



Long Island Rail Road
East Side Access

CONTRACT DOCUMENT

Specifications

Contract CM009 (Re-Bid) **Manhattan Tunnels Excavation**

BOOK 3 of 5
May 2006

CONFORMED, Addenda 1-10 Incorporated



Metropolitan Transportation Authority
Capital Construction
State of New York

Professional Engineer's Seals

Specification Sections:

02220, 02254, 02300, 02820, 03605,
10290, 02239, 02270, 02406, 02407,
02410, 02413, 02414, 02425, 02495,
03370, 03375, 03100, 03200, 03300,
04200, 05120, 07122, 07124, 08130,
15050, 15205, 13115, 16062

Original
Signed
&
Sealed

General Engineering Consultant (Parsons Brinckerhoff Quade & Douglas, Inc.)

Specification Sections:

02105, 02145, 02290, 02372, 02950

Original
Signed
&
Sealed

General Engineering Consultant (STV Incorporated)

Specification Sections:

13430, 13850, 16050, 16060, 16120,
16154, 16210, 16240, 16270, 16340,
16950

Original
Signed
&
Sealed

General Engineering Consultant (Parsons Transportation Group of New York, Inc.)

Specification Sections:

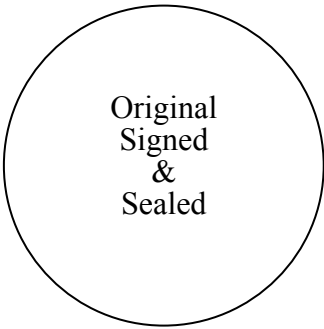
13280

Original
Signed
&
Sealed

Matrix Environmental & Geotechnical Services

It is a violation of the Professional License Law for any person to alter these documents in any way unless that person is acting under the direction of a licensed professional. The licensed professional shall affix to these documents the seal and the notation "Altered By", followed by the authorized signature and the date of the alteration.

Specification Sections:
02269, 02427, 03305



General Engineering Consultant (Parsons Brinckerhoff Quade & Douglas, Inc.)

It is a violation of the Professional License Law for any person to alter these documents in any way unless that person is acting under the direction of a licensed professional. The licensed professional shall affix to these documents the seal and the notation "Altered By", followed by the authorized signature and the date of the alteration.

DIVISION 1 - GENERAL REQUIREMENTS

01110	Summary of Work
01140	Work Restrictions
01160	Work Affecting the Railroad
01165	Railroad Construction Safety
01270	Measurement and Payment
01320	Construction Progress Documentation
01330	Submittal Procedures
01380	Code Compliance
01450	Quality Control Procedures
01515	Tunnel Communications
01520	Construction Facilities
01540	Safety Planning and Supervision
01545	Construction Safety and Health
01555	Maintenance and Protection of Traffic
01568	Construction Security
01570	Environmental Compliance
01572	Construction Noise and Vibration Control
01580	Project Identification
01592	East Side Access Project Office
01720	Surveying and Layout
01730	Operation and Maintenance Data

DIVISION 2 - SITEWORK

02105	Chemical Sampling and Analysis
02145	Groundwater Treatment System
02220	Site Demolition
02239	Tunnel Dewatering
02254	Maintenance, Protection, and Support of Existing Shafts, Tunnels, Facilities, Structures, and Utilities
02269	Permanent Rock Anchors
02270	Rock Reinforcement and Initial Support
02290	Environmental Monitoring, Well Construction, Protection, Maintenance, and Abandonment
02300	Earthwork
02372	Soil Erosion and Sedimentation Control
02406	Tunnel Excavation by TBM
02407	Tunnel and Cavern Excavation by Drill and Blast
02410	Muck Handling and Disposal
02413	Tunnel Boring Machine (TBM)
02414	Controlled Blasting
02425	Cast-in-Place Concrete Lining
02427	Precast Concrete Tunnel Linings
02495	Geotechnical and Structural Instrumentation
02820	Fences and Gates
02950	Street and Site Restoration

DIVISION 3 - CONCRETE

03100	Concrete Formwork
03200	Concrete Reinforcement
03300	Cast-in-Place Concrete
03305	Steel Fiber Reinforced Concrete
03370	Shotcrete
03375	Shotcrete Lining
03605	Tunnel Grouting

DIVISION 4 – MASONRY

04200	Unit Masonry
-------	--------------

DIVISION 5 - METALS

05120	Structural Steel
-------	------------------

DIVISION 6 – WOOD AND PLASTICS

NOT USED

DIVISION 7 – THERMAL AND MOISTURE PROTECTION

07122	Waterproofing - Cavern Structures and Tunnel
07124	Waterproofing - Bellmouth

DIVISION 8 – DOORS AND WINDOWS

08130	Custom Hollow Metal Stainless Steel Doors and Frames
-------	--

DIVISION 9 - FINISHES

NOT USED

DIVISION 10 - SPECIALTIES

10290	Rodent Control
-------	----------------

DIVISION 11 – EQUIPMENT

NOT USED

DIVISION 12 - FURNISHINGS

NOT USED

DIVISION 13 – SPECIAL CONSTRUCTION

13115	Corrosion Control System Testing
13280	Lead Paint Management
13430	AC Control Cabinet for Medium Voltage Substation Work
13850	Fire Detection and Alarm System for Medium Voltage Substation Work

DIVISION 14 – CONVEYING SYSTEMS

NOT USED

DIVISION 15 - MECHANICAL

15050	Basic Mechanical Materials and Methods
15205	Tunnel Drainage System

DIVISION 16 - ELECTRICAL

16050	Basic Electrical Materials and Methods for Medium Voltage Substation Work
16060	Grounding and Bonding for Medium Voltage Substation Work
16062	Bonding for Corrosion Control
16120	Wire and Cable for Medium Voltage Substation Work
16154	Auxiliary Electrical Equipment for Medium Voltage Substation Work
16210	Electrical Utility Services for Medium Voltage Substation Work
16240	Battery Power System for Medium Voltage Substation Work
16270	Medium Voltage Dry-Type Power Transformers for Medium Voltage Substation Work
16340	Medium Voltage Metal-Clad Switchgear for Medium Voltage Substation Work
16950	Testing for Medium Voltage Substation Work

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 DESCRIPTION OF WORK**

- A. The work of this Contract shall include, but not be limited to, the following:
1. The construction of tunnels excavated in rock from the existing rock faces west of the end of the existing approach tunnels, to the terminus of the tail tracks at East 38th Street and Park Avenue.
 2. The majority of the tunnels shall be excavated by utilizing tunnel boring machines (TBMs). Four TBM drives are required using two TBMs.
 3. Controlled drilling and blasting methods shall be utilized to excavate approach tunnels, TBM assembly chamber and adjoining starter tunnels, GCT 3 wye caverns and GCT 5 wye caverns with adjoining starter tunnels, cross passages, drainage pump room, central instrument room and cross flue.
 4. Installation of initial support in newly excavated tunnels, TBM assembly chamber with starter tunnels, GCT 3 wye caverns and GCT 5 wye caverns with adjoining starter tunnels, cross passages, drainage pump room, central instrument room, and cross flue; and pre- and post-grouting to meet inflow limitations.
 5. Installation of waterproofing, reinforced cast-in-place concrete tunnel lining or precast tunnel lining, reinforced cast-in-place arch lining in GCT 3 and GCT 5 wye caverns, cross-passages, central instrumentation room, cross flue, and drainage pump room, including specified contact grouting, drainage lines, and cleanouts.
 6. Removal of concrete overlay in the existing 63rd Street Tunnel.
 7. Installation of permanent structural invert and reframing of existing tunnel at Bellmouth.
 8. Upgrade, operation, maintenance, and extension of existing temporary construction utilities, throughout the Contract work areas, as required, to support construction. Installation, operation, and maintenance of new temporary construction utilities, throughout the Contract work areas.
 9. Furnish, install, and maintain geotechnical and structural instrumentation to be installed within the excavated tunnels and caverns, on the surface of existing structures along the alignment and within NYCT tunnels.
 10. Design, furnish, install, and maintain East Side Access Project Office at MTA's property at 63rd Street and Second Avenue.
 11. Provide furnishings, equipment, and parking for Resident Engineer and staff. Provide maintenance, utilities, and supplies for Resident Engineer's Office.

12. Transport excavated material (muck) to the Queens open-cut. Transport all TBM tunneling muck by elevated conveyor across Northern Boulevard to the loading facility in the existing rail yard and be transported to an off-site disposal area or beneficial re-use location.
13. Contractor's tunnel access and egress for personnel, equipment, muck transportation, and material delivery shall be through the Queens open-cut.
14. Maintain the existing LIRR 63rd Street tunnel and the Queens open-cut for the duration of this Contract.
15. Contractor shall be responsible for access, use, and maintenance of existing facilities, including, but not limited to, the following:
 - a. Ventilation equipment and ducts including two fans at existing Second Avenue substation.
 - b. Lighting on-site, in the tunnels, and access open-cut.
 - c. Temporary electrical services throughout the tunnels and access open-cut including wiring, connections, switches, boxes, transformers, and associated electrical equipment.
 - d. Construction water supply lines.
 - e. Dewatering discharge lines, pumps, and fittings.
 - g. Water treatment facilities.
 - h. Site fencing.
 - i. Noise barrier walls.
 - j. Stair towers.
 - k. Mining power cables
 - l. Mid-Channel Interceptor Pumps (NYCT Plant No. 4105)

Information on these facilities is provided as reference documents.

16. Design, furnish, install, test, commission, operate, and maintain an interim electrical system. The interim electrical system shall support Contractor's construction activities at the initial stage of the Project, and during the construction period for the medium voltage power substation. The electrical work shall include, but not be limited to, utility services and/or on site power generation; medium and low voltage power distribution within the existing tunnels and Queens site work areas; power and control wiring for temporary tunnel ventilation and temporary tunnel drainage systems; and upgrade of the existing lighting system within the existing tunnels. Pay all fees and all electric energy and fuel costs for operating the interim electrical services.

17. Design, furnish, install, test, commission, operate, and maintain a temporary electrical power system. After the medium voltage construction power substation is operational, reconnect all active construction loads from the interim electrical system to the temporary electrical system, and dismantle the remaining part of the interim system, including electrical service(s). The electrical work shall include, but not be limited to, medium and low voltage power distribution within the existing and new tunnels, caverns and chamber; power and control wiring for temporary tunnel ventilation and temporary tunnel drainage systems; new temporary lighting system within the new tunnels. Pay all fees and all electric energy and fuel costs for operating the temporary electrical services.
18. Design, furnish, install, test, commission, operate, and maintain a temporary tunnel ventilation system. Utilize existing equipment and shafts, to the extent which is practical, to provide temporary ventilation for the underground work areas in accordance with 29 CFR 1926 (OSHA) requirements, local codes and industry standards. Extend temporary ventilation system for the full extent of the underground tunneling work. The temporary ventilation system shall include, but not be limited to, fans, ductwork, sound attenuation provisions, air monitoring provisions, discharge treatment provisions and controls. Obtain any required permits, and coordinate power requirements with the temporary electrical system.

The Contractor should be aware that several shafts/adits will be excavated under a separate MTA-ESA contract prior to the completion of the Upper TBM drives. This work is shown in the reference drawings and includes Shaft #5. The use of this shaft as part of ventilation system for this contract can be considered and shall be coordinated through the Resident Engineer. Contractor may use Shaft #5 for personnel access and small tools. Additionally, Shaft #1 (located approximately 1,050-feet south of Shaft #5) may be used for delivery of concrete.

