shall be used for traffic signals. Video detection cameras shall be used for stop line presence and sampling detection at all traffic signals. Video detection cameras or non-invasive micro-loop probes shall be used for all advanced passage detection for traffic signals.

Traffic signal devices may be attached to OCS poles where approved by the AHJ.

Maximum traffic signal handhole spacing is 200'.

5.8.1 Traffic Signals at LRT Grade Crossings

Concessionaire shall design traffic signals at LRT grade crossings in accordance with the standards and guidelines of the AHJ, the approved Design Request forms, the Traffic Evaluation Report for LRT Grade Crossings, and the following requirements:

- use optically programmed signal lenses in situations as required to limit the field of view of the signal heads;
- left turns and right turns crossing LRT tracks (in semi-exclusive alignment) from a parallel highway shall occur from exclusive turn lanes;
- left turns crossing LRT tracks (in semi-exclusive alignment) from exclusive left-turn lanes along highway alignments parallel to the tracks shall be controlled by protected left-turn phasing.
- A minimum of two separate red arrow signal lenses shall be used at right turns crossing LRT tracks from exclusive right-turn lanes along roadway alignments parallel to tracks to provide turn prohibition indication to motorists. Where protected phasing with red arrow signal lenses cannot be accommodated additional design elements such as alternative signal displays, exclusive phasing, LED blank-out turn restriction signing, or other safety measures shall be considered to ensure safe operations for all modes of traffic through the intersection. The right turns shall not, in any case, run permissive with the parallel LRT movements. Concessionaire shall prepare additional designs and present to the Owner and AHJ for Review and Comment;
- turn prohibition or other LRT-activated blank-out signs shall be provided at locations where left turns or right turns from a roadway are prohibited across or onto (in the case of mixed-traffic LRT alignment) the tracks when an LRT vehicle is approaching the crossing. Red traffic signal arrows used for turn prohibition are an approved substitute for turn prohibition or other LRT-activated blank-out signage;
- provide TSPP at locations as specified by Owner and the AHJ;
- provide automated pedestrian gates at pathway and LRT grade crossings of specified locations or if deemed necessary by the Traffic Evaluation Report for specific sites;
- Uninterruptable Power Supply (UPS) shall be provided at all signalized LRV crossings; and
- bar type signals shall be provided for Light Rail Vehicles (LRV) movements. Bar signals may be mounted on traffic signal poles or mast arms, OCS poles or their own separate poles or mast arms as best accommodates the desired location.

5.8.2 Traffic Signals at Other Locations

Concessionaire shall design traffic signals at all other locations in accordance with the standards and guidelines of the AHJ, and the approved DR forms.

5.8.3 Temporary Traffic Signals

Concessionaire shall design temporary traffic signals as required by the Maintenance of Traffic Plans and the approved DR forms. Temporary traffic signals shall be designed in accordance with the standards and guidelines of the AHJ. Uninterruptable Power Supply (UPS) shall be provided at all signalized intersections.

5.8.4 Pedestrian Signals and Other Audible Devices

Concessionaire shall design Countdown Pedestrian Signals (CPS) and Accessible Pedestrian Signal (APS) push-buttons at all locations where signalized crossings are provided. CPS and APS shall be designed in accordance with the Codes and Standards, requirements of the AHJ, and the approved DR forms.

5.8.5 Transit Signal Priority and Preemption (TSPP)

Concessionaire shall equip all new traffic signal controllers with TSPP functionality. Concessionaire's design shall provide Peak Period TSPP signal sequencing at signalized LRT grade crossings in accordance with Exhibit 5.2 TSPP Matrix. Exhibit 5.2 TSPP Matrix shall be considered the initial configuration. TSPP is anticipated at additional intersections during Off-Peak Period times.

All proposed traffic controller operations, traffic signal phasing and timing plans shall be submitted as part of the Preliminary and Final Traffic Operations and Engineering Design Analysis Reports – Signal Timing Evaluations. Final Signal Timing Evaluations shall be provided in a summary document along with all electronic files to allow for system timings to be implemented in accordance with the standards and guidelines of the AHJ. System timings will include but not be limited to adjacent interconnect traffic signals, TSPP settings, minimum green/split, maximum split, pedestrian walk, countdown pedestrian signals, offsets, force offs, return to normal operations, special signal operating plans, associated phases, time of day, day of week and week of year plans as required by the AHJ. Final Signal Timing Evaluations, system timings and associated computer files shall be provided as parts of the Preliminary and Final Traffic Operations and Engineering Analysis. Concessionaire shall be responsible for coordinating the implementation of traffic system timings by or under the direction of AHJ.

Exhibit 5.2 – TSPP Matrix			
Intersection	**Required Improvement**	**TSPP**	**Traffic Signal Owner**
Silver Spring Transit Center Platform			
Bonifant Street at Dixon Avenue	New Signal	Preemption	Montgomery Co.
Bonifant Street at Georgia Avenue	Rebuild Signal	None	MDSHA
Silver Spring Library Platform			
Wayne Avenue at Fenton Street	Rebuild Signal	Priority	Montgomery Co.
Wayne Avenue at Cedar Street	Rebuild Signal	Priority	Montgomery Co.
Wayne Avenue at Dale Drive	Rebuild Signal	Priority (EB only)	Montgomery Co.
Dale Drive Platform			
Wayne Avenue at Mansfield Rd	Rebuild Signal	Priority	Montgomery Co.
Wayne Avenue at Sligo Creek Parkway	Rebuild Signal	Priority	Montgomery Co.
Wayne Avenue at Manchester Road	New Signal	Priority	Montgomery Co.
Wayne Avenue at Plymouth Tunnel	New Signal	Preemption	Montgomery Co.
Manchester Place Platform			
Arliss Street at Shopping Center	New Signal	Preemption	Montgomery Co.
Long Branch Platform			
MD 320 at Arliss Street	Rebuild Signal	None	MDSHA
MD 320 at Garland Avenue	New Signal	Priority	MDSHA
MD 320 at Barron Street	Rebuild Signal	Priority	MDSHA
MD 193 at MD 320	Rebuild Signal	None	MDSHA
Piney Branch Road Platform			
MD 193 at Seek Lane	New Signal	Priority	MDSHA
MD 193 at Carroll Avenue (MD 195)	Rebuild Signal	Priority	MDSHA
MD 193 at Merrimac Drive	New Signal	Priority	MDSHA
MD 193 at Lebanon Street	New Signal	Priority	MDSHA
MD 193 at West Shopping Center	Rebuild Signal	None	MDSHA
MD 193 at Transit Center	Rebuild Signal	None	MDSHA
Takoma/Langley Transit Center Platform			
University Boulevard at MD 650	Rebuild Signal	None	MDSHA
University Boulevard at East Shopping Center	Rebuild Signal	None	MDSHA
University Boulevard at 14th Avenue	New Signal	Priority	MDSHA
University Boulevard at 15th Avenue	Rebuild Signal	Priority	MDSHA
Riggs Road Platform			
University Boulevard at MD 212	Rebuild Signal	None	MDSHA
MD 193 at Guilford Road	New Signal	Priority	MDSHA
MD 193 at 23rd Avenue	Rebuild Signal	Priority	MDSHA
MD 193 at 24th Avenue (North)	New Signal	Priority	MDSHA
MD 193 at West Park Drive	Rebuild Signal	Priority	MDSHA
MD 193 at Campus Drive	Rebuild Signal	None	MDSHA

Exhibit 5.2 – TSPP Matrix			
Intersection	**Required Improvement**	**TSPP**	**Traffic Signal Owner**
Campus Drive at Adelphi Road	Rebuild Signal	None	MDSHA
Adelphi Road/West Campus Platform			
Campus Drive at Presidential Drive	Rebuild Signal	Preemption	See note 3.
Presidential Drive/Union Drive at Valley Drive	New Signal	Preemption	See note 1.
Campus Center Platform			
Campus Drive at Regents Drive	New Signal	Preemption	See note 1.
Rossborough Lane at US 1	Rebuild Signal	None	MDSHA
East Campus Platform			
Rossborough Lane at Paint Branch Parkway	New signal	Priority	See note 3.
Paint Branch Parkway at Paint Branch Trail	Rebuild Signal	Preemption	See note 3.
Paint Branch Parkway at MFRI Entrance	Rebuild Signal	Priority	See note 3.
Paint Branch Parkway at Metro Entrance	Rebuild Signal	Priority	See note 3.
College Park Metro Platform			
River Road at Rivertech Court	New Signal	Preemption	See note 3.
M Square Platform			
River Road at Haig Drive	New Signal	Preemption	See note 3.
River Road at MD 201	Rebuild Signal	None	MDSHA
Riverdale Park Platform			
MD 201 at Rittenhouse Street	Rebuild Signal	Priority	MDSHA
MD 410 at Mustang /62nd Place	Rebuild Signal	Priority	MDSHA
MD 410 at 64th Avenue/Eastpine Drive	Rebuild Signal	Priority	MDSHA
MD 410 and B/W Parkway SB Ramps	Rebuild Signal	Priority	MDSHA
MD 410 and B/W Parkway NB Ramps	Rebuild Signal	Priority	MDSHA
MD 410 and 66th Avenue	Unsignalized Gated Right-in /Right-out	Preemption	MDSHA
MD 410 and 67th Avenue	Rebuild Signal	Priority	MDSHA
Beacon Heights Platform			
Veterans Parkway and Glenridge Yard	New Signal	Preemption	MDSHA
Veterans Parkway and Annapolis Road	Rebuild Signal	None	MDSHA
Annapolis Road/Glenridge Platform			
Veterans Parkway and Ellin Road	Rebuild Signal	Priority	MDSHA
Elin Road at Hanson Oaks Drive	New Signal	Premption	See note 3.
Ellin Road and Bus Loop	New Signal	Preemption	See note 3.
New Carrollton Platform			

Note 1: Owned by UMD. Signal shall be provided to MDSHA Standards.
Note 2: Not Used.
Note 3: On Price Georges County Road. Owned by MTA. Signal shall be provided to MDSHA Standards.

Owner is establishing an ongoing working group to include Owner, Concessionaire, Montgomery County, Prince George's County and SHA to monitor and coordinate the operation of all signalized intersections along the Alignment. This working group will review and recommend TSPP sequencing in Off-Peak Periods and shall review and recommend proposed changes to the TSPP performance throughout the Term.

5.8.6 Interconnect Design

All traffic signals impacted or installed by the Project shall be interconnected, as defined by the AHJ. Concessionaire shall ensure all traffic controllers installed for the Project have communications capability and compatibility with the AHJ Traffic Management Centers in accordance with Exhibit 5.3.

Two of the signals to be reconstructed under this project are Paint Branch Parkway at MFRI Entrance and Paint Branch Parkway at Metro Entrance. These are part of a system controlled by the signal at Paint Branch Parkway at River Road. As such, the signal at Paint Branch Parkway and River Road shall be modified as required to maintain the interconnection and establish required TSPP. The system includes the signal at Paint Branch Parkway at Corporal Frank Scott Drive. As such, all four shall be reconstructed or modified by the Concessionaire and remain interconnected.

Two of the signals to be constructed under this project are Ellin Road at Hanson Oaks Drive and Ellin Road and Bus Loop. These shall be interconnected with the reconstructed signal at Ellin Road and Harkins Road.

All existing traffic signal detection, interconnect and communications shall be maintained throughout and after construction. Concessionaire shall prepare a plan identifying the existing location, type and strand count of all interconnect for Review and Comment by the AHJ. Concessionaire shall be responsible for interconnecting all existing interconnected and new traffic signals that are rebuilt, modified or installed by the Project. All existing or new interconnected traffic signal systems shall be a complete installation, including tying into the existing traffic signal communications system for the AHJ. This includes but is not limited to all new interconnect cables, conduits, interconnect equipment and manholes are to be provided by Concessionaire for a complete and functioning connection to the AHJ system. Data protocol for communication with the Traffic Management Centers and the control, status and alarm functions shall be as required by each AHJ. For the OCC Traffic Management Center, Concessionaire shall provide, at a minimum, automatic alarms for any condition that causes the traffic signal to default to a flashing mode, for the loss of all red aspects in any given direction and for any and all other fault conditions that the traffic signal controller is capable of detecting. Montgomery County and SHA will be responsible for all associated changes to their traffic network central servers, workstations and network switches, and for final splicing/cut-over of cables. Concessionaire shall be responsible for all equivalent activities associated with the OCC.

Traffic signal interconnect cables shall not utilize conduit or hand boxes/manholes/junction boxes that contain LRT system or lighting electrical cables. Maximum handboxes/manholes/junction box spacing shall be 200'.

Temporary and permanent interconnect design shall be shown with the Traffic Signal Plans.

Concessionaire shall obtain attachment agreements for any new attachments to utility poles.

Exhibit 5.3 – Signal Summary		
Intersection	**Required Improvement**	**Traffic Management Center**
Jones Mill Road at Jones Bridge Road	Rebuild Signal	Montgomery Co.
Brookville Road at Stewart Avenue	New Signal	Montgomery Co.
16th Street at Spring Street	New Signal	Montgomery Co.
Bonifant Street at Dixon Avenue	New Signal	Montgomery Co.
Bonifant Street at Georgia Avenue	Rebuild Signal	Montgomery Co.
Bonifant Street at Fenton Street	Rebuild Signal	Montgomery Co.
Wayne Avenue at Fenton Street	Rebuild Signal	Montgomery Co.
Wayne Avenue at Cedar Street	Rebuild Signal	Montgomery Co.
Wayne Avenue at Dale Drive	Rebuild Signal	Montgomery Co.
Wayne Avenue at Mansfield Rd	Rebuild Signal	Montgomery Co.
Wayne Avenue at Sligo Creek Parkway	Rebuild Signal	Montgomery Co.
Wayne Avenue at Manchester Road	New Signal	Montgomery Co.
Wayne Avenue at Plymouth Tunnel	New Signal	Montgomery Co.
Arliss Street at Shopping Center	New Signal	Montgomery Co.
MD 320 at Greenwood Street	Rebuild Signal	Montgomery Co.
MD 320 at Arliss Street	Rebuild Signal	Montgomery Co.
MD 320 at Garland Avenue	New Signal	Montgomery Co.
MD 320 at Barron Street	Rebuild Signal	Montgomery Co.
MD 193 at MD 320	Rebuild Signal	Montgomery Co.
MD 193 at Seek Lane	New Signal	Montgomery Co.
MD 193 at Carroll Avenue (MD 195)	Rebuild Signal	Montgomery Co.
MD 193 at Merrimac Drive	New Signal	MDSHA
MD 193 at Lebanon Street	New Signal	MDSHA
MD 193 at West Shopping Center	Rebuild Signal	MDSHA
MD 193 at Transit Center	Rebuild Signal	MDSHA
University Boulevard at MD 650	Rebuild Signal	MDSHA
University Boulevard at East Shopping Center	Rebuild Signal	MDSHA
University Boulevard at 14th Avenue	New Signal	MDSHA
University Boulevard at 15th Avenue	Rebuild Signal	MDSHA
University Boulevard at MD 212	Rebuild Signal	MDSHA
MD 193 at Guilford Road	New Signal	MDSHA
MD 193 at 23rd Avenue	Rebuild Signal	MDSHA
MD 193 at 24th Avenue (North)	New Signal	MDSHA
MD 193 at West Park Drive	Rebuild Signal	MDSHA
MD 193 at Campus Drive	Rebuild Signal	MDSHA

Exhibit 5.3 – Signal Summary		
Intersection	**Required Improvement**	**Traffic Management Center**
Campus Drive at Adelphi Road	Rebuild Signal	MDSHA
Campus Drive at Presidential Drive	Rebuild Signal	OCC
Presidential Drive/Union Drive at Valley Drive	New Signal	OCC
Campus Drive at Regents Drive	New Signal	OCC
Rossborough Lane at US 1	Rebuild Signal	MDSHA
Rossborough Lane at Paint Branch Parkway	New signal	OCC
Paint Branch Parkway at Paint Branch Trail	Rebuild Signal	OCC
Paint Branch Parkway at MFRI Entrance	Rebuild Signal	OCC
Paint Branch Parkway at Metro Entrance	Rebuild Signal	OCC
Paint Branch Parkway at River Road	Signal Modification	OCC
Paint Branch Parkway at Corporal Frank Scott Drive	Signal Modification	OCC
River Road at Rivertech Court	New Signal	OCC
River Road at Haig Drive	New Signal	OCC
River Road at MD 201	Rebuild Signal	MDSHA
MD 201 at Rittenhouse Street	Rebuild Signal	MDSHA
MD 201 at MD410	Rebuild Signal	MDSHA
MD 410 at Riverdale Road	Signal Modification	MDSHA
MD 410 at Mustang /62nd Place	Rebuild Signal	MDSHA
MD 410 at 64th Avenue/Eastpine Drive	Rebuild Signal	MDSHA
MD 410 and B/W Parkway SB Ramps	Rebuild Signal	MDSHA
MD 410 and B/W Parkway NB Ramps	Rebuild Signal	MDSHA
MD 410 and 67th Avenue	Rebuild Signal	MDSHA
MD 410 (Riverdale Road) at MD 410 (Veterans Parkway)	Rebuild Signal	MDSHA
Veterans Parkway and Glenridge Yard	New Signal	MDSHA
Veterans Parkway and Annapolis Road	Rebuild Signal	MDSHA
Veterans Parkway and Ellin Road	Rebuild Signal	MDSHA
Ellin Road at Hanson Oaks Drive	New Signal	OCC
Ellin Road and Bus Loop	New Signal	OCC
Ellin Road at Harkins Road	Rebuild Signal	OCC

5.8.7 Sightline Plans

Concessionaire shall prepare sightline plans for all roadway approaches to existing, temporary, and permanent traffic signals to verify that all traffic signal heads can be seen by approaching traffic at the required sight distance during and after construction.

Concessionaire shall prepare sightline plans for all overhead signs, bridges, and hazard identification beacons that are on traffic signal approaches.

5.8.8 Traffic Signal Plans

Plans shall be prepared in accordance with guidelines and standards of the AHJ. Concessionaire shall submit Traffic Signal Plans for Review and Approval at Intermediate and Final Design.

5.9 Lighting

5.9.1 General Requirements

Concessionaire shall provide lighting including, at a minimum, roadway, pedestrian, and LRT grade crossing lighting.

Existing lighting impacted by the Project shall be replaced to meet the Project requirements.

Existing lighting not impacted by the Project, but within the Project limits, shall be verified to be operational. Non-operational existing lighting, within the Project limits, shall be made operational.

Existing lighting shall remain operational throughout construction until the proposed lighting is operational.

Concessionaire may place lighting on joint use poles with OCS where approved by the AHJ.

LRT grade crossings include highway-LRT and pathway-LRT crossings. Where the LRT emerges from an exclusive ROW to cross a highway at-grade at an isolated location, Concessionaire shall design the lighting within 100 feet on either side of the crossing as follows:

- 1.0 fc minimum maintained average illuminance; or
- twice the level of the adjacent area of the same roadway, whichever is greater.

Concessionaire shall combine intersection lighting with traffic signals whenever possible. Concessionaire shall include in their design a photocell on each luminaire mounted on a traffic signal structure.

5.9.1.1 General Electrical Design for Lighting

The lighting system shall use cabinets, cables, conduits, manholes and other electrical equipment separate from those required for traffic signals, ITS and LRT systems.

Concessionaire shall meet the following requirements for voltage drop, unless required otherwise by the AHJ:

- voltage drop for each branch circuit shall not exceed 3 percent for new circuits and 5 percent for existing circuits, assuming an ambient temperature of 40 degrees Celsius; and
- voltage drop for each feeder circuit shall not exceed the maximum recommended by *National Fire Protection Association (NFPA) 70 National Electric Code (NEC)*, latest edition.

5.9.1.2 General Leased Lighting

For locations where luminaires are attached to Utility poles, Concessionaire shall be responsible for coordination with utility companies as needed to meet lighting requirements for the Project.

5.9.1.3 General Lighting Roll Plan

Concessionaire shall prepare a Lighting Roll Plan including, at a minimum:

- locations for all existing (to remain) and proposed light poles and fixtures;
- supporting photometric calculations, including light loss factor and lamp lumens; and
- point-by-point spacing (5 foot by 5 foot grid spacing required) computations including average illuminance, uniformity ratios (average-to-minimum illuminance), and veiling luminance calculations;

Concessionaire shall submit Lighting Roll Plan for Review and Comment at Preliminary design.

5.9.1.4 General Photometric Requirements

Concessionaire shall ensure all photometric analysis for light trespass shall utilize a light loss factor of 1.0. All other light loss factors shall be as required by the AHJ.

For all proposed lighting, whether temporary or permanent, the maximum allowable vertical and horizontal illuminance at residential property lines shall not exceed 0.01 foot-candles (fc). Concessionaire shall provide house-side shields on lighting fixtures within 75 feet of a residential structure, where necessary to achieve the 0.01 fc horizontal or vertical illuminance requirements.

Concessionaire shall meet or exceed the photometric values required by the AHJ.

5.9.1.5 General Lighting Plans

Concessionaire shall prepare Lighting Plans formatted in accordance with the requirements of the AHJ. Voltage drop calculations shall also be provided. The Lighting Plans shall be submitted for Review and Comment at Intermediate and Final Design.

5.9.2 Montgomery County Lighting Requirements

All Montgomery County roadways impacted by the Project including intersections shall be continuously illuminated according to IESNA RP-8-00 recommendations.

All luminaires utilized for roadway lighting shall be full cutoff LED. Pole and luminaire materials shall be installed according to Montgomery County standards with photoelectric control on each pole. Poles shall meet minimum clearance requirements from Utilities according to Montgomery County standards. The Concessionaire may utilize leased lighting on existing or proposed Utility poles in order to provide required illumination.

Concessionaire's electrical design for lighting along Montgomery County roadways shall meet the following requirements:

- provide Utility Owner approved splice boxes and conduit from the proposed lighting pole to the nearest Utility Owner power source;
- provide two (2) 1-Conductor No. 10 AWG, THWN Copper electrical cables in each pole to the nearest splice box (approved by Utility Owner); and
- coordinate with the Utility Owner to energize all lighting.

The following Montgomery County maintained roadways, including intersections, shall be illuminated to the following illuminance levels:

- Bonifant Street from Ramsey Avenue to Fenton Street;
    - 1.2 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio
- Wayne Avenue from Fenton Street to the Plymouth tunnel; and
    - 1.7 fc min. avg.
    - 3:1 min. uniformity ratio (avg./min.)
    - 0.3 max. veiling luminance ratio
- Arliss Street from Flower Avenue to Piney Branch Road (MD 320).
    - 1.2 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio

5.9.3 Prince George's County Lighting Requirements

All Prince George's County roadways impacted by the Project including intersections shall be continuously illuminated according to County requirements. Proposed pole and luminaire style shall be submitted to Prince George's County for Review and Approval prior to conducting photometric calculations. All roadway lighting along Prince George's County roadways will be constructed and maintained by the Utility Owner.

The design for Prince George's County roadway lighting shall include a street lighting schedule for existing and proposed poles listing pole number, station and offset, luminaire wattage, pole height and material and bracket arm length. All luminaires utilized for roadway lighting shall be full cutoff LED. Poles shall meet minimum clearance requirements from Utilities according to Prince George's County standards. The Concessionaire may utilize leased lighting on existing or proposed poles in order to provide required illumination.

The electrical design including conduit and wiring for lighting along Prince George's County roadways will be performed by the Utility Owner.

Where the minimum 'K' values on vertical alignment are substandard, existing street lighting shall be evaluated and if necessary upgraded or installed to provide the required nighttime sight distance.

The following Prince George's County maintained roadways including intersections shall be illuminated to the following illuminance levels:

- Campus Drive from Adelphi Road to Presidential Drive;
    - 1.2 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio
- Paint Branch Parkway from Rossborough Lane to River Road;
    - 0.6 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)

    - 0.4 max. veiling luminance ratio
- River Road from 1300 feet west of Rivertech Court to Kenilworth Avenue; and
    - 0.6 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio
- Ellin Road from Veterans Parkway to Harkins Road.
    - 0.6 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio

5.9.4 Town of Riverdale Park Lighting Requirements

All Town of Riverdale Park roadways impacted by the Project including intersections shall be continuously illuminated according to County requirements. Proposed pole and luminaire style shall be submitted to Town of Riverdale Park for Review and Approval prior to conducting photometric calculations. All roadway lighting along Town of Riverdale Park roadways will be constructed and maintained by the Utility Owner.

The design for Town of Riverdale Park roadway lighting shall include a street lighting schedule for existing and proposed poles listing pole number, station and offset, luminaire wattage, pole height and material and bracket arm length. All luminaires utilized for roadway lighting shall be full cutoff LED. Poles shall meet minimum clearance requirements from Utilities according to Prince George's County standards. The Concessionaire may utilize leased lighting on existing or proposed poles in order to provide required illumination.

The electrical design including conduit and wiring for lighting along Town of Riverdale Park roadways will be performed by the Utility Owner.

The following Town of Riverdale Park roadways including intersections shall be illuminated to the following illuminance levels:

- Quesada Road at Kenilworth Avenue.
    - 0.6 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio
- Quintana Street at Kenilworth Avenue.
    - 0.6 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio
- Patterson Street at Kenilworth Avenue.
    - 0.6 fc min. avg.
    - 4:1 min. uniformity ratio (avg./min.)
    - 0.4 max. veiling luminance ratio

5.9.5 Maryland State Highway Administration Lighting Requirements

Lighting along Maryland State Highway (MDSHA) maintained roadways shall be designed according to the current MDSHA Lighting Guidelines and Traffic Control Devices Design Manual. Light loss factor shall be 0.64.Continuous roadway lighting is not required along MDSHA roadways, with the exception of along MD 193 on which continuous lighting shall be maintained. All intersections of MDSHA roadways impacted by the Project shall be illuminated. Existing leased lighting impacted by the Project shall be replaced in appropriate locations to maintain uniform lighting levels. All proposed lighting shall be LED and in accordance with AHJ.

Lighting along MDSHA roadways shall be constructed in accordance with the MDSHA Book of Standards for Highway and Incidental Structures, MDSHA Standard Specifications for Construction and Materials, and MDSHA Supplemental Specifications and Provisions.

5.9.6 University of Maryland Lighting Requirements

All University of Maryland (UMD) roadways impacted by the Project including intersections shall be continuously illuminated. All lighting shall be designed and constructed according to the UMD 2012 Design Criteria / Facility Standards Manual unless otherwise modified below.

- The following illuminance levels must be maintained along UMD roadways:
  - 0.3 min. horizontal fc at grade
  - 4.0 max. horizontal fc at grade
  - 0.2 min. vertical fc at 4’0” above grade
- All lighting fixtures shall be Luminis W614 Series Eclipse Full Cut-Off 100-Watt Metal Halide with 15,000 hours of lamp life. All fixtures shall be mounted to Luminis W614 Series Eclipse 14’ poles spaced at 45’ to 60’.

The following UMD maintained roadways including intersections shall be illuminated:

- Presidential Drive from Campus Drive to Union Drive;
- Union Drive from Presidential Drive to Campus Drive;
- Campus Drive from Union Drive to Regents Drive; and
- Rossborough Lane from 350 feet west of US 1 to Paint Branch Parkway.

5.9.7 Lighting Plans

Concessionaire shall prepare Lighting Plans formatted in accordance with the requirements of the AHJ. Voltage drop calculations shall also be provided. Concessionaire shall submit Lighting Plans for Review and Comment at Preliminary, Intermediate and Final Design.

5.10 Intelligent Transportation Systems (ITS) Design

The ITS system shall consist of the required devices, equipment, apertures, cameras, cabling, conduit, cabinets and Project elements to provide integrated and compatible components to allow for a complete tie into video feed and communications within a framework consistent with Concessionaire’s Concept of Operations Plan for Owner, AHJ, and pursuant to the Third Party Agreement Requirements.

Exhibit 5.4 provides the existing and proposed transportation CCTV locations for the Project. Locations as defined in Exhibit 5.4 shall be considered the minimum configuration.

Exhibit 5.4 – CCTV Locations

Existing CCTV Locations to be replaced by Concessionaire					
County	**Camera**	**Route Number**	**Route Name**	**Intersecting Route Number**	**Intersection Route Name**
MO	182	US 29	Georgia Avenue		Bonifant Street
MO	157		Fenton Street		Wayne Avenue
MO	111	MD 193	University Blvd	MD 320	Piney Branch Road
PG	PGXX		Paint Branch Pkwy		UMFR
New CCTV Locations to be provided by Concessionaire					
County	**Camera**	**Route Number**	**Route Name**	**Intersecting Route Number**	**Intersection Route Name**
MO	1P		Wayne Avenue		Cedar Drive
MO	2P		Wayne Avenue		Dale Drive
MO	3P		Wayne Avenue		Sligo Creek Pkwy
MO	4P	MD 193	University Blvd		Carroll Avenue
PG	5P	MD 193	University Blvd	MD 650	New Hampshire Avenue
PG	6P	MD 193	University Blvd		Riggs Road
PG	7P	MD 193	University Blvd		Adelphi Road
PG	8P		Paint Branch Pkwy		Rossborough Lane
PG	9P	MD 201	Kenilworth Avenue		River Road
PG	10P	MD 201	Kenilworth Avenue	MD 410	East – West Highway
PG	11P	MD 295	BWI Pkwy	MD 410	Riverdale Road (2 Locations)
PG	12P	MD 410	Veterans Pkwy	MD 450	Annapolis Road
PG	13P	MD 410	Veterans Pkwy		Ellin Road

Concessionaire shall provide a communication system to connect all provided traffic signal controllers and traffic CCTV cameras with the applicable AHJ Traffic Management Center. The design shall be completed by the Concessionaire in accordance with the Concessionaire's Concept of Operations, including all comments on the Concept of Operations provided by the AHJ's. The communications system shall be in accordance with guidelines and standards of each AHJ. The AHJ will be responsible for all associated changes to the traffic network central servers, workstations and network switches.

The communications system will be fully compatible with the Train-to-wayside communications System.

5.10.1 Traffic CCTV System

Concessionaire shall provide complete traffic CCTV systems. This includes but is not limited to all wiring, conduit, cabling, system controls, control boxes, junction boxes, software, housings, brackets, and mounting hardware for 360 PTZ (pan, tilt, zoom) operations. All equipment shall conform to guidelines and standards of the AHJ.

5.10.2 Communications System

Concessionaire shall provide complete fiber optic and/or AHJ compatible communication interface and network connections for the traffic CCTV system and all traffic signal controllers.

Communications shall be provided from each traffic CCTV or traffic controller location to each respective AHJ traffic system network and, through those networks, to each respective AHJ Traffic Management Center and the Operations Control Center (OCC) and Backup Operations Control Center (BOCC). Connection to the OCC and BOCC may be through the MDOT CIB, via the internet and CCTV web servers at the AHJ Traffic Management Centers or by any other means proposed by Concessionaire and accepted by the AHJs.

The communications linkage shall also be able to transmit Priority and Preemption request generator signals to traffic signal controllers. The Communications System shall be fully compatible with the Train-to-wayside communications System in terms of communications protocols and data transferred.

The communications system shall be inclusive of all current and proposed data transfer elements and protocols as defined by Concessionaire's Concept of Operations. Phased integration of future elements of the data transfer elements and communications protocols shall be Concessionaire's responsibility.

5.10.3 ITS Integration and Testing

The complete ITS, data transfer and communications system shall be supported by a complete integration and testing program. The program shall be defined by Concessionaire's Concept of Operations. Specific elements of all ITS Integration and Testing shall be submitted for Review and Comment. All support information and documentation for the integration and testing program shall be included in the ITS Integration and Testing program.

5.10.4 Non-Fiber Optic Cable and Fiber Optic Cable Splicing and Testing Plan

Concessionaire shall provide a complete testing program for all communications (non-fiber and fiber optic) cable and splices. The testing program shall be in conformance for each specific cable type and for the use of the cable as prescribed (functionality for the system). Concessionaire shall provide a complete Non-Fiber Optic Cable, Fiber Optic Cable and Splicing Testing Plan for Review and Comment.

5.10.5 ITS Plans

Concessionaire shall prepare ITS Plans formatted in accordance with the requirements of the AHJ. Concessionaire shall submit ITS Plans for Review and Comment at Intermediate and Final Design.

5.11 Materials and Equipment Requirements

5.11.1 Pavement Marking Materials

Concessionaire shall use permanent pavement marking materials listed on the MDSHA's List of Qualified Permanent Pavement Markings or Concessionaire shall seek approval for alternate materials through the Maryland Product Evaluation List (MPEL) program.

All durable markings shall demonstrate wet retro-reflective properties when tested in accordance with ASTM #E 2177-01 (Test Method for Measuring the Coefficient of Retro-reflected Luminance of Pavement Markings in a Standard Condition of Wetness).

Whenever paint is listed as an application, the 50/50 blend of large and standard glass beads is required.

5.11.2 Signing Materials

Sheet aluminum signs shall be one continuous piece mounted on wood supports or square perforated tubular steel posts. Signs over 32 square feet shall be installed on steel supports, and shall be constructed of extruded aluminum material.

All new signs for the Project shall be constructed with non-reflective (black copy and background) or retro-reflective (all other colors) sheeting background and copy.

All wide flange steel I-beam sign supports shall be fabricated of ASTM A709 grade 36 or 50 steel. All square steel posts shall be fabricated of ASTM A500 grade B structural tubing.

5.11.3 Traffic Signal Materials and Equipment

Concessionaire shall use the following materials for installing traffic signals on the Project:

- video detection systems for vehicle detection and sampling;
- non-invasive detection (video preferred) for advanced detection;
- light-emitting diode (LED) traffic signal heads and LED CPS heads;
- APS pushbutton stations and all necessary signs;
- schedule 80 rigid PVC conduit for all underground locations;
- galvanized rigid steel conduit for all above ground or exposed locations;
- where conduits are carried on aerial structures and bridges fiberglass reinforced epoxy (FRE) conduits may be used. The use of FRE conduits on bridges shall be approved by the AHJ; and
- each traffic signal controller shall be connected to the appropriate fiber network with a minimum 12 strand, single mode, self-supporting, gel-free fiber cable conforming to ITU G.652.D.

All traffic signal materials and equipment shall be approved by the AHJ.

5.11.4 Lighting Materials

Electrical manholes shall be constructed of concrete.

Underground lighting conduits shall be constructed of Schedule 80 rigid PVC. Exposed lighting conduit shall be constructed of galvanized rigid steel. Where conduits are carried on aerial structures and bridges fiberglass reinforced epoxy (FRE) conduits may be used. The use of FRE conduits on bridges shall be approved by the AHJ.

All lighting materials shall be approved by the AHJ.

5.12 Construction Requirements

5.12.1 Signing Construction

Concessionaire shall install all new signs prior to Project need and cover until operationally required.

Concessionaire shall cover new and applicable existing signs until they are operationally required. If required for maintenance of traffic or other issue, Concessionaire shall submit signs needed outside of these requirements under the Traffic Management Plan, Concessionaire is preparing for the Project. Permanent signs used outside of these time specifications shall be submitted and noted within the Traffic Management Plan as permanent signs.

5.12.2 Traffic Signal, ITS and other TCD Construction

Concessionaire shall be responsible for the construction of all traffic signals, TCDs and for relocation of any existing AHJ fiber optic cable or other communications cable impacted by construction. Proposed traffic signalization and TCDs shown on the 2040 Build Conditions Wiring Diagrams provided in Book 5 Engineering Data shall be considered the minimum configuration. Concessionaire shall coordinate with the appropriate agency to facilitate the relocation of existing interconnect and fiber optic cables and equipment. All proposed splices shall occur in existing or proposed splice cabinets or traffic signal cabinets and shall be tested. If a section of interconnect run is not long enough to be relocated, the entire section of cable shall be replaced.

5.12.3 Lighting Construction

Electrical manholes shall not be installed in drainage ditches. All electrical manholes shall be installed with underdrain as shown in MDSHA Standard No. MD 811.04. The stone surrounding these structures shall not be considered a suitable outfall. Manholes shall be installed with concrete collars per MD 811.04.

Concessionaire shall install on breakaway transformer bases all light poles that are not protected by traffic barrier and are in the clear zone as defined in the AASHTO Roadside Design Guide. Light poles shall not be installed in front of traffic barrier or in drainage ditches.

Concessionaire shall maintain all new and existing lighting within the limits of work and throughout the Project construction area until the AHJ has accepted the work and accepted maintenance responsibility. Lighting shall not be interrupted for greater than 24 hours.

Where temporary lighting is needed to maintain IES minimum light levels Concessionaire shall install and maintain temporary lighting. Temporary overhead electrical service is acceptable for non-breakaway poles. Concessionaire shall remove temporary lighting when no longer needed. Concessionaire shall be responsible for the electrical costs of any and all temporary lighting that may be required and it is Concessionaire's responsibility to schedule all connections.

5.12.4 Electrical Service Requirements

Electrical services at all traffic signal locations shall be to the standards of the utility provider and AHJ. The minimum service shall be 100A 120/240V single-phase metered service pedestals. The metered service pedestal shall be located in the same intersection quadrant as the traffic signal cabinet and in proximity to the cabinet. Concessionaire shall install conduit between the metered service pedestal and the nearest hand box for intersection lighting. Metered service pedestals shall only be used to service traffic signal equipment and related intersection lighting. The current party responsible for any existing metered service that needs to be upgraded or replaced will continue to be responsible for all on-going electric costs after the Project is complete.

Lighting systems owned by different jurisdictions shall have separate power sources derived from the Utility Owner.

For new electrical services, no transformers shall be installed on the load side of power company meters servicing MDSHA devices.

5.12.5 Signing Database

Concessionaire shall inventory all signs installed under this Project. The inventory shall include, as required by the Owner or Third Party maintaining the sign, the sign size, support type, GPS location of the sign, sign position (left, right, ramp left, ramp right, overhead), pictures of the sign, and retro-reflectometer readings for each sign.

Digital pictures shall be taken and recorded of the front, back, and side of each sign. Concessionaire shall be responsible for inputting the field-inventoried information into a Microsoft Excel spreadsheet. Concessionaire shall obtain the latest template from Owner or Third Party maintaining the sign. Concessionaire shall be responsible for providing all signing plan sheets, accepted shop drawings, accepted source of supply, accepted catalog cuts and all manufacturer supplied parts lists, warranties and maintenance or operation manuals in .pdf format to the Owner or Third Party.

Concessionaire shall submit the Signing Database for Review and Comment prior to Final Acceptance.

5.12.6 Ramp Advisory Speed Study

Concessionaire shall provide an engineering study to establish the ramp advisory speeds for new and modified ramps in accordance with the requirements of the Annotated Code of Maryland, TR Section 21-801 thru 21-804, as specified in MD MUTCD, and the procedures provided in the Institute of Transportation Engineers, *Traffic Engineering Handbook*.

Concessionaire shall submit the Ramp Advisory Speed Study for Review and Comment prior to Final Acceptance.

5.12.7 Regulatory Signing Study

Concessionaire shall provide an engineering study to the Owner that documents all regulatory signing (such as speed limits and truck restrictions) installed as part of the Project. The study shall include a detailed discussion of applicable warrants in support of all regulatory signs installed under this Project. The study shall note the changes in existing roadway alignment as a result of the Purple Line System, and the resulting effects, if any, on the regulatory speeds along any sections of affected roadways in the LOD. The study shall also address the relation between vehicular and LRV speeds in mixed-traffic and semi-exclusive alignments.

Concessionaire shall submit the Regulatory Signing Study for Review and Comment prior to Final Acceptance.

5.13 Summary of Submittals

Item	Section	Submittal	Action
1	5.3.1	Traffic Operations System Concept of Operations Report – Preliminary	Review and Comment
2	5.3.1	Traffic Operations System Concept of Operations Report – Final	Review and Comment
3	5.3.1	Traffic Operations System Concept of Operations Report – Trial Running	Review and Comment
4	5.4.2	Preliminary Traffic Operations and Engineering Design Analysis Report – Preliminary Design	Review and Approval
5	5.4.3	Final Traffic Operations and Engineering Design Analysis Report – Intermediate Design	Review and Approval
6	5.5	Traffic Control Device Design Request Forms – Final Design	Review and Approval
7	5.7.3	Signing and Pavement Marking Plans – Intermediate Design	Review and Comment

Item	Section	Submittal	Action
8	5.7.3	Signing and Pavement Marking Plans – Final Design	Review and Comment
9	5.8.7	Traffic Signal Plans– Intermediate Design	Review and Comment
10	5.8.7	Traffic Signal Plans – Final Design	Review and Approval
11	5.9.4	Lighting Plans – Preliminary Design	Review and Comment
12	5.9.5	Lighting Plans –Intermediate Design	Review and Comment
13	5.9.5	Lighting Plans – Final Design	Review and Comment
14	5.10.4	ITS Plans – Intermediate Design	Review and Comment
15	5.10.4	ITS Plans – Final Design	Review and Comment
16	5.12.5	Signing Database	Review and Comment
17	5.12.6	Ramp Advisory Speed Study	Review and Comment
18	5.12.8	Regulatory Signing Study	Review and Comment

6 UTILITIES

This Section defines the responsibilities of Concessionaire with respect to Utilities, including the activities of the Contractors and Suppliers, to achieve an end product conforming to the Contract Documents and Owner Utility Agreements.

6.1 Overview

Except as otherwise specified by the Owner Utility Agreements, Concessionaire shall perform all Utility Work necessary for the Project including at a minimum protection, adjustment or relocation due to:

- a physical conflict between the Utility and the Project, including its construction, operation and maintenance, and maintenance of Utility by Utility Owner; and
- an incompatibility between the Utility and the Project based on the requirements of the Owner, Utility Owner, or Third Party.

Utilities shall be designed and constructed to meet the requirements (including referenced standards and specifications, if any) of the Utility Owner, Utility Owner Agreements, Third Party Agreement Requirements, and the Contract Documents.

Replacements of existing Utilities shall be designed and constructed to provide service at least equal to that offered by the existing facilities (unless Utility Owner specifies a lesser replacement), but shall not include any Betterments except as approved by Owner and as set forth in Section 7.6.6 of the Agreement. Utility Owners may request Owner to permit Concessionaire to perform work relating to Betterments, at Utility Owner's expense. If Owner approves any such request, then Concessionaire shall perform such Betterment work. Upon execution of an agreement by the Utility Owner, Owner and Concessionaire regarding such Betterment, such Betterment shall be added to the Work and shall be subject to the same standards and requirements that apply to other utility adjustments. Section 7.6.6 of the Agreement includes Concessionaire's right to additional compensation for any Betterment added to the Work, and sets forth certain additional provisions related to Betterments. Concessionaire shall provide all coordination, including all definitive cost estimates and billing information, required to address requested Betterments. Unless specifically authorized in the approved Utility Owner Agreement, Concessioniare shall not request or accept payment directly from Utility Owner for any Betterment added to the Work.

6.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American Railway Engineering and Maintenance-of-Way Association (AREMA), Manual for Railway Engineering Criteria;
- ASCE 38-02, Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data;
- IAEI SOARES Book on Grounding;
- Maryland High Voltage Line Act;
- MDSHA, Utility Policy Manual;
- MDSHA, Standard Specifications for Construction and Materials; and
- National Electrical Manufacturers Association (NEMA), Standard TC-10.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

6.3 Design Requirements

6.3.1 Utility Loading

All Utilities within the Project ROW shall be analyzed and/or designed to support all dead and live loads, including, at a minimum, that imposed by earth, sub-base, ballast, pavement, track, structures, and vehicles when the Utility is operating under internal pressure ranges varying from zero to maximum.

6.3.2 Utility Clearances

Utility clearances shall be as specified in the Codes and Standards, the requirements of the Utility, Third Party Agreement Requirements, Owner Utility Agreements and the requirements below. In the case of a conflict the most stringent criteria will govern.

Minimum horizontal clearances from transit tracks, measured in the horizontal plane and from the nearest outside edge of the Utility or Utility casing:

- For water mains longitudinal to the tracks, regardless of trackform, the minimum horizontal clearance is 10 feet from the centerline of the adjacent track;
- for ballasted track, the minimum horizontal clearance for all other underground Utilities longitudinal to the tracks is 10 feet from the centerline of the adjacent track;
- for embedded track, the minimum horizontal clearance for all other underground Utilities longitudinal to the tracks is 7 feet from the centerline of the adjacent track;
- for new or existing manholes, roadway boxes, meter vaults, and any other surface features which may require future entry or access (excluding inlets and drainage grates), the minimum horizontal clearance distance from the nearest edge of cover to the centerline of track shall be 10 feet from the centerline of track or one (1) foot beyond the dynamic envelope of the LRV, whichever is greater.

Minimum vertical clearances from transit tracks, measured in the vertical plane, and from the nearest outside edge of the Utility or Utility casing:

- the minimum vertical clearance for existing communications and power utilities to remain in place shall be 2’6” below bottom of rail;
- The minimum vertical clearance for all other existing utilities to remain in place shall be 4 feet below bottom of rail;
- the minimum vertical clearance for relocated and new utilities shall be 5’6” below bottom of rail;

For horizontal and vertical clearances between Utilities, measured in the horizontal or vertical plane, as applicable, and between the nearest outside edges of the Utilities or Utility casings:

- minimum horizontal clearance shall be 5 feet, except 10 feet between water mains and sanitary sewers;
- minimum vertical clearance shall be one (1) foot and sanitary sewers shall be below water mains; and

- minimum horizontal and vertical clearance from overhead electrical Utility lines shall be 10 feet from other Utilities and structures.

Existing Utilities to remain in place shall meet all horizontal, vertical and clearance between Utility requirements.

6.3.3 Utility Encasement

Encasement pipes shall be provided for new and relocated pipelines carrying oil, gas, petroleum products, or other flammable or volatile substances, or steam, water, or other nonflammable substances under pressure in accordance with the following:

- encasements shall be provided based on AREMA, Part 5, Chapter 1; however, the length of casing pipe required shall vary. At a minimum, the casing pipe shall extend 10 feet beyond the centerline of the track or 1 foot beyond the LRV dynamic envelope, whichever is greater;
- ferrous metal casing pipes shall be protectively coated against corrosion and have suitable cathodic protection and corrosion monitoring features; and
- encasement pipes shall be of a suitable diameter and length to permit removal and replacement of the carrier pipe without impacting transit operations.

With the exception of the requirements of Part 2B, Section 6.3.6 of the Technical Provisions, new or relocated electric and telephone conduits, ductbanks, gravity sewers and storm drains crossing beneath transit tracks shall not require encasement provided that the strength of the Utility line is capable of withstanding the transit system loading.

6.3.4 Concessionaire Utility Design Plans

Concessionaire shall submit Concessionaire Furnished Utility Design Plans for Review and Comment at Preliminary and Final Design.

6.3.5 Utility Owner Design Plans

For all Utility Relocation Plans to be furnished by a Utility Owner, Concessionaire shall coordinate the Utility Adjustments with the Utility Owner as well as with other elements of the Project, including other Utility Work. Concessionaire shall submit Utility Owner Design Plans for Review and Comment at Preliminary and Final Design.

6.3.6 WSSC Specific Requirements

Concessionaire shall perform a post-construction, pre-revenue service CCTV inspection of all existing sewer lines not relocated and that cross beneath or run lateral to the Guideway. For existing sewer lines running lateral to the Guideway the Concessionaire shall perform the CCTV inspection for those located no more than 10 feet from the centerline of the adjacent track, measured form the closest edge of the utility. For existing sewer lines crossing the Guideway the CCTV inspection shall be performed from manhole to manhole within the Project LOD.

For all WSSC relocations required by the Project Concessionaire shall, in addition to the WSSC Technical Requirements, comply with the 2015 Revisions to the WSSC 2008 Pipeline Design Manual with the exception of Sketch “UU” and Sketch “VV” as well as any references to said sketches therein. Clearance requirements for relocated WSSC water mains and gravity sewers shall be in accordance with Part 2B, Section 6.3.2 of the Technical Provisions. Relocated WSSC water mains and gravity sewers shall be encased in accordance with Part 2B, Section 6.3.3 of the Technical Provisions.

6.4 Material and Equipment Requirements

Concessionaire shall be responsible for ensuring that any materials supplied by the Utility to Concessionaire comply with, or a waiver has been obtained for, Section 165 of the Surface Transportation Assistance Act of 1982 as amended by Section 1041(a) and 1048(a) of the Intermodal Surface Transportation Efficiency Act of 1991 with regard to the furnishing and coating of iron and steel products as well as the use of domestically produced manufactured goods including related regulations and guidance issued by FTA.

6.5 Construction Requirements

6.5.1 General Requirements

Concessionaire shall permit, furnish, install, inspect and coordinate the construction of the Utility facility in accordance with requirements of the Contract Documents.

Concessionaire shall be responsible for any interruptions of service including coordinating all Utility service interruptions with the appropriate Utility and be responsible for ensuring that such interruptions are minimized. Concessionaire shall be responsible for notification of affected Utility customers of such shutdowns, and provide temporary service if the interruptions surpass Utility timeframes.

Concessionaire shall ensure that Utility Work is conducted in accordance with all the relevant requirements and all permits.

Concessionaire shall be responsible for ensuring the abandonment or removal of Utilities within the Project ROW.

Concessionaire shall be the responsible party to the Owner for timely performance of all Utility Work according to the Project Schedule.

Concessionaire shall prepare estimates and invoices, maintain the necessary records, and provide supporting documentation as may be requested for Owner to receive cost reimbursement from Utilities in accordance with the terms of Owner Utility Agreements.

6.5.2 Utility Service Connections

Concessionaire shall be responsible for maintaining all existing service connections and for providing new service connections as may be required for temporary or permanent aspects of the Project.

Prior to establishing the location for new Utility service connections, Concessionaire shall coordinate with the Utility concerning accessibility of the service connection, safety and maintenance of the service connection.

Concessionaire shall be responsible for all coordination activities with other elements of the Project and as required by the Utility to provide Utility service connections.

Concessionaire shall submit Utility Service Connection Plans for Information prior to commencing Utility Work.

6.6 Summary of Submittals

Item	Section	Submittal	Action
1	6.3.4	Concessionaire Furnished Utility Design Plans – Preliminary	Review and Comment
2	6.3.4	Concessionaire Furnished Utility Design Plans – Final	Review and Comment
3	6.3.5	Utility Owner Design Plans - Preliminary	Review and Comment
4	6.3.5	Utility Owner Design Plans - Final	Review and Comment
5	6.5.2	Utility Service Connection Plans	Information

7 OPERATIONS AND MAINTENANCE FACILITIES

This Section includes the general design and construction requirements for the operational and maintenance facilities, site work, storage yard, and the shop buildings. Each of these components is further defined with detailed requirements for each component.

7.1 Functional Requirements

This Section of the Technical Provisions does not include a space requirements program. Development of space requirements program, including design, equipment, and furnishings, shall be provided by Concessionaire as part of the basis of design report. Careful consideration shall be given to how the activities that are planned for both facilities fit into the overall Project. Concessionaire shall design, construct, and Commission the Operations and Maintenance Facilities (OMF) such that they are sized to accommodate the capabilities, functions, equipment, and personnel necessary for the O&M Work for the duration of the Term.

All facilities shall accommodate operations and maintenance functions 24 hours per day, 7 days per week.

Concessionaire shall design the operations and maintenance buildings and equipment for the following minimum design life:

- building structure, superstructure and foundations: 70 years;
- building exterior roof and walls: 50 years;
- building HVAC, Fire Protection, and Plumbing: 25 years;
- building electrical systems:
  - power 70 years; and
  - lighting: 35 years.
- major fleet maintenance equipment: 40 years.

7.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- Maryland State Fire Prevention Code (NFPA 1 and NFPA 101);
- Maryland Building Performance Standards (IBC, as modified); and
- Applicable OSHA and MOSH requirements.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

7.3 Design Requirements

7.3.1 Design Submittals

Concessionaire shall prepare, at a minimum, the following Submittals:

- OMF Basis of Design Report documenting the decision-making process and assumptions for all operational and maintenance features which will be incorporated into operations and maintenance buildings and sites. The BODR shall include a list of Critical design requirements. Concessionaire shall submit the OMF Basis of Design Report for Review and Comment prior to Preliminary Design;

- OMF Concept of Operations Report identifying all operations and maintenance functions which will be performed at each operations and maintenance facility, the number of personnel, equipment requirements, and space requirements needed to support each function in each building and throughout each site. Locations shall be identified for storage of rail-mounted equipment, outside bulk materials storage, hazardous materials storage, employee and visitor parking, security, work bay for maintaining Maintenance of Way (MOW) equipment, motor vehicle fueling, landscaping, signage, yard Traction Power, signal cases and bungalows. Concessionaire shall submit the OMF Concept of Operations Report for Review and Comment at Preliminary Design, Intermediate Design and Final Design; and
- OMF Site Plans showing buildings, trackwork, site layout, architecture, landscape, and all other aspects of the OMF Sites. The drawings and plans shall indicate that features are provided for storage capacity, efficiency of access to and from mainline, make up and break up of Train consists, daily service lane (cleaning and sanding), low speed Train testing, LRV loading and unloading, and efficient access to shop building. Building plans shall provide location and space requirements for each function to be performed within each building. Building layouts shall show locations of running maintenance, daily inspection, minor repairs, cleaning both interior and exterior, inspection pits, roof access platforms, shop Traction Power, heavy repair, heavy component change out, major repairs and overhaul, car hoists, overhead cranes, preventive and corrective maintenance, scheduled inspection, car wash, wheel truing, truck and wheel repair, body repair and painting, under steam cleaning, support shops, electronic testing and repair, screen room for communications, store room, tool room, loading dock, roof top repair OCC, BOCC, Security Center, management administrative and Owner offices, training rooms, lunch/break rooms, restroom and locker rooms. Concessionaire shall submit the OMF Site Plans for Review and Comment at Preliminary Design, Intermediate Design and Final Design.

7.3.2 Site Restrictions

If any building is constructed at the Glenridge site along Veterans Parkway, the building shall be oriented to front Veterans Parkway. Portions of buildings visible from Veteran's Parkway shall be clad in brick masonry, architectural precast concrete, or architectural metal panels.

7.3.3 Parking Facilities at Lyttonsville Site

Concessionaire shall coordinate with Montgomery County to ensure that a minimum of 200 parking spaces are available for exclusive use by Montgomery County for the duration of the Term. Such parking may be provided by keeping in place existing parking, providing replacement parking, or a combination thereof. At no time during Construction Work shall the number of parking spaces be reduced below the existing number.

7.3.4 Buildings and Parking Structures at Lyttonsville Site

The requirements of this section apply to all building and parking structures constructed at the Lyttonsville site. Portions of such buildings that are visible from Brookville Road or Lyttonsville Place shall comply with the following:

- buildings fronting on Brookville Road or Lyttonsville Place shall incorporate massing with varying roof heights, and/or a combination of flat and pitched roofs. Facades shall be relieved by recessed windows, shoulders, or other changes in plane;
- all facades and sloped portions of roofs shall incorporate cladding with a combination of materials and colors selected from those specified in the List of Finishes in Exhibit 7.1; and
- roof-mounted mechanical equipment shall be screened from view.

Exhibit 7.1 List of Finishes

Façade Element	**Materials and Finishes** (Note 1)
Modular Brick:	Belden Modular Brick; Color Black Diamond Velour
Metal Wall Panels / Horizontal Rib:	Centria Concept Series Concealed Fastener Panels Cs-660; Color #9946 Silversmith
Metal Wall Panel / Vertical Panel; Box Batten Seam Metal Roof Panels:	Centria Architectural Design Panel Adp100b; #181 Slate Gray
Architectural Louvers:	Prefinished Metal Louvers; Centria Color #181 Slate Gray
Prefinished Metal Coping, Gutters and Trim:	Centria Color #9946 Silversmith / Centria Color #181 Slate Gray
Glazing:	PPG Ideascapes Solarban 60 Glass; Color Solargray

Note 1: Manufacturers and products are specified as the basis of design; Concessionaire may provide equivalent products and matching colors.

7.3.5 Storage Yards

Yard storage and maintenance facilities shall be designed to be expanded to have the capacity to store initial and ultimate LRV fleet (operating Service Level 3) with capacity to enable all LRV movements in an efficient and timely manner. In general, the storage yards shall accommodate transfer of LRVs between the mainline, storage, service, and testing areas. Concessionaire shall determine the layout and functionality required for the storage yard to support the Project. At a minimum, Concessionaire shall incorporate the following:

- storage yard(s) shall be constructed to accommodate Service Level 1 plus one peak period Train with allocation of the LRV fleet divided between the maintenance and storage facility sites;
- space shall be provided for low speed Train testing resulting from maintenance activities and daily departure tests; and
- LRV movements from the storage tracks to the shop tracks shall be designed such that there is no inference with trains departing or arriving from the mainline.

7.3.6 Operations and Maintenance Buildings

Concessionaire shall size the buildings to accommodate all LRV maintenance activities, including all shop based maintenance activities, systems equipment, trackwork, facilities maintenance, OCC, unloading and storage of material and supplies, materials storage, and sufficient number of rooms for Concessionaire and Owner administrative functions. Concessionaire shall fit out building to handle the Service Level 1 fleet plus one peak period Train. Concessionaire shall provide sufficient Utilities to support the shop and operations areas and functions for the ultimate Service Level 3 fleet.

A minimum of 5 dedicated, lockable office spaces for MTA personnel shall be provided. Office space, furnishings and facilities shall be comparable to that provided for Concessionaire personnel.

7.3.7 Site work

Concessionaire shall design site to include requirements for MOW, outside materials storage, staff and visitor parking, security, motor vehicle fueling station, and other external elements required for the facility.

7.4 Summary of Submittals

Item	Section	Submittal	Action
1	7.3.1	OMF Basis of Design Report	Review and Comment
2	7.3.1	OMF Concept of Operations Report - Preliminary	Review and Comment
3	7.3.1	OMF Concept of Operations Report - Intermediate	Review and Comment
4	7.3.1	OMF Concept of Operations Report - Final	Review and Comment
5	7.3.1	OMF Site Plans - Preliminary	Review and Comment
6	7.3.1	OMF Site Plans - Intermediate	Review and Comment
7	7.3.1	OMF Site Plans - Final	Review and Comment

8 STATION AND GUIDEWAY ARCHITECTURE AND URBAN DESIGN

8.1 Scope

This Section includes requirements for architectural design of passenger Stations, passenger Station site planning and pedestrian access to Stations, urban design in Station areas and along the Project Corridor, static signage & graphics for Stations, and the Art in Transit Program.

8.2 Functional Requirements

8.2.1 General Functional Requirements

Concessionaire shall provide Stations and public facilities that are:

- safe and secure – Facilities design shall minimize risk of injury and property damage for transit Users, staff, and members of the public under both normal and Emergency operating situations. All passenger facilities shall incorporate means of egress and life safety systems in compliance with all applicable regulations. Site and facility designs shall incorporate principles of Crime Prevention through Environmental Design (CPTED);
- accessible – All transit facilities shall be accessible to persons with disabilities and meet the requirements of the U.S. DOT's ADA Standards for Transportation Facilities;
- convenient – Facilities shall encourage transit use by providing a pleasant, comfortable and efficient passenger experience; and
- respectful of the surrounding community – Infrastructure improvements, including passenger Stations, in the Project Corridor shall complement and enhance the urban environment.

8.3 Design Requirements

8.3.1 Station Design Functional Requirements

Concessionaire shall provide Stations that conform to the configurations and functional characteristics defined by the Book 4 Contract Drawings, as modified by Part 2B Sections 8.3.6.7, 8.3.6.8, 8.4.2.5, 8.3.6.5.2, 8.4.2.4, 8.3.7.8.3, and 8.5 of the Technical Provisions and subject to applicable codes and regulations.

8.3.2 Art in Transit Program

Responsibility for implementation of the Art in Transit Program will be allocated between the Owner and Concessionaire as described in the following sections:

8.3.2.1 Art in Transit - Owner Activities

The Owner has prepared a *Purple Line Public Art Master Plan*, which describes public art opportunities by type and location throughout the Project. The Owner will:

- conduct an initial Call to Artists;
- convene an Arts Advisory Committee;
- convene a selection committee to evaluate artist qualifications;
- identify a short list of artists who will be invited to participate in the second stage of competitive selection described in Part 2B, Section 8.3.2.2 of the Technical Provisions; and

- retain primary responsibility for public information and communications with respect to the Art in Transit Program in general accordance with Part 2A, Section 13 of the Technical Provisions.

8.3.2.2 Art in Transit - Concessionaire Requirements

Concessionaire shall manage all implementation of the Art in Transit Program subsequent to those activities described in Section 8.3.2.1. Concessionaire shall:

- provide a Public Art Manager to manage Concessionaire's implementation of the Art in Transit program. The Public Art Manager shall have demonstrated experience in implementation of art in a public setting, including programming and site selection, management of artist selection processes, coordination with architects and engineers, and interface with Project stakeholders and community members;
- based on the Public Art Master Plan, recommend the specific public art projects that will be offered for artist proposals, including their scope, location budget, and implementation process, including identification of the artist(s) who will be invited to submit proposals for each opportunity. Recommendations shall maintain equity and parity in the range, number and cost of projects offered in Montgomery and Prince George's counties. Concessionaire shall submit the Recommended Art in Transit Projects for Review and Approval;
- establish submission requirements and selection procedures that comply with FTA requirements;
- conduct the second stage of competitive selection, inviting the short list of artists selected by Owner for interviews, and/or to submit proposals for specific installation types and/or locations identified in the *Purple Line Public Art Master Plan*, and assemble entries for review by the Selection Committees;
- compensate each shortlisted artist who submits a proposal conforming to the submission requirements in accordance with the Agreement;
- establish up to six selection committees to select artists and match their projects to sites. Concessionaire's Public Arts Manager shall chair all selection committee meetings, and participate as a non-voting member. The committees shall be arranged according to location and comprise the following individuals:
    - six voting members common to all locations;
        - up to two representatives that will be designated by Owner;
        - two representatives of Concessionaire, one of whom shall be the Chief Architect; and
        - two art professionals, with curatorial or art administration experience. Concessionaire shall compensate these individuals for their time and travel expenses;
    - three voting members to vary by location:
        - one representative of Prince George's County Arts Commission, or Montgomery County Art and Humanities; and
        - two community members identified by Owner.
- for each project selected, determine costs eligible to be paid under the Art in Transit Program Allowance and submit Selected Art in Transit Projects for Review and Approval .

Owner will select which projects, if any, will be implemented, and approve eligible costs for each project selected; engage selected artists to become part of the final design team, and implement the art projects, including design, internal and external reviews, fabrication and installation. Concessionaire shall coordinate artwork design, scheduling and approvals with project design and construction activities

- develop and implement an appropriate community engagement strategy for each public art project; and
- support Owner for Art in Transit related public information and communications in general accordance with Part 2A, Section 13 of the Technical Provisions.

8.3.2.3 Art in Transit Program Allowance

Concessionaire shall include an Art in Transit Allowance as required in the Agreement. This allowance shall be used for:

- artist compensation;
- artwork fabrication, transportation and installation costs;
- artist proposal stipends described in Section 8.3.2.2;
- reimbursement of insurance costs incurred by artists during fabrication and installation of artwork; and
- construction cost of elements directly attributable to artwork.

The Art in Transit Allowance shall not be used for:

- base construction costs of facilities and features that would have been provided if the artwork were not there;
- Concessionaire's general conditions;
- Concessionaire's fee;
- Concessionaire's personnel labor; and
- maintenance of artwork after installation. Artworks shall meet standards of durability and longevity that will result in a projected useful life of not less than thirty-five years, assuming normal maintenance.

8.3.3 Urban Design

8.3.3.1 Urban Design Guidelines

Owner requires that transit projects complement the visual and aesthetic characteristics of the communities in which they operate. The *Purple/Red Line Urban Design Guidelines* have been developed to provide guidance to designers and reviewers with regard to urban design characteristics of transit infrastructure.

- Concessionaire's Architecture & Urban Design lead shall read the *Purple/Red Line Urban Design Guidelines*, and incorporate them to the extent practicable; and
- Concessionaire's Basis of Design Report shall definitively state that Concessionaire has read the *Guidelines*, and identify how the proposed design incorporates them to the extent practicable.

8.3.3.2 Ornamental Fencing

Functional requirements for fencing are provided in Part 2B, Section 21 of the Technical Provisions. Where fencing is required in locations visible from public right of way, Concessionaire shall provide ornamental fencing to comply with Part 2B, Section 21.5.2.1 of the Technical Provisions and the following:

- Pedestrian Barrier (B1): Ornamental metal fence; picket and rail construction. Minimum of two rails, each formed of rectangular sections or self-draining “U” channel. 1” square pickets, vertical with straight tops, spacing to resist 4” diameter ball, or closer if required to meet code and/or structural requirements. Square posts with flat caps, set in sleeves. Fence panels and post brackets to be constructed to allow fence to “rack” to follow grade. Provide multi-layer coating with polyester powder coat topcoat. Color: Federal Standard 36134, or as otherwise specified. Structural performance to meet code and operational requirements of application. Height as required under the Contract Drawings and Part 2B, Section 21.5.2.1 of the Technical Provisions.
- Security Fence (B2): Ornamental metal fence; picket and rail construction. Minimum of three rails, each formed of rectangular sections or self-draining “U” channel. 1” square pickets, vertical with straight tops, spacing to resist 4” diameter ball, or closer if required to meet code and/or structural requirements. Square posts with flat caps, set in sleeves. Fence panels and post brackets to be constructed to allow fence to “rack” to follow grade. Provide multi-layer coating with polyester powder coat topcoat. Color: Federal Standard 36134, or as otherwise specified. Structural performance to meet code and operational requirements of application. Height as required under the Contract Drawings and Part 2B, Section 21.5.2.1 of the Technical Provisions.
- TPSS Screening (B3), locations as indicated in the Book 4 Contract Drawings: Ornamental metal screen fence; picket and rail construction. 5” wide steel pickets, mounted on both sides of rails in staggered, shadow box style. Rails, channels and brackets to be high strength steel. Posts to be 4” square high strength steel with flat cap. Fence panels and post brackets to be constructed to allow fence to “rack” to follow grade. Provide multi-layer coating with polyester powder coat topcoat. Color to be selected by Owner from manufacturer’s standard color range. Structural performance to meet code and operational requirements of application. Height to be not less than 8’-0” and/or as required under the Contract Drawings and Part 2B, Section 21.5.2.1 of the Technical Provisions.
- Architectural Welded Wire Fence (B4): Ornamental crimped metal (welded wire) fence; fabricated welded wire mesh panels formed by one vertical wire placed between two horizontal wires. Wires to be resistance welded at each crossing to form rectangles. Grid to be 2” wide x 8” high max. Posts to be square with a flat cap, set in sleeves. Provide multi-layer coating with polyester powder coat topcoat. Color: Federal Standard 36134, or as otherwise specified. Structural performance to meet code and operational requirements of application. Height as required under the Contract Drawings and Part 2B, Section 21.5.2.1 of the Technical Provisions.

8.3.3.3 Stakeholder Coordination

Concessionaire shall coordinate his work with adjacent property owners to minimize adverse impacts with regard to pedestrian and vehicular access, and as follows:

- coordinate the design of the aesthetics of the vents and landscaping adjacent to Elm Street Park, and the design of the trail connection in coordination with the planned upgrade of Elm Street Park with M-NCPPC – Parks and Planning;
- comply with the Book 4 Contract Drawings, and coordinate with the University of Maryland with regard to integration of Purple Line System infrastructure into the campus, including at a minimum Station design at the following Stations:
  - Campus Center; and
  - East Campus.
- landscaping on NPS property shall use native and NPS-approved species.

8.3.4 Station Site Planning

8.3.4.1 Pedestrian Access

8.3.4.1.1 Pedestrian Walkway Dimensions

Pedestrian walkway dimensions shall meet the LOS criteria and conform to the following:

- all walkways shall be at least 5 feet wide;
- no walkway shall have less than 8 feet of vertical clearance;
- pedestrian at-grade track crossings shall be at least 12 feet wide;
- walkways adjacent to parallel parking shall be at least 10 feet wide;
- crosswalks connecting to pedestrian walkways shall be 10 feet wide; and
- pedestrian tunnels shall be at least 16 feet wide.

8.3.4.1.2 Pedestrian Walkway Grade Changes

Level changes shall be minimized along pedestrian walkways. Where possible, Concessionaire shall provide sloped walks instead of ramps or stairs at both the entrances and surface Stations. Where steeper slopes are necessary, provide ADAAG-compliant ramps.

Where site stairs are required, they shall be located adjacent to an accessible route. Stairs shall be the same width as the adjacent walkway width, with slip-resistant tread nosing with a radius edge, and a continuous handrail on both sides, and intermediate handrails where required.

8.3.4.1.3 Pedestrian Walkways at Intersections, Crosswalks, and Medians

Except as specifically indicated on the Book 4 Contract Drawings, light rail transit track crossings serving Station entrances shall be located a maximum of 30 feet from the end of the station Platform. In all cases railings shall be located along the access walks and ramps adjacent to the track alignment to discourage pedestrians from crossing tracks at locations other than designated crossings.

Bicycle routes shall be configured to avoid traversing stairs or escalators. In locations where site stairs are unavoidable, provide bike runnels on each side of the stair. Bike runnels shall not infringe on minimum stair widths.

Pedestrian walkways and crosswalks shall be illuminated.

Crosswalks shall be marked and clearly visible to motorists.

8.3.4.2 Bicycle Storage

Concessionaire shall provide bike racks at locations and in minimum quantities as set forth in the Book 4 Contract Drawings.

Concessionaire shall construct bicycle storage facilities on level, hard, and well-drained surfaces adjacent to one or more Station entrances, and shall site them so as to not impede Station access, pedestrian flow, access to fare vending, or other travel modes.

Bike racks are prohibited on Station Platforms.

Concessionaire shall provide stainless steel bike racks from one of the following manufacturers and models:

- Landscape Forms. Model: “Bola”, embedded mounted;
- Forms + Surfaces. Model: “Summit”; and
- Victor Stanley. Model: “BRWS-101”d.

8.3.4.3 Future Pedestrian Connections

Concessionaire shall configure Lyttonsville Station and the adjacent storage yard to accommodate future construction of grade-separated, ADAAG-compliant pedestrian access to the platform from Brookville Road via the east portion of Plat 24456 to the east end of the boarding platform. The station and yard configuration shall allow such future access to be constructed without modification to track, OCS, ductbank or structures provided by Concessionaire, and without additional property acquisition. Concessionaire shall indicate location of the future crossing on construction plans. Such future construction, if any, would be by others.

8.3.5 Station Operational Requirements

8.3.5.1 Station Control

Concessionaire shall design all Stations such that a Station attendant will not be required. Aerial Stations shall incorporate provisions for Station lock-up during nonoperating hours. Surface Stations will not be secured during non-operating hours.

8.3.5.2 Fare Collection & Control

Concessionaire shall configure light rail Stations to operate on a proof-of-payment fare collection system, and without fare barriers or turnstiles.

Concessionaire shall provide power and data connections as required under Part 2B, Section 19 of the Technical Provisions for self-service ticket vending machines at the locations indicated in Book 4 Contract Drawings for each Station.

8.3.5.3 Restrooms

Stations shall not be equipped with restrooms for general public use except as required by code. Restrooms shall be provided for Concessionaire’s and Owner’s employees at underground and Terminal Stations, and other locations if/as warranted by Concessionaire’s Operating Plan.

8.3.5.4 Advertising

Concessionaire shall not include advertising or provisions for advertising, unless approved in advance by Owner.

8.3.5.5 Break Rooms

Concessionaire may provide break rooms if/as warranted by Concessionaire’s Operating Plan.

8.3.6 Station Architectural Design

8.3.6.1 Elements of Continuity & Variability

Concessionaire shall design Station elements as elements of continuity, elements of variability, and arts opportunities, as defined below:

Elements of system continuity (C) shall be consistent across the Project.

Elements of variability (V) are elements or systems wherein a range of design solutions may be appropriate in response to local conditions.

Arts opportunities (A) indicate elements that may be appropriate for public art. This designation is not intended to preclude arts applications on elements not specifically identified in Exhibit 8.1 and 8.2.

Exhibit 8.1 – Continuity/Variability of System-Wide Procurement Items

Static Signage & Graphics	
Station Identification Signs (Exterior and Interior)	C
System and Station Area Maps	C
Transit Information	C
Wayfinding	C
Regulatory	C
Vertical Transportation	
Elevators	C
Escalators	C
Communications	
Passenger Information Displays	C
Station Control and System Security	C
SCADA	C
Public Address Speakers/Enclosures	C
Emergency Telephones	C
Fare Vending Equipment	
Ticket Vending Machines	C

Exhibit 8.2 – Continuity/Variability of Materials, Building Components, and Fixtures Integral with Station Construction

Exhibit 8.2 – Continuity/Variability of Materials, Building Components, and Fixtures Integral with Station Construction	
Site & Running Ways	
Guideways	V
Landscaping	V/A
Walkways	V/A
Retaining Walls and Portals	V/A
Bollards	C
Handrails/Guardrails	V/A
Seating	C
Local Bus Stop Shelters	C
Trash Receptacles	C
Planters	V/A
Lighting	C/A
Bicycle Racks	V
Bicycle Lockers	C
TPSS Enclosures	V/A
Station	
Entrance Canopy	V
Interior Finishes	V
Platform Paving	V/A
Platform Safety Edge/Tactile Warning Strips	C
Platform Seating	C
Trash Receptacles	C
Canopy & Windscreen Structural Components	C
Canopy & Windscreen Color	V/A
Canopy Glazing	C
Canopy Glazing Interlayer	V/A
Canopy Solid Roof Panel	V
Doors – Hardware	C
Hose Bibbs	C
Lighting Fixtures	C
Stairs	C
Guardrails	V/A

Exhibit 8.2 – Continuity/Variability of Materials, Building Components, and Fixtures Integral with Station Construction	
Electrical Outlets	C
Toilet Rooms - Fixtures, Accessories, Metals	C

8.3.6.2 Overhead Clearance

Concessionaire shall locate any Station element subject to damage, theft, or vandalism (such as lights, signs, and cameras) beyond the normal reach of the average person. Overhead clearances for the Station interior shall be as follows:

- headroom (clear distance from finished floor to any obstruction) shall be 8 feet 6 inches minimum (10 feet preferred);
- headroom at ceilings and structures (general case) shall be 10 feet minimum (12 feet preferred);
- average headroom at sloped ceilings and canopies shall be 10 feet minimum, and no portion of the ceiling or canopy shall be less than 8 feet 6 inches; and
- avoid locating equipment or fixtures near elements that can act as a step (e.g., benches, trash receptacles, etc.).

8.3.6.3 Station Furnishings and Service Connections

Concessionaire shall provide benches and trash and recycling receptacles at each Station as indicated in the Book 4 Contract Drawings. Benches shall be fabricated using durable materials and be configured to discourage individuals from reclining or sleeping. Trash and recycling receptacles shall be configured with translucent or transparent compartments so that dangerous contents are visible.

Concessionaire shall provide water connections or hose bibbs at Stations so any location on the Platform, mezzanine, or entrance can be reached by a 100-foot-long hose. Concessionaire shall provide 120 V AC receptacles so that any location on the Platforms, mezzanines, or entrances can be reached by a 100-foot-long cord.

Public telephones are not required in passenger facilities.

8.3.6.4 Integration of Infrastructure

Concessionaire shall visually integrate mechanical, electrical, and communications equipment and infrastructure into the architectural design of the Station.

All ductwork, conduit, and piping shall be concealed from public view. In public areas, they shall be fully concealed inside structural members or behind cladding.

Equipment, housings, and trim exposed to public view shall be integrated with Station finishes.

Concessionaire shall center light poles and OCS poles at Stations on control joints as indicated in the Book 4 Contract Drawings.

Concessionaire shall mount signs, lighting, speakers, cameras and other systems elements shall be mounted on utility modules or in other locations where so indicated in the configurations shown in the Book 4 Contract Drawings.

8.3.6.5 Boarding Platforms

Boarding Platforms shall conform to the following design requirements:

8.3.6.5.1 Vehicle Interface

Concessionaire shall configure boarding Platforms for level boarding with an ADAAG-compliant gap between vehicle and Platform.

8.3.6.5.2 Boarding Platform Dimensions

- length – Concessionaire shall design Platforms to not less than 200’ in length available for boarding and alighting. Concessionaire may construct Platforms to the length required for boarding and alighting from all doors of the maximum length Train at Service Level 3 and meeting the LOS requirements of Part 2B, Section 8.3.7 of the Technical Provisions, provided that Concessionaire shall not preclude future extension of the Platforms to the full 200’ length. At grade-separated stations, Concessionaire shall in all cases construct VCE in the quantities and locations shown in the Contract Drawings, regardless of reduced platform length.
- width – Concessionaire shall establish Platform widths based on patronage, egress requirements, the configuration of Vertical Circulation Elements (VCE), and Station site considerations. Platform widths indicated on the Book 4 Contract Drawings shall be considered minimums. Space needs shall be determined by LOS requirements, which for Platforms, is LOS C; and
- Platform obstructions –Concessionaire shall configure Platforms as follows:
- for Platforms with VCE the clear distance from the Platform edge to any VCE, or any other object that obstructs pedestrian circulation shall be 8 feet 2 inches preferred, and in no case less than 7 feet 6 inches; and
- at surface Stations with no VCE, the clear distance from the Platform edge to any object that obstructs pedestrian circulation shall be 8 feet 2 inches preferred, and in no case less than 5 feet 2 inches.

8.3.6.5.3 Platform Slope

Concessionaire shall design Platforms with flat cross-slope. Where the Platform must be sloped for drainage, the slope shall not exceed 1.75 percent.

In locations where Platform longitudinal slope exceeds 1.75 percent, Concessionaire shall provide continuous canopy coverage and/or an integral snow-melt system for the Platform. In no case shall the longitudinal Platform slope exceed 3 percent.

8.3.6.5.4 Platform Surface and Edge Treatment

Concessionaire shall provide surface of all Platforms to be non-skid and of durable, weather-resistant materials. Where Platforms are contiguous with sidewalks, the Platform shall be differentiated from the sidewalk by the use of material, color, or texture.

Tactile warning strips shall meet ADAAG requirements. The field between the domes and the tops of the domes shall meet the coefficient of friction requirements for walking surfaces.

8.3.6.5.5 Platform Siting, Access, and Configuration

Concessionaire shall locate surface Station Platforms as shown in the Book 4 Contract Drawings.

If a Platform edge radius must be used, it shall yield an ADAAG-compliant maximum gap. Visual obstructions, alcoves, or other blind or hidden areas on the Platform shall also be minimized.

Platform access points and vertical circulation elements shall be situated to encourage balanced vehicle loading and unloading. The path of emergency egress along the Platform must be clearly delineated and lead as directly as possible to an area of safety.

8.3.6.6 Architectural Requirements – Purple Line Mezzanine Connection

Concessionaire shall provide Purple Line Mezzanine Connection, including foundations and structure, architectural enclosure and finishes, mechanical, electrical, lighting, fire protection and plumbing systems, signage, communications, and station kiosk including all monitoring and control equipment, and vertical circulation to comply with the plan configuration shown in Contract Drawing A1.2, WMATA's Design Criteria, Technical Specifications, and Adjacent Construction Manual.

Concessionaire shall provide a gate or rolling grille between the Purple Line System mezzanine and WMATA connecting bridge.

Concessionaire shall provide elevator and escalator machine rooms as follows:

- Elevator machine room shall be in the existing dispatch room within platform end rooms. Concessionaire shall reconfigure existing doorways and interior end room partitions as required for this purpose.
- Escalator control rooms shall be below the escalators.

The mezzanine and vertical circulation elements shall be enclosed so as to prevent precipitation from entering. Any structure/roof overlapping existing WMATA structures shall be sloped away in order not to drain into existing station canopy or other existing structures.

8.3.6.6.1 WMATA Submittals and Approval

Concessionaire shall prepare architectural, structural, mechanical, electrical, lighting, fire protection, plumbing drawings, details and specifications, and obtain WMATA approval of the proposed design. Concessionaire shall perform all design and construction to comply with WMATA Design Criteria, Technical Specifications, and Adjacent Construction Manual. In addition to these requirements, Concessionaire shall prepare the following submittals and studies:

Provide platform load calculation where structural elements, escalators and elevators are proposed to be installed on existing station.

Exhibit 8.3 - Not Used

8.3.6.7 Architectural Detailing

Concessionaire shall provide Platform windscreens and canopies in the locations, configurations, and quantities indicated on the Contract Drawings. Concessionaire may incorporate alternative architectural profiles and details in lieu of those shown on the Contract Drawings for:

- typical Canopy Sections, Floor, Reflected Ceiling and Roof Plans, Elevations
- typical TVM Canopy;
- typical UMD Modified Canopies;
- typical Vertical Circulation Enclosure Details;
- typical Stair, Stair Canopy, and Stair Windscreen Details;
- typical Ramp and Platform Railings;
- typical Anti-Jaywalk and Ramp Center Railings. Where anti-jaywalking fence is shown on the Contract Drawings, it shall be Pedestrian Barrier Type B1, as required by Part 2, Sections 8 and 21 of the Technical Provisions;
- typical Platform Windscreen Details; and
- typical Signage Support Details.

Concessionaire's architectural profiles and details shall in all cases comply with the requirements of the Technical Provisions.

Escalator canopies at the WMATA New Carrollton station entrance shall be in general accordance with the following documents contained in Book 5 Engineering Data. This supersedes the canopy and windscreen configuration shown in Book 4, drawings AR9C11 and AR9C21. The details shall be extended or otherwise adapted to provide enclosure for the elevators in accordance with Book 2, Part 2B, Section 8.3.7.8.3 Weather Protection, and other specific site conditions.

- Drawings: WMATA Contract No. 14-MCAP-33, Escalator Canopies - Phase III, Metro Center North Escalator Canopy
- Contract Specifications: WMATA Contract No. FQ15104, Escalator Canopies

WMATA bus canopies and shelters shall comply with WMATA standards.

8.3.6.8 Lighting

Concessionaire may modify lighting configurations and fixtures specified in the Contract Drawings. The lighting schedule and legend on Contract Drawing Sheet EL0H02 is eliminated.

Lighting shall in all cases comply with Part 2, Section 9 of the Technical Provisions.

8.3.7 Passenger Circulation

8.3.7.1 General Design Requirements

8.3.7.1.1 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

Egress

- NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems, current edition.

Accessibility

- Maryland Department of Housing and Community Development, COMAR 05.02.02, Maryland Accessibility Code
- U.S. Access Board, ADA Accessibility Guidelines for Buildings and Facilities
- U.S. Access Board (adopted by U.S. Departments of Justice and Transportation), ADA Standards for Transportation Facilities.

Normal Operations

- TCRP Report 100, Transit Capacity and Quality of Service Manual.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

8.3.7.1.2 Design Principles

Passenger circulation shall be configured to provide safe, barrier-free, and convenient movement throughout the Station in compliance with the following standards and requirements:

The primary circulation route is defined as the route used by patrons between the Station entrance(s), fare control area(s), and boarding Platform(s). Accessible routes shall be coincident with the primary public route to the greatest extent feasible.

All transfer connections to existing transit facilities shall be accessible between the LRT Platform and the Platform of the existing facility. Concessionaire shall configure Station circulation to maintain accessibility to staff ancillary areas.

Concessionaire shall configure Station design and directional signage to support right-hand passenger circulation. When a stair and escalator are planned for side-by-side installation, the stair shall be placed to the right-hand side of the escalator when looking down. Similarly, down escalators shall be positioned to the right of up escalators when looking down. Station equipment (e.g., fare vending machines) and furnishings shall also be positioned to discourage Users from crossing the right-hand circulation pattern.

8.3.7.2 Performance Standards

If the physical requirements of emergency egress under NFPA 130 exceed those based on the following LOS standards, the former will govern.

8.3.7.2.1 Level of Service Minimum Standards

Exhibit 8.4 – Level of Service Minimum Standards

LOS	Application	Average Pedestrian Area Occupancy (square feet per person)
C	Walkways, for Circulation Corridors	15 to 25

C	Queuing, for Platforms (Note 1)	7 to 10
D	Stairways	7 to 10
D	Queuing, for Areas Immediately Adjacent to Stairs, Escalators, and Elevators	3 to 7

Note 1: For center platforms, the analysis shall be conducted assuming simultaneous arrival of trains on each track.

8.3.7.3 Queuing & Runoff Space

Concessionaire shall provide queuing and run-off zones at vertical circulation elements and certain Station equipment at the lengths set forth in Exhibit 8.5, below. The width of the queue zone shall match the width of the applicable element. Required queue zones shall not overlap one another except as specifically described below.

Exhibit 8.5 – Minimum Required Queue Distances*

Element	Minimum Required Queue Distance*	Remarks
Elevators	12 feet, or 1.5 times the depth of the passenger cab	(refer to Figure 8.13 for special conditions).
Escalators	30 feet from the escalator working point.	Refer to Figures 8.7, 8.9 and 8.10 for special conditions.
Stairs	10 feet from the riser, or width of the stair, or queuing and run-off distance of adjacent paired escalator (where applicable).	
Fare Vending Equipment	12 feet	

*Note: For each element, the minimum queuing distance shall be the largest of the scenarios listed and shall be measured to the nearest fixed object or similarly defined queue space.

8.3.7.4 Vertical Circulation Elements

8.3.7.4.1 Public Vertical Circulation – Public VCE Types

The Contract Drawings indicate minimum types, quantities, and locations of VCEs. In all cases, VCE types, quantities, and locations shall comply with applicable regulatory requirements, and the LOS requirements of these Technical Provisions.

8.3.7.4.2 Provisions of Adequate Capacity (Number of VCEs)

Concessionaire shall verify quantity, width, and distribution of VCEs by level of service needs, ridership analysis egress requirements, and travel/exit lanes. The minimum total number of public VCEs shall be adequate to handle the forecasted peak passenger design loads at LOS C during normal operations.

VCEs shall be located along the normal and direct path of passenger circulation and be visible and easily identifiable as a means of access to the levels they connect. In addition, VCEs shall be positioned to minimize the obstruction of circulation and sightlines within the Station.

At grade-separated Stations, enclosed exit stairs shall be provided at both ends of Platforms when public area VCEs are not sufficient to meet exiting requirements. Together, the public VCEs and the exit stairs shall be adequate to handle emergency egress requirements in compliance with NFPA 130.

8.3.7.4.3 Minimum Headroom

The minimum headroom over a primary stair or escalator, as measured vertically from the line of the tread nosing to the underside of the ceiling, structure, or overhead obstruction, shall be at least 10 feet as measured perpendicularly to the line of nosings. For signage, a minimum headroom of 8 feet 6 inches, measured vertically, shall be maintained.

8.3.7.4.4 Modular Planning and Interchangeability

Concessionaire shall provide space for VCEs in modular units corresponding to the width required to install, remove, and maintain an escalator, and to enable the future interchange of escalators and stairs. The modular planning envelope for escalators shall be determined by a review of acceptable manufacturers' requirements and shall accommodate the most restrictive envelope. In addition to these physical dimensions, space is required for inspection of escalator machinery and for installation and removal of escalator trusses.

Concessionaire shall make structural and mechanical provisions during design to accommodate the future interchange of stairs and escalators provided in the original construction.

8.3.7.5 Escalators – Planning Criteria

Concessionaire shall provide queuing and run-off space for escalators in accordance with Exhibit 8.6 to 8.10. Assume LOS C for queuing areas.

Exhibit 8.6 – Escalator Working Point (WP) to Obstruction, 30 feet

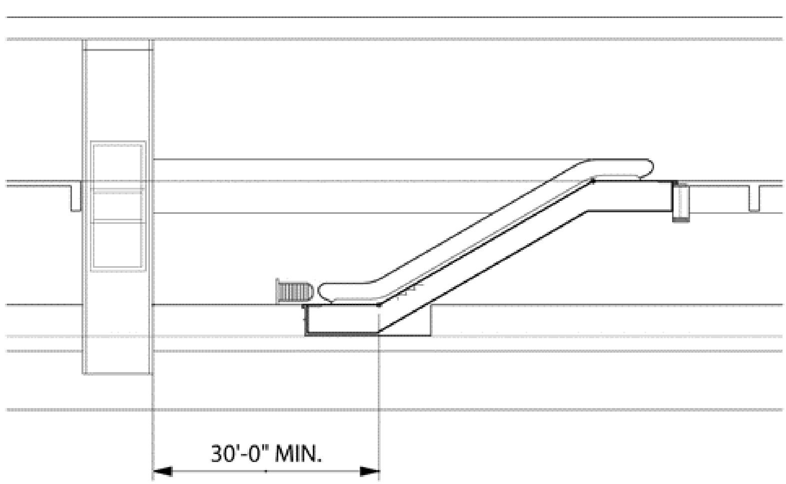


Exhibit 8.7 – Escalator WP to Escalator WP, 45 feet (Escalators in Series)

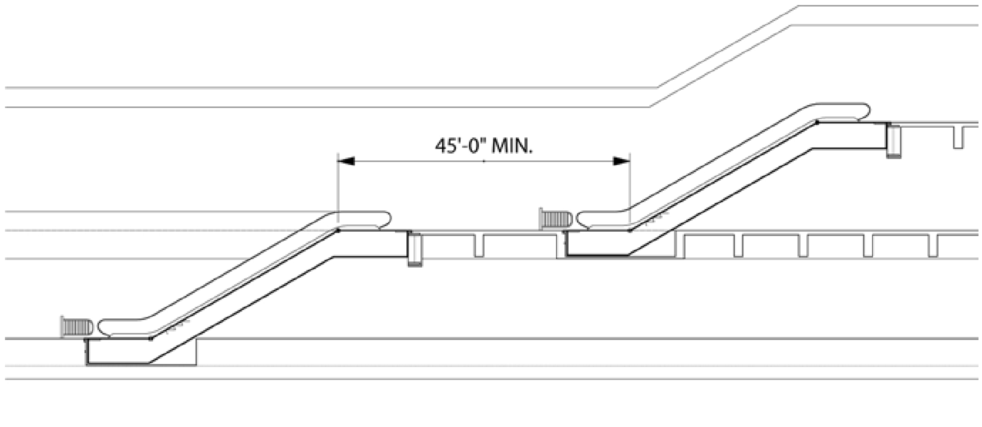


Exhibit 8.8 Not Used

Exhibit 8.9 – Escalator WP to Cross Circulation Area or Adjacent Queuing Area, 30 feet

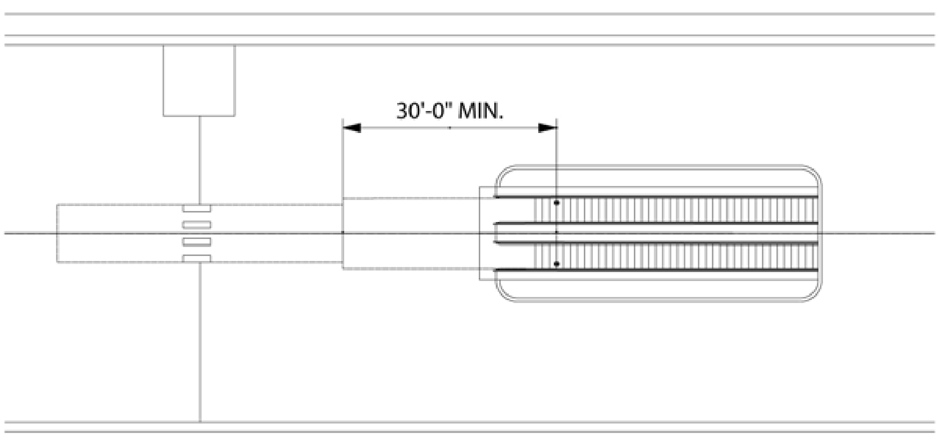
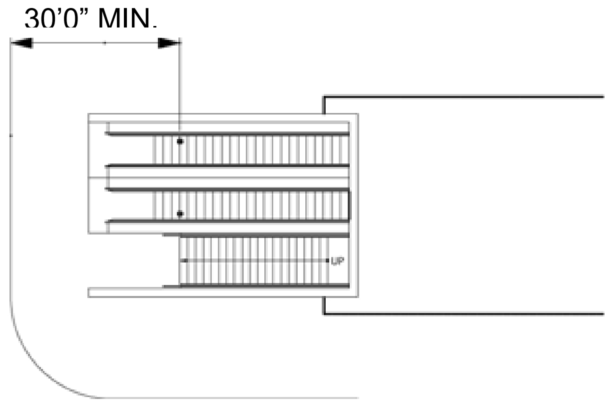
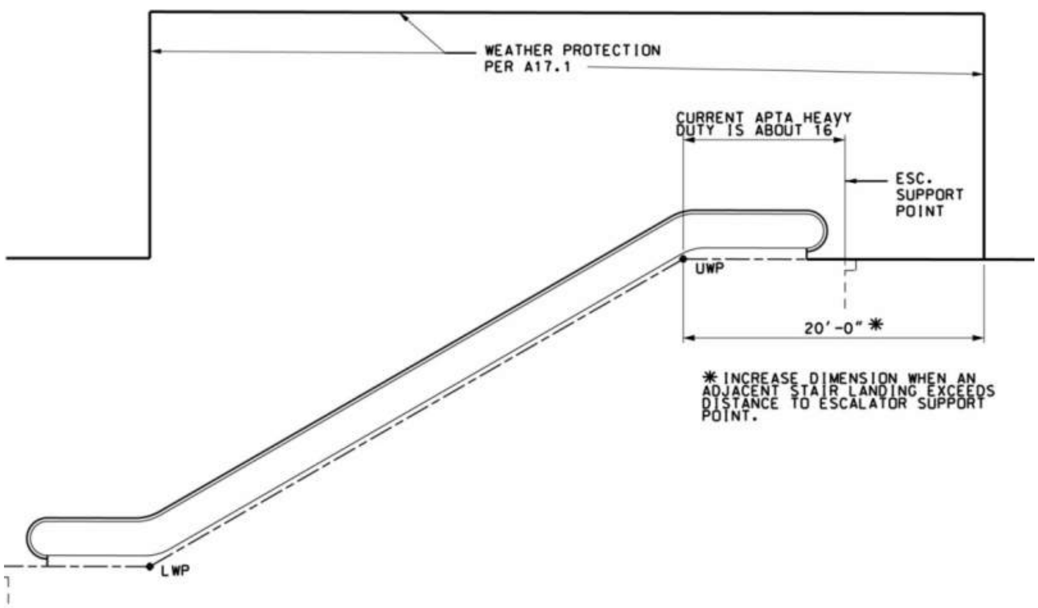


Exhibit 8.10 – Escalator WP to Driveway or Roadway, 30 feet



Per ASME A17.1, Paragraph 6.1.8, weather protection is required at outdoor escalators to protect equipment and riders from the elements. For design criteria of weather protection, see Exhibit 8.11.

Exhibit 8.11 – Weather Protection



8.3.7.6 Escalators – Equipment Criteria for Light Rail Stations

All escalators shall conform to the requirements set forth in the latest-adopted editions of the following:

- ASME A17.1, Safety Code for Elevators and Escalators;
- APTA RT-RP-FS-007-02, Heavy-Duty Transportation System Escalator Design Guidelines; and

- NFPA 130 and applicable life safety codes.

Key requirements are as follows:

- planning module: For a typical 40-inch unit, planning module of 6 feet;
- speed: 100 feet per minute (up to 70 Users per minute);
- operation:
  - escalators shall be reversible to allow for peak time travel in either direction;
  - during lower passenger traffic conditions, electronic sensors shall automatically phase back the power supplied to the motor and stop the escalators, when appropriate;
  - escalator start and stop controls and emergency procedures shall be coordinated with Fire-Life Safety/Systems and NFPA 130 requirements;
  - escalators shall be equipped with the following control features: PLC programmable logic controller, soft start, inspection speed, maintenance control station, and NEMA 3R or 4. A Central Controller Room shall also be provided;
  - provide stand-by power for escalators in the event of loss of the primary power source; and
  - provide remote monitoring of escalators.
  - configure escalators with a minimum of:
  - 3 flat steps for escalator rises less than 32 feet 10 inches; and.
  - 4 flat steps for escalator rises greater than 32 feet 10 inches.
  - provide passenger safety features at all escalators, including:
  - combplate lights;
  - traffic direction indicator lights;
  - skirt safety brushes.
- Escalator Components:
  - Truss – Structural steel construction, hot-dip galvanized, AWS certified welding, and galvanized drip pans. The deflection of the loaded truss shall not exceed one thousandth (1/1000) of the free supporting distance of not less than 50 feet under full static load including live load as of 320 pounds per 40-inch step instead of the 1/750 commercial grade requirement per ASME A17.1. Provide Automatic Sprinkler Systems and smoke detectors in the steel truss area of all escalators per NFPA 130;
  - Step Chains – Precision roller chains, matched sets, not less than 4-inch rollers with sealed bearings, automatic lubricator, and tension carriage with dual springs, minimum Factor of Safety of 6;
  - Steps – Certified for 674-pound loading, not less than 4-inch rollers with sealed bearings, spring clamp attachment to step chain shafts, die cast aluminum with demarcation. Heated steps for exterior escalators;
  - Step Loading – Steps shall have a minimum rated load of 650 pounds with a minimum Factor of Safety of 8;

- o Balustrade – All #316 stainless steel or ½-inch safety glass;
- o Spandrel – All #316 stainless steel;
- o Handrail – Indoor/outdoor type, traction drive sheave, return roller guides, newel rollers/wheels;
- o Combplates – Aluminum combplates, heated for street level escalators; and
- o Drive Machines – Acoustically quiet worm or helical gearbox, braking-code deceleration/stop distance, totally enclosed fan-cooled motors.
- o Escalator drives shall be internal.

8.3.7.7 Escalators – Equipment Criteria for WMATA Stations

Escalators at the following locations will be provided by Concessionaire and operated and maintained by WMATA. Such escalators shall be designed, fabricated, and installed in compliance with WMATA Design Criteria and technical specifications:

- Silver Spring Station at new Purple Line Mezzanine Connection serving WMATA platform; and
- New Carrollton Station at North side passenger entrance tunnel.

Concessionaire shall provide not less than two sump pits at each WMATA escalator pit.

All escalator equipment provided by Concessionaire shall be new. No existing escalator equipment shall be relocated or reused.

8.3.7.8 Elevators – Planning Criteria

Where elevators are warranted, Concessionaire shall provide not less than two elevators so that elevator service is available in the event that one elevator is out of service. Refer to Part 2B, Section 8.5.2 and Section 8.5.5 of the Technical Provisions for specific requirements at Chevy Chase Lake Station and Manchester Place.

8.3.7.8.1 Elevator Redundancy

The Concessionaire shall design and operate stations so as to provide ADAAG-compliant public circulation at all times. Where public circulation routes require the use of elevators, the Concessionaire shall provide not less than one additional elevator, other ADAAG-compliant VCE, or mobility shuttle for public use at times that the elevator is out of service.

8.3.7.8.2 Elevator Access and Queuing Distances

Concessionaire shall provide elevators with a queuing area to permit those Users who are disembarking the elevator to exit without interference from those waiting to board. The transfer area directly in front of a one or two-car bank adjacent to each other shall not be less than 1.5 times the car interior depth (see Exhibit 8.12) or 12 feet, whichever is greater. If the cars are opposite each other, the separation shall be 2 times the car interior depth (see Exhibit 8.13).

Exhibit 8.12 – Transfer Area, Adjacent Elevator Cars (Plan View)

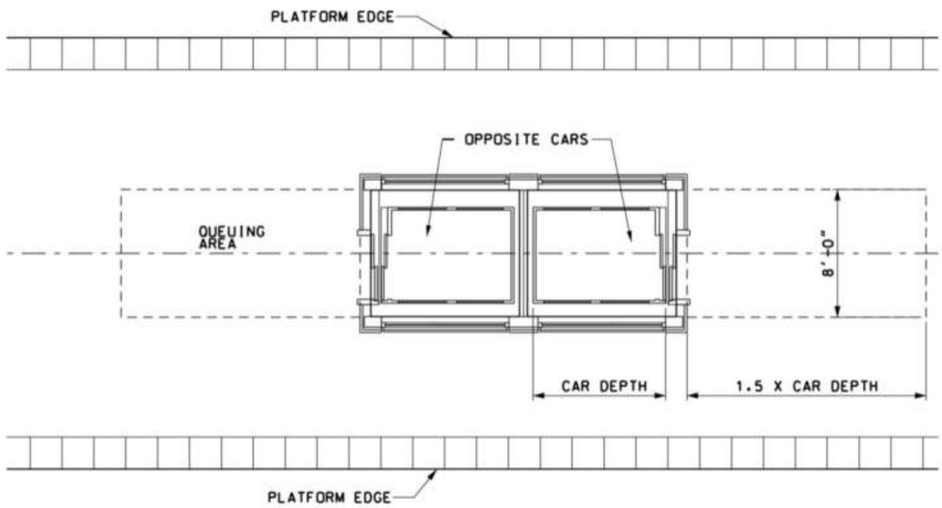
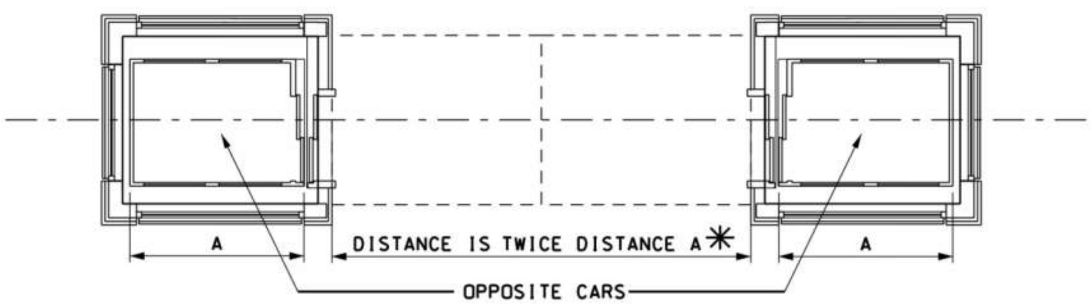


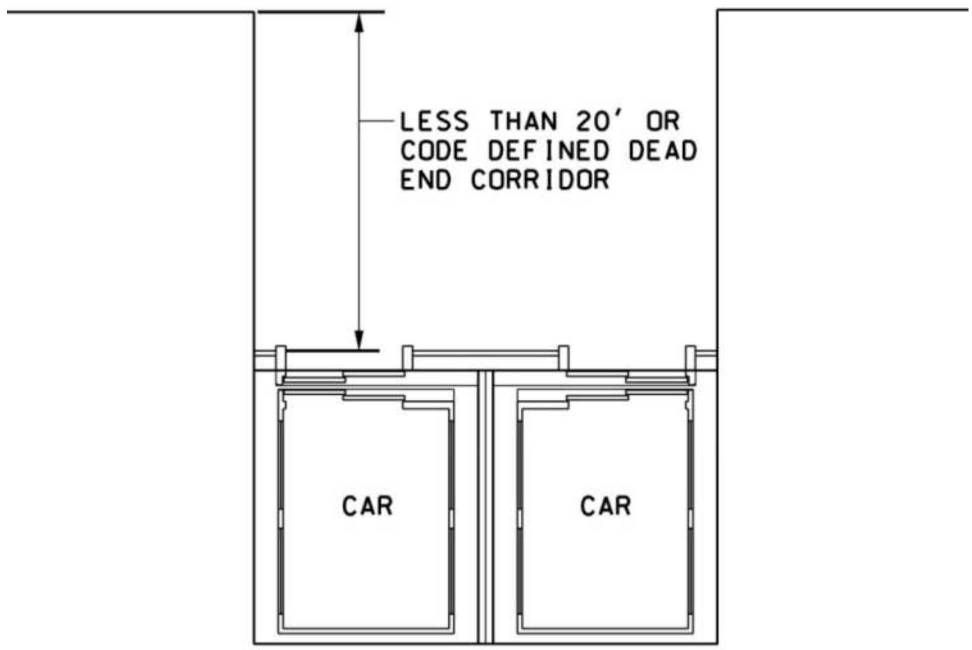
Exhibit 8.13 – Transfer Area, Opposite Elevator Cars (Plan View)



Platform level elevators shall not open in the direction of the Platform edge (see Exhibit 8.12).

Passageways and alcoves connecting elevators to mezzanines, concourses, corridors, lobbies, and other public circulation areas shall not create dead-end corridors (see Exhibit 8.14).

Exhibit 8.14 – Passageway Queuing Distance (Plan View)



Elevator landings and approaches, including queuing areas, shall be located on flat surfaces with positive drainage away from hoistways.

Consideration shall be given to servicing and replacing elevators and elevator equipment during Station operations. Elevators shall be designed so that routine operations and maintenance can be easily performed without disrupting normal Station operations.

8.3.7.8.3 Elevator Security

For hoistway and cab walls that abut public space, Concessionaire may modify the quantity of glazed vision panels shown in the Contract Drawings but in all cases shall provide sufficient glazed vision panels to allow persons and activities within the cab to be observed from outside the hoistway.

Provide security camera coverage inside each elevator cab and at each floor landing.

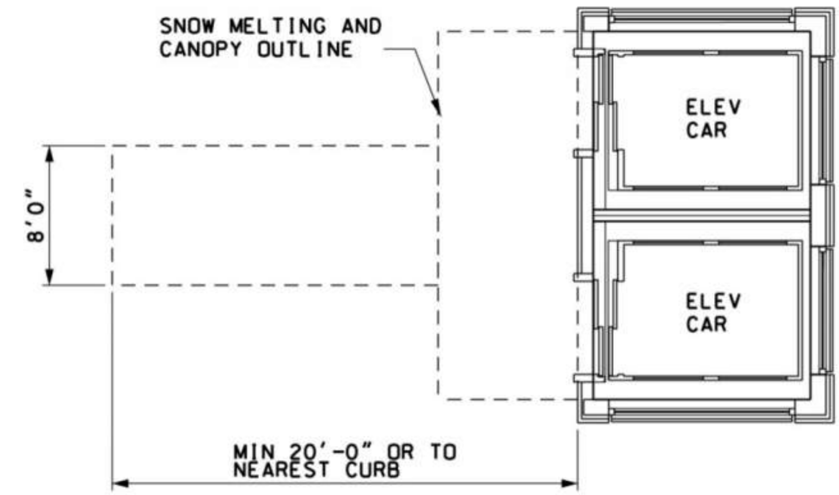
To the extent feasible, elevators shall be placed in a consistent manner on the Platform from Station to Station to facilitate customer wayfinding and orientation. In general, elevators shall be centered along the length of the Platform adjacent either to the middle car(s) of the Train or at Platform ends.

8.3.7.8.4 Weather Protection

Elevators that have landings at street level shall have overhead weather protection that projects out from the hoistway face, over the door, a minimum of 6 feet and a width of 8 feet.

Concessionaire shall incorporate snow-melting systems into the sidewalk areas in front of the elevator hoistway doors at exterior landings. These systems shall be a minimum of 8 feet wide and extend to the nearest street curb, or at least 20 feet. See Exhibit 8.15.

Exhibit 8.15 – Elevator Snow Melting Area

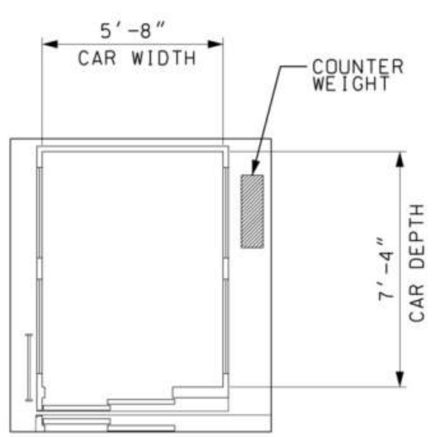


8.3.7.9 Elevators – Equipment Criteria

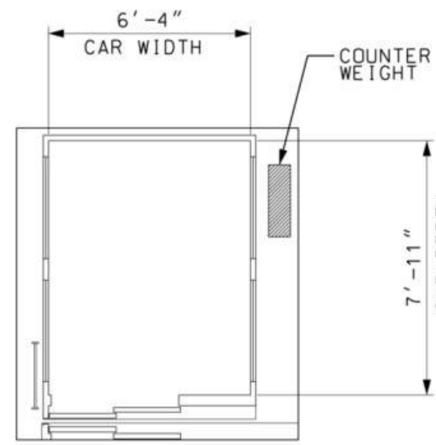
Concessionaire shall provide elevator equipment in passenger Stations as follows:

- elevators shall be machine room-less traction type;
- elevators shall comply with:
  - o APTA RT-RP-FS-007-02, Heavy-Duty Machine Room Less Transportation System Elevator Design Guidelines (or APTA's Mid to High Rise, Heavy Duty Transportation System Traction Elevator Design Guideline when warranted by vertical rise); and
  - o ASME A17.1, Safety Code for Elevators and Escalators.
  - o applicable ADAAG regulations on design, operation, controlling heights, identification and emergency communications.
- for purposes of this criteria, public passenger elevators and their equivalent cab sizes are classified as follows (also see Exhibit 8.16):
  - o Primary passenger elevators shall be provided in locations where the primary public circulation route requires the use of elevators. Each cab shall be designed for 20 people, 4,500-pound capacity; and
  - o ADA and gurney elevators may be provided in all other locations where elevators are warranted; each cab shall be designed for 18 people, 4,000-pound capacity, service shape (longer than wider).

Exhibit 8.16 – Public Passenger Elevator Sizes



ADA AND GURNEY



PRIMARY PASSENGER ELEVATOR

All elevator cabs shall be sized to accommodate a 24-inch by 84-inch ambulance stretcher in the horizontal, open position and shall be identified by the international symbol for emergency medical services (star of life).

Door sizes shall be chosen as required to accommodate wheelchairs/gurneys, and not less than 3 feet 6 inches wide by 7 feet 8 inches high.

Speed at the passenger carrying capacity shall be 200 fpm.

Elevators shall be customer-operated and not restricted during normal Station operations.

Security camera coverage of the cab interior shall be provided.

Emergency communication phones in the car shall connect to the OCC. Elevators shall be passenger/service type, using the larger passenger capacity criteria to determine the car's rated load while designing for the appropriate freight-type loading condition.

The programmable home floor recall shall be coordinated with the fire department (AHJ)/Systems.

All transit elevator cabs shall be designed with a minimum Class C3 rating, allowing for hand carts and driven floor washer machines.

8.3.7.10 Elevators – Equipment Criteria for WMATA Stations

Elevators at the following locations will be provided by Concessionaire and operated and maintained by WMATA. Such elevators shall be designed, fabricated, and installed in compliance with WMATA Design Criteria and technical specifications:

- Bethesda Station: all elevators serving new Red Line Mezzanine Level;
- Silver Spring Station: at new Purple Line Mezzanine Connection serving WMATA platform; and

- New Carrollton Station: at North side passenger entrance tunnel.

Concessionaire shall provide not less than two sump pits at each WMATA elevator pit.

Concessionaire shall provide a source of emergency power to elevators.

All elevator equipment provided by Concessionaire shall be new. No existing elevator equipment shall be relocated or reused.

8.3.7.11 Public Stairs

8.3.7.11.1 Planning Criteria

Public stairs are those intended for normal passenger circulation. In the event that these criteria conflict with applicable life safety requirements, the latter shall govern.

Stairs provided solely for emergency egress purposes or back-of-house use are governed by applicable life safety requirements.

All public stairs in Stations shall be planned to facilitate replacement by an escalator in the future, including space for a pit at the top and bottom. The effective width of a stair between handrails shall be 5 feet. Where use of an escalator modular dimension is not possible or appropriate, the minimum clear width of public stairs between handrails shall be 4 feet.

Exhibit 8.17 – Not Used

8.3.7.11.2 Design Requirements

Concessionaire shall comply with the following criteria in the design of public stairs:

- minimum landing length for straight-line stairs shall be 54 inches;
- maximum riser height shall be 7 inches;
- minimum tread depth shall be 11 inches;
- maximum height between landings shall be 12 feet;
- cleaning runnels 6 inches wide shall be provided on both sides of each stair;
- open risers are not permitted;
- a distinct visual contrast between the tread edges and treads and stringers shall be maintained. The upper approach and the lower tread of each stair shall be marked by a strip of clearly contrasting color at least 2 inches wide, placed parallel to and not more than 1 inch from the nose of the step or landing to alert the visually impaired. The strip shall be of material that is at least as slip-resistant as the other treads of the stair;
- exterior stairs and ramps at Station entrances shall be covered for protection from rain and snow;
- where feasible, stairs will be paired with escalators to facilitate efficient and economical passenger movement, as illustrated in Exhibits 8.18 and 8.19, below. Stairs adjacent to an escalator shall be parallel to the angle of inclination of the escalator (30 degrees). The angle of the treads and risers shall be determined by the dimensions below, and the landings shall be used to keep the stair parallel to the escalator; and
- stairs and queuing areas shall meet the performance standards of LOS C.

Exhibit 8.18 – Stair/Escalator Section

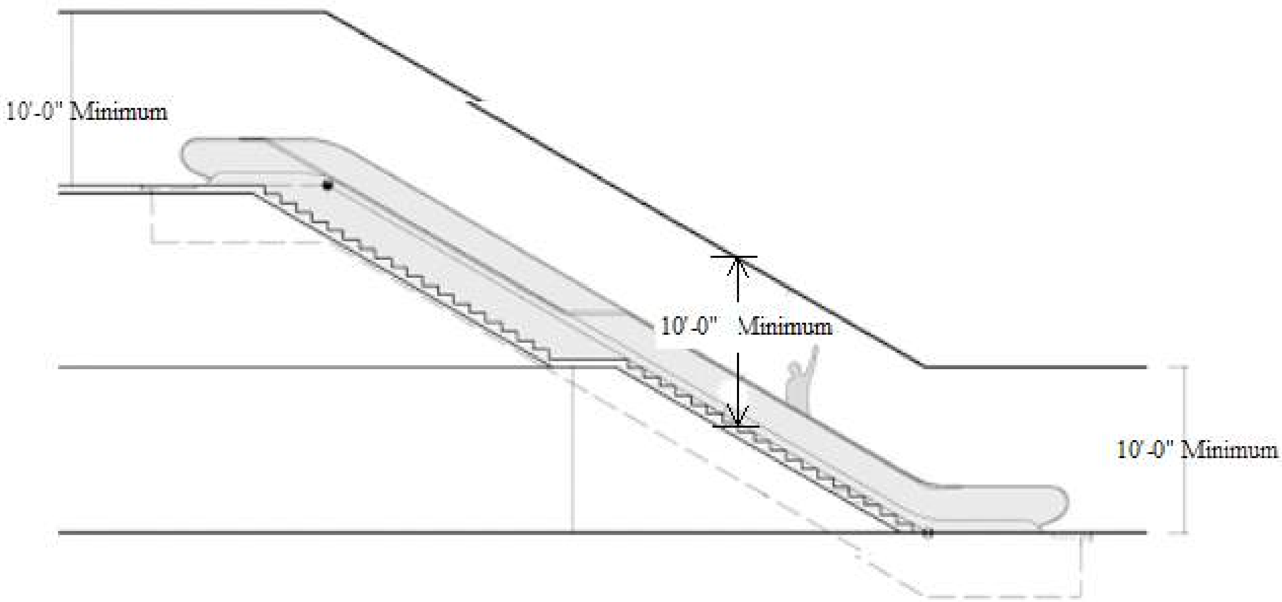
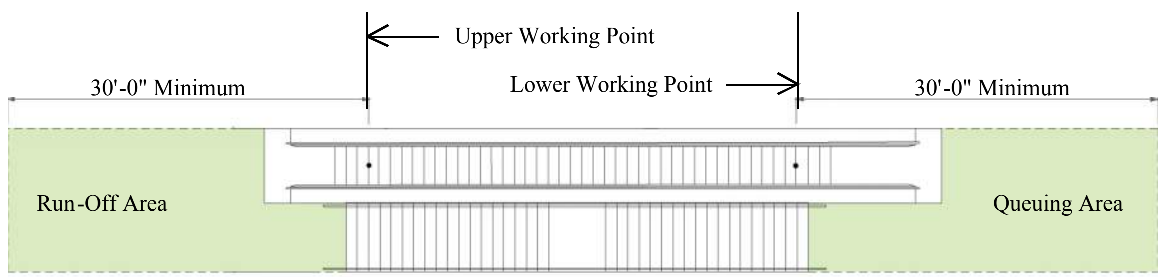


Exhibit 8.19 – Queuing and Run-Off Space for Escalators with Stairs



8.3.7.11.3 Grade-Separated Stations

8.3.7.11.3.1 Public Entrances

Concessionaire shall provide not less than two emergency exits at all grade-separated Stations, of which one or both may be public stairs, provided they conform to the requirements of NFPA 130. Overhead weather protection shall be provided at all such entrances. Entrances to grade-separated Stations shall be sited and configured so as to minimize conflict with existing pedestrian and vehicular movement. Connections to existing or proposed aerial or underground pedestrian passages are encouraged, subject to the requirements for private entrances.

The main public areas of the Station include the Station entrance, the control area, mezzanines, transfer concourses, and the Station Platform(s). The programmatic requirements for these public areas are determined by the capacity and functional requirements of their respective passenger circulation functions.

8.3.7.11.3.2 Ancillary Spaces

Concessionaire shall provide ancillary spaces in grade-separated Stations as indicated in the Book 4 Contract Drawings, and as required to accommodate required functions and equipment. Subject to the requirements of these Technical Provisions, Concessionaire may adjust the locations of interior ancillary room partitions and doors that are not visible to the public.

Ancillary spaces shall be provided with secure and restricted access from the public spaces.

8.3.8 Passenger Station Signage

This Section describes static signage requirements for passenger Stations.

8.3.8.1 Sign Types, Design & Construction

Concessionaire shall provide signage at all Stations in conformance with the Purple Line System-Wide Graphics Manual. The manual indicates sign types, sizes, materials, colors and typography required to be incorporated in sign design. It provides prototypical signage plans for the major station identification, directional and informational signs. The requirements indicated in the manual shall be adapted and completed by the Concessionaire as required to meet site-specific conditions. The manual is not inclusive of all signage that is required for the project. All details of signage mounting and coordination with other project elements are the sole responsibility of the Concessionaire.

8.4 Material & Equipment Requirements

8.4.1 Overall Material Performance Requirements

Concessionaire shall provide finish materials as indicated in the Book 4 Contract Drawings, and to meet the criteria listed below:

- safety – Non-combustible construction to comply with all applicable codes;
- durability – Minimum lifecycle of 50 years for principal materials;
- resistance to graffiti and vandalism – Materials and details that discourage vandalism and are difficult to deface, damage, or remove. All surfaces exposed to the public should be finished in such a manner that the results of casual vandalism can be easily removed with normal maintenance techniques;
- system identity -- A consistent palette of finish materials as elements of continuity across the system; and
- sustainability – Environmentally-friendly products with minimal adverse impacts on the environment.

8.4.1.1 Surface Reflectance

Concessionaire shall provide materials and finishes to comply with the following Reflectance Values in Exhibit 8.20.

8.4.1.2 Attachments

Concessionaire shall provide non-corrosive stainless steel attachments and exterior quality adhesives.

Exhibit 8.20 – Reflectance Values	
Material/Finish Choice	Reflectance Value
Painted Surfaces (Ceilings and Walls)	55 to 70%
Unpainted Surfaces (Ceilings and Walls)	40 to 60%
Floors (Dark)	15 to 20%
Floors (Light)	20 to 30%

8.4.1.2.1 Acoustic Considerations

Concessionaire shall design acoustical environment of the Stations based on reverberation times. The mid-frequency (500 Hz to 2 kHz) reverberation time (RT) within a Station shall not exceed 1.4 to 1.6 seconds.

Concessionaire shall prepare acoustical calculations for each grade-separated Station to determine the amount, type, and placement of acoustical treatment required. Concessionaire shall submit acoustical analyses for grade-separated Stations as part of the Intermediate Design for application Stations.

8.4.2 Public Area Surfaces

8.4.2.1 Surface Station Shelters and Entrance Canopies – Public Area

Shelters, entrance canopies, utility modules and other Station structures shall be constructed of stainless steel as indicated in the Book 4 Contract Drawings, or painted metal. Color for painted metal shall match Tnemec; #31GR, “Slate Gray”.

8.4.2.2 Floors – Public Area

Concessionaire shall provide flooring materials to comply with the *ADA Accessibility Guidelines for Buildings and Facilities* (ADAAG) and the coefficient of friction requirements specified in Exhibit 8.21.

Exhibit 8.21 – Coefficients of Friction (Floors)		
Area	Minimum Coefficient of Friction	
	Wet	Dry
General Floor – Level Interior	0.6	0.6
General Floor – Exterior (Including Areas Immediately Adjacent to Entrances)	0.8	0.8
Stair Tread – Interior and Exterior	0.7	0.8
Slopes greater than 3% – Interior and Exterior	0.8	0.8
Tactile Tile – Interior and Exterior	0.7	0.8

8.4.2.3 Walls and Railings – Public Area

Walls and railings in public areas shall be as follows:

- glass – Concessionaire shall provide laminated glass in Station interiors, except for glazed doors, and Station windscreens which may be constructed of tempered glass except when otherwise required to accommodate artwork or graphic interlayers;
- Guardrails and Handrails – Concessionaire shall provide handrails and guardrails of Grade 316 stainless steel; and
- access panels (floors/walls/ceilings) in public spaces – Concessionaire shall provide access panels of the same material, color, and finish as the surfaces surrounding them.

8.4.2.4 Platform Windscreen and Canopy Glazing

Windscreens and canopies on station platforms shall be:

- safety glass as indicated on the Contract Drawings; or
- exterior grade polycarbonate panels.

Polycarbonate panels shall not be used at:

- WMATA facilities;
- Bethesda Station, Elm Street headhouse and Woodmont Plaza ventilation tower;
- Manchester Station headhouse;
- Elevator cabs and hoistway enclosures;

Polycarbonate panels shall be clear, solid, and incorporate ultraviolet-resistant coatings or other treatment(s) to minimize discoloration and deterioration. Provide laminated panels where required to accommodate interlayers for dot matrix pattern or artwork. Polycarbonate panels shall meet the following criteria:

- ASTM D 2843 Smoke Density: 48.9; PASS Below 75
- ASTM D 635 Flame Spread: Self-extinguishing; PASS CC1
- ASTM D 1929 Self-ignition Temperature: 1004°F; PASS Greater than 650°F
- ASTM E84-03 Flame Spread, 1/2" thickness: 55; Class B: 26-75, Smoke Developed: 400; Class B: <450
- Safety Glazing. Material must attain a Class A impact rating in accordance with ANSI Z97.1-2004.

8.4.2.5 Finish Schedule

The Finish Schedule on Contract Drawing Sheet EL0H02 is revised as follows:

- revise description of the glass within GL-1, GL-2, GL-3, GL-4, GL-5, GL-6, GL-7, and GL-8 to allow panels as described in Part 1, Section 10.6.5 of the Technical Provisions.
- substitute the fritting on GL-2, GL-3, GL-4, GL-5, GL-6, GL-7, and GL-8 with a patterned polyester interlayer that copies the specified perforation patterns;
- change WF-1 woven stainless steel handrail/guardrail infill panel to Ornamental Fence, type B1, B2 or B4 as appropriate to application; and

- PE-1 porcelain enamel finish is not required.

Finishes shall in all cases comply with Part 2, Section 8.4 of the Technical Provisions.

8.5 Stations – Specific Requirements

The provisions in this Part 2B, Section 8.5 of the Technical Provisions provide specific requirement the Stations noted.

8.5.1 Bethesda Station

8.5.1.1 Finishes

For entrances, Concessionaire may provide cast-in-place, broom-finish concrete or the precast concrete pavers shown on the Contract Drawings.

8.5.1.2 Glazing

For the Ventilation Tower (Contract Drawing AR1N32), and Elm Street Entrance Pavilion (Bethesda South Entrance drawing A-301), Concessionaire may use either point-supported glazing or a framed curtainwall system comprising 4-sided mechanically captured glass panels with exterior structural silicone or weatherseal that provides a monolithic appearance when viewed from exterior.

8.5.2 Chevy Chase Lake Station

For entrance plazas, Concessionaire may provide cast-in-place, broom-finish concrete or precast concrete pavers shown on Contract Drawings.

Concessionaire may provide the stair enclosure shown on Contract Drawing AR1R73 or guard rails on stairs and landings.

Notwithstanding the requirements of Part 2A, Section 8.3.7.8 of the Technical Provisions, one elevator is required between street and platform levels.

8.5.3 Lyttonsville Station

Concessionaire shall provide stair canopy and canopies to cover the area indicated on Contract Drawing AR1Y12. The Concessionaire may incorporate alternative architectural profiles and details in lieu of those shown on the Contract Drawings. Refer to the architectural detailing in Part 2A, 10.5.1 of the Technical Provisions for typical canopies and windscreens. The free standing green screen indicated on Contract Drawing LS1Y01 is not required.

8.5.4 Silver Spring Transit Center

The tubular screen/canopy shown over the Platform and VCE is conceptual in nature. Concessionaire shall provide:

- continuous overhead canopy for the full length and width of the boarding Platform, access walkways, and VCE; and
- continuous 7’-9” high windscreen on outboard side of both Guideways, corresponding to the full length of boarding Platform.

One elevator is required between column lines 4.6 and 4.8 which connects the surface level with the Purple Line Mezzanine.

8.5.5 Manchester Place

Corrugated metal wall and ceiling panels at Station interior shown on Contract Drawings (AR4C41, AR4C31, AR4C21) are conceptual in nature. Concessionaire may provide walls and ceilings of exposed architectural concrete, except for acoustic treatment as required to meet the requirements of Part 2 Section 8.4.1.2.1 of the Technical Provisions.

Notwithstanding the requirements of Section 8.3.7.8 of these provisions, one elevator is required between the upper level entrance and platform.

8.5.6 Riverdale Park

The curved screen/canopy over the Platform is conceptual in nature. Concessionaire shall provide canopies and windscreens to match corresponding elements at Chevy Chase Lake Station.

The aerial structure at the intersection of Kenilworth Avenue and East West Highway is not required to be continuous through the Riverdale Park Station. The Riverdale Park Station shall be elevated on either aerial structure or retaining structure.

If Concessionaire elects to construct the Station with retained fill, the following requirements shall apply:

- Provide an at-grade pedestrian walkway beneath the station, directly connecting the East-West Highway with 57th Avenue. The walkway shall be at least 10 feet wide.
- Provide VCE as required to provide clear sightlines for patrons and minimize gaps between VCEs and retaining wall.

For plaza paving, Concessionaire may provide cast-in-place, broom-finish concrete or the precast concrete pavers shown on Contract Drawings.

8.5.7 New Carrollton

For the north entrance, Concessionaire may provide cast-in-place, broom-finish concrete or the precast concrete pavers shown on Contract Drawings.

8.6 Content of Station Plans

Concessionaire shall submit Station Plans for Review and Comment at Preliminary Design, Intermediate Design and Final Design. The content of each Submittal shall be, at a minimum, as follows:

- Preliminary Design:
    - Station plans, scale 1”=20’;
    - Station sections and elevations; and
    - Basis of Design Report.
- Intermediate Design:
    - Station plans, scale 1”=20’;
    - Station sections and elevations;
    - typical Station details;
    - acoustical analyses for grade-separated Stations;
    - outline specifications; and
    - typical signage plans and details.

- Final Design:
  - architectural plans, elevations and building sections;
  - architectural reflected ceiling plans;
  - specifications;
  - typical construction details showing material assemblies;
  - sign types, details with signage and messaging schedules;
  - door and finish schedules; and
  - Code compliance report.

8.7 Summary of Submittals

Item	Section	Submittal	Action
1	8.3.2.2	Recommended Art In Transit Projects	Review and Approval
2	8.3.2.2	Selected Art in Transit Projects	Review and Approval
3	8.5	Station Plans – Preliminary	Review and Comment
4	8.5	Station Plans – Intermediate	Review and Comment
5	8.5	Station Plans - Final	Review and Comment

9 MECHANICAL, ELECTRICAL, PLUMBING AND FIRE PROTECTION

This Section describes the requirements for the mechanical, electrical, plumbing, and fire protection elements of the Project.

9.1 Overview

Concessionaire shall provide the MEP systems per this Section and the Contract Documents.

- mechanical – Concessionaire shall provide HVAC and control systems to monitor and manage temperature, humidity, air velocity, air pressure, rate of air pressure change, dust, odors, smoke control, smoke movement and smoke direction during fire emergencies to protect and preserve life;
- electrical – Concessionaire shall provide normal and emergency electrical power for lighting and equipment where a unified design and standardized equipment selection is provided for Stations; buildings; tunnels; and other electrically powered equipment and facilities;
- plumbing – Concessionaire shall provide hot and cold water supply, waste collection, distribution piping, fixture and equipment selection Stations; tunnels; and building requirements for sanitary systems; and
- fire protection – Concessionaire shall provide code compliant wet, dry and chemical fire suppression systems, sprinklers, sprinkler piping, support systems (e.g., hangers), valves, fire department connections, water flow detection devices, and associated appurtenances for below-grade, at-grade and Aerial Stations; tunnels and buildings.

9.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

Mechanical Codes and Standards

- Air Conditioning and Refrigeration Institute standards;
- Air Diffusion Counsel standards;
- Air Movement and Control Association standards;
- American Boiler Manufacturers Association standards
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ASHRAE Handbook – HVAC Applications;
- ASHRAE, ASHRAE Handbook – Fundamentals;
- ASHRAE, Commissioning Process for Buildings and Systems;
- ASHRAE 62, Ventilation for Acceptable Indoor Air Quality;
- ICC International Mechanical Code, NFPA 130, ANSI/ASHRAE 62.1, the "Enclosed Vehicular Facilities" chapter of the ASHRAE Handbook – HVAC Applications, and the Urban Mass Transportation Administration's Subway Environmental Design Handbook, Volume I, Principles and Applications, Second Edition;
- American National Standards Institute (ANSI)/ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality;

- ASHRAE 90.1, Energy Standard for Buildings;
- American Society of Mechanical Engineers (ASME), ASME B31, Standards of Pressure Piping;
- ASME B16.10, Face-to-Face and End-to-End Dimensions of Valves;
- American Society for Testing and Materials (ASTM), Standard E84, Standard Test Method for Surface Burning Characteristics of Building Materials;
- ICC, International Energy Conservation Code;
- ICC, International Mechanical Code (IMC);
- National Fire Protection Association (NFPA), NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems;
- NFPA 1, Fire Code;
- NFPA 90A, Installation of Air Conditioning and Ventilating Systems;
- NFPA 90B, Installation of Warm Air Heating and Ventilating Systems;
- NFPA 92A, Smoke Control Systems;
- NFPA 92B, Smoke Control Systems in Atria, Covered Mall and Large Areas;
- NFPA 204M, Smoke and Heat Venting;
- NFPA 101, Life Safety Code;
- NFPA 111, Standard on Stored Electrical Energy Emergency and Standby Power Systems;
- NFPA 130, Standard for Fixed Guideway Transit and Passengers Rail Systems;
- NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials;
- Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA), HVAC Air Duct Leakage Test Manual;
- SMACNA, HVAC Duct Construction Standards – Metal and Flexible;
- SMACNA, HVAC Systems Duct Design;
- SMACNA, Rectangular Industrial Duct Construction Standards;
- Underwriters Laboratories, Inc., UL 723 (ASTM E84), Test for Surface Burning Characteristics of Building Materials;
- UL 555, Standard for Fire Dampers;
- UL 555S, Standard for Smoke Dampers;
- U.S. Army Corps of Engineers, Unified Facilities Criteria 3-450-01, Noise and Vibration Control;
- U.S. Department of Justice and U.S. Department of Transportation (DOT), Americans with Disabilities Act Accessibility Guidelines (ADAAG); and
- U.S. DOT, Urban Mass Transportation Administration, Subway Environmental Design Handbook. Volume I. Principles and Applications. Second Edition.

Electrical Codes and Standards

- AABC Commissioning Group;
- American National Standards Institute (ANSI), ANSI/IES RP-8, American National Standard Practice for Roadway Lighting;
- APTA SS-SIS-RP-001-10, APTA Security Lighting for Transit Passenger Facilities;
- APTA SS-SIS-RP-002-10, APTA Security Lighting for Nonrevenue Transit Facilities;
- ASHRAE - Standard 90.1, Energy Standard for Buildings;
- IESNA - The Lighting Handbook;
- IESNA G-1-03, Guideline on Security Lighting for People, Property, and Public Spaces;
- IESNA LM-80, Approved Method for Measuring Lumen Maintenance of LED Light Sources;
- IESNA RP-8, Roadway Lighting;
- IESNA RP-20-98, Lighting for Parking Facilities;
- IEEE C2, National Electrical Safety Code (NESC);
- IEEE C62.11, IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV);
- IEEE 80, IEEE Guide for Safety in AC Substation Grounding;
- IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems;
- Insulated Cable Engineers Association requirements;
- International Code Council (ICC), International Building Code (IBC);
- International Electrical Testing Association (NETA), Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems;
- NECA 1, Good Workmanship;
- NECA 90, Commissioning Building Electrical Systems;
- NECA 101, Installing Steel Conduits;
- NECA 111, Installing Nonmetallic Raceways;
- NECA 200, Temporary Electrical Power at Construction Sites;
- NECA 230, Installing Electrical Motors and Controllers;
- NECA 400, Installing Switchboards;
- NECA 406, Installing Panelboards;
- NECA 409, Installing Dry-Type Transformers;
- NECA 420, Standards for Fuse Applications;
- NECA 500, Installing Indoor Lighting;
- NECA 501, Installing Exterior Lighting;

- NECA 600 – Installing Medium Voltage CableNEMA ICS 18, Motor Control Centers;
- NEMA LA 1, Surge Arresters;
- NEMA SSL-3, High-Power White LED Binning for General Illumination;
- NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum);
- NFPA 30, Flammable and Combustible Liquids Code;
- NFPA 70, National Electrical Code (NEC);
- NFPA 70E, Standard for Electrical Safety in Work Place;
- NFPA 70B, Recommended Practice for Electrical Equipment Maintenance;
- NFPA 72, National Fire Alarm and Signaling Code;
- NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems;
- NFPA 1, Fire Code;
- NFPA 101, Life Safety Code;
- NFPA 110, Standard for Emergency and Standby Power Systems;
- NFPA 130, Standard for Fixed Guideway Transit and Passengers Rail Systems;
- NFPA 780, Standard for the Installation of Lightning Protection Systems;
- UL 845, Motor Control Centers;
- UL 1449, UL Standard for Safety for Surge Protective Devices; and
- UL 2196, Tests for Fire Resistive Cables.

Plumbing Codes and Standards

- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ASHRAE 90.1;
- ASME A17.1, Safety Code for Elevators and Escalators;
- ASME/ANSI B16, Fittings and Valves package of standards;
- ASME B31, Pressure Piping package of standards;
- American Society of Testing and Materials (ASTM), ASTM B88, Standard Specification for Seamless Copper Water Tube;
- NFPA 1, Fire Code;
- NFPA 54, National Fuel Gas Code;
- NFPA 101, Life Safety Code;
- NFPA 130, Fixed Guideway Transit and Passenger Rail Systems;
- The Plumbing and Drainage Institute, PDI-G 101 Testing and Rating Procedure for Hydro Mechanical Grease Interceptors with Appendix of Installation and Maintenance;
- Plumbing-Heating-Cooling Contractors Association, National Standard Plumbing Code;
- Underwriters' Laboratory, Inc. (UL) standards;

- U.S. Access Board, Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines (ADAAG); and
- Washington Suburban Sanitary Commission (WSSC), Plumbing and Fuel Gas Code (as adopted by the local jurisdictions).

Fire Protection Standards

- NFPA 1, Fire Code;
- NFPA 10, Standard for Portable Fire Extinguishers;
- NFPA 13, Standard for the Installation of Sprinkler Systems;
- NFPA 14, Standard for the Installation of Standpipe and Hose Systems;
- NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection;
- NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances;
- NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems;
- NFPA 72, National Fire Alarm and Signaling Code;
- NFPA 101, Life Safety Code;
- NFPA 130, Standard for Fixed Guideway Transit and Passengers Rail Systems; and
- NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

9.3 Mechanical Requirements

9.3.1 Ventilation Design Criteria

Outdoor Design Conditions shall be as follows:

- Summer dry bulb temperature: 91.2°F;
- Summer wet bulb temperature: 74.2°F; and
- Winter dry bulb temperature: 17°F.

9.3.2 Ventilation Rates

All HVAC systems and equipment shall comply with ASHRAE 62.1 and ICC *International Mechanical Code* requirements for ventilation rates for occupied spaces being heated, ventilated, and/or air conditioned.

9.3.3 Specialized Exhaust / Ventilation Systems

Concessionaire shall provide variable frequency drive based ventilation when operating diesel equipment, and control air-borne contaminants as follows:

- Maintenance Pits – Provide supplementary ventilation within the maintenance and service pits.

- Vehicle Wash – Provide freeze protection, moisture control and condensation control at the wash bay area and equipment rooms.
- Welding Exhaust Hoods – Provide stationary and/or flexible extraction hoods at each maintenance work-point.
- Paint Spray Booths – Provide heating and makeup air with dedicated air handling unit per Paint Spray Booth and provide explosion-proof HVAC equipment.
- Battery Rooms – Provide constant negative pressure per IMC and NFPA 111 - Standard on Stored Electrical Energy Emergency and Standby Power Systems.

9.3.4 Ventilation Design Velocities for Air Distribution Systems

Provide ductwork per SMACNA's HVAC Systems Duct Design and SMACNA's Rectangular Industrial Duct Construction Standards; meet air leakage requirements per SMACNA's, ASHRAE 90.1, ICC International Energy Conservation Code, and the ICC IMC.

9.3.5 Ventilation Concrete Ductwork

Provide concrete tunnel ductwork for plenums and shafts where tunnel ventilation shafts have a maximum air velocity of 2,000 feet per minute (fpm) and ductwork mains and plenums have a nominal air velocity of 1,500 fpm and a maximum air velocity of 1,800 fpm.

9.3.6 Ventilation Noise Abatement

Upper permissible limits for HVAC equipment and air devices shall be per *ASHRAE Handbook – HVAC Applications,* U.S. Army Corps of Engineers Unified Facilities Criteria 3-450-01, *Noise and Vibration Control* (which supersedes TM-5-805-4).

9.3.7 Ventilation of Above-Grade Stations and Platforms

Provide emergency smoke control/smoke management per NFPA 130 and code and ventilation per ASHRAE 62.1 and ICC IMC.

9.3.8 Ventilation of Underground Stations and Tunnels

Provide tunnel and Station ventilation systems per codes, regulations, standards per the AHJ inclusive of the LRV HVAC intake and discharge, and including at a minimum the following requirements:

- HVAC velocities and pressure transients per *ASHRAE Handbook – HVAC Applications* where average is not more than 600 fpm and not exceed OSHA guidelines.
- Control "piston effect" of LRV in and out of Underground Stations per *ASHRAE Handbook – HVAC Applications* where no person shall be subjected to a rate of pressure change greater than 0.06 psi per second (1.7 in. wg per second).
- Operate tunnel equipment continuously up to 94°F maximum wet bulb, maximum dry bulb of 108°F, and minimum dry bulb of -7°F. HVAC components in airflow shall be capable of operating in an ambient airflow temperature of 482°F for a minimum of 1 hour per NFPA 130.
- Provide ground level louvered ventilation structures (intake and discharge) where the structures are not located in sidewalks, roadways, driveways, motor vehicle stops, fuel storage, fuel vapor source, or near motor vehicle exhaust.

- Provide emergency smoke control/management per NFPA 130 for Emergency Ventilation Systems and vertical ventilation shaft separation per ASHRAE 62.1. The design fire for NFPA 130 engineering analysis shall be a 13.2 MW medium growth rate LRV fire.

9.3.9 Ventilation of Operations and Maintenance Facility - Occupied Spaces

Provide HVAC systems per *ASHRAE Handbook*, heat, ventilation, and outside air per ASHRAE 62.1 and IMC. Measure and monitor Particulate Matter, Carbon Monoxide, and Nitrogen Oxides contaminant quantity and connect to EMCS to modulate outside airflow.

9.3.10 Ventilation Air Distribution Systems

Provide air-distribution duct systems per the latest edition of the ASHRAE Handbook – Fundamentals and SMACNA's HVAC Duct Construction Standards – Metal and Flexible.

Provide ductwork leak testing per SMACNA HVAC Duct Construction Standards – Metal and Flexible and ANSI/ASHRAE/IES Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

9.3.11 Ventilation Fire/Smoke Dampers

Provide fire/smoke dampers per NFPA 1, NFPA 101, International Building Code (IBC) and per the AHJ. Fire and fire/smoke UL-listed for performance under dynamic conditions per UL 555 for fire dampers and UL 555S for fire/smoke dampers.

9.3.12 Ventilation Equipment Vibration Isolation

Isolate mechanical equipment vibration from the building per the "Noise and Vibration Control" chapter of the *ASHRAE Handbook – HVAC Applications*, latest edition.

9.3.13 Protection of Existing Ventilation systems

Concessionaire shall locate existing ventilation supply and exhaust systems within or adjacent to the Project ROW. Concessionaire shall protect existing facilities from fire, dust, smoke and other air-borne pollutants in accordance with Code and AHJ requirements.

9.3.14 Energy Management Control System

Provide BACnet-compliant internet web browser-based, centralized Energy Management Control System (EMCS) to monitor and control HVAC equipment of: OMF, tunnel HVAC systems, Underground Station HVAC systems and above-grade Station support space HVAC systems.

Provide real-time EMCS control and management system to adjust building systems, including read, display, log, and trend energy and domestic water consumption; real-time monitoring of system performance and equipment alarms; automated equipment maintenance scheduling; temperature setbacks from occupancy patterns; monitor and record indoor and outdoor conditions that affect HVAC systems, alarms, failures, and abnormal operating conditions; automatically control chillers, air handlers, pumps, fans, dampers, and lighting; meter chilled water, domestic water.

9.3.15 Boilers

Provide multiple natural gas or oil-fired condensing boilers. If oil-fired, provide above-ground fuel oil storage tanks for 30-day continuous operation. Size each of the multiple boilers for 60 percent of the design heating load.

9.3.16 Mechanical Design Submittals

Concessionaire shall submit Mechanical Design for Review and Comment at the following stages and including the following minimum content:

- Preliminary Design
    - Design Criteria and Basis of Design Report;
- Intermediate Design
    - HVAC Calculations, Single Line Drawings, Equipment Schedule, Power Load Schedules, Standard Project Specific Details;
    - NFPA 130 Engineering Analysis for Tunnel/Enclosed Trainway Emergency Ventilation Systems; and
    - Updated information from Preliminary Design.
- Final Design
    - Product Data Sheets for all materials, products and components;
    - Material Safety Data Sheets;
    - Samples of products exposed to view in public areas; and
    - Updated information and samples from Intermediate Design.

9.4 Electrical Requirements

Certain electrical loads such as TPSSs will be fed from PEPCO at 13.2kV. Other loads such as Train control CIHs, grade crossing cases and surface Stations could potentially be fed from low voltage, less reliable electrical services. Concessionaire shall evaluate the regional level of reliability of each type of PEPCO electrical service relative to the Train service and Station availability requirements to determine the need for enhancing electrical service reliability by means such as power distribution feeders fed from PEPCO 13.2kV services.

Provide electrical power distribution, equipment, and lighting for normal and emergency operations and conditions.

9.4.1 Utility Power Connections

Concessionaire shall determine all preliminary and final electrical loads and provide appropriate electrical utility power services for all necessary Project loads.

Concessionaire shall coordinate and interface with PEPCO and prepare all PEPCO service applications, single-line drawings, transformer locations, Utility Owner standard details and requirements, proposed routing of underground duct banks, number of conductors and conductor sizes for all electrical utility services for the Project. Concessionaire shall evaluate the service capacity, reliability and availability to determine the most appropriate service voltage.

Concessionaire shall obtain PEPCO engineering guide specifications, metering equipment standards, and other documents required for the design, construction, and commissioning of electrical service and develop all electrical designs in accordance with these documents and standards. Concessionaire shall provide AC power equipment that complies with all PEPCO requirements.

PEPCO service applications shall be prepared in a timely manner that is consistent with the Project Schedule and accommodates PEPCO’s required processing and construction periods. PEPCO service applications shall be submitted to PEPCO on Owner’s behalf along with all required service and construction costs.

Concessionaire shall perform all oral and written design and construction coordination with PEPCO required to obtain and establish all required utility power services and shall be responsible for PEPCO's completion of all utility power services in accordance with the Project Schedule.

9.4.2 Primary Medium-Voltage Service (12.47 kV to 34.5 kV)

Provide medium-voltage electrical service as coordinated with the Utility Owner for all applicable contract facilities as required by the Contract Documents.

9.4.3 Above-Grade Stations

Provide above-grade Station electrical service as coordinated with the Utility Owner.

Provide electrical room(s) with secondary service from the Utility Owner provided power to the load centers. Provide dedicated Station lighting panels and separate receptacle and lighting panels with 25 percent spare circuit breaker capacity.

Provide emergency power in accordance with NFPA 70, Article 700 and NFPA 110, Chapter 4 for above-grade Stations, and per NFPA 130. Provide 90-minute UPS system for fire alarm, CCTV, lighting, intrusion access control, and monitor through the SCADA system for communications and control systems per NFPA 70.

Provide Station main breakers with 125V AC control power. Provide a 90-minute Uninterruptable Power Supply (UPS) single source or a separate UPS power supply source for each breaker.

9.4.4 Underground Stations and Tunnels

Provide two separate primary medium-voltage (MV) services (12.47kV to 34.5kV) or two separate low voltage (LV) services at 480/277V from the Utility Owner. Services shall originate from separate bus sections in the PEPCO substation supplying the services.

Provide dedicated subsurface ductbank for primary MV service to the AC unit substations. Provide combined AC switchboard with open tie circuit breaker to connect the two AC unit substation secondary buses with associated interlocking mechanism to close the tie breaker.

Provide dedicated subsurface ductbank for primary LV service to the AC switchgear. Provide combined AC switchboard with open tie circuit breaker to connect the two AC services with associated interlocking mechanism to close the tie breaker.

Provide emergency power in accordance with NFPA 70, Article 700 and NFPA 110, Chapter 4 for Underground Stations, and per NFPA 130. Provide 90-minute UPS system for fire alarm, CCTV, lighting, intrusion access control, and monitor through the SCADA system for communications and control systems per NFPA 70.

Provide Station main breakers with 125V AC control power. Provide a 90-minute Uninterruptable Power Supply (UPS) single source or a separate UPS power supply source for each breaker.

Where battery and battery chargers are located, provide Class 1, Division 2 approved enclosures per NFPA 70.

9.4.5 Emergency Power Distribution – Life Safety

Provide emergency (backup) power generation per NFPA 1 - Fire Code, NFPA 101 - Life Safety Code, State of Maryland COMAR 05.02.07, county standards and regulations, and per AHJ at Stations and facilities.

9.4.6 Emergency Power Distribution - Essential Operations

Per NFPA 130 and the NEC, provide emergency (backup) power generation at Stations and facilities to provide contract compliant service availability.

9.4.7 Operational and Maintenance Facilities (OMFs)

Provide electrical systems including power, lighting, power and lighting controls, wiring, raceways, conduit, and electrical devices not associated with Traction Power. Provide per NFPA 70, *National Electrical Code*; NFPA 72, *National Fire Alarm and Signaling Code*; IEEE/ANSI C2, *National Electric Safety Code*; applicable local codes, and the AHJ.

Installation of electric equipment and wiring used in connection with overhead cranes and hoists shall conform to NFPA 70. Provide recessed overhead AC power bus system.

9.4.7.1 Emergency Power - Operation and Maintenance Facilities (OMFs)

Provide emergency power per NFPA 130, and as required to provide service Availability.

9.4.8 OCC and OMF – Emergency Power Generation

Provide 100 percent emergency power system of natural gas or diesel with 24-hour fuel storage, if diesel, for the OCC and OMF facilities per the requirements of the *Central Station Signaling Systems* chapter of NFPA 72, inclusive of a UPS system. The emergency system shall deliver full rated load. UPS batteries shall be capable of supplying a rated load for a minimum of 90 minutes.

9.4.8.1 Emergency Power – Control Centers

Provide 100 percent 90-minute uninterrupted power supply (UPS) to operate all internal and external Operation Control Center (OCC) and Backup Operation Control Center (BOCC) systems and associated OCC and BOCC control, monitoring and communications systems.

9.4.9 Grounding and Protective Measures

Comply with NEC and IEEE standards, regulations and procedures pertaining to system and equipment grounding and provide circuit protective devices to remove faulty circuits from the system regardless of fault type.

No person shall be exposed to a continuous electrical touch potential in excess of 50 volts alternating current, maximum at any time at any location.

Provide grounding electrode systems of buried interconnected ground conductors and electrodes that form a grid of 2 ohms or less.

Provide grounding systems which will not exceed the safety limits of IEEE Standard 80. Coordinate ground grid locations with underground Utilities to eliminate any electrical potential with Utilities.

Connection between a grounding grid system and the service side of a water line Utility, or any other Utility, is prohibited.

Provide ground plates at electrical and communication equipment and weld or bolt equipment grounding conductor to the plate for visible inspection of the connection.

Provide signal reference ground plate in each communications room and signal room. Except for a single point of interconnection to the ground grid, each signal reference network shall be insulated from other networks and elements of the facility ground grid system.

9.4.10 Lighting Design Criteria

Provide lighting system per APTA Security Lighting for Transit Passenger Facilities, APTA SS-SIS-RP-001-10; APTA Security Lighting for Nonrevenue Transit Facilities, APTA SS-SIS-RP-002-10; and the Illuminating Engineering Society of North America (IESNA), IESNA G-1-03, *Guideline on Security Lighting for People, Property, and Public Spaces,* the illumination levels set forth in this Section, and per the AHJ. Provide lighting raceways, conduits, conductors, wires, and cables per the National Electrical Code, NFPA 70, NFPA 130, and AHJ.

9.4.10.1 Design Documents

With the exception of mechanical and electrical ancillary spaces, Concessionaire shall include in the Intermediate Design computer calculations and drawings documenting the point-by-point illumination levels for each room 100 gross square feet and larger; document each area average maintained illumination and max-to-min ratios. Provide illumination levels per Exhibit 9.1 through Table 9.1.2. Provide light fixture type, mounting heights, mounting methods and a light fixture schedule.

9.4.10.2 Interfaces, Management and Control

Provide and coordinate the system-wide lighting design of the Stations, OMF, including the connections to the EMCS for operational management and control of the lighting systems.

9.4.10.3 Operations and Maintenance Facilities

Illumination levels per Occupational Safety and Health Administration (OSHA), APTA Security Lighting for Nonrevenue Transit Facilities, APTA SS-SIS-RP-002-10, and Illuminating Engineering Society of North America (IESNA) lighting guidelines.

9.4.10.4 Plazas

Illuminate outdoor plazas, Stations, pedestrian walkways, and pedestrian walkways and areas with low height luminaires a maximum of 16 feet in height above grade. Light fixture poles shall match the Overhead Contact System (OCS) poles in material, texture and finish. Security lighting includes, at a minimum, parking facilities, plazas, Stations, roadway entrances and exits.

9.4.10.5 Vehicular Roadways

Transition and modulate the illumination level on access and egress roads to the Station "feeder" street/highway for a distance of 120 feet or a minimum or three consecutive light fixtures/poles, to eliminate any abrupt and disorienting illumination condition.

9.4.10.6 Exclusive Right of Way

Where LRT crosses an existing roadway or highway, which is an LRT-roadway interface, the illumination level shall be per ANSI/IES RP-8, *Roadway Lighting* and per the AHJ, but not less than 5.0 foot-candles (fc) to identify the LRT crossing and provide visual acuity of vehicle and pedestrian traffic.

9.4.10.7 Underground Stations and Tunnels

Provide illumination of tunnel Guideway per NFPA 130. Provide an average-to-minimum uniformity ratio per APTA and NFPA 130. Provide tunnel portal daytime supplemental lighting per AREMA, and NFPA 130.

Provide tunnel lighting system controls to continuously operate under automatic and manual modes, and where portal lighting, public and non-public Station area lighting is controlled by an astronomical time clock and photocell.

9.4.10.8 Control System Requirements

Control the Station public area lighting locally from the Station lighting control panel and remotely from the OCC. Control pedestrian walkway lighting automatically with an astronomical time clock and photocell.

9.4.10.9 Capital Crescent Trail

In addition to the requirements for lighting at the Capital Crescent Trail entrances Concessionaire shall provide all conduit and handboxes to accommodate future lighting of the entire length of the trail. Provide 4-inch schedule 80 rigid PVC conduit trenched along the length of the trail. Handboxes shall be spaced every 100-feet.

9.4.11 Illumination Levels

9.4.11.1 Capital Crescent Trail (CCT)

Illumination of the CCT shall be coordinated with Montgomery County where the following illumination requirements shall be provided:

- illuminate CCT entry and exit locations and underpasses (i.e. under East West, under Jones Mill) per IESNA publication RP-8-00 Roadway Lighting, at 2.0 foot-candles horizontal luminance, 1.0 foot-candles at 4.9 feet vertical luminance, with 4.0:1 horizontal uniformity ratio; and
- areas of the CCT where security is a concern, i.e., at bridge underpasses and adjacent to or between retaining walls, Illuminating Engineering Society (IES) recommendations for "exclusive pedestrian underpasses" shall be provided. Provide an average horizontal luminance level of 10.0 foot-candles in the day and 4.0 foot-candles at night and an average vertical luminance level of 5.0 foot-candles in the day and 2.0 foot-candles at night (for facial recognition).

Pedestrian lighting fixtures at entrances to the Capital Crescent Trail shall be as described in the M-NCPPC Bethesda Streetscape Plan “Streetscape Concept, Materials, Details and Contracts” dated May 2007 with locations as follows:

- “Bethesda Lantern” at Pearl Street;and
- “Washington Globe” at all other locations.

9.4.11.2 Average Maintained Illumination Levels

Provide average maintained illumination levels per Exhibit 9.1 and 9.2 unless higher illumination levels are required by APTA Security Lighting for Transit Passenger Facilities, APTA SS-SIS-RP-001-10; APTA Security Lighting for Nonrevenue Transit Facilities, APTA SS-SIS-RP-002-10; IES, codes, standards and AHJ.

Exhibit 9.1 – Underground/Aerial Station - Public Area Illumination Levels		
Underground/Aerial Station Public Area	Illumination Level (Avg. FC)	Max/Min (Ratio)
Street Level Exterior Canopy	10	6:1
Street Level Entrance (threshold)	20	6:1
Street Level Entrance Lobby	20	6:1
Street Level Entrance Walls	10	6:1
Escalators/Elevators	30	6:1
Station Control Center &Ticket Offices	40	6:1
Fare Array	30	6:1
Mezzanine Floor	15	6:1
Mezzanine Vertical Surface	10	6:1
Corridors and Passageways	15	6:1
Platforms – General	15	6:1
Platforms – Edge	20	6:1
Platforms – Walls	10	6:1
Guideway – Walls	10	6:1
Ancillary Areas	15	10:1
Ticketing – Public Transaction Counter	40	6:1
Ticketing – TVM's & Validators (Vertical)	20	6:1

Note: If the Max/Min ratios recommended in the current IES handbook for Exhibit 9.1 areas are more restrictive, then IES handbook ratios prevail. Otherwise, Exhibit 9.1applies.

Note: FC values are measured at the grade/Platform horizontal plane for Stations and 30 inches above the finished floor for OMF.

Exhibit 9.2 – At-grade Stations & Facilities - Public Area Illumination Levels		
Public Station Areas	Illumination Level (Avg. FC)	Max/Min (Ratio)
Exterior		
Bus Platforms (Loading/Unloading)	5	15:1
Park & Ride	3	15:1
Kiss & Ride	3	15:1
Bicycle Stands	1	15:1
Walkways	2	10:1
Ramps and Bridges	2	10:1
Tunnels and Passageways (Public & Non-Public)	5	10:1
At-Grade Crossing	2	10:1
Platforms	5	10:1
Pedestrian Track Crossing	3	10:1
Parking		
Open Parking: Parking Lots	1	15:1
Vehicle Access/Parking Circulator	2	10:1
Covered Parking: Entrance, Day	50	10:1
Covered Parking: Entrance, Night	25	10:1
Traffic Lane	2	10:1
Ramps Basic – Day	2	10:1
Ramps Basic – Night	1	10:1
Parking Areas (Basic)	2	10:1
OMF Lyttonsville Staff & Visitor Vehicle Parking	1	10:1
OMF Glenridge Staff & Visitor Vehicle Parking	1	10:1
OMF Lyttonsville LRV Storage and Movement Tracks	1	10:1
OMF Glenridge LRV Storage and Movement Tracks	1	10:1

Note: If the Max/Min ratios recommended in the current IES handbook for Exhibit 9.2 areas are more restrictive, then IES handbook ratios prevail.

Note: FC values are measured at the grade/Platform horizontal plane for Stations and 30 inches above the finished floor for OMF.

9.4.12 Exit Lights

Provide LED exit signs in accordance with applicable codes and regulations, including NFPA 1, NFPA 101, IBC and OSHA regulations. Provide architectural grade exit signs in locations visible to the public.

9.4.13 Ramps, Stairs and Escalators - Emergency Lighting

Provide emergency lighting per NFPA 1, NFPA 101 and 130. Install and maintain emergency lighting per *Emergency Systems* section of NFPA 70, where sustained illumination level of 3 foot-candles (fc) is provided at ramps, stairs and escalators, as measured at the horizontal plane of the walking surface. Concentrate illumination at the top, intermediate and bottom landings at ramps, stairs and escalators. Connect newel and comb lighting on steps to emergency power circuits. Provide escalator service lighting where the service lighting is operable during maintenance.

9.4.14 Calculations

9.4.14.1 Lighting

Concessionaire shall perform interior and exterior lighting calculations that include Lamp Mean Lumens, Lamp Loss Depreciation of 64 percent, Uniformity, and other factors as listed in the Illuminating Engineering Society (IES) *Lighting Handbook*. Provide point-by-point calculation per IES *Lighting Handbook* and selected software.

9.4.14.2 Short Circuit

Provide short-circuit calculations based on short-circuit capacity in mega-volt amperes, which Concessionaire shall obtain from the electrical service provider.

9.4.14.3 Voltage Drop

Provide feeder voltage-drop calculations for feeders 100 feet and longer. Provide motor circuit calculations based on 90 percent lagging power factor and voltage drop limited to 3 percent. Voltage drop for the fan shafts and Underground Stations shall be limited to 2 percent from the secondary unit substation to service entrance switchboard/switchgear. Provide a maximum total voltage drop for feeders plus branch circuits of 5 percent.

9.4.15 Lightning Protection

Provide a lightning risk assessment to be performed per NFPA 780. Provide lightning protection per NFPA 780, *Standard for the Installation of Lightning Protection Systems* (previously the *Lightning Protection Code*). Provide lightning protection for buildings and structures that are more than 14 feet above grade.

9.4.16 Demand Factors

Utilize demand factors in Exhibit 9.3 for selecting switchboard feeder breakers, panelboards, feeders, and transformers.

Exhibit 9.3 – Demand Factors

Application	Demand Factor
Lighting and Signs	1.25 x Connected Load
Emergency Lighting	1.25 x Connected Load
Communications Systems	1.0 x Connected Load
Escalators	0.8 x Connected Load
Elevators	1.0 x Connected Load
Other HVAC Equipment	1.0 x Connected Load
Emergency Ventilation Equipment	1.0 x Connected Load
Chiller Plant	0.8 x Connected Load
Drainage Pumps and Ejectors	0.5 x Connected Load
Convenience Receptacles in office and administrative areas	1st 10 kVA @100%, Remainder over 10 kVA @ 50%
Convenience Receptacles in other areas	1.0 x Connected Load

Concessionaire shall provide all required exterior lighting, site lighting, parking lighting, and exterior equipment, including motorized gates and security booth in support of the OMF functions.

9.4.17 Equipment and Material Requirements

9.4.17.1 Electrical Service – Normal Utility Power

Provide, in collaboration with the Utility Owner, incoming electrical services and materials that are compliant with the written and published requirements of the Utility Owner.

9.4.17.2 Primary Medium-Voltage Service (12.47 kV to 34.5 kV)

In collaboration with the Utility Owner, (medium-voltage) provide primary service for facilities with an electrical demand exceeding 3000KVA. Provide a concrete-encased underground raceway system inclusive of conduit support and separation stanchions and reinforcement steel for incoming MV feeder(s). Size feeders for a maximum of 2 percent voltage drop and 25 percent spare capacity. At manholes and switchgear equipment, provide arc-proofed exposed medium-voltage cables.

Provide surge arresters per IEEE C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)*, distribution class, metal-oxide-varistor, and comply with NEMA LA 1, *Surge Arresters*.

Provide secondary unit substation(s), consisting of MV load interrupter switches, step down transformers, low-voltage switchgear/switchboard distribution at 480/277V three-phase, with metal-enclosed switchgear that is Utility Owner approved.

9.4.17.3 Secondary Low-Voltage Service (480/277V)

Provide secondary 480/277V, three-phase, four-wire service, where the secondary incoming feeders from the Utility Owner are terminated in the main circuit breaker(s) of the service-entrance-rated switchgear/switchboard.

9.4.17.4 Switchgear/Switchboard(s)

Provide 480/277V switchgear/switchboard main breakers, tie breakers, and distribution feeder breakers. Interlock the main circuit breakers and tie breaker so that the tie circuit breaker shall close automatically when either one of the main breakers opens on loss of power. Provide the tie breaker to open automatically after restoration of normal power to the main breaker.

9.4.17.5 Secondary Service (Low-Voltage, Below 600 V)

Provide surge protection device /transient voltage surge suppression CRIsystem for low-voltage power distribution equipment, per NFPA 70 and UL 1449.

9.4.17.6 Electrical Rooms

Provide electrical rooms sized to provide working clearances and area for installation and maintenance of equipment per NEC. Locate electrical rooms to minimize secondary feeder voltage drop and provide a 2-hour fire rating enclosure and two egress doors per the NEC.

9.4.17.7 Motor Control Centers

Provide the Motor Control Centers (MCC) in modular arrangement mounted in vertical sections of the MCC per National Electrical Manufacturers Association (NEMA) ICS 18 and UL 845. Concessionaire shall provide Motor Control Centers and individually mounted motor starters per NEMA 1, 4, and 12.

9.4.17.8 Controller Units

Provide combination controller units with motor controllers up to Size Three and molded-case circuit breakers UL489 on draw-out mountings with connectors that automatically line up and connect with vertical-section buses, while being racked into their normal, energized positions.

9.4.17.9 Power Distribution Panelboards

Provide distribution panelboards NEMA PB1-power and feeder-distribution with thermal magnetic circuit breaker.

9.4.17.10 Lighting and Appliance Panelboards

Provide lighting and appliance panelboards NEMA PB1-lighting and branch-circuit with thermal magnetic circuit breaker.

Exhibit 9.4 – Panelboard Designation	
Service	Recommended Panel Designation
480/277 Volts	
Lighting Panel	LP1, LP2, LP3, and so forth
Distribution Panel	DP1, DP2, DP3, and so forth
Motor Control Center	MCC1, MCC2, MCC3, and so forth
Emergency Panel	E1, E2, E3 and so forth
208/120 Volts	
Convenience Outlet and Misc. Power	RP1, RP2, RP3 and so forth
Distribution Panel	DD1, DD2, DD3 and so forth
Emergency Panel	EE1, EE2, EE3 and so forth

9.4.17.11 Interior Feeders and Branch Circuits

Provide copper feeders installed in exposed rigid galvanized steel conduit or embedded PVC conduit. Provide insulation using THWN and conductors sized per NEC.

9.4.17.12 Enclosures

Provide Indoor Enclosures – NEMA 250 Type 1 and Outdoor Enclosures – NEMA 250 Type 3R.

9.4.17.13 Power Cables and Wires

Provide wire and cables that are UL listed. Provide silicone rubber SF-2 rated 200°C fixture wires. Provide feeder, branch circuits, and control circuit conductors in annealed copper. Conductors No. 8 AWG and larger shall be stranded. Provide low smoke cable LSZH XHHW-2 or RHW-2 cable for all electrical distribution. In Underground Stations and tunnels provide LSZH type RHW-2 cable for emergency ventilation systems, and utilize LSZH type XHHW-2 cable at OMF. Provide cable and wire insulation per NFPA 70, the *National Electric Code* (NEC) where insulation is moisture- and heat-resistant with temperature ratings corresponding to the conditions of application, but no lower than 194°F (90°C). Provide wire and cable for power circuits to emergency equipment in conformance with the flame propagating requirements of NFPA 130. All emergency related system conductors shall be protected from physical damage and transit system fires by embedment or concrete encasement.

9.4.17.14 Manholes, Pull Boxes, and Vaults

Provide Manholes or pull boxes with cable pulling irons, cable racks, ladder and/or rungs and accessible ground rods. Provide aerial structure cableways of metal individually grounded by means of ground cable(s) welded to the cableway every 10 feet and at intersections and extend the ground cable to the nearest manhole. Provide separate electrical power manholes and underground cableways/conduits from the signals and communication manhole cableways/conduits.

9.4.17.15 Raceway Material

Where conduit runs exceed 270-degree bend limitation, or where conduit runs are longer than 100 feet, provide detailed engineering drawings which indicate conduit routing in ceilings, walls, and floor slabs.

9.4.17.16 Line Section Material

Provide wayside cables protected by an enclosed conduit, cableway or cable trough. Provide cableway with removable covers which will support human weight without deflection or damage. No facility power cable is to be placed in a wayside cableway. When track is at ground level, provide below-grade or direct burial conduits in concrete duct banks. Provide manholes, pull boxes, junction boxes, and cable vaults spaced per cable pulling requirements, applicable codes, and operational requirements without exceeding cable pulling tensions. Routing of Utility Owner feeder conduits within ROW shall not physically or electrically impact the transit system duct bank.

9.4.17.17 Light Fixture Lamps

Provide lamps that have a color rendering index of 80 and above.

9.4.17.18 Conduit Identification

Provide a conduit schedule and identify conduits and conductors and clearly indicate the conduits and conductors on the engineering drawings. Provide installation requirements for pull wires and permanent identification of each conduit and conductor.

9.4.18 Electrical Design Submittals

Concessionaire shall submit Electrical Design for Review and Comment at the following stages and including the following minimum content:

- Preliminary Design:
    - Electrical Design Criteria and Basis of Design Report;
- Intermediate Design:
    - Intermediate design drawings;
    - power and lighting load, short circuit, voltage drop calculations;
    - single line drawings and transformer locations;
    - standard details and requirements;
    - horizontal and vertical routing of underground ductbanks;
    - ductbank conductor type, location and size, including conduit schedules and cable/wire schedules;
    - lighting point-by-point calculations and plan distribution of foot-candle;
    - lighting schedule including type, mounting heights and methods;
    - samples of products exposed to view in public areas; and
    - updated information from Preliminary Design.

- Final Design:
    - Final Design drawings;
    - Product Data Sheets for all materials, products and components;
    - Material Safety Data Sheets;
    - power service applications; and
    - updated information and samples from Intermediate Design.

9.4.19 Energy Management Plan

Concessionaire shall develop an Energy Management Plan with the goal of minimizing Project energy costs by controlling energy consumption consistent with the requirements of the Contract Documents. Concessionaire shall select energy-efficient equipment and provide means to monitor and report energy usage on a continuous basis.