19. Design, furnish, install, test, commission, operate, and maintain a temporary tunnel drainage system. Utilize existing equipment and drain lines, to the extent which is practical, to provide temporary drainage for the underground work areas in accordance with local codes and industry standards. Extend temporary drainage system for the full extent of the underground tunneling work; construct sumps at low points. The temporary drainage system shall include, but not be limited to, pumps, pipelines, valves, flow monitoring provisions, discharge treatment provisions and controls. Obtain any required permits, and coordinate power requirements with the temporary electrical system.
20. Design, furnish, install, test, commission, operate, and maintain temporary water supply and compressed air systems. Utilize existing equipment and pipelines, to the extent practical, to provide temporary systems for the underground work areas in accordance with local codes, FDNY requirements, NFPA 130, and industry standards. Extend temporary systems for the full extent of the underground tunneling work. Provide backflow prevention devices and fire hose valve connections as part of the temporary water system; provide compressed air in accordance with tunnel construction equipment requirements. Obtain any required permits, and coordinate power requirements with the temporary electrical system.

21. Design, furnish, install, test, commission, operate, and maintain a temporary lighting system. Utilize existing equipment and wire connections, to the extent which is practical, to provide temporary lighting for the underground work areas in accordance with OSHA requirements, local codes and industry standards. Extend temporary lighting system for the full extent of the underground tunneling work. Select temporary fixtures that are consistent with heavy construction applications. Utilize portable lighting provisions, as necessary, within isolated work areas. Provide adequate illumination levels for emergency lighting, and coordinate power connections with the temporary electrical system
22. Provide the detailed engineering and design, obtain Consolidated Edison (ConEd) approvals, furnish, install, test, commission, operate, and maintain an underground medium voltage power substation and associated appurtenances at Second Avenue and East 63rd Street in the LIRR Underground Traction Power Substation Enclosure in Manhattan. Contractor's work shall include, but not be limited to, the following:
 - a. Detailed engineering and design of the substation in conformity with the ConEd requirements, specifications, and standards, including obtaining all required approvals. A Professional Engineer licensed in the State of New York shall perform detailed engineering and design of the substation. The work shall include, but not be limited to, three permanent property line manholes; duct banks from the manholes to the substation; indoor splice/pull boxes (one per service feeder circuit); ventilation system using existing intake and exhaust openings; lighting, fire alarm, and security system grounding system; short circuit study and protective relay coordination and settings; and review and approval of all submittals from equipment vendors.
 - b. Substation equipment and installation shall consist of 15-kV metal-clad switchgear, and ground and testing devices; cast coil (or resin encapsulated) 13.2-kV isolation transformers; AC switchgear control panel and annunciator panel; two - 125-volt DC batteries and chargers; power and control wiring with raceways; fire alarm system; ventilation system; and grounding system.
 - c. Construction includes maintenance and protection of traffic, excavation and support, property line manholes and duct banks, backfill, curb and street restoration.
 - d. Test, energize, and commission of underground medium voltage power substation.
 - e. Obtain permits, approvals, and pay all charges and fees.
 - f. Operate and maintain the underground medium voltage power substation as required; pay energy costs and all associated operation and maintenance costs; and provide spare parts and training as specified in Division 16 of these Specifications.

- g. Although the MTA has provided reference drawings and made underground space available in the existing Ventilation Building at 63rd Street and 2nd Avenue for a medium voltage substation to power the Contractor's TBMs, the Contractor has the option and prerogative to locate the medium voltage substation in the existing Rail Yard Queens, if approved by Con Edison and the Resident Engineer.

If the Contractor elects to locate the facility at a location other than 2nd Ave., then the East Side Access Project Office does not have to be completed, but the surface site must be regularly maintained as specified in Section 01592.

23. Provision of the necessary works and measures to ensure appropriate environmental compliance, construction dust, noise and vibration control, and mitigation of detrimental effects. Refer to Sections 01570 and 01572 for further details.
24. Install manhole and sewer connection at the Queens Work Site.
25. Operate, maintain, and upgrade existing sumps, oil separators, sedimentation basins, and water treatment plants, as necessary. Maintain PH and turbidity of wastewater discharges to meet NYCDEP requirements.
26. Identify and protect existing wells at the Queens open-cut working area installed by others for the duration of the Contract. Provide access to the Resident Engineer for monitoring and sampling purposes for the duration of the Contract.
27. Removal of miscellaneous metal containing Lead Based Paint in the existing 63rd Street Tunnel.
28. Removal of abandoned elevator plungers and/or casings at East 45th Street.
29. The general details of construction and the locations of the work are indicated more specifically on the Contract Drawings

1.02 REFERENCED SECTIONS

- A. Division 16 - Electrical
- B. Section 01592 - East Side Access Project Office

1.03 CITED STANDARDS

- A. National Fire Protection Association (NFPA)
 1. 130 - Fixed Guideway Transit and Passenger Railway Systems

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL**A. Regulatory Requirements:**

1. Code of Federal Regulations (CFR)
 - a. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)
2. New York City Department of Environmental Protection (NYCDEP)

1.06 SUBMITTALS

None Listed

1.07 DELIVERABLES

None Listed

1.08 MISCELLANEOUS AND INCIDENTAL WORK

- A. In addition to the construction of the Project and its appurtenances, it will be necessary for Contractor to do various miscellaneous and incidental items of work that are generally referred to in the General Terms and Conditions Article 1.01, "SERVICES TO BE PROVIDED".

PART 2 PRODUCTS**2.01 GENERAL**

- A. Except as otherwise indicated materials, products, and equipment furnished or provided shall be new, of current design, and produced by a manufacturer regularly engaged in the production of such materials, products, and equipment.
 1. Materials, products, and equipment of like description shall be products of the same manufacturer.

PART 3 EXECUTION**3.01 LOCATION**

- A. The location of the Work Site is shown on the Contract Drawings.

3.02 WORK BY THE RAILROAD

- A. Subject to the conditions and limitations specified elsewhere, furnishing of flaggers will be as required for performance of the work on, adjacent to, or in the vicinity of the Railroads' right-of-way.

3.03 PRE-CONSTRUCTION MEETING

- A. The Resident Engineer will conduct a pre-construction meeting within ten days after the Notice of Award. Contractor and each Subcontractor shall attend.

3.04 PROGRESS MEETING

- A. The Resident Engineer will conduct weekly progress meetings. Contractor and each affected subcontractor shall attend.
- B. As a minimum, the progress meeting attendees shall review:
1. Minutes from the previous meeting
 2. The schedule and progress of the Work since the last meeting
 3. Impacts to Railroad operations resulting from the Work including scheduled flagging requirements and need for General Orders
 4. Status of submittals and requests for information (RFIs)
 5. Safety issues including Work Site conditions as required
 6. Quality issues, non-conformances and corrective actions
 7. Compliance with work plans, environmental plans, health and safety plans, and security plans
 8. Address new issues and unresolved issues
 9. Coordination with other Contracts

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements and provisions for Work restrictions including, but not limited to: Work to be cleared; waste material; storage of materials; access requirements; and temporary construction; and archaeological discoveries.

1.02 REFERENCED SECTIONS

- A. Section 01160 – Work Affecting the Railroad
- B. Section 01520 – Construction Facilities
- C. Section 01545 – Construction Safety and Health

1.03 CITED STANDARDS

- A. National Fire Protection Association (NFPA):
 - 1. 70 - National Electric Code (NEC)

1.04 NOTED RESTRICTIONS

- A. Propose working methods and schedules for all Work of the Contract in accordance with the provisions specified herein for review by the Resident Engineer. Such methods and schedules must allow for the safe and continuous operation of the Railroad without any interruption of service or change in regular schedules of train operation except as may be specified.
- B. Flame cutting work to be performed on or adjacent to existing Railroads on MTA property will only be permitted with the use of a stable compressed gas such as MAPP Products “MAPP Gas”, or approved equal, in accordance with manufacturer’s recommendations.
- C. The amount of oxygen or MAPP-type gas available for Contractor’s use within MTA’s underground structures, or in confined spaces, may not exceed one day’s required supply. All such tanks shall be removed from the area daily at the conclusion of the Work. Before their removal, gauges shall be removed and protective caps installed. In addition to the above requirements, comply with all conditions of the FDNY Permit.
- D. Before commencement of welding, cutting or any other spark-producing operation, Contractor’s Safety Supervisor or designee shall issue a Hot Work Permit. No work requiring welding, cutting, or any other spark-producing operation will be allowed in MTA facilities without a Hot Work Permit in place.
- E. Where storage of material or equipment along the trackways is permitted by the Resident Engineer, the following restrictions shall apply:
 - 1. No storage will be permitted where storage will create a no-clearance condition based on personnel clearance diagrams.

2. No storage will be permitted on the side of track designated for personnel “clear-up”.
 3. Other restrictions on storage shall be applicable to suit specific Work Site conditions.
- F. Power Equipment: The use of gasoline, butane, or propane powered equipment in trenches or underground is prohibited. Appropriate electric or air operated equipment and diesel powered equipment equipped with catalytic converters are permitted for use.
- G. Contractor is advised that other contractors may be in areas adjacent to the Work Site during the Work of this Contract. Cooperate with other contractors or utility companies, and shall coordinate its Work with that of other contractors as required in the General Terms and Conditions Article 4.01 - “COORDINATION AND COOPERATION WITH OTHER CONTRACTORS, UTILITIES, AND OTHER PUBLIC AGENCIES”, and as required by the Resident Engineer.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
1. Administrative Code of the City of New York, Title 24, Section 24-216, Noise Abatement Contract Compliance, NYC Noise Control Code
 2. New York City Building Code (NYC Code) Article C26-1901.5, 27-1021 - Protection of Sidewalks
 3. New York City Department of Environmental Protection (NYCDEP)
 4. New York City (NYC) Electrical Code
 5. New York City Fire Department (FDNY)
 6. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)
 7. U. S. Environmental Protection Agency (USEPA)

1.06 SUBMITTALS

- A. Submit plans for storage of material adjacent to the Railroad.

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS**2.01 MATERIALS FOR TEMPORARY CONSTRUCTION**

- A. Lumber shall be new Douglas Fir, sound and square edged, and free from shakes, loose knots, and decay.
- B. Lumber shall be preservative treated with water-borne preservatives. Creosote and coal tar solutions, and oil-borne preservatives will not be permitted.
- C. Hardware fasteners, such as nails, spikes, screws, and bolts shall be galvanized.
- D. Paints shall be first-line products of nationally known manufacturers. Paint shall be colorless alkyd type and fire-retardant.

PART 3 EXECUTION**3.01 STORAGE OF MATERIAL**

- A. Storage of Materials Within MTA Property: A reasonable amount of material as may be necessary to avoid delay in construction or installation shall be stored on-site.
- B. If Contractor elects to erect enclosures on MTA property, make request in writing to the Resident Engineer for permission to construct the enclosures. Determine the size and design of the enclosures that will best suit its needs. Provide all lighting, heating, ventilation, and other facilities necessary for its own convenience. The enclosures shall be constructed, maintained, and removed as determined by the Resident Engineer.
- C. If required by the Resident Engineer, remove such stored material immediately. Keep walkways, accessways, and driveways free of all material and encumbrances at all times.

3.02 ACCESS

- A. Access to Fire Hydrants and Fire Alarm Boxes:
 - 1. Whenever the Work is being carried on, free access must be given to every fire hydrant and fire alarm box and connection to standpipe and, when required, extend fire hydrants by suitable tube or piping to an accessible point and to the satisfaction of the FDNY. Materials shall not be piled or placed within 15-feet of any fire hydrant or fire alarm box. Where materials are unavoidably piled or placed near a fire hydrant or fire alarm box to such height as to prevent the same from being readily seen, indicate the position of such fire hydrant or fire alarm box by suitable signals, both day and night.