Concessionaire shall submit the Energy Management Plan for Review and Comment at Preliminary Design.

Concessionaire shall update the Energy Management Plan to reflect all policy and design revisions and submit for Review and Comment at Final Design.

9.4.19.1 Design for Energy Efficiency

In developing an energy-efficient Project, Concessionaire shall identify the major energy use centers in order that conservation efforts can be consistently applied on a cost to benefit basis in terms of design effort and specificity of detail.

Traction Power is the major energy use. LRV operating voltage, substation power factor, LRV acceleration, LRV speed, propulsion control system, and LRV weight will impact energy use. LRV design coupled with the Operational requirements and load management monitoring shall be important determining factors for the final design of the power distribution system. The Energy Management Plan shall consider the Concessionaire's anticipated level of Traction Power regeneration (if applicable).

Concessionaire shall provide Stations and Facilities that minimize energy consumption. Concessionaire shall address heating, cooling, and lighting thresholds, insulation values, energy-efficient equipment, and the use of automatic sensors, motion detectors, thermostats and similar devices with programmable computer override.

Concessionaire shall evaluate the projected total power consumption and maximum power demand over a 24 hour, 15 minute, and 30 minute periods assuming normal weekday operations for the proposed design in comparison to the base case.

9.4.19.2 Monitoring, Control and Reporting of Energy Use

Concessionaire shall develop an Energy Management System for monitoring, controlling and reporting energy use. Traction Power and Electricity for Other Uses shall be tracked and reported separately. The Energy Management System shall be a computer-based, real time usage monitor, display, alarm, recording and reporting system.

The Energy Management Plan shall describe the sources of electrical power and the means of load control. The Energy Management System shall monitor electrical load at all delivery points where load control capability exists. The Energy Management System shall annunciate whenever the power demand at any delivery point or group of delivery points (conjunctive demand) is at 85 percent of the targeted peak demand, and a load control operating procedure shall be required to manage the condition.

The Energy Management Plan shall take into consideration abnormal events such as loss of power or failure of individual TPSS and [Recovery Operations], Procedures shall be included to evaluate performance of the system under these circumstances and institute revisions to improve performance.

The Energy Management Plan shall also account for the transition of electricity payment responsibility from Concessionaire to Owner at the initiation of Trial Running or permanent use of electricity, whichever occurs at the latest date.

9.5 Plumbing Requirements

9.5.1 LRV Drive-Through Train Wash Facility

Provide domestic water and reclaimed water connections to the LRV wash unit. The domestic water connection shall be provided with a reduced pressure backflow preventer and digital metering. This meter shall allow for the local and remote readings to be taken. Pipe connections shall be sized per manufacturer’s recommendations. Provide makeup water and remote capable readout, sub-meter where readout is at the Train wash facility control panel. Provide trench drains to collect wash water for return to the reclaim unit.

Provide plumbing connections to the reclaim system pumps, detergent tanks, and overflow drain connections for equipment operation.

9.5.2 Paint Spray Booth

Provide separate breathable compressed air and shop compressed air, with pressure regulators and separate piping distribution system to the paint spray booth. Provide redundant oil-free compressors and moisture dryer equipment for breathable and shop compressed air systems.

9.5.3 Drainage - Underground Stations, Tunnels and OMF

Provide trench drains 50 feet apart and parallel to tracks along the LRV’s drip line, and between tracks. Floor drains for specific shop drainage requirements, and where trench and individual floor drains are classified as industrial waste, require separation from the OMF stormwater system.

9.5.4 Drainage - Above-Grade Stations

Provide deck drains and/or trench drains with epoxy-coated, cast iron, heel-proof grates to collect surface drainage from Platforms and open concession areas.

9.5.5 Drainage - Guideway

Provide Guideway drains inside tunnel Stations and subsurface line sections with concrete drainage slots, concrete catch basins, and concrete manholes with cast-iron gratings.

9.5.6 Drainage - Subsurface

Provide gravity flow drainage. Where collection points are level or below the elevation of gravity outfalls, provide pumping stations. Station entries, ventilation shafts and similar openings shall not be conveyed to the Guideway drainage systems (Exception: Drainage from Station Platforms, tunnel Stations and tunnel seepage water). Subsurface drainage shall be intercepted before it enters into the track drainage system and diverted to a public stormwater system.

9.5.7 Drainage - Location

Provide drainage slot inlets or sumps in Stations at an interval of 100 feet along each Guideway. Provide drainage pumps where stormwater by gravity is not feasible or possible. Provide gravity drainage from the low point under Platforms and connect to storm or track drainage system. Provide under Platform wall sleeves to ensure continuous gravity flow.

Provide a drain or sump pump at elevator pit per ASME A17.1, *Safety Code for Elevators and Escalators*. Sump pump discharge shall be per the AHJ. Per the AHJ's direction, provide a floor drain or sump pump at the escalator recess/pit when the escalator uses hydraulic fluid. Provide an automatic sump pump oil sensor as part of the escalator control system.

9.5.8 Drainage – Piping

Provide piping per the requirements in Exhibit 9.5.

Exhibit 9.5 – Drainage - Pipe Sizes

Diameter (inches)	Material	Use
4	Extra-Heavy-Weight Cast Iron	Drain Connections in Structural Walls and Floor
6	Extra-Heavy-Weight Cast Iron	Drain Connections in Structural Walls and Floor
6	Extra-Heavy-Weight Cast Iron	Branch Connections in Structures and Underground
8	Polyvinyl Chloride (PVC) Sewer Pipe Schedule 80	Station Track Drain and Subsurface Line Track Drainage
10	PVC Sewer Pipe Schedule 80	Station Track Drain and Subsurface Line Drainage

Note: Drainage piping to provide a minimum velocity of 2.5 feet per second with the pipe flowing 50 percent full.

9.5.9 Drainage - Track Pumping Stations

Provide submersible track drainage pumping stations at all track low points where gravity drainage to the public storm sewer system cannot be achieved of three pumps, where each pump is sized for 100 percent of calculated total demand. Provide one seepage water interceptor pump at each track drainage pumping station. Provide water level controls inclusive of remote high water indication, electric "on-off-automatic" pump switch, lead lag control, electric alternators, level rise indicator, and connection to street mains.

Pumps shall be the non-clog sewage, submersible, wet basin type. Impellers shall be grinding, with clearance adequate to pass 3-inch solids.

Provide pumps with total dynamic head that is based on the static and friction head requirement calculated for each location. Determine friction head based on two pumps operating. Pump head calculations shall factor in the existing stormwater capacity and where the existing capacity is subject to overcharging, the pump discharge head shall be increased to exceed the overcharge head.

Provide non-overloading, explosion-proof motors for Guideway drainage pumps. Motors ½ HP or less shall be provided with 120V single-phase power supply and motors larger than ½ HP shall be provided with 480V three-phase power supply.

Provide local high-water alarm, remote high-water level condition, and local manual control and testing.

9.5.10 Sewage Ejection Systems

Provide triplex vertical dry pit sewage ejector pumps, each rated at 100 percent design load capacity at all locations where a gravity connection to a public sanitary sewer system cannot be achieved. Provide dry pits with hot-dipped galvanized steel access ladder and hot-dipped galvanized steel grating. Discharge effluent to a code compliant wet well that is sealed, vented and accessed through a gas-tight manhole.

9.5.11 Potable Cold Water Service

Provide domestic water service to each facility, sized for the total peak demand. Locate service immediately inside Station or building wall and provide a main shutoff valve, backflow preventer and a meter with remote reading capability. Provide Underground Stations with a minimum 2-inch diameter service connection. Provide water supply fixture unit requirements per the Plumbing-Heating-Cooling Contractors Association's *National Standard Plumbing Code*.

9.5.12 Domestic Water Heaters

Provide electric or gas-fired water heaters for facilities with lavatories, showers and service sinks. The heaters shall be sized for the plumbing fixture demand, shall be UL-Listed and shall bear the American Society of Mechanical Engineers (ASME) stamp of approval. Provide a hot water recirculation system when a fixture(s) is 100-feet or further from the water heater and include an aquastat in the return piping before the water heater. Provide branch isolation valves complete with access panels when valves are located within walls and non-lay-in ceiling systems. Insulate all hot water pipes.

9.5.13 Plumbing Fixtures for Persons with Disabilities

Provide ADA compliant fixtures. Accessible fixtures, including showers, lavatories, urinals, water coolers, and water closets per ANSI codes, IBC and ADA law.

9.5.14 Natural Gas System

Provide incoming main, service meter and service regulator coordinated with natural gas supplier. When meter and regulator are supplied by the local natural gas company, install these items per their written requirements of the local natural gas company.

9.5.15 Area Drains

Provide area drains at Station and building entrance areas, emergency exits, exterior elevators, and escalators where trench drains are unsuitable or unacceptable to Owner.

9.5.16 Sanitary and Vent Systems

Provide sanitary and vent systems to collect and convey sanitary sewage to the public sanitary sewer system from Stations, buildings, and subsurface locations.

9.5.16.1 Sanitary

Provide gravity drains for mechanical rooms, mop sinks, lavatories, water closets, and other sanitary waste sources, and extend to an existing public sanitary sewer system. Where a gravity system is not practical or possible, provide a sewage ejector pit and pump effluent to the nearest public sanitary sewer system with an electric duplex ejector pump, or a non-clog duplex vertical centrifugal wet sump pit pump. Air gap mechanical equipment drains and provides HVAC drainage to storm water system. Provide oil separators where required by code and AHJ.

9.5.16.2 Vents

Provide vent systems for soil and waste sized per the International Plumbing Code and per the AHJ. Street level vent risers serving underground facilities shall terminate in planting areas and shall be provided with rodent-proof non-corrosive caps secured with matching material tamper-resistant fasteners.

9.5.17 Stormwater System

When stormwater is collected and used for use in a gray water system, the system shall consist of a storage tank(s), UV filtration system, booster pumps, overflow discharge and a distribution system completely separate from the potable water system. A bypass from the potable domestic water system shall be provided for times when there is inadequate gray water. The bypass shall be protected by a reduced-pressure principle backflow prevention assembly. Identify and label gray water system as non-potable for Train wash makeup water use only.

9.5.18 Piping and Valves

9.5.18.1 Piping

Provide pressure piping systems per ASME B31, *Pressure Piping.* Provide pipe fittings, flanges, valves, accessories and comply with the requirements of AMSE B16, *Fittings and Valves*.

Piping in public areas of Stations shall be concealed from view. Battery room drainage piping shall be chemically-resistant and discharge shall be neutralized prior to connection to the sanitary drainage system.

9.5.18.2 Pipe and Fittings

Provide Underground Station track drainage and subsurface line track drainage pipes and waste and soil pipes of service-weight cast iron pipe with hub and spigot fittings. Vent piping shall be service-weight, cast iron, no-hub pipe with heavy-duty stainless steel couplings. Embedded cold water piping shall be hard-drawn copper type K tubing. Non-embedded hot and cold water piping shall be hard-drawn type L copper tubing with wrought brass or copper fittings. Type L and K copper shall be per ASTM B88, *Standard Specification for Seamless Copper Water Tube*. Water service pipe two (2) inches and larger shall be ductile iron with dual mechanical-joints for pipe, and type K copper with wrought fittings for pipe sizes less than two (2) inches in diameter. The minimum diameter of waste pipe installed underground or embedded in structural slabs shall be four (4) inches. Connect pipes of dissimilar metals and metallic pipe entering a building with dielectric couplings. Force mains shall be of ductile iron pipe with joints per AHJ.

9.5.19 Plumbing Design Submittals

Concessionaire shall submit Plumbing Design for Review and Comment at the following stages and including the following minimum content:

- Preliminary Design:
    - Plumbing Design Criteria and Basis of Design Report.
- Intermediate Design:
    - plumbing diagrams and equipment schedules; and
    - updated information from Preliminary Design.
- Final Design:

- Product Data Sheets for all materials, products and components;
- samples of products exposed to view in public areas;
- Material Safety Data Sheets; and
- updated information and samples from Intermediate Design.

9.6 Fire Protection

9.6.1 Fire Protection

Train signaling and communication rooms shall be protected by a clean agent automatic fire-extinguishing system per the Maryland State Fire Code (NFPA 1, Table 13.8), NFPA 2001, and approved by the AHJ (Note: The use of the non-aqueous alternative fire protection system shall be determined to not have a detrimental effect on equipment). Fire protection design shall permit activation automatically and manually from outside the room. Automatic activation shall be through a cross-zoned detection system.

9.6.2 Automatic Sprinklers

Concessionaire shall provide automatic sprinklers in concession areas, storage areas, trash rooms, and underside of escalators per NFPA 130. Sprinkler protection shall be provided in other similar areas with combustible loadings, except Guideways. Automatic sprinkler protection shall be installed, maintained, and tested in accordance with provisions of NFPA 130.

Water flow and trouble alarms shall be annunciated at the OCC and Station Fire Management Panel (FMP).

Concessionaire may design an alternative fire suppression system approved by the AHJ per NFPA 130.

9.6.3 Station Water Supply and Fire Hydrants

Provide Station areas with fire hydrants spaced per the AHJ in accordance with the Maryland State Fire Code (NFPA 1). Fire hydrants and water supply mains shall be per NFPA 24 and the AHJ. The hydrant system shall be in accordance with NFPA 1 or as amended by the AHJ and local jurisdictions.

9.6.4 Fire Pumps

When the existing water supply pressure is found to be inadequate, automatically controlled fire pump shall be provided per NFPA 14 and 20. If required to maintain system pressure, a jockey pump shall be provided per NFPA 20. Installation of fire pumps, jockey pumps, and associated equipment shall be per NFPA 20. If required, fire pumps shall be electrically driven and connected to a continuous power source and an emergency power generation source, and include automatic-transfer switches.

Per NFPA 20, provide Test Procedures where the fire pump is physically tested under load. Provide hose outlets to discharge the fire protection system water to the exterior of the building, Station or structure. Provide the location of testing facility that is coordinated with Concessionaire’s Project Architect and Concessionaire’s Project Civil Engineer. Concessionaire shall provide a direct connection to a stormwater inlet for the discharge hose outlet. Indirect connection to a stormwater inlet is not permitted.

9.6.5 Station Standpipe and Hose Systems

Station standpipe and hose systems shall be in accordance with NFPA 130. Standpipe and hose systems shall be tested and maintained in accordance with NFPA 25. Standpipe hose connections shall be accessible and located so that all portions of the building are within spacing requirement for class of service. Fire Hose Cabinets shall be identified in accordance with the Maryland State Fire Code, NFPA 14, and per the AHJ.

9.6.6 Aerial Stations

Design of Aerial Station standpipe and hose systems shall be in accordance with the requirements of NFPA 130 and NFPA 14.

9.6.7 At-Grade Stations

Open, at-grade Stations shall not be provided with standpipe systems.

9.6.8 Underground Stations

Design Underground Station standpipe and hose systems per NFPA 130 and NFPA 14. Provide 2½-inch hose outlet valves spaced within 150 feet of each hose valve outlet, including LRVs stopped at the Station. Provide a fire hydrant of the type approved by the AHJ at each of the following locations:

- Not more than 100 feet from each fire department connection to a standpipe system, or as approved by the AHJ.
- Not less than 40 feet from buildings to be protected or as approved by the AHJ.

9.6.9 Station Administrative Areas

Per NFPA 10 and 130, and per Owner requirements, provide sprinkler protection in administrative areas of open Stations. Per NFPA 10 and 130, provide sprinkler protection in administrative areas of enclosed Stations, and provide standpipe system coverage per NFPA 14.

9.6.10 Station Utility Spaces

Provide automatic sprinkler protection in storage areas, trash rooms, and enclosed escalator areas per NFPA 130. Unless otherwise required by code, electrical rooms shall be constructed with a minimum two-hour fire-rated assembly. Utility spaces in enclosed Stations shall be provided with standpipe system coverage per NFPA 14. Provide fire hydrants per NFPA 14 and the AHJ.

9.6.11 Fire Department Connections

Fire department connections for fire department use in supplying the standpipe system shall be located in accordance with the Maryland State Fire Code (NFPA 1) unless amended by the local jurisdiction.

9.6.12 Portable Fire Extinguishers

Per NFPA 130, portable fire extinguishers shall be provided in such number, size, type, and location as approved by the AHJ. Maintenance of the portable fire extinguishers shall be in accordance with NFPA 10.

9.6.13 Fire Protection Design Submittals

Concessionaire shall submit Plumbing Design for Review and Comment at the following stages and including the following minimum content:

- Preliminary Design:
  - Fire Protection Design Criteria and Basis of Design Report.
- Intermediate Design:

- o Fire Protection diagrams and equipment schedules; and
- o updated information from Preliminary Design.

- Final Design:
  - o samples of products exposed to view in public areas;
  - o Product Data Sheets for all materials, products and components;
  - o Material Safety Data Sheets; and
  - o updated information and samples from Intermediate Design.

9.7 Summary of Submittals

Item	Section	Submittal	Action
1	9.3.16	Mechanical Design - Preliminary	Review and Comment
2	9.3.16	Mechanical Design – Intermediate	Review and Comment
3	9.3.16	Mechanical Design - Final	Review and Comment
4	9.4.18	Electrical Design - Preliminary	Review and Comment
5	9.4.18	Electrical Design - Intermediate	Review and Comment
6	9.4.18	Electrical Design - Final	Review and Comment
7	9.4.19	Energy Management Plan - Preliminary	Review and Comment
8	9.4.19	Energy Management Plan - Final	Review and Comment
9	9.5.19	Plumbing Design - Preliminary	Review and Comment
10	9.5.19	Plumbing Design - Intermediate	Review and Comment
11	9.5.19	Plumbing Design - Final	Review and Comment
12	9.6.13	Fire Protection Design - Preliminary	Review and Comment
13	9.6.13	Fire Protection Design - Intermediate	Review and Comment
14	9.6.13	Fire Protection Design - Final	Review and Comment

10 LANDSCAPE AND STREETSCAPE

This Section provides requirements for hardscape and softscape elements of the Project.

10.1 Overview

Concessionaire shall provide hardscape and softscape elements to meet the requirements given in this Section and as shown on the Book 4 Contract Drawings.

10.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- M-NCPPC, Montgomery County Landscape Manual
- M-NCPPC, Prince George’s County Landscape Manual
- M-NCPPC, Dept. of Parks and Recreation Facilities Guidelines
- MDE, 2000 Maryland Stormwater Design Manual, Volumes I and II
- ANSI Z60.1, American Standard for Nursery Stock
- ANSI Z133.1, Safety Requirements for Pruning Trimming, Repair, Maintaining and Removing Trees and for Cutting Brush
- Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada (L.H. Bailey Hortorium 1976)
- APTA SS-SIS-RP-007-10, Crime Prevention through Environmental Design (CPTED) for Transit Facilities
- U.S. Fish & Wildlife Service, Native Plants for Wildlife Habitat and Conservation Landscaping, Chesapeake Bay Watershed
- John Mills Parrish, Native Woody Plants of Montgomery County
- University of Maryland Extension, Native Plants of Maryland
- MDSHA Landscape Design Guide

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

10.3 Functional Requirements

10.3.1 Landscape General Functional Requirements

Concessionaire shall provide landscaping for the following functional applications.

Plantings and ornamental fencing shall be used to:

- comply with applicable regulatory requirements, including at a minimum reforestation/afforestation, SWM and water quality;
- comply with the landscape plans for Stations and special locations as shown in the Book 4 Contract Drawings (tree quantities shown on Contract Drawings may be adjusted to match Exhibit 10.1, except for replacement of existing trees removed by the Work);

- comply with the total planting quantities set forth in Exhibit 10.1;
- comply with Third Party Agreement Requirements;
- protect existing trees in the Corridor;
- discourage jaywalking;
- mitigate loss of existing plantings displaced by construction;
- enhance the environment of the Guideway segements between Stations, blending the Project improvement with the surrounding context;
- visually screen TPSSs as shown on Contract Drawings, communication/signal equipment, and other infrastructure;
- stabilize steep slopes and other disturbed areas;
- contribute to tree canopy cover and the reduction of urban heat islands; and
- control and eliminate invasive and noxious plant species identified in the counties' respective reference documents within the Project's LOD.

In all landscape applications, Concessionaire shall:

- coordinate planting with the design of surveillance systems to maintain coverage with regard to long-term growth of plant materials;
- incorporate the principles of Crime Prevention through Environmental Design (CPTED) in landscape design;
- design plantings that do not reduce or obscure the sight lines between light rail vehicles, rubber-tired vehicles or pedestrians; and
- set trees back from track center lines and OCS poles not less than 20’.

10.4 Design Requirements

10.4.1 Project-wide Planting Quantities

Concessionaire shall provide plantings at Stations, maintenance facilities and along the Project Corridor in accordance with the functional requirements set forth in Section 10.3.1, specific location and arrangement where shown on the Book 4 Contract Drawings and the greater of the following:

- applicable regulations; and
- the following minimum quantities shown in Exhibit 10.1 (tree quantities shown on Contract Drawings may be adjusted to match Exhibit 10.1, except for replacement of existing trees removed by the Work, reforestation requirements as set forth in Section 10.4.4, and street trees as set forth in Section 10.4.8).

At the time of installation, plantings shall meet the minimum sizes given in the Exhibit 10.1.

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Exhibit 10.1 – Project-wide Minimum Landscape Quantities

		Bethesda to CC West	Country Club	CC to Rock Creek Park	Rock Creek Park to CSXT	CSXT to Silver Spring	Silver Spring to Manchester	Manchester to Piney	Piney to County Line
Plant Type/Item	Specification / Minimum Size	100+00-148+00	148+00-165+00	165+00-210+00	210+00-265+00	265+00-326+00	326+00-406+00	406+00-449+00	449+00-506+50
Shade Tree	2-inch caliper or as required by Law	17	40	27	92	129	0	0	0
Upright Shade Tree	2-inch caliper or as required by Law	0	0	7	0	0	0	0	0
Evergreen Tree	6-foot height	38	39	82	55	57	0	0	0
Flowering Tree	6-foot height	44	19	107	99	70	0	0	0
Shrub	24-inch height/spread, min. #3 container	928	563	1320	448	1006	724	679	2124
Groundcover / Perennial / Ornamental Grass	# 1 container @ 18" on center spacing (average)	7,267	3,305	8,088	19,243	8,313	4,162	2,788	3,727
Revegetation	Spacing and size per MDDNR Reforestation Standards - 5' height/ #3 container minimum	0.26 ac	0	0	0.42 ac	0.32 ac	0	0.33 ac	0
Vines	SP4 container	220	0	250	378	130	83	36	0
Benches (Trail)	6' long metal	14	0	8	10	8	0	0	0
Trash/Recycling Receptacles (Trail)		10	0	4	6	6	0	0	0
Trail Signs		7	0	4	5	6	1	0	0
Free-Standing Green Screen (SF)	Height varies	0	0	0	3,400	8,600	0	0	0

		County Line to West Campus	West Campus to Paint Branch	Paint Branch to College Park Metro	College Park Metro to Riverdale	Riverdale to Beacon Heights	Beacon to Glenridge	Glenridge Y&S	Glenridge to New Carrollton
Plant Type/Item	Specification / Minimum Size	506+50-586+50	586+50-668+00	668+00-692+00	692+00-782+00	782+00-831+50	831+50-875+50	875+50-902+00	902+00-963+14
Shade Tree	2-inch caliper or as required by Law	0	277	0	0	0	0	0	0
Upright Shade Tree	2-inch caliper or as required by Law	0	59	0	0	0	0	0	0
Evergreen Tree	6-foot height	0	34	0	0	0	0	0	0
Flowering Tree	6-foot height	0	26	0	0	0	0	0	0
Shrub	24-inch height/spread, min. #3 container	1,462	634	65	739	794	207	1016	494
Groundcover / Perennial / Ornamental Grass	# 1 container @ 18" on center spacing (average)	3,717	3,611	0	6,225	2,789	246	10,756	498
Revegetation	Spacing and size per MDDNR Reforestation Standards - 5' height/ #3 container minimum	2.07 ac	0	0	2.88 ac	0.93 ac	1.53 ac	3.03 ac	1.25 ac
Vines	SP4 container	0	0	0	0	0	0	0	0
Benches (Trail)	6' long metal	0	0	0	0	0	0	0	0
Trash/Recycling Receptacles (Trail)		0	0	0	0	0	0	0	0
Trail Signs		0	0	0	0	0	0	0	0
Free-Standing Green Screen (SF)	Height varies	0	0	0	0	0	0	0	0

Exhibit 10.1 notes:

- all stationing taken along Track 1; and
- plant quantities shown in this chart are minimum total quantities per corridor section indicated, and shall be provided in addition to green track (if used), reforestation requirements, storm water management facility plantings, street trees, mitigation as required by Part 2B, Section 10.4.4 of the Technical Provisions and elsewhere in the Contract Documents.

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10.4.2 Capital Crescent Trail

Concessionaire shall design landscaping for the Corridor through the Capital Crescent Trail in accordance with the prototypical design shown in the applicable Contract Drawing. Concessionaire shall provide landscaped buffer as indicated on the applicable contract drawing whether or not a bioswale is provided for SWM purposes.

10.4.3 Service Yards/Shops

Concessionaire shall screen light rail service yards and shops from adjacent land uses to minimize visual impacts on neighboring properties. Screening shall include a mixture of evergreen trees, shade trees, shrubs, and vegetated berms and ornamental fencing. Concessionaire shall select plant varieties that are compatible with nearby plantings and other adjacent site improvements.

10.4.4 Existing Forest, Tree and Landscape Resources

Concessionaire shall design and construct the Project so as to preserve existing forest, tree, plant materials and landscape resources to the greatest extent possible.

Every reasonable effort shall be made by Concessionaire to minimize the cutting or clearing of trees and the protection of remaining trees. Concessionaire's Maryland licensed tree expert shall, at a minimum:

- evaluate the forest and trees along and within the Project ROW prior to construction;
- identify forest and trees that must be removed, those that will remain, and those that require protection;
- develop plans, specification and procedures for tree protection including, at a minimum physical protection of root zones, selective pruning, root pruning, and stimulation of root growth;
- oversee forest and tree removal and protection during Construction Work; and
- periodically inspect trees during Construction Work and oversee any additional removals or protective measures.

Concessionaire's Design Documents shall illustrate the critical root zones of existing trees to remain as defined by the Maryland Department of Natural Resources. Concessionaire shall be responsible for preserving trees identified for preservation. Trees that die, or are displaced by construction, shall be replaced by Concessionaire at a one-inch caliper to one-inch caliper rate of replacement.

10.4.5 Stormwater Management

Planting design shall comply with the requirements of COMAR Title 26 Department of the Environment, Subtitle 17 Water Management, Chapter 02 Stormwater Management and MDE Maryland Stormwater Design Manual.

10.4.6 Reforestation

Concessionaire shall be responsible for meeting the requirements of the Maryland Forest Conservation Act, the Maryland Reforestation Law, and the Roadside Tree Law as applicable.

10.4.7 Island/median treatments

Concessionaire shall provide island/median treatments where as required by the Book 4 Contract Drawings, at medians associated with pedestrian crossings, and at median locations of full and partial intersecting streets, in accordance with the following:

- provide 3 gal min. shrubs planted at 3’ O.C. and/or 1 gal;
- groundcover/perennials/ornamental grasses planted at 18” O.C.;
- plant medians for a minimum length of 30’ to 50’ in either direction of the pedestrian crossing points or 30’ to 50’ of the length of medians on either side of intersecting streets. Medians shall be planted in their entirety if less than 50’ is remaining after planting the first 30’ to 50’; and
- plantings shall be selected to be complimentary to the area context and be selected from the Maryland State Highway Administration Preferred Plant List.

10.4.8 Street Trees

Concessionaire shall provide street trees where indicated on drawings and along streets at a 30’ to 35’ O.C. spacing as space permits. Where a uniformly spaced row of street trees cannot be provided Concessionaire shall plant trees randomly, as space permits. Concessionaire shall provide 2” caliper shade trees as a first priority and flowering/understory trees as a second priority where vertical and horizontal restrictions limit the use of shade trees.

10.4.9 Green Track

If provided by the Concessionaire, green track shall contain a mix of at least five different varieties of broadleaf and fine leaf, and deciduous and semi-evergreen sedums and succulents that are appropriate to the horticultural zone and micro-climates of the installation locations.

10.4.10 Site Preparation

Concessionaire shall grade cut and fill conditions to provide landforms that are natural in appearance, blend with the adjacent landscape and built environment, provide positive drainage, and minimize opportunities for erosion. Grading shall accommodate the retention of non-invasive existing vegetation and support proposed plantings. Slope changes shall be rounded and smooth to appear natural. Slopes to be routinely mowed shall be 4:1 maximum.

10.4.11 Studies & Reports

The Concessionaire shall comply with the Maryland Nutrient Management Law and regulations. Prior to performing turf establishment and/or sodding, the Concessionaire shall sample and test soils for texture, pH, organic matter, phosphorous and potassium needs in accordance with the procedures identified in the MDSHA MSMT 356 “Sampling and Testing Soil for Nutrient Management Plan”.

The procedures described in the above MSMT 356 shall be used in determining if stockpiles are suitable for use as furnished topsoil. The Concessionaire shall use the soil test results and obtain the services of a Maryland certified Nutrient Management Consultant to develop a Nutrient Management Plan for nitrogen, phosphorus, potassium, limestone, organic matter and sulfur input levels for the Project. Concessionaire shall submit the Nutrient Management Plan for Review and Comment. Concessionaire shall submit the Soil Test Results for Information.

10.5 Material & Equipment Requirements

10.5.1 Plant Selection Requirements

Concessionaire shall utilize the Codes and Standards in developing plant palettes.

Concessionaire plant selection shall be based on the intended plant function in the landscape and site conditions. Plant selection shall utilize hardy, drought-tolerant and low maintenance materials capable of surviving in the harsh urban conditions in which they will be planted.

Plants shall be selected that can survive on local rainfall after an initial one year establishment period.

Plant material shall be characterized as “hardy” for use in U.S. Department of Agriculture Climate Zone 7A.

- Plant material selections shall emphasize native species and shall not include invasive species.

Other considerations for plant selections shall include:

- suitable size and form for the proposed location;
- resistance to disease and pests;
- tolerance to drought;
- tolerance of harsh urban conditions including heat, pollutants, and salt spray;
- requirements for soil and drainage conditions;
- trees proposed for Station areas shall have an upright habit and be fruitless and high-branching;
- plant materials located at Station Platforms and immediately around the Station area shall be selected to survive in harsh urban conditions which include exposure to vehicle exhaust, full sun, winds, and winter salting; and
- plant materials for bio retention basins and other frequently wet areas shall be selected so as to withstand periods of inundation in addition to drought conditions.

10.5.2 Product Requirements

10.5.2.1 Benches

Concessionaire shall provide benches where indicated on the drawings. Benches shall be durable cast metal 6’ backed benches with armrests, silver color powder coated from one of the following manufacturers or equivalent:

- Landscape Forms. Model: “Stay”;
- Forms + Surfaces. Model: “Balance”; and
- Victor Stanley. Model: “Lily”.

10.5.2.2 Specialty Paving

Concessionaire shall provide unit pavers where indicated on the drawings.

Where new pavers are indicated next to existing adjacent pavers, Concessionaire shall provide a product to match existing adjacent pavers.

When no adjacent pavers exist, Concessionaire shall provide a minimum application of concrete unit pavers complying with ASTM C 936/C 963M and ASTM C 67over a concrete base with bituminous sand setting bed and sand joints. Unit pavers shall be 2-3/8” thickness by a minimum of 4” x 8” in pedestrian applications. Pavers that will carry vehicular loads shall be 3-1/8” thick. Eighty percent of paver areas are to be a blend of colors ranging from light to medium gray with 20 percent of the area to be a border or accent color to be selected from the manufacturer’s standard colors. Finish shall be a sand blast texture. Product shall be selected from one of the following manufacturers or equivalent:

- Hanover “Traditional Prest Brick” Color: Natural Charcoal Blend with tudor finish;
- Unilock “Hollandstone”; and
- Belgard “Holland.”

Concessionaire shall provide safety paving where indicated on the Book 4 Contract Drawings, and at locations where pedestrians must cross the tracks to access Stations. Provide unit pavers or stamped concrete suitable for the load requirements of the applicable area. Provide for a contrast in color and texture of the walking surface while maintaining compatibility with surrounding materials. Ensure that all applications meet ADA criteria for walking surfaces.

10.5.2.3 Not Used

10.5.2.4 Trash Receptacles

Litter & recycling receptacle shall be provided where indicated on the Book 4 Contract Drawings, 35 gal. minimum capacity, embedded mounted Silver color powder coated from one of the following manufacturers or equivalent:

- Landscape Forms. Model: “Petoskey”;
- Forms + Surfaces. Model: “ Dispatch”; and
- Conceptual Site Furnishings. Model: “Urbane with Slats.”

Blast resistant trash receptacle shall be provided where indicated on the Book 4 Contract Drawings. Provide stainless steel receptacle, 40 gal. minimum capacity, meeting ASTM E2831/E2831M from one of the following manufacturers or equivalent :

- Mistral Security Inc. Model: “BCR L2 ”;
- BlastGard International Model: “MTR 101-36”; and
- Centerpoint. Model: “Infinity.”

Clear trash receptacle shall be provided where indicated on the Book 4 Contract Drawings. Provide powder coated galvanized steel receptacle silver color with clear UV stabilized polycarbonate side walls, 36 gal. minimum capacity, surface mounted, meeting Homeland Security Directive SD RAILPAX -04-01from one of the following manufacturers or equivalent:

- Rubbermaid. Model: “Landmark Series FG3977589 ”;
- Securr Manufacturing. Model: “HS55IR-CS093”; and
- Commercial Zone. Model: “733201.”

10.5.2.5 Bollards

Collapsible bollard shall be provided where restriction of vehicular access is needed at trail entrances and other areas. Product shall be emergency vehicle bumper force collapsible, enabling emergency vehicles to pass over. Provide 30-inch post height 4-inch clearance bollards spaced 6-foot O.C. maximum, with powder-coated steel bollard embedded mount. The product color shall be selected from the manufacturer's standard colors, have reflective tape and be from one of the following manufacturers or equivalent:

- Blue Ember Technologies. Model: "Maxiforces Collapsible Bollard MCSP-SS1-U";
- Hess America. Model: "Regor 1030 Collapsible"; and
- TrafficGuard Direct Model "LPHDHB."

Fixed bollard shall be provided where indicated on drawings and as required for a fixed restriction of vehicular access. Bollard shall be 8" minimum diameter, 30" minimum height fixed steel K4 crash rated bollards spaced of 6' maximum O.C. Bollard shall be powder-coated steel, manufacturer's standard colors with reflective banding from one of the following manufacturers or equivalent:

- Calpipe Security Bollards. Model: "K-4 Viking Top, Embedded", embedded mount;
- Nasatka Security. Model: "NMSB VI-F K4"; and
- Ameristar Model: "K4- Fixed."

10.6 Content of Landscape and Streetscape Plans

Concessionaire shall submit Landscape and Streetscape Plans for Review and Comment at Preliminary Design, Intermediate Design and Final Design. The content of each Submittal shall be, at a minimum, as follows:

- Preliminary Design:
  - Station planting plans, Scale 1"=20'; and
  - preliminary plant lists.
- Intermediate Design:
  - Station planting plans, scale 1"=20';
  - Corridor planting plans, scale 1"=40';
  - hardscape plans;
  - plant lists;
  - plant quantity table, comparing required quantities to those provided;
  - grading plans; and
  - outline specifications.
- Final Design:
  - Station planting plans, scale 1"=20';
  - Corridor planting plans, scale 1"=40';
  - hardscape plans;

- planting plans;
- planting details;
- plant lists;
- plant quantity table, comparing required quantities to those provided; and
- grading plans.

10.7 Landscape Establishment Period

All plant materials and turf that have been identified in the design shall be planted in accordance with the Contract Requirements not later than Revenue Service Availability, except when growing season or construction conditions do not permit planting before Revenue Service Availability Concessionaire may wait until the next growing season but in no case shall plantings occur later than six months after Revenue Service Availability.

Between planting and Final Completion, Concessionaire shall replace any plant materials and turf that are not in healthy and thriving condition, such that all such plant materials and turf identified in the design have achieved Vegetative Success. Vegetative Success means:

- a minimum of 90% ground cover and adequate establishment to control erosion;
- all plant materials in a healthy, thriving condition; and
- all plant materials are reflective of the species and requirements of the Contract Documents.

Concessionaire shall conduct a Vegetative Success Survey within 30 days of Final Completion. Concessionaire shall submit the Vegetative Success Survey for Review and Approval.

10.8 Summary of Submittals

Item	Section	Submittal	Action
1	10.4.11	Nutrient Management Plan	Review and Comment
2	10.4.11	Soil Test Results	Information
3	10.6	Landscape and Streetscape Plans – Preliminary	Review and Comment
4	10.6	Landscape and Streetscape Plans – Intermediate	Review and Comment
5	10.6	Landscape and Streetscape Plans - Final	Review and Comment
6	10.7	Vegetative Success Survey	Review and Approval

11 SYSTEMS GENERAL

The requirements described in this Section apply to the Light Rail Vehicles (LRVs) and all operational systems.

11.1 LRV and Systems Overview

System safety is of paramount importance. Concessionaire shall provide LRVs and operational systems that prevent unsafe Train operations resulting from operator errors or equipment malfunctions and eliminate avoidable hazards to Users and operations and maintenance staff.

Concessionaire shall provide LRVs and operational systems with a useful life as described in the Contract Documents. Any elements or components of the LRVs or operational systems that are not expected to support the specified Project reliability over the specified service life shall be overhauled or replaced before the reliability drops below that specified.

All requirements specified in this Section and in other Sections of the Contract Documents for LRVs and operational systems shall apply to the entire useful life of the LRVs and operational systems. There shall be no degradation of system safety, availability or functionality over the lives of the LRVs or operational systems.

11.1.1 Interface Management

To establish the required reliable, safe and efficient public transportation service, all LRVs and operational systems shall properly interface and interoperate with each other and with outside systems and Fixed Facilities. To achieve this interoperability, Concessionaire shall identify, assign design and construction responsibilities, design and construct all interfaces and test all operational systems, equipment and interfaces.

Concessionaire shall utilize a systems integration engineer to manage the systems integration process including, at a minimum, design and development of all systems-to-systems interfaces and all systems-to-facilities interfaces and the demonstration of all interfaces through a Systems Integration Test program.

11.2 Functional Requirements

LRVs and operational systems shall be fully interfaced with one another and with Fixed Facilities to provide an integrated light rail transit facility that meets or exceeds all requirements of the Contract Documents.

All LRVs and operational systems shall be immune to any type of malfunction as a result of electromagnetic interference from any internal or external source.

11.2.1 LRT Service

In addition to the Normal Service and Alternate Service requirements, all LRVs and operational systems shall support, as a minimum, the following Train service operations:

- maximum length Trains operating at maximum allowable speeds with AW3.00 loads at normal LRV performance levels at five minute headways throughout the entire mainline;
- recovery service of four sequential maximum length Trains operating at maximum allowable speeds with AW4.00 loads at normal LRV performance levels at three minute headways at any location on the mainline with simultaneous service of maximum length Trains operating at maximum allowable speeds with AW3.00 loads at normal LRV performance levels at five minute headways on the other track;

- reversing maximum length Trains at three minute headways either east-to-west or west-to-east at any intermediate interlocking including all crossovers and pocket tracks;
- single track operations on any section of track designated for bi-directional operation with maximum length trains operating at maximum allowable speeds with AW4 loads at normal LRV performance levels. Single Trains may operate alternately in opposite directions or multiple following trains at three minute headways may operate alternately in each direction; and
- all other Train service configurations identified in Concessionaire's Concept of Operations Report.

11.2.2 Concept of Operations

For the Preliminary Design, Concessionaire shall prepare and submit for Review and Comment a Concept of Operations Report that describes all Project operational functions and systems related to the provision of Train service and other passenger services. The purpose of this report is to identify the LRV and operational systems functional requirements based on the methods Concessionaire plans to use to operate and maintain the Project. This report shall address normal, abnormal and emergency operating scenarios and shall identify, as a minimum, the following aspects of the planned Project operations:

- which functions will be executed automatically and which will be executed based on manual initiation. This section of the Concept of Operation Report shall also identify which field operational system will be used to implement each function;
- all control, monitoring and communications functions and operational systems required at the OCC, BOCC, Security Center and any other control and monitoring locations established by Concessionaire to interface with the field systems and enable all operations and maintenance staff to perform their designated roles and responsibilities;
- the means to control and monitor Train movements and set routes immediately for normal operations and in response to abnormal and emergency conditions;
- the means to control and monitor the Traction Power system and other mechanical, electrical, communications and monitoring systems;
- the means to encourage and promote safe and efficient Project operations under normal, abnormal and emergency operating conditions;
- the means to create and maintain a safe and secure environment for Users;
- the means to respond quickly and effectively to equipment failures and service disruptions; and
- daily, weekly, monthly, quarterly and annual performance reports to be generated to support Concessionaire's operations and maintenance reporting requirements.

11.3 Design Requirements

11.3.1 LRV and Operating Systems Design Process

Concessionaire shall utilize the requirements identified in the Concept of Operations Report in concert with the requirements of the Contract Documents to define the complete set of performance requirements for the LRVs and each of the operational systems.

11.3.2 System Safety

The Contract Document requirements for system safety shall be a prime consideration in Concessionaire's design and component selection of the LRVs, Train control, grade crossing warning systems and all other life safety critical systems. Safety-related functions shall be designed using vital principles and shall be consistent with the specified Project safety goals for Train operations and for Users. Concessionaire shall apply scientific and engineering principles to identify and analyze potential hazards from all possible sources and to eliminate, control, or minimize these hazards.

11.3.3 Reliability and Availability

Concessionaire shall utilize the reliability and availability requirements for the Train service and other operations and maintenance Performance Requirements to assign reliability and availability requirements to the PEPCO electrical services, LRVs, each operational system, the trackwork and any other Project elements that may adversely impact Project operational performance if they fail to function correctly.

For the Preliminary Design of the LRVs and each operational system, Concessionaire shall prepare and submit for Review and Comment an Availability Report that defines the availability requirements for the PEPCO electrical services, LRVs, each operational system and any other relevant Project elements required to support the overall Project availability and reliability goals. Concessionaire shall include analysis showing compliance with availability and Performance Requirements for the overall Project. For Project facilities using PEPCO electrical services at 480V or below, Concessionaire shall evaluate the need for internal power distribution from higher reliability PEPCO electrical services such as those feeding the TPSSs in order to meet the Station availability goals.

For the Intermediate Design of the LRVs and each operational system including major components and subsystems, Concessionaire shall prepare and submit for Review and Comment a System Reliability Analysis based on the Mean Time Between Failures or Mean Distance between Failures and Mean Time To Repair , to demonstrate how the reliability and availability goals assigned in the Availability Report will be met including calculation methods and supporting documentation to support calculations. The reliability predictions shall use certified field failure data if available or MIL-HDBK-217F part stress method for the appropriate installation environment if field data is not available.

Concessionaire shall determine the levels of power service, the need for and type of power service redundancy and/or back-up, power distribution and equipment redundancy required for the LRVs and operational systems by evaluating the levels of system reliability and availability assigned to each one and the extent to which they are performing life safety critical functions.

For the Intermediate Design of the LRVs and each operational system including all hardwired control and logic circuits, Concessionaire shall prepare and submit for Review and Comment an Electrical Circuit Failure Analysis including a sneak circuit analysis. For the LRVs, analyses shall be performed for both single and multiple-LRV configurations. Analyses shall identify all design errors and maintenance errors that may result in unsafe conditions. Existing hazard analyses of identical equipment operating under similar conditions may be submitted in lieu of performing a complete analysis of proposed equipment.

The System Reliability Analyses and Electrical Circuit Failure Analyses shall be updated to reflect the developing LRV and operational systems designs and resubmitted as part of the Final Design for Review and Comment.

11.3.4 Safety and Security

Concessionaire shall provide secure facilities for control centers, TPSSs, Train control CIHs and WICs, communications equipment rooms, electrical rooms, storage of LRVs, storage of maintenance equipment and any other equipment and personnel spaces that are required for Project safety and/or reliability. These rooms shall be equipped with vandal resistant doors and access shall be restricted to authorized personnel only. Such doors shall be equipped with unauthorized access detection and door left open detection.

Concessionaire shall provide perimeter fencing around yards, TPSS, Train control and communications facilities if required based on Threat and Vulnerability Assessments.

11.3.5 Electromagnetic Interference/Compatibility

All LRVs, operational systems and equipment shall comply will all requirements of all applicable sub-parts of EN 50121, Railway applications – Electromagnetic compatibility.

All LRVs, operational systems and equipment shall be immune to any type of malfunction as a result of electromagnetic interference from any internal or external source.

No system or component shall emit, transmit, or create emissions which may cause malfunctions of any LRV, LRV system, operating system wayside equipment, or other equipment or device in accordance with 47 CFR 15 Part 15.5.

Following Revenue Service Availability, all Project systems and equipment shall be maintained so that EMI levels do not exceed the specified parameters.

LRVs shall be compliant with and tested according to IEC 62236-3-1. Operational systems and LRV electronic and electrical equipment shall meet or exceed Class A requirements for digital equipment as specified in the following Federal Communications Commission (FCC) regulations:

- 47 CFR 15 / FCC Part 15, *Radio Frequency Devices*; and
- 47 CFR 2, Subpart B, §2.106, Table of Frequency Allocations.

All LRVs, operational systems and equipment shall comply with the requirements of IEEE C95.1 and IEEE C95.6 governing human exposure.

Concessionaire shall test devices using ANSI C 63.4, *Methods of Measurement of Radio Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.*

11.3.5.1 Radiated Emissions

LRVs and operational systems equipment shall not produce radiated emission levels that cause a functional impact on Project assets or adjacent systems or equipment as specified in this Section 11.3.5.

No mobile or portable radios or any other electronic transmission devices shall produce radiated emission levels that cause any adverse functional impact on Project systems or equipment including when mobile or portable radios or other electronic devices used in Train control or communications equipment rooms, control rooms or TPSSs.

SPECIAL MITIGATION MEASURES: Within the University of Maryland campus between stationing 598+00 and 658+00 radiated emissions shall not exceed the greater of 0.1mG or the existing ambient level at any Research Facility. Concessionaire shall comply with these limits by special treatment of any of the Project elements (LRV, OCS or other supplied operational system), by placing shielding or cancellation equipment in the vicinity of the Research Facility, any other means proposed and accepted by the Owner after Owner's consultation with the University of Maryland or its designee or any combination of these methods as necessary.

11.3.5.2 Conducted Emissions

LRVs shall not produce conducted emission levels that cause functional impact on Project assets or adjacent systems or equipment as specified in this Section 11.3.5. The worst case emission of conductive emission currents from a maximum length Train shall be at least 6 db below the minimum level that may interfere with Train control equipment at all frequencies. This condition shall be met by each individual piece of power equipment, by all LRV equipment during simultaneous operation and by multiple LRVs operating simultaneously in maximum length Trains at minimum headways on both tracks.

11.3.5.3 Inductive Emissions

LRVs shall not produce inductive emission levels that cause any adverse functional impact on any adjacent Project systems or equipment. The worst case inductive emissions from a maximum length Train shall be at least 6 db below the minimum level that may interfere with Train control equipment at all frequencies. This condition shall be met by each individual piece of power equipment, by all LRV equipment during simultaneous operation and by multiple LRVs operating simultaneously in maximum length Trains at minimum Headways on both tracks.

11.3.5.4 Electromagnetic Interference Mitigation

Electromagnetic interference (EMI) rejection by the LRVs and operational systems shall be designed to avoid any and all safety-related and performance-related effects from such interference throughout the entire service life of the equipment. EMI sources to be evaluated shall include, but not be limited to, the Traction Power system, LRV propulsion and internal power equipment, mobile or portable radios and various wayside sources, such as commercial power lines, commercial radio, television, and microwave transmission. Exposure to commercial high-power transmission lines shall be analyzed, evaluated and mitigated.

Concessionaire shall conduct an analysis of all potential sources of all types of EMI and identify how LRV and operational system designs shall prevent these sources from having a negative effect on LRVs and operational system safety and reliability. This shall include identifying the EMI sources, levels and frequencies expected from each, mitigation measures either inherent in equipment designs or necessary to be incorporated into the LRV and operational systems designs and testing programs.

Unless Concessionaire can demonstrate to the satisfaction of Owner after Owner's consultation with the University of Maryland or its designee that the radiated emission levels in the UMD campus area can be met by other means, Concessionaire shall provide a split wire high low Traction Power distribution system between sta. 598+00 and 658+00 to mitigate quasi-static and low frequency magnetic field disturbances that could affect the Research Facilities.

Between sta. 598+00 and 658+00, the traction power current drawn by a maximum length Train shall not exceed 1,000A with an allowable error of 10 percent.

During Preliminary Design, Concessionaire shall perform analysis and submit for Information a report entitled "Spectral Analysis of Existing Background Radiation Levels" analyzing background radiation levels over the entire Project at a distance of 100 feet from track centerline on both sides of the alignment. Ambient quasi-static and low frequency magnetic fields shall also be measured at all identified Research Facilities.

For the Preliminary Design, Concessionaire shall prepare and submit for Review and Approval an Electromagnetic Radiation and Magnetic Field Mitigation Plan for the University of Maryland area between sta. 598+00 and 658+00.

For the Intermediate Design, Concessionaire shall prepare and submit for Review and Comment an EMI Mitigation Study report detailing all the potential EMI sources identified and analyzed and the inherent rejection capabilities of the LRVs and operational systems or mitigation measures utilized to eliminate any impacts to system safety or reliability.

For the Intermediate Design, Concessionaire shall prepare and submit for Review and Approval a University of Maryland Traction Power Distribution System Analysis of Magnetic Fields. The Submittal shall include detailed plans for the Traction Power OCS system in the University of Maryland area between sta. 598+00 and 658+00 with an analysis of the expected peak levels of magnetic fields at each Research Facility resulting from the Traction Power currents. If a split wire high low Traction Power distribution system is provided, the analyses shall consider the impacts of traction current leakage from the contact wire and from the running rails.

Prior to energizing any section of the OCS, Concessionaire shall update its prior analysis and submit for Information a report entitled 'Spectral Analysis of Existing Background Radiation Levels - Pre-Energization" analyzing background radiation levels over the entire Project at a distance of 100 feet from track centerline on both sides of the alignment. Ambient quasi-static and low frequency magnetic fields shall also be measured at each Research Facility as part of this analysis. Concessionaire shall identify and perform required mitigation measures identified as part of the report.

During Trial Running, Concessionaire shall update its prior analysis and submit for Review and Comment a report entitled "Spectral Analysis of Radiated Emissions - Trial Running" analyzing radiation levels over the entire Project at a distance of 100 feet from track centerline on both sides of the alignment. Concessionaire shall also monitor low frequency and quasi static magnetic fields at each Research Facility to determine the impact of operational Trains and demonstrate that the specified EMI levels are not being exceeded. Concessionaire shall utilize a maximum length Train loaded to at least AW3.00 for this test. Concessionaire shall submit the results for Review and Approval.

If the update to the Concessionaire’s prior analysis during Trial Running finds that the specified EMI levels are exceeded, the Concessionaire shall, no more than 30 days after the update to its prior analysis submit an Operational Phase Mitigation Plan for Review and Approval. Such Plan shall include additional secondary mitigation measures, other required mitigation, and an update to the Project Schedule which demonstrates that Operational Phase Mitigation shall begin within 30 days of Approval. Concessionaire shall diligently and in good faith continuously implement the Operational Phase Mitigation.

11.3.6 Equipment Replacement Strategy

Concessionaire shall assess all items of equipment in the LRVs and all operational systems to determine which items will need to be removed for replacement or for overhaul at any time during the O&M Period. Concessionaire shall identify how all such items will be replaced in the Asset Management Plan.

During the Intermediate Design of the LRVs and each operational system, Concessionaire shall prepare and submit for Review and Comment an Equipment Replacement Strategy Report listing for inclusion in the Asset Management Plan.

11.4 Construction Requirements

For the LRVs and all operational systems, Concessionaire shall provide 14 days notice to Owner of any and all factory and field testing. Concessionaire shall grant Owner full access to witness any and all factory and on-site tests.

11.5 Summary of Submittals

Item	Section	Submittal	Action
1	11.2.2	Concept of Operations Report	Review and Comment
2	11.3.3	Availability Report	Review and Comment
3	11.3.3	System Reliability Analyses – Intermediate Design	Review and Comment
4	11.3.3	Electrical Circuit Failure Analyses – Intermediate Design	Review and Comment
5	11.3.3	System Reliability Analyses – Final Design	Review and Comment
6	11.3.3	Electrical Circuit Failure Analyses – Final Design	Review and Comment
7	11.3.5.4	Electromagnetic Radiation and Magnetic Field Mitigation Plan for the University of Maryland	Review and Approval
8	11.3.5.4	EMI Mitigation Study Report	Review and Comment
9	11.3.5.4	Spectral Analysis of Existing Background Radiation Levels – Preliminary Design	Information
10	11.3.5.4	Spectral Analysis of Existing Background Radiation Levels – Pre-Energization	Information
11	11.3.5.4	Test Report - Spectral Analysis of Radiation Levels – Trial Running	Review and Comment
12	11.3.5.4	Operational Phase Mitigation Plan (if required)	Review and Approval
13	11.3.6	Equipment Replacement Strategy Report	Review and Comment

12 LIGHT RAIL VEHICLES

This Section identifies requirements for revenue service Light Rail Vehicles (LRVs).

12.1 LRV Overview

Concessionaire shall provide a fleet of Light Rail Vehicles to meet or exceed the needs of the specified revenue service levels described in the Contract Documents when operated at the specified levels of service safety, reliability and availability including, but not necessarily limited to the following considerations:

- number of LRVs required to meet or exceed Peak Period service requirements at planned operating speeds with appropriate allowances for delays caused by traffic signals, street traffic interference and Users;
- allowance for unavailable LRVs due to Routine Maintenance activities;
- allowance for unavailable LRVs due to major overhauls;
- allowance for unavailable LRVs due to failure repair activities; and
- allowance for unavailable LRVs due to accident or vandalism repair activities.

Concessionaire shall provide and maintain a supply of spare parts adequate to support the needs of all planned Routine Maintenance activities and all failure and accident repair activities. Spare parts availability shall permit service and repair activities to be completed in the time periods required to support service availability requirements.

All LRVs provided for the initial and any subsequent fleets shall be essentially identical and shall operate interchangeably in any Train and on any part of the alignment.

The LRVs shall be electric powered with a minimum 70 percent low floor and have sufficient performance, capacity and efficiency to comply with the passenger carrying capacity requirements described in the Contract Documents. LRVs shall be designed to incorporate service proven subsystem hardware and design concepts while fulfilling all requirements defined in this Section of the Technical Provisions. All major subsystems shall be supplied by established manufacturers who have a documented operating history of service proven technology on previous and current projects in the domestic market.

LRVs shall be compatible with all mainline and yard horizontal and vertical geometry including all geometry transitions.

12.2 Codes and Standards

Codes and Standards specifically cited in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

12.2.1 Americans with Disabilities Act

The design of LRVs shall meet or exceed all requirements and considerations pertaining to the Americans with Disabilities Act (ADA), as set forth by the U.S. Department of Justice in 49 CFR Part 38, *Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles*, Subpart D, Light Rail Vehicles and Systems, Sections 38.71 through 38.87.

12.2.2 Fire/Life Safety

Materials chosen for LRV construction shall have the lowest smoke emission characteristics and the highest flammability resistance consistent with the capability to perform their functions. Materials used on the LRV interior shall meet or exceed the requirements of the National Fire Protection Association's NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*.

12.2.3 Shock and Vibration

All equipment shall be compliant with and tested per the International Electrotechnical Commission standard CEI/IEC 61373, *Railway Applications. Rolling Stock Equipment. Shock and Vibration Tests.*

12.2.4 Federal Requirements for Exterior Lighting

Concessionaire shall provide LRV headlights, taillights, stoplights, and marker lights that conform to the following standards as applicable to vehicles 2,032 mm [80 inches] or greater in width:

- SAE International, SAE J1383, *Performance Requirements for Replaceable Bulb Motor Vehicle Headlamps.* Lamps shall be focused consistent with CFR 49 guidelines;
- SAE J1889, L.E.D. Signal and Marking Lighting Devices;
- SAE J2040, Tail Lamps (Rear Position Lamps) for Use on Vehicles 2,032 mm or More in Overall Width;
- SAE J2042, Clearance, Sidemarker, and Identification Lamps for Use on Motor Vehicles 2032 mm or More in Overall Width;
- SAE J2139, Tests for Signal and Marking Devices Used on Vehicles 2,032 mm or more in Width;
- SAE J2261, Stop Lamps and Front- and Rear-Turn Signal Lamps for Use on Motor Vehicles 2,032 mm or more in Overall Width; and
- U.S. Government Printing Office, 49 CFR 571.108 / FMV SS108, *Lamps, reflective devices, and associated equipment*.

12.2.5 Not Used

12.2.6 Supply Voltage Requirements

All electrical equipment shall be compliant with and tested as per the following recommended practices:

- IEC-60850 Railway Applications – Supply of Voltages of Traction Systems.

12.2.7 Ergonomic Requirements

Concessionaire shall design all passenger and Train operator LRV features in accordance with either:

- AIA Architectural Graphic Standards;
- MIL-HDBK-759C, Human Engineering Design Guidelines; and
- SAE J680, J1517, J1522, J1050, J287 and J1139 driver ergonomic standards or

  MIL-STD-1472 Human Engineering Design Criteria.

12.3 Functional Requirements

12.3.1 LRV Functional Overview

The LRVs shall be a minimum 70 percent low floor light rail design powered from an overhead contact system. All passenger boarding and egress shall be via level Platforms at a height of 14 inches maximum above top of rail. LRV sections and truck arrangements shall provide high stability, safety and comfort for Users and be aesthetically pleasing within the operating environment.

Each LRV end shall be equipped with anticlimbers and energy absorbing folding couplers and the structure shall also be capable of absorbing collision energy in the event of a major collision.

All passenger doors of a maximum length Train shall open fully onto the useable area of all Station Platforms. Concessionaire's attention is directed in particular to the available Platform length at Silver Spring Library Station. Trains may contain multiple LRVs as long as each Train is capable of being operated bi-directionally.

Concessionaire shall define the length of a maximum length Train to carry Service Level 3 in accordance with Exhibit 3.1 of Part 3 of the Technical Provisions:

- a maximum length Train may contain a single or multiple individual LRVs so long as each Train can be operated bi-directionally;
- all passenger doors of a maximum length Train shall open fully onto the useable area of all Station Platforms; and
- the sections of a maximum length Train beyond the end doors may extend beyond the useable area of the Platform so long as a maximum length Train can stop at all Stations without interfering with adjacent street intersections or crosswalks.

Under Emergency conditions, a maximum length Train shall be able to couple with another Train of a similar length which is inoperable, without power, or only partially operational, and shall be capable of operating in rescue mode under reduced performance.

The LRV exterior and interior shall be of a modern and attractive design and shall be fully compliant with ADA requirements. The LRV low floor passenger area shall allow level boarding without bridge plates from Station Platforms and shall be compliant with 49CFR38 as applicable. With the exception of access to any higher interior level of the LRV, the floor throughout the passenger area shall be free of raised joint sections that may provide a trip hazard.

The forward ends of the main passenger sections may have raised floors to permit the installation of more traditional powered trucks.

For ease of passenger entrance and egress, a minimum of four, plug-type passenger doors per 100ft of LRV length shall be located on each side of the LRV within the low-floor area. Door widths shall be compliant with ADA requirements, shall permit entry and egress of Level 3 User counts at all Stations within the designated Station Dwell Times including allowances for wheel chairs and bicycles and shall support the calculated vehicle emergency evacuation times. Doors shall have a manual override and release for emergency egress. Other designs may be considered if sufficient passenger flow can be achieved to permit ease of passenger movement and minimized passenger contact.

Passenger comfort shall be maintained by a HVAC system suitably sized to accommodate the range of Project environmental conditions.

CCTV monitoring and recording shall be provided to cover the external side views, the exterior areas ahead of and behind the Train and 100 percent of the interior passenger areas; monitors shall be provided in each cab.

Exterior destination signs shall be provided on the ends and sides of each LRV. An interior audio/visual announcement system shall be provided to automatically annunciate the identity of each Station as the Train arrives.

Communications shall be controlled by an integrated LRV communications system and shall include voice and data radios, vehicle location system, public address system, passenger intercom Stations, exterior destination displays, interior variable message passenger information displays, automatic passenger counters, and a Station auto-announcer.

Any required cab signaling system, Train-to-Wayside Communication (TWC) system, as well as an events recorder shall also be provided and coordinated with the train control requirements of the Contract Documents.

12.3.2 Ergonomic/Universal/Accessibility Design

LRVs and LRV systems and subsystems shall be designed in an easy-to-use manner; that is, simple, efficient, reliable, accessible, and safe for the widest possible range of Users and operations and maintenance staff.

Corridors and aisles shall have a minimum height of 80 inches. Aisle width shall be in accordance with ADA requirements. All standing Users shall have access to vertical stanchions or handholds. LRV window area shall be maximized to emphasize a feeling of openness.

Within the LRV interior, handholds, lights, air vents, and other interior fittings shall appear to be integral with the LRV interior. There shall be no sharp, abrasive edges, corners, or surfaces, and no hazardous protuberances. Materials shall be strong enough to resist everyday use and shall be resistant to scratches and markings. The use of visible fasteners shall be minimal and any interior mullion trim, moldings, and trim strips shall match the adjacent panels/walls.

The Concessionaire shall maximize the seating capacity of a maximum length Train subject to the following requirements:

- up to eight bicycle and eight wheelchairs simultaneously in a maximum length Train. Bicycles and wheelchairs shall be accommodated in locations that permit direct access from door areas and in a manner that minimizes the potential for injury to all Users. The seating arrangement shall be designed so as to allow Users with bicycles, wheelchairs or other large, awkward items to enter at any doorway and access the low floor area adjacent to their door of entry with a minimum of effort;
- when seated in transverse seats, the knees of a 95th percentile North American male shall not be in contact with the seat back of the seat in front of him; and
- the floor area of the entire passenger space shall be available for seated or standing Users. Equipment under seats shall be kept to an absolute minimum. Each seat frame and its support shall be constructed as an integrated standard unit. Seat colors shall be in accordance with the approved interior color scheme.

If a maximum length Train consists of multiple LRVs, the quantity of seats, wheelchair positions, and bicycle positions shall be distributed evenly between LRVs.

During normal operation, full accessibility for Users shall be provided at all doors, including the elderly and/or persons with disabilities and those using assistive devices, such as wheelchairs, in accordance with ADA requirements.

Concessionaire shall provide a means to assist the evacuation of Users from the LRVs in an emergency when the LRV is not located within a Station Platform at not less than 50% of the passenger doors on each side of the LRV. The maximum single step-down for Users shall not exceed twelve inches for any step between the LRV floor and the adjacent grade for any type of track construction. All steps shall support the weight of a 300 lb. person.

For the Intermediate Design, Concessionaire shall prepare and submit for Review and Comment Sample Seat Prototypes of each seat type proposed for the LRVs in the form of a mock-up showing all aspects of the seat design. The mock-up shall include sufficient numbers of rows of each type of seat to demonstrate the relationship of the seats to the side walls, aisle and each other and to assess passenger comfort. The mock-up shall include a representative sample of each type of seat and each finish material choice.

The LRV floor shall be covered with slip-resistant flooring material and shall comply with all applicable ADA requirements for visibility and friction coefficients. Floor covering and step nosing colors shall complement the LRV's overall interior design.

12.3.3 Safety

Safety provisions to be evaluated through analysis and associated PHAs for Users, motorists and the general public shall include, at a minimum, the following:

- Concessionaire shall consider and evaluate the use of side marker lights, either permanently lit, flashing or both depending on circumstances to enhance the conspicuousness of the LRVs to parallel running motorists during daytime and nighttime conditions;
- Concessionaire shall consider and evaluate the use of flashing or pulsing LRV front lights either permanently or depending on circumstances to enhance the conspicuousness of the LRVs to approaching motorists, bicyclists and pedestrians during daytime and nighttime conditions;
- Concessionaire shall consider and evaluate the use of location data in conjunction with time-of-day data to automatically activate side marker lights, front lights, horn or bell at specific locations and in specific directions of travel;
- Concessionaire shall consider and evaluate the use of energy absorbing bumpers on both sides of the couplers extending approximately 14 to 30 inches above top of rail to match the bumper heights of roadway vehicles and minimize structural damage to both the LRVs and the roadway vehicles in the event of a collision; and
- Concessionaire shall consider and evaluate the use of seat belts for operators' seats. If such seat belts are provided, they shall comply with the relevant sections of the following:
    - 49 CFR 571.207/FMV SS207, *Seating Systems*;
    - 49 CFR 571.207/FMV SS209, *Seat Belt Assemblies*; and
    - 49 CFR 571.207/FMV SS210, *Seat Belt Assembly Anchorages*.

There have been several recent incidents around the world in which a person suffered fatal injury when a Train started to move while the person was attempting to cross the track between two coupled vehicles of the Train. To prevent such incidents, the design of the LRV ends and couplers shall prevent a pedestrian from traversing from one side of a Train to the other by passing between two coupled LRVs irrespective of whether initial access is from the Platform or non-Platform side of the Train.

12.3.4 Security

Security provisions for Users and operations and maintenance staff shall include, but not be limited to, the following:

- a vandal resistant means of reliable, direct communication between Users and the Train operator. Whenever a passenger communications device is activated, a CCTV view of that passenger area shall be automatically displayed on the cab CCTV monitor;
- each LRV shall be uniquely numbered for positive identification. The identification number shall be displayed on the outside of the LRV adjacent to each door and on the roof and on the inside of the LRV adjacent to each door. The roof numbers shall be of sufficient size to be readable from a police helicopter at an altitude of 500 ft above the LRV;
- A “Silent Alarm” in each cab to enable the Train operator to alert the OCC and the Security Center to a problem. Activation of the silent alarm shall also activate a distinct light, visible during day and night conditions, on the LRV roof adjacent to the LRV number and above each door;
- LRVs shall utilize different access authorization mechanisms for cab access, controls and equipment cabinets. The use of access control system cards to activate/operate LRVs shall be considered. Special, limited distribution keys shall be used for event and video recorders.

12.3.5 Propulsion and Braking

In order to afford the highest passenger comfort and safety, propulsion and braking systems shall incorporate a spin/slide system, load weigh compensation and jerk limitation which shall function at all times during LRV acceleration, service braking and maximum braking.

A maximum acceleration rate of not less than 3.0 mphps shall be available up to a minimum of 20 mph with vehicle loading up to AW2.00 on level tangent track with nominal line voltage. Acceleration rates may decrease linearly for weights greater than that with AW2.00 loading. The acceleration time from 0 to 50 mph at AW2.00 on level tangent track shall not exceed 35 seconds.

In normal operation, the braking system shall provide a continuously variable service braking capability for all LRV weights over the entire range of operating speeds using a blended combination of friction and dynamic braking. The maximum service brake rate shall be not less than 3.0 mphps for speeds below 45 mph and not less than 2.2 mph for speeds above 45 mph.

Maximum braking shall be a combination of maximum service braking capability plus the magnetic track brake, to produce the maximum braking rate possible.

Emergency braking shall produce a maximum brake rate application without the use of friction brake control electronics. The emergency brake shall be separately Train lined and shall be fail-safe in operation. At vehicle weights up to that with AW3.00 loading, the minimum average deceleration rate under emergency braking shall comply with the requirements of the APTA Light Rail Vehicle Procurement Guidelines.

The LRV shall be provided with a zero speed detection system which shall be generated when the LRV speed is less than 2 mph.

12.3.5.1 Parking Brake

A parking brake system shall be capable of holding an AW0 loaded LRV on the maximum Project track gradient for an indefinite period of time.

12.3.6 Maximum Operating Speed

The maximum LRV service operating speed shall be not less than 50 mph at AW2.00 loading on level, tangent track. Maximum operating speed for LRV design purposes shall be not less than 55 mph.

12.3.7 Maximum Jerk Rate

In response to the instantaneous input command signal, the rate of change of acceleration or deceleration shall be adjustable over the range of 1.0 mphpsps and 2.0 mphpsps [0.45 m/sec^3 and 0.9 m/sec^3] ±10% for all LRV weights up to and including that with AW2.00 loading under normal operating conditions.

The maximum jerk rate is not applicable for emergency brake modes of operation.

12.4 Design Requirements

12.4.1 LRV Fleet Size

Concessionaire shall prepare and submit for Review and Approval a Rail Fleet Management Plan in accordance with Part 3, Section 1.2 of the Technical Provisions. The Rail Fleet Management Plan submitted 90 days after Financial Close will support the Concessionaire’s initial Operating Plan (included in Exhibit 17 of the Agreement) and the Preliminary Operating Plan. This Rail Fleet Management Plan shall also include the Project Schedule for delivery of LRVs during the D&C Period.

12.4.2 System Safety

Failures or malfunctions of any type in life safety critical systems shall not result in unsafe operations or conditions.

All cabinets, cases and circuit devices where the circuit voltage may cause injury if touched shall be provided with appropriate identifications in accordance with transit industry standard practices and codes. Power circuits shall be physically separated from communications and control circuits.

12.4.3 Crashworthiness

The car body shall be designed so that in the event of a collision occurring on level, tangent track between two trains, the deformation of the structure shall commence at the extreme ends and progress toward the coupler anchor, with all of the end structural members retaining their attachments to one another and to the roof and floor structures.

The LRV carbody structure shall be designed to meet or exceed the requirements for LRVs as defined in ASME RT-1-2009, *Safety Standard for Structural Requirements for Light Rail Vehicles*.

12.4.3.1 Couplers

The LRV shall be provided with energy-absorbing, folding, automatic couplers that, when not in use, are stored behind moveable covers that blend into the overall LRV appearance. If a maximum length Train is comprised of only a single LRV, the couplers need not be energy absorbing and need not be automatic.

12.4.3.2 Anticlimbers

LRV anticlimbers shall be located 30 to 37 inches [762 to ~940 mm] above top of rail, depending on the final adopted LRV design. When the LRV design is chosen, its dimensions shall be used to ensure a match with track end buffers and future LRV procurements.

12.4.4 Shock and Vibration

Components mounted on an LRV carbody, trucks, or axles shall have structural integrity and shall be operationally reliable over the life of the LRV in the vibration and shock environment existing at the point of attachment of the component. Components and mounting arrangements shall prevent unacceptable vibration levels at any location within the LRV.

All equipment shall be compliant with and tested as per IEC 61373, *Railway applications. Rolling stock equipment. Shock and vibration tests*, including all functional and durability requirements.

12.4.4.1 Vibration Transmission to Environment

The LRV shall be designed to minimize the transmission of vibration into trackwork by minimizing the unsprung mass and by careful design of the LRV suspension system. This design shall ensure that no more than 75 VdB (vibration decibels) as measured in 1/3-octave bands of frequency over the frequency range of 8 to 80 Hz are transmitted beyond any point 35 feet from the center line of either track based on the assumption that the overall system shall be maintained against degradation which would adversely affect vibration levels, such as the condition of special trackwork, corrugated or worn track, and flattened or out of round wheels.

Vibration decibels shall be directly related to vibration velocity by the following formula:

$VdB = 20 \log(V/V_{ref})$

Where:

- V = Velocity amplitude in inches per second.
- Vref = 10^{-6} inches per second.

In addition, vibration transmitted to the environment in the area of the University of Maryland campus shall comply with the requirements of the Third Party Agreement Requirements.

12.4.4.2 Interior Vibration

The LRV interior, including wall and ceiling panels, floor, seats, lighting fixtures, HVAC ductwork, and other furnishings, shall be free from rattles, creaks, and any other audible or visible vibrations at any speed from 0 to 55 mph and at any acceleration or braking request, except emergency braking. Equipment and auxiliaries mounted anywhere on or in the vehicle, carbody or trucks shall not cause vertical or horizontal vibrations anywhere on the vehicle floor, walls, ceiling panels or seat frames at any speed from 0 to maximum operating speed or at any acceleration or braking rate except emergency braking in excess of the following:

- below 1.4 Hz - maximum deflection (peak-to-peak) of 0.10 in;
- 1.4 Hz to 20 Hz - maximum acceleration of 0.01g; and
- above 20 Hz - maximum velocity of 0.03 ins/sec.

All components and mounting systems shall be designed to limit vibration to levels stated herein.

12.4.4.3 LRV Body Natural Frequency

The LRV body natural frequency shall be between 2.5 and 7 times the secondary suspension natural frequency for AW4.00 to AW0 loading respectively.

12.4.5 Weight Distribution

LRV equipment installation shall be arranged to evenly distribute weight to provide the lowest possible center of gravity in order to limit any tendency of an LRV to overturn, to maximize adhesion and to minimize axle loads.

Weight distribution on any LRV truck shall remain within +/- 5% of the total LRV weight divided by the total number of LRV trucks at any assigned weight.

Lateral imbalance shall not exceed 30,000 inch-pounds.

12.4.6 Passenger Seat Strength

The seat construction and its attachments to the car body shall withstand, without permanent deformation, the loads to be expected in transit operation, but in no case less than the following:

The seat design and installation shall withstand a longitudinal force (acting in either direction from front of seat to back, and back of seat to front, and equally distributed along the grab handle) of not less than 300 lb. per sitting position (total 600 lb) for two-passenger seat with no deflections anywhere more than 0.75 in. and with no failure. A maximum permanent set of 0.125 in. is permitted under these conditions.

The seat design and installation shall withstand a downward vertical load applied uniformly along the front edge of each sitting position of not less than 400 lb. (total 800 lbs.) for a two-passenger seat with no failure. A maximum permanent set of 0.125 in. is permitted under these conditions.

Transverse seat attachment (floor, side structure, and/or seat boxes) shall be constructed to resist the load resulting from two 95th percentile adult males being thrown against the seat with a longitudinal force of 5g from both the front and back of the seat. Minimal seat distortion shall be allowed but the seat shall not tear loose from its fastenings.

Gaps between seats and walls or windows shall be controlled or held rigid to prevent injury when the seat moves.

12.4.7 Passenger Doors

A positive door lock shall prevent doors from opening while the Train is in motion. .

A door sensing circuit shall prevent the Train from moving until all doors are closed and locked and shall activate an alarm in the cab if an object is trapped in any door.

Door edges shall permit withdrawal of trapped clothing when doors are closed.

Warning chimes or bells shall be provided to give an audible annunciation when the doors are closing.

The door control circuits shall ensure that non-commanded doors will not open.

Doors shall comply with all requirements of APTA-PR-M-S-18-10 standard for Powered Exterior Side Door System Design for New Passenger Cars.

For the Preliminary Design, Concessionaire shall prepare and submit for Review and Comment a Train Egress Calculation to identify the time to evacuate AW1.00, AW1.90, AW2.00, and AW3.00 passenger loads including wheelchair Users based on the arrangement of seats, doors and any interior steps to high floor areas and the widths of doors and aisles. Calculations shall be performed for evacuating Users to a Station Platform and to a designated evacuation path outside the limits of a Station Platform and shall provide justification that the times are reasonable.

12.4.8 LRV Interiors

12.4.8.1 Interior Graphics

Concessionaire shall provide suitable graphics throughout the LRVs to provide Users with information. All graphics shall meet or exceed ADA requirements. All controls, devices, and equipment intended for Users shall be clearly labeled both with text and graphical figures or icons, including multilingual decals and graphics.

The following text and graphics shall be provided at a minimum:

- LRV numbers - in the interior of the LRV;
- ownership nameplate, where applicable;
- graphics for passenger and safety information, including door emergency releases, emergency evacuation routes and means, intercom Station locations and instructions, information for persons with disabilities, bicycle storage information, and other information as appropriate;
- safety warnings on equipment boxes containing wiring or components operating at high voltage; and
- system maps, transfer point for adjacent transit systems, and other passenger assistance information as appropriate.

12.4.8.2 System Maps and Display Panels

System route maps shall be provided in each LRV in sufficient quantity and locations to be easily visible to all seated and standing Users. If Concessionaire chooses to use decals or printed system route maps, the LRV design and configuration shall not preclude the future installation of a minimum of four flat screen electronic (e.g., LCD, LED, or plasma) system route displays per LRV in the passenger areas. Conduit for power and communications cables for these flat screens shall be provided in each LRV.

An audio/visual annunciator system shall announce the identity of each Station and all WMATA and county rail and bus transfer services as the Train pulls into the Platform and the identity of the next Station as the Train departs from each Station. Visual signs shall be of sufficient size and quantity to be readable from any unimpeded (by other Users) standing or sitting position in the passenger area of the LRV.

12.4.8.3 Advertising

Concessionaire shall provide facilities for passive advertising displays along the sidewalls of the LRVs above the windows.

12.4.8.4 Window Glazing

The side windows and door glazing in the passenger sections shall be impact and fire-resistant laminated safety glass to ANSI Z26.1 and 49 CFR Part 223. Single-glazed, fixed windows shall be attached to the structure so as to present a flat outside side appearance.

All body side window glass and door glazing shall be low-e, thermal reflective and provided with tints, screens, or other solar/thermal limiting measures as required by the HVAC design. The tints shall not preclude Users from being seen from outside the LRV or limit their vision when looking out the body side windows.

Side windows that permit emergency egress shall be provided as necessary such that no location along the length of the passenger compartment is more than 15 feet from the centerline of a passenger door or the centerline of an emergency egress window. If no location along the length of the passenger compartment is more than 15 feet from the centerline of a passenger door, then no emergency egress windows are required.

Side windows shall not prevent emergency ingress.

12.4.8.5 Stanchions and Handrails

All stanchions, handrails and grab rails shall meet or exceed the applicable ADA requirements, ergonomic design criterion and universal design criterion. They shall also be of a color and finish in accordance with the approved interior color scheme. Full height vertical stanchions shall be avoided wherever practical and ceiling suspended, seat back or wall mounted handrails used instead. The position and general design of the stanchions and handrails shall be reviewed by the Owner.

12.4.8.6 Emergency Equipment

A fire extinguisher, 10 pounds capacity, minimum rating 4A-300: C, marine type, mounted in a clearly visible location, and with clear instructions for its use shall be provided in each LRV.

A manual method for retracting and/or de-energizing LRV-born catenary equipment in emergency applications shall be provided on each LRV.

12.4.9 Automatic Passenger Counters

Automatic Passenger Counter (APC) equipment utilizing infrared motion detection (or the functional equivalent) shall be provided at each passenger door. All sensors shall be robust, vandal resistant and protected against intrusion of water. The APC equipment shall also be equipped with fault indication and test facilities. A sufficient number of sensors shall be provided per door to yield raw data passenger count accuracies of at least 95 percent.

12.4.10 Event Recording

One or multiple event recorder(s) shall be provided on each LRV to record operational and fault data to support accident investigations. At a minimum, data recorded shall include:

- date (synchronized with the video recording system);
- time (synchronized with the video recording system);
- LRV number;
- Train number;
- ATP maximum allowed speed;
- LRV actual speed;
- direction of movement;
- active end;
- traction demand/application;
- dynamic brake demand/application;
- service brake demand/application;

- emergency brake demand/application;
- track brake demand/application;
- sanding application;
- bypass/cutout active;
- ATP request for service brake application;
- ATP request for emergency brake application;
- warning bell activation;
- warning horn activation;
- door status (open/close): and
- passenger intercom pushbutton activated.

As a provision for future needs, at least two spare digital and one spare analog channel shall also be provided.

The events recorder shall be in accordance with IEEE 1482.1 – Standard for Rail Transit Event Recorders and be based on service-proven designs with at least 5 years successful operating history. Recorders shall be secured to eliminate access by unauthorized personnel. If multiple recorders are provided, all event time stamps shall be synchronized to a common time signal so that the times of events on each recorder relate accurately to the times of events on all other recorders.

12.4.11 Noise Levels

Special LRV noise abatement measures, including resilient wheels, sound damping liners, and body side skirts, shall be provided to minimize the emission of noise. Under normal operating conditions with all equipment functioning, noise levels shall not exceed the levels indicated. Lower noise levels are desirable.

12.4.11.1 Interior Noise

The measurement of interior noise levels shall be made in a fully equipped vehicle with only necessary operating and test personnel on board. Measurement points, as a minimum, shall include the following:

- three feet below the center of each return air grill;
- not less than ten measurements at the height of the average passenger's ears at representative locations throughout the seated areas of the vehicle;
- not less than ten measurements at the height of the average standing passenger's ears at representative locations throughout the standing areas of the vehicle including the longitudinal centerline of each door area.
- One in each cab at the height of the average Train operator's ears when seated in the cab seat

With all auxiliary equipment operating simultaneously under normal operating conditions, the noise level inside the LRV shall average no more than the levels on non-corrugated, tangent track indicated in Exhibit 12.12.1.

Exhibit 12.12.1 – Interior Noise Limits

Condition	Limit
LRV Stationary, Empty, No Auxiliary Systems Operating	68 dBA
LRV Stationary, Auxiliary Systems Operating and HVAC Units in Full Cooling Mode	72 dBA
LRV Stationary, with any One System Operating	70 dBA
LRV Moving, Empty, Full HVAC, at 40 mph [65 km/h] on a minimum radius mainline curve rated for 40 mph	75 dBA
LRV Moving, Empty, Full HVAC, at maximum permitted speed on a minimum radius mainline curve	75 dBA

12.4.11.2 Exterior Noise

The measurement of exterior noise levels shall be made on level ground and in an essentially free-field environment, 50 feet [~15 m] from the centerline of track perpendicular to the LRV, on newly ground-welded rail at a height of 5 feet [~1.5 m] away from reflecting surfaces, and on adjacent ground other than ballast, ties, and track.

The average noise levels emanating from the LRV shall not exceed the levels indicated in Exhibit 12.2 for non-corrugated, tangent track with all auxiliary equipment operating simultaneously.

Exhibit 12.2 – Exterior Noise Limits

Condition	Limit
LRV Stationary, Empty, Full HVAC	68 dBA
LRV Moving, Empty, Full HVAC, on Horizontal Tangent Track at 40 mph [65 km/h]	75 dBA
In Maximum Dynamic Braking or Maximum Friction Braking from 40 mph [65 km/h] with New Wheels	75 dBA

12.4.11.3 Noise / Wheel Squeal Prevention

Special wheel profiles, wheel dampers, and/or other noise mitigation measures shall be provided on LRVs to ensure that wheel squeal in curves does not exceed 78 dBA. Noticeable pure tones are not permitted. Additionally, Concessionaire shall comply with the noise limitations within the University of Maryland campus as stated in the Third Party Agreement Requirements.

For the Intermediate Design, Concessionaire shall prepare and submit for Review and Comment a LRV Noise Calculations Report detailing the estimated noise levels and frequencies developed over the required range of operating conditions including track radius and demonstrating that the design will meet or exceed the requirements of this Section. For Final Design, Concessionaire shall prepare and submit for Review and Comment an LRV Noise Calculations Report including tests conducted to demonstrate conformance.

12.4.12 Ride Quality

For any single Station-to-Station run (not including dwells), root mean square accelerations between 1 and 80 Hz shall fall below the levels outlined in ISO 2631, *Evaluation of* Human *Exposure to Whole-Body Vibration*, for 1-hour exposure to the reduced comfort boundary.

12.4.13 Traction Power and Overhead Catenary System

Concessionaire shall provide automatic and manual means to disconnect the pantograph from the catenary.

12.4.14 Heating, Ventilating, and Air Conditioning

The LRV design shall minimize the necessity for air conditioning through the utilization of passive and active measures, which reduce the LRV solar and radiated heat load while minimizing cool air loss. The capacity and initial functionality of the heating, ventilating, and air conditioning (HVAC) system shall be proven by full-LRV, climate chamber qualification testing. Supplemental staged floor heat arrangements may be necessary to meet or exceed passenger comfort standards provided herein.

The LRV HVAC system shall meet or exceed the following performance requirements:

- ventilation and air circulation – Ventilated air shall be introduced through A/C equipment and shall not rely on air introduced when LRV doors are open. The LRVs shall have no passenger-operable windows;
- heating – The total heating system shall have a capacity equal to the maximum calculated heating requirement for the LRV. Layover heat shall be provided;
- condensation and humidity – The HVAC system shall minimize condensation on interior surfaces, including windows. Reheat is permitted, if required, to limit interior humidity;
- controls/temperature uniformity – The interior temperature shall be automatically controlled in cooling, ventilating, and heating modes without manual intervention;
- air flow, diffusion, and discharge temperature – The air distribution system shall provide sufficient diffusion at the outlet or diffuser so that air mixing prevents the direct impingement of air on Users; and
- environmental emission standards – The A/C system shall meet or exceed international environmental emission standards and shall utilize environmentally friendly refrigerant meeting all US standards.

Heated air from the condenser shall be exhausted from the roof area. Refer to cooling loads for heat exchange values.

HVAC system controls shall maintain LRV interior conditions within the comfort zone of acceptable indoor operative temperature ranges as shown in ASHRAE Summer and Winter Comfort Zones, ASHRAE Fundamentals handbook, Chapter 9, Figure 5.

The maximum allowable variations in temperature in LRV passenger areas shall be as follows:

- less than 4°F [2.2°C] variation at any height from 6 inches to 48 inches [150 to 1,220 mm] above the floor; and

- the average LRV temperature shall be within 4°F [1.1°C] of the comfort zone requirements within 2 minutes following a 30 second opening of all LRV passenger doors on one side.

The maximum allowable variation in temperature in LRV operating cabs shall be as follows:

less than 4°F [2.2°C] variation at any height from 6 inches to 48 inches [150 to 1,220 mm] above the floor.

12.4.14.1 Interior Fresh Air Intake

The intake of filtered fresh air shall be provided for each LRV. The required fresh air intake volume shall be 1,200 cubic feet per minute (ft³/min) [34 m³/min] minimum, regardless of LRV position in a Train or LRV speed, and shall be adequate to maintain the positive pressurization requirements.

12.4.14.2 Interior Air Filtration

HVAC system filter elements shall be capable of removing fine dust and allergens to an 85-percent efficiency level as per ASHRAE 52.2, *Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size*.

12.4.14.3 Interior Positive Pressurization

The ventilating system shall maintain a LRV internal positive static pressure at all LRV speeds and a minimum static pressure of 0.10 inches [2.54 mm] of water when doors and windows are closed.

12.4.14.4 Interior Maximum Air Velocity

To increase system efficiency and minimize air noise, the maximum air velocity through HVAC ductwork shall be 1,200 feet per minute (ft/min) [~6 m/sec].

12.4.14.5 Cooling Loads

For the purposes of HVAC cooling system design, the following thermal load parameters shall be used in calculating HVAC system performance and sizing HVAC units:

- Users – assume LRV AW2.00 loading;
- seated Users – 400 Btu/hr [117.2 W/hr] TH, 245 Btu/hr [71.79 W/hr] SH per passenger;
- standees – 450 Btu/hr [131.85 W/hr] TH, 250 Btu/hr [73.25 W/hr] SH per passenger;
- carbody conduction – Concessionaire shall provide ‘U’ factors and associated surface areas for LRV walls, doors, ceilings, floors, window glass, and LRV ends based on worst-case LRV skin temperature and the specified interior temperature for use in HVAC calculations;
- solar gain – Attendant solar gain shall be calculated based on a worst-case Washington, D.C. metropolitan location on July 21st at 1600 hours, with a maximum possible area of LRV window, door, and windshield glass facing into the sun;
- external radiated heat loads – Radiated heat loads generated by both roof-mounted equipment and underfloor-mounted equipment, including the effect of any skirts, shall be provided. The radiated heat generated by the Guideway/roadbed shall be included in HVAC calculations with no deduction for any shading effects arising from the passing of an LRV (i.e., LRV underfloor is fully exposed to this heat source);

- door opening loss – Assume a worst-case loss of interior air, where all doors on one side of LRV are open for 20 seconds at each non-terminal Station and for the full layover time at both Terminal Stations and that 300 ft^3/min [8.5 m^3/min] of air is lost per door. The cooling or heating which occurs as a result of the periodic door opening (convection and radiated) shall be included in HVAC calculations; and
- internal heat loads – Concessionaire shall provide detailed information regarding heat generated inside the LRV by lighting, control electronics, and similar items for input into HVAC calculations.

12.4.14.6 Fire Prevention

Heater elements and power wiring circuits shall include protective devices to prevent overheating and fires in the event of an air flow failure, a temperature control failure or a wiring short circuit.

12.4.15 Smoke Detectors

Each passenger area shall have smoke detectors that, when activated, shall be annunciated by a discrete alarm in the operator cab. The detectors shall be appropriate for transit vehicle applications. At least one shall be mounted on the ceiling at the center of the passenger area, and not directly in the discharge air flow from the HVAC system. Smoke detectors shall also be located in the return air stream of each air conditioner. Smoke detector functionality shall be continuously monitored and a discrete trouble indication displayed in the operator's cab if a fault is detected.

12.4.16 Aesthetic and Ergonomic Design

Professional industrial design services shall be used to create a pleasing, inviting, easy to use, and attractive overall LRV aesthetic interior and exterior design that portrays a modern, forward-thinking image and incorporates the requirements of the Purple Line Systemwide Graphics Manual. The LRV shall provide enhanced physical, sensory and cognitive features to accommodate a wide spectrum of Users with diverse capabilities who may be expected to ride on a LRV.

For ergonomic design purposes, LRVs shall be able to accommodate, at an absolute minimum, Users and operations and maintenance staff ranging from the U.S. 5th percentile female to the 95th percentile male. See the AIA's Architectural Graphic Standards, 10th Edition, Section 1: Human Dimensions, for current U.S. anthropometric details. Where these details are insufficiently comprehensive, MIL-HDBK-759C, Human Engineering Design Guidelines, Section 5.6, Tables 16a though 16f, "General Forces," and SAE driver ergonomic standards SAE J680, J1517, J1522, J1050, J287, and J1139 shall be used.

For the Preliminary Design, Concessionaire shall prepare and submit for Review and Approval LRV Design and Branding Scheme Documentation showing external and internal (passenger area) designs, color schemes and branding schemes that conform to the requirements of the Purple Line Systemwide Graphics Manual and consider the safety requirements for LRV conspicuousness. Submittal shall include, but not be limited to, exterior plan and elevation drawings including all exterior fitments such as rear view CCTV cameras and all communications antennas, interior plan and elevation drawings that depict the seating configuration, disabled/elderly and bicycle locations, supports for standing Users and internal screens, photo-realistic renderings of the LRV interior and exterior, color elevations of vehicle exterior, drawn to scale showing positioning and size of decals and paint finishes; physical samples of paint applied to 24" x 24" samples of the proposed substrate, interior finishes and a schedule of materials. Specific branding decisions related to paint schemes, decals and other aesthetics shall conform to the Purple Line Systemwide Graphics Manual. In the period between the Preliminary and

Intermediate Designs, Concessionaire shall hold meetings with Owner representatives to refine the initial proposal into a final and acceptable design and color scheme/palette.

12.4.16.1 Interior Lighting

LRV interiors shall be designed with low-energy, high-efficiency lighting fixtures, which are secure, rattle-free, and vandal-resistant. Powered fixtures shall be inaccessible to Users. Diffusers shall be shatterproof. Illumination levels, as follows, shall be consistent and shall be measured with light-diffusing panels in place:

- the average interior intensity of illumination at a height of 33 to 66 inches [~840 to 1,680 mm] above LRV floor shall be at least 30-foot candles [320 Lux] at the rated voltage;
- the light intensity at the LRV floor, in passenger aisles and gangways, shall not be less than 20 foot-candles [215 Lux];
- the average interior light intensity at LRV entrances and exits, within 20 inches [~500 mm] of the doors, shall not be less than 20 foot-candles [215 Lux] at floor level;
- illumination shall not be less than 2 foot-candles [22 Lux], measured on the surface of the Station Platform in the door area, up to 3 feet [~910 mm] away from the LRV side in the horizontal direction with the door open;
- emergency exit lighting shall illuminate the path to each LRV emergency exit. Such lighting shall be at least 5 foot-candles [54 Lux] and shall be powered from the LRV battery for no less than 1 hour;
- the average illumination intensity measured on the operator control panel shall be 20 foot-candles [215 Lux];
- the brightness ratio between lighting fixtures and the adjacent ceiling shall not be greater than 40 to 1; and
- the brightness ratio of lighting fixtures to walls (except windows) shall not be greater than 10 to 1.

It shall not be possible for anyone other than authorized operations and maintenance staff to turn interior lights on or off.

12.4.16.2 Exterior Lighting

LRV exteriors shall be designed with low-energy, high-efficiency lighting fixtures which are secure, rattle-free, and vandal-resistant. Powered fixtures shall be inaccessible to Users. Illumination levels shall be consistent and shall be measured with light-diffusing panels in place.

In addition to the Federal requirements for exterior lighting, one 200 watt minimum sealed beam railway type lamp shall be mounted centered above each end destination sign. The railway and headlight lamp arrangement shall enable the operator to see a 5 to 95 percentile adult standing in the center of the track at a distance of 800 feet.

12.4.17 Automatic Train Control

Each LRV shall include a carborne element of the Train Control System which shall communicate with the wayside Train Control System and interface with LRV systems to execute commands and monitor status. Train speed, including acceleration and braking rates, shall be subject to enforcement by vital elements of the Train Control System if not maintained within defined parameters.

12.4.17.1 TWC System

A Train-to-wayside communication system shall be provided for the remote control of Train Control System devices. Cab console control and indication devices shall be ergonomically integrated with other console equipment.

12.4.18 Communications and Location Systems

A LRV Communications System (VCS), and Automatic Vehicle Location (AVL) system, shall be provided to facilitate unique LRV identification, LRV location, destination display activation, auto-announcer activation, and voice and data radio communications. This system shall also provide data messaging and route/schedule adherence status, and may be used to provide input to street traffic control systems at intermediate Stations in order to initiate proper LRV signal and automobile traffic light phasing when a LRV is ready to depart.

Concessionaire shall provide each LRV with the following onboard communications subsystems:

- Train-to-wayside radio system(s) – voice/data/Wi-Fi;
- networked GPS/AVL/VCS systems;
- exterior forward and rearward facing and Platform monitoring CCTV cameras/recorder including cab monitors;
- interior passenger area monitoring CCTV cameras/recorder including cab monitors;
- passenger to OCC full duplex communication system via the radio system for use in emergencies;
- PA system (interior, exterior);
- passenger (to Operator) Intercom System;
- interior variable message passenger information displays;
- auto-announcer and passenger display (for automatic passenger information such as next Station annunciation); and
- exterior destination displays.

All display and PA system controls and messages shall be trainlined to all LRVs in a Train.

A maintenance and diagnostic system shall be provided on each LRV to provide information regarding malfunctions of systems and equipment. Each malfunction message shall be trainlined and shall be uniquely indicated on an onboard status panel, readily accessible to maintenance personnel. Each indicator shall continue to display the specific malfunction until it is reset. This system shall be interfaced to the Wi-Fi system to report fault alarms immediately to the OCC and to download system data automatically at intervals not to exceed 24 hours.

Cameras and video data recorders shall be placed on and in the LRV to capture video. Cameras shall provide high quality video recordings under all day and night lighting conditions. Video recordings shall be automatically stamped with GPS date & time (synchronized with the LRV event recorder), LRV vehicle number, LRV speed, camera/zone identification and LRV location. The onboard video data storage capacity shall allow for a minimum of 3 days recording of all LRV cameras. Periodic video and data transfer to wayside storage devices at intervals not to exceed 24 hours shall be via the Wi-Fi system. Security sensitive cameras shall transmit live video to the control and monitoring facilities via the Wi-Fi system upon request.

Provisions shall be made for future installation of a multi-media display and advertising system. Data communications between LRVs and OCC subsystems shall utilize an Owner-approved, non-proprietary, open-published communications protocol.

Communications equipment (including processing equipment, power supplies, and transceivers) shall be co-located to the greatest extent possible within a single carborne cabinet/closet/compartment.

Tri-mode or physically separate communications antennas may be used. Wireless performance to Wayside interfaces testing shall be realized with a maximum length Train. This potentially close-spaced antenna interference between coupled LRVs shall be considered in the LRV wireless design.

Antenna cabling shall adhere to carborne communications cabling criteria.

12.4.19 Fare Collection Interfaces

No fare collection equipment shall be mounted on board the LRV.

12.4.20 Warning Devices

12.4.20.1 Warning Bell

A warning bell shall produce a repeating sound at a level of at least 80 dBA at a distance of 50 feet [~15 m] anywhere in front of an LRV.

12.4.20.2 Warning Horn

A warning horn shall produce a strident, attention-getting sound at a level of at least 97 dBA at a distance of 100 feet [~30 m] anywhere in front of an LRV. Warning horns shall be oriented to provide the maximum sound level directly ahead of the LRV.

12.4.21 Scale Model

For the Intermediate Design, Concessionaire shall submit for Review and Comment a 1:20 Scale Model of the exterior of the LRV. This model shall be used to display the exterior LRV aesthetics and paint schemes. The model shall be attractively mounted on a base suitable for exhibit with a clear plastic cover. The roof-mounted equipment, doors, couplers, signs, lettering, handholds, lights and all other external features, shall be included to present an accurate exterior representation of the LRV. All windows shall be delineated with either glass or clear plastic with the appropriate tint.

This model shall be delivered to the Owner and shall become the property of Owner to allow it to be used for publicity displays. The model shall be supplied along with a foam-rubber-lined, permanent shipping container.

12.4.22 Design Related Submittals

Concessionaire shall submit the LRV Preliminary Design submittal for Review and Comment. The LRV Preliminary Design submittal shall include, at a minimum, the following items:

- LRV Design Criteria for all LRV equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- LRV Rail Fleet Management Plan in accordance with Section 12.4.1;
- LRV Performance Report including all system-level hardware components and their impacts on overall performance demonstrating the LRV's ability to comply with the

performance requirements that Concessionaire has determined to be necessary to meet or exceed the revenue service requirements described in the Contract Documents;

- LRV Duty Cycle Report demonstrating the LRV's ability to comply with the duty cycle requirements that Concessionaire has determined to be necessary to meet or exceed the revenue service requirements described in the Contract Documents. This report shall demonstrate that all LRV systems are capable of sustaining continuous service operation within their respective rated thermal, electrical and mechanical values as well as details of the equipment failure scenario duty cycles that can be tolerated; and
- LRV Preliminary Design Report. This shall be an update of the LRV proposal as part of Concessionaire's response to the solicitation and shall include all major system suppliers as well as conformance to Buy America and specific design requirements; In addition, this report shall include drawings representing the static and dynamic outlines, clearance diagrams, relationships and integration of major subsystems and identification of the interfaces between the LRVs and all other equipment, facilities, and systems

Concessionaire shall submit the LRV Intermediate Design submittal for Review and Comment. The LRV Intermediate Design submittal shall include, at a minimum, the following items:

- LRV Technical Specification for all LRV equipment and systems;
- Carbody Structural Analysis of the carbody elements and the trucks to include finite element analysis of each structural component;
- Crashworthiness Analysis Report. This report shall include the same reference information (including drawing numbers, material properties, references for formulas, and buckling coefficients) as required in the Structural Analysis Report;
- LRV Intermediate Drawing Sets for LRV construction. Completed drawing sets shall include, but not be limited to, assembly drawings showing all equipment locations, mounting, power connections, functional diagrams, wiring diagrams, communication antenna location(s), on board equipment interfaces, system sizing and performance calculations, equipment enclosures, racks and terminal connections, power distribution diagrams, interface control documents describing the method of interface to other required systems and equipment or facilities, and installation details;
- LRV Camera View Diagrams showing the field of view of each internal and external CCTV camera;
- LRV HVAC Performance Report demonstrating compliance with the requirements of the Contract Documents;
- a LRV Operating Systems Functionality Report describing all LRV operating systems;
- LRV Product Catalog Cuts and Component Shop Drawings for all active components, wire and cable used in the LRVs; and
- a LRV Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the LRV Final Design submittal for Review and Comment. The LRV Final Design submittal shall include, at a minimum, the following items:

- LRV Drawing Sets and Car History Books. Completed drawing sets shall include, but not be limited to, assembly drawings showing all equipment locations, mounting, power connections, functional diagrams, wiring diagrams, communication antenna location(s), on board equipment interfaces, system sizing and performance calculations, equipment enclosures, racks and terminal connections, power distribution diagrams, interface control documents describing the method of interface to other required systems and equipment or facilities, and installation details. Car history books shall, at a minimum, include serial numbers for all components, test records for assembly processes, and test records for acceptance/performance tests;

- an updated Rail Fleet Management Plan incorporating all modifications identified since the Preliminary Design submittal justifying the quantity of LRVs to be provided and supporting the equipment and spare parts to be supplied;
- an updated LRV Operating Systems Functionality Report including details of all major system suppliers, performance requirements for the LRVs and all subsystems to use as a basis for qualification and acceptance testing as performed by Concessionaire and witnessed by the Owner; and
- an updated LRV Operating Systems Functionality Report including details of all major system suppliers, performance requirements for the LRVs and all subsystems to use as a basis for qualification and acceptance testing as performed by Concessionaire and witnessed by the Owner.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information an LRV Application Software Listing for each processor.

12.5 Material and Equipment Requirements

12.5.1 General

Concessionaire shall select materials with properties that include, but are not limited to, the following:

- resistance to vandalism and graffiti; and
- ability to be cleaned and maintained.

Seat cushions and interior panels and fittings shall be of vandal-resistant materials without compromising comfort or aesthetics. Those elements where comfort is a primary concern such as seat backs and cushions shall be of modular design and easily replaceable, but only removable with the use of special tools.

12.5.2 Fire Performance

Materials used on LRVs shall meet or exceed the fire performance requirements of NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*. A series of fire performance analyses shall be undertaken to verify that these requirements are fully met. These analyses shall include a materials flammability matrix, LRV fire load estimate, heat release rate calculations, and independent laboratory Test Reports for combustible materials.

At a minimum, the following applicable fire performance tests for the materials/components shall be performed in order to demonstrate compliance.

LRV Interior:

- seat frame, cushion, and shroud;
- ceiling, walls, panels, windscreens, moldings, and linings;

- flooring assembly, covering;
- insulation;
- air ducts and lighting diffusers; and
- wire, cable, and conduit.

LRV Exterior:

- window glazing and sealing strips;
- rubber materials, such as door nose seal;
- wire, cable, and conduit;
- equipment boxes, battery box;
- rubber and elastomer materials, such as articulation diaphragm;
- panels, side skirts, shrouding; and
- roof assembly.

The LRV total heat content goal shall be 90 million BTUs (94.95 $x10^9$ joules) for a 95 feet long LRV and the LRV hourly rate goal shall be 45 million BTUs (47.48 x 10^9 joules) per hour for a 95 feet long LRV for a medium growth rate fire.

12.5.2.1 Smoke and Flammability

The materials used in LRVs shall be tested to demonstrate compliance with the smoke and flammability requirements specified in Exhibit 12. This exhibit is based upon NFPA 130 and 49 CFR Part 238, Appendix B; however, the more restrictive requirements shall govern.

Exhibit 12.3 – Test Requirements for LRV Material Fire Risk Assessment

Function of Material	Test Procedures	Performance Criteria
Seat Cushion	ASTM D 3675 ASTM E 662 ASTM E 662	Is < 25 Ds (1.5) < 100 Ds (4.0) < 175
Seat Frame	ASTM E 162 ASTM E 662 ASTM E 662	Is < 35 Ds (1.5) < 100 Ds (4.0) < 200
Seat Shroud/Arm Rests	ASTM E 162 ASTM E 662 ASTM E 662	Is < 35 Ds (1.5) < 100 DS (4.0) < 200
Upholstery	FAR 25.853 (vertical) ASTM E 662	Flame Time < 10 sec. Burn Length < 150.0 millimeters [6 inches] Ds (4.0) < 200
Wall and Ceiling Panels, Partitions, Shelves, Opaque Windscreens (Non-Glass), End Caps, and Roof Housings	ASTM E 162 ASTM E 662 ASTM E 662 ASTM 1354-99	Is < 35 Ds (1.5) < 100 DS (4.0) < 200 Average HRR@180 < 120 kW/m²

Exhibit 12.3 – Test Requirements for LRV Material Fire Risk Assessment

Function of Material	Test Procedures	Performance Criteria
	50 kW/m² applied heat flux with a retainer frame	Maximum HRR@180 < 140 kW/m²
HVAC Ducting	ASTM E 162	Is < 35
	ASTM E 662	Ds (4.0) < 100
	ASTM 1354-99	Average HRR@180 < 120 kW/m²
	50 kW/m² applied heat flux with a retainer frame	Maximum HRR@180 < 140 kW/m²
Windows/Windscreen (Glass)	ASTM E 162	Is < 100
	ASTM E 662	Ds (1.5) < 100
	ASTM E 662	DS (4.0) < 200
Light Diffusers	ASTM E 162	Is < 100
	ASTM E 662	Ds (1.5) < 100
	ASTM E 662	DS (4.0) < 200
Flooring (Structural)	ASTM E 119	Pass (with a minimum 30 minute endurance period at AW3.00 loading), Alternatives to demonstrate safety may be proposed
Ceiling/Roof	ASTM E 119	Pass (with a minimum 15 minutes endurance period), Alternatives to demonstrate safety may be proposed
Flooring (Covering)	ASTM E 648	CRF > 0.5 W/cm2
	ASTM E 662	Ds (1.5) < 100
	ASTM E 662	DS (4.0) < 200
Thermal Insulation	ASTM E 162	Is < 25
	ASTM E 662	Ds (4.0) < 100
Acoustical Insulation	ASTM E 162	Is < 25
	ASTM E 662	Ds (4.0) < 100
Elastomers	ASTM C 542	Pass
	ASTM E 662	Ds (1.5) < 100
	ASTM E 662	Ds (4.0) < 200
Exterior Shell including Shrouding, Equipment Box Covers, Equipment Boxes, and Articulation Section Panels	ASTM E 162	Is < 35
	ASTM E 662	Ds (1.5) < 100
	ASTM E 662	DS (4.0) < 200
Battery Cases	ASTM E 162	Is < 35
	ASTM E 662	Ds (1.5) < 100
	ASTM E 662	DS (4.0) < 200

The following notes apply to Exhibit 12.3:

- Note 1: The materials tested for surface flammability shall not exhibit any flaming running or flaming dripping;
- Note 2: Surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, according to FED-STD-191A *Textile Test Method 5830, Leaching Resistance of Cloth; Standard Method;*
- Note 3: Surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry cleaning, if appropriate, to ASTM D2724. Materials that cannot be washed or dry-cleaned shall be so labeled and shall meet or exceed applicable performance criteria after being cleaned as recommended by the manufacturer;
- Note 4: The seat cushion material to be tested for surface flammability and smoke emissions shall be first tested in accordance with ASTM D3574, Test I2, "Dynamic Fatigue Test by Roller Shear at Constant Force, Procedure B." After conducting a roller shear test, the same test sample shall be tested for flammability and smoke emission. Test Reports for the roller shear test shall be forwarded to Owner for review with flammability and smoke emission Test Reports;
- Note 5: Electric wire insulation shall pass IEEE 383, ICEA-S-66-524 and MIL-C-26240A smoke and flammability requirements; and
- Note 6: In the event that elastomeric primary or secondary suspension parts are unable to meet or exceed smoke, flammability, and functional requirements, specific materials may be granted a variance from smoke and flammability test requirements.

12.5.2.2 Toxicity

Materials and products exhibiting highly toxic products of combustion shall not be used. Materials used in LRV construction, except for materials used in small parts or quantities such as knobs, rollers, fasteners, clips, grommets, and small electrical parts that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall also be tested for toxicity using Boeing Specification Support Standard BSS-7239.

Materials shall meet or exceed the following maximum toxic gas release limits as determined per BSS 7239:

- carbon monoxide (CO): 3,500 ppm;
- hydrogen fluoride (HF): 200 ppm;
- nitrogen dioxide (NO2): 100 ppm;
- hydrogen chloride (HCL): 500 ppm;
- hydrogen cyanide (HCN): 150 ppm; and
- sulfur dioxide (SO2): 100 ppm.

12.6 Construction Requirements

12.6.1 LRV Configuration Control

Throughout the Term Concessionaire shall maintain a fleet wide LRV configuration control system. All LRV equipment, subassembly and major components shall be permanently identified with the manufacturer's name, part number, serial number, and revision level. This may be by use of an engraved metal label riveted in place or other method with equivalent longevity. Provision shall be made for updating the revision level when upgrades are implemented. This identification shall be supplemented by identification using bar codes, RFID tags or other suitable machine readable method.

12.6.2 Car History Books

Concessionaire shall maintain a car history book for each LRV upon completion of manufacture and keep it up to date throughout all subsequent factory and on-site activities including commissioning, acceptance testing, operations and maintenance for the duration of the Term. Concessionaire shall make electronic copies of the Car History Books continuously available to Owner for information. Car History Books shall include dated records including, at a minimum, the following information:

- car number;
- a written report of each test performed;
- serial numbers for each item of equipment as listed above;
- weight of the car as delivered;
- wheel and axle mounting records and charts;
- heat numbers and mill reports for wheels and axles;
- main reservoir certificates;
- details of approved changes and deviations;
- details of repair and rework modifications;
- a copy of each Test Report log sheet for all equipment tests performed; and
- dimensions record sheet.

12.6.3 LRV Testing

A LRV Test Program Plan shall cover all tests necessary to be performed in order to verify LRV performance, functionality and safety; the plan shall include the number and title of each Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, each LRV shall be ready for Integration Testing with other systems and Fixed Facilities.

The LRV factory and field testing shall satisfy all LRV related prerequisites of the Integration Test Program Plan and all LRV required inputs for Safety Certification.

Concessionaire shall resolve all identified hazards and implement all required corrective actions before any LRV begins powered operation on the Project.

12.6.4 Construction Related Submittals

90 calendar days prior to the start of Factory Testing, Concessionaire shall prepare and submit for Review and Comment a LRV Test Program Plan detailing all tests to be performed during factory and on-site testing.

At least 60 calendar days prior to the start of factory testing of the first LRV, Concessionaire shall prepare and submit for Review and Comment LRV Factory Test Procedures for all factory tests.

At least 60 calendar days prior to the start of on-site testing of the first LRV, Concessionaire shall prepare and submit for Review and Comment LRV on-site Test Procedures for all on-site tests.

No later than 30 calendar days after completion of factory testing of each LRV, Concessionaire shall prepare and submit for Review and Comment factory LRV Factory Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of on-site testing of each LRV, Concessionaire shall prepare and submit for Review and Comment LRV on-site Test Reports detailing the results of all tests completed including tests of carborne Train control and communications equipment.

No later than 30 calendar days after completion of on-site testing of each LRV, Concessionaire shall prepare and submit for Information all LRV Mechanical, Electrical and Software Configuration Settings.

No later than 30 calendar days after completion of on-site testing of each LRV, Concessionaire shall submit for Review and Comment the Car History Book.

12.7 Summary of Submittals

Item	Section	Submittal	Action
1	12.4.22	LRV Preliminary Design	Review and Comment
2	12.4.22	LRV Intermediate Design	Review and Comment
3	12.4.22	LRV Final Design	Review and Comment
4	12.6.4	LRV Mechanical, Electrical and Software Configuration Settings	Information
5	12.6.4	LRV Test Program Plan	Review and Comment
6	12.6.4	LRV Factory Test Procedures	Review and Comment
7	12.6.4	LRV On-Site Test Procedures	Review and Comment
8	12.6.4	LRV Factory Test Reports	Review and Comment
9	12.6.4	LRV On-Site Test Reports	Review and Comment
10	12.6.4	Car History Books	Review and Comment

13 TRAIN CONTROL

This Section identifies requirements for the Train Control System that includes, but is not limited to, Train location detection, signaling and route controls, Train speed enforcement, safe Train separation, highway grade crossings, Train-to-wayside communications, automatic vehicle location (AVL), traffic signal interfaces and associated interfaces with other operational systems.

13.1 System Overview

Concessionaire shall provide a commercially available Train control technology that meets or exceeds all specified functional, safety, reliability, availability and maintainability requirements and has a service proven record in a similar transit environment with an equivalent EMI environment.

Functions of the system that are safety critical shall be implemented with Vital hardware and software.

Concessionaire shall provide a Train Control System that includes, as a minimum, a wayside and carborne Automatic Train Protection (ATP) system including Vital and Non-Vital subsystems for Train detection, route setting and locking and vehicle maximum speed enforcement; Vital highway-light rail transit grade crossing warning; a Non-Vital railroad worker secondary warning system; and a Non-Vital interface to highway traffic signal controllers. LRV speed, including acceleration and braking rates, shall be subject to enforcement by Vital elements of the ATP system if not maintained within authorized limits.

The Project alignment includes areas of Exclusive Alignment, Dedicated Alignment and Mixed-Traffic Alignment:

In areas of Exclusive Alignment and Dedicated Alignment where the track is located to the side of the road, Concessionaire shall provide the full functional capabilities of ATP and railroad worker secondary warning system as described in this Section of the Contract Documents. Railroad style grade crossing warning systems shall be provided where required to comply with the Maryland State Highway Administration's (MDSHA) *Maryland Manual on Uniform Traffic Control Devices* (MDMUTCD).

In areas of Dedicated Alignment where the track is in the median of a road and in Mixed-Traffic Alignment, Concessionaire shall provide the full functionality of railroad worker secondary warning system and limited functionality of ATP. Limited ATP functionality shall include enforcement of pre-assigned maximum ATP speed limits over general areas which may include relatively short sections with lower MAS limits that are not enforced, route and detector locking, and status indications at interlockings and automatic vehicle location detection and reporting.

In areas of Dedicated Alignment and Mixed-Traffic Alignment, grade crossing warning systems and cross-street warning systems shall be as specified with refinements based on a site-specific study of each intersection in accordance with the MDMUTCD.

Train Traffic Management (TTM) describes the remote control and monitoring of Train control equipment from the Operations Control Center (OCC) or the Backup Operations Control Center (BOCC). Concessionaire shall provide TTM in accordance with the requirements of the Contract Documents. Interface of controls and indications and system demarcation between TTM and ATP shall be coordinated between the Train Control Systems and the control and monitoring systems designs.

13.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American Railway Engineering and Maintenance-of-Way Association (AREMA), *Communications and Signals Manual of Recommended Practices*;
- American Society for Testing and Materials (ASTM) standards;
- Federal Railroad Administration (FRA), 49 CFR Part 236, Rules, Standards, and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Appliances;
- National Transportation Safety Board (NTSB), Safety Recommendations;
- Insulated Cable Engineers Association (ICEA) standards;
- Institute of Electrical and Electronics Engineers (IEEE), IEEE C2, *National Electric Safety Code* (NESC);
- Maryland State Highway Administration (SHA), Maryland Manual on Uniform Traffic Control Devices for Streets and Highways (MDMUTCD);
- National Fire Protection Association (NFPA) 70, *National Electric Code*;
- Underwriters' Laboratory, Inc. (UL) standards; and
- U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA), *Manual of Uniform Traffic Control Devices* (MUTCD).

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

13.3 Functional Requirements

The overall safety of the Train Control System shall be consistent with the requirements for service, vehicle and passenger safety. The ATP system shall maintain safe Train separation and prevent over-speed derailments, movement of Trains through improperly aligned switches and incursions into established work zones. Elements of the Train Control System intended to maintain the safety of Trains and other rail mounted vehicles shall be designed to be Vital. Any malfunction affecting safety shall cause these System Elements to revert to a state that is known to be safe.

Concessionaire shall install Train control equipment in accordance with Project clearance criteria. Sites for the installation of Train control equipment shall be selected to avoid interference with other systems and civil elements.

13.3.1 LRT Service

Concessionaire shall provide a Train Control System that supports, as a minimum, the following headway requirements for maximum length revenue service Trains operating at maximum allowed speed:

- Normal Service minimum operating headway: five minutes;
- absolute minimum operating headway during Recovery Service including stopping at all Stations: three minutes; and
- A margin of no less than 30 seconds between the absolute minimum operating headway requirement and the design headway.

In areas of Exclusive Alignment and Dedicated Alignment where the track is located to the side of the road, the Train Control System shall provide for Train operations in either direction on either track. In areas of Dedicated Alignment where the track is in the median of a road and in Mixed-Traffic Alignment, Concessionaire shall perform a safety analysis to determine if bi-directional operation on a single track is safe and feasible, particularly considering possible conflicts with vehicular traffic movements in shared traffic lanes. In sections of the alignment where bi-directional single track operation is determined to be safe and feasible, the Train Control System shall provide for Train operations in either direction on either track. In sections of the alignment where bi-directional single track operation is determined to be unsafe and/or unfeasible for any reason, the Train Control System may provide for Train operations in the normal direction of traffic only .

Single track run times in areas of Exclusive Alignment and Dedicated Alignment where the track is located to the side of the road, defined as the time required during the use of one track to maintain traffic in one direction between two interlockings, including the time required to establish the route and for the Train to clear the exit end interlocking, shall not exceed 5 minutes, unless suitable locations cannot be identified. Where suitable locations cannot be identified, the single track run times shall be as close to 5 minutes as possible. Concessionaire shall use single track run times as a guide in locating crossovers and other interlockings in coordination with track design.

If Concessionaire places an interlocking at sta. 645, the CIH shall be located in the existing parking lot adjacent to the Armory in accordance with the Third Party Agreement Requirements.

Interlockings at Terminal Stations shall support the routine movement of trains between both tracks in both directions.

Mid-line interlockings adjacent to yard locations shall support the routine movement of Trains between either mainline track and the yard. Mid-line interlockings with pocket tracks shall support the short-term storage of trains and the reversing of Trains short of the terminus. Trains shall be able to enter or leave pocket tracks in either direction using any available track connection.

Other mid-line interlockings, in Exclusive Alignment and Dedicated Alignment where the track is off to the side of the road, shall support routing of Trains for Normal Service, for switching from normal operation to single track operation on either track on either side of the interlocking, and for reversing Trains in either direction. Other mid-line interlockings, in Dedicated Alignment where the track is in the middle of a road and in Mixed-Traffic Alignment, shall support routing of trains for Normal Service and for reversing trains in either direction and for single track operation where it has been determined to be safe.

Concessionaire shall perform an operational analysis to determine the optimum locations and configurations of all mainline interlockings and to identify those sections of the alignment where bi-directional single track operation is safe and those areas of the alignment where bi-directional single track operation is not safe.

Concessionaire shall perform an operational analysis to determine if there are locations where a Train needs to be routed into an occupied track for routine coupling purposes. If any such locations are identified, the Train Control System shall facilitate the necessary Train movements.

13.3.2 Automatic Train Protection (ATP)

Concessionaire shall provide full ATP functionality in areas of Exclusive Alignment and in areas of Dedicated Alignment where the track is off to the side of the road. Concessionaire shall provide either full ATP or limited ATP in areas of Dedicated Alignment where the track is in the middle of a road and in areas of Mixed-Traffic Alignment.

The ATP system shall ensure safe Train operation by using Vital logic design principles to perform, at a minimum, the following functions:

- Within interlockings, prevent head-on, sideswipe, and rear-end collisions between Trains by preventing conflicting, converging, or opposing routes (full ATP and limited ATP);
- between interlockings, prevent head-on collisions between Trains by preventing conflicting opposing routes at adjacent interlockings and prevent rear-end collisions between Trains by limiting speed or authorization to proceed based on track occupancy ahead (full ATP);
- route integrity and security for Trains approaching and traversing established routes, and preventing derailments caused by improperly aligned switches or by switch operation directly ahead of or beneath Trains (full ATP and limited ATP);
- broken rail detection unless an alternative means of detecting broken rails is proposed and accepted by Owner (full ATP);
- detection of insulated joint failures (full ATP);
- traffic integrity between interlockings (full ATP);
- prevent trains from exceeding the designated Maximum Authorized Speed (MAS) except as may be permitted by the safe braking model (full ATP);
- following Train separation in the normal direction and, where designated, the reverse direction of traffic (full ATP);
- detect incursions into the Project alignment by derailed WMATA or CSXT trains and prevent Project Trains from entering the area of the detected derailment (full ATP);
- enforced Train stopping at passenger Stations at locations where a Train could enter a following grade crossing before the gates are down if it failed to stop at the Station (full ATP); and
- activate highway and pedestrian grade crossings (full ATP).

The ATP system shall perform the following function which may be implemented using either vital or non-vital design principles:

- prevent trains from exceeding the pre-assigned maximum ATP speed which may be equal to or greater than the MAS (limited ATP).

The ATP system shall also perform the following Non-Vital functions to support light rail operations:

- interface with the OCC control and monitoring system as described in the Contract Documents to accept system controls and deliver system status indications and alarms via the communications infrastructure backbone (CIB) as defined in the Contract Documents (full ATP and limited ATP);
- provide local control inputs and status and alarm indication outputs to the local maintenance test panel (full ATP and limited ATP); and
- provide Train-to-wayside communications for route controls, grade crossing supplemental controls to cancel or re-request access through a grade crossing when a Train is stationary, traffic signal Preemption and Priority requests, Train locations, Train identities, LRV identities, and Train destinations (full ATP and limited ATP).

Within interlocking limits Train locations shall be detected by Vital means. In track sections between interlocking limits in areas of limited ATP, Concessionaire shall propose the means of Train location detection.

13.3.3 Grade Crossing Warning Systems

Concessionaire shall provide Vital grade crossing warning systems at all roadway and designated pedestrian grade crossings in areas of Exclusive Alignment and in areas of Dedicated Alignment if required by the MDMUTCD or required by this Section of the Contract Documents. When Trains are approaching grade crossings, the grade crossing warning system shall warn motorists and pedestrians that it is unsafe for them to cross the tracks. Grade crossing equipment and associated signage shall meet or exceed all AREMA and MDMUTCD requirements.

Grade crossing warning systems shall include flashing warning lights and audible annunciators at a minimum and, if required or recommended by AREMA, MDMUTCD, crossing geometry or use, shall also include gates to block the roadway when Trains are approaching.

13.3.4 Cross-Street Warning Systems

Concessionaire shall provide cross-street warning systems at designated street intersections in areas of Dedicated Alignment. When Trains are approaching street intersections, they shall warn motorists and pedestrians that it is unsafe for them to cross the tracks by supplementing the traffic signal stop aspects with grade crossing type gates and flashers or with additional visual warning devices. Gates and flasher equipment and associated signage shall meet or exceed all AREMA and MDMUTCD requirements.

Cross-street warning systems shall include flashing warning lights, audible annunciators and gates to block the roadway when Trains are approaching.

13.3.5 Warning Management Plan and Supplemental Warning Devices

To promote motorist, pedestrian and bicyclist safety in conjunction with LRV operations, audible warnings shall be sounded at grade crossings and other locations as determined by the operating rules and SOPs. Such audible warnings may come from LRV bells and horns and/or from wayside audible devices. Concessionaire shall perform an operational analysis and develop a Warning Management Plan to identify the proposed operating approach to audible and visual warnings at every crossing. The Plan shall also identify any and all supplemental visual and audible warning devices that need to be included in the design of the grade crossing and roadway intersection warning systems and any other wayside devices.

The Warning Management Plan shall, at a minimum:

- meet applicable MDMUTCD, AREMA, FRA and ADA requirements;
- meet MTA's policy for the use of LRV horns and bells;
- identify proposed on-board LRV and/or wayside visual warning devices;
- provide pedestrian audible alerts at all pedestrian crossings controlled by traffic signal systems;
- provide wayside audible warning devices at all grade crossing warning system locations. Warning systems shall be directional to maximize impact on the crossing road and minimize nuisance to adjacent residences and businesses; and
- provide wayside audible warning devices in the vicinity of the Manchester Place tunnel east portal and the east side of the Air Rights Building at Bethesda that activate when any

westbound Train is approaching the portal. Warning systems shall be directional to minimize nuisance to areas outside of the alignment.

13.3.6 Railroad Worker Secondary Warning System

Concessionaire shall provide a Non-Vital railroad worker secondary warning system to automatically warn track workers of approaching Trains through both audible and visual warnings and also to alert LRV and maintenance vehicle operators to the presence of personnel on the tracks. The system shall be activated by a Train, work train, track car, or other rail vehicle approaching the work zone or portal from either direction on any track, regardless of the ability of the vehicle to initiate or maintain a shunt between the running rails. This system shall be adjustable for both the distance and warning time provided.

Concessionaire shall provide a permanent warning system in the vicinity of the Manchester Place tunnel east portal and the Air Rights Building east portal at Bethesda. Each system shall provide audible and visual warnings whenever a westbound Train is approaching the portal. At each location, warning devices shall extend for a minimum of 300ft east and west of the portal.

13.3.7 Yard Train Control Systems

A Train Control System and switch heaters within any Project yard are optional except that switch operating mechanisms shall be provided that prevent switch operation while a Train is traveling through the switch and power bonding shall be provided for all tracks equipped with OCS. The interface with the mainline Train Control System shall prevent any Train from entering the mainline without proper authorization from the mainline Train Control System.

13.4 Design Requirements

Concessionaire shall locate Train control equipment not required to interface directly with light rail vehicles, track components or other wayside devices and associated power distribution in central instrument houses (CIHs) or wayside equipment cases. In areas of underground alignment, or if required by aesthetic considerations, equipment shall be installed in constructed signal equipment rooms. CIHs, wayside equipment cases, and signal equipment rooms may also be used to house related communications equipment.

Concessionaire shall install all cables external to CIHs, signal equipment rooms and wayside equipment cases in conduits, duct banks or cable troughs for their entire length.

13.4.1 System Numbering Requirements

Concessionaire shall propose a consistent numbering scheme for equipment rooms and all wayside equipment.

13.4.2 Block Design and Run-Time Analysis

The block design in areas of full ATP shall support maximum length Trains operating at Maximum Allowed Speed (MAS) and minimum headways as specified in the Contract Documents and shall incorporate LRV power and braking characteristics, track, grade, and curvature effects, and other track speed reductions. Maximum ATP speeds shall allow Trains to operate at speeds up to and including the MAS which shall be the lesser of the following plus an appropriate tolerance to permit Train operators to operate Trains at the MAS without incurring overspeed penalties:

- the maximum operating speed capability of the LRVs;
- the civil speed limit based on the track geometry;
- the posted street speed limits as detailed below;

- the maximum permitted speed through grade crossings and intersections as described in the Manual of Uniform Traffic Control Devices; and
- any lower speed in a particular area for other safety reasons such that the end-to-end run time in each direction is minimized while operating at safe speeds.

In areas of limited ATP, the ATP system shall allow Trains to operate at speeds up to and including the pre-assigned maximum ATP speed on each section of the alignment. Maximum ATP speeds shall be assigned by zones using the speed which is typical for each zone. Maximum ATP speed shall be the lesser of the following plus an appropriate tolerance to permit Train operators to operate Trains at the pre-assigned maximum ATP speed without incurring overspeed penalties:

- the maximum operating speed capability of the LRVs; and
- the posted street speed limits as detailed below; and
- the Third Party Agreement Requirements.

Concessionaire shall provide other ATP speed capabilities as required for all operating scenarios and conditions.

Concessionaire shall limit the pre-assigned maximum ATP speeds relative to posted street speed restrictions as follows:

- areas of exclusive ROW – posted street speed limits are not applicable;
- areas of mixed traffic ROW – pre-assigned maximum ATP speed shall not exceed the posted street speed limit;
- Arliss Street, Piney Branch Road and University Blvd (426+00 to 566+00 – pre-assigned maximum ATP speed shall not exceed the posted street speed limit;
- East end of University Blvd (566+00 to 587+00) – pre-assigned maximum ATP speed may exceed the posted street speed limit by up to 10 MPH;
- Campus Drive and University of Maryland (587+00 to 694+00 – pre-assigned maximum ATP speed shall not exceed the posted street speed limit;
- River Road and Kenilworth Avenue (724+00 to 760+00) – pre-assigned maximum ATP speed may exceed the posted street speed limit by up to 10 MPH;
- Riverdale Road (800+00 to 840+00 – pre-assigned maximum ATP speed shall not exceed the posted street limit; and
- Veterans Highway (840+00 to 921+00 – pre-assigned maximum ATP speed may exceed the posted street speed limit by up to 10 MPH.

Concessionaire shall develop a safe braking model to determine the maximum safe speeds and minimum Train separation distances for Trains approaching stop signals, grade crossings in cut-out mode, and following Train movements:

- a civil braking model shall be used in control line design for track speed reductions;
- control line speeds shall be optimized for both directions of travel; and
- a low-speed signal shall be provided to allow Trains to creep up to a red signal. If a Train then overruns the red signal, a full emergency brake application shall be initiated immediately.

In the Manchester Place tunnel the block design shall be coordinated with the Traction Power and tunnel ventilation systems designs in accordance with the requirements of NFPA 130.

In conjunction with the block design, Concessionaire shall develop a Normal Service run time analysis including, at a minimum, the following:

- eastbound and westbound terminal-to-terminal run times for peak periods and each off-peak period;
- round trip run times including terminal turnaround/recovery times for peak periods and each off peak period;
- directional operational string diagrams showing speed profiles (in MPH) on the vertical axis and distance on the horizontal axis, station-to-station run times and average speeds, dwell time at each station, average schedule recovery time at each station (as applicable), time points (if any), and terminal station recovery/turnaround time for peak periods and each off-peak period;
- description of the operating strategy to be used through the University of Maryland;
- assumptions regarding civil and other speed limits for each section of the alignment, acceleration and deceleration rates, dwell times at each station, time points and any other factors affecting run time; and
- a table or chart showing the cycle phasing and timing for each traffic signal and the assumption for traffic signal Preemption, Priority and sequencing with adjacent traffic signals and the consequential assumptions regarding delay that are included in the terminal-to-terminal run times for peak periods and each off-peak period. Traffic signal characteristics are identified in Book 5 shall be incorporated into this data.

13.4.3 ATP System

Concessionaire shall provide an ATP System to perform the functions of Vital wayside and Vital carborne Train control which shall be implemented using Vital equipment.

13.4.4 Wayside ATP Speed Control

In areas of full ATP functionality Concessionaire shall limit maximum allowable Train speeds based on the MAS and track conditions ahead of the Train.

In areas of limited ATP functionality Concessionaire shall, as a minimum, limit maximum allowable Train speeds to a pre-assigned maximum ATP speed in each alignment section. It shall be possible to assign and enforce different maximum ATP speeds on different sections of the alignment. Maximum ATP speeds shall be provided based on typical speeds in a track section and need not reflect small sections of lower MAS speeds on curves. For example, the speed limit along the Wayne Avenue section between 368+17 and Manchester Place station is generally 25 MPH but there are two short sections where the limit is 20 MPH and one short section where the limit is 10 MPH. The enforced maximum ATP speed throughout this section may be 25 MPH.

The pre-assigned maximum ATP speed through the University of Maryland campus shall comply with the Third Party Agreement Requirements unless higher speeds are approved by the University.

13.4.5 Carborne ATP Speed Control

The carborne ATP system shall continuously compare actual LRV speed with the maximum speed allowed by the ATP system. The maximum allowable speed at which the Train can operate shall be displayed in the operator cab. The following modes of operation shall be part of the cab-signaling system: ATP cab signal, ATP By-pass, and ATP cut-out.

13.4.5.1 ATP Cab Signal Mode of Operation

ATP cab signal mode of operation shall be used in areas of full ATP functionality and shall be initiated automatically whenever a Train enters an area of full ATP. The ATP unit onboard each LRV shall detect overspeed occurrences and initiate audible and visual alarms. Failure of the operator to acknowledge an overspeed condition or any failure of a decoded speed command shall automatically bring the LRV to a complete stop.

13.4.5.2 ATP Cut-Out Mode of Operation

ATP cut-out mode of operation shall allow Trains to transition from full ATP to limited ATP areas and to operate throughout limited ATP areas by establishing pre-assigned maximum ATP speed restrictions. This mode shall be initiated automatically when Trains leave full ATP territory and shall impose a maximum speed limit on Trains. Pre-assigned maximum ATP speed limits shall be applicable to the specific geography of the Guideway and shall be coordinated with the MAS.

The Train speed shall be internally governed by the carborne ATP unit not to exceed the current pre-assigned ATP speed restriction by more than an appropriate tolerance to permit Train operators to operate Trains at the pre-assigned ATP speed limit without incurring overspeed penalties. ATP carborne equipment shall maintain similar overspeed protection as the ATP cab signal mode of operation.

13.4.5.3 ATP By-Pass Mode of Operation

If Concessionaire includes an ATP By-Pass mode of operation to be used in the event of an ATP equipment failure, it shall be manually invoked by a sealed switch and shall illuminate an indication on the cab console, illuminate external LRV indication lights when the ATP By-Pass mode is active, log the event on the LRV event recorder and transmit an alarm to OCC.

13.4.6 Interlockings

13.4.6.1 Interlocking Functions

Concessionaire shall implement interlocking circuit design in accordance with principles of route interlocking as defined by AREMA and FRA, and as described herein. Vital logic applications shall be implemented with Vital equipment. Non-Vital logic may be implemented with Vital or non-Vital equipment.

13.4.6.2 Interlocking Design

Interlocking design shall prevent Train collisions and shall prevent switch movement when an authorized route has been established or accepted by a Train.

At interlockings in areas of Mixed-Traffic Alignment, Concessionaire shall determine the level of route security that can be provided in conjunction with the ability to provide reliable Train detection.

13.4.6.3 Electrical Isolation

Switch machines and any other Train control devices that are mechanically connected to the rails and extend below the bottom of rail shall be electrically isolated from both running rails using dielectric materials.

13.4.6.4 Switch Heaters

All switches shall be equipped with point heaters and crib heaters. Heaters shall be controllable from the OCC.

13.4.7 Signal and Power Bonding

Concessionaire shall provide signal and power bonding in interlockings to create an adequate conductivity path for track circuit and Traction Power return current without compromising the functional integrity of Train detection or broken rail detection.

Concessionaire shall provide crossbonding to electrically connect both rails of both tracks. Crossbonding shall be consistent with the assumptions for system impedance used in the Traction Power load flow studies as specified in the Contract Documents.

- cross bonds shall be installed within 500ft of all Station Platforms; and
- if hi-lo magnetic field mitigation techniques are used in the UMD campus area, crossbonding shall be modified to be consistent with the requirements of the magnetic field mitigation system requirements.

13.4.8 Grade Crossing Warning Systems

Grade crossing warning systems shall be provided for grade crossings in areas of Exclusive Alignment. In areas of Dedicated Alignment where the alignment is located at the side of the road, highway-light rail transit grade crossings may be protected by either grade crossing warning systems or by an adjacent traffic signal controller and associated signal aspects alone or by an adjacent traffic signal controller and associated signal aspects supplemented by a cross-street protection system.

At a minimum, gated grade crossing warning systems shall be provided at the following road crossings:

- Stewart Avenue – to include automatic gates for vehicular traffic in both directions and pedestrians in both directions on both sides of the street;
- ACP Entrance Road
- Rivertech Court– to include automatic gates for vehicular traffic in both directions and pedestrians in both directions on both sides of the street;
- Haig Drive– to include automatic gates for vehicular traffic in both directions and pedestrians in both directions on the east side of the street;
- 66th Avenue– to include automatic gates for vehicular traffic in both directions and pedestrians in both directions on both sides of the street; and
- Glenridge Yard Entrance.

In addition, gates and warning lights shall be provided on Presidential Drive at approximate stationing 605+00 in line with the traffic island and future UMD guardhouse. Gates shall span the single eastbound shared LRT/vehicular lane and the two westbound lanes for LRT/Vehicular shared traffic and Vehicular traffic only. Separate gates shall be provided for each of the westbound lanes. All gates shall be normally up during the daytime period to allow free flow of Trains and vehicular traffic and normally down at night to prevent vehicular traffic from entering or leaving the campus area. Raising and lowering of the gates shall be automatic based on time of day and shall occur at the same time each day but the time shall be adjustable. During the times when the gates are normally down, the gates shall be automatically raised and lowered by detecting the approach and departure of eastbound and westbound trains to raise only the gate required for the approaching Train and lower it after the Train has passed through. Concessionaire shall also provide sensors and gate controls to permit transmitter equipped buses, emergency vehicles and security vehicles to operate the gates when they are in the normally down periods. Activation shall be by commercially available transmitters. Concessionaire will not be responsible for equipping vehicles with transmitters. Concessionaire shall also provide manual control inputs and a 3 inch conduit between the gate control case and the future guardhouse location to permit future manual operation of the gates from the guardhouse.

For the Preliminary Design, Concessionaire shall prepare and submit for Review and Approval Grade Crossing Site-Specific Intersection Studies for all intersections to determine all devices to be used, and their locations.

- sight line computations at grade crossings shall consider both moving LRVs and pedestrians, providing maximum visibility with no hidden spaces behind objects and corners; to include trees, shrubbery, fences, alcoves and other obstructions. Landscaping and lighting levels shall support the intended means of surveillance. Computations shall utilize the visibility triangle, safe stopping point and crossing sight distances in the FHWA's Railroad-Highway Grade Crossing Handbook, Chapter III.C, "Assessment of Crossing Safety and Operation, Engineering Study" and the Maryland MUTCD Chapter 5.F; and
- Concessionaire shall evaluate the following factors when determining the appropriate control and warning devices:
  - configuration and geometry of crossing;
  - Train and motor vehicle operating speeds;
  - lines of sight for Train and motor vehicle operators;
  - pedestrian activity;
  - school zones;
  - motor vehicle and pedestrian volume surges;
  - pedestrian channeling;
  - pedestrian swing gates, automatic gates and barriers;
  - swing gates shall open away from the tracks, permit quick exit from the Guideway, be light and easy to operate and automatically close after use;
  - barriers shall be ADA compliant and shall cause pedestrians to turn to face the oncoming Trains in both directions prior to crossing the Guideway; and
  - TVAs and PHAs shall be performed for each crossing to determine if there is a need for CCTV surveillance.
- each Site Specific Intersection Study shall be prepared in coordination with the associated Traffic Evaluation Report.

Concessionaire shall provide directional audible warning devices at all grade crossings that maximize the sound level along the crossing road and minimize the sound level to adjacent residences and businesses. Concessionaire shall provide extended crossing start zones to keep crossing gates from rising for a short time and then lowering again for a Train from the opposite direction. "Second Train Approaching" signs shall be provided for motorists to advise them that a second Train has also activated the crossing traffic control system. These signs shall illuminate when the first Train passes through the crossing and shall extinguish after the second Train has passed through the crossing. Extended starts shall not be applied at passenger Stations. Grade crossing gates shall rise as soon as the end of the Train clears the roadway crossing.

Concessionaire shall provide an 8-hour minimum battery backup for crossing signals, gates, flashing light signals, bells, and any other equipment powered from the grade crossing control case.

13.4.9 Roadway Intersections

In areas of Mixed-Traffic Alignment and Dedicated Alignment, Concessionaire shall control Trains at roadway intersections by use of bar signal aspects as described in the MDMUTCD controlled by the traffic signal controller. See Part 2B, Section 5 of the Technical Provisions for bar signal mounting criteria. The request for passage through a street intersection may be granted by the traffic signal controller on the bases of Preemption, Priority, or no special consideration. For intersections where Preemption or Priority authorization is to be granted, Train locations shall be detected and the request presented to the traffic signal controller in adequate time for the request to be granted before the Train arrives at the intersection.

13.4.9.1 Cross-Street Protection Systems

At certain roadway intersections and pedestrian crossings as described below, and at additional roadway intersections if determined to be necessary by the Traffic Evaluation Report or the Preliminary Hazard Analysis, Concessionaire shall supplement the traffic signal aspects and pedestrian walk/don’t walk audio-visual annunciations with grade crossing type gates, flashers and audible indicators to enforce the stop aspects of certain pedestrian and traffic signals. Stop phases to be enforced at the specified intersections listed below shall include as applicable the right turn move from the parallel roadway across the tracks, the right turn from the cross street that crosses the tracks prior to reaching the parallel roadway and, where identified, pedestrian movements.

- Arliss Street at Walden Road (2 gate assemblies for pedestrians only)
- Arliss Street at South Shopping Center (2 gate assemblies)
- Kenilworth Avenue at River Road (2 gate assemblies for pedestrians only)
- Riverdale Rd (MD410) at Mustang Drive (2 gate assemblies for vehicular traffic and pedestrians and 2 gate assemblies for pedestrians only)
- Riverdale Rd (MD410) at East Pine Drive/64th Avenue (2 gate assemblies for vehicular traffic and pedestrians and 2 gate assemblies for pedestrians only)
- Riverdale Rd (MD410) at BW Parkway S/B On Ramp (1 gate Assembly)
- Riverdale Rd (MD410) at BW Parkway N/B Off ramp (1 gate assembly)
- Riverdale Rd (MD410) at 67th Avenue (2 gate assemblies)
- Veterans Parkway at Annapolis Rd (1 gate assembly for vehicular traffic only, one gate assembly for vehicular traffic and pedestrians and 1 gate assembly for pedestrians only)

Concessionaire shall provide an 8-hour battery minimum backup for crossing signals, gates, flashing light signals, bells, and any other equipment added for this Project that supplements the traffic signal aspects.

13.4.10 Speed Limit Signs

In all areas of the alignment not equipped with full ATP, speed limit signs shall be provided in advance of every location where the permissible speed (which may be greater or less than the pre-assigned maximum ATP speed) changes or at 1,000 ft intervals (individual locations adjusted as necessary to accommodate site conditions), whichever occurs first. Where the Train speed limit is different to the posted traffic speed limit, speed limit signs shall either not be visible to vehicular traffic or shall be distinctive in a manner that makes it clear that they only apply to Trains.

13.4.11 Train-to-Wayside Communication (TWC)

Concessionaire shall provide TWC for the following applications:

- TSPP requests in areas of Dedicated and Mixed-Traffic Alignment;
- Train destination and location data for passenger information signs and public access web applications; and
- other applications as determined by Concessionaire.

TWC functionality may be integrated with LRV-related status data and CCTV data into a common Wi-Fi communications system.

13.4.12 Yard Train Control

The extent of Train control and switch heater functionality provided in yards shall be determined by Concessionaire based on the proposed Concept of Operations. Operational considerations to be taken into account when making this determination shall include:

- route setting and route security;
- switch operation;
- switch movement in ice and snow conditions;
- Train operators’ authorities to move;
- LRV number tracking; and
- LRV condition/status tracking.

13.4.13 System Maintainability

The system maintainability features shall support the service reliability requirements. Concessionaire shall incorporate built-in checks to initiate alarms whenever system failures are detected that, as a minimum, impact the normal passage of trains.

Interlocking and highway grade crossing warning system logic shall have the capability of performing data recording or data logging of Vital and non-Vital controls and indications. Data recording or data logging shall have a minimum storage capacity of 30 days with all events recorded during that period. The data recorder shall be capable of downloading to a laptop computer via a remote network or local connection. However, the remote downloading function shall not have the ability to erase any information stored in the data logger.

Whenever available as a standard equipment feature, Concessionaire shall provide capabilities for remote equipment diagnostics which enable equipment status evaluation and analysis from a remote location.

13.4.14 Design Related Submittals

Concessionaire shall submit the Train Control Preliminary Design submittal for Review and Comment. The Train Control Preliminary Design submittal shall include, at a minimum, the following items:

- a Train Control Design Criteria for all Train control equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- a Warning Management Plan describing proposed audible and visual warnings to be utilized at Stations, grade crossings, street intersections, pedestrian crossings and approaching railway staff working on the alignment;
- a Safe Braking Model and Block Design including all input data, calculations, results and associated information used to establish safe Train separation;
- a Train Control Equipment Numbering Scheme including the proposed system for numbering Train control equipment;
- Control Line Drawings showing the required areas of unoccupied track for each Train movement authorization in both directions of traffic on both mainline tracks and yard connection tracks. Submittal shall include calculations to demonstrate how the length of each control line was calculated;
- a Run Time Analysis showing run times between each pair of adjacent interlockings, between each pair of adjacent Stations and for the entire alignment; and
- System Architecture Drawings, System Network and Typical Drawings including systems functionality descriptions of the proposed technology for each major element of the Train control system.

Concessionaire shall submit the Train Control Intermediate Design submittal for Review and Comment. The Train Control Intermediate Design submittal shall include, at a minimum, the following items:

- Train Control Technical Specification for all Train control equipment and systems;
- Example Location Complete Train Control Drawing Sets. Completed drawing sets shall include, but not be limited to, site plans, underground utility drawings, power and control circuit diagrams, track and cable plans, wiring diagrams, panel faceplates or GUIs as applicable, a detailed description of all processor software functionality, internal and external plans and elevations showing all Train control, lighting, communications, control and monitoring and fire and security equipment, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules. Example locations shall include, as a minimum, one mainline CIH, one yard CIH and one highway grade crossing WEC;
- Train Control Typical Installation Drawings for all wayside Train control equipment, CIHs, foundations and raceways;
- a Complete Drawing and Documentation Set for Carborne Train Control Equipment. Completed drawing sets shall include, but not be limited to, power and control circuit diagrams, wiring diagrams, panel faceplates and/or GUIs as applicable, a detailed description of all processor software functionality, internal and external plans and elevations showing all Train control, equipment, interface control documents describing

the method of interface to the LRVs, typical installation details for all components and cable schedules;

- Train Control Product Catalog Cuts and Component Shop Drawings for all active components, wire and cable used in the Train control system;
- a List of Train Control Functional Components to be supplied; and
- a Train Control Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the Train Control Final Design submittal for Review and Comment. The Train Control Final Design submittal shall include, at a minimum completed Train Control Drawing Sets for Subsystems at Wayside Locations and for Carborne Train Control Equipment. Completed drawing sets shall include, but not be limited to, block diagrams, System Architecture diagrams, network diagrams, site plans, underground utility drawings, power and control circuit diagrams, track and cable plans, wiring diagrams, panel faceplates or GUIs as applicable, a detailed description of all processor software functionality, internal and external CIH and WEC plans and elevations showing all Train control, lighting, communications, control and monitoring and fire and security equipment, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules. Final Design updates of all previously submitted drawings and reports shall also be included.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information a Train Control Application Software Listing for each processor.

13.4.15 Joint Use Poles

Concessionaire may attached wayside signals or bar signals to OCS poles if approved by the AHJ.

13.5 Material and Equipment Requirements

13.5.1 Device Security

Concessionaire shall provide wayside equipment security measures including, at a minimum, tamper-resistant covers for switch machines, equipment cases and junction boxes and vandal-resistant trackside electrical connections. Further protection may be provided through intrusion detection devices. All Train control CIHs and WICs shall utilize a three point vandal resistant locking device.

13.5.2 Signal Equipment Rooms and Central Instrument Houses

In addition to operational needs determined by Concessionaire, signal equipment rooms and CIHs shall include the following features and requirements:

- underground exit/entry for AC supply and all control and monitoring cables;
- lightning protection design in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems, and Lighting Protection Institute (LPI) 175, Standard of Practice;
- two means of egress with maximum achievable separation;
- tamper-resistant exterior hardware and fasteners;

- normal and emergency indoor and outdoor lighting including enclosure-mounted outdoor lighting fixtures above each access door;
- HVAC equipment to maintain all equipment within its temperature parameters under all operating and external temperature conditions and to provide a suitable working environment for maintenance personnel;
- access control and intrusion detection devices and control panel;
- internal and external CCTV coverage; and
- smoke/heat detectors, alarm annunciators and fire alarm control panel.

13.5.3 CIH Visual Impact Mitigation

If the designated CIH locations are utilized, landscaping and fencing/screening treatments for each CIH site shall be as shown. If different CIH locations are used, Concessionaire shall coordinate CIH landscaping and screening/fencing with the local community and submit to Owner for Review and Approval CIH Visual Mitigation.

13.5.4 Raceway Systems

Train control wayside cables shall be installed in raceway systems (cable troughs, ductbanks or conduits) complying with the following requirements:

- buried conduits shall not break or crush under all anticipated loading conditions;
- conduits for individual items of equipment shall terminate directly to equipment junction boxes;
- troughs, ducts, conduits, and fittings shall be listed for 90°C cable;
- buried and embedded Train Control conduits and raceways shall be designed with 50-percent spare conduits subject to limits of not less than one and not more than three conduits (spare capacity in ductbanks shall be provided in the form of spare conduits in the ductbank);
- surface cable troughs shall not be used to cross ballasted track;
- manholes shall have a minimum interior height of 6.5 feet floor-to-ceiling, and be provided with stainless steel pulling irons and sump; and
- cable supports in manholes and handholes shall be nonmetallic.
- The Train control raceway system may be integrated with the Communications raceway system.

13.5.5 Wire and Cable

Stranded-wire and cable of standard sizes shall be used for the interconnection of signal apparatus. Wire and cable used in underground tunnel sections as defined in NFPA 130 shall use low-flame, low-smoke, zero halogen insulation and jacket materials. The alignment sections in the Manchester Place tunnels and below the Apex and Air Rights buildings at Bethesda have been designated by the AHJ as “underground” for the purpose of applying NFPA 130 requirements.

13.6 Construction Requirements

All CIHs shall be installed with the top of the foundation above the 100 year floodplain.

Concessionaire shall test all Train control subsystems and equipment in accordance with the Test Program Plan in preparation for Integration Testing with all other operating systems, LRVs and facilities. All test results shall be entered into the Safety Certification program.

Concessionaire shall perform all testing that requires the movement of trains under the control of safety procedures that set limits on Train movements and Train speeds and establish a test director to direct and coordinate all Train movements.

Concessionaire shall provide Police protection for all highway grade crossings and street intersections to manage and control the passage of highway vehicles and Trains through the intersections until such time as the crossing warning system or traffic signal system is fully commissioned.

13.6.1 Train Control Testing

A Train Control Test Program Plan shall cover all tests required to verify Train control performance, functionality and safety; the plan shall include the number and title of each Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, the Train Control System at each location shall be ready for Integration Testing with other systems and Fixed Facilities.

The Train control factory and field testing shall satisfy all Train control related prerequisites of the Integration Test Program Plan and all required Train control inputs for Safety Certification.

Concessionaire shall resolve all identified hazards and implement all required corrective actions before conducting any tests that require the movement of Trains.

13.6.2 Construction Related Submittals

At least 90 calendar days prior to the start of factory testing, Concessionaire shall prepare and submit for Review and Comment a Train Control Test Program Plan detailing all tests to be performed during factory and on-site testing.

At least 60 calendar days prior to the start of factory testing, Concessionaire shall prepare and submit for Review and Comment Train Control Factory Test Procedures for all factory tests.

At least 60 calendar days prior to the start of on-site testing at the first location, Concessionaire shall prepare and submit for Review and Comment Train Control on-site Test Procedures for all on-site tests.

At least 60 calendar days prior to the start of LRV on-Site testing, Concessionaire shall prepare and submit for Review and Comment on-site Test Procedures for Carborne Train Control equipment.

No later than 30 calendar days after completion of factory testing of each site, Concessionaire shall prepare and submit for Review and Comment Train Control Factory Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of field testing at each site, Concessionaire shall prepare and submit for Review and Comment Train Control on-site Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Information all Mechanical, Electrical and Software Configuration Settings.

13.7 Summary of Submittals

Item	Section	Submittal	Action
1	13.4.8	Grade Crossing Site Specific Intersection Studies	Review and Approval
2	13.4.14	Train Control Preliminary Design	Review and Comment
3	13.4.14	Train Control Intermediate Design	Review and Comment
4	13.4.14	Train Control Final Design	Review and Comment
5	13.4.14	Train Control Application Software Listing	Information
6	13.5.3	CIH Visual Mitigation	Review and Approval
7	13.6.2	Train Control Test Program Plan	Review and Comment
8	13.6.2	Train Control Factory Test Procedures	Review and Comment
9	13.6.2	Train Control On-Site Test Procedures	Review and Comment
10	13.6.2	Test Procedures for Carborne Train Control	Review and Comment
11	13.6.2	Train Control Factory Test Reports	Review and Comment
12	13.6.2	Train Control On-Site Test Reports	Review and Comment
13	13.6.2	Train Control Mechanical, Electrical and Software Configuration Settings	Information

14 TRACTION POWER SUBSTATIONS

This Section identifies requirements for the overall Traction Power supply system, including the TPSSs, the Traction Power feeder cables and associated raceways. Concessionaire shall provide TPSSs to convert AC electrical power from the electric Utility Owner to DC power suitable for powering the trains along the entire length of the mainline and in all yard and shop tracks including all site preparation, duct banks and cables.

14.1 System Overview

Concessionaire shall provide TPSSs including, at a minimum, all of the following functions:

- TPSS site preparation including, at a minimum, grading, landscaping, perimeter security, driveways and parking areas, substation foundations and underground duct banks for all cables;
- mainline, yard and shop TPSS;
- electric Utility power supply to all TPSSs;
- corrosion control measures;
- if the TPSS is sufficiently close to a passenger Station that voltage drop calculations are consistent with NEC requirements and if approved by the electric Utility Owner, the Utility power supply for the TPSS may also be used as a source of power for the passenger Station;
- Traction Power positive feeder cables between the feeder breakers and pole mounted disconnect switches; and
- Traction Power negative feeder cables between the rectifier negative bus and impedance bonds or running rails.

14.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- APTA 2005 Rail Conference Paper, Cable Ampacity Tables for Direct-Current Traction Power Systems;
- C95.6 – IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz
- International Electrotechnical Commission (IEC) 61850, Communications Networks and Systems in Substations;
- IEC 62128-1:2003, Railway applications – Fixed installations – Part 1: Protective provisions relating to electrical safety and earthing;
- Institute of Electrical and Electronics Engineers (IEEE) 80, IEEE Guide for Safety in AC Substation Grounding;
- IEEE 81, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System;
- IEEE 81.2, IEEE Guide to Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems;

- IEEE 135 / Insulated Cable Engineers Association (ICEA) P-46-426, Power Cable Ampacities;
- IEEE 485, IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications;
- IEEE 1653.2, IEEE Standard for Uncontrolled Traction Power Rectifiers for Substation Applications up to 1500 V DC Nominal Output;
- Lighting Protection Institute (LPI) 175, Standard of Practice;
- NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems;
- NFPA 780, Standard for the Installation of Lightning Protection Systems; and
- Engineering guide specification, metering equipment standards, and other documents from supplying Utility Owners.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

14.3 Functional Requirements

14.3.1 System Configuration and Sectionalization

Concessionaire shall provide TPSSs to power all LRVs, whether operating individually or coupled into Trains throughout all areas of the mainline, yards and shops unless a yard or shop track is specifically designated to be unpowered for safety or maintenance reasons. The TPSSs shall support the specified levels of Train service Headways in accordance in with Part 3, Section 3, Exhibit 3.1 of the Technical Provisions, Train lengths, Train speeds and service reliability under all expected environmental conditions and single or multiple electric Utility supply service outages so long as two adjacent substations are not without power.

Concessionaire shall sectionalize the OCS system as described in the Contract Documents. Each mainline OCS section shall be fed from a minimum of two TPSSs except those sections that have one end at a bumping post. Each TPSS shall use a separate DC feeder breaker to feed each OCS section.

If Concessionaire uses a TPSS to also provide utility power to a passenger Station, the Station power feed shall comply with all applicable requirements for Station utility power feeds described in Part 2B, Section 9 of the Technical Provisions.

14.4 Design Requirements and Documents

14.4.1 Traction Power System Voltages

Concessionaire shall limit the maximum rail-to-remote-earth voltage for durations exceeding one second to 50 V DC when all Traction Power equipment is in service and 75 V DC when a TPSS is out of service.

14.4.2 Traction Power System Load Flow Simulation Studies

Concessionaire shall conduct traction power system load flow simulation studies including contingency operations with substation outages to determine the locations and ratings of TPSSs using industry recognized and proven software packages designed specifically for simulating railway DC Traction Power systems. The substation outage conditions considered shall be consistent with the specified levels of service reliability. The load flow simulations shall, as a minimum:

- simultaneously model interconnected positive and negative return electrical networks;
- model OCS conductors using electrical branches which are distinct from those used to model running rails;
- calculate current flows in rectifiers, OCS, parallel feeder, positive feeder and negative return cables;
- calculate TPSS bus voltages and OCS voltages at all LRVs as they move along the alignment;
- calculate rail-to-remote-earth voltages at any location under peak normal and recovery service conditions, with multiple trains in operation on the ROW;
- calculate rms energy demand for the electric utility supply demand interval; and
- calculate energy consumption.

The load flow studies shall incorporate the following criteria for equipment representation and modeling:

- contact wire: worn to a level consistent with Concessionaire's wire replacement criteria;
- running rail wear: worn to a level consistent with Concessionaire's rail replacement criteria;
- OCS conductor operating temperature for equivalent resistance calculations: 75°C;
- DC cable operating temperature for equivalent resistance calculations: 90°C;
- running rail operating temperature for equivalent resistance calculations: 60°C;
- LRV regenerative braking: with and without;
- simulation calculation time interval ("snapshot" interval): 1 second maximum; and
- modeling of mainline DC switch and crib heater operation when ambient temperatures are low enough for switch heaters to be operational.

In addition, the load flow studies shall consider multiple offsets between eastbound and westbound Train departure times to establish worst-case combinations.

Available sites for TPSSs are shown in the Contract Drawings.

14.4.3 Safety Features

Concessionaire shall provide safety features in the TPSS equipment including, at a minimum, the following:

- switchgear shall have shutoff capability and an interlocked tripping mechanism to protect personnel from accidental contact with live power circuits when the circuit breakers are removed;
- circuit interrupting devices which do not have load break capabilities shall be equipped with interlocks to prevent unsafe operation. Arc chutes shall be provided on load break equipment, where necessary, to control the power interruption process;
- high voltage terminations shall be protected to prevent accidental intrusions from an external source;

- indication devices shall be provided on main AC and DC circuit breakers to identify the breaker “Open” and “Closed” status and the presence of voltage;
- doors to the Traction Power rectifier and transformer compartments shall be provided with safety interlocks to prevent operation with the doors open;
- during power failures, emergency substation control power shall be available for those functions that are critical to safe operation of the equipment;
- physical lockout/tagout capability of all DC breakers and primary AC breakers shall be provided;
- draw out switchgear shall have safety shutters to protect personnel from accidental contact with live power circuits when the circuit breaker is removed;
- High resistance ground isolation shall be utilized. High dielectric strength treatment shall be used as insulation protection on the floor around the perimeter of DC conversion and switchgear equipment and shall extend a minimum of 5 feet from the equipment. Clearance around this equipment shall prevent personnel from bridging grounded and ungrounded surfaces. If such clearance cannot be provided, grounded surfaces shall be adequately insulated 8 feet in the vertical and horizontal directions; and
- if any part of the DC equipment metal enclosure is grounded or a positive bus is faulted to the enclosure, these conditions shall be detected and annunciated.

14.4.4 Stray Current Mitigation and Measurement

There shall be no permanent direct electrical connections between the Traction Power negative return system and the substation ground system, or any other grounded structures except as specified for shop rectifiers.

Concessionaire shall provide Traction Power Substations (TPSSs) with stray current monitoring facilities to allow the temporary connection of the negative bus to an earth ground mat through a relay (normally open), diode, variable resistor, fuse, and current monitoring shunt. The test facility shall be implemented to allow for periodic monitoring of the stray current return to identify changing conditions associated with the rail-to-earth resistance.

Concessionaire shall provide access to the negative bus for stray current monitoring. Access shall be provided either inside through use of dedicated wall space, if available, or outside through use of a weathertight enclosure with an open conduit between the enclosure and the negative bus.

Concessionaire shall provide substations with access to record the negative bus-to-earth potential, negative return shunt, and stray current return.

Concessionaire shall provide space in each substation for future installation of stray current mitigation drainage devices as follows:

- the designated area shall have direct access to the DC negative bus or have access through a 3-inch PVC conduit or cable run;
- the drainage bus shall be electrically isolated from all grounded facilities in the substation;
- four 3-inch PVC conduit stub-outs for single transformer/rectifier substations or six such conduits for double transformer/rectifier substations shall connect the designated area to a manhole or weathertight enclosure conveniently located outside the substation;
- the number and size of cables and the number of drainage circuits shall depend on structures in the area and shall be determined during final design; and

- the dedicated area inside the substation shall have easy access for test personnel.

14.4.5 Yard and Shop Substations

Concessionaire shall provide yard and shop substations that conform to the following requirements:

- DC Traction Power for each LRV storage yard shall be provided from a dedicated yard substation. For purposes of stray DC current mitigation, the OCS and running rails for storage yard tracks shall be electrically isolated from the mainline under normal operating conditions;
- tie switches or tie breakers shall be provided for the emergency feeding of the yard from the mainline in the event of a yard substation outage;
- DC power for use inside LRV maintenance shop buildings, blowdown pit buildings if provided, and Train wash tracks shall be provided from a dedicated shop rectifier that is not connected to the yard or the mainline. The negative pole of this dedicated power supply shall be grounded at a single point in or near the shop, and shop, blowdown pit and car wash rails shall be bonded to the same single grounding point with insulated cables. Shop running rails shall be insulated from earth, from building structures and other equipment, and from rails in the yard. The continuous rating of the shop substation rectifier shall be based on the load requirements of the shop. Access to the negative buses shall be provided for making power and stray current cable connections. The incoming AC supply neutral shall be electrically separate from the DC negative system; and
- tie switches or tie breakers shall be provided for the emergency feeding of the shop from the yard in the event of a shop substation outage.

Energization controls for shop track OCS sections shall include safety interlocks with the applicable shop door positions.

14.4.6 Substation Visual Impact Mitigation

Concessionaire shall mitigate TPSS visual impacts which may include any combination of special treatment of TPSS exterior appearance and/or site development including, at a minimum ornamental roofing, ornamental wall and door treatments, specific color schemes to match Owner’s office samples which may include custom colors and brick and siding wall finishes, TPSS exterior materials, landscaping as shown and perimeter screening walls/fences as appropriate to each TPSS location and is subject to coordination with local communities. TPSS structural design shall incorporate the additional loads associated with these treatments. All special treatments and site configurations shall be designed to accommodate equipment installation and replacement.

If the designated TPSS locations are utilized, landscaping and fencing/screening treatments for each TPSS site shall be as shown. If different TPSS locations are used, Concessionaire shall coordinate TPSS appearance, finish materials, landscaping and screening/fencing with the local community and submit to Owner TPSS Aesthetics for Review and Approval. TPSS locations where visual impact mitigation in additional to landscaping and screening/fencing shall be provided include, but are not limited to:

- Q6 – Wayne Avenue – residential neighborhood integration;
- Q7 Long Branch @ Plymouth Tunnel – residential neighborhood integration; and
- Q12 – East Campus – locate adjacent to the service area behind Richie Coliseum and extend matching brick wall around the TPSS in accordance with the Third Party Agreement Requirements.

14.4.7 TPSS Audible Noise

External audible noise from Concessionaire’s TPSSs shall not exceed 60 dB (A) maximum at any point 3 feet away from the TPSS when energized at rated input voltage and at 100-percent full load current.

14.4.8 Utility Power Supply and Metering

Concessionaire shall determine all preliminary and final electrical loads and provide appropriate electrical utility power services for all necessary Project loads.

Concessionaire shall coordinate and interface with PEPCO and prepare all PEPCO service applications for the provision of three-phase, 60 Hz, medium voltage “primary service” power for each TPSS. Concessionaire shall evaluate the service reliability and availability to determine the most appropriate service voltage. Concessionaire shall conform to PEPCO requirements that new primary services be underground type.

Concessionaire shall obtain PEPCO engineering guide specifications, metering equipment standards, and other documents required for the design, construction, and commissioning of TPSS primary utility power services and develop all system designs in accordance with these documents and standards.

Concessionaire shall provide TPSS AC power equipment that complies with all PEPCO requirements.

PEPCO service applications shall be prepared in a timely manner that is consistent with the Project Schedule and accommodates PEPCO’s required processing and construction periods. PEPCO service applications shall be submitted to PEPCO on Owner’s behalf along with all required service and construction costs.

Concessionaire shall perform all oral and written design and construction coordination with PEPCO required to obtain and establish all required utility power services and shall be responsible for PEPCO’s completion of all utility power services in accordance with the Project Schedule.

14.4.9 DC Feeder Cable Sizing

Concessionaire shall size DC positive feeder and negative return cables at each substation based on the results of the load flow studies so as to not to exceed their rated continuous 90°C operating temperature under normal or fault conditions.

14.4.10 Design Related Submittals

Concessionaire shall submit the TPSS Preliminary Design submittal for Review and Comment. The TPSS Preliminary Design submittal shall include, at a minimum, the following items:

- a Traction Power Load Flow Simulation for Normal, Contingency and Recovery Service configurations. Submittal shall include all input data, output results and a written analysis of the results with an interpretation of expected system performance relative to all performance requirements;
- a TPSS Design Criteria for all TPSS equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- Traction Power Sectionalization Diagrams for the mainline, each yard and each shop;
- a Typical Single Line Diagram and Floor Plan for each type of substation; and

- an Example Mainline TPSS Site Plan including substation foundation, manhole, hand hole and duct bank placements. Structural calculations for the foundation design shall be included.

Concessionaire shall submit the TPSS Intermediate Design submittal for Review and Comment. The TPSS Intermediate Design submittal shall include, at a minimum, the following items:

- a TPSS Technical Specification for all TPSS equipment and systems;
- Completed Mainline, Yard and Shop TPSS Typical Drawing Set showing one mainline TPSS, one yard TPSS and one shop TPSS. Completed drawing sets shall include, but not be limited to, 1) site plans, 2) underground utility drawings, 3) power and control circuit diagrams, 4) emergency trip and transfer trip circuit diagrams, 5) wiring diagrams, 6) cable plans, 7) internal and external plans and elevations showing all TPSS, lighting, communications, control and monitoring and fire and security equipment, 8) interface control documents describing the method of interface to other required systems, 9) typical installation details for all components, 10) ground grids including resistance and step and touch potential calculations, 11) conduit schedules, 12) wire and cable schedules and 13) bills of material;
- TPSS Product Catalog Cuts and Component Shop Drawings for all active components, wire and cable used in the TPSSs;
- a TPSS Detailed Functionality Description of each major component of the TPSSs;
- a TPSS List of Functional Components to be supplied; and
- a TPSS Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the TPSS Final Design submittal for Review and Comment. The TPSS Final Design submittal shall include, at a minimum, the following items:

- an updated TPSS Detailed Functionality Description of each major component of the TPSSs; and
- TPSS Drawing Sets for all locations. Completed drawing sets shall include, but not be limited to, 1) site plans, 2) underground utility drawings, 3) power and control circuit diagrams, 4) emergency trip and transfer trip circuit diagrams, 5) point-to-point wiring diagrams, 6) cable plans, 7) internal and external plans and elevations showing all TPSS, lighting, communications, control and monitoring and fire and security equipment, 8) interface control documents describing the method of interface to other required systems, 9) typical installation details for all components, 10) grounding grids including resistance and step and touch potential calculations, 11) conduit schedules, 12) wire and cable schedules and 13) bills of material.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information a TPSS Application Software Listing for each processor.