2. Maintain, and protect the wires, cables, ducts, manholes, posts and poles, signals and fire alarm boxes of the FDNY. Do not cause the interruption of the FDNY Fire Alarm Telegraph Service. Do not disturb FDNY wires, cable, ducts, manhole, post or pole, signal or fire alarm box except in the presence of a representative of the Bureau of Fire Alarm Telegraph. In case any such wire, cable, duct, manhole, post or pole, signal or fire alarm box may be disturbed, restore to original condition, and notify FDNY of the location and fact of such disturbance and restoration.
- B. Access to Buildings: Provide and maintain every access for entrance to and exit from adjacent buildings and property at all times. Where access for the delivery or removal of commodities or for the removal of refuse to or from any adjacent property is temporarily cut off because of occupancy of the street by Contractor, render every assistance to the owner or occupant in the handling of such commodities or refuse of any description, including all refuse to be removed by the New York City Department of Sanitation (NYCDOS), as may have to be taken to or removed from such property; such commodities or refuse shall be taken by Contractor to or from the nearest accessible point that, in the opinion of the Resident Engineer, is convenient for handling.

3.03 ARCHAEOLOGICAL DISCOVERIES

- A. Immediately report all articles of archaeological interest that may be uncovered during the progress of the Work to the Resident Engineer. The further operations of Contractor with respect to the find will be determined under the direction of the Resident Engineer. Deliver said articles to the MTA for proper disposition as required by the Resident Engineer.

3.04 WORK TO BE CLEARED

- A. Keep the Work Site, adjacent streets and sidewalks in Queens, and the existing MTA facility site at 63rd Street and Second Avenue in Manhattan, and all public places occupied during the course of the Project clear of all refuse, rubbish, and debris that may accumulate from any source whatever, and leave them in a clean and neat condition to the satisfaction of the Resident Engineer.
- B. In addition to requirements for clean-up and maintenance of the Work Site, keep in a cleared and clean condition, including snow removal and the placement of sand and/or salt as required, the following adjoining public areas:
1. All Queens Work Site entry and exit locations, including pedestrian entrances.
 2. All sidewalks along the Queens Work Site boundaries and sidewalks along 63rd Street and Second Avenue in Manhattan adjacent to the MTA facility.
 3. Maintain site within the fenced area of Block No. 1437 Lot No. 49 for the duration of the Contract. Maintenance shall include watering of plantings, trimming of hedges, cutting grass, and removal of cuttings, leaves, and debris. Access to the fenced-in site shall be coordinated through the Resident Engineer.

3.05 WASTE MATERIAL

- A. Waste Material: Waste material will not be permitted to remain on the Work Site or access streets, but must immediately be removed by Contractor. Thoroughly clean and keep clean all roadways, sidewalks, and other public places in which the Work is to be done or which are to be used in connection therewith. Protect such areas against unauthorized dumping of waste material by others and remove such material pursuant to legal requirements and the requirements as specified herein. Do not dump waste material in or on any part of the City's property except by special permission of the Resident Engineer. Do not wash out concrete mixing trucks and grouting operation equipment onto City streets and do not discharge the waste material from the washing out of concrete mixing trucks into any sewer manhole, catch basin, sewer, or street.
- B. The Resident Engineer reserves right to have waste material removed at Contractor's expense: In case waste material, refuse, debris, and/or rubbish is not removed from the Work by Contractor as specified, the Resident Engineer reserves the right to have the said waste material, refuse, debris, and/or rubbish removed by MTA forces or others, and the expense of said removal and disposal will be charged to Contractor and the amount of such expense will be deducted from any monies due or becoming due to Contractor hereunder.
- C. Rejected Material to be Removed: If any material brought to the Work Site for use in the Work or selected for same is rejected by the Resident Engineer as unsuitable or not in conformity with the Specifications, remove such material immediately from the Work Site.

3.06 PHASING

- A. Coordinate phasing and construction sequence of Work, including diversion work, with other projects under construction and as required by the Resident Engineer.

3.07 PROTECTION AGAINST FIRE

- A. Exercise the utmost care to avoid angles, recesses, or pockets in which papers or rubbish may collect and produce a fire hazard. Such covers or other provisions as may be necessary, in the opinion of the Resident Engineer, to prevent or counteract such fire hazards shall be installed by Contractor at its own expense.
- B. Install, maintain, and periodically inspect sufficient firefighting equipment of suitable types to provide ample firefighting protection in the work area for any type of fire that might occur therein. The equipment shall always be filled, in good condition, and in readily accessible locations. Fire extinguishers shall be Chemical ABC.

3.08 TEMPORARY CONSTRUCTION**A. Temporary Structures Within MTA Property:**

1. Temporary structures such as enclosures, shields, barricades, and bulkheads on or adjacent to Railroad operations within MTA property shall be constructed of metal, non-combustible, or fireproofed (fire-retardant pressure impregnated) materials. Paint and repaint temporary structures as required at intervals not to exceed six months.
2. Fireproofed (fire-retardant pressure impregnated) wood shall meet the requirements of the BCNYS.
3. Clearly identify all fireproofed (fire-retardant pressure impregnated) wood by impressing on both faces the type and grade of treatment and name of manufacturer.
4. Maintain all temporary structures graffiti-free. Remove all graffiti within 24 hours and repaint temporary structure(s) as required.

B. Fences and Temporary Buildings:

1. Wherever necessary and as required herein, erect and maintain fences for the protection of public travel, adjoining property, and adjoining public places.
2. Unless otherwise specified, all temporary buildings and fences shall be neat in appearance and substantially constructed of new Douglas Fir lumber. Paint, repaint, and repair such buildings and fences as required. Paint temporary buildings initially with two coats of an acceptable fire-retardant paint, colors as selected by the Resident Engineer, and thereafter, repaint with one coat of fire-retardant paint at intervals not to exceed 12 months; however, sidewalk sheds and barricades shall be painted at more frequent intervals specified herein. Fences shall be not less than 6-feet high and shall consist of a framework of studs and plates tightly covered.
3. Whenever illumination by artificial means becomes necessary to protect persons and property, as well as to prevent the commission of nuisances, furnish and maintain necessary lighting.
4. Equip all temporary buildings with acceptable fire extinguishers that are inspected periodically in accordance with manufacturer's recommendations.

C. Barricades and Sidewalk:

1. Erect barricades and sidewalk sheds for the protection of the Work or use of the public; they shall be substantial in character and neat in appearance. Paint and repaint barricades and sidewalk sheds as required, at intervals not to exceed six months, with two coats of an acceptable paint with colors as selected by the Resident Engineer.

2. Sidewalk sheds shall conform to NYC Code. Sidewalk sheds shall have no less than 12-feet vertical clearance.
3. Illuminate sidewalk sheds by artificial means between dusk and dawn. Furnish and maintain necessary lighting.

D. Temporary Electrical Lighting and Power:

1. Provide and maintain suitable temporary electrical lighting, power, and power facilities required for the proper performance and inspection of the Work until the final completion and acceptance of the Work under this Contract. Contractor will not be permitted to proceed with any portion of the Work if, in the opinion of the Resident Engineer, adequate lighting levels and power facilities are not provided.
2. Temporary wiring for light and power shall conform to the NYC Electrical Code.
3. Effectively ground all temporary wiring for light and power in accordance with the NEC Articles 250 and 305.
4. Wire and cable for temporary electrical lighting and power shall be of adequate size, shall be covered with insulation, and shall conform to the applicable sections of the NYC Electrical Code, the NEC, and the requirements of the MTA, as specified herein, whichever is more stringent. No frayed or broken insulation will be permitted. Keep power circuits separate from lighting circuits.
5. Take every precaution to make any necessary open wiring inaccessible to unauthorized personnel.
6. Equip temporary lighting with heavy-duty electric cords with connections and insulation maintained in safe condition. Keep cords clear of working spaces, walkways, and other locations where they may be readily exposed to damage.
7. Unless otherwise specified, furnish all energy for temporary power and lighting required for the performance of Work under this Contract.

E. Water Supply and Shut-off for Water Pipes:

1. Provide the water supply necessary for Work of this Contract, bear the cost of water usage and any inspection charge in connection therewith.
2. Project Fire Hydrant: The on-site construction fire hydrant located near the pedestrian entrance gate along Northern Blvd. is available for use by Contractor. MTA makes no representation that the Project fire hydrant is adequate or suitable to meet Contractor's requirements. Contractor will be permitted to use this hydrant as a source of water supply for other than fire protection, subject to the following requirements:
 - a. Installation of RPZ devices per NYCDEP regulations.

- b. Arrangements are made with NYCDEP for the payment of water usage.
- c. Contractor does not have exclusive use of this hydrant, which will also be made available for use by adjacent contractors. Maintain access to the hydrant at all times.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements and provisions for the Work affecting the Railroad. For purposes of this Section, the term “Railroad” shall mean the Long Island Rail Road (LIRR), Metro-North Railroad (MNR), New York City Transit (NYCT), the National Railroad Passenger Corporation (Amtrak), and the New York and Atlantic Railway (NYAR), as indicated on the Contract Drawings and or specified herein.
- B. It is anticipated Contractor shall carry out Work on or adjacent to the Railroad during the course of this Contract that shall require flag protection, track outages and/or power outages. Except as noted and subject to requirements herein, Railroad force account resources will be provided to Contractor at no cost.

1.02 REFERENCED SECTIONS

- A. Section 01545 – Construction Safety and Health

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Use of Railroad property shall be restricted as follows, unless specifically authorized.
 - 1. All workers must maintain a distance of no less than 25-feet from the centerline of track.
 - 2. Any tools and equipment being utilized must not extend closer than 25-feet from the centerline of track.
 - 3. No worker shall be permitted to cross the railroad tracks at any location without the permission of the railroad employee in charge of providing worker protection.
 - 4. No tools or working materials are permitted to be left along the Railroad right-of-way.
 - 5. In no event shall equipment or material be transported across a track or tracks without permission and inspection, as required, and appropriate flagging protection.
 - 6. All personnel, equipment, and materials to be used during construction shall be kept at all times at least 15-feet from all electrical, signal and communication systems unless protected by Railroad personnel.
 - 7. All personnel, equipment, and materials to be used during construction in electrified territory shall also be kept at all times at least 15-feet from overhead trolley, messenger, static, and transmission lines unless clearance and protection is provided by qualified Railroad electrical employees.

8. Blasting shall not be permitted on or along the right-of-way without prior written permission of the Resident Engineer.
9. In advance of any Work scheduled on Railroad property, successful completion of a required Roadway Worker Protection (RWP) class is mandatory for all employees that plan to work on the property. RWP Refresher Training is required on an annual basis. Contact the Resident Engineer to schedule the required training sessions. MTA will provide the railway safety trainer and facilities for the safety training at no cost to Contractor.
10. Installed instrumentation devices and associated items including but not limited to piping, boxes, cabling, conduit, and any other equipment and their connections shall not encroach into the dynamic train envelop as indicated on clearance diagrams included in this Section.

1.05 QUALITY CONTROL

- A. Regulatory Requirements: Refer to ESA Railroad Interface Manual.
 1. Federal Railroad Administration (FRA):
 - a. 49CFR 214, Subparts A and C
 2. Long Island Rail Road (LIRR):
 - a. Appendix D - Timetable and Special Instructions
 - b. Roadway Worker Protection Manual
 3. Metro-North Railroad (MNR):
 - a. Roadway Worker Safety Manual (RW-1), Effective April 3, 2005
 - b. Operating Rules(MN-400), Effective April 3, 2005
 4. New York City Transit (NYCT):
 - a. Operations Training – Track Safety Participant’s Guide
 5. Amtrak:
 - a. Amtrak Northeast Corridor Operating Rules and Instructions
 - b. Norac Operating Rules
 - c. Amtrak Electrical Operating Instructions-AMT-2

- B. At all times comply with the requirements of the Contract Documents as to the disposal and handling of materials, placing of lights, use of scaffolding, shields, and other structures, and with all other reasonable requirements for the purpose of avoiding interference with the safe and continuous operations of the Railroad and of avoiding interference with or injury to passengers and employees of the Railroad or the public.

1.06 SUBMITTALS

- A. Railroad Work Plans:
 - 1. For any Work to be performed within, below or above the right-of-way that may affect railroad operations and/or safety, provide a written Railroad Work Plan for review not less than 15 days before commencing said Work. The detailed Railroad Work Plan shall include the dates and times of proposed Work, methods of construction, and an estimation of type and duration of flagging, track outages, work trains, and/or related force account protection.
 - 2. Whenever in the judgment of the Resident Engineer Work within or above the Railroad's right-of-way may affect or involve the safe movement of its trains, the time and method of doing such Work shall first be submitted in writing to the Resident Engineer and reviewed by the MTA and the affected Railroad. This review shall not be considered as releasing Contractor from responsibility or liability for any damage which the Railroad or the MTA may suffer, or for which either the Railroad or the MTA may be held liable, by the action or omissions of Contractor or those of his subcontractors, or his or their employees.
- B. Engineering Data: In addition to any Railroad Work Plans, the following engineering data shall be required for proposed erection, demolition or other hoisting operations within, below, or above the right-of-way:
 - 1. A detailed plan showing location of cranes or hoisting devices (both horizontally and vertically), operating radii, positive stops, and delivery or disposal locations. The location of all tracks and other railroad facilities shall also be clearly shown (with distance and dimension information).
 - 2. Crane rating sheets showing cranes to be adequate for 150-percent of the maximum lift. Crane and boom nomenclature is to be indicated.
 - 3. Plans and computations are to be included with the submission showing weight of pick, safety factors and what Work is being performed over the railroad. Plans also must show a positive stop attachment and general plans of the existing and proposed facilities, showing complete and sufficient details with supporting data for the demolition or erection of the structure or hoisting operations.

4. A location plan showing all physical limitations, restrictions, or obstructions such as wires, poles, adjacent structures, etc., showing that the proposed swings are possible. In the event of any hoisting operation proposed to be adjacent to aerial lines, Contractor shall furnish the railroad with sufficient fluorescent orange rubber goods, as determined by the railroad, to be installed as an aid in visually locating the aerial lines and as additional protection.
 5. Plan shall include a listing of the type, size and arrangements of slings, shackles, or other connecting equipment. Include copies of catalog or information sheets of specialized equipment being used.
 6. A complete lifting procedure shall be included, indicating the order of lifts and any repositioning of crane or cranes including reattachment of positive stop.
 7. A time schedule of various stages shall be provided as well as a schedule for the entire lifting procedure. Temporary support of any components or intermediate stages shall be shown.
 8. All demolition and hoisting procedures and plans submitted shall be signed and sealed by a Professional Engineer licensed in the State of New York.
- C. Railroad Crossings: If a temporary crossing, other than those shown on the Contract Drawings, of railroad tracks is necessary, Contractor shall submit detailed plans to the Resident Engineer.
- D. Flag Protection Requirements: Provide Resident Engineer with a projection of flagger requirements, in writing, not less than 15 days in advance of the commencement of said Work to allow for sufficient flaggers to be available when required. This projection shall be updated by the first working day of every month.

1.07 DELIVERABLES

None Listed

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

- A. The Railroad shall maintain continuous operation during the performance of Work. The Work of this Contract shall be performed without interruption of or change in the regular schedule of operations of trains on the Railroad, except as herein expressly provided. No Work shall be performed on or affecting the Railroad until Contractor has received express written permission to proceed from the Resident Engineer.

- B. Cooperate at all times with officials of the Railroad and use all reasonable care and diligence in their work to avoid accidents, damage, any delay to or interference with railroad employees, officials, trains, other railroad operations, and other property of the Railroad.
- C. A special pre-construction meeting with Contractor, Subcontractor, representatives of the Railroad and the Resident Engineer shall be required before any work commencing on Railroad property (within the right-of-way).
- D. All construction operations within and over the limits of the Railroad's right-of-way shall be accomplished by methods which shall in no way cause damage to the tracks, facilities, aerial or underground lines, embankments or drainage systems. It shall be Contractor's responsibility to provide for protection of the tracks and embankments in a safe and satisfactory manner; to install and maintain such shoring, sheeting and bracing as may be required, and to remove and dispose of such protective facilities upon completion of the Work.
- E. All damage to Railroad property caused by Contractor's operations shall be repaired by Contractor at its cost or repaired by the Railroad and charged to Contractor. Work shall not continue until such damage is repaired as determined by the Resident Engineer.
- F. When crane operators' visibility is impaired during any hoisting operation, spotters shall be used to guide the operator. Universal hand signals shall be used and their meaning clearly understood between operator and spotter. When visual contact between the operator and spotter is impaired, two-way radio contact shall be used.
- G. General Railroad Protection (Flagging) Requirements: The Railroad shall require Railroad protective personnel to be on duty to protect its operations when Contractor is working within the property right-of-way. Flag protection shall be required when Contractor is on, above or below, or immediately adjacent to Railroad property, or having the capability of obstructing an adjacent track.
 - 1. If by reason of Contractor's operations, it is found necessary to employ flaggers or other employees of the Railroad to protect employees or personnel of the Railroad, Contractor, or others engaged in Work on or adjacent to the tracks and/or to ensure the safe conduct of traffic on the Railroad, submit a written request for review by the Railroad by Monday at 10:00 AM for the Work week beginning at 5:00 AM on Monday two weeks later, to allow the MTA to schedule such arrangements as necessary for the stationing of such employees.
 - 2. All requests for such services shall be written and shall include Work Plans containing details of the Work to be performed, locations, areas to be occupied, equipment to be used, labor force to be assigned, and the date, duration, and time of the Work. Any need for relief shifts, and overtime shall be detailed.
 - 3. Similarly, written notice, 72 hours in advance, shall be given when canceling flaggers. For Sunday Work, the cancellation deadline is Wednesday 2:30 PM.

4. The MTA shall coordinate the necessary flagging employees needed by Contractor. The furnishing of such employees does not relieve Contractor of its responsibility for performance of this Contract, nor shall it relieve Contractor of its responsibility or liability for personal injuries including death or property damages to any passenger, person, or employee of Contractor, subcontractor, or of any of the parties designated in the General Terms and Conditions Chapter 10, Article 10.03, "INDEMNIFICATION", or of any other person for which Contractor is responsible pursuant to the provisions of General Terms and Conditions Chapter 10, Article 10.02, "RESPONSIBILITY FOR INJURIES TO PERSONS AND PROPERTY".
 5. At all times while working on or adjacent to operating tracks, Contractor, subcontractors, and all of their employees shall closely observe the applicable flagging rules and regulations of the Railroad, and the requirements of Section 01545. It shall be Contractor's responsibility to ensure that all of its employees and subcontractors are familiar with the contents thereof including the latest revisions and additions, and that these employees shall so conduct themselves as not to violate any of such safety rules and abide by the instructions from the railroad employee in charge of providing access and protection.
 6. The MTA reserves the right to determine the number of flagmen or other employees necessary based on the details of Contractor's Work Plan submittal.
 7. Should Contractor's actual procedure or labor force vary from that accepted, thereby causing increased costs to the MTA by the uneconomical use of its employees and services, Contractor shall be charged for all such increased costs as determined by the Resident Engineer. All such costs shall be in accordance with prices in effect at the time the services are performed. The MTA shall deduct the same from any payments due or that may become due to Contractor; and Contractor shall be responsible and liable to the MTA for any deficiency. The aforementioned charges and costs are separate and distinct from any liquidated damages imposed.
 8. In case of adverse weather conditions or emergencies on the Railroad, making it impractical for Contractor to perform Work, Contractor shall not be subject to the above costs.
- H. Monthly Reconciliation of Services Provided: Meet with the Resident Engineer on a monthly basis to reconcile the usage of all railroad-related services (diversions, flagging, work trains, and access and protection). The purpose of this meeting shall be to review and confirm usage of each type of service used during the previous month and to date, as well as to discuss any other related issues.
- I. Final Reconciliation of Services Provided: In the event that there are unused MTA-provided services after Substantial Completion, and whether or not MTA approved a reallocation of services, Contractor shall not be entitled to receive, by way of claim, offset or other means, the value of such unused services. If Contractor was provided with more of one service(s) and less of another service(s), whether or not a reallocation was made, Contractor shall not be charged for the service(s) that exceeded the original or reallocated (if applicable)

amount provided the total cost of the MTA-provided services actually used does not exceed the total cost provided for herein, as may have been adjusted at the time a reallocation request was permitted.

- J. Flexibility of MTA-provided Services: In case the MTA-provided services designated herein are not available as requested by Contractor, the MTA reserves the right to exchange these with services that are available in order to mitigate Project delay.
- K. Allowable Hours Of Work Without Diversions of Train Service/Track Outages: In order to reduce to a minimum any interference with the convenient, safe and free use of the train platforms, passageways, stairways and other portions of the Railroad for customer traffic, perform the Work affecting such portions, including the transportation of materials in and out of the Work Site, at such hours of the day and night as the Railroad may require.

3.02 LIRR REQUIREMENTS

- A. LIRR General Requirements: Work adjacent to LIRR facilities is not anticipated for this Contract.
- B. LIRR Flagging Requirements: The need for LIRR flagging resources is not anticipated for this Contract.
- C. LIRR Diversions of Train Service: LIRR service diversions are not anticipated for this Contract.
- D. LIRR Work Trains: The use of LIRR work trains is not anticipated to support this Contract.