14.5 Material and Equipment Requirements

14.5.1 TPSS Enclosures

In addition to operational needs determined by Concessionaire, substation enclosures shall include the following features and requirements:

- underground exit/entry for AC supply, DC Traction Power and all other corrosion control and monitoring and control cables;
- lightning protection design in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems, and Lighting Protection Institute (LPI) 175, Standard of Practice;
- two means of egress with maximum achievable separation shall be available from any TPSS;
- emergency trip pushbuttons at each access door;
- tamper-resistant exterior hardware and fasteners;
- normal and emergency indoor and outdoor lighting including enclosure-mounted outdoor lighting fixtures above each access door;
- HVAC equipment to maintain all equipment within its temperature parameters under all operating and external temperature conditions, to provide a suitable working environment for maintenance personnel and, where required, to evacuate smoke in an emergency.
- access control and intrusion detection devices and control panel;
- internal and external CCTV coverage; and
- smoke/heat detectors, alarm annunciators and fire alarm control panel.

14.5.1.1 Substation Grounding

TPSS shall be equipped with a suitable grounding scheme designed in accordance with IEEE Standard 80, *IEEE Guide for Safety in AC Substation Grounding*.

Design of the grounding grid shall incorporate the following design input parameters at a minimum:

- soil resistivity electrical measurements obtained in accordance with IEEE Standard 81, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System, and/or IEEE Standard 81.2, IEEE Guide to Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems; and
- the maximum line-to-ground fault current from the supplying electric Utility and the line-to-ground fault clearing time.

Negative grounding devices shall be provided at TPSS if design studies indicate necessity. Negative grounding devices shall connect the TPSS negative bus to the TPSS grounding grid when the voltage between them exceeds either of the conditions specified and shall automatically disconnect after the voltage falls below the threshold. Negative grounding devices, if used, shall be voltage-limiting devices in conformance with EN 50122-1, *Railway applications – Fixed installations – Part 1: Protective provisions relating to electrical safety and earthing*.

Concessionaire shall provide conduits from the negative bus stray current drainage equipment to an interface hand hole for future use. This shall be coordinated with other requirements of the Contract Documents.

14.5.1.2 Protective Relaying and Instrumentation

Concessionaire shall perform a protective relaying coordination study to determine the appropriate settings for all circuit breaker trip devices. Settings shall be coordinated such that no breaker shall trip before all other breakers closer to the fault have tripped.

DC feeder breakers shall trip with a short circuit at any location in the Traction Power section supplied by the breaker. If necessary, use transfer trip circuits to meet this requirement.

DC feeder breakers shall not trip when two maximum length trains start simultaneously at any location within the Traction Power section supplied by the breaker.

14.5.2 DC Feeder Cables

Concessionaire shall provide DC positive and negative return circuit cables that conform to the following requirements:

- the NEMA standard for power cables for the appropriate voltage rating;
- cables in underground areas shall conform to the requirements for low smoke, low flame and zero halogen as required by NFPA 130; and
- all cables shall be installed in conduits. Direct burial of cables is not permitted.

14.5.3 Ductbank and Conduit Systems

Concessionaire shall install DC Traction Power cables in Traction Power ductbank or conduit systems that comply with the following requirements:

- 50-percent spare conduits subject to limits of not less than one and not more than three conduits;
- ductbanks and conduits installed in tunnels and underground passenger Stations shall comply with NFPA 130. Exposed conduit for DC power distribution shall be NFPA130-compliant phenolic type; and
- ductbanks and conduits shall comply with all requirements of NFPA 72 for raceway systems.

14.5.3.1 Miscellaneous Raceways

Concessionaire shall provide raceways for TPSS operation in addition to the DC power distribution system ductbanks and conduits. These raceways shall include, but not necessarily be limited to, the following:

- raceways between TPSSs for transfer trips (if required), emergency trips, and other protective functions;
- raceways for Station power and other external low voltage AC loads;
- raceways for telephone and SCADA system communications;
- raceways for stray current mitigation/drainage circuits;

14.6 Construction Requirements

All TPSSs shall be installed with the top of the foundation above the 100 year floodplain.

Prior to the start of field testing, at each TPSS, Concessionaire shall set all protective relays to the setting identified in the protective relay coordination study.

Concessionaire shall test all TPSSs in accordance with the Test Program Plan in preparation for Integration Testing with the OCS, LRVs, communications, control and monitoring and fire and security systems. All test results shall be entered into the Safety Certification Program.

Concessionaire shall implement lock-out/tag-out and red tag safety procedures on all circuit breakers and disconnect switches once the incoming electric service has been connected.

14.6.1 Traction Power Testing

A Traction Power Test Program Plan shall cover all tests required to verify Traction Power performance, functionality and safety; the plan shall include the number and title of each Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied under this Contract may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, the Traction Power system at each location shall be ready for Integration Testing with other systems and Fixed Facilities.

The Traction Power factory and field testing shall satisfy all Traction Power related prerequisites of the Integration Test Program Plan and all required Traction Power inputs for Safety Certification.

Concessionaire shall resolve all identified hazards and implement all required corrective actions before conducting any tests that require the movement of Trains.

14.6.2 Construction Related Submittals

At least 90 calendar days before the start of factory testing, Concessionaire shall prepare and submit for Review and Comment a TPSS Test Program Plan detailing all tests to be performed during factory and on-site testing.

At least calendar 60 days prior to the start of factory testing, Concessionaire shall prepare and submit for Review and Comment TPSS Factory Test Procedures for all factory tests.

At least calendar 60 days prior to the start of on-site testing at the first location, Concessionaire shall prepare and submit for Review and Comment TPSS on-site Test Procedures for all on-Site tests.

At least calendar 60 days prior to the start of on-site testing at the first location, Concessionaire shall prepare and submit for Information TPSS Protective Relay Coordination Studies for each TPSS.

No later than calendar 30 days after completion of factory testing at each site, Concessionaire shall prepare and submit for Review and Comment TPSS Factory Test Reports detailing the results of all tests completed.

No later than calendar 30 days after completion of field testing at each site, Concessionaire shall prepare and submit for Review and Comment TPSS on-site Test Reports detailing the results of all tests completed.

No later than calendar 30 days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Review and Comment TPSS on-site Test Reports detailing the results of all tests completed.

No later than calendar 30 days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Information all Mechanical, Electrical and Software Configuration Settings.

14.7 Summary of Submittals

Item	Section	Submittal	Action
1	14.4.6	TPSS Aesthetics	Review and Approval
2	14.4.10	TPSS Preliminary Design	Review and Comment
3	14.4.10	TPSS Intermediate Design	Review and Comment
4	14.4.10	TPSS Final Design	Review and Comment
5	14.4.10	TPSS Application Software Listing	Information
6	14.6.2	TPSS Test Program Plan	Review and Comment
7	14.6.2	TPSS Factory Test Procedures	Review and Comment
8	14.6.2	TPSS On-Site Test Procedures	Review and Comment
9	14.6.2	TPSS Protective Relay Coordination Studies	Review and Comment
10	14.6.2	TPSS Factory Test Reports	Review and Comment
11	14.6.2	TPSS On-Site Test Reports	Review and Comment
12	14.6.2	TPSS Mechanical, Electrical and Software Configuration Settings	Information

15 OVERHEAD CONTACT SYSTEM (OCS)

This Section identifies requirements for the Overhead Contact System including, at a minimum, the poles, pole foundations, down guys, balance weight anchors, fixed end and mid-point anchors, wire support assemblies, messenger wire, contact wire, hangers, section insulators and other insulation, pole mounted disconnect switches, underground parallel feeder cables and duct banks, other associated cables and all other appurtenances required for a complete functional system. Light Rail Vehicles (LRVs) shall collect current from the OCS contact wire by means of pantographs and return the current to the substations via the running rails.

15.1 System Overview

Concessionaire shall provide an OCS above all mainline tracks including all crossovers and terminal tail tracks, all yard tracks except tracks specifically designated as not for use by LRVs, all transfer tracks between yards and the mainline and all shop tracks unless not required for maintenance safety reasons. The OCS shall include all electrical and structural components required to connect the positive feeder cables from the TPSSs with the vehicle pantographs.

The OCS shall maintain system voltages above the minimum required for specified LRV operations. System Current capacity and resistance shall be consistent with the values used in the load flow studies. Concessionaire shall design and construct the OCS to avoid arcing (and resultant LRV propulsion faults) and provide even pantograph wear during current collection by ensuring that a properly adjusted LRV pantograph maintains continuous contact with the contact wire at all speeds up to the maximum allowable speed on each section of track. OCS poles shall be used as joint-use lighting or signal poles to support traffic signals and/or luminaires if requested or approved by the AHJ.

15.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- ACI, Building Code Requirements for Reinforced Concrete (ACI 318 App. D);
- AISC, Specification for the Design, Fabrication and Erection of Structural Steel for Buildings;
- AREMA, Manual for Railway Engineering, Chapter 33;
- ASTM A36, Standard Specification for Carbon Structural Steel;
- ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless;
- ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength;
- ASTM A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength;
- ASTM A436, Standard Specification for Austenitic Gray Iron Castings;
- ASTM A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes;
- ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts;

- ASTM A572, Standard Specification for High Strength Low Alloy Columbium Vanadium Structural Steel;
- ASTM A595, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use;
- ASTM A992, Standard Specification for Structural Steel Shapes;
- ASTM B1, Standard Specification for Hard-Drawn Copper Wire;
- ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft;
- ASTM B47, Standard Specification for Copper Trolley Wire;
- ASTM F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength; and
- IEEE C2, National Electrical Safety Code (NESC).

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

15.3 Functional Requirements

15.3.1 Climatic and Environmental Conditions

Concessionaire shall provide an OCS that will withstand the local environmental conditions including, but not necessarily limited to, temperature, wind, ice, ground topography, seismic zone, lightning, soil resistivity and corrosivity, atmospheric pollution and all other climatic and environmental conditions in which the system will operate. Conductor positions, tensions, and sags shall be designed to meet NESC Rule 250B for operating conditions and NESC Rule 250D for non-operating conditions under extreme weather conditions beyond the normal temperature range and climate conditions including, at a minimum, buildup of ice on the supports and conductors and high wind speeds. These factors shall be addressed by careful consideration of contact wire normal, maximum, and minimum design heights so that the pantograph will operate properly over its full height and sway range.

15.3.2 OCS Sectionalization

Concessionaire shall divide the OCS into electrically isolated sections to enable protective relays to initiate disconnection of any faulted section and to provide flexible operation during system emergencies.

- sectionalization shall allow any single track section of OCS between any two adjacent interlockings to be de-energized without affecting the ability to operate Trains on any other section of track. Under these conditions, Trains shall be able to operate through the interlocking using any straight or crossover tracks that do not lead solely to the de-energized section;
- yard OCS sections shall be separate from mainline sections; and
- shop OCS sections shall be separate from yard OCS sections.

Insulated overlaps and bridgeable electrical insulators used for section breaks shall not be located where the pantograph of a Train stopped at a Station Platform or at a red interlocking signal may bridge the section gap.

Electrical insulators used at crossovers to isolate parallel tracks shall be non-bridgeable by a LRV pantograph.

15.3.3 Electromagnetic Radiation Mitigation

In the area of the University of Maryland campus between stationing 598+00 and 658+00, Concessionaire shall design and construct an electromagnetic radiation mitigation scheme that meets or exceeds the Third Party Agreement Requirements.

15.4 Design Requirements and Documents

15.4.1 Engineering Studies

Concessionaire shall perform engineering studies and calculations to determine the design of the OCS and document the results in an OCS Design Report. Studies shall include calculations of all OCS structural, geometric and electrical design parameters and shall take into account all factors that contribute to support and placement of the contact wire, including, but not necessarily limited to:

- climatic conditions such as wind, temperature, ice, and snow loading;
- conductor sizes;
- conductor stagger;
- stagger changes;
- balance weight movement;
- stagger effect;
- along-track movement of in-running cantilevers;
- foundation sizes, pole sizes and pole deflection due to imposed loads, such as supporting assemblies, wind, conductor tensions, and termination facilities, such as wire tensioning apparatus;
- OCS erection and maintenance tolerances;
- track maintenance tolerances;
- LRV truck roll and lateral displacement, or 50 percent maximum roll into “operating” wind (per AREMA, Chapter 33, Part 4);
- pantograph width; and
- pantograph sway.

Results of these studies shall include:

- pantograph security (maximum displacement of the contact wire with respect to the centerline of the pantograph);
- maximum structure spacing as a function of track curvature;
- conductor blow-off, stagger effect, and allowable static offset;
- conductor rise and fall (at supports and mid-span);
- conductor along-track movement and stagger variation;
- conductor tensions, sags, and factors of safety under various climate conditions;

- contact wire deviation due to movement of hinged cantilevers;
- conductor profile, hanger lengths, and spacing;
- equipment vertical and radial loads;
- maximum tension section length; and
- loss of conductor tension along the system.

15.4.2 Overhead Contact System Types

Between sta. 99+95 and sta. 111+75, the OCS type and application shall be consistent with the available overhead clearance below the Apex and Air Rights buildings.

Between sta. 408+50 and sta. 423+50 the OCS type and application shall be consistent with the available overhead clearance in the tunnel and Manchester Place Station structures.

Between and including the Adelphi Rd/West Campus and the East Campus Stations the OCS type and application shall be consistent with the EMI design and in accordance with the Third Party Agreement Requirements.

At Silver Spring Library, the OCS type and application shall be consistent with the available overhead clearance, the aesthetics of the Library building and the Third Party Agreement Requirements.

OCS type and application shall be consistent with all overhead bridges and structures throughout the mainline and yards.

15.4.3 Contact Wire Height

Concessionaire shall establish minimum mid-span contact wire heights for all mainline, yard and shop OCS spans based on the worst case environmental conditions, requirements of the NESC and the maximum contact wire voltage.

15.4.4 Contact Wire Gradient

Where contact wire height needs to be changed, Concessionaire shall transition the height gradually to prevent bouncing of the pantograph and arcing. Contact wire gradients shall be consistent with AREMA Chapter 33 guidelines and the ability of the LRV pantographs to maintain continuous contact with the contact wire when travelling at MAS.

15.4.5 Support Structures

Concessionaire shall design and construct OCS structures in accordance with the requirements of the Contract Documents with particular attention to the requirements of AREMA, NESC, AISC, ACI, and applicable local and State codes. Support structure design shall be based on NESC Section 25, “Loading for Grades B and C,” and Section 26, “Strength Requirements.”

Design loads shall include the dead load of the OCS system itself combined with certain live loads, including, at a minimum, wind load, other dynamic loads, wire tension, and seismic load (where applicable).

Wherever the alignment passes under an overhead structure, the OCS shall only be attached to the underside of the overhead structure for structural support if the overhead structure width is such that supporting the OCS from poles on either side of the overhead structure is not achievable or if attachment is identified in a Third Party Requirement with the overhead structure owner.

Concessionaire may use short lengths of alternate OCS configurations in areas of limited overhead clearance provided that all applicable NESC criteria are met.In the vicinity of the Silver Spring Library Station, Concessionaire shall coordinate the OCS supports with the library building where the alignment passes under the building in accordance with the Third Party Agreement Requirements.

At the Silver Spring Library, Concessionaire shall not place OCS poles within the Library building footprint. Concessionaire shall utilize OCS attachment points in the building ceiling provided by others at approximate station 350+70 and 351+60. Loads on these supports shall not exceed: 1) for load case LC1: RV1 = +12.0k; RV2 = -10.0k; RH = +0.5k and 2) for load case LC2: RV1 = -10.0k; RV2 = +12.0k; RH = -0.5k. Concessionaire shall survey supports to determine the exact locations.

In the vicinity of Bethesda Station where the alignment runs under the Apex Building, the Wisconsin Avenue bridge and the Air Rights Building, Concessionaire shall coordinate the OCS supports in accordance with the Third Party Agreement Requirements; and

Between sta. 826+00 and 830+00, the OCS shall be attached to the BWI Parkway bridges to minimize the number of poles within the park. Locations and attachment details shall be coordinated with the NPS.

15.4.5.1 OCS Pole Foundation Design

Concessionaire shall coordinate pole foundation designs with OCS design, track design, and underground Utilities, and shall meet or exceed the seismic requirements of AREMA, Chapter 33, 12.3.3.1.16. Design and construction of pole foundations and guy anchor foundations shall conform to established civil and structural engineering practices and ASTM, AREMA, NESC, and ACI 318 standards.

Concessionaire shall base foundation designs on the subsurface conditions encountered in the subsurface exploration program. SPT borings or other in situ testing and laboratory testing shall be performed in accordance with the Geotechnical requirements of the Contract Documents. Design of OCS foundations shall be based on a rational design methodology. Deflections shall be in accordance with the structural requirements of the Contract Documents.

15.4.6 Structure Spacing and Staggers

Concessionaire shall establish pantograph security by maintaining a minimum contact wire edge distance (from the tip of the pantograph) under worst operating condition.

Concessionaire shall design the OCS span lengths to prevent harmonic oscillation.

15.4.7 Minimum Design Requirements

Concessionaire shall design the OCS in accordance with the requirements shown in Exhibit 15.1.

Exhibit 15.1 – Minimum Design Parameters	
Climatic Conditions	
Maximum Ambient Temperature	108º F
Minimum Ambient Temperature	-7º F
Radial Ice Loading	½ in operating ¾" non-operating
Max. Wind Speed, Pantograph Security	55 mph
Max. Wind Speed, Structural Design	90 mph
Minimum Electrical Clearances	
Static Clearance	Per AREMA and NESC
Passing Clearance	Per AREMA and NESC
Minimum Contact Wire Heights	
See Section 15.4.3	
Maximum Contact Wire Gradients	
Constant Gradient	See Section 15.4.4
Gradient Change	See Section 15.4.4
Pantograph Security	
Minimum	6 inches
Maximum Tension Variation for Auto-Tensioned Simple Catenary	
Within a Tension Length	4%

Device	Minimum Factor of Safety	
	Operating	**Non-Operating**
Messenger Wire	2	1.6
Contact Wire (30% Worn)	2	-
Tension Insulators	3	-
Stand-Off Insulators	2.5	-
Hardware	2.5	2
Foundations	**Minimum Factor of Safety**	
Overturning and Lateral Sliding	1.5	
Vertical Bearing Capacity (AREMA)	2.5	
Uplift Capacity (AREMA)	2.5	

15.4.8 Stray Current Mitigation and Grounding

The OCS shall be double-isolated from supporting structures to limit current leakage to ground. The maximum leakage current shall not exceed 2.5 milliamperes (mA) per mile of single track OCS with 2,500 V DC applied between the OCS and ground.

For locations other than on aerial or bridge structures, electrical ground facilities for adjacent catenary system support poles shall not be interconnected to each other or to a common ground electrode system. Separate ground rods and copper cable shall be provided for each catenary system support pole.

For support poles located on aerial structures, common grounding through electrical connection to either bonded (welded) reinforcing steel in the deck or to each other and a common ground electrode system shall be provided. Where catenary system support poles are located on elevated structures other than bridges, the poles shall be grounded individually or in groups.

Where catenary system support poles are located on bridge structures, grounding provisions shall be made to interconnect each pole to a bonded and grounded bridge reinforcement cage.

For OCS bridge soffit catenary supports (embedded and externally attached) under a bridge, provisions shall be made for OCS support/attachment components to be interconnected through an appropriately sized copper grounding cable. This grounding cable shall be extended to ground. Any embedded portions of catenary support hardware, concrete inserts, and studs shall be epoxy coated.

15.4.8.1 OCS Pole Foundation Grounding

To ensure that OCS poles are only grounded through the designated grounding cables, Concessionaire shall coat metallic components, inclusive of the pole baseplate, partially embedded in concrete or coming into contact with concrete surfaces with a sacrificial or barrier coating. The sacrificial coating shall be applied to the entire component. The barrier coating shall extend a minimum of 3 inches into concrete and a minimum of 6 inches above the surface of concrete. Grounding shall be coordinated with electrical, Traction Power, and OCS designs.

15.4.8.2 At-Grade OCS Support Poles

Concessionaire shall establish electrical continuity of reinforcing steel within support pole foundations to provide an adequate means for dissipating any leakage current from the contact wire and, where applicable, the messenger wire. The following minimum provisions shall be provided:

- the outermost layer of vertical reinforcing steel within the concrete foundation shall be tack welded at intermediate vertical lap joints and to two reinforcing bar collector rings installed at top and bottom of the reinforcing bar cage;
- a copper cable shall be connected between the base of the catenary support pole, as close to the top of the concrete foundation or existing grade as possible, and a ground rod. The cable shall be thermite welded or brazed to the support pole or connected to a grounding stud on the base plate and routed in such a manner that it shall not be susceptible to damage or vandalism during Construction Work or transit operations;
- the copper cable shall be sized based upon anticipated fault current and fault clearing time;
- the copper ground cable shall be connected to a ground rod driven as close to the base of the support pole as possible; and

- Concessionaire shall provide a separate grounding system, with maximum resistance-to-earth of 5 Ω, for surge arrestors, allowing for excessive current to dissipate.

Different electrical continuity requirements may be used as necessary to match the actual reinforcing configuration for the support pole foundations.

Concessionaire shall coat copper-to-steel weld locations (bond cables) with a suitable cold-applied, fast-drying mastic consisting of bituminous resins and solvents or approved suitable epoxy.

15.4.8.3 Aerial OCS Support Poles

For OCS poles on aerial structures, Concessionaire shall include one of the following minimum sets of provisions, depending on the type of aerial structure:

- where the aerial structure includes welded deck reinforcing steel connected to a ground electrode system, the OCS support poles on the structure shall be electrically interconnected and connected as a group to the ground electrode system; and
  - cabling used to interconnect poles and the ground electrode system shall be sized based upon anticipated fault current and fault clearing time;
  - cabling shall be routed in conduit and terminated in junction boxes or test cabinets that also house wires from the deck reinforcing steel and ground electrode system;
  - cabling shall be designed to allow for connection of interconnected OCS poles along the aerial structure to ground electrode systems installed with a particular aerial structure;
  - provide a copper cable from each OCS support pole or a grounding stud on the base plate to the deck reinforcing steel. The copper cable shall be sized based upon anticipated fault current and fault clearing time;
  - thermite weld or braze the cable to the OCS support pole and preferably to the nearest transverse collector bar installed in the aerial structure deck;
  - where it is not practical to connect an OCS pole directly to a transverse collector bar because of excessive distance or other factors, connect the pole to a local transverse reinforcing bar using a copper cable and weld the transverse reinforcing bar to at least three upper layer longitudinal reinforcing bars in the deck;
  - separate cabling to the ground electrode system, with maximum resistance-to-earth of 5 Ω including the cabling, shall be provided for surge arrestors; and
  - copper-to-steel weld locations (bond cables) shall require coating with a cold-applied, fast-drying mastic consisting of bituminous resins and solvents or an approved epoxy.
- Where the aerial structures do not include welded reinforcement in the deck, tie the OCS poles together with copper cable in conduit and connect to grounds at each end of the structure or at maximum spacing of 1,500 feet.

15.4.9 Design Related OCS Submittals

Concessionaire shall submit the OCS Preliminary Design submittal for Review and Comment. The OCS Preliminary Design submittal shall include, at a minimum, the following items:

- a OCS Design Criteria for all OCS equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- an OCS Design Report detailing all OCS design assumptions, design calculations and design results;
- The type of OCS pole to be used along each section of the alignment
- OCS Example Design Calculations for pole foundations, poles and wire supports; and
- OCS Master Overlap Plans.

Concessionaire shall submit the OCS Intermediate Design submittal for Review and Comment. The OCS Intermediate Design submittal shall include, at a minimum, the following items:

- an OCS Technical Specification for all OCS equipment and systems;
- OCS Design Calculations for all pole foundations, poles and wire supports. Concessionaire may utilize typical worst case calculations to cover multiple individual locations where appropriate. OCS Design Calculations shall also include design calculations for pantograph security, blow-off and stagger, radial loads, temperature vs. tension, wire sag, along track movement, load summaries, structure spacing and hanger tabulations;
- OCS Shop Drawings for all OCS components, assemblies and equipment;
- The proposed color of each pole to be used in each section of the alignment;
- OCS Product Catalog Cuts for all components, wire and cable;
- a OCS List of Functional Components to be supplied;
- OCS Layout Drawings including tabulated details for each pole and foundation;
- OCS Typical Installation Drawings for all OCS components, assemblies and equipment; and
- OCS Ductbank Drawings for all underground parallel feeders to include all conduits, manholes, handholes and connections to feeder poles.

Concessionaire shall submit the OCS Final Design submittal for Review and Comment. The OCS Final Design submittal shall include, at a minimum, completed OCS Layout Drawings including at a minimum tabulated design data for each pole and foundation and completed OCS Ductbank Drawings for all underground parallel feeder cables.

15.5 Material and Equipment Requirements

15.5.1 Overhead Contact Wire System

Concessionaire shall provide an OCS that is double-insulated with each level of insulation compatible with the system insulation class. In areas where the grade separation or other means may allow bystanders to approach in close proximity to the OCS, a minimum 10 feet of separation and a physical barrier (e.g., a grounded chain link fence) shall be provided to prevent access to any energized component. In cases where any energized component is less than 10 feet from the edge of the ROW, a solid barrier or panel shall be installed to prevent access to the energized component.

15.5.1.1 Clearances

Clearances between live conductors (including pantograph) and any grounded fixed structures shall be in accordance with the AREMA Manual, Chapter 33, Part 2, Section 2.2.5 - "Electrical Clearances from Energized Parts to Grounded Parts (Air Clearances)".

15.5.2 Poles and Supporting Hardware

Concessionaire shall utilize poles that are designed to be freestanding with the exception of termination poles which may be guyed. Additional exceptions shall be made for wide flange yard poles as required, and when along-track down guys must be used to minimize pole and foundation size.

OCS poles shall be round tubular, round tapered tubular, or wide flange shapes with steel base plates. Mainline poles shall be all tubular or all tapered tubular, except as allowed by Exhibit 15.2. Round tubular or round tapered tubular poles may be true round or 18-sided to present the appearance of round but all poles shall be of the same general type.

Exhibit 15.2 – Acceptable Mainline Locations for wide flange poles

Stationing	Remarks
266+00 to 279+00	
279+00 to 314+00	Woodside-16 station platform
314+00 to 339+00	SSTC station platform
668+00 to 694+00	
711+00 to 760+00	M Sq Station Platform
760+00 to 782+00	
782+00 to 800+00	Riverdale Park Station Platform
800+00 to 923+00	Beacon Heights Station and Annapolis Rd Station platforms
923+00 to 949+00	

Note 1: Round tapered poles shall be used within 50' of all Station Platforms.

Note 2: Mainline wide flange poles, if any, shall present a consistent and orderly appearance. Cross-sectional height and width of poles shall be approximately equal.

OCS pole finishes shall be:

- epoxy painted or weathering steel in wooded areas and adjacent to pedestrian/bicycle trails only;
- epoxy painted in all other mainline areas;
- epoxy painted or galvanized in yard and shop areas, including wide flanged poles;
- the color of epoxy painted poles shall be appropriate for the location in which they are installed and shall be submitted for Review and Comment; and
- architectural coatings and shapes shall be provided in aesthetically sensitive areas as described in the Third Party Agreement Requirements.

If weathering steel or galvanized poles are utilized, Concessionaire shall provide all pole attachments to prevent corrosion from any cause including, at a minimum, dissimilar metals, trapped moisture and exposed unfinished steel.

Pole foundations shall have provisions for feeder conduits where necessary. Pole strength and load rating shall be in accordance with NESC Rules 250 and 260. Where LRFD is used, the applicable load factors from NESC Rule 253 shall apply. In all cases, steel structures shall be designed to carry OCS loads, as outlined in the Contract Documents, under all climatic conditions without experiencing failure.

Concessionaire shall provide feeder poles to carry TPSS feeder cables and connections to underground parallel feeder cables such that the cables are installed within the poles. Conduits shall not be attached to the outside of the poles.

15.5.3 OCS Support Assemblies

15.5.3.1 Multi-Track Supports (Mainline)

To minimize overhead clutter portal structures shall not be used.

15.5.3.2 Tunnel Supports

In tunnels and other subsurface locations, Concessionaire shall utilize OCS support assemblies that are consistent with the available clearances, provide the same level of insulation integrity as for other locations and maintain the wire registration within required tolerances.

15.5.3.3 Lyttonsville Yard

In the area of Lyttonsville Yard with the covered parking structure, the OCS may be supported from poles or from the overhead structure.

15.5.4 Bridge and Shop Building Supports

Concessionaire shall utilize bridge and shop building supports where sufficient clearance to accommodate a cantilever-type assembly is not available.

15.5.5 Raceway Systems

Concessionaire shall provide raceway systems as specified in the Traction Power requirements of the Contract Documents for all underground parallel feeder cables.

15.5.6 Insulated Cables

Compliant with the DC feeder cable requirements specified for Traction Power in the Contract Documents.

15.6 Construction Requirements

OCS wires shall be attached to the undersides of the Baltimore-Washington Parkway over-bridges to minimize the number of poles in the park. Locations and details shall be coordinated with the National Park Service.

Concessionaire shall perform all work in street areas, street median areas and where the alignment crosses streets and driveways in accordance with approved Maintenance of Traffic plans.

Concessionaire shall adjust and register the OCS messenger and contact wires and all supports and poles in accordance with the designs. All measurements shall be recorded and retained as a baseline for future maintenance adjustments.

Concessionaire shall test OCS in accordance with the OCS Test Program Plan and Test Procedures in preparation for Integration Testing with the TPSSs and LRVs. All test data shall be recorded on Test Record Sheets and shall be entered into the Safety Certification Program.

15.6.1 OCS Testing

An OCS Test Program Plan shall cover all tests required to verify OCS performance, functionality and safety; the plan shall include the number and title of each Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, the OCS system at each location shall be ready for Integration Testing with other systems and Fixed Facilities.

The OCS factory and field testing shall satisfy all OCS related prerequisites of the Integration Test Program Plan and all required OCS inputs for Safety Certification.

Concessionaire shall resolve all identified hazards and implement all required corrective actions before conducting any tests that require the movement of Trains.

15.6.2 Construction Related OCS Submittals

No later than 90 calendar days before the start of factory testing, Concessionaire shall prepare and submit for Review and Comment an OCS Test Program Plan detailing all OCS tests to be performed during factory and on-site testing.

At least 60 calendar days prior to the start of factory testing, Concessionaire shall prepare and submit for Review and Comment OCS Factory Test Procedures for all factory tests.

At least 60 calendar days prior to the start of on-Site testing at the first location, Concessionaire shall prepare and submit for Review and Comment OCS on-site Test Procedures for all on-Site tests.

No later than 30 calendar days after completion of factory testing, Concessionaire shall prepare and submit for Review and Comment OCS Factory Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of adjustment and registration at each location, Concessionaire shall submit for Review and Comment OCS Adjustment and Registration Measurements.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Review and Comment OCS on-site Test Reports detailing the results of all tests completed. Test Reports for each location as appropriate shall be submitted separately.

15.7 Summary of Submittals

Item	Section	Submittal	Action
1	15.4.9	OCS Preliminary Design	Review and Comment
2	15.4.9	OCS Intermediate Design	Review and Comment
3	15.4.9	OCS Final Design	Review and Comment
4	15.6.2	OCS Test Program Plan	Review and Comment
5	15.6.2	OCS Factory Test Procedures	Review and Comment
6	15.6.2	OCS On-Site Test Procedures	Review and Comment
7	15.6.2	OCS Factory Test Reports	Review and Comment
8	15.6.2	OCS Adjustment and Registration Measurements	Review and Comment
9	15.6.2	OCS On-Site Test Reports	Review and Comment

16 COMMUNICATIONS

This Section identifies requirements for the Communications subsystems to be provided at the Operations Control Center (OCC), Backup Operations Control Center (BOCC), Stations, and other locations required within the Project scope. Facilities shall be located according to best system practices and where suitable space is available. Internal communications systems within the LRV are defined in the Light Rail Vehicle section of the Contract Documents.

16.1 System Overview

Concessionaire shall account for constraints established by commercially available systems and equipment. Commercially available service-proven hardware and software components shall be used for all communications requirements.

Communications room equipment may be housed in stand-alone Station communications rooms or cabinets, central instrument houses (CIHs), signal equipment rooms (SERs), TPSSs, or other suitable locations.

In addition to the Communications systems specifically identified in this Section of the Contract Documents, Concessionaire shall provide any and all Communications systems required to support all Project functionality, irrespective of whether that functionality is required by the Contract Documents or identified as necessary or desirable by Concessionaire.

Concessionaire shall provide, as a minimum, the following Communications systems in an integrated, flexible configuration that can be modified and easily expanded:

Communications Infrastructure Backbone (CIB), along with associated raceway, conduit and cabling, shall provide the Wide Area Network (WAN) backbone link for communications to and from the OCC, BOCC, Security Center, CIHs, TPSSs, OMF, Station Platforms, and any other Project facilities requiring communication with other locations, the MTA Police Monitoring Facility (PMF) and the MTA Treasury Office.

Wayside communications shall support Train operations and passenger notifications. Voice communications shall be provided to and from the LRVs, maintenance workers, and transit system controllers in the OCC, BOCC and Security Center. Data, video and voice communications shall be provided to and from the OCC, BOCC, Security Center and all wayside communications nodes in Stations, equipment rooms and maintenance and storage facilities as necessary to support the requirements of the Contract Documents and Concessionaire's other functional requirements. Systems shall include:

- Supervisory Control and Data Acquisition (SCADA) – all functional and design requirements shall be determined by Concessionaire except as described in the Contract Documents;
- Radio System – required system;
- Telephone System; and
  - o Administrative telephones – all functional and design requirements shall be determined by Concessionaire;
  - o Station Emergency Telephones (SETs) – required system; and
  - o Wayside Emergency Telephones (WETs) – all functional and design requirements shall be determined by Concessionaire in accordance with NFPA 130.
- Wi-Fi/Wi-Max for LRT Operations – required system.

Station communications shall support passenger information and safety. Systems shall include:

- Passenger Information System (PIS).
    - Public Address (PA) – required system; and
    - Variable Message Signs (VMS) – required system.

Operations Control Centers shall support Train operations and passenger safety by use of communications system work stations that monitor, control, and configure the CIB/PSLAN network and all other communications systems and control systems as described in the Contract Documents. Systems and facilities shall include:

- Operations Control Center (OCC);
- Back-Up Operations Control Center (BOCC);
- Security Center;
- MTA Policing Monitoring Facility;
- MTA Treasury Office; and
- Master Clock Time System (MCTS) subsystem.

Concessionaire shall interface the Communications systems with other Project systems and facilities and with external systems and networks including, but not necessarily limited to the following:

- Fire and Security Systems;
- Train control;
- TPSS;
- Tunnel Ventilation;
- Control and Monitoring;
- Fare Collection;
- Train to wayside Communications;
- Light Rail Vehicles (LRVs);
- Traffic signal systems;
- Outside agency CCTV systems; and
- Web applications.

Concessionaire shall include built-in redundancy in network designs such that a single failure will not result in the degradation of safety, security or reliability requirements.

Concessionaire shall configure all communications systems required to communicate with the OCC to be capable of independent and like/identical communication directly to the BOCC in the event that the OCC loses all power and/or OCC equipment is non-operational and/or the CIB connections to the OCC are non-operational.

The Security Center shall be located within the same building as the OCC. Concessionaire shall provide equipment in the Security Center as described herein.

Radio System shall be interoperable and adhere to the digital trunk radio specification of P25 Phase 2. The radio system shall support rail operations and emergency personnel, and shall support and be compatible with Maryland FiRST (First Responders Interoperable Radio System Team), and also support local jurisdiction's emergency and rescue radio system.

16.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American National Standards Institute (ANSI);
- American Public Transportation Association (APTA);
- American Railway Engineering and Maintenance-of-Way Association (AREMA);
- American Society for Testing and Materials (ASTM);
- Code of Federal Regulations Title 47 Part 15 (47 CFR 15), *Radio Frequency Devices*;
- Federal Communications Commission (FCC) Regulations;
- Institute of Electrical and Electronic Engineers (IEEE), IEEE C2, *National Electrical Safety Code* (NESC);
- Internet Engineering Task Force ;
- Metro Ethernet Forum (MEF);
- Motorola R56, Standards and Guidelines for Communications Sites;
- National Electrical Manufacturers Association (NEMA);
- NFPA 70, National Electrical Code (NEC);
- NFPA 72, National Fire Alarm and Signaling Code;
- NFPA 101, Life Safety Code;
- NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems;
- TIA/EIA 568, Commercial Building Telecommunications Cabling Standard;
- TIA/EIA 607, Commercial Building Grounding and Bonding Requirements for Telecommunications;
- TIA TSB-88-B-1, Wireless Communications Systems;
- IEEE 802.11, Wireless LAN / WiFi;
- IEEE 802.16, Broadband Wireless Access (Wi-Max / Wireless MAN);
- IEEE 802.3, Ethernet;
- IEEE 802.1p and Q, Ethernet QoS and VLAN/STP, respectively;
- ANSI T1.102-107: Digital Hierarchy;
- EIA-455 Series: Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices;
- TIA/EIA-204: Minimum Standards for Land Mobile Communications FM or PM Receivers (25-866 MHz);

- TIA/EIA-222: Structural Standards for Steel Antenna Towers and Antenna Supporting Structures;
- EIA RS-329: Minimum Standards for Land Mobile Communications Antennas, Part I - Based or Fixed Station Antennas, and Part II - Vehicular Antennas;
- TIA/EIA-603: Land Mobile FM or PM Communications Equipment Measurement and Performance Standards;
- FIPS (Federal Information Processing Standard) 140-2 and -3: Security Requirements for Cryptographic Modules;
- FIPS 197 AES Advanced Encryption Standard, or current NIST approved standard(s);
- Underwriters Laboratories, Inc (UL);
- U.S. Access Board, Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG); and
- U.S. Department of Justice, 28 CFR Part 36, *ADA Standards for Accessible Design.*

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

16.3 Functional Requirements

16.3.1 Communications Infrastructure Backbone

The OCC, BOCC, Security Center, PMF, MTA Treasury Office, Station Platforms, maintenance and storage facilities, TPSSs, CIH/signal equipment room and communications equipment room applications shall, as required and/or as necessary communicate with each other over the CIB system using communication terminals and interfaces at each facility.

Two separate and independent CIBs shall be provided:

- Line-specific for rail operations; and
- MDOT.

All information (data / voice / video) sent on/across the line-specific and MDOT CIBs shall be Ethernet-based. The Ethernet interface to both CIBs at the OCC, BOCC and Security Center shall be as a redundant configuration.

Concessionaire shall provide a separate, dedicated, line-specific CIB to carry essential mission critical data for Train control and monitoring, SCADA, passenger information (PA and VMS), station and wayside emergency telephones (SETs and WETs), fire alarm system, ACS at Concessionaire’s option and other communications needs. This system shall utilize a System Architecture whereby no single point of failure will result in loss of communications between any points on the network. This network shall not have any outside connection and shall be a closed network with no remote access or internet connection.

Concessionaire shall provide a physically independent CIB, which shall be an extension of the MDOT CIB, to carry data for any systems but not necessarily limited to: the Fare System, CCTV, ACS at Concessionaire’s option, Owner’s internal intranet and any other data exchange with outside agencies. This network has existing nodes at the PMF and the MTA Treasury Office.

The separation of CIB functionality, between line-specific CIB and MDOT CIB, shall guarantee that there is no possibility of access to the essential line specific data from any location or facility that is external to the Project.

Concessionaire shall coordinate with MDOT to facilitate external MDOT network connection/tie-in points into the Project's MDOT CIB network. These points shall very likely be at multiple locations for MDOT availability purposes. Location for additional MDOT communications equipment shall be provisioned in the vicinity of the CIB fiber distribution panel(s).

16.3.1.1 Passenger Station Local Area Network (PSLAN)

Concessionaire shall provide individual IP/Ethernet LANs for each CIB at each geographic location serving the application's data connections. Each application shall include the necessary connections at terminal hardware, software, equipment, and associated infrastructure. Ethernet switches shall connect each PSLAN to the line-specific and/or MDOT CIB as required.

16.3.2 Radio System

Owner has initiated discussions with the FCC and DoIT, the operators of the Maryland FiRST statewide emergency services radio system, regarding the use of this system for Project operations, maintenance and emergency voice communications. Owner anticipates that these discussions will result in agreement that the Project can use the Maryland FiRST system but the discussions will not be completed prior to the Setting Date. Consequently, the definition of radio system requirements contained herein assumes that the discussions with Maryland FiRST will result in an agreement to use the system for Project purposes. If Owner's discussions do not result in such an agreement, then Concessionaire will be issued a Change Order to address the consequential changes to the radio system requirements.

Owner will make available to Concessionaire at no cost to Concessionaire up to four dedicated talk groups in the 700 MHz band on the Maryland FiRST system cells in both Montgomery and Prince Georges counties for Project operations, maintenance and emergency radio communications. The system will provide surface coverage over an area of one mile on both sides of the Project ROW between Bethesda and New Carrollton. It will be a P25 Phase 2 compliant Time-Division Multiple Access) digital trunk radio system. The Maryland FiRST radio system will work with fixed console, mobile and portable radios, and will provide portable coverage along all areas of the Project surface alignment.

Concessionaire shall provide equivalent functionality for all underground sections of the Guideways, all underground public and non-public areas and equipment spaces of all underground and sub-surface Stations, equipment spaces of aerial stations, OCC, BOCC, Security Center and onboard LRVs. Concessionaire shall determine and provide additional coverage area requirements based on Concessionaire's Operations and Maintenance requirements. No single point failure at the OCC, BOCC or Security Center shall simultaneously disable the radio and telephone systems.

In underground areas, Concessionaire shall interface the P25 radio system, or extend existing local jurisdiction 800 MHz radio system(s) with fire, police, and EMS radio systems such that radios used by emergency and rescue personnel will function seamlessly in the underground transit facilities. Interoperability shall be achieved through direct support of existing local radio system or inter RF subsystem interface. Local jurisdiction support shall be provided for:

- Montgomery County Bomb Squad; and
- Montgomery County Fire and Rescue Service.

16.3.3 Passenger Information Systems

Concessionaire shall provide an audio/visual announcement and display Passenger Information System (PIS) to update Users on current Train schedule status, safety information, and ad hoc messages as needed. The PIS shall be comprised of a fully integrated information system with two principal subsystems: Public Address (PA) for audible notifications and Variable Message Signs (VMS) for visual notifications.

16.3.3.1 Public Address

Concessionaire shall provide a PA system at each Station. The system shall cover all public areas of all Stations. The system shall support live, ad hoc and pre-recorded audible messages. Ad-hoc message generation shall be simple, allowing the operations and security personnel to react to immediate situations. Live announcements shall interrupt pre-recorded and/or ad-hoc messages

Concessionaire shall determine if PA coverage in shop and yard areas is required to support operational requirements.

In facilities equipped with fire detection and alarm systems, the PA system may be used as the audible annunciation system of the fire alarm system as described in the Contract Documents. In this event, the PA system shall also provide coverage in all non-public areas and shall be compliant with the requirements of NFPA 72.

Public Address functionality for the purpose of live announcements shall be present on each of the two Owner personnel workstations located in the Security Center.

16.3.3.2 Variable Message Signs

Concessionaire shall provide a VMS system at each passenger Station, including VMS displays on all Platforms. At Aerial and Underground Stations, coverage shall also be provided at Station entrance and mezzanine areas. The system shall display pre-recorded messages that sync with equivalent pre-recorded PA audio messages and also Train destination and time-to-arrival messages. VMS displays shall be located and positioned so as to be visible at any point standing on the Platform.

VMS displays and backend system shall be configured and setup with the ability to display non-operational information, e.g., advertisements and associated information.

16.3.4 Telephone Systems

Concessionaire shall provide telephone functional capabilities as follows:

- an Administrative Telephone function shall be provided for use by OCC, BOCC and Security center personnel to communicate with outside agencies and Emergency Services. Other system requirements shall be determined by Concessionaire.
- a Station Emergency Telephone (SET) function shall be provided at each passenger Station for patron assistance information and emergency assistance, in elevators to call for assistance in the event of an emergency (calls shall be directed to a 24-hour monitoring station), in “areas of refuge assistance” as required by NFPA 72, and in “holding areas” as required by NFPA 130. Elevator emergency telephones may be circuited independently to the monitoring station.
- WETs function shall be provided at intervals along any sections of ROW for system employees and patrons to communicate as required for compliance with NFPA 130.

Concessionaire may combine or separate these telephone functional requirements into separate systems or a common system so long as all applicable reliability and availability requirements are met.

16.3.5 Wi-Fi/Wi-Max

Concessionaire shall deploy a Wi-Fi/Wi-Max system throughout the service area to provide communications between LRVs and the wayside along the entire mainline alignment, and at yards and shops including building interior LRV space. The respective systems shall be designed to afford timely transmission of onboard CCTV video monitoring, either on-demand live views or mass downloading of recorded images. Concessionaire may also use this system for (up/down load) of onboard data including TWC and AVL data if carried on the Wi-Fi/Wi-Max system, LRV diagnostics/data, control center access to the LRV PA systems. The system shall have onboard data storage capability for when connectivity to the OCC/network may be temporarily unavailable. The Wi-Fi/Wi-Max systems shall be capable of transmitting data and video to/from each LRV.

Concessionaire shall provide Wi-Fi/Wi-Max radios onboard each LRV and along the wayside that are compatible, scalable, and used to transmit data for sub-systems back to the OCC. The wireless system(s) connectivity shall be determined during the engineering design phase.

Wi-Fi and Wi-Max carrier frequency flexibility (variety) shall be considered based upon emerging technology, implementing a practical and adaptable migration path forward.

16.3.6 LRV Communications

LRV communications refers to the equipment and communications link between LRVs and the designated control and monitoring facilities. The onboard LRV systems shall include capabilities to support transmission of multiple CCTV cameras (video monitoring) in real-time, PA, VMS, AVL, radio, and LRV environmental/diagnostic/status data.

16.3.6.1 Automatic Vehicle Location Systems

Concessionaire shall equip each LRV with an automatic vehicle location (AVL) system for tracking and monitoring LRV locations throughout the entire alignment.

AVL data shall be transmitted in real-time to the Train Control System for monitoring of LRV locations and identities. The AVL system shall interface to the scheduling system as well as the passenger information system for Train time-to-arrival messages. An interface shall also be provided to enable Train arrival information to be presented on publicly accessible web sites.

16.3.7 Master Clock Time System

Concessionaire shall provide a Master Clock Time System (MCTS) as part of the communications design package to provide a single common time reference for synchronized time stamping in all systems, equipment and devices. The MCTS with GPS and an antenna system with hot standby backup shall be located at the OCC and BOCC communication room(s) for distribution over the CIB.

16.4 Design Requirements

16.4.1 Communications Infrastructure Backbone

The CIB node equipment Ethernet bandwidth shall be scalable to meet or exceed both initial and future demands of all network applications.

Concessionaire shall provide one 144 strand fiber optic (FO) cables continuously along the length of the alignment for the MDOT CIB with local terminations at the fiber distribution panels. The Project fiber optic cables for the MDOT CIB shall be spliced into the existing network cables at two locations. At each location, except as noted below Concessionaire shall provide one 144 strand fiber cable and two conduits (one for the cable and one spare) between the Project network and the existing network and shall arrange for the splice connections into the existing network cables including all associated fees.

- New Carrollton – existing MDOT network cables are located in the Security Room in the New Carrollton MARC/Amtrak Station. Concessionaire shall provide conduits and cable for this location. The Security Room is located on the same level as the pedestrian underpass beneath the MARC/Amtrak platform, and approximately 250 feet north of the east/west pedestrian tunnel.
- College Park – existing MDOT network cables are located in a manhole at the southwest corner of the intersection of Kenilworth Avenue and Crescent Road just north of I-495. Conduits will be installed by others between a pull box approximately 20 ft from the College Park TPSS Q13 and the network interface manhole. Concessionaire shall provide conduits to connect to the pull box adjacent to TPSS Q13 and cable between the Project network and the existing network interface manhole on the southwest corner of Kenilworth Avenue and Crescent Road.

Concessionaire shall determine the fiber optic cable requirement for the line-specific CIB and also the vital Train control. Where separate FO cables are provided for redundancy/availability, the FO cables shall be installed in separate conduits or separate cable trough compartments at all times.

The CIBs shall support secure connection-oriented service protocol to establish an end-to-end logical or physical connection before any data may be sent.

The CIBs shall be designed to provide for redundant, separate paths to minimize single points of failure that may interrupt service similar to Synchronous Optical Network (SONET) or other schemes that support a self-healing ring configuration. For the line specific CIB and vital Train control, the redundant paths shall be in separate cables in separate conduits or trough compartments. For the MDOT CIB, redundant paths shall be in separate buffer tubes within the single 144 strand cable. The failover/recovery time from primary route to/from secondary route for the CIBs shall be less than 50 ms. The CIBs shall survive the single point of failure, operating at the same performance level before failure event.

Concessionaire shall assign Ethernet standard QoS priority levels to each network system (or VLAN) carried by the CIBs. The end-to-end QoS priority level goals of the data, voice and video transported from each subsystem to the OCC or other head ends shall be maintained under aggregate ‘normal busy hour’ and ‘emergency’ traffic conditions across the CIB to the OCC, BOCC and Security Center. Each subsystem (or VLAN) shall receive a commensurate and appropriate QoS value.

CIB network availability shall support all Project reliability and availability requirements and shall include physically diverse re-route protection and the capability for various levels of QoS requirements.

CIB and PSLAN design shall include firewalls and/or network appliances at each passenger Station to block or otherwise safeguard against network intrusion (e.g., DDoS attacks caused by internal or external unauthorized network entry attempts).

MDOT CIB: 10-GigE-base managed Ethernet switches shall be provided in each designated communications room or other suitable locations as proposed by Concessionaire and shall be the active demarcation point of interface to the CIBs. (For line-specific CIB the uplink bandwidth shall be 1-GigE minimum). These shall serve as interface points for connection of all other systems that use the CIB for data transport. The managed switch shall fully support IPv6 addressing. 24-port minimum switches shall be provided to connect device-level (edge) components or equipment.

The managed Ethernet switch configuration at OCC, BOCC and Security Center shall be a redundant hot-standby type; and shall apply to both CIBs (line-specific and MDOT).

All equipment for the MDOT CIB shall be approved by MDOT.

16.4.1.1 Passenger Station Local Area Network (PSLAN)

Concessionaire shall connect individual PSLANs to the CIB via a managed Ethernet switch to create a seamless, end-to-end(s) Ethernet communication transport facility.

Each PSLAN shall support mechanisms to segregate and prioritize traffic according to supported applications. Multiple priority levels and/or QoS levels shall be assigned to traffic types to meet or exceed the specific needs of each application. The PSLAN uplinked to the CIB shall support virtual LANs (VLANs) to segregate and secure the data of each sub-system including, but not necessarily limited to, SCADA, PA, VMS, SET, CCTV (Section 18), FC, WET, and any other communications sub-system to maintain the required QoS of each application.

16.4.2 Radio System

Owner will provide a radio system for surface area coverage of the Project alignment which will include:

- core radio system containing processing and networking equipment (minimum of two locations); and
- radio transmitter, receiver, antennas, power conversion and connections, electric Utility coordination and tower structure and sites.

The radio system will support channel group patches, which involves temporarily combining two or more modules, such that each member hears every other member.

Each site core will be redundant. The core will have a NMS (Network Management System). Any failed device will be annunciated and recorded at the NMS.

Both core sites will have an associated dispatch point or center.

Core system connectivity will be Ethernet/IP. Connectivity to telephones (voice over internet protocol and through the PSTN) will be implemented.

The radio system will provide end-to-end encryption, sender to receiver, whether console or subscriber units.

The radio system will provide reception to a 2.5-watt ERP portable radio worn at the hip over 95 percent of the required coverage area with all base stations operating. Talk path availability will not be less than 99%.

Concessionaire shall compatible Radio system equipment for all frequencies available for Project use on the Maryland FiRST system that includes, as a minimum, the following elements:

- handheld units (portable radios);
- radio units mounted within LRVs and high-rail equipment (mobile radios);
- radio units mounted within service and support roadway vehicles (mobile radios);
- dispatcher console station radios, located in OCC, BOCC and Security Center; and
- tunnel radio systems for underground sections (also supporting local jurisdictions); and.

- supplementary coverage augmentation as necessary in other Project buildings and structures.

Radio system shall comply with NFPA 130, Section 10.3.

Radio system shall be capable of providing the required coverage to operate a 2.5-watt portable radio, worn at the hip with a lapel microphone, anywhere in the designated coverage area.

Minimum radio system two-way path availability shall be 99%.

The trunked radio system shall operate fully functional in the event of the loss of both cores.

The radio system shall have no single point of failure. Scheduled maintenance shall not disrupt radio service.

The radio system shall provide a minimum of 3.4 Delivered Audio Quality (DAQ) to in-building and LRV portable and mobile radios. Refer to TIA/EIA *Technical Service* Bulletin *TSB-88* for a description of DAQ.

The system design shall enable future channel expansion and groups without the replacement of existing equipment.

Radio system shall support 800 MHz Montgomery County Emergency Services radio systems where existing system will not have adequate signal strength.

16.4.3 Passenger Information Systems

Concessionaire shall provide a PIS to present dynamic information required for the guidance and convenience of Users. Information shall be presented both audibly and visually and shall meet or exceed ADA and ANSI A117 requirements. The system shall be stand-alone and controlled from the OCC, BOCC and Security Center. The VMS display data construct shall conform to that of Concessionaire supplied scheduling software and customer information system to ease integration. Audible messages and sign data may be stored at the central servers and disseminated via the CIB and/or stored locally at the station. Adaptive amplification shall be used when required to adjust to variations in ambient noise sources.

Information to be presented includes:

- time of day;
- approaching trains, with Train destination and time to arrival;
- general service messages;
- adjustments to service;
- Train delays;
- emergency situations; and
- advertising messages.

16.4.3.1 Public Address

Concessionaire shall equip each Station with a PA system. A network communication line shall serve each location for remote announcements from locations as determined by Concessionaire plus the Security Center. Concessionaire shall determine and incorporate any requirements for local access to the PA systems.

The PA system shall be a multi-zoned system allowing appropriate messaging that is coordinated with dynamic signage (simple at-grade center Station Platforms may not require separate zones).

Speakers shall be wired in redundant A/B configuration where alternating speakers are controlled by separate amplifiers.

Speaker placement and zoning shall be individually designed for each Station, with consideration to the following:

- speaker placement;
- speaker type;
- amplifier and decoder type; and
- equipment location.

Concessionaire shall locate speakers to cover all areas of the Station. If the PA system is used for audible annunciations/alarms from the fire alarm system, it shall meet or exceed applicable requirement as defined in the Contract Documents.

Concessionaire shall perform an acoustic study based on the specific architecture of each Station and its Platform(s) to ensure sufficient sound levels are maintained, interference is minimized, and announcements cannot be heard in adjacent zones and properties. If the PA system is to be used as the audio annunciation system of the fire alarm system, then ancillary equipment rooms and spaces shall be covered.

PA system design shall consider Station background volume and possible interference from nearby sound sources. Adaptive noise sensing shall be used to adjust volumes based on current ambient conditions.

The Station agent, if on-site, shall be able to hear announcements and to make local announcements.

Sound/speaker systems shall meet the following standards:

- wiring in separate conduits;
- conduit runs hidden or inconspicuous;
- capable of accurate, 64kps (8 bit x 8kHz) signal throughput speech reproduction;
- speakers installed at 10 feet height minimum or in approved, vandal-proof enclosure if less than 10 feet;
- exterior speakers suitable for long term exposure to the full range of climatic conditions for the region;
- uniform sound distribution; and
- individual volume controls for each zone.

16.4.3.2 Variable Message Signs

Concessionaire shall place signs in a prominent position and clearly viewable to Users from all positions along Platforms. Signs shall have an attention-getting light to indicate that a PA announcement is being made and an informational message is being displayed.

The VMS system shall be interfaced to the Owner's web site to allow patrons to see the same next Train arrival messages that are displayed on the Station signs.

16.4.4 Telephone Systems

To the extent possible, administrative telephones, SETs, and WETs shall be integrated into a common telephone system.

16.4.4.1 Administrative Telephone System

Concessionaire shall utilize standardized IP telephone devices in the administrative telephone system. Locations and mounting methods shall be developed during the design. These devices shall be installed, as a minimum, in the OCC, BOCC and Security Center. Concessionaire shall determine requirements for yards and shops and any other required areas to support employee activities.

16.4.4.2 Station Emergency Telephones

Concessionaire shall provide a minimum of one SET device per Platform at each Station located in the center of the Platform plus all other locations identified in the Contract Documents and clearly marked for User purpose and use.

SETs shall be vandal resistant and shall comply with applicable ADA requirements for use by patrons who are visually and/or hearing impaired.

Concessionaire shall designate the SET receiving station at the OCC/BOCC, the Security Center or an outside monitoring service.

When activated, SETs shall automatically call to the designated receiving station and shall annunciate the location of the SET calling unit at the receiving station. SETs shall incorporate a blue light to call attention to their locations and, when activated, shall initiate a CCTV image of their location at the SET receiving station. If a Station is staffed with a local Station agent, the SET shall first call to the Station agent's position and, if not answered, shall roll over to the designated SET receiving station.

16.4.4.3 Wayside Emergency Telephones

Unless the emergency communications requirements defined in NFPA 130 are satisfied by alternate means, Concessionaire shall provide WETs for transit system personnel along at-grade, aerial and underground Guideway sections and shall provide connectivity to the telephone system at Stations and integrated to the OCC and BOCC. An off-hook condition shall be automatically reported to the OCC and BOCC.

Blue Light Stations shall be located as per NFPA 130. These stations shall be identifiable by a blue light affixed above two-way devices to comply with NFPA 130 requirements. They shall be installed in tunnels and Aerial Stations and shall include a WET.

16.4.5 Wi-Fi/Wi-Max

Concessionaire shall provide wireless Wi-Fi/Wi-Max coverage over all mainline and yard track areas to support railway systems operations. Signal strength shall be sufficient to support the reliability requirements for the transmission of Train control AVL and TWC data. Bandwidth shall be sufficient to support the simultaneous transmission of one CCTV video signal from each of four LRV cars plus all other data from the maximum number of LRVs in service. Wayside antenna placement shall be located on alignment property; and the associated radio (access point, AP) shall be powered from a backup electrical supply.

16.4.6 Train Control Vital Communications

Vital/ATP communications between CIHs may be implemented using fibers in the line-specific CIB, or as separate independent fiber optic cable(s). CIHs 10A/10B shall be treated and implemented as a single (network) node for vital communications.

16.4.7 Master Clock Time System

Concessionaire shall provide a Master Clock Time System (MCTS) to generate precise time-of-day signals to synchronize digital clocks, communication systems, control systems, employee computers and other equipment that relies on timing functions located throughout the Project facilities. These communication systems shall include:

- CCTV System
- Access Control System (ACS);
- Fire Alarm System (FAS);
- Public Address/Variable Message Signs (PA/VMS) System;
- Traction Power/Mechanical, Electrical, Plumbing (MEP), Elevator / Escalator System, Supervisory Control and Data Acquisition (SCADA) Systems;
- Train Traffic Management (TTM) servers
- Train Control System and interlocking processors;
- Telephone Systems – SETs, WETs, Administration;
- Radio System;
- OCC, BOCC and Security Center
- Network switches for PSLAN, LAN, SCADA, and all other networks;
- Communication Infrastructure Backbone (CIB); and
- Vehicle on-board systems via the Wi-Fi/Wi-Max system.

The MCTS shall utilize standard protocol Network Time Protocol between Network Time Protocol servers at OCC and the BOCC. Network Time Protocol data shall be sent to all managed Ethernet switches. Base Network Time Protocol server date/time shall be derived from the master GPS, and Network Time Protocol server(s) shall broadcast date/time over the CIB via Ethernet communications.

The MCTS shall be configured in a hierarchy as specified by the Internet standard, Request for Comment (RFC) 5905 or later edition if available. Systems synchronized by the MCTS shall be referenced to UTC, which is also U.S. Standard Time.

Concessionaire shall transmit UTC from remote locations to Stations in multicast mode. UTC shall be received from GPS satellites by the servers. The Network Time Protocol servers shall broadcast the UTC signal to the system.

16.4.8 Communications Power

Concessionaire shall provide power for all wayside communications systems and equipment from UPSs with capacity to support the fully loaded communications equipment for a period of not less than 2 hours.

Specific to all managed Ethernet switches uplinked to both CIBs, all RJ45 ports shall support PoE per IEEE 802.3af or 802.3at.

16.4.9 Design Related Submittals

Concessionaire shall submit the Communications Preliminary Design submittal for Review and Comment. The Communications Preliminary Design submittal shall include, at a minimum, the following items:

- a Communications Design Criteria for all Communications equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- a Bandwidth Calculation for Each CIB to identify the bandwidth assigned to each subsystem between each set of required locations;
- an 800 MHZ Radio System Availability Study for those portions of the 800MHz radio system provided by the Concessionaire;
- a Coverage Study for the Wi-Fi/Wi-Max System;
- Communications Network Architecture Diagrams including a system-level graphic representation of all hardware components and their interconnections. This shall include identification of the interfaces between all existing and proposed devices and systems. Architecture diagrams shall be provided for each CIB and each corresponding site PSLAN and MDOT LAN;
- Communications Preliminary System Drawings including schematic, plan and interface drawings for each communications system. Where similar systems will be installed at multiple locations, drawings for typical locations including the OCC will be sufficient; and
- an Acoustic Study based on the specific architecture of each Station and its Platform(s) to ensure sufficient sound levels are maintained, interference is minimized, and announcements cannot be heard in adjacent zones and properties. Study shall identify the locations of speakers and incorporate a sound pressure diagram with sound pressure contours within and around each location where a PA system is to be provided.

Concessionaire shall submit the Communications Intermediate Design submittal for Review and Comment. The Communications Intermediate Design submittal shall include, at a minimum, the following items:

- Technical Specification for all communications equipment and systems;
- Communications Drawings for all communications networks;
- Complete Communications Drawing Sets for Typical Locations for the typical systems and locations used in the Preliminary Design. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of equipment enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- Communications Product Catalog Cuts for all active components, wire, and cable used in the communications system;
- a Communications List of Functional Components to be supplied for each communications system;

- a Communications Detailed Functionality Description of the central servers and workstations for each communications system including typical graphical displays, icons and controls; and
- a Communications Software Configuration Management Plan describing how Concessionaire will identify software revisions, and control and track what software version is installed on each processor.

Concessionaire shall submit the Communications Final Design submittal for Review and Comment. The Communications Final Design submittal shall include, at a minimum, the following items:

- Complete Communications Drawing Sets for All Locations. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of equipment enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules; and
- an updated Communications Detailed Functionality Description of the central servers and workstations for each communications system including all software functions, graphical displays, icons and controls.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information a Communications Application Software Listing for each processor.

16.5 Material and Equipment Requirements

16.5.1 Environmental Requirements

Concessionaire shall design all communications systems and equipment to function normally in the Project environment. As such, equipment mounted outside shall function normally under the conditions described in the Contract Documents.

Equipment mounted within an equipment room or equipment case shall function normally without artificial heating and without mechanical cooling of the room or case. If certain equipment is unable to meet this requirement, then the reliability of the climate control equipment shall be included in the system reliability analyses.

Equipment located in tunnels and Underground Stations shall be protected against water intrusion to the same level as equipment mounted in the open.

16.5.2 Equipment Cabinets

Cabinets, wiring, and components shall be vandal-proof and rated for the installed environment.

At Silver Spring Library, Concessionaire shall utilize a Station electrical and communications room that has been constructed by others in the northeast corner of the ground level of the Silver Spring Library Residences building adjacent to the back of the westbound Platform at approximate stationing 350+25.

16.5.3 Radio System

Equipment shall meet or exceed all applicable standards of the Electronic Industries Association and the rules and regulations of the CC in addition to the requirements specified herein.

Core radio system components and equipment shall be like/identical at both core site locations. The equipment and mounting chassis system shall be industry standard 19 inches.

Chassis/equipment shall be located in a secure area.

The NMS shall be an integral part of the core, and shall interface and connect to the CIB.

16.5.4 Variable Message Signs

Concessionaire shall provide VMS displays that are full sunlight viewable and ambient light adaptive to adjust to light variations. VMSs shall be mounted in outdoor enclosures which are a minimum of 40 inches long.

16.5.5 MDOT CIB

Any and all new equipment or software that is placed on the MDOT Enterprise network shall be required to follow the MDOT Configuration Change Process and comply with MDOT standards.

- all new hardware/software planned on the MDOT Enterprise network shall be subject to a Vulnerability Assessment prior to being approved for production on the MDOT network.
- the Project Management Institute (PMI) PMBOK® Guide is designated as the project management procedural and communications guideline for MDOT IT projects.
- information system(s) development shall also be consistent with the State of Maryland System Development Life Cycle manual.
- all information system(s) development/design, including hardware/software shall be in compliance with the State Data Security Policy.
- all information system(s) development/design, including hardware/software shall be in compliance with the MDOT Security Plan with standards.
- all information system(s) development/design, including hardware/software shall be in compliance with the MDOT Security Plan with standards.
- all information system(s) development/design shall be consistent with the MDOT Network Architecture document.
- all information system(s) development/design shall be consistent with the MDOT Systems Architecture.
- all information system(s) development/design shall be compliant with Device Naming Standards document.
- all employees developing or maintaining information systems shall comply with the Premise and Operational Security document.

Note: Copies of the above Reference Documents will be provided to the successful Proposer.

16.5.6 Raceway Systems

Communications wayside cables shall be installed in Communications raceway systems (cable troughs, ductbanks or conduits) complying with the following requirements:

- buried conduits shall not break or crush under all anticipated loading conditions;
- conduits for individual items of equipment shall terminate directly to equipment junction boxes;
- troughs, ducts, conduits, and fittings shall be listed for 90°C cable;

- buried and embedded conduits and raceways shall be designed with 50 percent spare conduits subject to limits of not less than one and not more than three conduits (spare capacity in ductbanks shall be provided in the form of spare conduits in the ductbank);
- surface cable troughs shall not be used to cross ballasted track;
- manholes shall have a minimum interior height of 6.5 feet floor-to-ceiling, and be provided with stainless steel pulling irons and sump; and
- cable supports in manholes and handholes shall be nonmetallic.

The communications raceway system may be integrated with the Train control raceway system.

In addition to all other utilized and spare capacity in the systemwide raceway, Concessionaire shall provide two 4" schedule 80 conduits or the equivalent cable trough capacity throughout the entire length of the Transitway for the future exclusive use of Owner for fiber optic network cables:

- the size of all intermediate pull boxes, handholes and manholes shall be sufficient to accommodate the additional conduits or trough capacity;
- at the Transitway cross streets listed below, Concessionaire shall provide two 24" x 36" x 36" handholes for external access to the conduits/trough. The eastbound and westbound sections of one conduit shall be separately connected to one handhole and the eastbound and westbound sections of the other conduit shall be separately connected to the other handhole. All cross street access handholes shall be placed in the public right-of-way of the cross street outside of the vehicular traffic lanes wherever possible and sufficiently far from the tracks that access is possible without impact to Train service or need for any workblock rules to apply;
- external access handholes shall be:
  - rated to ANSI 77-2010 Tier 22 standards;
  - of composite construction and UL listed to ANSI 77-2010;
  - straight walled with an open bottom;
  - fitted with cable racks with stirrups on both sides of the handhole; and
  - RDUP/RUS listed products.
- each external access handhole shall be provided with a ground rod, a minimum of 6 inches depth of #57 stone below the handhole and 2 inches depth of gravel in the bottom of the handhole;
- cross street handholes shall be provided at East-West Hwy. (MD 410), Connecticut Ave. (MD 185), Jones Mill Rd., Grubb Rd., Lyttonsville Pl., 16th St., Spring St., Georgia Ave., Fenton St., Dale Dr., Sligo Creek Pkwy., Arlis Dr., Carroll Ave. (MD 195), Riggs Rd. (MD 212), Union Dr., Rivertech Ct., Paint Branch Pkwy., 58th Ave., 66th Ave., Annapolis Rd. (MD 450), and Corporate Dr.;
- in addition to the cross street locations listed above, Concessionaire shall provide two similar external access handholes near the east and west extremities of the systemwide ductbank (west end of the alignment ROW on the east side of Woodmont Ave. and north of the alignment on Ellin Rd at approximate sta. 951+50. Each of these terminal locations shall have a 700ft coil of slack cable;
- where conduits are provided, a three-cell fabric innerduct shall be provided in each conduit;

- Concessionaire shall provide one 288 strand single mode ribbon fiber optic cable throughout the length of the Transitway in one innerduct cell in each of the two 4” conduits or in the equivalent cable trough capacity (total of two cables);
- single mode ribbon fiber optic cables shall be:
    - ribbon optical cables containing 12-strand ribbons;
    - compliant with international standards ITU-T G.652.D and Telcordia G-20;
    - constructed of All Dielectric materials;
    - high tensile strength pull member(s);
    - gel-free design incorporating dry weather-blocking elements;
    - clearly marked in permanent characters with the manufacturer’s name, month and year of manufacture, number of optical fibers and sequential length markings at a minimum of every two feet.
- Cable lengths shall be manufacturer minimum of 18,000 feet. Cables shall only be spliced in cross-street access handholes where needed to join the ends of the minimum 18,000 feet cable lengths;
- all strands of both cables shall be fusion spliced where necessary at cross-street access handholes such that all 288 fibers in each cable are continuous along the entire length of the Transitway;
- fiber strand splice loss shall not exceed 0.1dB per splice;
- Concessionaire shall leave 100 ft slack cable loop in systemwide ductbank manholes and handholes at approximately 1,000 feet intervals and 300 ft slack cable loop in each cross-street access handhole;
- all fibers shall be tested for acceptable end-to-end loss;
- all subsequent connections to these cables at the cross-street handholes from outside of the Purple Line System will be performed by others; and
- where conduits are carried across aerial structures and bridges fiberglass reinforced epoxy conduits may be used.

16.6 Construction Requirements

Concessionaire shall install communications equipment in assigned locations within designed facilities. Equipment enclosures shall be designed to house all required communications equipment and fit within designated locations. All conduits in public areas of Stations shall be embedded or otherwise concealed from view.

Concessionaire shall ground all racks, enclosures, cabinets and raceways per code requirements.

Concessionaire shall test Communications Systems in accordance with the overall Test Program Plan in preparation for Integration Testing with the Light Rail Vehicles, Monitoring and Control Systems, Train Control System, Fare Collection Systems and Fire and Security systems. All test results shall be entered into the Safety Certification Program.

16.6.1 Communications Testing

A Communications Test Program Plan shall cover all tests required to verify communications performance, functionality and safety; the plan shall include the number and title of each Test

Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, the communications system at each location shall be ready for Integration Testing with other systems and Fixed Facilities.

The communications factory and field testing shall satisfy all communications related prerequisites of the Integration Test Program Plan and all required communications inputs for Safety Certification.

Concessionaire shall resolve all identified hazards and implement all required corrective actions before conducting any tests that require the movement of Trains.

16.6.2 Construction Related Submittals

No later than 90 calendar days before the start of factory testing, Concessionaire shall prepare and submit for Review and Comment a Communications Test Program Plan.

No later than 60 calendar days prior to the start of factory testing at the first location, Concessionaire shall prepare and submit for Review and Comment Communications Factory Test Procedures for each communications system.

No later than 60 calendar days prior to the start of on-site testing at the first location, Concessionaire shall prepare and submit for Review and Comment on-site Communications on-Site Test Procedures for each communications system.

No later than 30 calendar days after completion of factory testing of each site, Concessionaire shall prepare and submit for Review and Comment Communications Factory Test Reports detailing the results of all tests completed. Communications Test Reports for each network or site as appropriate shall be submitted separately if the test schedules for the site do not coincide.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Review and Comment Communications on-site Test Reports detailing the results of all tests completed. Communications Test Reports for each network or location as appropriate shall be submitted separately if the test schedules for the site do not coincide.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Information all Communications Mechanical, Electrical and Software Configuration Settings.

16.7 Summary of Submittals

Item	Section	Submittal	Action
1	16.4.9	Communications Preliminary Design	Review and Comment
2	16.4.9	Communications Intermediate Design	Review and Comment
3	16.4.9	Communications Final Design	Review and Comment
4	16.4.9	Communications Application Software Listings	Information
5	16.6.2	Communications Test Program Plan	Review and Comment
6	16.6.2	Communications Factory Test Procedures	Review and Comment
7	16.6.2	Communications On-Site Test Procedures	Review and Comment
8	16.6.2	Communications Factory Test Reports	Review and Comment
9	16.6.2	Communications On-Site Test Reports	Review and Comment
10	16.6.2	Communications Mechanical, Electrical and Software Configuration Settings	Information

17 CONTROL AND MONITORING

This Section identifies requirements for the control centers and Supervisory Control And Data Acquisition (SCADA) as well as the requirements of the system users within the constraints established by Project operations.

17.1 System Overview

Concessionaire shall provide an Operations Control Center (OCC) for the normal control and monitoring of all Project operations.

Concessionaire shall provide a Backup Operations Control Center (BOCC) at a different site to the OCC that can provide the same functionality as the OCC in the event that the OCC systems are unpowered, otherwise non-functional or disconnected from the CIB.

Concessionaire shall provide a Security Center for the monitoring and management of CCTV surveillance and all other security functions. The Security Center shall be located in the same building as the OCC. Concessionaire shall provide equipment in the Security Center as described herein.

Concessionaire shall provide a SCADA system with the functional capabilities described in this Section of the Contract Documents plus any and all additional functionality identified by Concessionaire's Concept of Operations.

Concessionaire shall provide a Train traffic management (TTM) system with the functional capabilities described in this Section of the Contract Documents plus any and all additional functionality identified by Concessionaire's Concept of Operations.

The SCADA and TTM systems may be integrated into a single unified system.

Concessionaire shall determine the extent of workstation equipment permanently placed in the OCC and BOCC to be consistent with the Concept of Operations, SOPs and training requirements.

Concessionaire shall provide all control system servers, workstations, switches and other associated requirements for a complete and functional control and monitoring system at the OCC, BOCC, the Security Center and any other control and monitoring locations established by Concessionaire.

17.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- American Railway Engineering and Maintenance of Way Association (AREMA);
- Building Industry Consulting Service International;
- Consultative Committee for International Telephone and Telegraph;
- Electronic Industries Association (EIA);
- Federal Communication Commission (FCC);
- 47 CFR Part 15, Radio Frequency Devices.
- Institute of Electrical and Electronics Engineers (IEEE);
- International Organization for Standardization (ISO);
- National Electrical Manufactures Association (NEMA);

- National Fire Protection Association (NFPA);
- NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems; and
- National Institute of Standards and Technology (NIST), NIST SP 800-82, Guide to Industrial Control Systems (ICS) Security | Supervisory Control and Data Acquisition (SCADA) systems, Distributed Control Systems, and other control system configurations such as Programmable Logic Controllers (PLC).

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

17.3 Functional Requirements

17.3.1 Objectives

To determine the functional and design requirements for the control and monitoring system, Concessionaire shall consider and evaluate the following;

- the need to control and monitor Train movements and set routes immediately for normal operations and in response to abnormal and emergency conditions;
- the need to control and monitor the Traction Power system and other mechanical and electrical systems;
- the need to encourage and promote safe and efficient Project operations under normal, abnormal and emergency operating conditions;
- the need to create and maintain a safe and secure environment for Users; and
- the need to respond quickly and effectively to equipment failures and service disruptions.

Concessionaire shall utilize the Concept of Operations Report as described in the Contract Documents as a basis for these requirements.

17.3.2 Operations Control Centers

Concessionaire shall provide an OCC, BOCC and any other control and monitoring locations established by Concessionaire. The following functionality shall be available at the OCC and BOCC within two hours of loss of use of the OCC for all possible reasons:

- monitor and control all Train movements;
- monitor and control the Traction Power system;
- schedule all Revenue Service Train trips;
- receive and respond to alarm, supervisory and trouble states of the FMS;
- receive and respond to alarm conditions in threat detection, security, escalators, elevators, and surveillance systems;
- receive and respond to fault conditions in threat detection, fare collection, security, escalators, elevators, electrical power, surveillance, and local and wide area networks systems hardware;
- receive and respond to fire detection system alarms and fault conditions;

- monitor and control; underground ventilation/smoke control systems and Platform/facility snow melters;
- receive and respond to high water alarms and drainage pump trouble indications;
- communicate verbally with light rail vehicle (LRV) operators, maintenance personnel, emergency responders, other operations personnel, and others via radio and telephone systems;
- make visual and audible announcements to Users at any individual or group of Stations via the PA/VMS system;
- record all forms of voice communications;
- house all control and monitoring systems and related communications equipment;
- serve as central command center for normal operations, service disruptions and emergency incident response;
- serve as a repository of control and monitoring system historical data;
- play back stored historical data and present the sequence of events on system displays equivalent to the live system displays;
- receive calls from SETs; and
- receive calls from WETs.
- make and receive telephone calls as required;
- make and receive fax messages as required;
- facilitate the evaluation of the performance of operation and maintenance activities by providing capabilities to manipulate, trend, and analyze control and monitoring system data;
- create, save, and print reports pertaining to the efficiency of systems for operations and maintenance; and
- any other required functionality identified in the Concept of Operations Report and identified by Concessionaire as required to be available at the BOCC within two hours.

The following functionality shall be available at the OCC and at the BOCC within twenty four hours of loss of use of the OCC for all possible reasons:

- monitor video feeds from the CCTV system, local video recordings and external video connections;
- business functions as required; and
- any other required functionality identified in the Concept of Operations Report and identified by Concessionaire as required to be available at the BOCC within twenty four hours.

The following functionality shall be available at the OCC but provision at the BOCC shall be determined by the Concessionaire:

- maintain clock synchronization among networked subsystems, including at a minimum LANs, wide area networks (WANs), SCADA, LRVs and the signaling system;

- calculate the time to arrival and announce the destination and time to arrival of the next Train to each destination at each Station. System shall be able to handle up to three destinations at each Station;
- record video of the OCC and BOCC;
- facilitate the training of control center personnel; and
- any other functionality identified in the Concept of Operation Report.

Through the common database servers, Owner shall have access to Concessionaire's control center data and information residing at the OCC. In the event that OCC servers are unavailable, the database servers at BOCC shall provide that same information.

17.3.3 Central Data Management and Operating Platform

The Purple Line System data shall be stored and organized centrally in a database application

Dedicated MTA workstations shall have access to the database

Software applications and databases shall run or execute on the same operating system, or the same virtual operating environment if different operating systems are used.

17.3.4 Security Center

Concessionaire shall provide systems and equipment in an Owner Security Center to permit Owner to perform the following functions and any additional functions identified in the Concept of Operations:

- monitor all mainline Train movements;
- monitor the Traction Power system;
- receive alarm, supervisory and trouble states of the FMS;
- receive alarm conditions in threat detection, security, escalators, elevators, and surveillance systems;
- receive intrusion alarms from the Fare System;
- communicate verbally with LRV operators, maintenance personnel, emergency responders, other operations personnel, and the outside world via radio and telephone systems;
- make live audible announcements to Users via the PA/VMS system;
- monitor and control video feeds from the CCTV system, local video recordings and external video connections;
- make video recordings;
- record all forms of voice communications;
- record video of the Security Center; and
- receive calls from SETs.

The control and monitoring system shall also provide the means to perform managerial functions, including, but not necessarily limited to:

- business functions as required;
- make and receive telephone calls as required;

- make and receive fax messages as required;
- facilitate the training of control center personnel; and
- create, save, and print reports pertaining to the efficiency of systems for operations and maintenance.

The Security Center shall be placed at the same location as the OCC. Desk and console workstation area shall be provided for two Owner personnel. The workstations shall maintain secure separation between the line-specific and MDOT networks.

17.3.5 Supervisory Control and Data Acquisition

Concessionaire shall provide a SCADA system to monitor and control various systems installed throughout the Project. Mandatory functional requirements are as follows:

- SCADA - Fire Alarm and Security Systems:
  - fire alarms and supervisory and trouble indications from the FMS at all locations;
  - emergency alarms and conditions managed by existing WMATA SCADA system at Bethesda (such as fire indications, threat, and emergency mode operation of ventilation system,);
  - telemetry of electrical and mechanical parameters of smoke control/underground ventilation systems; and
  - intrusion alarms, door states, and health conditions of access control systems.
- SCADA - other systems:
  - threat alarms and health condition of threat detection systems.
- SCADA – Tunnel Ventilation:
  - state and mode of operations of smoke control/underground ventilation systems.

In addition, the SCADA system shall monitor and control the following systems if required by Concessionaire’s Concept of Operations:

- SCADA - TPSS:
  - state of TPSS breakers;
  - telemetry of electrical parameters of the TPSS, including stray current; and
  - energization status of overhead catenary sections.
- SCADA – HVAC:
  - fan and damper status of HVAC systems; and
  - temperature and health conditions of HVAC systems.
- SCADA - Elevator/Escalator System:
  - health conditions, emergency alarms, and the maintenance alarms of elevators;
  - telemetry of the mechanical parameters of elevators;
  - telemetry of escalator mechanical parameters; and
  - functional status of elevators – up, down or off.
- SCADA – miscellaneous electrical systems:

- Utility supply power breaker states and loss of commercial power alarms at TPSSs, Train control equipment rooms and wayside cases, communications equipment rooms and Stations;
  - telemetry of electrical parameters of electrical power services; and
  - telemetry of electrical parameters of emergency power systems (e.g., battery charger/UPS/batteries).
- SCADA - other systems:
  - high water alarms and pumps;
  - health condition of Fare System equipment; and
  - facilities' snow melters.
- SCADA overview shall be present on each of the two Owner personnel workstations located in the Security Center.

17.3.6 Train Traffic Management

Concessionaire shall provide a Train Traffic Management (TTM) system to control and monitor the Train Control System including the AVL and TWC subsystems. Mandatory functional requirements are as follows:

- TTM - mainline Train location and Train routing:
  - Train locations;
  - Train identifications and destinations;
  - interlocking status;
  - route setting;
  - interface to PA/VMS for Train time-to-arrival-at-Station information; and
  - Interface Train location and time-to-arrival data to an external MTA web site database in the Google General Transit Specification Feeds (GTSF realtime) format per http://code.google.com/transit/realtime.

In addition, the TTM system shall monitor and control the following systems if required by Concessionaire's Concept of Operations:

- TTM - Train location and Train routing:
  - auxiliary switch controls.
- TTM - automatic terminal operation:
  - set and monitor mode of operation; and
  - set and monitor scheduled or unscheduled operation.
- TTM - timetable function:
  - store timetables for weekday, Saturday, Sunday, and special event services;
  - automatically advise LRV operators of departure times and set routes;
  - track Train numbers and LRV numbers with Train locations;

  - assign LRV numbers to Train numbers and interface with yard operations so that the location of every LRV is always known; and
  - track the readiness for service status of all LRVs in maintenance and storage facilities.
- TTM - switch and crib heater controls and indications.
- TTM - system alarm indications.
- TTM - yard signal (control and monitoring:
  - Train locations;
  - signal status;
  - route setting;
  - auxiliary switch controls;
  - LRV number tracking; and
  - LRV status tracking.

TTM overview shall be present on each of the two Owner personnel workstations located in the Security Center.