3.03 MNR REQUIREMENTS

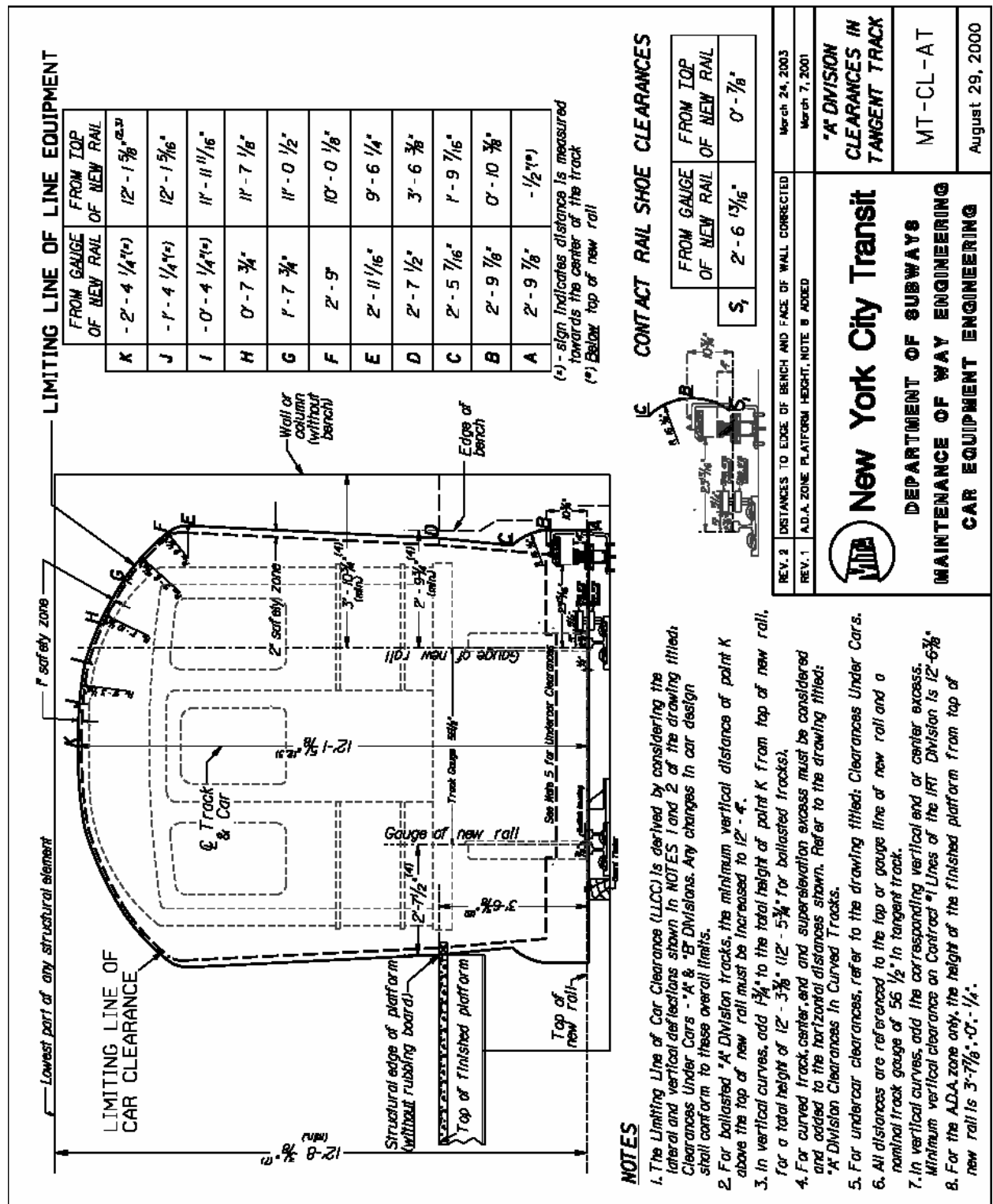
- A. MNR General Requirements: Work adjacent to MNR facilities is not anticipated for this Contract.
- B. MNR Flagging Requirements: The need for MNR flagging resources is not anticipated for this Contract.
- C. MNR Diversions of Train Service: MNR service diversions are not anticipated for this Contract.
- D. MNR Work Trains: The use of MNR work trains is not anticipated to support this Contract.

3.04 NYCT REQUIREMENTS

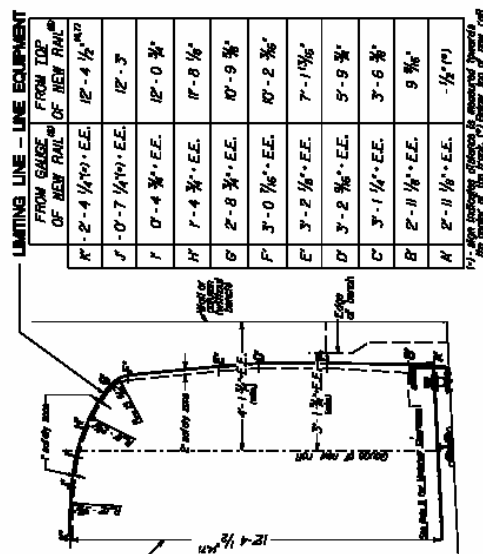
- A. General Requirements:
 - 1. Contractor's use of NYCT force account resources will be subject to the requirements and limitations defined herein.

2. Work Near Contact Rails: Within the NYCT system, the existing contact rails (third rails) are live and used for the transmission of electricity at approximately 600-volts DC. The shutting off or turning on of contact rail power by Contractor is forbidden.
- B. NYCT Flagging Requirements: Flagging and/or force account resources will be required during installation of instrumentation in NYCT subway tunnels. The MTA will furnish the necessary flagging and/or Force Account resources at no cost to Contractor. All requests for such services shall be written and shall include details of the Work to be performed, areas to be occupied, equipment to be used, labor force to be assigned, and the date and hours for the proposed Work. In determining Contractor's flagger usage, the following rules shall govern:
1. One flagger-day occasion is considered 8 hours of Work or any portion thereof at straight time pay and includes time for a flagger to travel to and from flaggers crew quarters, where portal to portal time is up to and including 8 hours.
 2. In case a flagger works through his 20 minutes lunch time, then an additional one half hour shall be paid at straight time. Where portal to portal time exceeds 8 hours, time-and-a-half shall be paid on excess time, exceeding 8 hours portal to portal, for that shift.
 3. A relief shift of flaggers may be brought in when scheduled flagger hours exceed 8 hours portal to portal. This is determined by the MTA division responsible for flagger assignments.
 4. To determine number of flagger-day occasions usage, all overtime charges shall be converted to a straight time 8-hour portal-to-portal Workday and equated to equivalent flagger occasions.
 5. Flagger cancellation by Contractor with less than required notice, except due to inclement weather as noted herein, will cause flaggers to be charged to Contractor.
 6. Flaggers cancelled by the MTA or flaggers standing by for more than 3 hours per flagger shift due to the unscheduled cancellation by the MTA will not be charged.
 7. One Flagger for sheet/equipment and one Flagging Office Supervisor will be assigned to Flaggers' crew quarters on a full time basis, when more than 9 flaggers report to crew quarters at any particular Work shift. Both of these employees shall remain at crew quarters and shall report one half hour before and leave one half hour after the hours of the assigned flaggers for a particular shift.
 8. Direct and indirect fringe benefits and overhead costs, effective in the year flagger service is rendered, shall be applied to all flagger charges.

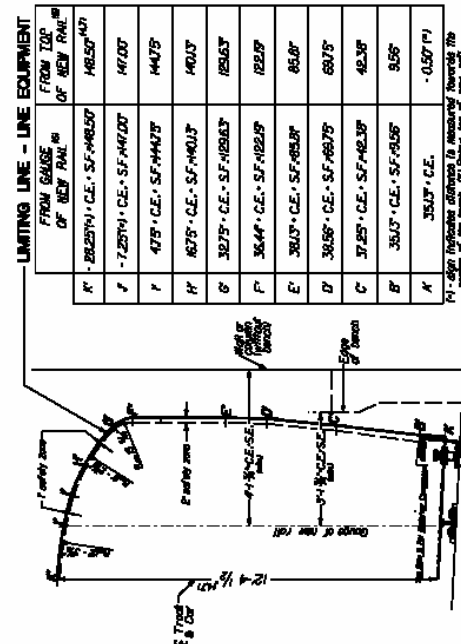
- C. NYCT Diversions of Train Service:
1. Limited weeknight service diversions are anticipated for this Contract. To the greatest extent possible Contractor shall plan the instrumentation work to take full advantage of track outages under General Orders in effect for other work in NYCT facilities.
 2. Allowable Hours Of Work Without Diversions of Train Service: It is contemplated that Contractor may perform such particular Work without suspension of train operations or removal of power during the following hours:
 - a. The following requirements are for daily, Saturday and Sunday. At no time will flagging be permitted when the scheduled train service has a frequency of 10 minutes or shorter. No flagging is permitted during rush hours, which on all lines is approximately between 5:00 AM to 9:30 AM and from 3:00 PM to 10:30 PM.
 - b. At all other times, flagging is permitted only with approval from the NYCT Control Center and/or the line superintendent.
 - c. The approximate hours of flagging on elevated structure are:
 - 1) Weekdays: 10:00 AM to 3:00 PM
 - 2) Weekends: Dawn to Dusk
 - 3) Nightly: No flagging shall be permitted on elevated structures during night hours.
 - d. It shall be understood that the hours mentioned above are approximate only, subject to change by NYCT and shall form no basis for any claim in case they do not correspond with the hours finally determined by the Resident Engineer.
- D. NYCT Work Trains: The use of NYCT work trains is not anticipated to support this Contract. It is Contractor's option to arrange for the use of NYCT work trains.
- E. Available Power in NYCT Tunnels:
1. Contractor shall coordinate with Resident Engineer on the location of power sources within NYCT tunnels.
 2. Power sources will generally be available to Contractor within 100 feet of required locations of power sources indicated in Contractor's approved instrumentation plan.
- F. Subway Train Clearances: Installed equipment, devices, piping, conduits, and cabling shall not encroach into the subway train clearance envelope as indicated in the following clearance diagrams for A and B Subway Divisions. A Division consists of the IRT subway lines. B Division consists of the IND and BMT subway lines.



CLEARANCES ON THE HIGH SIDE OF CURVES



CLEARANCES ON THE LOW SIDE OF CURVES



NOTES

1. Definitions:

$$E.E. = \text{End Excess} = \frac{2945}{R}, \text{ in inches}$$

$$C.E. = \text{Center Excess} = \frac{4374}{R}, \text{ in inches}$$

$$S.E. = \text{Superelevation Excess} = \frac{E \cdot H}{\text{Gauge}}, \text{ in inches} \cdot S.F. \cdot x \cdot H, \text{ in inches}$$

where R = Curve radius, ft.

E = Curve superelevation, in inches

H = Height from top of rail used for the calculation of excess, in inches

$S.F.$ = Superelevation Factor = E/Gauge

2. All distances are referenced to the top of gauge line of new rail with a nominal track gauge of 55 1/2" in tangent track.

3. Refer to the drawing showing "B" Division Clearances in Tangent Track for the definition of the Limiting Line of Car Clearance (LLCC), Limiting Line of Line Equipment (LLE) and platform/body relationship.

4. For ballasted "B" Division tracks, the minimum vertical distance of point "K" above the top of new rail must be increased to 12' - 7 1/4" (151/2").

5. For undercar clearances, refer to the drawing titled: Clearances Under Cars.

6. In curved "B" Division tracks, the 75' Car LLCC and LLE govern.

7. In vertical curves, add 1 3/4" to the total height of point "K" from top of new rail, for a total height of 12' - 6 1/4" 112' - 9 1/2" for ballasted tracks.

SUPERELEVATION FACTOR (S.F.)

Superelevation of Curve (inches)	r	1 1/2	2 1/2	3 1/2	4 1/2	5 1/2	6	6 1/2
Superelevation Factor (S.F.)	0.008	0.007	0.005	0.004	0.003	0.002	0.001	0.001



New York City Transit

DEPARTMENT OF SUBWAYS
MAINTENANCE OF WAY ENGINEERING
CAR EQUIPMENT ENGINEERING

"B" DIVISION
CLEARANCES IN
CURVED TRACK

MT-CL-BC

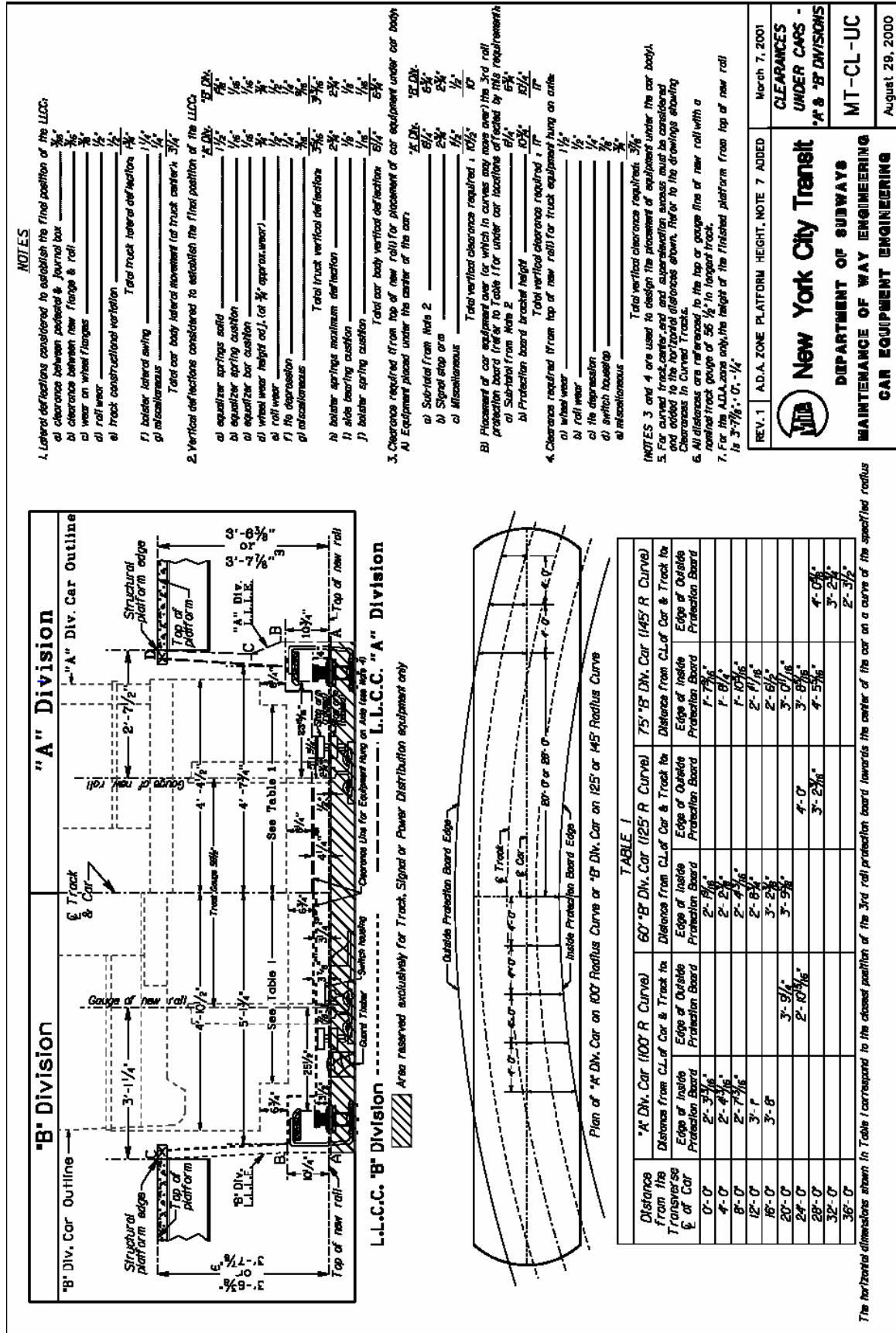
August 29, 2000

DEPARTMENT OF SUBWAYS
MAINTENANCE OF WAY ENGINEERING
CAR EQUIPMENT ENGINEERING

MT-CL-BT

August 29, 2000

7. On "B" Division tangent tracks the Limiting Line of Line Equipment (LLE) is based on the old 67' car LLE; on curved tracks the 75' car LLE governs.
8. In vertical curves, add the corresponding vertical center and end excess.
9. For the ADA zone only, the height of the finished platform from top of new rail is 3'-7 1/8" 0' - 1/4".



3.05 AMTRAK REQUIREMENTS

- A. Amtrak General Requirements: Work adjacent to Amtrak facilities is not anticipated for this Contract.
- B. Amtrak Flagging Requirements: The need for Amtrak flagging resources is not anticipated for this Contract.
- C. Amtrak Diversions of Train Service: Amtrak service diversions are not anticipated for this Contract.
- D. Amtrak Work Trains: The use of Amtrak work trains is not anticipated to support this Contract.

3.06 NYAR REQUIREMENTS

- A. NYAR General Requirements:
 - 1. Work adjacent to NYAR facilities is anticipated for this Contract.
 - 2. NYAR Flagging Requirements: Work under flagging when entering the Queens Street crossing.
 - 3. MTA will provide the necessary flagging service at no cost to Contractor associated with the Queens Street crossing.
 - 4. Plan and sequence operations to minimize traffic flows and requirements for NYAR flag protection.
 - 5. Should Contractor's actual operation vary from the accepted plan, thereby causing increased costs to the MTA by the uneconomical use of its employees and services, Contractor will be charged for all such increased costs as determined by the Resident Engineer.
- C. NYAR Diversions of Train Service: NYAR service diversions are not anticipated for this Contract.
- D. NYAR Work Trains: Use of NYAR work trains is not anticipated to support this Contract. If the Contractor chooses to use NYAR tracks and/or services to haul muck off site, all associated costs for NYAR services shall be borne by the Contractor.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for site-specific Railroad Construction Safety specified herein.

1.02 REFERENCED SECTIONS

- A. Section 01160 – Work Affecting the Railroad
- B. Section 01540 – Safety Planning and Supervision
- C. Section 01545 – Construction Safety and Health

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Code of Federal Regulations (CFR):
 - a. 49 CFR 214 - Roadway Worker Protection (FRA)
 - 2. Long Island Rail Road (LIRR) Safety Regulations
 - 3. National Railroad Passenger Corporation (Amtrak) Safety Regulations
 - 4. New York City Transit (NYCT) Safety Regulations

1.06 SUBMITTALS

- A. See Section 01545

1.07 DELIVERABLES

- A. See Section 01545.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION**3.01 GENERAL REQUIREMENTS**

- A. Each work shift that involves work activities on or near right-of-way shall begin with a mandatory Roadway Worker Protection (RWP) briefing of Work Site personnel (49CFR Part 214.315 A), describing the RWP measures and procedures to be used (See Section 01160). Set aside a 15-minute period for the RWP briefing. The RWP briefing shall be conducted by the Railroad's Roadway Worker in Charge (RWIC).
- B. Contractor's equipment operators shall be qualified, certified, and have demonstrated proficiency on the equipment they are to operate (49CFR Part 214.353).

3.02 RAILROAD SAFETY TRAINING

- A. Roadway Worker Protection (RWP) Training is required for work on regulated railroads (including the LIRR, Amtrak, and New York and Atlantic Railway) by the Federal Railroad Administration (FRA) Code of Federal Regulations (CFR), 49 CFR Part 214.301. NYCT has comparable training that is also required for this Work. Each employee of Contractor and its subcontractors, including all safety representatives, whose duties include working on or near the railroad right-of-way, shall attend a minimum 4-hour RWP training session before performing such duties for the first time and annually thereafter.
 - 1. The RWP training session shall be given by the MTA as required during the term of the Contract, and will be conducted in the English language.
 - 2. The availability of RWP training sessions is limited and requires registration at least 1-week prior to the session. Timely coordination for this training shall be made through the Resident Engineer.
 - 3. RWP training sessions are available once each week from 3:30 PM to 7:30 PM at the LIRR Hillside Maintenance Facility. Additionally, this training may be scheduled monthly at the ESA Queens Area Construction Office (29-76 Northern Blvd. 5th Fl., Long Island City).
- B. NYCT Track Training: Any employee of Contractor or their subcontractors, including all safety representatives, whose duties include working on or near NYCT tracks, shall attend the NYCT 8-hour "Track Safety Seminar" conducted in Brooklyn, NY. Timely coordination for this training shall be made through the Resident Engineer. A minimum of 21 days notice from Contractor is required to schedule this training. Refresher training is required every three years.

3.03 RAILROAD RIGHT OF WAY RESTRICTIONS

- A. Measuring Tapes: Only cloth or fiberglass measuring tapes shall be used on or near the Railroad right-of-way.

- B. Ladders: Only ladders made of fiberglass shall be used in manholes, near power lines, and on or near the Railroad right-of-way.
- C. Orange Paint: The use of orange paint on or near the railroad tracks is prohibited.
- D. Rubber Mats: The use of rubber mats, and the type of mats to be employed, shall be reviewed and accepted prior to use in the field.
 - 1. Rubber mats shall be used to cover the contact rail while working nearby.
 - 2. Defective or damaged mats shall be replaced immediately and removed from the jobsite. Under no circumstances shall rubber mats be altered in the field.
 - 3. All rubber mats shall have the proper colored stripe delineated on the smooth side to verify that they have been tested.
 - 4. Wet rubber mats are not to be used as third rail insulation protection until they are thoroughly dried out.
- E. All tools and equipment used to work on or near high- or low-voltage electrical equipment or circuits shall be reviewed and accepted prior to use in the field and shall be properly insulated with approved materials.

3.04 RAILROAD SAFETY REQUIREMENTS

- A. Rail Construction Safety: The Railroad work environment presents unique hazards including, but not limited to, the following:
 - 1. High Speed Trains: Trains can move at speeds up to 90-mph in both directions on every track.
 - 2. High voltage overhead catenaries and third rails.
 - 3. Treacherous Footing on Rail, Ties, and Ballast: Slippery rails, creosote-soaked ties, and uneven crushed stone ballast make walking difficult and hazardous.
 - 4. Work areas with limited clearance, including minimal or no tunnel clearances.
 - 5. Obstructed Visibility: Worker visibility of approaching trains is restricted in many locations by a combination of grades, curved tracks, stone walls, bridges and bridge abutments, and buildings adjacent to the tracks.
 - 6. Moveable switch points and remote control switches.
 - 7. All tracks in the Railroad work zones are electrified with high voltage overhead catenary and/or third rail.
- B. Specific safety rules and procedures of the Railroads (and in accordance with RWP) shall be followed to protect workers from these hazards. Supervisors shall learn these rules, follow them, and make sure that workers do the same. Contractor is responsible for monitoring to make sure that all work is being done in conformance with railroad safety requirements.

- C. Fouling Limits: Without Railroad authorization and flag protection, the following shall apply:
1. No equipment shall be placed or used within 25-feet of the centerline of outermost track.
 2. No personnel shall stand or work within 25-feet of the centerline of the outermost track.
 3. No unsecured material shall be place within 25-feet of the centerline of the outermost track.
 4. No excavation shall be done within 25-feet of the centerline of the outermost track (unless authorized by the Railroad).
 5. No personnel or equipment shall occupy space within 15-feet of energized electric wire.
- D. Flagging Protection: All work performed within the fouling limits shall be done under flagging protection (see Section 01160).
- E. Limitations on Access to Right of Way: Before working on a live track, permission shall be obtained. Only a qualified railroad employee, the Roadway Worker In Charge (RWIC) or employee-in-charge (EIC), can grant such permission or remove a track from service and put it back into service. No contractor personnel will be allowed access unless they have received rail construction safety training within the last 12 months and can produce their Safety Training ID card.
1. Contractor shall not enter a track unless it is necessary in performance of their duty, and only when given permission by a qualified railroad employee. The use of an umbrella on or about the tracks is prohibited.
 2. All personnel working on the right of way shall maintain continual awareness of the possibility of train movements through the work site and know the location of the nearest place where one can safely stand while the train passes by. Train movements can occur at any time, in any direction, on any track. If a train is moving through the work site, it is critical for each and every worker to move to a safe location. All tools, materials, and equipment shall be moved beyond the fouling limits.
 3. At the end of the shift, all tools, materials, and equipment shall be moved beyond the fouling limits. If any items can roll, fall, or be blown onto the right of way, they shall be secured in such a manner that they will not unintentionally foul the right of way.
 4. Monitor how equipment is being operated, particularly cranes and other lifting machines. Machine booms and lifted loads are not permitted to cross the fouling lines, making it necessary to position equipment in such a way as to assure that, in the worst case, there will not be an accidental protrusion across a foul line. If this cannot be done, the piece of equipment shall be treated as if it were within fouling limits.