17.4 Design Requirements

Concessionaire shall implement the following requirements into the design of the control and monitoring system:

- Concessionaire shall utilize US national standard interfaces and technologies to the maximum extent possible;
- Concessionaire shall utilize commercially available service proven hardware and software. All equipment shall comply with the radiated and conducted electromagnetic emission limits of Part 15 of Title 47 of the Code of Federal Regulation (CFR) unless more stringent requirements are specified in the Contract Documents;
- Concessionaire shall utilize open, extensible System Architectures;
- Concessionaire shall utilize N+1 redundancy at the subsystem level;
- Concessionaire shall apply TIA-942-A Tier 2 availability for new construction as needed to meet or exceed the Project reliability requirements;
- workstations/servers (hardware/software) and associated network connections shall be redundant if needed to meet or exceed the Project reliability requirements;
- all equipment shall be powered from a UPS backed power source;
- if a failure of mechanical environmental control equipment could result in a system failure because the equipment cannot survive the resulting temperature, then back-up of the mechanical equipment and its power source shall be provided;
- Concessionaire shall utilize redundant power circuits and power supplies as required to meet or exceed the Project availability and reliability requirements;
- Concessionaire shall utilize redundant LANs as required to meet or exceed the Project availability and reliability requirements;

- Concessionaire shall utilize client/server-distributed computing architecture; and
- Concessionaire shall apply human factors design principles to the design of overall systems and individual displays, consoles and components. The grouping of indications and controls for accurate response and the visibility of indications from the operators' positions shall be considered.

17.4.1 Control Centers

Concessionaire shall include the following major components into all applicable control centers, including the Security Center, as required to provide the functionality required by all sections of the Contract Documents and Concessionaire's Concept of Operations:

- computer hardware including workstations, servers, and storage with operating system and associated firmware. Operating system shall be an industry-established platform.
- Network Management System (NMS) workstations for Operations, Administration, Maintenance, and Provisioning (OAMP) of the CIB network switches and the PSLAN network switches. The NMS shall also be used for diagnostics, planning, and reporting and configuration of the CIB/PSLAN for rapid fault/outage recovery, restoration, and backup;
- workstations for OAMP of network appliances and/or firewalls at each passenger Station to block network intrusion [e.g., DDoS attacks caused by internal or external unauthorized network entry attempts];
- Human-Machine Interface (HMI) and associated software;
- playback software to process historical recorded data and present the original sequence of events on workstation displays equivalent to those used for the live systems. System shall permit the playback of data for a specifically desired time period and allow data to be played back at various selected speeds, both faster and slower than real time;
- database and database management system (DBMS);
- consolidated video display units (mapboard overview system);
- video and audio recording equipment of the control theater;
- integrated communications console system for Administrative Telephone, SET, WET, land mobile radio, public address, and variable messaging;
- Enterprise Resource Management software suite to manage, including at a minimum,: inventory, work orders, O&M and planning and documents, training documents, Purple Line System build and installation documents, labor, services management and contracts.
- secure LANs that carry control and monitoring system traffic data within the OCC and other offices;
- voice recording for radio, telephone and passenger information systems;
- office furniture to house hardware, such as ergonomic console desks, and chairs;
- office and equipment room real estate to house all control center equipment and personnel;
- UPS backed power supply and distribution equipment;

- back-up power generators to allow the control centers to maintain operation in the event of a long term loss of the Utility power source; and
- the communication connectivity between computer equipment located throughout various facilities shall be provided by the CIB as defined in the Contract Documents.

17.4.1.1 Central Data Management and Operating Platform

Centralized data storage shall be implemented for all systems where data is acquired/used by the Purple Line System. Each application shall have access to all of its data stored or archived and shall be able to play back any desired period of stored or archived data and present the sequence of events on displays equivalent to those used for the live system.

- data (identical) shall be stored permanently- both on like/mirror OCC and BOCC servers. Data types, formats and storage intervals shall be identified during Intermediate Design.
- functionally, the data storage system shall be a "data warehouse", used for archiving, retrieval, managing and viewing. The "data warehouse" shall be implemented on a common database program with a proven commercial, industrial or governmental installed base of 10 years.
- individual software application data shall be able to be imported/exported and integrated seamlessly into the central database application program. Manual effort shall be kept at a reasonable minimum, concerning sharing of data to/from applications to the database.

Along with user access and privileges, OCC and BOCC user logon and usage statistics shall be stored on a server. This information shall be made available seamlessly across OCC and BOCC alike.

MTA-manned console workstations shall have access to the PL system data. This may be accomplished through either individual software applications or the central database application program "data warehouse",

The general transit feed specification database shall be implemented, and used for its intended purpose of transit data sharing. It's core database (to be shared outside the Purple Line System) shall not reside on the "data warehouse" database; and need not be linked or integrated into the "data warehouse".

If OCC (BOCC) application and database servers execute/run on different processor software operating systems, virtualization of the network/machine servers shall be implemented so as to run on or through a common Platform.

- the virtual server shall be logically and functionally located between the software application and operating system level.
- virtualization shall also provide an enterprise-class security.
- network/machine virtualization shall be seamless across the OCC and BOCC

17.4.1.2 Console Workstations

Concessionaire shall provide workstations for all control centers, maintenance shops, system administration, management, and training as identified in the Concept of Operation Report. These workstations shall be equipped with HMIs to facilitate monitoring and control of the SCADA/TTM system(s) and all other fire, security and communications systems described in the Contract Documents. The OCC and BOCC control center computer hardware shall be geographically diverse, redundant, and capable of operating independently of one another. Training workstations may serve the dual function of training and BOCC.

Additionally, two console workstations shall be provided to accommodate two Owner personnel in the Security Center. Two console workstations shall be provided to accommodate two Owner personnel responsible for oversight of the O&M Work.

17.4.1.3 External Interfaces

To implement the full functionality of the control and monitoring system, the OCC, the BOCC and the Security Center, Concessionaire shall implement interfaces with other systems including, but not necessarily limited to, the following:

- Train Control System including TWC and AVL;
- CCTV system;
- ACS;
- FMS;
- Traction Power system;
- tunnel ventilation;
- elevators and escalators;
- mechanical and electrical systems;
- telephone systems;
- radio system;
- customer information systems; and
- CIB.

17.4.1.4 Local Area Network

Concessionaire shall provide control center LANs that incorporate required bandwidth, latency, adherence to standards, and allow for future growth. LANs shall avoid any single point of failure and shall be fully redundant.

17.4.2 Supervisor Control and Data Acquisition System (SCADA)

Concessionaire shall provide a SCADA system consisting of networked switches, servers, workstations, field equipment interfaces, software and communication components as required to provide the functionality required by all sections of the Contract Documents and Concessionaire's Concept of Operations. The SCADA system shall include, but not necessarily be limited to, the following:

- networked programmable logic controllers (PLCs) or networked Remote Terminal Units (RTUs) using open control and communications protocols;
- secure, industrial-grade LANs;
- interposing relays;
- control loops;

- local HMI panels to allow interactive monitoring, control, and troubleshooting of PLCs, RTUs and supervised systems; and
- NEMA-rated enclosures or rack space to house SCADA equipment.

the SCADA system may also execute automatic, preprogrammed control sequences in response to predetermined input states as required for Underground Station ventilation system control and automatic responses to detected fire alarm conditions.

Concessionaire shall provide communications among SCADA system components at different facilities and Stations utilizing the CIB defined in the Contract Documents. The SCADA system at each location shall be autonomous such that it can maintain automatic and local operation of systems being monitored and controlled in the event of a loss of communications with the OCC or LAN.

17.4.2.1 PLCs and RTUs

Concessionaire shall provide components and control configuration so that no single operational, component or system event will cause the loss of any control and monitoring of life safety functionality.

Tunnel Ventilation Control: Concessionaire shall provide redundant components so that no single failure of hardware, software, firmware, or communications will cause the loss of any control and monitoring of life safety functionality.

Concessionaire shall incorporate a hierarchical mode of operations into the SCADA system by means of physical and software configurations to allow manual, local, and emergency override control over the automatic and remote controls.

Concessionaire shall utilize standard protocols such as Profibus, Modbus, Ethernet, and Distributed Network Protocol (DNP3) for communications between the PLCs and RTUs and other intelligent devices.

17.4.2.2 External Interfaces

Concessionaire shall provide functional interfaces between the SCADA system and other external systems to support the assigned functionality including, but not necessarily limited to, the following:

- elevators;
- FMS;
- HVAC facilities;
- Traction Power, including stray current;
- threat detection systems;
- Fare System;
- smoke control/underground ventilation;
- ACS;
- escalators;
- drainage systems;
- shop electrical substations;

- emergency power systems;
- snow melters;
- control centers; and
- CIB.

17.4.3 Train Traffic Management System

Concessionaire shall provide a TTM system consisting of networked switches, servers, workstations, field equipment interfaces, software and communication components as required to provide the functionality required by all sections of the Contract Documents and Concessionaire's Concept of Operations.

Concessionaire shall provide interfaces between the TTM function of the control and monitoring system and the Train Control System via a dedicated PLC in each CIH or signal equipment room. These PLCs shall interface with the Train control non-vital interlocking control, automatic vehicle location, and Train-to-wayside communications systems.

17.4.4 Design Related Submittals

Concessionaire shall submit the Control and Monitoring Preliminary Design submittal for Review and Comment. The Control and Monitoring Preliminary Design submittal shall include, at a minimum, the following items:

- a Control and Monitoring Design Criteria for all Control and Monitoring equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- Control and Monitoring Network Architecture Diagrams including a system-level graphic representation of all hardware components and their interconnections. This shall include identification of the interfaces between the control and monitoring system and all other devices and systems; and
- Control and Monitoring Room Layouts for all control rooms and associated equipment rooms.

Concessionaire shall submit the Control and Monitoring Intermediate Design submittal for Review and Comment. The Control and Monitoring Intermediate Design submittal shall include, at a minimum, the following items:

- a Control and Monitoring Technical Specification for all control and monitoring equipment and systems;
- Control and Monitoring Drawing Sets for all control and monitoring networks, subsystems and equipment;
- Control and Monitoring Floor Plans and Equipment Layouts for all control centers and associated equipment rooms and elevations of control center consoles and workstations;
- Complete Drawing Sets for Control and Monitoring Typical Field Locations. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of equipment enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;

- a Control and Monitoring List of Functional Components to be supplied for the control and monitoring system;
- Control and Monitoring Product Catalog Cuts for all active components, wire and cable used in the control and monitoring system;
- Control and Monitoring Detailed Functionality Description of the central servers and workstations including typical graphical displays, icons and controls;
- a Control and Monitoring Interface Control Document that defines the functional, physical and performance details of all interfaces between the control and monitoring system and all other systems; and
- a Control and Monitoring Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the Control and Monitoring Final Design submittal for Review and Comment. The Control and Monitoring Final Design submittal shall include, at a minimum, the following items:

- complete Control and Monitoring System Drawing Sets For All Locations, including at a minimum, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of equipment enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules; and
- an updated Control and Monitoring Detailed Functionality Description of the central servers and workstations including all software functions, graphical displays, icons and controls.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information a Control and Monitoring Application Software Listing for each processor.

17.5 Equipment Requirements

17.5.1 Environmental Requirements

Concessionaire shall provide control and monitoring system equipment that is suitable for its intended environment and that accommodates the ergonomic requirements of the operations and maintenance staff.

All system hardware and software provided by Concessionaire shall be commercially available and service proven in a similar application.

17.6 Construction Requirements

Concessionaire shall install control center, TTM and SCADA equipment in all locations designated in Concessionaire's systems designs. Equipment enclosures shall be designed to house all required hardware and fit within designated locations.

Concessionaire shall ground all racks, enclosures, cabinets and raceways per NEC requirements.

Concessionaire shall test the control and monitoring system in accordance with the overall Test Program Plan in preparation for Integration Testing with the LRVs, communications systems, Train Control System, fare collection system, Traction Power system, fire and security system, and other mechanical and electrical systems. Concessionaire shall enter all test results into the Safety Certification Program.

17.6.1 Control and Monitoring Testing

A Control and Monitoring Test Program Plan shall cover all tests required to verify control and monitoring performance, functionality and safety; the plan shall include the number and title of each Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, the control and monitoring system at each location shall be ready for Integration Testing with other systems and Fixed Facilities.

The control and monitoring factory and field testing shall satisfy all control and monitoring related prerequisites of the Integration Test Program Plan and all required control and monitoring inputs for Safety Certification.

Concessionaire shall resolve all identified hazards and implement all required corrective actions before conducting any tests that require the movement of Trains.

17.6.2 Construction Related Submittals

No later than 90 calendar days before the start of factory testing, Concessionaire shall prepare and submit for Review and Comment a Control and Monitoring Test Program Plan.

No later than 60 calendar days prior to the start of factory testing of the first location, Concessionaire shall prepare and submit for Review and Comment Control and Monitoring Factory Test Procedures for all control and monitoring subsystems and equipment including interfaces with all other systems.

No later than 60 calendar days prior to the start of field testing at the first location, Concessionaire shall prepare and submit for Review and Comment Control and Monitoring on-site Test Procedures for all control and monitoring subsystems and equipment including interfaces with all other systems.

No later than 30 calendar days after completion of factory testing of each location, Concessionaire shall prepare and submit for Review and Comment Control and Monitoring Factory Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of field testing of each location, Concessionaire shall prepare and submit for Review and Comment Control and Monitoring on-site Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of on-site testing at each site, Concessionaire shall prepare and submit for Information all Control and Monitoring Electrical and Software Configuration Settings.

17.7 Summary of Submittals

Item	Section	Submittal	Action
1	17.4.4	Control and Monitoring Preliminary Design	Review and Comment
2	17.4.4	Control and Monitoring Intermediate Design	Review and Comment
3	17.4.4	Control and Monitoring Final Design	Review and Comment
4	17.4.4	Control and Monitoring Application Software Listings	Information
5	17.6.2	Control and Monitoring Test Program Plan	Review and Comment
6	17.6.2	Control and Monitoring Factory Test Procedures	Review and Comment
7	17.6.2	Control and Monitoring On-Site Test Procedures	Review and Comment
8	17.6.2	Control and Monitoring Factory Test Reports	Review and Comment
9	17.6.2	Control and Monitoring On-Site Test Reports	Review and Comment
10	17.6.2	Control and Monitoring Electrical and Software Configuration Settings	Information

18 FIRE AND SECURITY

This Section identifies requirements for the Fire and Security Systems including a Fire Management System (FMS), an Access Control System (ACS) and a Closed Circuit Television (CCTV) system.

18.1 System Overview

Concessionaire shall provide a FMS to detect hazardous conditions caused by fire, smoke, chemical hazards and bio-hazards, issue local and remote alarms and interface with other systems to activate immediate responses to the detected condition.

Concessionaire shall provide an ACS to permit only authorized operations and maintenance staff into non-public areas, to record the identity of authorized operations and maintenance staff who are granted access and issue local and remote alarms when doors, gates, hatches, windows or other means of entry are opened without proper authorization or are left in an open state.

Concessionaire shall provide a CCTV system to observe, and record conditions in public spaces, egress areas between public and non-public spaces, critical equipment rooms including, but not necessarily limited to, Traction Power and other electrical substations and Train control equipment rooms (CIHs and signal equipment rooms).

Concessionaire shall adhere to Federal Regulation 49 CFR 1520, *Protection of Sensitive Security Information*, for handling of documentation pertaining to transportation facility security systems.

18.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- Department of Health and Human Services, *Older Americans Act (OAA)*;
- Code of Federal Regulations, 49 CFR 1520, Protection of Sensitive Security Information;
- European Committee for Electro-technical Standardization, EN50121-4, Railway Applications - Electromagnetic compatibility - Part 4 - Emissions and immunity of the signaling and telecommunications apparatus;.
- Homeland Security Presidential Directive , HSPD 12, Policy for a Common Identification Standard for Federal Employees and Contractors;
- International Code Council (ICC), International Building Code (IBC);
- ISO/IEC 14443, Identification cards – Contactless integrated circuit cards – Proximity cards;
- Montgomery and Prince George’s Counties Fire and Building Codes;
- MTA, Safety, Security, and Infrastructure Policy;
- MTA Safety and Security Program Plan;
- National Fire Protection Association (NFPA), NFPA 1, *Fire Code*;
- NFPA 70, National Electric Code;
- NFPA 70E, Electrical Safety in the Workplace;
- NFPA 72, National Fire Alarm and Signaling Code;
- NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems;

- NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Non-combustible Particulate Solids;
- NFPA 101, Life Safety Code;
- NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems;
- NFPA 110, Standard for Emergency and Standby Power Systems;
- NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces;
- NFPA 750, Standard on Water Mist Fire Protection Systems;
- NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems;
- Public Law 101-36, Final Rule of the Americans with Disabilities Act (ADA);
- Underwriters Laboratories (UL), UL 268, *Smoke Detectors for Fire Alarm Systems*;
- UL 521, Heat Detectors for Fire Protective Signaling Systems;
- UL 864, Control Units and Accessories for Fire Alarm Systems;
- UL 1480, Speakers for Fire Alarm, Emergency, and Commercial and Professional Use;
- UL 1971, Signaling Devices for the Hearing Impaired;
- U.S. Access Board and U.S Department of Transportation, Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines;
- U.S. DOT/FHWA, 49 CFT Part 27, Nondiscrimination on the Basis of Disability in Programs and Activities Receiving or Benefitting from Federal Financial Assistance;
- U.S. DOT/FHWA, 49 CFR Part 37, Transportation Services for Individuals with Disabilities (ADA); and
- U.S. DOT/FHWA, 49 CFR Part 38, Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

18.3 Functional Requirements

The overall safety of the fire and security systems shall be consistent with the requirements for passenger, operations and maintenance staff and system safety.

18.3.1 Codes and Standards

Unless otherwise indicated, all fire and security systems shall comply with the current NFPA 130 and Maryland-adopted editions of all applicable Codes and Standards and shall be subject to the approval of the AHJ.

For this Project, the designated AHJ is the Maryland State Fire Marshal.

18.3.2 Fire Management System Overview

The Fire Management System (FMS) shall be a code-compliant, state-of-the-art system to protect Users, operations and maintenance staff, general public, and emergency responders by providing visual and audible notifications upon detecting emergency conditions such as fire, smoke, and related hazards. The FMS shall be addressable and shall comply with ADA requirements for alarms and occupant notification and NFPA 72.

The FMS shall provide an electrically supervised, continuously monitored, closed-circuit fire, smoke, and water flow detection system for transit-related occupancies. The system shall include monitoring, control and alarm interface panels, remote workstations, addressable field devices, and all appurtenances for required interfaces. The system shall also provide for detection and notification of malfunctions and equipment tampering.

The FMS shall interface to the line-specific CIB through the PSLAN.

18.3.3 Access Control System Overview

The Access Control System (ACS) shall allow entry to non-public spaces by authorized operations and maintenance staff and deny access by unauthorized persons. It shall generate alarms if a secured door, gate, hatch or window is open without authorization or if a system malfunction is detected. Secured areas shall include non-public ancillary spaces, signaling and communications rooms, equipment and storage facilities, remote buildings such as Traction Power and gap/tie breaker substations, and yards and shops. Additional placements shall be guided by any Threat and Vulnerability Assessments (TVAs) performed during design.

The ACS shall be comprised of a network of verification and communication devices to detect occupancy and control unauthorized entry into secured areas, as well as detect malfunctions and equipment tampering. The system shall consist of state-of-the-art components, be electronically supervised, closed circuit, selectively coded, and continuously self-monitoring. The system shall be IP addressable through LANs and WANs. It shall be capable of modifying access protocols including adding, revoking, or temporarily disabling credentials.

The ACS shall interface to the line-specific CIB through the PSLAN.

18.3.4 Closed-Circuit Television System Overview

The CCTV system shall provide visual surveillance and recording at Stations, support facilities, access points to sections of exclusive alignment and on board LRVs. The CCTV system shall be used as a tool to assist in assessing, monitoring and potentially responding to a broad range of criminal activities, including acts of terrorism and also to support operational oversight of the Project. CCTV shall be designed to provide views including, at a minimum, all public areas of all Stations and Station access routes, non-public areas; tunnel portals; separate equipment rooms; entrances and exits to support facilities; and designated areas within support facilities. CCTV systems shall also cover all locations monitored by the ACS. Additional placements shall be guided by any hazard analyses and TVAs performed during design.

Video analytics shall be utilized to identify and alarm any pedestrian or vehicular encroachment into any tunnel, open cut or aerial section of the mainline alignment or into yard areas and also to identify and alarm the presence of foreign objects and packages.

Concessionaire shall provide a Security Center to be operated by Owner as the primary location for monitoring the CCTV images and managing recorded video. In addition, live CCTV images shall be available at the OCC, BOCC, any local Station attendant booths, Owner’s existing Police Monitoring Facility (PMF) and any other locations required by Concessionaires operations and security plans unless blocked by the Security Center.

The CCTV system shall include software, work stations, monitors, displays, cameras, lenses, enclosures, transmitters, receivers, recording and storage devices, network switches, servers, power supplies, brackets and saddles, fittings, connectors, cables and wire, and other associated equipment and materials necessary for a complete functional system.

The CCTV System shall interface to the MDOT CIB locally through the MDOT-specific LAN for transmission of video signals to all monitoring locations.

CCTV System functionality shall be present on each of the two Owner personnel workstations located in the Security Center. In addition:

- two console workstations shall be provided to accommodate two Owner personnel responsible for oversight during the O&M Term; and
- Concessionaire shall interface with the existing Aralia video surveillance system at Owner's PMF to enable the display of live CCTV images only or Concessionaire shall provide one console workstation including a suitable console at Owner's PMF with capability for viewing live Project CCTV images only.

The CCTV system shall function 7 days a week, 24 hours a day to provide comprehensive coverage at all designated locations utilizing cameras with day and night capabilities. Video shall be shared with external users, including Maryland State and county Agencies in accordance with the Third Party Agreement Requirements.

CCTV images shall be shared live with Third Parties in accordance with the Third Party Agreement Requirements and as follows:

- areas within and adjacent to UMD campus shall be shared with UMD Police Department;
- areas within Montgomery County shall be shared with the Montgomery County government;
- areas within Prince Georges County shall be shared with the Prince Georges County government;
- areas along roadways owned by MDSHA shall be shared with MDSHA;

It is anticipated that the sharing of CCTV both to and from Third Parties will be accomplished by interfacing the CCTV signals to a web server which the other party will be granted access to via the internet. However, Concessionaire may implement these shared CCTV signals by any other means that is acceptable to the Third Party.

18.3.5 Chemical, Biological, Radiological, Nuclear, and Expolives (CBRNE)

If the Threat and Vulnerability Assessments (TVA) identify any locations where a CBRNE detection and alarm system is necessary to mitigate potential threats, Concessionaire shall provide such CBRNE system to include appropriate local and OCC/BOCC alarms and interfaces with other systems.

18.4 Design Requirements

18.4.1 Fire Management System

Concessionaire shall equip all locations to be protected by the FMS with field devices as required including but not necessarily limited to smoke detectors, heat detectors, harsh environments smoke detectors, manual pull stations, strobes, audible annunciators, a Fire Alarm Control Panel (FACP) for alarm management and interfaces, a fire management panel (FMP) for emergency responder local monitoring and control and other necessary appurtenances for installation completion and interfaces.

FACPs at all locations shall form a peer-to-peer network and be capable of functioning separately in degraded mode as independent fire alarm control panels.

Concessionaire shall provide a FMP at complex locations as stated in the Contract Documents and as required by the authority having jurisdiction (AHJ) which provides a graphical interface for fire department personnel that displays alarms and can control ventilation equipment.

Fire / smoke alarms shall be displayed on each of the two Owner personnel workstations located in the Security Center and the two console workstations provided to support Owner personnel responsible for contract oversight during O&M Work.

18.4.1.1 Locations

Concessionaire shall provide a FMS at Station and tunnel facilities as follows:

- all underground and subsurface Stations, air rights structures and end and mid-tunnel egresses;
- all elevated Stations and any other Station where access to the Platform is constricted by stairs or escalators;
- all at-grade Stations that include any kind of walk-in equipment room or facility; and
- any other Station where the requirements of NFPA 72 require such a system.

Concessionaire shall provide a FMS in support facilities and equipment rooms as follows:

- all enclosed spaces in maintenance shops and service and repair facilities;
- all control centers and associated equipment rooms;
- all parking structures;
- all individual walk-in equipment rooms including, but not necessarily limited to, TPSSs, Train control equipment rooms (CIHs and signal equipment rooms and communications equipment rooms; and
- any other Station where the requirements of NFPA 72 require such a system.

Concessionaire shall provide a FMS in each LRV as described in the Contract Documents.

18.4.1.2 Communications

18.4.1.2.1 Network

Concessionaire shall connect all FACPs onto a common data network for the communication of FMS events.

Audible and visual alarms and indications shall be simultaneously transmitted to the Station kiosks or Station attendant booth (where provided) as well as the OCC, BOCC and the designated monitoring station. Provisions shall be made to facilitate remote testing of FMS devices.

If all FMPs cannot be located in safe locations to the satisfaction of the AHJ, Concessionaire shall provide an independent fire alarm monitor and equipment control station at the OCC and BOCC.

18.4.1.2.2 FACP Monitoring

Concessionaire shall continually monitor all FACPs for alarm and trouble conditions. Concessionaire shall provide each FACP with redundant telephone connections to the selected monitoring location. Interface to the telephone system shall allow for transmission of system alarm and trouble details to the monitoring location.

18.4.1.2.3 LRV Monitoring

Alarms on LRVs shall be presented visually and audibly on the LRV cab console and transmitted to the OCC.

18.4.1.2.4 Signaling Line Circuit Loops

Concessionaire shall group FMS fire and smoke detectors and manual pull stations into Signaling Line Circuit (SLC) loops at all locations as follows:

- no SLC loop shall cover more than four rooms plus a connecting passageway; and
- a separate SLC loop shall be assigned to each elevator and escalator or group of escalators. At single-entrance passenger Stations, a separate SLC loop shall be assigned exclusively for detectors which have extra contacts to operate the deluge solenoid. Escalators grouped within a single fire loop shall be located within 150 feet of each other.

18.4.1.3 Activation

Alarm and trouble conditions shall initiate a call-out to the monitoring location. Alarm conditions shall automatically initiate the following actions as required:

- Station occupants in public areas shall be notified with strobes, pre-recorded public address (PA) messages, and messages on Variable Message Signs (VMSs) within the Station;
- Station occupants in non-public ancillary areas and support facility occupants shall be notified with strobe and audible alarms;
- HVAC equipment shall be shut down as required to provide proper smoke ventilation and to protect HVAC equipment from smoke damage;
- at subsurface locations, ventilation equipment shall be activated per specific ventilation scenarios as required;
- elevators shall be recalled to the level accepted by the AHJ (or an alternate level, if required), cab doors shall be opened and elevators shall dwell at that level until key restart by emergency responders;
- initiate and monitor activation of fire suppression equipment, and display type and location;
- any reported alarm or emergency condition shall activate display of CCTV images at monitoring workstations at the OCC, BOCC, Security Center and select locations such as kiosks or Station attendant booths with automatic activation of security cameras in the affected area and/or location of the manual pull station;
- an alarm shall be sounded before slowly stopping or reversing inbound escalators after a preset time to egress-only mode (escalators moving in the direction of egress may remain in operation upon fire alarm activation, per NFPA 130 paragraph 5.5.2);
- fire suppression equipment shall be initiated and monitored and display type and location;
- all fire-rated doors, louvers, and smoke barriers shall be in a predetermined position; and
- all gates and barriers including fare gates if provided shall be unlocked;

Concessionaire shall establish separate FMS areas/SLC loops for display on local FACPs and FMPs to monitor detection units and fire suppression equipment and supervise main control valves. Alarm panels locations shall be easily accessible by emergency response personnel and be approved by the AHJ. Panels shall have a keypad or similar device for use by responders to activate, shut down, reset, control, and/or display the status of systems, equipment, and appliances.

The activation of a fire detector at a Station shall, through the FACP, cause the display of an alarm indication at the Station FMP if provided, which shall show the area and identify the detector where the alarm condition exists. All indicator signals for fire alarms, smoke detection, valve switches, and water flow shall be simultaneously transmitted to the OCC where the specifics of the alarm shall be recorded and assigned a label with the date and time of occurrence, and become part of the historical alarm log for future recall.

All equipment and devices providing alarm signals shall be audible or visible to all persons in the Station. The visual indication shall remain active until the detection system is reset, and the alarms shall continue until acknowledged at the FACP. A malfunction on any addressable device or detector circuit, or an input power failure, shall cause the FMP to display an indication showing the area in which the detector circuit has malfunctioned, or other trouble indication.

Emergency fan control and status communication circuits shall also be supervised by the FACP, and malfunction indications transmitted to the OCC. Visual indications shall remain until the malfunction is corrected and the system restarted.

18.4.1.4 Interfaces

18.4.1.4.1 Fire Suppression Systems

Concessionaire shall provide interfaces to all aqueous and non-aqueous fire suppression systems to monitor water flow, valve tamper and system activation.

18.4.1.4.2 Fare Gates

Alarms causing Station evacuation shall trigger release of fare gates (if used).

18.4.1.4.3 Public Address/Message Signs

Concessionaire shall provide an interface between the FMS and the Public Address/Variable Message Signs (PA/VMS) system at each location so that upon detection of a fire alarm within the passenger Station limits, except TPSSs and tie breaker and gap breaker stations (if applicable), the PA system shall be activated after a predetermined time delay and broadcast prerecorded or real-time emergency messages. A "reset" circuit shall be provided to reset the prerecorded messages as required.

Concessionaire shall provide a PA microphone with each FMP or with the FACP is no FMP is required at the location.

18.4.1.4.4 SCADA

Concessionaire shall provide an interface between the FMS and the SCADA system at each location, including, but not necessarily limited to, the tunnel ventilation system, building management system, and elevator/escalator system. Integration with SCADA shall comply with the isolation requirements of NFPA 72. Alarm, trouble, and supervisory indications shall be transmitted to the Station SCADA system for transmission to the OCC and to an auxiliary visual and audible indicator in the Station attendant booth, where one is provided.

Emergency ventilation interface at aerial and at-grade Stations may not be required. Concessionaire shall coordinate with the AHJ regarding this requirement.

Emergency ventilation interface at maintenance and storage facilities shall comply with the International Building Code.

18.4.1.4.5 CCTV

Concessionaire shall integrate the FMS with the CCTV system to provide an automatic display of security camera video at the site of an activated fire alarm device or pull station.

18.4.1.4.6 Master Clock Time System

Concessionaire shall utilize the MCTS for date and time stamping of FMS alarms and events.

18.4.1.5 Power

Concessionaire shall power the FMS from a primary and a secondary source of power in accordance with NFPA 72.

18.4.1.6 Cable

Class A circuits shall have outgoing and return conductors located in separate conduits, physically separated by a distance of not less than 4 feet and arranged such that severing one of the conduits will not put any portion of the system out of service.

18.4.1.7 FMS Design Related Submittals

Concessionaire shall submit the FMS Preliminary Design submittal for Review and Comment. The FMS Preliminary Design submittal shall include, at a minimum, the following items:

- a FMS Design Criteria for all FMS equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- a FMS Location List showing locations to be equipped with an FMS system and a summary of the major items (not quantities) of equipment to be provided at each location;
- FMS Typical Schematics and Plans for typical locations including the OCC showing all FMS hardware; and
- FMS Preliminary Network Drawings showing how all locations will communicate with one another.

Concessionaire shall submit the FMS Intermediate Design submittal for Review and Comment. The FMS Intermediate Design submittal shall include, at a minimum, the following items:

- a FMS Technical Specification for all FMS equipment and systems;
- FMS Complete Drawing Sets for Typical Locations used in the Preliminary Design. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of FMS enclosures, racks and cabinets, power supply diagrams, FMP faceplate graphics, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;

- FMS Final Network Drawings showing how all locations will communicate with one another;
- an FMS Monitoring Station Detailed Functionality Description of the monitoring station including typical graphical displays, icons and controls if an independent fire alarm monitoring station is provided at the OCC;
- an FMS List of Functional Components to be supplied as part of the FMS system;
- FMS Product Catalog Cuts for all active components, wire and cable used in the FMS system;
- an FMS Detailed Functionality Description of the FACPs, FMPs, central servers and workstations including typical graphical displays, icons and controls;
- an FMS Interface Control Document that defines the functional, physical and performance details of all interfaces between the FMS system and all other systems; and
- an FMS Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the FMS Final Design submittal for Review and Comment. The FMS Final Design submittal shall include, at a minimum, the following items:

- FMS Complete Drawing Sets for All Locations. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of FMS enclosures, racks and cabinets, power supply diagrams, FMP faceplate graphics, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- An updated FMS Detailed Functionality Description of the monitoring station including all graphical displays, icons and controls if an independent fir alarm monitoring station is provided at the OCC; and
- FMS Final Network Drawings showing how all locations will communicate with one another to include any changes that have occurred since the Intermediate Design.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information an FMS Application Software Listing for each processor.

18.4.2 Access Control and Intrusion Detection

18.4.2.1 Stations and Right of Way

Concessionaire shall provide, as a minimum, access control and intrusion detection in accordance with UL Standard 827, Standard for central-Station Alarm Services within the following Station areas as applicable to each Station:

- equipment rooms including, at a minimum, Traction Power and gap/tie-Breaker substations, Train control CIHs and signal equipment rooms, communications equipment rooms, mechanical equipment rooms, battery rooms and electrical equipment rooms;
- elevator and escalator machine rooms;
- all transitions between public and non-public areas;
- end of Platform gates;

- service stair entrances;
- valve/sprinkler/deluge rooms;
- attendants' booths;
- emergency exits and hatches; and
- gated Station entrances;

18.4.2.2 Yards and Shops

Concessionaire shall provide, as a minimum, access control and intrusion detection within the following areas of maintenance and storage facilities as applicable to each location:

- entrance gates;
- building entrances, including roll-up doors;
- mechanical, electrical, battery and IT equipment rooms;
- control rooms, associated equipment rooms and viewing rooms; and
- other areas as designated by Concessionaire

Concessionaire shall provide intercoms at main entrances including entrance gates and control rooms. Intercom control station locations shall be determined during design.

18.4.2.3 Alarms and Notification

Concessionaire shall provide audible and visual notifications at control panels and monitoring workstations for the following:

- access granted or denied;
- tampering with control panels, field devices or wiring;
- doors held open;
- doors forced open;
- deactivated portals; and
- other similar conditions.

Trouble indications shall be activated if any of the following occur:

- an end unit detector is not reporting or is malfunctioning;
- a zone becomes inoperable;
- power system faults; and
- charges and locks malfunction.

Alarms shall be simultaneously transmitted to local panels as well as the OCC, BOCC and Security Center so that the appropriate response can be determined by safety, security operations, and maintenance personnel. Alarm annunciation shall continue until acknowledged at the control panel and manually reset.

Concessionaire shall provide audible alarms and strobes to annunciate unrecognized entry into emergency doors, stairwells, hatches, end of Platform gates, Station entrances, and other select locations. Station entrances shall have a key-activated control switch to disable door alarms;

indicators at the local and remote control panels shall monitor the disabled status. The activation or disabling of alarms shall not interfere with egress or access into unprotected areas.

Locations of access panels, door panels, points of interface, and other related space requirements shall be verified and coordinated during Design Work.

Alarms shall also be displayed on each of the two Owner personnel workstations located in the Security Center. In addition, two console workstations shall be provided to accommodate two Owner personnel responsible for oversight during O&M Work.

18.4.2.4 Egress

For each secured door, gate, or hatch, Concessionaire shall provide presence detectors for the automatic release of the device for egress. Egress shall be available in the event of a system power loss without need for any special key or other device.

18.4.2.5 System Management and Administration

Concessionaire shall provide an ACS administration workstation for assigning access rights to individual operations and maintenance staff members.

18.4.2.6 Communications

18.4.2.6.1 Network

Concessionaire shall network the ACS sub-systems at all locations such that information is readily available to all system users as required.

18.4.2.6.2 Redundancy

Servers or head-end equipment shall provide hot standby failover redundancy. Redundant servers shall be geographically separated; locations shall be determined during the Design Work.

18.4.2.7 Interfaces

18.4.2.7.1 CCTV

Concessionaire shall provide a CCTV system interface for real-time visual monitoring of alarm locations. Alarms in both public and non-public areas shall activate camera views at the monitoring locations.

18.4.2.7.2 Fire Management System

Concessionaire shall provide an interface to the FACP at each location to release all doors, gates and hatches for emergency egress in the event of a fire alarm and to suppress emergency egress door open alarms.

18.4.2.7.3 Battery Room Alarms

Concessionaire shall provide an interface to the gas detection alarm in each battery room to prevent badge entry except for specified individuals.

18.4.2.7.4 SCADA

Concessionaire shall interface intrusion detection points to the SCADA system for display at the control centers and the annunciator panel at the Station attendant’s booth (if provided).

18.4.2.7.5 Master Clock Time System

Concessionaire shall utilize the MCTS for date and time stamping of alarms and events.

18.4.2.8 Power

Concessionaire shall connect system power from the local UPS. Specific power requirements for all ACS components shall be coordinated with the requirements of the Station power systems.

18.4.2.9 Access Boxes

Concessionaire shall provide access boxes where immediate access is necessary for Emergency Services personnel per NFPA 1. Access boxes shall be approved by the AHJ and shall be installed in obvious, accessible locations.

18.4.2.10 ACS Design Related Submittals

Concessionaire shall submit the ACS Preliminary Design submittal for Review and Comment. The ACS Preliminary Design submittal shall include, at a minimum, the following items:

- a ACS Design Criteria for all ACS equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- an ACS Locations List showing locations to be equipped with an ACS system and a summary of the major items (not quantities) of equipment to be provided at each location;
- ACS Typical Schematics and Plans for typical locations including the OCC showing all ACS hardware; and
- ACS Preliminary Network Drawings showing how all locations will communicate with one another.

Concessionaire shall submit the ACS Intermediate Design submittal for Review and Comment. The ACS Intermediate Design submittal shall include, at a minimum, the following items:

- an ACS Technical Specification for all ACS equipment and systems;
- ACS Complete Drawing Set for Typical Locations used in the Preliminary Design. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of ACS enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- ACS Final Network Drawings showing how all locations will communicate with one another;
- an ACS Monitoring Station Detailed Functionality Description of the system servers and workstations including typical graphical displays, icons and controls;
- an ACS List of Functional Components to be supplied as part of the ACS system;
- ACS Product Catalog Cuts for all active components, wire and cable used in the control and monitoring system;

- a ACS Detailed Functionality Description of the central servers and workstations including typical graphical displays, icons and controls;
- an Interface Control Document that defines the functional, physical and performance details of all interfaces between the ACS system and all other systems; and
- an ACS Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the ACS Final Design submittal for Review and Comment. The ACS Final Design submittal shall include, at a minimum, the following items:

- ACS Complete Drawing Sets for All Locations. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of ACS enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- updated ACS Monitoring Station Detailed Functionality Description of the system servers and workstations including all graphical displays, icons and controls; and
- the ACS Final Network Drawings showing how all locations will communicate with one another to include any changes that have occurred since the Intermediate Design.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information an ACS Application Software Listing for each processor.

18.4.3 CCTV

18.4.3.1 Coverage Locations

Concessionaire shall provide CCTV camera surveillance at security sensitive areas and those with high-risk safety concerns. Such areas include, but are not necessarily limited to the following:

- all public areas in all Stations;
- ticket vending machines, fare gates, and turnstiles;
- Platform edges and end of Platform gates;
- Station approach walkways and pedestrian bridges within the Project ROW;
- stairs, escalators, elevators, and lobby areas;
- elevator cab doors and interior compartment;
- intercoms, emergency telephones, and manual pull stations;
- Station bicycle racks;
- emergency exits and areas of refuge;
- interior of access-controlled doors to rooms containing Station equipment (except janitorial and refuse rooms);
- parking structures, lots, and drop-off points;
- portals at tunnel entrances and exits;

- access points from at-grade alignment to aerial and open cut sections of the alignment;
- yards, shops, repair, and maintenance areas used for the storage of assets or housing mechanical, electrical, communications or control equipment;
- interior and exterior of electrical equipment rooms;
- interior and exterior of communication equipment rooms;
- interior and exterior of Train control and communications rooms;
- interior and exterior of TPSSs;
- interior and exterior of LRVs;
- areas monitored by the ACS; and
- areas where other sensing devices are installed, as deemed necessary by process hazard analyses and TVAs conducted during design.

Coverage in public spaces shall be nominally 100 percent such that a person cannot be on the property without being visible from a camera. A minimum of six cameras shall simultaneously and completely view any Station Platform. The surveillance camera system shall be able to digitally zoom up to 800 percent and digitally scroll live video from any camera. Any camera view shall be able to be displayed on the local surveillance and backend systems. User(s) shall be able to specify the field of view for each camera. During multiple alarm instances the video shall either be “cascaded” across the chosen viewing panes or “queued” behind the chosen viewing panes.

All CCTV camera views as displayed on any monitor shall meet one of the following DCRI surveillance levels as developed by the US Army Night Vision laboratory:

- Recognition – human target can be determined to be a threat by the type of clothing and/or equipment being carried; or
- Identification – human target can be identified as a specific individual.

18.4.3.2 Monitoring and Administration Locations

Concessionaire shall provide CCTV monitoring workstations at the following locations:

- Security Center - two console workstations shall be provided to accommodate two Owner personnel in the Security Center;
- OCC;
- BOCC;
- Owner’s PMF; and
- two console workstations shall be provided to accommodate two Owner personnel responsible for oversight during O&M Work.

Concessionaire shall establish the Security center as the primary location for monitoring live CCTV image and managing recorded video. Only those workstations at the Security Center shall have the capability to create video clips from any system camera and play back recorded video. All other workstations shall only be capable of displaying live CCTV images. The Security Center workstations shall have the capability to block the display of images from any combination of cameras on all other CCTV workstations.

Concessionaire shall provide CCTV system administration workstation(s) at the Security Center to manage operations and maintenance staff access rights to the system and to manage data storage facilities.

The CCTV System video shall integrate and be displayed on the viewing console(s) located at the Owner PMF.

18.4.3.3 Video Management System

Concessionaire shall provide a video management system to allow any Security Center operator to select and view video from any camera at any location and execute the following actions:

- conduct scene analysis studies, define boundaries and classify cluster segments;
- process rules and historic data;
- define and edit regions of interest including, at a minimum:
  - left luggage or object;
  - intrusion detection; and
  - perimeter protection.
- set up pre-sets and groups;
- view “all sides” of an incident simultaneously by placing camera views on a split screen display;
- recall and view incident video;
- set up reports either through pre-defined templates or custom processes;
- search video using rapid image retrieval to find and track a particular person throughout the PL System with the following capabilities:
  - ability to set up a file transfer protocol from remote server to host server to transfer any video image at any time;
  - retrospective search tool;
  - analysis of the analytic metadata stored in the system database;
  - full audit trails and report writing capabilities; and
  - metadata searches using multiple sensor inputs.
- monitor performance of each camera at all locations at any time including:
  - allow system users to set up user names and define reports;
  - maintain the overall health of the CCTV system; and
  - maintain back-up copies of evidential files.
- enable the transfer of images to external agencies as specified; and
- automatically report any failure in image generation at any camera at the Security Center.

18.4.3.4 Video Surveillance Analysis Software

Concessionaire shall include video surveillance analysis software including, but not necessarily limited to, the following capabilities:

- motion detection, object detection, and object tags through the use of intelligent video analytics (facial recognition is not required);
- viewable MJPEG, MPEG4, H.264 and H.265 image-stabilized video streams at 30 frames per second for simultaneous viewing and recording onto the system's hard drives and archiving to video storage units;
- multicast (50 plus users) and configurable system priorities transmitted through an IP network; Multicast routing shall be compatible and integrated with MDOTs routing scheme for security and CCTV video.
- Video camera, workstation and server IP addresses shall be coordinated with MDOT, as they will sit on the MDOT CIB network.
- viewing monitors configured to support 8, 16, and 32 camera viewing configurations;
- a full GIS interface;
- drivers for cameras and encoders from a number of major camera and equipment manufacturers;
- full alarm management, including at a minimum acknowledgement with and without operator comment, confirmation with and without operator comment, and closeout with and without operator comment; and
- search of recorded video data from selected cameras over a selected time period for a selected event.

18.4.3.5 Video Recording and Retrieval

Concessionaire shall provide video recording and retrieval hardware and software at the Security Center for use by authorized Emergency Services personnel. Performance capabilities shall include, at a minimum, the following:

- video from all cameras shall be recorded digitally uncompressed at a full frame rate no less than eight frames per second;
- after 5 days, video recording may be digitially compressed at a full frame rate no less than three frames per second which shall be available for retrieval for no less than 30 days following the original recording date;
- all alarm incidents shall be recorded starting 30 seconds before the incident alarm until 30 seconds after the incident is cleared by a security officer;
- all incident images shall be indexed, catalogued and stored in SQL in real time such that recall of any image throughout the entire system is essentially instantaneous;
- all archived event video recordings shall be stored indefinitely;
- all recorded video shall be date and time stamped and shall identify the source camera in accordance with established legal standards;
- at the Security Center, only authorized users shall be able to create and display video clips from recorded or live video. Recorded video shall be available for playback by selecting time and date ranges. Video clips shall be stored at the Security Center. Concessionaire shall provide a minimum of 1TB of storage capacity for video clips at the Security Center. The Security Center workstations shall be able to off-load video clip data to an external hard drive;

- video clip files shall be secured to prevent alteration by any person in accordance with established legal standards; and
- at the Security Center only, authorized users shall be able to select recorded video data from a selected group of cameras for a selected time period and perform a retrospective search for a selected event. Search criteria shall include, but not be limited to human characteristics, clothing characteristics and object characteristics.

18.4.3.6 User Authorization

Concessionaire shall assign user roles and responsibilities based on user login. Roles shall range from guest, with configurable read-only privileges, to administrator, with full access and configuration rights; and

It shall be possible to assign cameras and groups of cameras to individuals and classifications of individuals, including PTZ control, which shall be assigned based on user roles and responsibilities. Video clip creation and playback functions shall also be based on user roles and responsibilities.

18.4.3.7 Communications Network

The CCTV security, surveillance camera video communicates (transmitted on) on the MDOT CIB only.

Concessionaire shall provide a CCTV system at each location that supports a regional network. The regional network shall include a Network Video Recorder (NVR) to store video images collected from cameras throughout the site. The system may be configured with an NVR/archive at hub locations such as each Train control CIH serving a cluster of passenger Stations with archival storage capacity for each camera. For every Underground Station, an NVR shall be located in the Station communications room.

Concessionaire shall network the CCTV systems at all locations such that information is readily available to the Security Center, OCC, BOCC, Stations Attendants/Kiosks, Owner PMF and remote parties as required.

The system shall be electrically supervised and continuously monitored with an alarms distribution list and advanced list configuration.

18.4.3.8 Interfaces

18.4.3.8.1 Intrusion Detection and Access Control

Concessionaire shall interface the CCTV system to the ACS system to monitor areas of active alarms.

18.4.3.8.2 Chemical Detection and Other Sensing Devices

Concessionaire shall interface the CCTV system to CBRNE detection devices to monitor areas of active alarms.

18.4.3.8.3 Fire Management System

Concessionaire shall interface the CCTV system to the FMS system to monitor areas of active alarms.

18.4.3.8.4 Wi-Fi System

Concessionaire shall interface the CCTV system to the Wi-Fi system to download CCTV data from the LRVs to long term storage and to enable live monitoring of LRV video on request from the Security Center.

18.4.3.9 Power

Concessionaire shall source system power from the local UPS. Specific power requirements for all CCTV components shall be coordinated with the requirements of the local power systems.

18.4.3.10 CCTV Design Related Submittals

Concessionaire shall submit the CCTV Preliminary Design submittal for Review and Comment. The CCTV Preliminary Design submittal shall include, at a minimum, the following items:

- a CCTV Design Criteria for all CCTV equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements;
- CCTV Network Bandwidth Calculations showing the ability of the network to handle the video and data load;
- a CCTV Location List showing locations to be equipped with a CCTV system and a summary of the major items (not quantities) of equipment to be provided at each location;
- CCTV Typical Location Preliminary Drawings including preliminary camera view/coverage, system schematic and plan drawings for typical locations including the Security Center showing all CCTV hardware; and
- CCTV Preliminary Network Drawings showing how all locations will communicate with one another.

Concessionaire shall submit the CCTV Intermediate Design submittal for Review and Comment. The CCTV Intermediate Design submittal shall include, at a minimum, the following items:

- a CCTV Technical Specification for all CCTV equipment and systems;
- CCTV Typical Location Complete Drawing Sets for the typical locations used in the Preliminary Design. Completed drawing sets shall include, but not be limited to, camera view/coverage drawings, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of CCTV enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- CCTV Final Network Drawings showing how all locations will communicate with one another;
- a CCTV Detailed Functionality Description of the system servers and workstations including typical graphical displays, icons and controls;
- a CCTV List of Functional Components to be supplied as part of the CCTV system;
- CCTV Product Catalog Cuts for all active components, wire and cable used in the control and monitoring system;

- an CCTV Interface Control Document that defines the functional, physical and performance details of all interfaces between the CCTV system and all other systems; and
- a CCTV Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each processor.

Concessionaire shall submit the CCTV Final Design submittal for Review and Comment. The CCTV Final Design submittal shall include, at a minimum, the following items:

- CCTV Complete Drawing Sets for All Locations. Completed drawing sets shall include, but not be limited to, camera view/coverage drawings, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of CCTV enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- an updated CCTV Detailed Functionality Description of the system servers and workstations including all graphical displays, icons and control; and
- Comment the CCTV Final Network Drawings showing how all locations will communicate with one another to include any changes that have occurred since the Intermediate Design.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information an CCTV Application Software Listing for each processor.

18.5 Equipment Requirements

18.5.1 Fire Management System

18.5.1.1 Workstations

Concessionaire shall provide UL listed fire alarm workstations at all designated fire command centers.

18.5.1.2 Fire Alarm Control Panels (FACPs)

Concessionaire shall provide each required facility with an NFPA 72-compliant pre-signal FACP. The FACP shall house all necessary supervisory and monitored circuits. The panel shall support external monitoring and control circuits, including remote network, password-protected access. Two separate sources of electrical power shall be provided, including internal battery backup.

The pre-signal function shall sound a local alarm upon detection of fire or smoke. If the alarm is not aborted locally within a defined time, a general alarm shall sound, and the fire suppression system in the space shall be activated. The pre-signal and general alarms, as well as the abort signal, shall be reported to the FMP.

Concessionaire shall provide each FACP with a display for showing the status of all alarm, supervisory, and trouble signals, and shall include alarm reset and disable controls and generation of summary alarms for display at FMPs. Each fire alarm system shall utilize an alphanumeric system of identification.

Each FACP shall support all addressable devices in the alarm mode. Each FACP shall individually monitor detectors for calibration, sensitivity, and alarm condition and adjust each detector. This shall include continuously performing self tests on each detector to assure the accuracy of the values transmitted. Each FACP shall be able to recall and print a history of alarms and trouble conditions. In addition, a separate electronic alarm and trouble log shall be provided.

18.5.1.3 Fire Management Panels (FMPs)

Concessionaire shall provide each FMP, as required, associated with a FACP, to present a graphic display of the Station or facility. Two sources of power shall be provided for each FMP. Additionally, a public address microphone shall be provided.

Concessionaire shall coordinate the locations of the FMPs with the AHJ in order to provide first-arriving firefighters with visual mapping for unobstructed access to various areas of the facility. The FMPs shall be placed in readily accessible and protected areas, preferably in close proximity to the main facility entrance. The FMP at each location shall serve as the on-site fire command center for emergency response personnel.

The graphic display presented by the FMP shall be a rendition of all public and non-public areas of the facility. It shall depict all circulation elements and the means by which firefighters may reach the area where a fire condition or related emergency is indicated. In addition, each area provided with fire or smoke detection shall be indicated on the FMP graphic display. When the control and monitor systems at the FACP detect a fire or smoke condition, the FMP shall mimic that condition. Every loop annunciated at the FACP shall likewise be represented at the FMP on the graphic display. The displays shall include a schematic representation of all activated detectors, sprinklers, wet standpipes, and emergency fans.

The FMP shall be able to monitor and control select devices and systems, including, at a minimum, the following:

- tunnel and Station emergency ventilation;
- fire and smoke detection and suppression;
- intrusion access (lock/unlock);
- vertical circulation elements (elevators and escalators);
- public address through microphone access;
- CCTV system; and
- SETs.

18.5.1.4 Peripherals

18.5.1.4.1 Heat and Smoke Detectors

Concessionaire shall locate heat and smoke detectors according to the requirements of NFPA 72 and in coordination with the AHJ. Heat and smoke detectors shall be of the following types:

- addressable UL 286 spot-type photoelectric smoke detectors with self test capacity;
- addressable UL 286 spot-type ionization smoke detectors with self test capacity;
- addressable UL 286 spot-type photoelectric sampling tube HVAC duct detectors;
- addressable UL 521 spot-type fixed-temperature 135^0 F heat detectors;
- addressable UL 521 combination rate-of-rise/fixed-temperature heat detectors; and
- addressable UL 521 linear heat detectors.

Smoke detectors shall not be used in locations where they are subject to contamination at levels that may result in false alarms.

18.5.1.4.2 Tamper Devices

Concessionaire shall provide tamper detection devices for all sprinkler valves.

18.5.1.4.3 Flow Sensors

Concessionaire shall provide flow sensors on all sprinkler systems.

18.5.1.4.4 Pull Stations

Concessionaire shall provide addressable manual fire alarm pull stations finished in a fire engine red color with the word "FIRE" in molded, raised, white letters. Operating instructions in a contrasting color such as white shall also be included. The manual fire alarm pull stations shall be of a type as required by NFPA 72 and shall be constructed of a metal which is capable of withstanding harsh or outdoor environments.

Concessionaire shall provide pull stations in hallways which connect passenger Station service rooms to public areas, ancillary spaces, yards and shops, parking structures, and other select locations. Pull stations shall be installed within 5 feet of each exit. Pull stations shall not be installed in Station public areas (except as noted above) to reduce the possibility of false alarms resulting from pranks or possible criminal activity.

Activation of the manual fire alarm pull stations shall signal alarms at the FACP and FMP with date, time, and location recorded. The use of a key or wrench shall be required to reset the pull station.

18.5.1.4.5 Strobes

Concessionaire shall provide notification appliances containing visual and audible components. Audible notification shall be 15 dBA over ambient noise, and shall include:

- notification through the PA system where provided; and
- wall-mounted horns and speakers or combination speaker-and-strobe or horn-and-strobe units.

Visual components shall include:

- strobe visual devices in common areas per NFPA 72 or ADA Accessibility Guidelines requirements, whichever is more stringent;
- strobes shall have a minimum of 15 and maximum of 110 candela seconds; and
- all signaling devices shall be listed in accordance with UL 1971.

18.5.1.4.6 Non-Aqueous Suppression

Concessionaire shall provide appropriate fire suppression in equipment rooms housing sensitive electronic equipment such as Train control processors, servers, workstations, PLCs, and network hardware. An appropriate system is any means of fire suppression that has the capability to suppress any anticipated fire and/or smoke condition and minimizes damage to the equipment resulting from the activation of the fire suppression system and thereby minimizes the time required to return the equipment to service. The system may be aqueous or non-aqueous.

The sensitive equipment room systems shall be monitored by the FMS and shall allow for local manual initiation, local abort within a programmable time period, system by-pass switch, and pre-discharge and discharge alarms. Alarms shall be local and shall also be transmitted to the FACP and FMP with date, time, and location recorded

18.5.2 Intrusion Detection and Access Control

Concessionaire shall provide ACS equipment and components including, but not necessarily limited to:

- servers;
- workstations;
- programmable smart cards;
- contactless credential readers;
- reader interfaces;
- numeric keypads;
- intelligent security management controllers;
- intercoms and controllers;
- software packages;
- alarm control and annunciator panels;
- displays;
- metal enclosures and racks;
- door strikes;
- releases;
- release locks and hinges;
- recording and storage devices;
- photoelectric and infrared detectors (as required);
- alarm speakers, bells, horns, and strobes;
- network and tamper switches;
- power supplies and batteries;
- fittings and connectors;
- cables;
- conduit;
- wire; and
- associated equipment and materials.

18.5.2.1 Servers

Concessionaire shall provide a security management system, including software and front-end hardware, in the ACS for system configuration, event and alarm monitoring, and report generation. Hardware shall provide hot-standby failover redundancy.

18.5.2.2 Workstations

Concessionaire shall provide workstations at monitoring facilities to interface to the system for configuration, monitoring, control, and report creation/generation.

18.5.2.3 Annunciator Panels

Concessionaire shall provide local intrusion alarm control panels. An equipment malfunction or the detection of an intrusion condition shall initiate an alarm indication identifying the location and device(s) at which the alarm condition exists and the control panel shall transmit this information to the central servers. The panels shall provide visual and/or audible indications for:

- intrusion alarm condition;
- tampering alarm condition;
- detector circuit malfunction;
- loss of controller connection;
- detector disabled or not reporting; and
- power source alarms and condition.

The audible annunciators shall indicate an alarm and trouble condition by using a distinct tone which is differentiated from those utilized in the fire alarm system. The visual panel indication shall remain on until the detection system is reset, and the audible alarm shall continue until acknowledged at the panel, or the detection device is reset or disabled.

18.5.2.4 Intercom

Yard and shop facilities shall be equipped with audio/video entry intercom systems. The intercom system shall include PC-based master control software, independent master control stations, and vandal-resistant door stations.

18.5.2.5 Access Gates

Maintenance and storage facility and other support facility entrances shall be secured with motor-operated gates.

18.5.2.6 Remote Exit Devices

Concessionaire shall provide photoelectric sensors, as required, with transmitter and receiver elements mounted at appropriate elevations to discourage false alarms.

18.5.2.7 Enclosures

Concessionaire shall provide all control equipment, relays, modules, circuit boards, and other such devices contained within enclosures of all-metal construction. All enclosures shall be closed with tamper-resistant screws. NEMA enclosures shall be provided for all equipment that is not provided by the manufacturer in a suitable enclosure. The intrusion alarm control unit shall be housed in a NEMA-I2 enclosure with locking cover.

18.5.3 CCTV

18.5.3.1 Video Management System

The video management system shall meet the following requirements:

- The video management system shall be configurable by the application program interface and software development kit;
- All IP camera driver support shall be implemented through a standards compliant real time streaming protocol (MPEG4 or H.264) or server-push hypertext transfer protocol (MJPEG);
- Real-time transport protocol compliant to enable delivery of audio and video over IP networks;
- The real-time transport protocol shall be configured to carry a range of multi-media formats including, at a minimum, H.264, MPEG4, MJPEG and MPEG;
- The video management system shall have the capability to carry the G.711, G.723, G.726, G.729, GSM, QCELP, MP3 and DTMF audio formats;
- The system shall be integrated using video encoders;
- The system shall enable configurable unicast and multicast data streams; and
- The system shall comply with ONVIF profiles C, G, Q and S.

18.5.3.2 Cameras and Appurtenances

18.5.3.2.1 Cameras

Concessionaire shall provide IP-based fixed dome or pan, tilt, and zoom (PTZ) video cameras with Power over Ethernet (PoE) capabilities if required. Independent of power source, the camera video data interface shall be and remain IP-based Ethernet.

Analog cameras shall support the NTSC and PAL standards.

Cameras shall be adjustable for brightness, contrast, color, sharpness, saturation, hue, and white balance. Controls shall be provided for angle of view, zoom, varying focus, shutter speed, and lighting conditions. Cameras shall be capable of operating at emergency or low light levels and have both day and night capacities.

Cameras shall support wireless applications and be suitable for bi-directional audio, including external microphones for sound pick-up from selected locations.

Alarms shall be provided for loss of power, fan malfunction, high temperature detection, signal loss, and a defective recording device or disk. Outdoor cameras shall be designed to withstand heat, cold, rain, ice, snow, and similar environmental hazards through the use of heaters, blowers, and defoggers.

PTZ cameras shall include masking and mechanical auto flip functions. Spherical zone masking shall allow unwanted areas to be excluded regardless of camera angle or rotation. Auto flip shall provide a 90-degree tilt capacity with 360-degree rotation.

18.5.3.2.2 Housing

Concessionaire shall house cameras in corrosion-resistant and vandal-proof environmental enclosures with shatter-proof lenses and a viewing port. Enclosures shall be suitably sealed, environmentally controlled, and weatherproofed if installed in an exposed or exterior environment. Camera environmental protection shall be rated IP66.

18.5.3.3 Poles

Poles used on and adjacent to Station areas shall be aesthetically coordinated with the architectural design of the Station. Poles shall constrain the maximum vibration of the cameras within the performance tolerances of the cameras and analytic software to eliminate image vibration on viewing monitors.

18.5.3.4 Servers

Concessionaire shall provide NVRs to store the high resolution video for a minimum 30-day period. Each system shall be expandable up to 20 percent for future needs.

The primary and redundant NVRs at the Security Center shall be capable of retaining all video images for a minimum period of 30 days. The Security Center recording equipment shall be expandable to provide additional future capacity.

18.5.3.5 Workstations

Concessionaire shall provide computer-based workstations for system monitoring with color monitors, servers, storage devices, racks, switches, hardware, and software. Workstation computers shall have high resolution flats screens, keyboard access, and mouse-based controls. Computers shall have storage devices such as hard drives and DVD drives for local recording. Microphones shall be provided to allow users to access camera audio functions and interface with the PA system.

The system shall include enhanced graphical user interface capabilities and full geographic information system capabilities. The workstations shall display mimic diagrams and overlays for selecting and moving cameras. Operators shall have point and click controls to operate the system and view selected real-time camera video streams, as well as call up previously recorded videos by time and date.

The system shall assign an alphanumeric identifier to enable users to determine the location of each camera view. The date and time shall be superimposed on videos as they are being monitored or recorded. Users can view and adjust each camera’s recorded frame rate, resolution, and bandwidth plus adjust pan, tilt, zoom, and focal length as required. The workstations shall monitor all alarm conditions and configurations and include alarm reset and mute capabilities.

18.6 Construction Requirements

Concessionaire shall ground all racks, enclosures, cabinets and raceways per code requirements.

Concessionaire shall Test Fire and Security Systems in accordance with the overall Test Program Plan in preparation for Integration Testing. Enter all test results into the Safety Certification Program.

18.6.1 Fire and Security System Testing

A Fire and Security Test Program Plan shall cover all tests required to verify fire and security system performance, functionality and safety; the plan shall include the number and title of each

Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified qualification tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, the fire and security system at each location shall be ready for Integration Testing with other systems and Fixed Facilities.

The fire and security factory and field testing shall satisfy all fire and security related prerequisites of the Integration Test Program Plan and all required fire and security inputs for Safety Certification.

18.6.2 Construction Related Submittals

No later than 90 calendar days prior to the start of factory testing, Concessionaire shall prepare and submit for Review and Comment an FMS, ACS and CCTV Test Program Plan.

No later than 60 calendar days prior to the start of factory testing of the first location, Concessionaire shall prepare and submit for Review and Comment FMS, ACS and CCTV Factory Test Procedures.

No later than 60 calendar days prior to the start of on-site testing at the first location, Concessionaire shall prepare and submit for Review and Comment FMS, ACS and CCTV on-site Test Procedures.

No later than 30 calendar days after completion of factory testing of each location, Concessionaire shall prepare and submit for Review and Comment FMS, ACS and CCTV Factory Test Reports. Test Reports for each location shall be submitted separately if the test schedules for the location do not coincide.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit FMS, ACS and CCTV on-site Test Reports. Test Reports for each location shall be submitted separately if the test schedules for the location do not coincide.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Information FMS, ACS and CCTV Mechanical, Electrical and Software Configuration Settings.

18.7 Summary of Submittals

Item	Section	Submittal	Action
1	18.4.1.7	FMS Preliminary Design	Review and Comment
2	18.4.1.7	FMS Intermediate Design	Review and Comment
3	18.4.1.7	FMS Final Design	Review and Comment
4	18.4.1.7	FMS Application Software Listings	Information
5	18.4.2.10	ACS Preliminary Design	Review and Comment
6	18.4.2.10	ACS Intermediate Design	Review and Comment
7	18.4.2.10	ACS Final Design	Review and Comment
8	18.4.2.10	ACS Application Software Listings	Information
9	18.4.3.7	CCTV Preliminary Design	Review and Comment
10	18.4.3.7	CCTV Intermediate Design	Review and Comment
11	18.4.3.7	CCTV Final Design	Review and Comment
12	18.4.3.10	CCTV Application Software Listings	Information
13	18.6.2	FMS, ACS and CCTV Test Program Plan	Review and Comment
14	18.6.2	FMS, ACS and CCTV Factory Test Procedures	Review and Comment
15	18.6.2	FMS, ACS and CCTV On-Site Test Procedures	Review and Comment
16	18.6.2	FMS, ACS and CCTV Factory Test Reports	Review and Comment
17	18.6.2	FMS, ACS and CCTV On-Site Test Reports	Review and Comment
18	18.6.2	FMS, ACS and CCTV Mechanical, Electrical and Software Configuration Settings	Information

19 FARE SYSTEM

Concessionaire shall provide a fare system that is fully compatible with, and procured in conjunction with the WMATA New Electronic Payment Program (NEPP) fare system. All NEPP equipment and associated software is required to have a minimum useful life of fifteen years.

Owner will provide any additional requirements for the Fare System no later than six months after Financial Close. At that time, Concessionaire shall execute the requirements of this Section 19 related to the scope of work for the Fare System Allowance as described in Section 19.7.1 including all associated engineering and design. No additional requirements will be provided for Work excluded from the Fare System Allowance as described in Section 19.7.2.

This Section identifies requirements for the overall Fare System. Concessionaire shall provide:

- ticket vending machines and validators at all Project stations;
- NEPP central server functionality;
- workstations;
- Communications network devices; and
- validation devices for fare inspectors to check all types of travel authorization.

19.1 Fare System Overview

Concessionaire shall provide a Fare System that includes, but is not necessarily limited to, equipment and provision for:

- vending and distributing fare media for Users meeting established fare policy and tariffs;
- collecting and reconciling cash fares;
- documenting and reconciling debit/credit sales;
- automatically collecting fare sales data and statistics; and
- supporting revenue sharing agreements with other regional service providers.

Concessionaire shall provide a Fare System based upon proof of payment; no Fare System Equipment shall be installed on LRVs. Concessionaire shall provide sufficient performance, capacity and efficiency to support the expected passenger loads for Service Level 3.

Concessionaire shall incorporate into the Fare System WMATA NEPP compliant hardware and software.

For all equipment placed in the Stations, the full functional availability shall be not less than 98 percent.

19.1.1 Fare Policy

Owner will provide any additional requirements no later than twelve months before the scheduled start of Trial Running.

19.1.2 Fare Tariffs

Concessionaire shall provide a Fare System that can accommodate up to ten different fare tariffs.

19.2 Codes & Standards

The Project shall comply with the requirements of the Codes and Standards including, at a minimum, the following:

- MTA - Fare Policy for the Purple Line Light Rail;
- Code of Federal Regulations, Title 49 – Transportation, Part 27 (49 CFR 27), Nondiscrimination on the Basis of Disability in Programs and Activities Receiving or Benefitting from Federal Financial Assistance;
- Code of Federal Regulations, Title 49 – Transportation, Part 30 (49 CFR 30), Denial of Public Works Contracts to Suppliers of Goods and Services of Countries that Deny Procurement Market Access to U.S. Contractors;
- Code of Federal Regulations, Title 49 – Transportation, Part 37 (49 CFR 37), Transportation Services for Individuals with Disabilities (ADA) including Appendices;
- U.S. Access Board’s Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG);
- U.S. Department of Transportation (DOT) / Department of Justice Americans with Disabilities Act (ADA);
- DOT-FTA-MA-26-5005-00-01 Hazard Analysis Guide for Transit Projects;
- DOT-FTA-IT-90-5001-02.1, Quality Assurance and Quality Control Guidelines;
- AIA’s Architectural Graphic Standards;
- ISO/IEC 14443-1:4, Identification Cards – Contactless integrated circuit cards – Proximity cards – Parts 1 through 4;
- ISO 7816:4, Identification Cards – Integrated Circuit Cards – Part 4: Organization, security and commands for interchange;
- ISO/TR 14806, Intelligent Transportation Systems – Public transport requirements for the use of payment applications for fare media; and
- ISO 24014-1, Public Transport – Interoperable fare management system – Part 1: Architecture.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

19.3 Functional Requirements

19.3.1 Fare System Functional Overview

Concessionaire shall provide a Fare System that includes, but is not necessarily limited to, ticket vending machines (TVMs), validators, handheld units, back office equipment (such as point of sale devices, concentrators, and encoders), communications devices, data accumulators, NEPP server functionality, mobility systems, clearinghouse services and provide automatic reloads. In addition, Concessionaire shall provide initial stocks of all types of paper fare media for revenue service.

Primary intermodal operations will require cooperation with WMATA Metro Rail, WMATA Metro Bus, and various other regional service providers that have adopted the NEPP system. Owner expects to have interagency agreements executed by Revenue Service Availability. Concessionaire shall be responsible for provision and full maintenance of the equipment, systems and data support services, stocking TVMs with fare and receipt media, collecting cash, counting and reconciling the collected cash and depositing it into a bank or other financial institution as directed by Owner.

Concessionaire shall incorporate contemporary features to enhance passenger convenience, and usability.

Concessionaire shall supply a modern Fare System that:

- utilizes convenient, secure fare media and payment options that improve customer service;
- provides for integration of Fare System equipment and software from multiple suppliers;
- provides for integration of up-and-coming payment methods and various media without need for equipment modification;
- ensures accurate revenue reporting and accountability as well as accurate and timely ridership data; and
- is secure and reliable.

19.3.2 Ticket Vending Machines (TVMs)

At a minimum, Concessionaire shall provide TVMs capable of:

- open payment processing to allow acceptance of a variety of contactless credit/debit cards;
- communicating with near field communication (NFC) enabled cell phones as a potential fare payment method. Functions shall include the ability to receive “hot lists” and record all transactional data;
- vending paper tickets for Purple Line System one-way trips. Paper tickets shall be printed on receipt stock paper with a pre-printed custom color design provided by Owner. Tickets shall be printed with date, time and ticket type in both readable and bar code form by the TVM at time of issue;
- adding value to an existing User account (but not vending new electronic fare media);
- accepting cash, debit cards and credit cards for payment (but not issuing change);
- issuing a receipt on User request;
- the value of any fare media in the tariff shall be adjustable on each TVM installed and in service to accommodate tariff revisions;
- operating such that the display decreases to zero as money (single bills and/or multiple coins) is inserted by Users. When the display reaches zero, indicating that the passenger has submitted sufficient payment for the fare, the TVM shall automatically print and vend the ticket(s) selected;
- monitoring TVM security conditions and reporting alarms to a central location as well as providing a local alarm;
- accumulating and summarizing data to enable an audit of transactions occurring between coin and/or bill vault replacements. TVMs shall generate and imprint audit tickets with this data; and

- processing and storing all ticket/pass sales, TVM status, failures, security and service events, and diagnostics in the data memory unit of the TVM processor and transmitting this information on demand to the CC.

19.3.3 TVM Passenger Interface

Owner will provide requirements no later than six months after Financial Close.

19.3.4 Fare Media

Concessionaire shall provide a Fare System that handles single-trip and round-trip tickets as well as day passes, 7-day passes, 30-day passes, special timed-passes, and stored-value media.

Owner will provide any additional requirements no later than six months after Financial Close.

19.4 Design Requirements

Concessionaire shall assign space and make provisions for Fare System equipment power and network connectivity at all locations at each Station as shown in Book 4 Contract Drawings. Concessionaire shall dedicate these locations to Fare System equipment. Concessionaire shall provide conduits in each Station for power circuits and network connectivity to all Fare System equipment locations identified in Book 4 Contract Drawings. Power conduits shall connect to the Station power distribution panel and network conduits shall connect to the Station MDOT CIB node. Concessionaire shall size Station power systems to include the power requirements of fare collection equipment at all Fare System equipment locations shown in Book 4 Contract Drawings.

Concessionaire shall provide network connectivity cables and CIB node equipment for fare collection equipment at all locations shown in Book 4 Contract Drawings. The Fare System network shall be carried on the MDOT CIB.

Concessionaire shall provide power cables from the Station power panel to each item of fare system equipment at each Station.

Concessionaire's Station architectural drawings shall indicate all designated Fare System equipment locations and which locations are actually to be used for equipment placement.

Owner will provide any additional requirements no later than six months after Financial Close.

19.4.1 Ergonomic/Universal/ Accessibility Design

Concessionaire shall design the Fare System equipment, systems and subsystems for ease-of-use; that is, simple, efficient, reliable, accessible, and safe for the widest possible range of Users and operations and maintenance staff.

Concessionaire shall provide equipment to accommodate, at an absolute minimum, Users and operations and maintenance staff ranging from the U.S. 5th percentile female to the 95th percentile male. See the AIA's *Architectural Graphic Standards* Section 1: Human Dimensions, for current U.S. anthropometric details.

Equipment shall have no sharp, abrasive edges, corners, or surfaces, and no hazardous protuberances. Materials shall be strong enough to resist everyday use and shall be resistant to scratches and markings. The use of visible fasteners shall be minimal.

Concessionaire shall provide Fare System equipment with a safe, reliable and intuitive interface for Users in accordance with human engineering principles. The equipment shall provide Users with displays, graphics and signage, controls and mechanisms, which are simple to use, easy to understand, and conveniently located. An inexperienced passenger shall be able to understand the ticket purchase and activation process. Equipment shall accommodate the broad range of Users that may include commuters, tourists, shoppers, children and students, the elderly, Users with impaired vision, Users in wheelchairs, Users with limited communications skills, and Users who are hearing impaired.

19.4.2 Fare System Interfaces

19.4.2.1 Software

Owner will provide any detailed requirements no later than six months after Financial Close.

19.4.2.2 Data Systems

Concessionaire shall provide Central Computer (CC) database functionality that is an integral element of the WMATA NEPP central servers.

The CC shall perform the central data and equipment management functions for the Fare System including fare payment transaction processing, reload transaction processing, “hot listing,” action list processing, and configuration management.

The CC shall generate daily, monthly and annual accounting reports of money collected from each ticket vending machine, total money collected, total money deposited to the bank or other financial institution, credit and debit card payments at each ticket vending machine, total credit and debit card payments received, money loaded onto smart cards or other electronic fare media at each ticket vending machine and total money loaded onto smart cards or other electronic fare media.

Concessionaire shall provide appropriate interfaces in support of CC functions including, but not necessarily limited to the following:

- automatic checking of the integrity of the communications link on a periodic basis to confirm functionality;
- verification of transaction record integrity when moving data from TVMs to the CC;
- daily polling of TVMs and validators to ensure transmittal of data from the TVMs to the CC;
- verification of data repository for all event and transactional data;
- control and setting of various TVM operating parameters from the CC to allow new system files to be sent to the TVMs; and
- ensuring collection and verification of data to generate required system reports.

Concessionaire shall provide TVMs, validators and handheld units capable of remote alteration of all configuration parameters from the CC system including date and time, fare tables, security access codes, ticket printing formats, alarm messages, in-service/out-of-service times, accepted types of credit/debit cards. The abilities to place an individual TVM “in service” and “out of service,” perform self-diagnostics, and reset machines shall also be provided from the CC.

The CC system shall receive status information and other data from the TVMs (all event information and data shall be stored on the CC and dispensed according to adopted security policy). The CC shall also periodically poll all Stations for status to ensure that all Station network interfaces are functioning properly.

19.4.3 Design Related Submittals

Concessionaire shall submit the Fare System Preliminary Design submittal for Review and Comment. The Fare System Preliminary Design submittal shall include, at a minimum, the following items:

- a Fare System Design Criteria for all Fare System equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, functional, performance and equipment requirements;
- an On-Site Ticket Sales Analysis to determine the quantity of ticket vending machines and validators required at each Station and the preferred locations; and
- Fare System Network Architecture Diagrams including a system-level graphic representation of all hardware components and their interconnections, system network drawings, typical drawings and systems functionality descriptions of the proposed technology for each major element of the Fare System. This shall include identification of the interfaces between the Fare System and all other devices and systems.

Concessionaire shall submit the Fare System Intermediate Design submittal for Review and Comment. The Fare System Intermediate Design submittal shall include, at a minimum, the following items:

- a Fare System Technical Specification for all Fare System equipment and systems;
- Fare System Drawings for the Fare System network, subsystems and equipment
- Fare System network, subsystems and equipment;
- Complete Drawing Sets for Typical Field Locations. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of equipment enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules;
- a Fare System List of Functional Components to be supplied for the control and monitoring system;
- Fare System Product Catalog Cuts and Component Shop Drawings for all active components, wire and cable used in the Fare System;
- an Fare System Interface Control Document that defines the functional, physical and performance details of all interfaces between the Fare System and all other systems;
- Fare System Detailed Functionality Descriptions of the TVMs, validators, central servers and workstations including typical graphical displays, icons and controls; and
- a Fare System Software Configuration Management Plan describing how Concessionaire will identify software revisions and control and track what software version is installed on each device.

Concessionaire shall submit the Fare System Final Design submittal for Review and Comment. The Fare System Final Design submittal shall include, at a minimum, the following items:

- Fare System Complete Drawing Sets for All Locations. Completed drawing sets shall include, but not be limited to, plan drawings showing all equipment locations and conduit connections, network diagrams, wiring diagrams, cable plans, plans and elevations of equipment enclosures, racks and cabinets, power supply diagrams, interface control documents describing the method of interface to other required systems, typical installation details for all components, conduit schedules and cable schedules; and
- an updated Fare System Detailed Functionality Description of the central servers and workstations including all software functions, graphical displays, icons and controls.

Prior to the start of factory testing, Concessionaire shall prepare and submit for Information an Fare System Application Software Listing for each processor.

19.5 Equipment Requirements

Concessionaire shall determine the number of TVMs and validators for each location based on Service Level 3 patronage projections, the estimated proportion of fares that will be sold by Station ticket vending machines, the estimated numbers of each transaction type and the TVM transaction times. Irrespective of the conclusions of this analysis, there shall be not less than two ticket vending machines and two validators in addition to any validators incorporated into TVMs at any Station. Fare system equipment shall be operational 7 days per week, 24 hours per day. All equipment shall function normally while exposed to its operating environment, and shall accommodate the broad range of Users using public transportation.

In addition to TVMs and validators at each station, TVMs and validators shall be placed on the UMD campus at two locations slightly distant from the Campus Center Station as follows:

- approximately 40ft north of the east end of the westbound platform (approximately 30 ft west of Union Lane); and
- approximately 50 ft south of the center of the eastbound platform (in the vicinity of the northwest corner of St. Mary's Hall).

Owner will provide any additional requirements to determine actual equipment quantities no later than six months after Financial Close.

19.5.1 TVMs

At a minimum, Concessionaire shall incorporate the following physical requirements into TVMs:

- the overall dimension of an installed TVM (including pedestal) shall not exceed 80 inches (height) by 36 inches (width) by 18 inches (depth). The top of the TVM shall slant at least 5 degrees downward and to the rear in order to prevent accumulation of rain; and
- TVMs shall be weather and environmentally protected and be suitable for the installed locations.

Owner will provide any additional requirements no later than six months after Financial Close.

19.5.1.1 Coin Processing

Owner will provide coin processing requirements no later than six months after Financial Close. TVMs shall not provide change.

19.5.1.2 Bill/Note Processing

Owner will provide bill/note processing requirements no later than six months after Financial Close. TVMs shall not provide change.

19.5.1.3 Credit/Debit Card Processing

Owner will provide credit/debit card processing requirements no later than six months after Financial Close.

19.5.1.4 Smart Card Readers and Fare Media

Owner will provide requirements for smart card readers and fare media no later than six months after Financial Close.

19.5.2 Handheld Units

Concessionaire shall provide handheld units/devices that support tariffs and business rules of Owner. Handheld units shall support reading and validation of all utilized electronic and paper fare media. Handheld units shall not exceed 1 pound in weight and may utilize any applicable technology supporting minimal size and weight such as suitably ruggedized smart phones, portable media players, tablet computers, personal digital assistants, or other NFC-compliant devices.

Owner will provide any additional handheld units/device requirements no later than six months after Financial Close.

19.5.3 Enclosures

Concessionaire shall provide exterior enclosures that are watertight and environmentally tested to simulate driving rain. Appropriate intrusion protection shall be provided for all Fare System Equipment.

Concessionaire shall provide locks for all exterior doors of equipment containing coins or bills with at least a three-point latching device with a bascule bolt and hook bar, or equivalent. Overlapping doors shall be constructed with a joining gap equal to or less than 2 mm.

Owner will provide any additional enclosure requirements no later than six months after Financial Close.

19.5.4 Fare Media

Concessionaire shall be responsible for any and all fare media necessary for testing and supporting the Fare System throughout the Term.

19.6 Construction Requirements

19.6.1 Configuration Control and Data Security

Throughout the Term, Concessionaire shall maintain an equipment and software configuration control system. All Fare System Equipment shall be permanently identified with the supplier’s name, part number, serial number, and revision level. This may be by use of an engraved metal label riveted in place or other approved method. Provision shall be made for updating the revision level when upgrades are implemented. This identification shall be supplemented by identification using bar codes, RFID tags or other suitable machine readable method.

Each box used to transport cash and to hold cash within the ticket vending machines shall have a unique identification.

Concessionaire shall be responsible for all data security and any encryption protections including at a minimum DES (Data Encryption Standard) and Verisign.

19.6.2 Station Fare System Equipment Installation

Concessionaire shall provide Fare System Equipment at Stations. Each TVM and validator shall be located so that the front of the machine faces the approaching Users and

Concessionaire shall provide all conduits and cables required to connect all elements of the Fare System Equipment. Embedded conduits and raceways shall include 50 percent spare capacity or one spare conduit, whichever is greater.

TVMs shall be within range of CCTV cameras mounted in the Station area and coordinated with CCTV camera angles to ensure that TVMs are viewed by at least one camera.

Concessionaire shall provide canopies over TVMs, sized to allow cabinet doors to be fully opened without allowing the entry of driving rain, unless otherwise protected from the environment. All TVMs shall be protected from direct sunlight onto the PID screen.

Concessionaire shall mount all equipment cabinets by means of stainless steel anchor bolts, embedded in a concrete base. Fare System Equipment cabinets shall have a mounting pedestal with suitable means for the leveling of installed machines to accommodate longitudinal and transverse slopes of up to 5 percent. Access to the anchor bolts shall be secured through access panels. Gaps between the pedestal base and mounting pad shall be sealed to prevent water intrusion.

Concessionaire shall provide mounting pedestals that contain sufficient room and mounting hardware for a power circuit breaker panel, communications network interface, and convenience outlets. Separate ground wires shall be used to properly ground TVMs and validators. All equipment, components, and parts shall be grounded. Grounding shall be provided to ensure all conductive materials are connected to a common ground point. Data cabling shall be separated in dedicated conduit runs and shielded from power cabling. Equipment shall be operable under electrical interference, as well as shock and vibration conditions, present at, and adjacent to, the Purple Line System.

Concessionaire shall provide a system workstation in the Security Center for reporting intrusion alarms.

Concessionaire shall provide fare system management workstations for its own use plus one fare system management workstation for Owner’s use. The Owner workstation shall be provided in the shop area assigned for Owner’s use.

19.6.3 System Testing and Acceptance

For the Final Design, Concessionaire shall prepare and submit for Review and Comment a Fare System Test Program Plan. The plan shall cover all tests necessary to verify the Fare System equipment and system performance and functionality; the plan shall include the number and title of each Test Procedure, requirements being verified, a brief description of each test, and a schedule showing each test to be performed. For any of the identified tests, results of a test of the same (or essentially the same) material or equipment as supplied for the Project may be submitted in lieu of performing the test. At the conclusion of all tests in this Test Plan, each unit of equipment and the congregate Fare System shall be ready for Integration Testing with other systems and fixed facilities.

19.6.4 Construction Related Submittals

No later than 90 calendar days prior to the start of factory testing, Concessionaire shall prepare and submit for Review and Comment a Fare System Test Program Plan.

No later than 60 calendar days prior to the start of factory testing of the first location, Concessionaire shall prepare and submit for Review and Comment Fare System Factory Test Procedures for all Fare System Equipment including interfaces with all other systems.

No later than 60 calendar days prior to the start of on-site testing at the first location, Concessionaire shall prepare and submit for Review and Comment Fare System on-site Test procedures for all Fare System Equipment including interfaces with all other systems.

No later than 30 calendar days after completion of factory testing of each site, Concessionaire shall prepare and submit for Review and Comment Fare System Factory Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of field testing at each site, Concessionaire shall prepare and submit for Review and Comment Fare System on-site Test Reports detailing the results of all tests completed.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Information Fare System Mechanical, Electrical and Software Configuration Settings.

19.7 Fare System Allowance

19.7.1 Work Included in Allowance

As established by Section 7.7.4 of the Agreement, the Fare System Allowance shall include the following Work:

- complete Fare System Preliminary, Intermediate and Final Design (except as noted below in Section 19.7.2 for power calculations, conduit and cable) including network communications through the MDOT and WMATA networks;
- TVM, validator and handheld unit procurement, installation (including TVM and validator pedestals and/or support posts), software programming, configuration set-up and testing;
- NEPP server hardware and software procurement, software programming, configuration set-up and testing at existing NEPP central office/backend primary and back-up locations;
- Purple Line System station network hardware procurement, installation and configuration set-up. Station rack-mount communications chassis will be furnished under Section 19.7.2;
- interface with WMATA/NEPP network for debit/credit card validation;
- NEPP console, workstation and software procurement, installation, software programming, configuration set-up and testing for Concessionaire and Owner;
- Station signage specifically related to the fare system;
- MDOT and WMATA network equipment hardware, software, configuration set-up and network-level testing required to support NEPP system functionality;
- procurement of initial revenue supply of fare media, receipt media and any other TVM consumables;
- development and implementation of TVM and validator displays;
- procurement of equipment required to support TVM cash collections and media stocking;
- procurement and set-up of fare media distribution at local retail locations prior to Revenue Service Availability;
- Fare System operations and maintenance manuals prior to Revenue Service Availability;
- Fare System training prior to Revenue Service Availability; and
- Fare System spare parts procured and stocked prior to Revenue Service Availability.

19.7.2 Work Excluded from Fare System Allowance

Work which is not specifically included in 19.7.1 Fare System Allowance may not be deducted from the Fare System Allowance and will be paid for as a part of the Work for the Project, including at a minimum:

- design of conduits and cables in Stations, UMD campus and OMFs for power and data cables;
- supply and installation of conduits in Stations, UMD campus and OMFs for power and data cables;
- Fare System power load calculations shall be included in the development of the overall power capacity requirements for stations, UMD campus and OMFs;
- station and OMF power distribution equipment shall have sufficient capacity to power all Fare System Equipment including designated circuit breakers in distribution panels for the Fare System Equipment;
- supply, installation and testing of power cables at each location for all items of Fare System Equipment;
- power distribution backup for Fare System Equipment;
- supply, installation and performance testing of data cables at each location for all items of Fare System Equipment;
- supply, installation and performance testing of LRT alignment backbone communications network for use by the Fare System, including interface of the MDOT communications network to the WMATA NEPP network located at the MDOT/MVA Data Center in Glen Burnie;
- supply and installation of any necessary weather protective canopies or screens in stations to provide a suitable environment for TVMs and validators;
- mounting location of Fare System equipment; and
- time generation and distribution for synchronization of Fare System equipment.

19.8 Summary of Submittals

Item	Section	Submittal	Action
1	19.4.3	Fare System Preliminary Design	Review and Comment
2	19.4.3	Fare System Intermediate Design	Review and Comment
3	19.4.3	Fare System Final Design	Review and Comment
4	19.4.3	Fare System Application Software Listings	Information
5	19.6.4 19.6.4	Fare System Test Program Plan	Review and Comment
6	19.6.4	Fare System Factory Test Procedures	Review and Comment
7	19.6.4	Fare System On-Site Test Procedures	Review and Comment
8	19.6.4	Fare System Factory Test Reports	Review and Comment
9	19.6.4	Fare System On-Site Test Reports	Review and Comment
10	19.6.4	Fare System Mechanical, Electrical and Software Configuration Settings	Information

20 CORROSION CONTROL AND GROUNDING

20.1 Overview

This Section identifies requirements for facilities and systems including specialized construction materials and coatings to minimize corrosion and prevent premature corrosion failures on all Project and adjacent above ground and below ground Fixed Facilities. These Project designs shall control corrosion caused by contact with corrosive environments, soils, and water, and the effects of stray current. Mechanisms to be utilized for corrosion control shall include stray current control, materials selection, protective coating, and cathodic protection.

The mechanisms described in this Section of the Contract Documents are minimum requirements. If Concessionaire believes that additional measures are required to properly limit rates of corrosive deterioration, whether due to a corrosive environment, soils, water or the effects of stray current, then Concessionaire shall include such additional measures in the design and construction of the Project.

20.2 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe;
- ASTM C150, Standard Specification for Portland Cement;
- ASTM C452, Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate;
- ASTM D257, Standard Test Methods for DC Resistance or Conductance of Insulating Materials;
- ASTM D512, Standard Test Methods for Chloride Ion in Water;
- ASTM D513, Standard Test Methods for Total and Dissolved Carbon Dioxide in Water;
- ASTM D516, Standard Test Method for Sulfate Ion in Water;
- ASTM D1293, Standard Test Methods for pH of Water;
- ASTM D1498, Standard Test Method for Oxidation-Reduction Potential of Water;
- ASTM D1452, Standard Practice for Soil Exploration and Sampling by Auger Borings;
- ASTM D4220, Standard Practices for Preserving and Transporting Soil Samples;
- ASTM D4327, Standard Test Method for Anions in Water by Suppressed Ion Chromatography;
- ASTM D4658, Standard Test Method for Sulfide Ion in Water;
- ASTM G51, Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing;
- ASTM G57, Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method;
- ASTM G200, Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil;

- Institute of Electrical and Electronics Engineers (IEEE), IEEE C2, National Electrical Safety Code (NESC);
- NACE No. 2/SSPC-SP 10, Joint Surface Preparation Standard: Near-White Metal Blast Cleaning;
- NACE No. 3/SSPC-SP 6, Joint Surface Preparation Standard: Commercial Blast Cleaning;
- NACE SP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems;
- NACE RP0274, Standard Recommended Practice High-Voltage Electrical Inspection of Pipeline Coatings;
- NACE SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates;
- NACE TM0497, Standard Test Method Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems; and
- TCRP Report 155, Track Design Handbook for Light Rail Transit Second Edition.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

20.3 Functional Requirements

Concessionaire shall include corrosion control systems, features and materials as described in this Section of the Contract Documents in all applicable elements of the Project Work. The design criteria for each of these categories, and their implementation, shall meet or exceed the following objectives:

- achieve the design life of system facilities by avoiding premature failure caused by corrosion;
- minimize aesthetic deterioration resulting from the failure of material coatings and the consequential onset of visible corrosion;
- minimize annual operating and maintenance costs associated with material deterioration and degradation;
- provide continuity of operations by reducing or eliminating corrosion-related failures of Project facilities, systems, and subsystems; and
- minimize detrimental effects of stray earth currents during normal transit operations to facilities owned by others.

20.3.1 System Interfaces

Concessionaire shall coordinate, as required, the corrosion control designs with other Project element designs, including mechanical, Utilities, electrical, civil, structures, trackwork, Traction Power, vehicles, environmental, geotechnical, architecture, grounding, signaling, communications, safety, and security in order to produce a fully comprehensive and integrated design.

20.3.2 Pre-Design Corrosion Control Surveys

Concessionaire shall conduct a pre-design investigation to determine the chemical make-up of existing soil and atmospheric conditions as they may impact the development of corrosive effects on the Project (see also Part 2B, Section 20.4.3.1 of the Technical Provisions). Concessionaire shall use the results of this investigation to confirm or enhance the soil and atmospheric corrosion control requirements of this Section of the Contract Documents.

Concessionaire shall conduct a pre-design stray current survey to determine the existing levels of stray current at intervals along the alignment not to exceed one half mile apart. Concessionaire shall use the results of this survey to confirm or enhance the stray current corrosion control requirements of this Section of the Contract Documents.

20.3.3 Expansion Capability

The corrosion control system shall be easily expandable to future line expansions and/or additional structures along the existing alignment without major reconfiguration, reconstruction, redundancy, or duplication of equipment. Experimental designs, equipment, and prototypes of a research nature shall not be used.

20.3.4 Special Design Provisions

During Preliminary Design and Intermediate Design of the Project, corrosion control designs shall identify unique and special design cases such as existing building foundations, abandoned foundations, paralleling power lines, stray currents, unusual soil conditions, and other conditions that may be revealed during the baseline soil surveys, boring program, and stray current surveys.

In these cases, the corrosion control design shall evaluate and recommend appropriate special design measures.

20.4 Design Requirements and Documents

20.4.1 Corrosion Control Design

These corrosion control requirements are separated into three areas: stray current corrosion control, soil and water corrosion control, and atmospheric corrosion control.

20.4.1.1 Stray Current Corrosion Control

Concessionaire shall apply stray current corrosion control requirements to systems and measures to minimize the corrosive effects to a reasonably achievable level of Direct Current (DC) stray currents on Project and other adjacent structures, primarily by providing and maintaining high levels of electrical isolation from ground for the TPSSs, positive distribution systems, and negative return systems, and maintaining acceptable levels of rail-to-earth insulation.

20.4.1.2 Soil and Water Corrosion Control

Concessionaire shall apply soil and water corrosion control requirements to systems and measures installed to mitigate corrosion of Project facilities and facilities installed for Utility Owners caused by contact with soil, rock, and groundwater. Structures and systems shall be protected against environmental conditions by the use of non-metallic materials, coatings, electrical isolation, electrical continuity provisions, cathodic protection, or a combination of these measures, as appropriate. Concessionaire shall conduct corrosion surveys to determine and document the corrosive characteristics of soil and groundwater which shall be used as the basis for the soil and water corrosion control system designs.

20.4.1.3 Atmospheric Corrosion Control

Concessionaire shall apply atmospheric corrosion control requirements to systems and measures installed to mitigate corrosion caused by local climatological conditions, air pollutants and applied ice melting chemicals. Structures and systems shall be protected against atmospheric conditions, meteorological conditions, air pollutants and ice melting chemicals by the use of materials selection, coatings, sealants, and design details that provide for proper drainage in order to maintain necessary function and appearance of transit system structures exposed to the environment. Concessionaire shall conduct corrosion surveys to determine and document the corrosive characteristics of the atmosphere and ice melting chemicals which shall be used as the basis of the atmospheric corrosion control system designs.

20.4.2 Stray Current Corrosion Control Systems

This Section provides requirements for designs to minimize, within reasonable levels, stray current emissions from the Project that could detrimentally affect Project structures and adjacent structures owned by others. Stray current corrosion control systems shall reduce or limit the level of stray earth currents at the source, under normal operating conditions, rather than mitigating the corresponding effects (possibly detrimental) which may otherwise occur.

The system structures which may be affected by stray current shall be identified and designed to limit the impact of stray currents.

20.4.2.1 Traction Power System

20.4.2.1.1 Mainline Negative Return System

Concessionaire shall design the mainline running rails, including special trackwork and ancillary system connections to have the following minimum as-constructed rail-to-earth resistances normalized to 1,000 feet of track (two rails):

- embedded track: 500 Ω;
- direct-fixation track: 1,000 Ω;
- at-grade ballasted track: 1,000 Ω;
- green track: 1,000 Ω; and
- grade crossings: 500 Ω.

Concessionaire shall meet or exceed these criteria through the use of appropriately designed isolating track fastening devices, such as isolated tie plates, isolated rail clips, plastic ties, isolated direct-fixation fasteners, rail fastener coating, or other approved methods. Concessionaire shall include test facilities to determine rail-to-earth resistance levels during Construction Work and operations.

Concessionaire shall design and furnish ballasted track to meet the following minimum provisions:

- use of a hard rock, non-porous, well-drained ballast material free of dirt or debris; and
- a minimum 1-inch clearance between the ballast material and metallic surfaces of the rail and metallic track components in electrical contact with the rail.

Concessionaire shall design and furnish embedded track and green track, if used, to meet the following minimum provisions:

- electrical insulation materials shall be provided with a minimum volume resistivity of 1014 ohm-centimeters (Ω-cm) as measured in accordance with ASTM D257;
- the surface profile of the finished grade adjacent to the rails shall be sloped away from the rail to allow for drainage and reduced accumulation of debris;

- rails, rail fasteners, and related metallic components shall be dielectrically coated and encased in rubber boots at roadway and pedestrian crossings;
- switch machines shall be isolated at the switch rods and gauge plates;
- impedance bond tap connections shall be isolated from the impedance bond housing case; and
- rail and boot configurations shall minimize the reduction in rail-to-ground resistance caused by precipitation.

20.4.2.1.2 Green Track

If used, green track, which is designed for plant material to grow alongside and between the running rails, shall meet or exceed the criteria established in Section 20.4.2.1.1. Special attention shall be made in the design, construction, and maintenance of the green track in order to maintain a minimum 4-inch horizontal clearance between any plant, growing medium, and/or soil material and metallic surfaces of the rail and/or metallic track components in electrical contact with the rail.

20.4.2.1.3 Yards

Concessionaire shall provide substations with access to the negative buss for stray current monitoring. Access shall be provided either inside through the use of a dedicated wall space, if available, or outside through the use of a weathertight enclosure with an open conduit between the enclosure and the negative buss.

Concessionaire shall include the following minimum provisions at ends of track, or prior to rail insulated joints where bumper posts are installed:

- use of high-resistivity, well-drained ballast material;
- minimum 1-inch clearance between the ballast material and metallic surfaces of the rail and of metallic track components in electrical contact with the rail;
- dead-ended tracks shall have isolated joints installed to isolate bumping posts or similar devices that are electrically grounded. Isolated rail joints shall be located to prevent a LRV from bridging the isolators;
- dead-ended track shall have the negative return rails cross-bonded to other negative return rails within 10 feet of the end of the track;
- cross-bonding negative return cables shall utilize a main cable run (possibly several cables) with taps to negative power rail(s) as opposed to long runs of individual cables connected to single negative power rails; and
- minimum in-service rail-to-earth resistance of 500 Ω normalized to 1,000 feet of track (two rails). Refer to Section 20.4.2.1.1.

20.4.2.1.4 Water Drainage

Grade, tunnels, under passes, or other below grade sections shall be designed to prevent water from dripping or running onto the running rails and appurtenances and to prevent accumulation of freestanding water under normal operating conditions. Water drainage systems shall be designed to prevent water accumulation from contacting the running rails and rail appurtenances.

20.4.2.1.5 Barrier Coating

Metallic components, with the exception of grounding materials, that will be partially embedded or come into contact with concrete or soil shall be coated with sacrificial or barrier coatings. Sacrificial coatings shall be applied to the entire components. Barrier coatings shall extend a minimum of 3 inches into the concrete or 18 inches into the soil and a minimum of 6 inches above the surface of the concrete or soil.

20.4.2.2 Transit Fixed Facilities

20.4.2.2.1 Underground Guideway Structures

Concessionaire shall make reinforcing steel in underground Guideway structure inverts electrically continuous. Minimum requirements for the reinforcing steel from the top of the rail down shall include the following:

- epoxy coated reinforcement steel shall not be used for track slabs or other reinforced concrete structures that may be subject to detrimental levels of stray current from the transit system;
- longitudinal lap splices in the top layer of first-pour reinforcing steel shall be welded;
- longitudinal members shall be welded to a transverse (collector) member at intervals not exceeding 500 feet and at electrical (physical) breaks in the longitudinal reinforcing steel such as at expansion joints; and
- test facilities shall be installed at each end of Station structures and at every collector bar so that a maximum spacing of 500 feet between test facilities is maintained. Facilities shall consist of isolated copper wires, conduits, and enclosures terminated at an accessible location.

Design and construction of precast tunnel segments shall be coordinated with the structural design. Precast segmented concrete ring tunnel construction shall meet or exceed the requirements in Section 20.4.3.5.5, or shall be reviewed on an individual basis to determine alternative criteria when they cannot be practically modified to meet or exceed the provisions specified below:

- embedded steel reinforcing members do not require special provisions for establishing electrical continuity, but may be welded, if desired;
- connecting hardware between adjacent rings and ring segments shall not contact the segment reinforcement. The segment shall be designed so that the connecting hardware is inside the segment gasket;
- any metallic components exposed to the soil/groundwater shall be coated with a fluidized-bed epoxy resin system or coal-tar two-part epoxy polyamide system; and
- Concessionaire shall evaluate soil conditions and environmental corrosivity to determine the need for barrier coating application. If soils are deemed unacceptably aggressive, select protective coatings in accordance with Section 20.5.2.4.

Concessionaire shall review steel liner tunnel construction to determine the need for special measures, such as increased liner thickness, external coating system, stray current mitigation, and/or cathodic protection. Evaluation of increased corrosion control measures shall be based upon the corrosivity of the local soils. Such soils shall be evaluated and steel liner components and corrosion control measures designed to ensure system design life is maintained. The design and construction of the tunnel steel liner shall be coordinated with the structural design.

20.4.2.2.2 Embedded Track Slabs

Concessionaire shall meet or exceed the following provisions for embedded track slabs:

- epoxy coated reinforcement steel shall not be used for track slabs or other reinforced concrete structures that may be subject to detrimental levels of stray current from the transit system;
- electrical continuity of top layer reinforcing steel in the slab shall be provided by welding longitudinal lap splices;
- top layer longitudinal reinforcing steel shall be electrically interconnected by welding to transverse collector bars installed at breaks in longitudinal reinforcing steel, such as at expansion joints, hinges, and abutments. Collector bars, installed on each side of a break, shall be connected by exothermically welding multiple insulated copper jumpers to the collector bar on adjoining track slabs. Jumper cables shall be extended to a test station. Where the track slab crosses bridges or other structures and the track slab continues on the other side, then copper jumpers shall be exothermically welded between the two separate track slabs so the slabs are electrically continuous. The jumper cables shall be installed in PVC conduit. The number of cables required shall be determined by the Corrosion Engineer of Record during final design;
- additional transverse collector bars shall be provided at intermediate locations to maintain a maximum spacing of 500 feet between collector bars;
- a test station shall be provided approximately every 500 feet at collector bar locations and at each end of the slab. Test stations installed at breaks shall be located within the system ROW, preferably on sidewalks or Platforms, to allow testing with minimum impact to Train and vehicular traffic. The test box shall contain equipment and wiring to enable electrical separation of adjacent track slabs. Test stations installed in accordance with the two previous bullets shall be taken into consideration during the design, when scheduling the breaks between adjacent embedded track slabs;
- two 4-AWG isolated wires shall be connected to each collector bar. A minimum of 6 feet shall separate wires wherever possible. Wires shall be run to the nearest test box. Wire tags with numbers shall be provided on both ends of the wire and the wires shall be color-coded;
- copper-to-steel weld locations (bond cables) shall be coated with a cold applied, fast drying mastic consisting of bituminous resins and solvents or an approved epoxy; and
- prior to and after the pouring of the concrete, the rebar system shall be tested for continuity. The rebar system resistance shall be within 20 percent of the theoretical resistance of the system.

20.4.2.2.3 Aerial Guideway Structures

20.4.2.2.3.1 Column and Bearing Assemblies, Direct-Fixation

Concessionaire shall apply the requirements of this Section to aerial structures and bridges that use a column and bearing assembly that can be electrically isolated from deck or girder reinforcing steel. Such structures and bridges shall have isolated trackwork construction.

- epoxy coated reinforcement steel shall not be used for track slabs or other reinforced concrete structures that may be subject to detrimental levels of stray current from the transit system;
- provide electrical continuity of top layer reinforcing steel in the deck/girder by welding all longitudinal lap splices;
- electrically interconnect all top layer longitudinal reinforcing steel by welding to transverse collector bars installed at breaks in longitudinal reinforcing steel, such as at expansion joints, hinges and at abutments. Connect collector bars installed on each side of a break (except at abutments) by exothermically welding a minimum of two 1/0 AWG isolated copper jumper cables per Guideway;
- provide additional transverse collector bars at intermediate locations to maintain a maximum spacing of 500 feet between collector bars;
- provide a ground electrode system at each end of the structure and at intermediate locations to maintain a maximum spacing between ground electrode systems of 1,500 feet. The number, location and resistance-to-earth of the ground electrode system shall be determined on an individual structure basis;
- provide test facilities at each end of the structure and at intermediate locations to maintain a maximum spacing of 500 feet between test points. The test facilities shall be located within system ROW to allow testing with minimum impact to Train and vehicular traffic;
- color-coded wires with wire tags shall be run from the collector bars and ground electrode system, if present, to the nearest test facility;
- provide electrical isolation of reinforcing steel in deck/girders from columns, abutments, and other grounded elements. Isolation can be established through the use of isolating elastomeric bearing pads, dielectric sleeves, and washers for anchor bolts, and dielectric coatings on selected components; and
- copper-to-steel weld locations (bond cables) shall require coating with a cold-applied, fast-drying mastic consisting of bituminous resins and solvents or an approved epoxy.

20.4.2.2.3.2 Column and Bearing Assemblies, Tie-and-Ballast

This Section covers the same type of aerial structures covered in Section 20.4.2.2.3.1, above, but for tie-and-ballast track construction. Welding of reinforcing steel in the deck is not required for this configuration.

- provide a waterproofing, high volume resistivity membrane over the entire surface of the deck that shall be in contact with the ballast. The membrane may be fiberglass mesh/poured asphalt system, rolled membrane, polyurea or other coating with a demonstrated transit history. The membrane system shall have a minimum volume resistivity of 1010 Ω-cm, as measured in accordance with ASTM D257. Membranes shall be protected with an asphaltic protective board immediately after the membrane is installed;
- provide an electrically continuous collector grid, such as steel welded wire fabric, directly on top of the protection board over the waterproofing membrane and beneath the ballast. The collector grid shall extend the full width of the Guideway. Extend test leads to test facilities as referenced previously in Section 20.4.2.2.3.1; and

- provide ground electrodes, test facilities, electrical isolation and coatings as described in Section 20.4.2.2.3.1.

20.4.2.2.3.3 Bents and Girders, Direct-Fixation

Concessionaire shall apply the requirements of this Section to aerial structures that use bent type supports with reinforcing steel extending into the deck/girders. Girders may be pre- or post-tensioned. This type of construction precludes the electrical isolation of deck/girder steel from bent/column steel. Ground electrode systems are not required for these types of structures.

- epoxy coated reinforcement steel shall not be used for track slabs or other reinforced concrete structures that may be subject to detrimental levels of stray current from the transit system;
- provide the applicable features as described in Section 20.4.2.2.3.1. Provide the same features, only to the deck side, as described in Section 20.4.2.2.3.1, Bullet 2. Collector bars shall be provided at every bent;
- provide electrical continuity of column/bent steel by welding appropriate reinforcing to at least two vertical column bars. Make these connections to each of the two vertical bars at top and bottom of column/bent. Weld lap splices, if any, in the vertical bars to ensure electrical continuity;
- electrically interconnect column/bent steel to deck/girder steel by welding at least two vertical column bars to collector bars installed at bents;
- electrically interconnect column/bent steel to footing steel when column/bent steel penetrates the footing. Weld at least two vertical column/bent bars to footing reinforcing steel;
- electrically interconnect pre- or post-tensioned cables to continuous longitudinal reinforcing steel by welding a cable between each anchor plate and the longitudinal reinforcing steel; and
- provide test facilities at each abutment, hinge and expansion joint and at every column/bent. Test facilities at hinges and expansion joints shall house bonding cables from adjacent collector bars on each side of the hinge/joint. Facilities at columns/bents shall house two wires from vertical column/bent steel and from collector bar at top of bent. Test facilities shall be located within system ROW to allow testing with minimum impact to Train and vehicular traffic.

20.4.2.2.3.4 Bents and Girders, Tie-and-Ballast

This Section covers the same type of aerial structures covered in Section 20.4.2.2.3.3, above, but with tie-and-ballast track construction:

- provide the same features as described in Section 20.4.2.2.3.2 (Bullet 1 and 2) and in Section 20.4.2.2.3.3.

20.4.2.2.3.5 **Abutments**

- Provide a traverse collector bar in the top of the abutment backwall in seat-type abutments.
- Weld all backwall exterior face vertical rebars to the collector bar for the full width of the bridge backwall for electrical continuity.

- Provide a traverse collector bar at the top of the abutment diaphragm.
- Exothermically weld a minimum of one #1/0 AWG HMWPE copper cable to each of the collector bars.
- Apply an insulating membrane on the abutment diaphragm end surface.
- Use epoxy coated rebar for approach slab tie rods for the full length of the bridge.

20.4.2.2.3.6 Concrete Deck/Exposed Steel, Direct-Fixation

Concessionaire shall apply the requirements of this Section to bridge structures using reinforced concrete deck with exposed steel superstructure and having isolated trackwork construction. This type of construction precludes the electrical isolation of deck reinforcing steel from superstructure steel.

- provide the applicable features as described in Section 20.4.2.2.3.1; and
- if electrical isolation of reinforcing steel in the deck and superstructure steel from columns, abutments, and other grounded elements cannot be obtained, then electrical continuity of metallic components within these latter elements must be established by appropriate welding and bonding procedures.

20.4.2.2.3.7 Concrete Deck/Exposed Steel, Tie-and-Ballast

This Section covers the same type of aerial structures covered in Section 20.4.2.2.3.6, but with tie-and-ballast track construction. Welding of reinforcing steel in the deck is not required for this configuration. Provide the applicable features as described in Section 20.4.2.2.3.1, Section 20.4.2.2.3.3, and Section 20.4.2.2.3.6.

20.4.2.2.3.8 Existing Concrete Deck Structures, Tie-and-Ballast

Concessionaire shall apply the requirements of this Section to existing aerial structures. Stray current corrosion control for existing aerial type structures shall be addressed by limiting earth current levels at the source (running rails). Meeting the criteria established in Section 20.4.2.3 and those items indicated in the following bullet shall provide primary stray current control for these facilities. Provide the applicable features as described in Section 20.4.2.2.3.1 and Section 20.4.2.2.3.2.

20.4.2.2.4 Reinforced Concrete Retaining Walls

Concessionaire shall weld longitudinal bar overlaps in both faces of cast-in-place retaining walls, including the top and bottom bars of the footing to ensure electrical continuity. Longitudinal bars in the footing shall be made electrically continuous to the longitudinal bars of the walls. Collector bars and bonding cables shall be installed at intervals not exceeding 500 feet and at electrical (physical) breaks in the longitudinal reinforcing steel such as at expansion joints. Test facilities shall be installed at each end of the retaining wall and at every collector bar such that the maximum spacing between test stations does not exceed 500 feet.

20.4.2.2.5 Utility Structures

Concessionaire shall provide non-metallic piping and conduit unless metallic facilities are required for specific engineering purposes. There are no special provisions required if nonmetallic materials are used.

20.4.2.2.5.1 Metallic Facilities (Systemwide)

Pressure or non-pressure piping exposed within tunnel structures or crawl spaces, supported by aerial structures, or embedded in concrete inverts, shall not require special provisions, except for those specified in Section 20.4.3.6.

Concessionaire shall electrically isolate pressure piping that penetrates a surface from the external piping to which it connects, surface reinforcing steel, and from watertight sleeves. Electrical isolation of interior piping from external piping shall be made on the inside of the structure for underground penetrations, as close as practical to the location of the penetration. Electrical isolation of interior piping from external piping shall be made on the outside of the structure for aboveground penetrations, as close as practical to the location of the penetration. Testing facilities shall be provided if the isolation fitting is not readily accessible for testing. The need for surge/lightning arrestors shall be determined on a case-by-case basis during the final design process.

Buried pressure piping outside of the tunnel and Station structures shall meet or exceed the criteria of Section 0.

20.4.2.2.5.2 Metallic Facilities (Yard)

Buried pressure piping shall meet or exceed the criteria of Section 20.4.2.2.5.1 and Section 0, including the following minimum provisions:

- electrical continuity as described in Section 20.4.3.4.2;
- electrical isolation from interconnecting non-transit facilities and possibly additional isolation to establish discrete electrical units; and
- test/access facilities installed at isolated connections and at intermediate locations as determined during final design.

Metallic fencing shall be made electrically continuous and grounded in accordance with IEEE C2, *National Electrical Safety Code* (NESC).

20.4.2.2.5.3 Metallic Facilities (Shops)

Concessionaire shall provide reinforcing steel, structural steel, rails, and metallic piping within shop buildings, perimeters of shop foundations, or within foundation slabs that are electrically continuous and connected to a shop grounding grid. The electrical connection to the ground grid shall be at sufficiently frequent intervals, so that potential differences between the metallic facilities piping and grounding network at normal and fault conditions is negligible.

Pressure piping within shop buildings, perimeters of shop foundations, or foundation slabs shall have the following minimum provisions:

- designed to be run above or within the foundation slab. Below slab installations shall be reviewed on an individual basis to determine the need for special measures;
- electrical isolation from interconnecting pressure piping located outside the shop building or perimeter of the foundations/foundation slabs. Isolating devices shall be installed above grade or inside buildings, in lieu of burying directly. The need for surge/lightning arrestors shall be determined on a case-by-case basis during the final design process. Testing facilities shall be provided if the isolation device is not readily accessible for testing; and
- electrical isolation from watertight wall/floor sleeves shall include dielectrically isolating, watertight closures between cathodically protected piping and sleeves through floor or wall slabs. Closures shall be made with modular mechanical seals consisting of interlocking synthetic rubber links shaped to continuously fill the annulus between the pipe and sleeve.

Closure seals shall use non-conductive pressure plates and corrosion-resistant hardware. Seals shall be properly sized for the pipe and sleeves, without the use of intermediate sleeves.

20.4.2.3 Facilities Owned by Others

20.4.2.3.1 Replacement/Relocated Facilities

Corrosion control requirements for buried Utilities installed and/or relocated or modified by a Utility Owner as part of Project construction shall be the responsibility of the individual Utility Owner. Minimum stray current corrosion control criteria, when guidance is requested by the Utility Owner, shall be in accordance with Section 20.4.2.3.2.

Relocated or replaced ferrous and reinforced concrete pressure piping, installed by Concessionaire on behalf of a Utility Owner, shall be installed in accordance with Utility Owner Agreements, Utility Owner specifications, and Third Party Agreement Requirements, and include the following minimum provisions:

- electrical continuity through the installation of isolated copper wires across mechanical joints for which electrical continuity cannot be assured;
- the requirement for electrical access to the Utility structure via test facilities shall be evaluated on a case-by-case basis based on the Utility Owner's requirements; and
- the need for additional measures, such as electrical isolation, application of a protective coating system, installation of cathodic protection, or any combination of these measures, shall be based on the characteristics of the specific structure and to not adversely affect the existing performance within the environment.

Other materials and structures shall require individual review.

20.4.2.3.2 Existing Utility Structures

Concessionaire shall provide stray current corrosion test and control facilities for existing below ground utility lines and structures that may be subject to degradation due to stray currents from the Project as determined by Utility Owners' standards. If Utilities require assistance, the following minimum provisions shall be suggested:

- test facilities may be installed at select locations for the purpose of evaluating stray earth current effects during start-up and revenue operations. Suggested guidelines for location of test facilities are as follows:
  - at Utility crossings within the LRT system and on structures proximal and parallel to Project ROW; and
  - at locations on specific Utility structures proximal to Project TPSSs.

If existing protective measures are in place, Concessionaire shall inspect the condition and capabilities of those existing measures, determine the nature of any changes or replacements needed and implement those changes or replacements. The following minimum provisions shall be provided for new and existing test and protection systems:

- test facilities for the purpose of evaluating stray earth current effects during start-up and revenue service operations; and
- cathodic protection facilities to protect the structures from the detrimental effects of stray currents.

20.4.2.3.3 Existing Bridge Structures

Stray current corrosion control for existing bridge-type structures that will be utilized by the Project, including supporting substructures (e.g. steel pilings), shall be addressed by limiting earth current levels at the source as specified in the Contract Documents. Existing structures that will be utilized by the Project shall be reviewed on an individual basis to determine compatibility with the methods of controlling stray current as described in this Section of the Contract Documents. If there are no compatibility issues, the methods described herein shall be applied. If the methods described herein are incompatible with the nature of the structure, Concessionaire shall propose alternate methods to achieve the equivalent level of stray current control.

20.4.2.3.4 Other Existing Structures

Concessionaire shall provide stray current corrosion test and control facilities for other privately or publicly owned existing above or below ground structures that may be subject to degradation due to stray currents from the Project. If existing protective measures are in place, Concessionaire shall inspect the condition and capabilities of those existing measures, determine the nature of any changes or replacements needed and implement those changes or replacements. The following minimum provisions shall be provided for new and existing test and protection systems:

- test facilities for the purpose of evaluating stray earth current effects during start-up and revenue service operations; and
- cathodic protection facilities to protect the structures from the detrimental effects of stray currents.

When determining the stray current corrosion protection and test facilities required for other existing structures, Concessionaire shall apply the same evaluation and design criteria as used for the Purple Line System structures with appropriate consideration of the location of the structures relative to the alignment and other adjacent conductive structures.

20.4.2.4 Stray Current Corrosion Control Design Submittals

Concessionaire shall submit the Stray Current Corrosion Control Preliminary Design submittal for Review and Comment. The Stray Current Corrosion Control Preliminary Design submittal shall include, at a minimum, the following items:

- the results of all stray current corrosion control surveys conducted;
- a Stray Current Corrosion Control Design Criteria for all stray current corrosion control equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements; and
- written design proposals describing how each specified stray current corrosion control requirement will be implemented accompanied by typical design drawings. Typical design drawings may utilize appropriate drawings from the traction power, OCS, trackwork and structural designs to avoid duplication.

Concessionaire shall submit the Stray Current Corrosion Control Intermediate Design submittal for Review and Comment. The Stray Current Corrosion Control Intermediate Design submittal shall include, at a minimum, the following items:

- a Technical Specification for all stray current corrosion control equipment and systems;

- product catalog cuts and component shop drawings for all active components, wire and cable used in the stray current corrosion control system; and
- Comment the completed typical stray current corrosion control design drawings and a tabulation of specific locations where each stray current corrosion control measure shown on the typical drawings is being implemented.

For the Stray Current Corrosion Control Final Design, Concessionaire shall submit for Review and Comment an updated tabulation of specific locations where each stray current corrosion control measure is being implemented to include specific drawing references for each discipline at each location. All final drawings depicting stray current corrosion control measures shall be included in the final design Submittals for the facilities and systems to which they relate.

20.4.3 Soil Corrosion Control

The purpose of this Section is to provide criteria for the design of systems and measures to prevent corrosion of Project structures due to soil and water conditions. Concessionaire shall protect structures and systems from environmental conditions by the use of coatings, electrical isolation, electrical continuity provisions, cathodic protection, or combination of these measures, as appropriate.

Corrosion control design for buried structures shall be the responsibility of the individual Utility Owner. The Project designs shall be coordinated with stray current corrosion control design in order to allow for proper placement of test facilities so that proper evaluation of soil and stray current corrosion control is provided, while minimizing the number of test facilities required.

All corrosion control designs for structures owned by others shall be coordinated among all cognizant disciplines to minimize stray current interference resulting from cathodic protection installations and minimize other undesirable conflicts.

20.4.3.1 Soil Corrosivity Analysis

Concessionaire shall perform an analysis of area soils to determine the corrosive tendencies of the soil and groundwater along the ROW. Soil analysis shall include in-situ resistivity measurements, in accordance with ASTM G57, at an approximate spacing of 1,000 feet between measurement locations and to a general depth of 15 feet. Soil layer resistivity shall be analyzed at 2.5, 5.0, 7.5, 10.0, and 15.0-foot depths where practical. When possible to coordinate with geotechnical boring activities, soil box resistivity measurements at similar depths shall be taken.

Soils shall be measured in depths which allow for a Barnes Layer Analysis, where practical, to correlate the corrosivity specifically to the depth of buried Utilities. In addition, soil samples shall be obtained (ASTM D1452 and ASTM D4220) at locations identified by corrosion engineering, based on the location of the geotechnical soil boring schedule. Soil and water chemical analysis at the locations identified shall include: pH (ASTM D1293 and ASTM G51), reduction-oxidation potential (ASTM D1498 and ASTM G200), saturated resistivities (ASTM G57), chloride concentration (ASTM D512 and ASTM D4327), sulfate concentration (ASTM D516 and ASTM D4327), presence of sulfides (ASTM D4658), and carbon dioxide concentration in groundwater (ASTM D513). These parameters shall be used to further classify the soil corrosivity to construction materials.

20.4.3.2 Safety and Continuity of Operations

Concessionaire shall provide corrosion control provisions for facilities where failure of such facilities caused by corrosion may affect safety or interrupt continuity of operations, regardless of location and material or construction.

20.4.3.3 Accessibility of Installations

Permanent test facilities installed with certain corrosion control provisions shall be accessible after installation, allowing for periodic maintenance and monitoring.

20.4.3.4 Special Considerations

Design and installation of corrosion control measures for facilities owned by others, but designed as part of the Project, shall be coordinated with the AHJ.

20.4.3.4.1 Electrical Isolation of Piping

Concessionaire shall provide electrical isolating devices for corrosion control that include nonmetallic inserts, isolating flanges, couplings, unions, and/or concentric support spacers. Devices shall meet or exceed the following criteria:

- following insertion of an isolating device into the operating piping system, the insulation shall have sufficient electrical resistance so that no more than 2 percent of a test current applied across the device shall flow through the isolator and through any conductive fluids, if present;
- mechanical and temperature ratings equivalent to the structure in which they are installed;
- where isolating devices are used in metallic pipelines, internal polyamide epoxy coating shall be applied on each side of the isolating device for a distance equal to two times the pipe diameter on which they are used. Where conductive fluids with a resistivity of less than 2,000 Ω-cm are present, internal coating requirements shall be based on a separate evaluation determining the need for additional coating. Coatings that will be in contact with potable water shall be compliant with ANSI/NSF 60 and 61;
- isolating devices for metallic pipelines buried in soils shall be provided with a protective coating or be accessible in a hand hole, vault, or chamber;
- non-metallic, concentric support spacers and watertight end seals shall be used where piping is routed through a metallic casing;
- isolating devices for metallic pipelines (except non-metallic units) installed in hand hole, vault, or chamber, or otherwise exposed to partial immersion or high humidity, shall have a protective coating applied over its components;
- an isolated connection shall be provided at tie-ins to non-protected facilities;
- design shall specify the need for, and location of, isolating devices. Inaccessible isolating devices, such as buried or elevated isolators, shall be equipped with accessible permanent test facilities. Test facilities shall include, at a minimum, two insulated, tagged wire test leads connected to each side of the isolating device and terminated at a test station box; and
- a minimum clearance of 12 inches shall be provided between new and existing metallic structures. When conditions do not allow 12-inch clearance, the design shall include the following additional provisions to prevent electrical contact between existing structures:
    - installation of a non-metallic (PVC or similar material) block or sheet between the structures; and
    - installation of a pre-formed, correctly sized, reinforced fiberglass pipe saddle around the appropriate pipe where it crosses those structures.

20.4.3.4.2 Electrical Continuity of Piping

Concessionaire shall provide electrical continuity for non-welded metallic pipe joints that meets or exceeds the following criteria:

- electrical continuity shall be achieved by directly buried, isolated, stranded copper wire with the minimum length necessary to span the joint being bonded. Wires shall be rated at 600 V with High Molecular Weight Polyethylene (HMWPE) isolation;
- to minimize current attenuation in cathodic protection installations, wire size shall be based on the electrical characteristics of the structure and resulting electrical network;
- a minimum of two #6-AWG wires shall be used per joint for redundancy. Wire resistance shall be such that the bond resistance is a maximum of 110 percent of the theoretical calculated pipe resistance for an 18-inch length of pipe. Bonding wires shall be installed using the thermite welding method; and
- exothermic welds and adjacent bared piping shall be coated with a cold-applied, fast-drying mastic consisting of bituminous resins and solvents, or an approved epoxy.

20.4.3.4.3 Cathodic Protection

Concessionaire shall use cathodic protection systems for buried metallic structures where soil conditions indicate that soil corrosion may reduce the service life of the facility below the design requirements consistent with the structure life objectives. The presence of stray currents may also require design and installation of cathodic protection for underground metallic structures. Design of cathodic protection shall be performed by a licensed professional engineer, a NACE International Corrosion Specialist, or a NACE International Cathodic Protection Specialist. Cathodic protection shall be provided by galvanic or impressed current protection systems. Testing of cathodic protection systems shall be performed in accordance with NACE TM0497.

Galvanic cathodic protection shall be used wherever feasible to minimize interference with other underground Utilities. When galvanic cathodic protection is used for new facilities, the facilities shall be provided with a compatible coating system. All galvanic anodes shall be connected to the structure via test stations. Anodes shall not be directly connected to the structure.

Concessionaire shall only use impressed current systems when the use of galvanic systems is not technically feasible. The systems shall utilize separate and isolated anode ground beds. Cathodic protection schemes requiring connection to the LRT system’s negative return system, in lieu of using a separate isolated anode ground bed, shall not be permitted.

Cathodic protection design shall incorporate consideration of the following:

- presence of anaerobic bacteria;
- need for mutual protection schemes;
- limitation of structure-to-electrolyte potential;
- accessibility after construction is completed;
- optimum location of anodes for ease of replacement and avoidance of interference with other structures;
- need for monitoring facilities; and
- power availability, space available for installation, structure geometry.

Cathodic protection system design shall be based on theoretical calculations, including the following parameters:

- cathodic current density, suggested minimum of 1 milliampere per square foot (mA/ft2) of bare area;
- current requirements;
- estimated/anticipated current output per anode;.
- estimated/assumed percentage bare surface area (minimum 1 percent);
- estimated/indicated total number of anodes, size, and spacing;
- estimated/anticipated anode bed resistance; and
- minimum anode life of 30 years (maximum 50 percent current efficiency for magnesium anodes and an 85 percent utilization factor). The sum of the anticipated anode life and time to failure based upon corrosion rates anticipated at 90 percent cumulative probability level shall not be less than 50 years.

Concessionaire shall design impressed current rectifier systems using constant output voltage rectifiers or automatic potentially controlled rectifier units, with permanent reference electrode facilities. Rectifiers shall be rated a minimum of 50 percent above calculated operating levels to overcome higher-than-anticipated anode ground bed resistance, lower-than-anticipated coating resistance, or the presence of interference mitigation bonds. Other conditions which may result in increased voltage and current requirements shall be considered.

The design shall include test facilities which permit initial and periodic testing of cathodic protection levels, structure-to-electrolyte potentials, interference currents, and system components (such as anodes, isolating devices, and continuity bonds). At a minimum, the test facilities shall contain the following:

- two structure connections for each structure;
- one reference electrode test wire connection; and
- conduits and terminal (test) boxes.

Wherever the Project passes over or beneath another structure owned by others (e.g. bridges or overpasses), test stations shall be suggested and coordinated for the top layer of reinforcing steel, at each Utility pipe or structure, and at a minimum spacing of two column structures (or equivalent).

The design team shall specify the locations and types of test facilities for each cathodic protection system and coordinate approval and/or permits as necessary for the facilities to be installed. The number, type, and spacing of the test facilities shall be sufficient to determine the adequacy of cathodic protection, electrical continuity, and electrical isolation. Testing of new facilities for private or public Utilities and associated costs shall be the responsibility of the Utility Owner.

20.4.3.4.4 Water Treatment

Concessionaire shall design chemical treatment of chiller, condenser, and boiler supply and return systems to minimize internal corrosion and to prevent component fouling. The corrosive properties of the water to be used shall be determined prior to design of the water treatment corrosion mitigation systems. Water treatment systems shall be designed to prevent corrosion rates in excess of 2.0 mils per year for steel and 0.1 mils per year for copper. Provisions for corrosion rate measurements shall be made in the return lines. Chemical treatment systems shall comply with environmental protection requirements. Corrosion control design shall include appropriate measures and provide space requirements for treatment equipment.

20.4.3.5 Structures and Facilities

The following sections establish the protective measures to be considered for underground metallic Utilities, buried structures, and other structures discussed in this Section.

20.4.3.5.1 Ferrous Pressure Piping

Concessionaire shall cathodically protect new buried cast iron, ductile iron, and steel pressure piping on an individual structure basis, in accordance with Section 20.4.3.4.3. In addition to cathodic protection, the piping system design shall include the following minimum features:

- conformance with existing MTA standards and specifications;
- conformance with Federal, State, and local codes for regulated piping;
- application of a protective coating to the external surface of the pipe in accordance with Section 20.5.1.1.1. All coatings shall be electrically tested to ensure they are holiday-free prior to backfilling. Holiday detector voltage shall depend on coating thickness in accordance with manufacturer recommendations and in accordance with NACE RP0274 and SP0188;
- electrical isolation of pipe from interconnecting pipe, casings, and other structures, and segregation into discrete electrically isolated sections depending upon the configuration and total length of piping. Electrical isolation fittings located within 50 feet of rail shall be provided with zinc grounding cells or other appropriate surge suppression devices on both sides of the isolating device;
- for pressure piping entering Owner facilities below grade, pipe shall be electrically isolated immediately inside of the wall penetration. For pressure piping entering Owner facilities above grade, pipe shall be electrically isolated immediately outside of the wall penetration. Pipe penetrations through walls and floors shall be electrically isolated from building structural elements;
- piping encased in concrete, including thrust blocks, shall be provided with a coating material extending minimum of 6 inches beyond the concrete to soil interface;
- electrical continuity through the installation of insulated copper wires across mechanical pipe joints or fittings other than intended isolating device (see Section 20.4.3.4.2); and
- permanent test/access facilities shall be installed at all isolating connections to allow for verification of electrical continuity, electrical effectiveness of isolating devices and coating, and evaluation of cathodic protection levels. Additional test/access facilities shall be installed at intervals determined on an individual structure basis (see Section 20.4.3.4.3).

20.4.3.5.2 Copper Piping

Concessionaire shall electrically isolate buried copper pipe from piping of differing material (i.e. ductile iron) and from non-buried piping, such as that contained in a Station structure, through use of accessible isolating unions.

Pipe penetrations through walls and floors shall be electrically isolated from building structural elements. The isolating device shall be located inside the structure and not buried.

20.4.3.5.3 Pre-Stressed/Post Tensioned & Reinforced Concrete Cylinder Pipe (Pressure)

Pre-stressed/post-tensioned concrete cylinder pressure pipe shall not be used in the vicinity of Project tracks or substations.

Concessionaire shall design reinforced concrete pipe with steel cylinder, including mortar coated steel pipe, in accordance with applicable AWWA standards. Cement requirements shall be in accordance with ASTM C150.

Design and installation of reinforced concrete cylinder pipe shall include the following minimum provisions:

- electrical continuity between adjacent pipe sections by installation of continuity joint bonds. The number and size of bonds shall be determined on an individual basis;
- in-line electrical isolating devices for electrical isolation of pipe from interconnecting pipe, other structures, and segregation into discreet electrically isolated sections depending upon the total length of piping (see Section 20.4.3.4.1);
- permanent test/access facilities to allow for verification of continuity and effectiveness of isolators and mortar coatings. Test facilities shall be installed at isolated connections and at intermediate locations, with intervals determined on an individual basis; and
- an external protective coating to provide an electrical and waterproof barrier shall be considered.

20.4.3.5.4 Gravity Flow Piping (Non-Pressure)

Concessionaire shall coat corrugated steel piping internally and externally with a sacrificial metallic coating and a protective organic coating.

Cast or ductile iron piping shall be designed and fabricated to include the following provisions:

- an internal mortar lining with a bituminous coating on ductile iron pipe only (not required for cast iron soil pipes); and
- a bituminous mastic coating on the external surfaces of pipe 6 inches on each side of a concrete/soil interface.

Concessionaire shall evaluate the need for electrical continuity, electrical isolation, and cathodic protection on an individual basis.

Reinforced concrete non-pressure piping shall include the following provisions:

- water/cement ratios meeting the minimum provisions of AWWA;
- chloride concentration shall not exceed 150 ppm in the total concrete mix of mixing water, cement, admixture, and aggregates;
- pipe design shall be in accordance with ASTM C76; and
- concrete used in the manufacture of this pipe shall be in accordance with ACI 201.2R and ASTM C150.

20.4.3.5.5 Buried Concrete/Reinforced Concrete Structures

Concessionaire shall base the design of cast-in-place concrete structures, precast Utility structures, and precast tunnel liner segments on the structural requirements of the Contract Documents and the following criteria:

- the type of cement utilized shall be based on the anticipated exposure conditions in accordance with ACI 201.2R and ASTM C150. Use of a concrete mix with a cement type not specifically listed in ACI 201.2R shall be reviewed and must be approved by Owner. ASTM C452 shall be used as criteria for evaluation of the sulfate resistance of concrete mixes with non-standard cement types;
- concrete to be in contact with soil or groundwater shall have a water/cement ratio not greater than 0.45. Refer to applicable sections of ACI 201.2R, Guide to Durable Concrete;
- the concrete mix shall be such that water soluble and acid soluble chloride concentrations, at the concrete/reinforcing steel interface, do not exceed the values stated in ACI 222R, Protection of Metals in Concrete against Corrosion, for reinforced concrete in wet conditions;
- concrete cover over reinforcing steel shall comply with ACI codes. Provide a minimum cover of 2 inches on the soil/rock side of reinforcement when pouring within form and minimum cover of 3 inches when pouring directly against soil/rock or excavation support systems; and
- the need for additional measures, as a result of localized special conditions, shall be determined on an individual basis. Additional measures may include increased cover, application of sealers, corrosion inhibitors, and protective coating to concrete and reinforcing steel.

Precast standardized facilities, such as segmented concrete ring construction, vaults, and pull boxes, shall meet or exceed the requirements specified in this Section or must be reviewed on an individual basis to determine alternative criteria when these facilities cannot be practically modified to meet or exceed some or all of the provisions specified.

Below grade shotcrete used for permanent support shall be in accordance with ACI 506.2 and applicable provisions specified in this Section. In the case of conflicting specifications, the more rigid or conservative specification shall be applicable. No special corrosion control measures are required for shotcrete applications, which are not used for permanent support.

20.4.3.5.6 Reinforced Concrete Retaining Walls

Concessionaire shall provide cast-in-place concrete retaining walls in accordance with the requirements in Section 20.4.3.5.5.

Mechanically Stabilized Earth (MSE) retaining walls with metallic restraining devices or reinforcing strips placed beneath LRT tracks or walls less than 200 feet from the nearest rail shall meet or exceed the requirements in Section 20.4.3.5.5, FHWA Publication No. FHWA-NHI-09-087, and shall require special consideration for stray current mitigation and monitoring due to the location of critical structural components. Concessionaire shall provide for stray current and soil corrosion control for MSE retaining walls with metallic structural support components beneath Project tracks.

MSE retaining walls that do not place critical metallic structural components beneath Project tracks and are in excess of 200 feet from the nearest rail shall meet or exceed the requirements in Section 20.4.3.5.5, FHWA Publication No. FHWA-NHI-09-087, and the following provisions:

- steel reinforcement and embedded tie strip anchors of the modules shall be constructed without special provisions for establishing electrical continuity;

- steel reinforcement of adjacent modules shall not be electrically interconnected. Reinforcing strips shall be galvanized or coated with a fluidized-bed epoxy resin system or liquid 100 percent epoxy system;
- tie-strips shall be coated with a fluidized-bed epoxy resin system or liquid 100 percent epoxy system prior to module construction;
- longitudinal reinforcing steel within precast concrete parapets and cast-in-place junction slabs shall not be made electrically continuous; and
- modular block walls that utilize a non-metallic reinforcement grid do not require special considerations for stray current control.

20.4.3.5.7 Support Pilings

The following is applicable only to support piling systems providing permanent support. Pilings used for temporary support do not require corrosion control provisions.

Concessionaire shall design metallic supports exposed to the environment to meet or exceed the following minimum criteria. The minimum requirements listed shall be coordinated with the structural design discipline. The minimum corrosion control specification may not be appropriate in all conditions.

- application of a barrier coating to the pile from the surface to a minimum of 10 feet below expected low groundwater level. Barrier coating shall conform to Section 20.5.2.4.6 and include exposed surfaces, including splices;
- inclusion of additional wall thickness to the structural requirements for the pile. A minimum of 0.125 inch shall be included for each face or surface contacting the soil from grade level to a minimum of 10 feet below the expected low groundwater level;
- the interior of open-ended pipe piles shall be considered exposed to soil and provided with a corrosion allowance of a minimum 0.125 in. The interior of closed-end pipe piles shall be considered as a surface contacting soils unless filled with a cementitious mortar; and
- the need for special measures, such as electrical isolation measures, electrical continuity, monitoring devices, and cathodic protection, shall be determined on an individual basis, based on type of structure, analysis of soil borings for corrosive characteristics, and degree of anticipated structural deterioration caused by corrosion.

Reinforced concrete piling, including fabrications with pre-stressed members, shall be designed to meet or exceed the requirements in Section 20.4.3.5.5.

Concrete-filled steel cylinder columns, where the steel is an integral part of the load bearing characteristics of the support structure, shall be designed considering the need for special measures, such as increased cylinder wall thickness, external coating system, stray current mitigation, and/or cathodic protection. Design shall be determined on an individual basis, based on type of structure, analysis of soil borings for corrosive characteristics, and degree of anticipated structural deterioration caused by corrosion. Chloride restrictions for the concrete fill shall be in accordance with ACI 222R, *Protection of Metals in Concrete against Corrosion.*

20.4.3.5.8 Electrical Conduits

Concessionaire shall provide galvanized steel conduits with the following minimum provisions:

- direct burial conduit shall be externally coated with PVC and internally coated with urethane or other accepted coating system regularly in use for direct burial;

- conduit within duct banks shall have a minimum of 3-inch concrete cover on soil sides. Internal coating only may be provided when conduits are installed in concrete;
- internal and external coating shall be provided for conduits installed above grade, in corrosive atmosphere, and in wet atmosphere. Coating shall be of a type suitable for exposure to wet and corrosive atmosphere; and
- couplings and fittings shall be coated with the identical coating materials used for the conduit lengths.

Concessionaire shall establish electrical continuity throughout each conduit as follows:

- use of standard threaded joints; and
- installation of bond wires across non-threaded joints. Bond wires shall be installed using the thermite weld method. Bond wire sizing shall depend on the conduit diameter, as follows:
    - 1 to 3-inch diameter conduit, #10 AWG bond wires; and
    - 4 to 6-inch diameter conduit, #8 AWG bond wires.

Concessionaire shall encase buried non-metallic conduits in concrete, including couplings and fittings, except at transitions where metallic materials are required (such as stub-ups and penetrations).

20.4.3.5.9 Piping and Conduits in Tunnel

Concessionaire shall route metallic piping and conduits installed in tunnels through vent shafts, inside the tunnel structure, or embedded in the concrete structure as much as possible. Routing of conduits in vent shafts shall meet or exceed NFPA 130 requirements for concrete encasement.

Piping and conduit routing in earth shall be avoided. Where this is not practical, Concessionaire shall coat buried metallic pressure piping and include provisions for cathodic protection. Non-pressure piping shall include corrosion control provisions as required on a site-specific basis.

20.4.3.5.10 Casings

If required, Concessionaire shall install pipeline casings bare, unless coating and cathodic protection are required by AHJ. Casing isolators and spacers shall be installed on the carrier pipe to avoid electrical contact between the casing and the carrier pipe. Test facilities shall be provided at each end of the casings to allow testing of the status of electrical isolation between the casing and the carrier pipe. The test stations shall have as a minimum:

- two test wires connected to the carrier pipe;
- two test wires connected to the casing;
- a reference electrode located adjacent to the surface of the carrier pipe as close as possible to the end of the casing; and
- a terminal (test) box located as close as possible to the pipeline and in an accessible location.

20.4.3.5.11 Hydraulic Elevator and Lift Cylinders

Concessionaire shall design, fabricate and install steel hydraulic elevator and lift cylinders to meet or exceed the following minimum provisions:

- application of an external protective coating (see Section 20.5.1.1.1) resistant to deterioration by petroleum products (hydraulic fluid);
- an outer concentric Fiberglass Reinforced Plastic or PVC casing in accordance with ASME A17.1. Casing thickness diameter and resistivity shall be designed to prevent moisture intrusion, including the bottom, to maximize electrical isolation between cylinder and earth and to withstand physical conditions. The casing diameter shall provide a minimum 1-inch clearance between the cylinder and casing;
- silica sand fill between the cylinder and casing with a minimum resistivity of 25,000 Ω-cm, a pH of between 6 and 8, and a maximum chloride concentration of 100 ppm;
- cathodic protection through the use of sacrificial anodes installed in the sand fill or galvanic ribbon anode wrapped around cylinder. Cathodic protection systems sacrificial anodes shall have a useful life consistent with the Project design life;
- permanent test facilities installed on the cylinder, anodes, and reference electrode to permit evaluation, activation, and periodic retesting of the protection system;
- a removable moisture-proof sealing lid shall be installed on the top of the casing prior to installation of the cylinder. The top of the casing shall be permanently sealed against moisture intrusion after installation of the cylinder; and
- as an alternative to Bullets 4 and 5 of this Section for protecting the hydraulic cylinder from corrosion, Concessionaire may install a gel or wax-based inhibited dielectric material in the interstitial space between the cylinder and casing. Corrosion monitoring equipment (e.g. resistance probes) shall be installed in the interstitial space and leads shall be routed to a test station to allow evaluation of the protection system.

Hydraulic piping to elevator cylinders shall be placed in pipe chases or constructed of double wall pipe with provisions for leak detection. Connections to the cylinder and to the hydraulic fluid reserve tank shall use a dielectric isolator suitable for use with the hydraulic fluid and the design pressure of the cylinder if cathodic protection is installed on the cylinder. Where hydraulic piping must be placed in direct contact with soil or concrete, a barrier coating, dielectric isolation, and cathodic protection shall be included in the design.

20.4.3.5.12 Non-Metallic Materials

Plastics, fiberglass, and other non-metallic materials for pressure piping may be appropriate to aid in corrosion control. The following shall be considered:

- manufacturer recommendations;
- mechanical strength and internal pressure limitations;
- elasticity/expansion characteristics;
- expected life;
- failure modes;
- local codes; and
- prior experiences with the proposed non-metallic material in similar applications.

20.4.3.6 Soil Corrosion Control Design Submittals

Concessionaire shall submit the Soil Corrosion Preliminary Design submittal for Review and Comment. The Soil Corrosion Preliminary Design submittal shall include, at a minimum, the following items:

- results of all soil corrosion control surveys conducted.
- a Soil Corrosion Control Design Criteria for all soil corrosion control equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements.
- written design proposals describing how each specified soil corrosion control requirement will be implemented accompanied by typical design drawings. Typical design drawings may utilize appropriate drawings from other disciplines to avoid duplication.

Concessionaire shall submit the Soil Corrosion Intermediate Design submittal for Review and Comment. The Soil Corrosion Intermediate Design submittal shall include, at a minimum, the following items:

- product catalog cuts and component shop drawings for all active components, wire and cable used in the soil corrosion control system.
- typical design drawings and a tabulation of specific locations where each soil corrosion control measure shown on the typical drawings is being implemented. Site specific soil corrosion control drawings shall be submitted with the intermediate design drawings for the system or facility to which they apply.
- Technical Specifications for each type of soil corrosion control materials, coatings, equipment and systems to be utilized.

Concessionaire shall submit the Soil Corrosion Final Design submittal for Review and Comment. The Soil Corrosion Final Design submittal shall include, at a minimum an updated tabulation of specific locations where each soil corrosion control measure is being implemented to include specific drawing references for each discipline at each location. All final drawings depicting soil corrosion control measures shall be included in the final design Submittals for the facilities and systems to which they relate.

20.4.4 Atmospheric Corrosion Control Systems

The purpose of this Section is to provide criteria for designs that shall ensure the required service life of a particular facility is not compromised because of corrosion-related problems or failures due to exposure to the atmosphere or ice melting chemicals. Concessionaire shall protect structures and systems against atmospheric conditions, meteorological conditions, air pollutants and ice melting chemicals by material selection and the use of coatings and sealants in order to maintain necessary function and appearance of Project system structures exposed to the environment.

20.4.4.1 Atmospheric and Meteorological Evaluation

Concessionaire shall conduct baseline corrosion surveys to determine atmospheric and meteorological corrosion conditions.

Evaluation of atmosphere shall be conducted by research of the local air quality agency to identify pollutant types and levels. The pollutants and levels identified shall be evaluated to determine approximate corrosion rates based on the atmospheric exposure to these materials.

Evaluation of past meteorological history of the region shall be conducted through research of local weather agencies. The data gathered shall be used to evaluate the impact on atmospherically exposed structures. Design of the atmospheric corrosion control systems shall be based on recommendations of the reports and shall be used to significantly decrease atmospheric corrosion rates.

20.4.4.1.1 Graffiti-Resistant Coatings

Concessionaire shall protect surfaces which are susceptible to graffiti with graffiti-resistant coating. This includes concrete and painted steel surfaces within Stations, such as walls, columns, and equipment enclosures. Such areas shall be protected up to a height of 10 feet. The coating shall be a urethane-type coating, applied in accordance with the latest-published manufacturer instructions.

20.4.4.2 Atmospheric Corrosion Control Design Submittals

Concessionaire shall submit the Atmospheric Corrosion Control Preliminary Design submittal for Review and Comment. The Atmospheric Corrosion Control Preliminary Design submittal shall include, at a minimum, the following items:

- the results of all atmospheric corrosion control surveys conducted;
- a Atmospheric Corrosion Control Design Criteria for all atmospheric corrosion control equipment and systems to identify how the requirements of the Contract Documents have been interpreted in terms of the system configuration, performance and equipment requirements; and
- written design proposals describing how each specified atmospheric corrosion control requirement will be implemented accompanied by typical design drawings. Typical design drawings may utilize appropriate drawings from other disciplines to avoid duplication.

Concessionaire shall submit the Atmospheric Corrosion Control Intermediate Design submittal for Review and Comment. The Atmospheric Corrosion Control Intermediate Design submittal shall include, at a minimum, the following items:

- product catalog cuts and component shop drawings for all active components, wire and cable used in the atmospheric corrosion control system;
- the completed typical design drawings and a tabulation of specific locations where each atmospheric corrosion control measure shown on the typical drawings is being implemented. Site specific atmospheric corrosion control drawings shall be submitted with the intermediate design drawings for the system or facility to which they apply; and
- specifications for each type of atmospheric corrosion control material and coating to be utilized.

Concessionaire shall submit the Atmospheric Corrosion Control Final Design submittal for Review and Comment. The Atmospheric Corrosion Control Final Design submittal shall include, at a minimum, an updated tabulation of specific locations where each atmospheric corrosion control measure is being implemented to include specific drawing references for each discipline at each location. All final drawings depicting atmospheric corrosion control measures shall be included in the final design Submittals for the facilities and systems to which they relate.

20.4.5 Coordination of Safety and Electrical Grounding Systems

The purpose of this Section is to ensure that safety grounding and corrosion control requirements do not conflict so as to render either system ineffective. The key to accomplishing complementary systems is proper location of isolation points and proper means of grounding systems.

20.4.5.1 General Grounding Criteria

Concessionaire shall provide grounding in conformance with the Transit Cooperative Research Program's (TCRP) Report 155, *Track Design Handbook for Light Rail Transit, Second Edition* and applicable sections of IEEE C2, NFPA 70, NFPA 130 and the National Electric Safety Code. The codes are to be considered as the minimum requirements for the protection of life and property and shall be carefully reviewed during the course of system design.

Grounding shall extend around the alignment to all metallic objects, structures and cases that could become energized by a fallen overhead contact wire.

20.4.5.2 Lightning Protection

Concessionaire shall provide lightning protection systems for all buildings, structures, Station canopies, TPSSs, CIHs and other walk-in equipment enclosures.

20.4.5.3 Connection to Utilities

Concessionaire shall not make connection between any Project grounding system and any Utility, including water, outside the dielectric coupling, used to isolate facilities from Utilities outside the building.

20.4.5.4 Coordination Requirements

Concessionaire shall incorporate the following considerations to provide compatible grounding systems for aerial structures and corrosion control systems:

- ground electrode component materials;
- ground electrode locations;
- aerial component electrical continuity details; and
- pier support/isolation details.

20.4.5.5 Grounding System Design Submittals

For the Preliminary Design, Concessionaire shall submit for Review and Comment written design proposals describing how each specified grounding requirement will be implemented accompanied by design criteria and typical design drawings. Typical design drawings may utilize appropriate drawings from other disciplines to avoid duplication.

For the Intermediate Design, Concessionaire's submittal shall include the completed typical design drawings and a tabulation of specific locations where each grounding measure shown on the typical drawings is being implemented. Site specific grounding drawings shall be submitted with the intermediate design drawings for the system or facility to which they apply.

The Intermediate Design shall also include at a minimum Technical Specifications for each type of grounding material to be utilized.

For the Final Design, Concessionaire shall submit for Review and Comment an updated tabulation of specific locations where each grounding measure is being implemented to include specific drawing references for each discipline at each location. All final drawings depicting grounding measures shall be included in the final design Submittals for the facilities and systems to which they relate.

20.5 Material and Equipment Requirements

Concessionaire shall utilize materials and equipment for corrosion control purposes that conform to the requirements and referenced Codes and Standards of this Section of the Contract Documents.

20.5.1 Soil Corrosion Control Materials

20.5.1.1 Materials and Methods

Concessionaire shall provide non-metallic piping (pressure and non-pressure) unless metallic materials are required for specific engineering purposes. Use of metallic materials shall be supported by engineering calculations when used in lieu of non-metallic materials.

Aluminum and aluminum alloys shall not be used for direct burial purposes.

If non-native fill is to be used for backfilling concrete or ferrous structures, then it shall meet or exceed the following criteria:

- pH value of 6 to 8 (ASTM G51);
- maximum chloride ion concentration of 150 ppm (ASTM D512 and ASTM D4327);
- maximum sulfate ion concentration of 150 ppm (ASTM D516 and ASTM D4327);
- minimum resistivity of 10,000 Ω-cm (ASTM G57); and
- free of angular rock (>3/4 inches), clay lumps, un-decayed organic matter or other deleterious material.

Protection of metal structures shall include corrosion control techniques such as coating, electrical isolation, electrical continuity, and cathodic protection. The corrosion control design team shall coordinate designs to identify concrete structures subject to attack, and shall specify cement types in accordance with ASTM C150. For severe environments, supplemental coatings shall be specified.

The following sections establish the materials and methods to be used for soil corrosion control.

20.5.1.1.1 Coatings

Concessionaire shall use coatings for corrosion control of buried metallic or concrete facilities that satisfy the following criteria:

- minimum volume resistivity of 1010 Ω-cm as measured in accordance with ASTM D257;
- minimum thickness as recommended for the specific system, but not less than 15 thousandths of an inch (mils);
- bonded systems shall be used on metal or concrete surfaces. Non-bonding or pressure sensitive (i.e., cold-applied tape) systems may be used in special instances (for non-pressure piping systems), after review and approval by Owner;
- surface preparation of the structure to be coated shall be required in accordance with the coating manufacturer's recommendations and applicable industry standards;

- factory coated materials shall be used wherever possible. Field application shall be performed using a compatible coating system only;
- minimum 5-year satisfactory performance record shall be required for the intended service;
- coatings shall have mechanical characteristics capable of withstanding reasonable abuse during handling and earth pressure after installation for the design life of the Project element; and
- generic coating systems include, but are not limited to, the following:
    - fusion-bonded epoxy;
    - extruded polyethylene/butyl based system;
    - coal-tar epoxies (two-component systems);
    - bituminous mastics (airless spray);
    - polyamide epoxy for internal coating of pipe at isolating fittings; and
    - wax tape systems.

20.5.2 Atmospheric Corrosion Control Materials and Coatings

20.5.2.1 Materials

Concessionaire shall select and provide metals exposed to the atmospheric environment as follows:

20.5.2.1.1 Steels and Ferrous Alloys

Concessionaire shall provide carbon steel, ductile, and cast iron exposed to the atmosphere, except for track and track fasteners, such as spring clips, spikes, and rail plates, with a barrier or sacrificial coating applied to external surfaces. Barrier coatings may be appropriate for track fastening hardware inside tunnels. High strength, low alloy steels shall be protected similarly to carbon steels except where used as a weathering steel exposed to the outside environment. The design shall incorporate complete drainage of surfaces, the coating of metal-to-metal contacting surfaces, and the sealing of crevices. The potential staining of adjacent structures shall be considered.

Concessionaire shall provide stainless steel surfaces that have been cleaned and passivated after fabrication. Series 200 and 300 stainless steels are suitable for use in most exposed situations without further protection, with Type 316 being preferred for superior corrosion resistance. Series 400 stainless steel may also be used, if staining over time is not detrimental. A barrier coating shall be used on stainless steel exposed to roadway deicing salts and certain marine environments. Hardware used to couple or connect shall be the same stainless series, or as approved by corrosion control engineering.

20.5.2.1.2 Aluminum Alloys

Aluminum alloys shall receive a sealed, hard anodized finish to provide the best weather-resistant surface. A barrier coating shall be used on aluminum exposed to roadway deicing salts or atmospheric corrosive pollutants.

20.5.2.1.3 Copper Alloys

Copper and copper alloys can be used where equipment is exposed to weather without additional protection. A coating shall be utilized only where a natural patina is not desired. Bimetallic couplings shall be prohibited.

20.5.2.1.4 Magnesium Alloys

Magnesium alloys shall have a barrier coating applied when long-term appearance is critical. Bimetallic coupling shall be prohibited.

20.5.2.1.5 Zinc Alloys

Zinc alloys can be used without additional protection. A shop-applied barrier coating may be utilized to extend the design life of components or to enhance the component appearance. Bimetallic coupling shall be prohibited, unless the intent is for sacrificial protection by the zinc alloy.

20.5.2.2 Metals Exposed to Below-Grade Atmospheric Environments

Concessionaire shall minimize water seepage into below-grade (tunnel) portions of the Project and any water that might enter shall be drained in the most efficient manner. Below-grade (tunnel) metals and protective coatings shall be selected after the corrosiveness of the environment is identified.

20.5.2.3 Miscellaneous Electrical Equipment

Concessionaire shall provide non-metallic electrical equipment enclosures, such as, at a minimum, switch boxes, transformers, and connection cabinets where practical. Where metallic equipment is required, it shall include the following minimum provisions:

- enclosures shall be placed in an air-conditioned environment, if possible. Otherwise, metallic surfaces shall be coated with a barrier coating;
- vapor phase inhibitors shall be used in sealed cabinets; and
- compressor mounting hardware shall be a corrosion-resistant material, such as a stainless steel.

20.5.2.4 Coatings

Concessionaire shall provide coatings that have established performance records for the intended service and be compatible with the base metal to which they are applied. Coatings shall be able to demonstrate satisfactory gloss retention, color retention, and resistance to chalking over their minimum life expectancies. Coatings shall have minimum life expectancies, defined as the time prior to major maintenance or reapplication, of 15 to 20 years.

20.5.2.4.1 Metallic-Sacrificial Coatings

Acceptable coatings for carbon and alloy steels for use in atmospheric exposure are as follows:

- zinc, hot-dip galvanizing [2 ounces per square foot (oz/ft2)] or flame sprayed;
- aluminum, hot-dip galvanizing [2 mil thickness] or flame sprayed;
- flame sprayed aluminum-zinc alloy;

- cadmium and electroplated zinc, for fastening hardware located in sheltered areas only; and
- inorganic zinc (used as primer).

20.5.2.4.2 Organic Coatings

Organic coating systems typically consist of a wash primer (for galvanized and aluminum substrates only), a primer, intermediate coat(s), and a finish coat. Acceptable organic coatings, for exposure to the atmosphere, include, but may not be limited to:

- aliphatic polyurethanes;
- aromatic polyurethanes;
- vinyl copolymers;
- fusion-bonded epoxy polyesters, polyethylenes, and nylons;
- acrylics;
- alkyds
- epoxy as a primer where exposed to the atmosphere or as the complete system where sheltered from sunlight; and
- organic zinc, used as a primer.

20.5.2.4.3 Conversion Coatings

Concessionaire shall use conversion coatings, such as phosphate and chromate coatings as pretreatment only for further application of organic coatings.

20.5.2.4.4 Ceramic-Metallic Coatings

Ceramic-metallic coatings are acceptable for use on metal panels and fastening hardware.

20.5.2.4.5 Sealants

Concessionaire shall seal crevices with a polysulfide, polyurethane, or silicone sealant as appropriate for the application and exposure conditions.

20.5.2.4.6 Barrier Coating Systems

Concessionaire shall use the following generic barrier coating systems where corrosion protection is needed but appearance is not a primary concern:

- near white blast cleaning according to NACE No. 2/SSPC-SP 10, followed with a three-coat epoxy system;
- near white blast cleaning according to NACE No. 2/SSPC-SP 10, followed with a two-coat inorganic zinc and high build epoxy system;
- near white blast cleaning according to NACE No. 2/SSPC-SP 10, followed with a three-coat epoxy zinc, high build epoxy system; and
- coatings shall be applied and inspected according to manufacturer specifications. All coating system components shall be from the same manufacturer.

Concessionaire shall use the following generic barrier coating systems where corrosion protection and good appearance are needed:

- near white blast cleaning according to NACE No. 2/SSPC-SP 10, followed with a three-coat inorganic zinc, high build epoxy, polyester urethane system;
- near white blast cleaning according to NACE No. 2/SSPC-SP 10, followed with a three-coat vinyl system. Volatile Organic Compounds (VOC) limits must be satisfied for approved coatings;
- commercial blast cleaning according to NACE No. 3/SSPC-SP 6 or NACE No. 2/SSPC-SP 10 is required for immersion, followed with a three-coat epoxy zinc, high build epoxy and polyester urethane system;
- commercial blast cleaning according to NACE No. 3/SSPC-SP 6 or NACE No. 2/SSPC-SP 10, followed with a three-coat epoxy zinc, high build epoxy and acrylic urethane system; and
- coatings shall be applied and inspected according to manufacturer specifications. All coating system components shall be from the same manufacturer.

20.6 Construction Requirements

Prior to the start of construction, Concessionaire shall repeat the stray current survey conducted prior to the start of design. This survey shall be used as the baseline when evaluating the results of subsequent surveys.

Concessionaire shall incorporate all corrosion control materials and coatings identified in the Released for Construction Design Documents into the all applicable aspects of the construction. Where materials will be buried or otherwise inaccessible after the completion of construction, the correct use of all materials and coatings shall be verified and documented by inspection prior to placement of covering material or structure.

Concessionaire shall furnish, install and test all cathodic protection systems and other corrosion control features and systems shown in the Released for Construction Design Documents.

Concessionaire shall construct and test all ground mats, ground rods and any other grounding schemes shown in the Released for Construction Design Documents.

Following completion of OCS construction, Concessionaire shall test each section to confirm that it meets or exceeds the specified leakage current requirement. All measured values shall be recorded for comparison with subsequent readings.

Following completion of track construction, Concessionaire shall test each section rail to confirm that is meets or exceeds the requirements of Article 20.4.2.1.1. All measured values shall be recorded for comparison with subsequent readings.

No later than 30 calendar days after completion of on-site testing at each location, Concessionaire shall prepare and submit for Information all mechanical, electrical and software configuration settings.

Following completion of construction and prior to the energization of any section of OCS, Concessionaire shall repeat the stray current survey conducted prior to the start of construction. In addition to all the test locations used in previous stray current surveys, this survey shall include all stray current test facilities installed on the Project.

During the Trial Running, during periods of peak Train service, Concessionaire shall repeat the stray current survey conducted prior to energization utilizing all the test points from the previous survey. All measured values shall be less than 20mV fluctuation. All measured values shall be recorded for comparison with subsequent readings.

Concessionaire shall record all measured values from corrosion control systems on all structures and Utilities for comparison with subsequent tests performed throughout the Term.

20.6.1 Corrosion Control Submittals

Immediately following release of the Issued for Construction drawings, Concessionaire shall prepare and submit for Review and Comment a Test Program Plan describing all corrosion control and grounding tests that will be performed to confirm the correct application and performance of all corrosion control materials, coatings and systems.

Following acceptance of the corrosion control Test Program Plan and before any testing is performed, Concessionaire shall prepare and submit for Review and Comment a Test Procedure for each corrosion control and grounding test type identified in the corrosion control Test Plan.

Within 30 calendar days of completion of each test, Concessionaire shall submit for Review and Comment a Test Report detailing the results of the test. Test Reports may be grouped by system and/or location for the purpose of these Submittals.

20.7 Summary of Submittals

Item	Section	Submittal	Action
1	20.4.2.4	Stray Current Corrosion Control Preliminary Design	Review and Comment
2	20.4.2.4	Stray Current Corrosion Control Intermediate Design	Review and Comment
3	20.4.2.4	Stray Current Corrosion Control Final Design	Review and Comment
4	20.4.3.6	Soil Corrosion Preliminary Design	Review and Comment
5	20.4.3.6	Soil Corrosion Intermediate Design	Review and Comment
6	20.4.3.6	Soil Corrosion Final Design	Review and Comment
7	20.4.4.2	Atmospheric Corrosion Control Preliminary Design	Review and Comment
8	20.4.4.2	Atmospheric Corrosion Control Intermediate Design	Review and Comment
9	20.4.4.2	Atmospheric Corrosion Control Final Design	Review and Comment
10	20.4.5.5	Grounding System Preliminary Design	Review and Comment
11	20.4.5.5	Grounding System Intermediate Design	Review and Comment
12	20.4.5.5	Grounding System Final Design	Review and Comment
13	20.6.1	Test Program Plan	Review and Comment
14	20.6.1	Test Procedures	Review and Comment
15	20.6.1	Test Reports	Review and Comment
16	20.6.1	Configuration Settings	Information

21 SAFETY AND SECURITY

Concessionaire shall implement the following design requirements for fire/life safety, system safety, and security throughout the Term. This Section identifies requirements for fire resistant Station design, emergency access, emergency egress, and fencing for safety and security for Stations, the Guideway, and operations and maintenance facilities.

21.1 Codes and Standards

The Project shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including, at a minimum, the following:

- NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems;
- 49 CFR 1520, Protection of Sensitive Security Information;
- Code of Maryland (COMAR);
- NFPA 101 Life Safety Code;
- NFPA 251 Standard Methods of Test of Fire Resistance of Building Construction and Materials;
- NFPA 1 Fire Code;
- Maryland State Fire Prevention Code;
- NFPA 90A Standard for the Installation of Air-conditioning and Ventilating Systems;
- NFPA 91 Standard for Exhaust Systems for Air-conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids;
- IEEE 484 Recommended Practice for Installation Design and Installation of Vented Lead-acid Batteries for Stationary Applications; and
- MDSHA Standard BR-SS(3.05)-75-25.

Codes and Standards specifically cited above and in the body of this Section shall have precedence over Book 3 Codes and Standards. Concessionaire shall use the most current version of each listed Code or Standard as of the Setting Date unless specified otherwise in the Technical Provisions and except as provided in Section 7.2.6 of the Agreement.

21.2 General Requirements

Concessionaire shall provide emergency access at Stations and along the Guideway for emergency responders. Emergency egress pathways shall also be provided along the Guideway for use of egressing Users during emergencies and also maintenance personnel.

Concessionaire shall adhere to Federal Regulation 49 CFR 1520, *Protection of Sensitive Security Information*, for handling of documentation pertaining to transportation facility security systems.

21.2.1 Codes and Standards

Unless otherwise indicated, all emergency access, emergency egress, and fencing shall comply with the current Maryland-adopted editions of all applicable Codes and Standards and shall be subject to the approval of the AHJ.

For this Project, the designated AHJ is the Maryland State Fire Marshal.

21.2.2 Code application

Transit elements of the Project, Stations and Guideway, shall be designed in accordance with NFPA 130 and its referenced Codes and Standards. Other elements of the Project, such as the Operations and Maintenance Facilities and the Operations Control Center shall be in accordance with the Code of Maryland (COMAR).

The Maryland State Fire Marshal has also indicated that they will consider local jurisdiction (i.e., Montgomery County and Prince George's County) preferences in determining code precedence.

21.3 Station Safety

21.3.1 Station Compartmentation

Station compartmentation shall be in accordance with NFPA 130.

21.3.2 Station Combustible Furnishings and Contents

Where combustible furnishings or contents not specifically addressed in NFPA 130 are installed in a Station, Concessionaire shall submit a Fire Hazard Analysis for Review and Comment demonstrating that the level of occupant fire safety is not adversely affected by the furnishings and contents. If included in the design, agent and information booths shall be constructed from non-combustible materials.

21.3.3 Occupancy

Contiguous non-transit occupancies that share a common interface with the Station, shall require special fire protection, such as fire-resistive construction, and security measures, such as restricted access to the transit facility during non-revenue hours. Special considerations may be necessary which shall require Fire/Life Safety and Security Committee (FLSSC) review, including where appropriate, the AHJ and local fire officials.

The Station shall be classified as an assembly occupancy in accordance with NFPA 101, unless amended by the local jurisdiction. Maximum occupancy loads shall be based on NFPA 130, used for sizing means of egress routes.

21.3.3.1 Station Ancillary Spaces/Occupancy Separations

Per NFPA 130, public areas shall be fire-separated from non-public areas. Transit occupancies shall be fire-separated from non-transit occupancies. Fire resistance rating of separations between ancillary occupancies shall be established as required by NFPA 101 in accordance with NFPA 251. The fire resistance rating of the required fire separation shall be determined based on evaluation of such factors as the type of Station configuration (open versus enclosed); fire suppression provided in the nonpublic areas, and NFPA 101 requirements for separation of similar occupancies.

Doors shall be self-closing and latching. Where emergency exit doors are provided in public areas, panic and fire exit hardware shall be provided in accordance with NFPA 101. Doors in a non-environmentally controlled application shall be designed for ambient conditions.

21.3.4 Access

Fire department access shall be per NFPA 1, which is included in the Maryland State Fire Prevention Code, and coordinated with the local jurisdiction and reviewed by the AHJ.

Access by emergency-response personnel to at-grade Stations shall be from any accessible point along the Guideway, including, among others, through passenger Stations or directly from crossing or parallel public streets. Where conditions such as landscaping, structures, or contiguous private property ownership hinder emergency response personnel, special provisions may be necessary.

Concessionaire shall provide a means for emergency responders to have access to spaces that have an Intrusion Access Control (IAC) system.

21.3.5 Egress

For underground, at-grade, and aerial passenger Stations, the number and capacity of the means of egress shall be in accordance with NFPA 130. A minimum of two means of egress from the Platform shall be provided.

- Passenger Stations shall be provided with a sufficient exit capacity to permit evacuation of the Platform occupant load as defined in NFPA 130. Evacuation calculations shall be in accordance with NFPA 130, "Means of Egress," and Annex C. Areas of safe refuge shall comply with applicable portions of NFPA 101, as modified by COMAR.
- The minimum number of exits based on occupancy level, shall be per NFPA 101, as modified by COMAR.

21.3.5.1 Vertical Circulation Elements

Stairs and escalators regularly used by Users need not be enclosed to be used in NFPA 130 exit calculations, unless specifically required by the local jurisdiction and reviewed by the FLSSC.

21.3.5.1.1 Escalators

If escalators are to be stopped remotely, only Platform-bound escalators shall be stopped in a situation requiring Station evacuation. Prior to the stop of an escalator, which is based on a preset time, a message alerting patrons may be announced over the Public Address (PA)/Variable Message Sign (VMS) systems. Escalators shall be designed to decelerate per NFPA 130 requirements.