5. All material, whether secured or unsecured, shall be kept at least 25-feet from the centerline of track. Erect fences and/or solid barriers to prevent any debris from construction activity from fouling the tracks.
- F. Overhead Catenary: The fouling limits for catenary is within 15-feet of electrical lines. Unless authorized by the Railroad, no work shall take place within 15-feet of electrical lines unless they are de-energized and properly grounded, and the work has been properly authorized. Any construction equipment located within the fouling limits shall also be grounded with a grounding cable, even though the power is off.
- G. Third Rail: The third rail or "contact" rail can be encountered on either side of the right of way. When work shall be done on the right of way in third rail territory, the third rail shall be de-energized. It will be necessary, from time to time, to walk across sections of third rail territory where the third rail is energized. It shall always be assumed that the third rail is energized.
- H. Walking Hazards: No worker shall enter a Railroad work site without proper shoes. This means shoes or boots that are at least six inches high (to support and protect the ankles), have a definite heel, and are in good condition. Workers shall be mindful of the walking hazards and step carefully, always stepping over rails and third rail covers, never on them. Special care shall be taken to step over switches so as to avoid getting caught in the mechanism which may be activated remotely and without warning. Walking between the third rail and its adjacent running rail is prohibited.
 1. When crossing tracks use approved walkway when available; otherwise take the shortest safe route after looking in both directions. If more than one track is to be crossed, stop and look before crossing each track. Jumping from truck, car, platform, or other elevated location is prohibited.
 2. When going to or from work locations workers shall walk, not run, keeping hands out of pockets and using established paths or routes.
 3. Personnel shall be alert to avoid tripping and slipping hazards and walk around, not jump across, excavations, holes, or open pits. If practicable, remove tripping or slipping hazard encountered on paths, walkways, platforms, or work areas; otherwise, promptly inform your immediate supervisor of its nature and location.
 4. Contractor personnel shall use designated routes, paths, or crosswalks to or from yard office, parking lot, station, shop, or other work locations.
 5. When walking or working in poorly lit areas (tunnels, etc.), have sufficient light to permit moving about and performing work safely. If necessary to look away from direction in which walking, stop while doing so. Use a plastic or rubber flashlight or lantern when conditions, such as passing through tunnels or poorly lit areas, require it. The use of a flashlight or lantern with metal case is prohibited when working near electrified railroads.

6. If necessary to use a surface made slippery by weather or other conditions, clean, if practicable, and/or scatter salt, sand, calcium chloride, or other suitable material, in accordance with railroad limitations.
- I. Hand and/or Power Tools, Jacks, and Other Equipment: All tools shall be used only for the purposes for which they are intended; they shall be inspected before being used. Before operating equipment, vehicles, devices, or tools, determine that all persons who might be affected are in the clear. Leave equipment, tools, materials, scrap, debris, and other items clear of tracks, pathways, platforms, and other such places where they would constitute an obstruction or tripping or slipping hazard. The use of metallic tools and equipment, such as aluminum ladders, metallic tape measures, etc. is prohibited. In their place, the use of wooden or fiberglass ladders and cloth tape measures is recommended.
- J. Safety Checklists: Incorporate the following Railroad-specific checklist items into the worker safety meetings, Safe Work Plans and related planning documents and training:
 1. On-track safety established. Fouling limits clearly marked.
 2. Needed track outages arranged and flagging provided.
 3. Needed electrical outages arranged and qualified Railroad electrical employee provided.
 4. Needed tools, equipment and machinery available and inspected. Needed railroad equipment available and inspected.
 5. Working area clean and neat. Lighting adequate. Roads and walks clearly defined.
 6. Waste containers provided. Sanitary facilities available. Potable water available.
 7. Fire extinguishers in place and inspected. No smoking signs posted where required. Other required signage in place.
 8. Task-specific personal protection equipment available (welding masks, insulating gloves, hearing protection, etc).
 9. Needed electrical power available with Grand Fault Protection (GFP).
 10. Hazardous materials and combustible fluids properly identified and stored. Required Material Safety Data Sheets (MSDS) postings in place.
- K. Fire Prevention: The use of portable incinerators is prohibited. Open flames or lights shall be kept at least 25-feet from painting operations, whether done by spraying, hand brushing, or dipping. Spray booths or enclosures shall be types approved by the Safety Departments. There shall be no storage of any flammables, in any quantity, below grade or in tunnels.
- L. Accident and Incident Reporting: Certain accidents may have to be reported by the Railroad to the Federal Railroad Administration (FRA), such as those involving train movement, train passengers, railroad employees, trespassers, or

contractor employees performing railroad maintenance work. Accidents involving contractor employees doing construction work would generally be reported only if train movement was involved. Contractor personnel shall use approved Railroad forms to report accidents involving personal injury. This form includes information that shall be needed for compliance with FRA regulations.

3.05 RAILROAD SAFETY RULES

- A. The Railroads expect Contractor personnel to be properly rested and to abstain from any activity that would affect the safe and efficient performance of their duties.
- B. No contractor employee shall go on duty or remain on duty if under the influence of alcohol and/or drugs, or if there is any evidence of drug use. No contractor personnel shall have in his/her possession, while on duty, alcohol and/or drugs whether prescribed or over-the-counter, that shall impair the ability to perform his/her duties, or that might constitute a threat to the safety of others. Contractor employees under medication, whether prescription or over the counter, before or while on duty, shall be certain that such medication will not affect the safe performance of their duties.
- C. Contractors and their employees shall be aware of the location of first-aid kits and lifesaving and firefighting equipment. That equipment is to be used only for the purposes intended.
- D. Supervision: The Contractor Supervisor shall be responsible for the safe performance of all those under his/her jurisdiction, shall inform such employees of all potential hazards before they begin work, and shall promptly advise his or her immediate supervisor of any employees who resist correction and/or fail to improve their unsafe work practices.
- E. Conduct of Employees: Employees shall not engage in scuffling, horse play, or practical jokes, either on or off duty on company property. Any activity not directly associated with employees' duties and which shall adversely affect safety is prohibited. The following are prohibited while on duty or at any time on company property:
 - 1. Sleeping or assuming the attitude of sleep.
 - 2. Reading books, magazines, newspapers, or any printed matter other than work-related materials.
 - 3. Use or possession of unauthorized radios, headsets, TVs, or computer terminals.
 - 4. Unauthorized persons shall not be permitted on locomotives, trains, equipment, or railroad/transit property.
 - 5. Employees are prohibited from any act that defeats the purpose of a safety device.
 - 6. The possession or use of firearms on Railroad property is prohibited.

7. Smoking or the use of open flames where explosives, flammables, combustibles, or hazardous material and hazardous waste are stored or are being handled or in other unauthorized areas is prohibited.
 8. Material conveyor, chute, bucket, or other such facility shall not be used as a means of personal transportation.
 9. Never eat, drink, or store food or beverages in toilet rooms or in any area exposed to toxic material.
- F. In tunnels, where side clearance is limited and no manholes or other places of safety are provided, arrangements for use of track and protection against approaching trains shall be made. Keep clear of standing train, self-propelled vehicles, and machinery or other wheeled equipment.
- G. Contractors are prohibited from sitting, stepping, standing, or walking on rail, frog, switch, interlocking machinery, third rail, and protection board, or other such parts of track structure unless specifically required to do so in the performance of their duties.
- H. Keep as far as practicable from passing trains. If in confined places, secure loose clothing, large or long coats, and, if possible, maintain a handhold until the train has passed. Do not rest any object on your shoulder while close to a moving train.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. This Section consists of the measurement and payment clauses for all Contract unit price, lump sum, and allowance items that make up the Contract Price. Progress payments will be made in accordance with the General Terms and Conditions Chapter 7, "PRICE AND PAYMENTS".
- B. Work shown on the Contract Drawings, specified in the Contract Documents, or otherwise required by the Contract Documents that does not have a specific Bid Item is deemed to be included in Item No. 1 of the Bid Price Schedule.

1.02 BID ITEMS

- A. Item No. 1 - All Required Work Except the Bid Items Listed Below:
 - 1. All Required Work Except the Bid Items Listed below will not be measured separately for payment. Work shown on the Contract Drawings, specified in the Contract Documents, or otherwise required by the Contract Documents that does not have a specific Bid Item is deemed to be included in Item No. 1 of the Bid Price Schedule and will not be paid for separately.
 - 2. Payment for All Required Work Except the Bid Items Listed below will be made at the Contract Lump Sum Price for Item No. 1 of the Bid Price Schedule, which price shall include the cost of all work, labor, and materials required by Division 1, and all other work, labor, and materials necessary therefore or incidental thereto referred in other sections of Divisions 2 through 16; and including associated indirect costs and profit.
 - 3. Progress payments made under Bid Item No. 1 shall be based on the approved Detailed Cost Breakdown and in accordance with General Terms and Conditions Chapter 7, "PRICE AND PAYMENTS".
 - 4. The cost of establishing Contractor's field and Resident Engineer's field offices, and other temporary offices required by the Contract, the construction of temporary buildings and facilities at the Work Site, and at approved or adjacent construction yards is included under this Item.
 - 5. Included under this Item are all Contractor's construction plant, equipment, tools and materials furnished to complete the Work including but not limited to: tunnel and shaft/open-cut conveyor systems, rail transportation system, temporary project utilities such as ventilation system, compressors and air lines, water supply lines, pumps and discharge lines, electrical system including medium voltage power substation, rail and switches, shaft and surface equipment, exclusive of "Tunnel Boring Machines (TBMs) and Appurtenant Equipment" paid for separately under Bid Item No. 2 – Tunnel Boring Machines (TBMs) and Appurtenant Equipment Mobilization.