Escalators used for NFPA 130 exiting calculation shall not constitute more than half of the means of egress capacity at any one level, unless the NFPA 130 requirements for escalators are met. The escalator having the most adverse effect upon egress capacity shall be considered as being out of service per NFPA 130.

21.3.5.1.2 Stairs

Stairs used for egress shall comply with NFPA 101, as modified by COMAR.

Emergency stairs required to meet exiting capacity shall:

- Conform to NFPA 130 and applicable portions of NFPA 101, as modified by COMAR.
- Be continuous to grade.
- Be rated for 2 hours, with 1½-hour, self-closing and latching doors.
- Access to grade shall be through standard, code-conforming openings in a facility or structure with panic hardware.

21.3.5.1.3 Elevators

Elevators shall be permitted to account for part of the means of egress capacity in Stations provided they meet the requirements of NFPA 130.

21.3.6 Mechanical Requirements

Concessionaire shall conduct a ventilation engineering analysis to determine critical battery room fans and ancillary room ventilation fans that shall remain operational during a fire emergency. Ancillary rooms that may be considered critical include, but are not limited to automatic Train control rooms and communications rooms. Concessionaire shall submit the Ventilation Engineering Analysis for Critical Ancillary Ventilation for Review and Comment.

21.3.6.1 Ancillary Ventilation

Ancillary area ventilation systems shall be arranged so that air is not exhausted into Station public occupancy areas in any ventilation mode. Also, fresh air intake from the Guideway shall be prohibited. Ventilation fresh air intakes shall be located where contaminants such as exhaust fumes, vapors, and dust cannot be ingested. Installation of ancillary area ventilation systems shall be in accordance with NFPA 130 and NFPA 90A. Exit enclosure ventilation/pressurization shall be in accordance with NFPA 130 and NFPA 101.

21.3.6.2 Battery Storage/Systems Ventilation

If valve-regulated, lead-acid battery systems are selected in the design, rooms housing valve-regulated, lead-acid batteries shall be in accordance with NFPA 1. A “no-airflow” condition shall activate an alarm and be annunciated at the OCC.

Critical fans required in battery rooms or similar spaces where hydrogen gases or other hazardous gases might be released shall be designed to meet the ventilation requirements of NFPA 91 and IEEE 484.

Interlocks shall be provided to prevent operation of the battery charger when there is no power to the ventilation fan motor or when exhaust air velocity is less than the design velocity. The no-air-flow signal shall also activate an alarm at the OCC.

Exhaust ducts from battery rooms shall not connect with duct systems used for other purposes.

21.4 Guideway Safety

21.4.1 General Access/Egress Requirements

The following requirements apply to at-grade, aerial, and underground portions of the Guideway.

21.4.1.1 Guideway Marking

Lane markings, curbs, fencing, and other appropriate means shall be provided to identify the Guideway and warn the general public of potential danger. Curbs, tactile surfaces, or other techniques shall be used to separate LRV Guideways in roadways where traffic analysis deems they are appropriate.

21.4.1.1.1 Warning Signs

Concessionaire shall design warning signs for the Guideway in accordance with NFPA 130. Warning signs identifying the appropriate hazards shall be posted at access points to the Guideway at fences and barriers.

Concessionaire shall meet the track and LRV clearances. In the event that physical limitations of the Guideway create areas of limited clearance for maintenance personnel and Users egressing the Guideway, a hazard analysis shall be conducted and signage shall be provided to warn of the Guideway constriction.

21.4.1.1.2 LRT Speed Limit Signs

Concessionaire shall design speed limit signs that are clearly visible from the LRV operator cab at all times. They shall be posted in advance of speed change zones and at intermediate points on the Guideway if the speed zone exceeds 1,000 feet in length. Where sight lines do not permit easy identification of a Station location, warning signs shall be posted on the Guideway.

21.4.1.1.3 Egress – Directional Signs on Guideway

Concessionaire shall install directional signs on the Guideway in accordance with NFPA 130, indicating direction of the following, including at a minimum, Stations, portals, and points of exit from the Guideway.

21.4.1.1.4 Emergency Egress Pathway Minimum Envelope

The minimum unobstructed clear width and height for a field-side egress pathway within a tunnel with curved walls shall be in accordance with NFPA 130.

For other egress pathway applications, the minimum unobstructed clear width shall be 30 inches (760 mm) from the walking surface to 80 inches (2,025 mm) above the walking surface.

The emergency egress pathway width shall extend as close as possible to the skirt of the rail vehicle while maintaining the proper LRV and track clearances; the required egress pathway width shall be located and delineated clear of the vehicle dynamic outline.

21.4.1.1.5 Emergency Egress Pathway Construction

Pathways designated for evacuation of Users shall be constructed of non-combustible materials. Walking surfaces shall be slip-resistant.

Pathways in ballasted track shall be compacted to maintain a level surface and shall use pathway ballast consisting of clean, smaller-sized fractured rock. The pathway ballast shall extend to the skirt of the LRV where possible. Track-level pathway requiring Users to step down from the LRV to a level below top of rail shall require Owner approval.

21.4.1.1.6 Emergency Egress Pathway Clearance

Pathway design and construction and minimum clear unobstructed envelope above the walking surface shall meet clearance requirements from the LRV dynamic envelope and other tolerances (such as running clearances, wayside structures construction tolerances, track construction and maintenance tolerances).

In addition to the LRV dynamic envelope, the pathway clearance envelope shall be clear of obstructions and appurtenances (such as handrail/guard, signal cases, light standards, and OCS poles) and in no case shall the egress pathway clear width be reduced below the minimum stated above.

21.4.1.1.7 Crosswalks

Crosswalks shall be 44 inches wide in accordance with the Maryland State Fire Code (NFPA 1) means of egress width for corridors/passageways. Crosswalks shall have a uniform level walking surface at top of rail and shall be provided at the following locations, including at a minimum:

- Where safety walks are discontinued on one side of the tunnel and continued on the opposite side to assure walkway continuity,

- Where access is required from safety walks and track walkways to emergency stairs or cross-passages,
- End of special trackwork sections,
- Adjacent to crossovers if required to move from the egress pathway to the end of Platform or to an egress point.

Crosswalks shall be provided at areas where pedestrians will be crossing mainline tracks, including at a minimum areas near Stations. Crosswalks shall be located away from special trackwork.

21.4.1.1.8 Points of Emergency Access

Blue Light Stations (BLS) shall be provided at points of emergency access in accordance with NFPA 130. Alternate means of disconnecting Traction Power, such as communication with the OCC, may be used per NFPA 130.

At emergency access points, information shall be provided that identifies the route and location of access.

Graphics shall be provided adjacent to each gate identifying the track section, geographic location, and Traction Power feeder zone.

21.4.1.1.9 Guideway Exit Identification

Emergency exit facilities from Guideway shall be identified and maintained to allow for their intended use. Signs shall be readily visible by Users for emergency evacuation. Points of exit from elevated and underground or enclosed Guideways shall be marked with internally or externally illuminated signs.

21.4.2 At-Grade

21.4.2.1 Access

Access gates shall be provided in security fences along the Guideway. Access gates shall be operable with a key-box entry system complying with the Maryland State Fire Code (NFPA 1) for use by emergency response personnel provided in security fences as determined by Owner. Key box entry systems shall be coordinated with the local jurisdiction requiring access including at a minimum Montgomery County and Prince George’s County.

Where a roadway is fenced, at-grade roadway access gates shall have a minimum unobstructed opening of 20 feet.

Maintenance access used by Owner shall be suitable for use by emergency vehicles.

Personnel access gates shall be at least 44 inches wide and shall be of the hinged or sliding type. Hinged gates shall not swing into the Guideway.

Adjacent roadways or special access roads at maximum intervals of 2,500 feet shall be provided for Guideways on fenced ROW where conditions such as landscaping, structures, or contiguous private property ownership hinder access by emergency response personnel.

Access by emergency response personnel to U or cut sections of the Guideway shall be from the adjacent at-grade access points, or when the length of the open cut exceeds 2,500 feet, by some appropriate means of access, such as ladders, to be reviewed by the FLSSC.

21.4.2.2 Egress

Where an unrestricted egress path from the at-grade Guideway exists, no pathway is required.

Where a restricted egress route exists, including at a minimum retained cuts and retained fills, an emergency egress pathway shall extend along the field-side of the Guideway between the structure and the track. For restricted egress routes, a means of egress to a point of safety shall be provided every 2,500 feet, or more frequently, if required by the AHJ.

In certain instances where the Guideway is constrained by physical limitations and cannot accommodate egress pathways on the field-side of the tracks, the walkway may be located between the two tracks, if supported by a hazard analysis and Owner approval.

The pathway clearance envelope shall meet the minimum safety envelope described above.

A transition in the pathway shall be provided at the abutment of at-grade structures to aerial structures.

Transition in an egress pathway shall be provided at locations where the open cut/trench changes to a different alignment configuration.

21.4.3 Aerial

21.4.3.1 Access

Access to the Guideway shall be from Stations or by mobile ladder equipment from roadways adjacent to the Guideway. If no adjacent or crossing roadways exist, access roads at a maximum of 2,500-foot (762 m) intervals shall be required.

Access gates shall be provided in security fences along the Guideway. Fire department access roads shall be provided to the elevated Guideway in accordance with the Maryland State Fire Code (NFPA 1).

21.4.3.2 Egress

Concessionaire shall incorporate a walk surface for Users to evacuate a Train along aerial Guideway so that they can either proceed to the nearest Station, point of egress, or wait for an evacuation Train to arrive. Maximum travel distance to a point of safe egress shall be in accordance with NFPA 130 or as approved by the AHJ.

- For elevated structures, an unobstructed walkway shall comply with the minimum safety walk envelope described above, and shall extend along the field-side of the Guideway, outside of each track.
- Safety walks shall be at vehicle floor height (plus 0 inches, minus 7 inches) to facilitate egress through LRV side doors. Safety walks shall extend from crosswalk to crosswalk.
- A continuous wall handrail or guard/handrail combination shall be provided outside of the walkway on the field side.
- Guards and handrails shall be in accordance with NFPA 130 and NFPA 101.

21.4.4 Tunnel/Enclosed Guideway

21.4.4.1 Access

Access by emergency response personnel to underground Guideway shall be through passenger Stations, vent shafts, emergency exits, portals, rescue trains, or hi-rail vehicles. Access gates shall be placed as close as practical to tunnel portals to permit easy access to tunnels.

21.4.4.2 Egress Paths

Concessionaire shall incorporate a walk surface for Users to evacuate a Train in tunnels/enclosed Guideways so that they can either proceed to the nearest Station, a point of egress to exit the tunnel/enclosed Guideway, or wait for an evacuation Train to arrive. Maximum travel distance to a point of safe egress shall be in accordance with NFPA 130 or as approved by the AHJ.

- An unobstructed walkway shall comply with the minimum safety walk envelope described above, and shall extend along the field-side of the Guideway, outside of each track.
- Safety walks shall be at vehicle floor height (plus 0 inches, minus 7 inches) to facilitate egress through LRV side doors. Safety walks shall extend from crosswalk to crosswalk.
- A continuous wall handrail shall be provided outside of the walkway on the tunnel walls (field-side). Continuous wall handrails shall be designed in accordance with the Maryland State Fire Code (NFPA 101 and NFPA 130), as amended by the AHJ. No protrusions into the walkway shall extend further than a perpendicular line tangent to the handrail.
- Level walkways shall be provided with a maximum cross slope toward the Guideway not to exceed 2 percent, and slope in the direction of travel not to exceed 5 percent per NFPA 101.
- Safety walks shall be brought down to rail elevation at track level at each end of a Station Platform to provide access to the underside of LRVs for lengths not less than 15 feet, but not greater than 150 feet. Safety walks shall also be brought down to rail elevation at crosswalks.
- Walkway continuity shall be maintained at special track sections (such as crossovers, pocket tracks, and switches). Crosswalks shall be provided the full width of Guideways at both ends of special track sections.

21.4.4.3 Egress - Exits to Surface

Exit stairs and doors shall comply with the Maryland State Fire Code (NFPA 101), as amended by the local jurisdiction, except as herein modified.

- Number and location of means of egress routes – Within underground or enclosed Guideways, the maximum distance between exits shall not exceed 2,500 feet (762 m).
- For exit stairs serving underground or enclosed Guideways, the width of exit stairs shall be 44 inches (1,120 mm).

21.4.4.4 Egress - Cross-passageways

Concessionaire may use cross-passageways meeting NFPA 130 in lieu of emergency exit stairways to the surface where Guideways in tunnels are divided by a minimum of 2-hour-rated firewalls or where Guideways are in twin bores.

21.4.4.5 Egress – Doors

Doors in the means of egress, except cross-passageway doors, shall open in the direction of exit travel.

Doors in the means of egress shall be in accordance with NFPA 130.

21.4.4.6 Egress – Exit Hatches

Exit hatches shall be permitted in the means of egress, provided that the conditions meet those specified in NFPA 130.

Where exit hatches are installed in spaces such as walkways or access areas, appropriate design features, such as readily visible signs, markings, or bollards shall be provided to prevent blockage of the exit hatch. In addition, provisions shall be included in the design to protect the exterior side of the hatch, including the outside latch, from accumulation of ice and snow, which may render the hatch inoperable.

21.5 Safety & Security Fencing

21.5.1 General

Where fencing is required in locations visible from public right of way, Concessionaire shall provide ornamental fencing to comply with the requirements of Part 2B, Section 8 of the Technical Provisions.

Safety and Security Fence Types are defined as follows:

Type “A” Chain-link fabric : Hot-dipped galvanized steel or aluminum coated steel/aluminum alloy. Provide polyvinyl chloride (PVC) coated woven wire fence fabric in either 6 or 9-gauge hot dipped galvanized steel or aluminum wire. Provide PVC coated fence posts and fence components. Provide woven wire fence fabric in 5/8-inch, 1-inch or 2-inch diamond mesh openings as required to limit climbing and to obscure views. The top and bottom selvages are to be knuckled or twisted and barbed.

Type “B1” Ornamental Pedestrian Barrier: as set forth in Part 2B, Section 8 of the Technical Provisions.

Type “B2” Ornamental Picket and Railing: as set forth in Part 2B, Section 8 of the Technical Provisions.

Type “B3” Ornamental Architectural Welded Wire Fence: as set forth in Part 2B, Section 8 of the Technical Provisions.

Type “B4” Architectural Welded Wire Fence, as set forth in Part 2B, Section 8 of the Technical Provisions.

Type “C” Post/Rail with Cable, Glass or Mesh Infill Panel: Provide Type 316 stainless steel posts, cables, brackets and associated hardware. Provide tempered glass infill panels in monolithic or laminated configurations complete with stainless steel hardware. Provide hot dipped galvanized steel woven welded wire rod infill panels complete with corrosion and ultraviolet resistant coating. Provide hot dipped galvanized steel or anodized aluminum die-punched sheet infill panels with ultraviolet resistant coating.

Type “D” Anti-Climb Welded Woven Wire Rod Panel : Provide hot-dipped galvanized steel posts, rails, welded woven wire rod panels and mounting components. Provide PVC coated welded woven wire fence fabric panels in 9-gauge hot dipped galvanized steel wire. Provide the fence opening in approximately 3/8-inch by 3-inch horizontal openings to limit climbing and to defeat hand operated cutting tools.

21.5.2 Guideway Fencing

21.5.2.1 Guideway Fencing - General

Guideway shall be protected to prevent vehicular or pedestrian encroachment for exclusive alignments and where shown in the Book 4 Contract Drawings except at designated points of entrance and egress such as Stations, surface transit interchange areas, and parking lots. Additional Guideway fencing shall be included if determined to be necessary by the TVA or Preliminary Hazard Analysis.

Specific fence, barrier or railing guidelines specified in Part 2B, Section 3 of the Technical Provisions shall take precedence over the requirements herein.

Access gates shall be provided every 2,500 ft. or as specified by the local AHJ. Access gates shall open away from the tracks.

Fence material shall have a minimum life expectancy of 30 years.

Where LRVs operate in a roadway median and Guideway fencing is provided between the roadway and Guideway, vehicular encroachment devices shall be provided on the fencing, which alarm audibly and visually at the OCC.

Ground metallic fencing within 15 feet of the centerline of the LRT track.

Fencing shall be bonded at all gate hinges and at fence openings to ensure a continuous grounding path.

21.5.2.2 Fencing Application

Fencing shall be installed per Exhibit 21.1 using the fencing types described above. Where more than one type is indicated, Owner shall select the type based on stakeholder coordination.

Exhibit 21.1

Application/Location	Acceptable Fence Type(s)	Minimum Height	Remarks
Guideway Fencing, exclusive R.O.W. • Prevent pedestrian and deter vehicular encroachment • Setbacks to meet local building codes • Support and mounting structures on trackside of fence. • Initial fence clearance zero to 2 inches	B2 or B3 – Ornamental, shall be installed as shown on Book 4 Contract Drawings	6 ft above walking surface on public side of fence	
At Median LRT and/or Roadway for pedestrian control	B1 – Ornamental or B4 - Ornamental	3.5 ft	When required for pedestrian control

Application/Location	Acceptable Fence Type(s)	Minimum Height	Remarks
CCT	B4 - Ornamental	6 ft above walking surface on public side of fence	
CSXT	As defined in Book 4 Contract Drawings	8 ft	
New Structures	B2 – Ornamental or B4 - Ornamental	9 ft from adjacent walkway or roadway	
LRT Bridges over trails or roadways, • Length equal to the overall bridge parapet length to provide code-compliant fall protection for bridge maintenance staff and passenger emergency egress	B1 - Ornamental or B4 - Ornamental	3.5 ft.	Refer to Book 4 Contract Drawings
LRT Bridges over railroad • Length equal to the overall bridge parapet length • Coordinated with passenger and freight train track owner(s).	B1 – Ornamental or B4- Ornamental	3.5 ft	
LRT Bridges over streams	Railings	3.5 ft. above walking surface	Fencing not required for stream bridges with restricted access.
Portals and retaining walls over LRT Guideway • Width of the OCS plus 20 feet on either side of the OCS centerline. • Electrically grounded with the portal/retaining wall electrical grounding system.	D, B2, or B3	6 ft	
Highway Bridges over LRT electrified track			Part 2B, Section 3

Application/Location	Acceptable Fence Type(s)	Minimum Height	Remarks
OMF • A clear zone shall be provided on each side of the fence to avoid offering protection or concealment to vandals or intruders. • Motor-operated horizontally sliding pedestrian access gate with a minimum four (4) foot clear unobstructed opening. • Motor-operated horizontally sliding vehicle access gate with a twenty-five (25) foot clear unobstructed opening to the OMF.	B2 or B4 (ornamental) where visible from the public ROW, Type “A” elsewhere.	8 ft	
Bonifant St. and Georgia Avenue • Railing is on the northeast corner of the intersection • From TRK 1 STA 342+80, Offset 19.4 ft left to TRK 1 STA 343+15, Offset 20.3 ft. left. • Approximately 32 foot length	C, Mesh Panel	3.5 ft	
Arliss Street • TRK 1 426+50 to TRK 1 427+15. • North of westbound track and south of eastbound track. • Extending from tunnel portal	C, Mesh Panel	3.5 ft	

21.5.2.3 Guideway Fencing – Capital Crescent Trail

Concessionaire shall provide security fencing for the entire Guideway along the Capital Crescent Trail. The location of the gates shall be as per above and coordinated with Owner and Montgomery County. Gates shall be provided at every trail connection. The design of the Guideway fence adjacent to the trail shall be as set forth in Part 2B, Section 21.5.2.2 of the Technical Provisions, Part 2B, Section 8 of the Technical Provisions, and the Book 4 Book 4 Contract Drawings landscape drawings.

21.5.3 Traction Power Substations

Concessionaire shall provide hazard warning signage at each entrance to the TPSS that clearly indicates and states the hazard (e.g., "DANGER HIGH VOLTAGE — 750 VOLTS") with letter sizes and colors in conformance with NFPA 70 and the Occupational Safety and Health Administration (OSHA) requirements. TPSS enclosures and access doors shall be designed to prevent access by unauthorized persons.

If TPSS perimeter fencing is provided, fence and gate(s) shall be electrically grounded.

21.5.4 Guideway Fencing – CSXT

Concessionaire shall provide security fencing for the Guideway next to CSXT right of way. Fence type is to be determined based on location as defined in Book 4 Contract Drawings.

21.5.5 Operations & Maintenance Facilities

Concessionaire shall provide the following fencing for the Operations & Maintenance Facilities (OMF), including at a minimum:

- Combination motor and hydraulically operated vertical swing-arm operator complete with proximity card access reader to the employee parking area(s). At elevated parking deck structures physically limit/prevent vehicle access to vehicles weighing more than 40 lbs. / sq. ft. gross vehicle weight, and/or vehicles that are 6'8" in height and higher.

21.5.6 Pedestrian Fencing

Concessionaire shall replace all pedestrian fencing impacted by the Project or within the Project Limits that does not meet current AHJ standards. Concessionaire shall provide new pedestrian fencing at the locations specified in Exhibit 21.2 below. All new pedestrian fencing shall be provided according to the Codes and Standards and requirements of the AHJ with a minimum fence height of 6 feet.

Exhibit 21.2

Road Name	Limits of Fencing		WB/SB (LT)	EB/NB (RT)	Median
	Begin (Sta.)	End (Sta.)			
MD 193 (University Blvd)	TRK 1 451+80	TRK 1 454+42	X		
MD 193 (University Blvd)	TRK 1 452+83	TRK 1 455+51		X	
MD 193 (University Blvd)	TRK 1 454+41	TRK 1 457+25			X
MD 193 (University Blvd)	TRK 1 485+79	TRK 1 487+21			X

Road Name	Limits of Fencing		WB/SB (LT)	EB/NB (RT)	Median
	Begin (Sta.)	End (Sta.)			
MD 193 (University Blvd)	TRK 1 488+36	TRK 1 490+25			X
MD 193 (University Blvd)	TRK 1 491+27	TRK 1 495+32			X (RT)
MD 193 (University Blvd)	TRK 1 491+31	TRK 1 494+43			X (LT)
MD 193 (University Blvd)	TRK 1 497+06	TRK 1 500+21			X
MD 193 (University Blvd)	TRK 1 501+49	TRK 1 505+24			X
MD 193 (University Blvd)	TRK 1 506+50	TRK 1 516+64			X(RT)
MD 193 (University Blvd)	TRK 1 509+58	TRK 1 516+61			X(LT)
MD 193 (University Blvd)	TRK 1 518+23	TRK 1 525+00			X(RT)
MD 193 (University Blvd)	TRK 1 520+83	TRK 1 524+50			X(LT)
MD 193 (University Blvd)	TRK 1 527+00	TRK 1 535+40			X
MD 193 (University Blvd)	TRK 1 536+21	TRK 1 548+29			X
MD 193 (University Blvd)	TRK 1 549+50	TRK 1 555+25			X
MD 193 (University Blvd)	TRK 1 556+50	TRK 1 563+50			X

21.6 Guideway Security

21.6.1 At-grade Vehicle Incursion

Where there is a high probability of unauthorized vehicle entry into the Guideway, such as transition to embedded track, a means to warn and or prevent unauthorized vehicle entry into the Guideway shall be provided, including, at a minimum:

- Warning signs
- Tactile surfaces
- Contrasting color surfaces
- Raised surfaces

21.6.2 Train Incursion

Concessionaire shall provide a means of detecting an incursion of CSXT and WMATA trains into the Project Guideway in the event of a CSXT or WMATA derailment. The means of train intrusion detection shall be incorporated on those areas of the Project alignment where CSXT and WMATA tracks run next to the Project tracks. Concessionaire shall coordinate with CSXT and WMATA on reciprocal means of detection in the event a Project LRV derails and crosses into CSXT and/or WMATA Guideways.

21.6.3 Aerial Guideway

Concessionaire shall provide gates/barriers at Station Platforms where there is a potential for patrons to access aerial structures/bridges from the Platform ends. Gates/barriers shall be secured Platform level to ensure entry by authorized individuals only, while allowing easy opening from the Guideway for emergency egress.

Concessionaire shall submit a Blast Analysis of Aerial Structures for Review and Comment. References on blast analysis include, but are not limited to, AASHTO Bridge Security Guidelines and the National Academies and Department of Homeland Security Fact Sheet on IED Attack. Concessionaire shall perform blast analyses for at least, at a minimum, the following:

- Silver Spring Transit Center Station and aerial structure; and
- Riverdale Park Station and aerial structure.

21.6.4 Tunnels/Enclosed Guideways

Concessionaire shall design and install intrusion detection devices and alarms (combined, as appropriate, with CCTV surveillance, video software, and analytics) at tunnels and enclosed Guideways within the Project Guideway. Alarms shall annunciate at the OCC and the Security Center and a video image of the location shall be displayed at the monitoring location when the following intrusion events are detected, to include, at a minimum:

- Pedestrian encroachment from the end of an Underground Station Platform into the tunnel Guideway; and
- Pedestrian or vehicular encroachment from the at-grade section into the tunnel Guideway at the portal.

Physical barriers separating the end of Platform from the tunnel shall be provided to prevent Users from accessing the tunnel.

Concessionaire shall submit a Blast Analysis of Tunnels and Enclosed Trainways for Review and Comment. References on blast analysis include, but are not limited to, AASHTO Bridge Security Guidelines and the National Academies and Department of Homeland Security Fact Sheet on IED Attack. The following tunnels/enclosed Guideways shall have blast analyses done for them including, at a minimum:

- Bethesda Station & enclosed Guideway
- Silver Spring Library Station
- Manchester Place Station & Plymouth Tunnel

21.6.4.1 Vehicle Incursion into Tunnels/Enclosed Trainways

A means to prevent unauthorized vehicle entry into the tunnel Guideway at the approach to the tunnel portal shall be provided. Concessionaire shall evaluate means including, at a minimum:

- Bollards;
- Retractable vehicular barrier;
- Tank-traps;
- Curbs;
- Barriers;
- Tactile warning;
- Contrasting color;
- Warning signs; and
- Flashing lights.

Sizing and design details of the means of prevention of vehicle incursion shall be based on structural analysis considering vehicle size (per Owner direction) and maximum speed attainable by the vehicle in the road segment leading to the portal.

Monitoring/control of the means of prevention of vehicular incursion shall be at the OCC and the Security Center.

21.6.4.2 Tunnel Ventilation Shafts

Concessionaire shall incorporate the results of a TVA in determining the height of vent shaft openings considering the possibility of objects or liquids being thrown into them.

Tunnel and enclosed Guideway evacuation pathways and ventilation shafts must be secured at the street level to ensure entry by authorized individuals only, while allowing easy opening from the inside for emergency egress.

21.7 Facility Security

21.7.1 Operations & Maintenance Facilities

21.7.1.1 Parts Security

Concessionaire shall design security features to protect parts, spares, tools, and other equipment. Entry into parts rooms shall be controlled by the intrusion access control system and by established system procedures.

21.7.1.2 Access Control System

Concessionaire shall design an ACS to secure equipment against damage, vandalism, and risk due to unauthorized personnel. Systems to be under the intrusion access control system include, but are not limited to:

- LRV control;
- Traction power; and
- Communications equipment rooms.

Additionally, the controlled-access system shall be applied throughout the LRT system to allow Owner personnel entry to non-public areas. Controlled-access systems shall not inhibit egress to an area of safety.

21.7.1.2.1 Unique Keys in Critical Access Areas

Concessionaire shall design unique keys for the following applications including, at a minimum:

- fare collection equipment;
- rooms associated with money;
- restrooms;
- communications, computer, data processing, and signal rooms;
- security-related areas;
- central control;
- yard control towers;
- mechanical rooms; and
- fire control rooms.

21.7.1.2.2 Access Boxes

Concessionaire shall design and install access boxes where immediate access is necessary for security, lifesaving, or firefighting purposes per NFPA 1; an access box shall be installed in an accessible location. The access box shall be of a type approved by the AHJ (i.e, Knox Box).

21.8 Summary of Deliverables

Item	Section	Submittal	Action
1	21.3.2	Fire Hazard Analysis	Review and Comment
2	21.3.6	Ventilation Engineering Analysis for Critical Ancillary Ventilation	Review and Comment
3	21.6.3	Aerial Structure Blast Analysis	Review and Comment
4	21.6.4	Tunnel and Enclosed Guideway Blast Analysis	Review and Comment

PART 2C, TESTING, CERTIFICATION AND REVENUE SERVICE PREPARATION

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1 TEST PROGRAM

The Concessionaire’s Test Program shall include testing plans and processes for both the Purple Line System and other Project improvements specified in Part 1 of the Technical Provisions. For the Purple Line System, the Test Program shall establish that the required reliable, safe and efficient public transportation service, all Project LRVs, Subsystems, Systems, Fixed Equipment and Fixed Facilities properly operate within themselves individually and shall interface and interoperate with each other and with external systems and facilities as required in the Contract Documents. This Section identifies requirements for verification and validation of all Project elements (including the Purple Line System) and capabilities utilizing a structured test program. The Concessionaire’s Test Program shall ensure that the Purple Line System and other Project improvements specified in Part 1 of the Technical Provisions are functioning as required by the Contract Documents and the Concessionaire’s Design Documents.

The Test Program shall at a minimum:

- be incorporated into the Concessionaire’s Project Management Plan;
- demonstrate compliance of the Work with all materials, functional, safety, availability and performance requirements of the Contract Documents and the Concessionaire’s Design Documents;
- establish the baseline Total Trip Run Time in accordance with Part 3, Section 3.15 of the Technical Provisions;
- demonstrate compliance of the Work with all applicable Codes and Standards; and
- demonstrate compliance of the Work with all specified requirements of applicable AHJs.

For the Purple Line System, Concessionaire shall subject all LRVs, Systems, Subsystems, Fixed Equipment and Fixed Facilities to inspection and testing throughout manufacturing, construction, installation and until the O&M Commencement Date. As more fully described below, these inspections and tests shall progress from the component to the Subsystem level, to the System level, to the Purple Line System level. Tests shall also include tests of all interfaces identified in the Interface Control Matrix described in Part 2.A, Section 3.9.7.2 of the Technical Provisions. As individual Systems and Fixed Facilities become operational, Integration Tests shall be performed to confirm operational readiness, reliability, safety and operational capabilities. All such inspections and testing shall be documented and reported by Concessionaire in accordance with Part 2C, Sections 1.4.2 through 1.4.4 of the Technical Provisions. Implementation of the Concessionaire’s Test Program shall occur throughout the Design-Build Period and comply with the Concessionaire’s Quality Program. Implementation of certain aspects of the Rail Activation Program Plan, Safety and Security Certification, and Operational Readiness Plan may occur concurrently with the Concessionaire’s Testing Program. In addition, Concessionaire’s implementation of the Test Program may result in different phases of tests being performed on different Project elements at the same time.

For Project improvements that are not a part of the Purple Line System, the Test Program shall be as specified in the approved Quality Program.

1.1 Codes and Standards

The test program as described in this Section 1 shall comply with the requirements of the Codes and Standards listed in Book 3 Codes and Standards including the following:

- NFPA 3, Recommended Practice on Commissioning and Integration Testing of Fire Protection and Life safety Systems; and

- ACG Commissioning Guideline.

1.2 Test Phases

Concessionaire shall organize the Test Program into a logical and progressive sequence of test phases beginning at the component level of each LRV, Subsystem, System, piece of Fixed Equipment and Fixed Facility and progressing sequentially to Integration Testing and performance demonstrations. Such test phases shall include:

- qualification tests;
- factory demonstration tests;
- installation tests:
  - installation verification inspections; and
  - Site tests on individual items of Fixed Equipment, System components, Subsystems or Systems at a single Site to verify standalone functional performance
- performance and Integration Tests:
  - startup/functional performance tests;
  - Integration Tests; and
  - performance demonstration tests.

All qualification and factory demonstration tests shall be performed in a factory environment. All installation tests and all performance and Integration Tests shall be performed at the Project Site. All applicable qualification and factory demonstration tests shall be successfully completed prior to delivery of LRVs or any other equipment to Site.

Installation tests shall include post-installation checkout tests, inspections, and various site acceptance tests which provide verification of standalone functional performance and contract compliance. All physical facilities-to-facilities and facilities-to-systems interfaces will be verified by these tests. Successful execution of installation tests is a prerequisite for beginning actual Integration Testing.

Performance and Integration Tests shall include functional performance testing of individual Systems that are distributed over multiple locations along the Transitway, all System-to-System interfaces, all System-to-Fixed Facilities interfaces related to control and monitoring and all performance demonstration tests. As this testing progresses, Concessionaire shall complete the submittals required for Safety and Security Certification of the Project for Trial Running and then for Revenue Service as described in Part 2C, Section 2 of the Technical Provisions.

Concessionaire may institute a Test Program in which Project improvements are in different test phases. For example, a portion of the Project may be ready for Integration Testing while another portion is being constructed or has components that are in proof of manufacture testing.

1.3 Verification Methods

For each test activity, Concessionaire shall identify in each Test Program Plan the verification method that shall be used. Concessionaire shall use the following verification methods:

- demonstration – this verification method shall be used for all factory demonstration tests, all installation tests and all performance and Integration Tests unless, with respect to particular elements, Concessionaire requests a verification method other than demonstration, and conspicuously notes such request in the Test Program Plan with reference to the element.

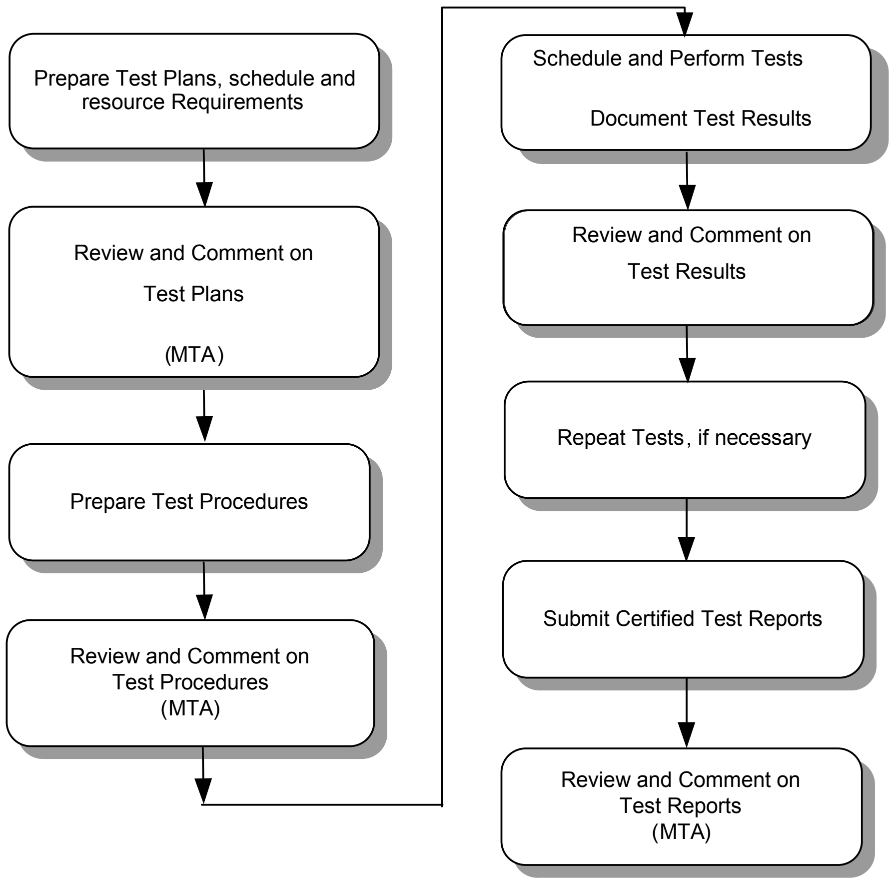
- inspection – this verification method shall be used for all installation verification inspections.
- special test – this verification method may be used for those qualification tests that require special test conditions or environments to ensure performance of the item in accordance with manufacturer specifications. For example, a special test may be destructive testing of cables to demonstrate compliance with NFPA130 fire survivability requirements.
- manufacturer's certification – this verification method may only be used for qualification testing of commercial off-the-shelf components and Fixed Equipment based on previously completed product testing of identical components or Fixed Equipment under environmental conditions that meet Purple Line System requirements. Manufacturer's certifications must be provided by the original manufacturer of each component or Fixed Equipment.
- Concessionaire's certification – this verification method may be used only for qualification testing of LRVs, other Project specific equipment and Fixed Facilities, if Concessionaire documents as part of the Test Report existing test data from previously performed tests of equivalent materials or equipment in environmentally similar conditions to those required for the Purple Line System. Concessionaire's certification shall be accompanied by the existing test data in lieu of performing a new test.
- analysis – this verification method shall be used for requirements that cannot be verified wholly by demonstration, inspection or special test and for which Owner has agreed in writing as of part of its Review and Comment of the specific Test Program Plan that verification by analysis is acceptable. For example, Concessionaire may include the analysis verification method for the expansion capability of a particular System and the Owner may Review and Comment that the analysis verification method is acceptable.

Demonstration, special test, and analysis shall be used to calculate the baseline Total Trip Run Time.

1.4 Testing Process

Concessionaire shall follow a process similar to that shown in Exhibit 1.1 for managing and executing the test program.

Exhibit 1.1 – Test Process Sequence



Test Program Plans and Test Procedures shall be developed for all tests in all phases of the Test Program for LRVs, Systems, Fixed Equipment and Fixed Facilities and all interfaces identified in the Interface Control Matrix described in Part 2A, Section 3.9.7.2 of the Technical Provisions.

1.4.1 Test Program Plans

No later than 90 calendar days prior to the scheduled start of the qualification test phase of any element of any LRV, Subsystem, System, Fixed Equipment or Fixed Facility, Concessionaire shall prepare and submit for Review and Comment a Test Program Plan.

No later than 90 calendar days prior to the start of the first Integration Test, Concessionaire shall prepare and submit for Review and Comment an Integration Test Program Plan for any testing that combines multiple LRVs, Systems, Fixed Equipment, or Fixed Facilities.

All such tests to be performed shall be identified in a Project Test Program Plan or the Integration Test Program Plan.

Each Test Program Plan shall at a minimum be developed by Concessionaire so that when Concessionaire executes the Test Program Plan, it:

- validates Concessionaire's Design Documents and required performance characteristics at all Project Sites;
- demonstrates operational compatibility;

- verifies compliance with the Contract Documents and Concessionaire's Design Documents;
- identifies the verification method for each test;
- ensures uniform production quality;
- identifies key LRV, System, Fixed Equipment, Fixed Facility and human interfaces;
- identifies all specific tests to be conducted and provides a brief description of the purpose of each test;
- identifies whether or not each test is required for Safety and Security Certification;
- identifies Concessionaire's required manpower resources, including the Concessionaire's representative in responsible charge and the person leading the test;
- identifies requirements for test instrument calibration; and
- identifies test schedules and the dependence of each test on the prior completion of other tests.

1.4.2 Test Procedures

No later than 60 days before the start of the first test identified in any Test Program Plan, Concessionaire shall prepare and submit for Review and Comment the Test Procedures for all specific tests identified in that Test Program Plan. Each Test Procedure shall include the following at a minimum:

- test objectives;
- pass/ fail criteria based on the most stringent requirements of the Contract Documents, Concessionaire's Design Documents, Concessionaire's reliability and availability assignments in accordance with Part 2B, Section 11.3.3 of the Technical Provisions, and safety functions required instrumentation/equipment/facilities;
- test set-up configuration;
- sequence of test steps;
- description of test steps;
- estimated test duration;
- visual inspection of equipment;
- all necessary safety precautions required to protect persons and property; and
- Test Report format to record results.

1.4.3 Test Performance

Concessionaire shall organize, coordinate and perform all tests on each LRV, Subsystem, Systems, Fixed Equipment and Fixed Facilities at all Project Sites in accordance with Test Procedures that have been submitted by Concessionaire and Concessionaire has received Review and Comment from Owner. Concessionaire shall advise Owner a minimum of 10 business days prior to the start of each test. Owner shall have the right to witness any test. Prior to the start of each test, Concessionaire shall represent the following:

- all required LRVs, Systems, Fixed Equipment and Fixed Facilities can support the test safely in accordance with Part 2A, Section 7 of the Technical Provisions;

- all necessary safety precautions have been complied with in accordance with Part 2A, Section 7 of the Technical Provisions;
- Test procedures will be followed; and
- qualified personnel are available, will conduct the test and that the person to lead the test is clearly identified.

Following each test, the completed Test Report and any associated forms and materials, including the representation stated above, shall be signed and dated by the Concessionaire's representative in responsible charge of the test.

1.4.4 Test Reports

Concessionaire shall review, evaluate and approve all successfully completed Test Reports documenting test results in accordance with the Quality Program prior to submitting them to Owner for Review and Comment. After Concessionaire has approved the successfully completed Test Reports and no later than 15 days after completion of each test, Test Reports shall be submitted for Review and Comment.

All inspection records and Test Reports documenting successful completion of an inspection or test shall be utilized to support either the Safety and Security Certification and the similar process that Concessionaire implements to record all inspections and Test Reports that are not required for the Safety and Security Certification.

Inspection and Test Reports that are required for Safety and Security Certification shall be checked, catalogued and utilized as required by the Safety and Security Certification Program. For those tests failing to meet the test criteria, Concessionaire shall document the test discrepancy, implement appropriate corrective action and repeat the test. All Test Records for a test failing to meet the test criteria shall be submitted to Owner for Review and Comment.

Concessionaire shall prepare and submit for Review and Comment a Non Safety and Security Inspection and Test Monitoring Plan to catalog and monitor the status of all inspections and tests identified in all Test Program Plans that are not required for Safety and Security Certification. This plan shall separately identify tests for similar Fixed Facilities, Fixed Equipment or Systems at different locations. Concessionaire shall submit the first Non Safety and Security Inspection and Test Monitoring Plan no later than 30 days after submitting the first Test Program Plan and shall make quarterly updates thereafter until all applicable tests from all Test Program Plans have been included in the Test Program. As inspections and tests are completed, Concessionaire shall maintain a current and complete status of all such inspections and tests.

1.4.5 Repeat and Regression Testing

In the event of a test failing to meet the test criteria or follow test procedures, Concessionaire shall investigate the cause and implement corrective action. Prior to the resumption of testing, Concessionaire shall:

- fix, as may be required, any or all LRVs, Subsystems, Systems, Fixed Equipment or Fixed Facilities being tested, the test set-up, Test Procedure, or a combination of these elements as appropriate;
- document the cause of the test discrepancy and the corrective action being taken in Regression Testing or Repeat Testing;
- document all configuration changes to the Design Work or Construction Work for incorporation into Record Documents;

- evaluate the need for Regression Testing because the previous successful test results are invalidated by a configuration change and, if invalid, undertake additional Regression Testing; and
- implement revisions to Test Procedures or Test Reports and have the revised documents available for use.

Repeat Testing shall include the entire scope of the Test Procedure that previously failed following resolution of the failure. Repeat Testing shall be performed until compliance with that Test Program Plan and a successful test is demonstrated.

Regression Testing requires that, after Concessionaire resolves a discrepancy, testing resumes from the last point at which the test data taken to that point is unaffected by the changes made to resolve the discrepancy. Concessionaire shall determine the need for, and extent of, Regression Testing on a case-by-case basis based on the following:

- severity of the discrepancy;
- overall impact and implications on the Subsystem;
- overall impact and implications on the System;
- software and hardware discrepancy;
- technical judgment of the Concessionaire's representative in responsible charge of the test; and
- Concessionaire's Quality Program requirements.

Repeat Testing and Regression Testing, as applicable, shall be performed until compliance with that Test Program Plan and a successful test is demonstrated.

1.4.6 Performance and Integration Testing

Concessionaire's performance and Integration Tests shall verify that the Systems function as required and that the entire Purple Line System performs in accordance with the requirements for each individual LRV, System, Fixed Equipment and Fixed Facility. These tests shall include verification of internal interfaces and interfaces to external systems and sites specified in the Contract Documents or Concessionaire's Design Documents. Concessionaire shall not begin performance and Integration Testing until all prerequisite inspections and tests as identified in the Test Program Plans have been successfully completed.

Concessionaire shall perform Integration Tests to verify the Purple Line System internal and external interfaces and the ability of remote sites specified in the Contract Documents or Concessionaire's Design Documents to monitor and control the installed Systems and Subsystems.

The Integration Test Program Plan shall document specific tests, Test Procedures, and Test Performance that address the integration of all Subsystems in a structured manner to achieve System integration and performance including at a minimum the following:

- operation of each System between different geographical locations in the Project ROW;
- operation of all Systems within each Fixed Facility;
- functional performance of each Fixed Facility;
- operation of the LRVs with the track;
- clearances between LRVs and wayside structures and Fixed Equipment;

- operation of the train control system with the track;
- operation of the LRVs with the TPSSs and OCS;
- operation of the LRVs with the train control and traffic signal systems;
- operation of LRV voice, CCTV and data communications with wayside systems;
- operation of the OCC, BOCC and Security Center with LRVs and all other remote sites identified in the Contract Documents;
- integration between the Stations, OCC, BOCC, Security Center and all other remote sites identified in the Contract Documents or Concessionaire's Design Documents;
- verification of all application operational capabilities over the Project and MDOT CIB networks - data layer testing including at a minimum the following:
    - reliability of connectivity tests – verify network connectivity by transmitting and receiving logic errors;
    - communications data throughput tests – ensure that the networks shall perform as expected when stressed to its maximum or near maximum capacity;
    - provisioning of circuits – ensures that there are no timing issues, ensures no pointer adjustments are made due to timing inaccuracies and are properly reported throughout the networks;
    - ensure that the networks perform as expected under abnormal network conditions;
    - ensure bit error rates are below the system/services maximum allowable values; and
    - communications error handling tests – verify the proper functioning of the network's error and alarm detection systems;
- verification of the failover capability between OCC and BOCC.

1.4.7 Verification Cross Reference Matrix

Concessionaire shall identify all Integration Tests to be conducted and enter them in the Verification Cross Reference Matrix. Prior to the start of any performance and Integration Testing, Concessionaire shall prepare and submit for Review and Comment a Verification Cross Reference Matrix including the associated database.

Concessionaire shall include Integration Tests to verify:

- all operational and safety features of all Systems and Fixed Facilities;
- compatibility of Systems and Fixed Facilities incorporated into the Purple Line System; and
- compatibility of operational methods and procedures with Fixed Equipment and System operational capabilities.

The Verification Cross Reference Matrix shall include at a minimum the following:

- test number - assigned to facilitate tracking and monitoring;
- interface reference number - assigned to facilitate tracking and monitoring;
- specification number/referenced paragraph - the location where testing requirements appear in Concessionaire's specifications;

- Systems and/or Fixed Facilities involved in the test;
- test type – to include Subsystem, System, Fixed Facility, and Project level integration/operational tests;
- test location - the location of the Systems and/or Fixed Facilities to be tested;
- System test lead - the portion of Concessionaire's organization, including the Concessionaire's representative in responsible charge and the person leading the test; and
- dates - Test Procedure submitted and reviewed by Owner; test scheduled, actually performed, and Test Report submitted and reviewed by Owner.

1.5 Trial Running Testing

After successful completion of all performance and Integration Testing and submission of the Safety Certification Verification Report by Concessionaire, Concessionaire shall conduct Trial Running in accordance with Part 2C, Sections 4.5 and 4.6 of the Technical Provisions. Trial Running tests shall be demonstrations of service operations and Concessionaire shall follow the requirements of Part 2C, Section 1.4 of the Technical Provisions. These demonstrations may be witnessed by the Owner and shall include at a minimum the following:

- Demonstrations to verify the integration of personnel, the Purple Line System and Concessionaire's Final Operating Plan. These tests shall supplement Concessionaire's formal training and familiarization of Concessionaire's personnel as well as Emergency Services personnel in the Purple Line System in an operational environment, while also providing an opportunity to validate the Concessionaire's Final Operating Plan under operating conditions and environment;
- Special tests as required along the entire length of the mainline to measure actual values and demonstrate compliance with requirements for stray current levels, noise levels including rail squeal, vibration levels and electromagnetic interference levels in accordance with Part 2A and Part 2B of the Technical Provisions;
- Simulation of Purple Line System Revenue Service using Concessionaire's Service Plan for Normal Service. Simulation shall mimic all actual Revenue Service conditions except that no Users will be carried. These tests shall include simulation of the full operational capability of all LRVs, Systems, Fixed Equipment and Fixed Facilities along the Transitway; and
- Simulation of Purple Line System Revenue Service under abnormal conditions including Alternate Service Plans, Incidents and Emergencies. Each simulation shall include the transition to, and actual operation of an appropriate Alternate Service Plan and the transition back to Normal Service at the conclusion of the simulated event. These tests shall include simulation of the full operational capability of all LRVs, Trains, Systems, Fixed Equipment and Fixed Facilities along the Transitway.

In addition, as part of Trial Running period but immediately prior to Revenue Service Demonstration, Concessionaire shall perform the demonstrations, special tests, and analysis set forth in Part 2C, Section 4.6.4 of the Technical Provisions.

1.6 Revenue Service Demonstration

During the Trial Running period, Concessionaire shall conduct a Revenue Service Demonstration using Concessionaire's Service Plan for Normal Service during which time Concessionaire shall demonstrate that the Purple Line System can perform at a minimum level of 94 percent of each day's DOPF no less than 14 of 16 consecutive days. On each day of the Revenue Service Demonstration, Concessionaire shall operate in accordance with the approved Final Operating Plan. DOPF shall be calculated as set forth in Exhibit 4D, Appendix D of the Agreement.

1.7 Reliability Demonstration Test

Starting at the commencement of Trial Running, Concessionaire shall perform a 12 month reliability demonstration test which may occur in part during the O&M Period. If the cumulative failures of any lowest replaceable unit exceed ten percent of the total population during the 12 month test period, Concessionaire shall redesign, fix, and replace or modify the entire population of the lowest replaceable unit. All such redesign, fix, replacement, or modification shall be Nonconforming Work in accordance with Section 7.14 of the Agreement.

1.8 Quality Control

The Test Program shall meet the requirements of the Quality Program as specified in Part 2A, Section 14 of the Technical Provisions. In addition, such Quality Program shall include a defined process for auditing the quality and progress of all Test Program activities including at a minimum the following:

- development, Concessionaire approval and submittal of Test Program Plans;
- development, Concessionaire approval and submittal of Test Procedures;
- Test performance;
- Testing process and procedures of all Project elements that are not part of the Purple Line System Testing Program;
- Concessionaire approval and submittal of Test Reports; and
- development and maintenance of the Verification Cross Reference Matrix, requirements traceability documentation, test discrepancy documentation and test verification documentation.

As part of Quality Control, as a condition to commencement of the qualification test phase of testing, Concessionaire shall prepare and submit for Review and Comment a Test Audit Plan complete with checklist and form to be used for the auditing process in accordance with Part 2A, Section 14.1.14 of the Technical Provisions. This Test Audit Plan may be integrated into the appropriate portion of the QA/QC procedures.

1.9 Certification

Concessionaire shall utilize all safety related Test Reports to support the Safety and Security Certification process as described in Part 2A, Section 7 of the Technical Provisions.

Concessionaire shall utilize all Test Reports that are not applicable to the Safety and Security Certification process to support the non-Safety and Security Certification process as described in Part 2A, Section 7 of the Technical Provisions.

1.10 Products

To support the Test Program, Test Program Plans, Test Procedures and Test Reports, Concessionaire shall maintain the following as part of Record Documents:

- requirements traceability;
- test discrepancies; and
- test verification;

1.10.1 Requirements Traceability

Concessionaire shall develop a means to record and store the relationship between each performance requirement and interface and the tests that will be used to verify their correct operation. Concessionaire is encouraged to support the interface control matrix, requirements traceability and the verification cross reference matrix from a common database.

1.10.2 Test Discrepancies

Concessionaire shall develop a means to record and store all discrepancies identified by the Test Program. Concessionaire shall document, track and ensure that all discrepancies are rectified. The information recorded for each discrepancy shall include the following:

- test number assigned to facilitate tracking and monitoring;
- interface reference number assigned to facilitate tracking and monitoring;
- date that the discrepancy originated;
- Test Report that identifies the original discrepancy;
- description of test;
- description of discrepancy, include any supporting/conflicting references to documentation;
- Concessionaire's representative in responsible charge of resolution of the discrepancy;
- decisions made and description of actions to resolve discrepancy including any supporting documents including meeting minutes, telephone conversations, emails, and drawings.;
- sign-off when discrepancy is closed out; and
- date the discrepancy is closed out.

1.10.3 Test Verification

Concessionaire shall develop a means to record and store all tests completed. The information recorded for each test shall include the following:

- test number assigned to facilitate tracking and monitoring;
- interface reference number assigned to facilitate tracking and monitoring;
- name of test;
- date of test performance;
- date that test is closed out; and
- list of reference documents used to confirm that the interfaces have been implemented as required.

1.11 Summary of Submittals

Item	Section	Submittal	Action
1	1.4.1	Test Program Plans (for any element)	Review and Comment
2	1.4.1	Integration Test Program Plan (for any testing)	Review and Comment
3	1.4.2	Test Procedures	Review and Comment
4	1.4.4	Test Reports	Review and Comment
5	1.4.4	Non Safety and Security Inspection and Test Monitoring Plan	Review and Comment
6	1.4.7	Verification Cross Reference Matrix	Review and Comment
7	1.8	Test Audit Plan and Documents	Review and Comment

2 SAFETY AND SECURITY CERTIFICATION

Concurrent with Concessionaire's implementation of the Test Program and Quality Program, Concessionaire shall implement the approved Safety and Security Certification Plan to validate that all safety and security requirements of the Contract Documents and those required by Concessionaire's Design Documents, hazard analyses, and Threat and Vulnerability Assessments are properly identified, tracked, resolved and verified. Owner shall use such verification to determine at a minimum that the Purple Line System is safe to begin Dynamic Testing, Trial Running and Revenue Service. Part 2A, Section 7.7.2 of the Technical Provisions includes the requirements for the Safety and Security Certification Plan including the submittal process.

The Safety and Security Certification Program shall be consistent with the System Safety Program Plan and the Purple Line Safety and Security Certification Plan in accordance with Part 2A, Section 7 of the Technical Provisions.

2.1 Safety and Security Certification Plan

Concessionaire shall prepare the Safety and Security Certification Plan in accordance with Part 2A, Section 7 of the Technical Provisions.

Concessionaire shall allow appropriate time in the Project Schedule to permit Owner to complete the Safety and Security Certification process in accordance with Part 2A, Section 7 and this Part 2C, Section 2. Separate activities for Owner's responsibilities shall be included in the Project Schedule in accordance with the MTA SSPP.

2.2 Safety and Security Certification Committee Approval

Concessionaire shall submit documents, including at a minimum the SSCP, the certifiable elements list, the certifiable items list, and the design criteria conformance checklist to the SSCC for Review and Approval on behalf of the Owner in accordance with Part 2A, Section 7 of the Technical Provisions.

2.3 Not Used

2.4 Manufacture, Construction and Installation Specification Conformance

Concessionaire shall develop a construction specification conformance checklist that it shall use to verify that elements of the Project as built and tested satisfy all the safety and security requirements of the Contract Documents and Concessionaire's Design Documents.

Concessionaire shall assemble and organize the required construction and test documentation that supports the construction specification conformance checklist in accordance with Part 2A, Section 14.1.4 of the Technical Provisions. This documentation shall include at a minimum the following:

- Test Program Plans;
- Test Procedures;
- Test Reports;
- inspection checklists for design and construction conformance;
- inspection reports;
- mill certificates;
- photos;

- site inspections to verify actual field conditions where safety requirements can be readily observed;
- as-built drawings;
- quality records;
- Progress Reports;
- records of all approved changes; and
- Submittals required by the Contract Documents.

Concessionaire shall also support the safety and security audit process by assisting Owner in walk-through inspections of Fixed Facilities, Fixed Equipment, Transitway and LRVs.

2.5 Inspection and Test Verification

2.5.1 Inspection Program

Concessionaire shall perform in-process inspections and completion of construction/installation in accordance with Concessionaire's Quality Program and Test Program Plans.

2.5.2 Test Program

Concessionaire shall perform all testing in accordance with the requirements of Part 2C, Section 1 of the Technical Provisions. Systems subject to Safety and Security Certification shall be tracked in the SSVTL.

2.5.3 Integration Testing

Concessionaire shall track all Integration Testing results that verify safety and security requirements in the SSVTL.

2.6 Operational Readiness Verification

Concessionaire shall document Trial Running operations testing results that verify safety and security requirements in the SSVTL.

2.7 Safety and Security Certification Requirements

The Safety and Security Certification process for all physical, non-operational elements of the Project shall be completed and all Unacceptable Hazards/Risks eliminated or effectively controlled prior to the start of Revenue Service.

2.7.1 Certificates of System Element Compliance and Evidence of Owner Approval

Concessionaire shall prepare and submit for Review and Approval a Certificate of System Element Compliance when Concessionaire determines that a certifiable element, sub-element, Subsystem, System, LRV, Fixed Equipment, Fixed Facility is ready for certification. Each Certificate of System Element Compliance shall represent that all relevant safety and security requirements have been met and signed by Concessionaire's Authorized Representative. Concessionaire's Authorized Representative shall document that Concessionaire's Project Manager, Engineer of Record, Design Manager, Construction Manager, Quality Program Manager, Chief Safety Officer, Operations Manager and Maintenance Manager concur with the certification prior to its submittal.

Upon completion of a Certificate of System Element Compliance for a specific Purple Line System location, Concessionaire shall submit the certificate and accompanying checklist(s) along with the supporting documentation. Supporting documentation shall include, at a minimum, evidence that all identified CELs and CILs have been inspected and tested, and found to be in conformance with designated safety requirements. After Owner's Review and Approval, Owner will issue a signed Certificate of System Element Completion (refer to the SSCP, Appendix E, Figure E-3), noting any restrictions, exceptions or approved temporary measures in accordance with Part 2C, Section 2.7.4 of the Technical Provisions.

Concessionaire shall retain each original, signed Certificate of System Element Completion and verification package. Any Owner-approved restrictions, exceptions, and temporary measures shall be tracked in accordance with the Quality Program until Concessionaire submits all documentation to provide evidence and Owner approves that all restrictions, exceptions, and temporary measures can be removed and that the final certificate can be issued.

Prior to the movement of any LRV or Train on any portion of the Transitway, Concessionaire shall prepare and submit for Review and Approval a Certificate of System Element Compliance as formal notification to Owner that a specific location or portion of the Purple Line System is safe and secure for Dynamic Testing. Such Certificate of System Element Compliance shall be submitted with all relevant, previously issued, Certificates of System Element Completion and supplementary evidence that all additional relevant systems integration, safety and security requirements have been met.

2.7.2 Certificates of System Integration Testing Compliance and Evidence of Owner Approval

Prior to the start of Trial Running, Concessionaire shall prepare and submit for Review and Approval a Certificate of System Integration Testing Compliance. Such submission shall include all applicable Certificates of Systems Element Compliance that have been previously submitted and all applicable Certificates of System Element Completion. The Certificate of System Integration Testing Compliance shall be signed by Concessionaire's Authorized Representative. Concessionaire's Authorized Representative shall document that Concessionaire's Project Manager, Engineer of Record, Design Manager, Chief Safety Officer, Construction Manager, Quality Program Manager, Operations Manager and Maintenance Manager concur with the certification prior to its submittal.

After Owner's Review and Approval of the Concessionaire's Certificate of System Integration Testing Compliance, Owner will issue the Certificate of System Integration Testing Completion for the Purple Line System. Concessionaire shall retain the original signed copy. Any Owner-approved restrictions, exceptions, and temporary measures shall be tracked in accordance with the Quality Program until Concessionaire submits all documentation to provide evidence and Owner approves that all restrictions, exceptions, and temporary measures can be removed and that the final certificate can be issued.

2.7.3 Project Safety and Security Certificate of Conformance and Evidence of Owner's Approval

Prior to the start of Revenue Service, Concessionaire shall prepare and submit for Review and Approval a Project Safety and Security Certificate of Conformance to summarize the Certificate of System Integration Testing Completion plus all additional Certificates of Systems Element Completion that have been completed during the Trial Running period. The Project Safety and Security Certificate of Conformance shall also include a Certification Verification Report. Concessionaire's Project Safety and Security Certificate of Conformance shall be signed by the Concessionaire's Authorized Representative and shall have all Concessionaire Certificates of Systems Element Compliance, Owner Certificates of System Element Completion and Owner Certificates of System Integration Testing Completion attached. Concessionaire's Authorized Representative shall document that Concessionaire's Project Manager, Engineer of Record, Design Manager, Construction Manager, Quality Program Manager, Chief Safety Officer, Operations Manager and Maintenance Manager concur with the certification prior to its submittal.

After Owner's Review and Approval of the Concessionaire's Certificate of Safety and Security Certificate of Conformance, Owner will issue the Project Safety and Security Certificate of Completion. Concessionaire shall retain the original signed copy.

Any Owner-approved restrictions, exceptions, and temporary measures shall be tracked in accordance with the Quality Program until Concessionaire submits all documentation to provide evidence and Owner approves that all restrictions, exceptions, and temporary measures can be removed and that the final certificate can be issued.

2.7.3.1 Safety and Security Certification Verification Report

With the Project Safety and Security Certificate of Conformance, Concessionaire shall prepare and submit for Review and Approval a Safety and Security Certification Verification Report (SSCVR) in accordance with Owner's SSPP. The report shall summarize the Concessionaire's safety and security certification effort. The report shall also contain an annotated matrix of the SSVTL indicating the status of each item (open/closed), open items list, recommended actions, schedule for permanently closing out all open items, restrictions, and approved temporary measures. The SSCVR shall include the System Integration Test Reports.

2.7.4 Safety and Security Certification Requirements Temporary Restrictions, Exceptions, and Waivers

During Concessionaire's Testing Program and implementation of the SSMP, Concessionaire may submit a request for temporary restrictions, exceptions and waivers for a requirement in Part 2A or Part 2B of the Technical Provisions or Concessionaire's Final Design or Release for Construction Documents. Such request shall include the Concessionaire's actions that will permanently fix the reason for the temporary restriction, exception or waiver. Such temporary restrictions, exceptions and waivers requests shall be Reviewed and Approved by Owner.

After any Owner Review and Approval for such request, Concessionaire shall prepare and submit as part of the required certificate in Part 2C, Sections 2.7.1 through 2.7.3 of the Technical Provisions the documentation of the temporary restrictions, exceptions and waivers as well as the approved fix.

Prior to achieving Final Completion in accordance with Section 7.10.4 of the Agreement, Concessionaire shall meet all the requirements of Part 2A and Part 2B of the Technical Provisions, its Final Design, and Release for Construction Documents for which any temporary restriction, exception or waiver has been approved by Owner. Concessionaire may apply for Owner approval of Deviations from requirements of the Technical Provisions and Technical Documents in accordance with Section 7.2.3 of the Agreement.

Concessionaire shall prepare and submit for Review and Approval an addendum to the original applicable certificate and certificate checklist(s) to document how the temporary restriction, exception or waiver was corrected and tested satisfactorily in accordance with Part 2C, Section 1. If Concessionaire's submittal represents that the safety and security requirements and the conditions to the issuance of the certificate have been met and Owner has Reviewed and Approved, Owner will issue an addendum to the applicable certificate.

During the completion of the compliance checklists required in Part 2A, Section 7 of the Technical Provisions, instances of noncompliance with safety or security requirements shall be documented.

2.8 Summary of Submittals

Item	Section	Submittal	Action
1	2.7.1	Certificates of System Element Compliance	Review and Approval
2	2.7.2	Certificate of System Integration Testing Compliance	Review and Approval
3	2.7.3	Project Safety and Security Certificate of Conformance	Review and Approval
4	2.7.3.1	Safety and Security Certification Verification Report	Review and Approval
5	2.7.4	Addendum to Original Applicable Certificate	Review and Approval

3 RAIL ACTIVATION

Rail Activation encompasses the planning and execution of activities required to transition the Project from the Design-Build Period to the O&M Period in accordance with this Part 2C, Section 3. Concessionaire activities include at a minimum the following:

- completion of the Rail Activation Program Plan;
- hiring and training of operations and maintenance personnel;
- completion of the Final Operating Plan;
- procurement of necessary vehicles and equipment for O&M Work;
- establishing an operations and maintenance staff identification system; and
- procurement of spare parts, test equipment and consumables.

3.1 Management Activities

3.1.1 Rail Activation Program Plan (RAPP)

No later than 12 months before the scheduled start of Trial Running, Concessionaire shall prepare and submit for Review and Approval a Rail Activation Program Plan (RAPP). The RAPP shall address all the rail activation activities identified in this Part 2C, Section 3 of the Technical Provisions as well as all other rail activation activities identified by Concessionaire as necessary pre-requisites to Trial Running. For each rail activation activity, the RAPP shall define at a minimum the following:

- a description of the activity;
- Concessionaire's representative in responsible charge for the performance of the activity or responsible for coordinating with the Owner;
- all prerequisite activities that must be completed before the activity can be performed; and
- the schedule for performing all stages of planning and execution of the activity.

Concessionaire may integrate the RAPP with the Operational Readiness Plan/Strategy described in Part 2C, Section 4.3 of the Technical Provisions.

Once rail activation activities have begun, Concessionaire shall prepare and submit for Review and Comment a Rail Activation Status Report that describes the status of each activity and evaluates whether it is proceeding according to schedule. No later than 180 days before the scheduled start of Trial Running, Concessionaire shall submit the Rail Activation Status Report within 7 days of the end of each calendar month. In the interval between 180 days before the scheduled start of Trial Running and 90 days before the start of Trial Running, Concessionaire shall submit the Rail Activation Status Report every 14 days. In the interval between 90 days before the start of Trial Running and the start of Trial Running, Concessionaire shall submit the Rail Activation Status Report weekly. The Rail Activation Status Reports may be integrated with the Operational Readiness Status Reports described in Part 2C, Section 4.2 of the Technical Provisions.

3.1.2 Hire Personnel

Concessionaire shall hire personnel in accordance with Concessionaire's Personnel Management Policies and Procedures and as required by the Contract Documents to allow sufficient time for training and other necessary acclimatization prior to the start of their assigned duties for the Purple Line System.

No later than 180 days before the start of Dynamic Testing, Concessionaire shall prepare and submit for Review and Comment an organization chart including job descriptions, qualification requirements and proposed training for all personnel responsible for operating LRVs and directing the movement of LRVs throughout the Dynamic Testing program.

3.1.3 Training

Concessionaire shall provide all necessary operations, maintenance and any other training to enable all personnel to perform their assigned commissioning duties in an efficient and effective manner during rail activation.

Based on satisfactory performance at training courses and actual on-the-job performance, Concessionaire shall prepare and maintain a directory of staff who are qualified and authorized to operate LRVs, direct movement of LRVs or perform any other safety critical functions during rail activation.

3.1.4 Policies, Rules and Standard Operating Procedures

Concessionaire shall prepare the Final Operating Plan including appendices in accordance with Part 3, Section 1 of the Technical Provisions. No later than three months before the energization of the first traction power substation, Concessionaire shall prepare and submit for Review and Comment equivalent policies, rules and SOP as required for use during the Site, performance and Integration Testing phases of the Project. Policies, rules and SOP shall emphasize applicable safety precautions and shall include, but not be limited to, the activation, operation and maintenance of all electrical and mechanical equipment, the movement of LRVs, other rail vehicles and road vehicles, and the management of Train movements. Policies, rules and SOP shall address how Train movements will be accomplished safely in the absence of commissioned Train control, grade crossing and traffic signal systems.

3.1.5 Law Enforcement Support for Testing and Commissioning

Concessionaire shall arrange for, and pay all costs of, all law enforcement services for testing and commissioning activities to ensure public safety in accordance with Section 8.10.1 of the Agreement. Such law enforcement services shall include at a minimum:

- traffic and pedestrian control during static testing of grade crossings and traffic signals;
- traffic and pedestrian control at grade crossings during all tests that require the movement of Trains across the crossing prior to the time when the crossing is safety certified and placed into Revenue Service;
- traffic and pedestrian control at traffic signals during all tests that require the movement of Trains through the intersection prior to the time when the traffic signal is safety certified and placed into Revenue Service; and
- traffic and pedestrian control at all locations where the tracks transition into and out of a shared traffic lane during all tests that require the movement of Trains through the transition prior to the time when the transition protection is safety certified and placed into Revenue Service.

Irrespective of which law enforcement agency Concessionaire arranges to use for the provision of these services, Concessionaire shall coordinate the performance of all activities requiring law enforcement services with the AHJ where the activities will be performed.

3.1.6 Project Opening Events

Concessionaire shall support Owner in planning and executing all Project opening events. All such events will occur during Trial Running.

3.1.7 Coordination with Emergency Services

Concessionaire shall attend meetings with Owner and all Emergency Services agencies assigned by AHJs to address Emergencies and Incidents on the Purple Line System to determine and define how Concessionaire's personnel will work with Owner and the Emergency Services agencies. These meetings will be organized and chaired by Owner.

As part of the Final Operating Plan, Concessionaire shall prepare and implement SOP as necessary to reflect Concessionaire's responsibilities based on any agreements regarding Emergency Services. Such SOP shall also address Concessionaire's participation in meetings and activities with regional Governmental Entities regarding safety and security.

3.1.8 Local Bus Routes

Concessionaire shall attend local bus routing/scheduling meetings with Owner and all local bus operating agencies to determine and define how the local bus routes operating along the Project alignment may be adjusted to interact effectively and efficiently with the Concessionaire's Service Plan. These meetings will be organized and chaired by Owner.

As part of the Final Operating Plan, Concessionaire shall prepare and implement SOP as necessary to reflect Concessionaire's responsibilities based on the agreements at the local bus routing/scheduling meetings.

3.1.9 Not Used

3.1.10 Not Used

3.1.11 Personnel Identification System

During Rail Activation, Concessionaire shall follow Concessionaire's Personnel Management Policies and Procedures including personnel identification in accordance with Part 3, Section 1.7 of the Technical Provisions. For Owner and Emergency Services personnel, Concessionaire shall provide personnel identification that can be read visually and electronically by access control door readers.

3.2 Summary of Submittals

Item	Section	Submittal	Action
1	3.1.1	Rail Activation Program Plan (RAPP)	Review and Approval
2	3.1.1	Rail Activation Status Reports	Review and Comment
3	3.1.2	Organization Chart	Review and Comment
4	3.1.4	Equivalent Final Operating Plan Policies, Rules and Standard Operating Procedures	Review and Comment
5	3.1.8	Purple Line System Continuity of Operations Plan	Review and Approval

4 OPERATIONAL READINESS

This Section identifies requirements for Concessionaire's determination of the Operational Readiness of the Project. Concessionaire shall successfully meet all Operational Readiness requirements prior to issuance of Independent Engineer's Certificate of Revenue Service Availability in accordance with Section 7.10.2 of the Agreement. Conditions identified in Section 7.10.4.2 of the Agreement shall not be required to be met as part of the Concessionaire's determination of Operational Readiness.

4.1 Overview

Concessionaire's Operational Readiness Plan/Strategy shall demonstrate the process to validate and verify that all requirements of the Contract Documents are met and that the Project is fit for purpose. Where applicable, Operational Readiness shall incorporate all equipment manufacturers' recommendations for operational testing prior to Revenue Service.

Concessionaire may integrate the Operational Readiness Plan/Strategy with the Rail Activation Program Plan described in Part 2C, Section 3.1.1 of the Technical Provisions.

In executing the Operational Readiness Plan/Strategy, Concessionaire shall verify that:

- the Project is operating in accordance with the Contract Documents and Concessionaire's Design Documents;
- training has been provided that meets the requirements of the Contract Documents including training of Emergency Services personnel;
- all personnel, tools and equipment to operate and maintain the Project are available; and
- Concessionaire's Final Design Documents have been provided to Concessionaire's personnel that will operate and maintain the Project.

Upon such verification, the determination of Operational Readiness by Concessionaire shall require completion of the following activities for the Purple Line System:

- Integration Testing;
- Trial Running;
- verification, documentation and certification that all inspections have been completed;
- verification, documentation and certification that all tests not required for Safety and Security Certification have been completed;
- Safety and Security Certification;
- establishment of baseline Total Run Time in accordance with Part 3, Section 3.15 of the Technical Provisions;
- Concessionaire's completion of any and all Work required to obtain use and occupancy certificates from outside agencies including:
    - elevators and escalators from the Maryland DLLR; and
    - fire detection, alarm and suppression systems from the Maryland State Fire Marshal.
- verification that all Quality Program requirements for Project elements have been met;

- maintaining and cleaning the Project assets throughout the Trial Running to the same standards as required by Part 3 of the Technical Provisions; and
- verification that all plans including appendices required to be submitted prior to Trial Running or RSA have been submitted and, if so required, approved by Owner.

4.2 Operational Readiness Parameters

Concessionaire shall prepare and execute an Operational Readiness Plan/Strategy to demonstrate the successful performance of the Project.

No later than 12 months before the scheduled start of Trial Running, Concessionaire shall prepare and submit for Review and Comment an Operational Readiness Plan/Strategy. The scope of the Operational Readiness Plan/Strategy shall include Trial Running of the entire Purple Line System.

The Operational Readiness Plan/Strategy shall include at a minimum the following:

- organization chart of the Operational Readiness team with discipline responsibilities;
- planned resources;
- support from outside organizations and agencies;
- identification of all individual Operational Readiness activities;
- integration of testing activities into the Operational Readiness process;
- plan for operating, maintaining and cleaning Project assets throughout the Trial Running period to the same standards as Revenue Service;
- identification of required data, Submittals and reports;
- all safety and security requirements including System safety and personnel safety;
- specific requirements for Owner and outside stakeholder interfaces; and
- scheduling of activities.

Following the start of the first Operational Readiness activity described in the Operational Readiness Plan/Strategy, Concessionaire shall prepare and submit for Review and Comment Operational Readiness Status Reports. Prior to six months before the scheduled start of Trial Running, Concessionaire shall submit the Operational Readiness Status Report within one week of the end of each subsequent calendar month. In the interval between six months before the scheduled start of Trial Running and three months before the start of Trial Running, Concessionaire shall submit the Operational Readiness Status Report every two weeks. In the interval between three months before the start of Trial Running and the start of Trial Running, Concessionaire shall submit the Operational Readiness Status Report weekly. The Operational Readiness Status Reports may be integrated with the Rail Activation Status Reports described in Part 2C, Section 3.1.1 of the Technical Provisions.

4.3 Test and Inspection Certification

Concessionaire shall perform all inspections and tests identified in all Test Program Plans in accordance with Part 2C, Sections 1.4 and 1.5 of the Technical Provisions.

4.4 Plan and Reports Submittals

Concessionaire shall submit all required plans and reports required prior to Trial Running or RSA as specified in Part 3 of the Technical Provisions including at a minimum the following:

- Operating Plan;

- Rail Fleet Management Plan;
- Maintenance Plans;
- Cleaning Plans;
- maintenance manuals;
- Software and Firmware Manuals and Programs;
- Personnel Management Policies and Procedures Manual;
- Safety and Security Plan for the O&M Period;
- Format of Operations and Maintenance Daily Report; and
- Asset Management Plan.

4.5 Readiness for Trial Running

Prior to the start of Trial Running, Concessionaire shall prepare and submit for Review and Approval evidence that Concessionaire is ready to start Trial Running and, if found to be satisfactory, Owner will issue an Approval to Start Trial Running. Evidence that Concessionaire is ready to start Trial Running shall include at a minimum the following:

- Safety and Security Certification;
- Certificate of Systems Integration Testing Completion;
- certification with supporting documentation that all inspections and tests that are not required for Safety and Security Certification and Certificate of Systems Integration Testing Completion but are required for Trial Running have been satisfactorily completed;
- certification with supporting documentation that all Rail Activation activities required to be completed prior to the start of Trial Running have been successfully completed by Concessionaire;
- certification with supporting documentation that any other activities identified in the Operational Readiness Plan/Strategy that are required to start Trial Running have been successfully completed; and
- Concessionaire's certification with supporting documentation that all Rail Activation activities required for the start of Trial Running have been successfully completed.

4.6 Trial Running

4.6.1 Trial Running Objectives

Concessionaire shall conduct Trial Running when all Integration Testing and Rail Activation activities have been satisfactorily completed and Owner has issued the Approval to Start Trial Running. Trial Running shall be the final step in confirming and demonstrating readiness for Revenue Service.

Trial Running shall exercise the entire integrated Purple Line System. The following key objectives shall be fulfilled by Concessionaire:

- Train operators shall be familiar with the characteristics of the entire Transitway and yard alignments;
- personnel shall be familiar with the operations of the Purple Line System and all operating procedures;

- exercise and validation of operating schedules and all operational performance requirements;
- exercise and documentation of performance of all traffic signals along the alignment with notation of any adverse impacts to Trains or vehicular traffic;
- exercise and confirmation of the operational availability of all Systems, Fixed Equipment, Fixed Facilities, LRVs, and Trains under Normal Service, abnormal service including Alternate Train Service and Emergency operating conditions;
- exercise and confirmation of the operational safety of all Systems, Fixed Equipment, Fixed Facilities, LRVs, and Trains under Normal, Alternate Train Service and Emergency operating conditions; and
- exercise and confirmation of the operational security of all Systems, Fixed Equipment, Fixed Facilities, LRVs, and Trains under Normal, Alternate Train Service, and Emergency operating conditions.

4.6.2 Scope of Trial Running

Concessionaire shall conduct Trial Running for as long as is required to successfully complete all Trial Running requirements.

Concessionaire shall demonstrate that there are no deficiencies to prevent reliable, safe and secure operation of the Purple Line System.

Concessionaire shall demonstrate that an adequate number of fully trained operations and maintenance staff are available to operate, maintain and manage the Purple Line System.

Trial Running performance shall be reviewed daily by Concessionaire's Operational Readiness team and any issues identified shall be documented and fixed promptly.

During the Trial Running period, tests shall be performed to demonstrate response to a variety of service impact scenarios that could reasonably be expected to occur during Normal Service. Owner will Review and Comment on the proposed service impact scenarios and may request additional scenarios be included.

Concessionaire shall perform simulated Emergency drills at selected sites along the Transitway. Concessionaire shall coordinate with Owner and Emergency Services. The drills shall verify the adequacy of Concessionaire's Final Operating Plan to address Emergencies, and that Emergency Services personnel are prepared to adequately respond to Emergencies on the Project. Owner shall determine what Emergency Services personnel shall participate in individual drills from Owner, Prince George's County, Montgomery County, State Highway Administration, University of Maryland and WMATA. Emergency drills shall be developed and conducted to:

- familiarize Emergency Services personnel with Purple Line Systems, Fixed Facilities, Fixed Equipment, LRVs, Trains, operations and inherent hazards;
- familiarize and train Emergency Services personnel in Concessionaire's Rule Book for responding to Emergencies and Incidents and Standard Operating Procedures for Emergency conditions;
- train, evaluate and confirm that operations and maintenance staff act in coordination with Emergency Services personnel;
- confirm that Project has available all necessary specialized appliances and equipment needed to support Emergency Services personnel;

- evaluate and identify improvements to response procedures before an actual Emergency or Incident occurs; and
- maintain an adequate level of preparation for a possible Emergency or Incident.

Concessionaire shall measure the actual run times in accordance with Part 3, Section 3.15 of the Technical Provisions, and complete the Revenue Service Demonstration.

4.6.3 Performance Criteria for Trial Running

Concessionaire shall use Trial Running to collect operational data to evaluate system reliability, availability, maintainability, safety and security performance and to demonstrate that the process to collect, evaluate and validate the operating data has been properly established. Using prepared procedures, data on service deviations shall be collected and assigned to responsibility causes. This database shall provide verification of system and equipment reliability to the lowest replaceable unit (LRU) level. Concessionaire shall prepare all performance reports required in Part 3, Section 1.13 of the Technical Provisions.

Trial Running shall demonstrate to Owner that the Concessionaire has met the required run times, Headways and performance requirements and that the availability and reliability requirements established by the Concessionaire in the System Reliability Analyses shall be achieved during Trial Running. Concessionaire's failure to demonstrate the ability to meet these requirements shall cause Trial Running to continue until the performance requirements are successfully demonstrated.

Trial Running shall demonstrate to Owner that the Purple Line System meets all Test Program requirements.

4.6.4 Total Trip Run Time Demonstration

Prior to Revenue Service demonstration and as part of the Trial Running period, Concessionaire shall perform Total Trip Run Time demonstrations, special tests, and analysis in accordance with the Measurement Process Plan developed under Part 3, Section 3.15 of the Technical Provisions. Such activities shall be performed to calculate the actual Total Trip Run Time ("Ttot") for the Project and to determine any differences between the assumptions for traffic signals and traffic congestion ("Tsc") included in Table AA-5 of Attachment 3 to Exhibit 2 of the Agreement and actual traffic conditions. Concessionaire shall notify Owner in writing no less than 30 days prior to the scheduled start of the first such activities. Owner shall participate in all such demonstrations, special tests, and analysis in accordance with Part 3, Section 3.15 of the Technical Provisions.

Upon completion of the analysis Concessionaire shall provide a report to Owner documenting the results as described in Part 3, Section 3.15.3 of the Technical Provisions and if the report identifies any differences in Tsc requiring an adjustment to the requirements of the Contract Documents, the Parties shall proceed as described in Section 8.3 of the Agreement.

4.7 Readiness for Revenue Service

Prior to the start of Revenue Service, Concessionaire shall prepare and submit for Review and Approval evidence that Concessionaire is ready to start Revenue Service and, if found to be satisfactory, that all other conditions for Revenue Service described in the Section 7.10.2 of the Agreement have been met, the Independent Engineer may issue the Independent Engineer's Certificate of Revenue Service Availability. Evidence that Concessionaire is ready to start Revenue Service shall include at a minimum the following:

- Safety and Security Certification Certificate of Completion;

- certification with supporting documentation that all inspections and tests that are not required for the Safety and Security Certification Certificate of Completion have been satisfactorily completed;
- certification with supporting documentation that all Rail Activation activities required to be completed prior to the start of Revenue Service have been successfully completed;
- certification with supporting documentation that any other activities identified in the Operational Readiness Plan/Strategy that are required to start Revenue Service have been successfully completed;
- certification with supporting documentation that all operations and maintenance preparatory activities required for the start of Revenue Service have been successfully completed; and
- certification with supporting documentation that all testing and operational preparedness activities required to be performed during Trial Running have been successfully completed.

Any and all items of work that Owner does not require to be completed prior to the start of Revenue Service (i.e. punch list items) shall be completed prior to Final Completion in accordance with Section 7.10.4 of the Agreement.

4.8 Summary of Submittals

Item	Section	Submittal	Action
1	4.2	Operational Readiness Plan/Strategy	Review and Comment
2	4.2	Operational Readiness Progress Status Reports	Review and Comment
3	4.5	Safety and Security Certification - Certificate of Systems Integration Testing Completion for Trial Running	Review and Approval
4	4.5	Non Safety and Security Certification - Systems Integration Testing for Trial Running Certification	Review and Approval
5	4.5	Completion of Rail Activation Activities for Trial Running Certification	Review and Approval
6	4.5	Completion of Other Operational Readiness Plan Activities for Trial Running Certification	Review and Approval
7	4.5	Completion of O & M Preparatory Activities for Trial Running Certification	Review and Approval
8	4.6.2	Service Impact Scenarios	Review and Comment
9	4.7	Safety and Security Certification - Certificate of Completion	Review and Approval
10	4.7	Non Safety and Security Certification – Completion Certification	Review and Approval
11	4.7	Completion of Rail Activation Activities for Revenue Service Certification	Review and Approval
12	4.7	Completion of Other Operational Readiness Plan/Strategy Activities for Revenue Service Certification	Review and Approval
13	4.7	Completion of O & M Preparatory Activities for Revenue Service Certification	Review and Approval
14	4.7	Completion of All Testing and Operational Preparedness Activities during Trial Running Certification	Review and Approval

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