6. The cost of transportation of construction plant and equipment, unloading and assembly of such plant and equipment; as well as unloading and assembly of equipment identified under General Terms and Conditions Article 7.06; and other items not expressly included in other payment items; is included under this item. All other indirect and associated support costs are included in Item Nos. 3 and 4.
7. Payment for excavation, initial support, and any additional initial support required for approach tunnels, TBM assembly chamber and adjoining starter tunnels, GCT 5 wye caverns and adjoining starter tunnels, GCT 3 wye caverns, cross passages, central instrument room, and cross flue will not be measured or paid for separately and shall be deemed included in the cost of Item No. 1, which price shall include excavation, transportation of excavated muck to the rail yard or truck loading facility and disposal off-site.
8. Test blasting, line drilling, and other measures to limit vibrations as specified in Section 02414 will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
9. Reinforced and/or non-reinforced shotcrete used to replace defective shotcrete and finish shotcrete, as defined in Section 03370, will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
10. Shotcrete to fill overbreak and over-excavation will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
11. Drill and blast excavation including muck removal, transportation and disposal, and installation of initial support for niches, cross adits and temporary or future sump pump pits, and pump stations for use of Contractor's convenience will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
12. All testing and associated work as described in the Specifications will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
13. Flashcrete, GRP dowels, and additional initial support as identified on the Contract Drawings, will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
14. Face support for stoppages as described in Section 02407 will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
15. All pre-excavation tunnel grouting performed, where pre-excavation grouting is as defined in Section 03605, will not be paid for separately, but will be deemed included in Item No. 1, subject to the following:

- a. Pre-excavation tunnel grouting (Type “a”), up to the quantity indicated in Table 3 from Contract Drawing CM009-GT-2000, is included in the Contract Work for Item No. 1. Pre-excavation tunnel grouting is grout injected through probe holes and grout holes drilled in advance of the tunnel face from within the tunnel being mined.
- b. Pre-excavation tunnel grouting (Type “b”), up to the quantity indicated in Table 3 from Contract Drawing CM009-GT-2000, is grout pumped through holes drilled from a completed section of one tunnel to an area in advance of the tunnel face of an adjacent tunnel that is being mined or will be mined.
- c. Contractor shall maintain accurate and contemporaneous daily records of the crew-hours and Contractor’s costs incurred for pre-excavation grouting Types “a”, and “b”. These records will be maintained and submitted in accordance with Article 8.04.F, “INTERIM TIME AND MATERIALS RECORD KEEPING AND EQUITABLE ADJUSTMENTS BASED ON TIME AND MATERIALS.”
- d. A crew-hour is defined as an hour of time expended by a crew that is comprised of labor, equipment, and materials required for the direct performance of pre-excavation tunnel grouting.
- e. For purposes of determining crew-hours expended, time periods expended by the grouting crew covered under the crew-hour definition shall commence at the specific time when drilling of grout holes starts for an individual grouting operation being performed (which occurs after the TBM is stopped for type a pre-excavation grouting), except when the grouting operation commences by grout injection performed from a probe hole drilled previously, in which case the time period expended by the grouting crew shall commence when installation of the grout line connection in the probe hole commences.
- f. For purposes of determining crew-hours expended, time periods expended by the grouting crew covered under the crew hour definition shall end two hours after the specific time when the grout lines to the last hole being injected in that same individual grouting operation are disconnected.
- g. Any time incurred by interruptions in this individual grouting operation that are caused by equipment failure, lack of grouting materials, idle time or delays to grouting for any reason other than the requirements of the grouting operation itself, other contractor or subcontractor caused delays or inefficiencies, or absence of grouting crew labor will not be included in the measurement of grouting crew-hours.

- h. The time for the performance of pre-excavation tunnel grouting is included in the Contract performance period. Contractor's submitted schedule shall identify and provide for all activities and appropriate logic and durations for the pre-excavation tunnel grouting included in the original Contract Work, regardless of whether any portion of that pre-excavation tunnel grouting may be on the critical path.
- 16. Stoppage time of the TBM excavation works, as a result of drilling and grouting operations for the quantity of grouting included in the Contract Work as specified herein, will not be measured or paid for separately, but will be deemed included in the cost of Item No. 1.
 - a. To the extent feasible, Contractor shall reschedule maintenance and other required or anticipated TBM down time to occur during periods of type a pre-excavation grouting.
- 17. Testing of the grouted zones will not be measured or paid for directly, but will be deemed included in the cost of Item No. 1.
- 18. All post-excavation tunnel grouting performed, where post-excavation tunnel grouting is as defined in Section 03605, will not be paid for separately, but will be deemed included in Item No. 1, subject to the following:
 - a. Contractor shall maintain records of the sacks of each of the types of cement used, as noted herein below, and Contractor's costs incurred for post-excavation grouting. These records will be maintained and submitted in accordance with revised Article 8.04.F "INTERIM TIME AND MATERIALS RECORD KEEPING AND EQUITABLE ADJUSTMENTS BASED ON TIME AND MATERIALS".
 - b. Post-excavation tunnel grouting to be included in the Contract Work for Item No. 1, is all work (labor, materials and equipment) required for the injection of up to the quantity indicated in Table 3 from Contract Drawing CM009-GT-2000 for the number of sacks of cement and/or micro-fine cement pumped into the ground surrounding the tunnel, where cement is as defined in Section 03605, micro-fine cement is as defined in Section 03605, and one sack is defined as a bag weighing 94-pounds.
 - c. The time for the performance of post-excavation tunnel grouting is included in the Contract performance period. Contractor's submitted schedule shall identify and provide for all activities and appropriate logic and durations for post-excavation tunnel grouting included in the original Contract Work regardless of whether any portion of that Work, if any, may be on the critical path.
- 19. The cost for upgrading and maintaining existing temporary utilities and facilities, will not be measured or paid for separately, but will be deemed included in Item No. 1.

20. The cost for maintenance and protection of existing structures, facilities, utilities and subway infrastructure will not be measured or paid for separately, but will be deemed included in Item No. 1.
 21. The cost for furnishing and installation of waterproofing, drainage, reinforcement and CIP concrete arch lining in the GCT wye caverns 3 and 5, cross passageways as shown on the drawings, cross flue, pump room and central instrument room will not be measured or paid for separately, but will be deemed included in Item No. 1.
 22. The cost for reframing the Bellmouth wall will not be measured or paid for separately, but will be deemed included in Item No. 1.
 23. The cost for constructing the permanent concrete invert in the Bellmouth will not be measured or paid for separately, but will be deemed included in Item No. 1.
 24. The cost for removal of concrete overlay within the lower level of the existing 63rd Street Tunnel will not be measured or paid for separately, but will be deemed included in Item No. 1.
 25. Except as provided herein below, payment for removal, handling and disposal of hazardous and non-hazardous contaminated muck will be considered for payment in accordance with General Terms and Conditions ARTICLE 8.04 "EQUITABLE ADJUSTMENTS IN PRICE".
 26. Muck contaminated from Contractor's operations including but not limited to tunneling excavation process, handling procedures, or stockpiling methods will not be considered for additional payment. All additional costs incurred for handling, transportation, sampling, laboratory analyses, and disposal of muck contaminated by Contractor's operations shall be borne by Contractor. The additional cost will not be measured or paid for separately, but will be deemed included in Item No. 1.
 27. Geotechnical and Structural Instrumentation will not be measured or paid for separately, but will be deemed included in Item No. 1.
- B. Item No. 2 – Tunnel Boring Machines (TBMs) and Appurtenant Equipment Mobilization:
1. Progress payments for Item No. 2 – Tunnel Boring Machines (TBMs) and Appurtenant Equipment Mobilization will be made against the total stipulated price in the Bid Price Schedule in accordance with the General Terms and Conditions, Article 7.06– as revised by Supplemental Article 7.06 "MOBILIZATION PAYMENT FOR TBM AND APPURTENANT EQUIPMENT".

- C. Item No. 3 - TBM Tunnel Excavation and Initial Support Classes – SC I TBM, SC II TBM, SC I E TBM, and SC II E TBM in Excavation Without Bored Tunnel Lining:
1. Measurement for TBM Tunnel Excavation and Initial Support Classes – SC I TBM, SC II TBM, SC I E TBM, and SC II E TBM in Excavation Without Bored Tunnel Lining will be made per Linear Foot, measured to the limits specified. Measurement will be made along the longitudinal centerline complete and accepted in-place.
 2. Payment for TBM Tunnel Excavation and Initial Support Classes – SC I TBM, SC II TBM, SC I E TBM, and SC II E TBM in Excavation Without Bored Tunnel Lining will be made at the Contract Unit Price per Linear Foot for Item No. 3 which price shall include excavation, initial support, any additional initial support required, transportation of excavated muck to the rail yard or truck loading area and disposal off-site, and the cost of all work, labor, materials, including all variable and indirect costs, required by various sections under Divisions 2 through 16 as referenced therein, and all the Contract Documents including other work, labor, and materials necessary therefore or incidental thereto; including associated indirect costs and profit.
 3. Incidental stoppage time for the TBM(s) resulting from the installation of additional initial support will not be measured or paid for separately, but will be deemed included in the cost of Item No. 3.
 4. Probe drilling and filling the probe holes with grout, as indicated in the Contract, will not be measured or paid for separately, but will be deemed included in the cost of Item No. 3.
 5. Welded wire fabric for surface protection shall be incidental to the tunnel excavation and will not be measured or paid for separately, but will be deemed included in the cost of Item No. 3.
 6. The cost for removal, transportation and disposal of abandoned elevator plungers and/or casings at East 45th Street encountered during TBM excavation works will not be measured or paid for separately, but will be deemed included in the cost of Item No. 3.
- D. Item No. 4 - TBM Tunnel Excavation and Initial Support Class – SC III TBM in Excavation Without Bored Tunnel Lining:
1. Measurement for TBM Tunnel Excavation and Initial Support Classes – SC III in Excavation Without Bored Tunnel Lining will be made per Linear Foot, measured to the limits specified. Measurement will be made along the longitudinal centerline complete and accepted in-place.
 2. Payment for TBM Tunnel Excavation and Initial Support Classes – SC III TBM in Excavation Without Bored Tunnel Lining will be made at the Contract Unit Price per Linear Foot for Item No. 4 which price shall include excavation, initial support, any additional initial support required, transportation of excavated muck to the rail yard or truck loading area and disposal off-site, and the cost of all work, labor, and materials required by various sections under Divisions 2 through 16 as referenced therein, and

- all Contract Documents including other work, labor, and materials necessary therefore or incidental thereto; including associated indirect costs and profit.
3. Incidental stoppage time for the TBM(s) resulting from the installation of additional initial support will not be measured or paid for separately, but will be deemed included in the cost of Item No. 4.
 4. Probe drilling and filling the probe holes with grout as indicated in the Contract will not be measured or paid for separately, but will be deemed included in the cost of Item No. 4.
 5. The cost for removal, transportation and disposal of existing plungers and/or casings at East 45th Street encountered during the TBM tunnel excavations will not be measured or paid for separately, but will be deemed included in the cost of Item No. 4.
- E. Item No. 5 – Dispute Review Board and Geotechnical Advisory Committee (Chairperson):
1. Dispute Review Board and Geotechnical Advisory Committee (Chairperson) is an allowance item and will not be measured separately for payment.
 2. Payment for Item No. 5 will be made up to a total of the allowance amount:
 - a. For the Disputes Review Board in accordance with General Terms and Conditions, Article 12.04 “DISPUTE REVIEW BOARD”; and
 - b. For the Geotechnical Advisory Committee Chairperson in accordance with General Terms & Conditions, Article 1.09 “PARTNERING AND GEOTECHNICAL ADVISORY COMMITTEE”.
- F. Item No. 6 – Con Edison Services:
- a. Con Edison Services is an Allowance Item and will not be measured separately for payment.
 - b. Payment for Item No. 6 will be made up to the total of the allowance amount.
 - c. Reimbursable costs for Con Edison services will include Con Edison’s direct and indirect costs for providing electrical service to the Medium Voltage Construction Power Substation. Con Edison services include furnishing and installing duct banks and property line manholes, furnishing and installing medium voltage feeders including splices from service manholes to property line manholes, furnishing of metering equipment and instrument transformers; as well as costs for Con Edison’s services for engineering, attendance at meetings, inspections during construction, testing and commissioning of the Medium Voltage Construction Power Substation.

- d. In order to be reimbursed under this item the Contractor shall provide invoices and proof of payment to Con Edison for their services with the Contractor's monthly payment request.
- G. Item No. 7 - TBM Tunnel Excavation and Initial Support Classes – SC I TBM, SC II TBM, SC I E TBM, and SC II E TBM in Permanent Lining Designated Areas:
- 1. Measurement for TBM Tunnel Excavation and Initial Support Classes – SC I TBM, SC II TBM, SC I E TBM, and SC II E TBM in Permanent Lining Designated Areas will be made per Linear Foot, measured to the limits specified. Measurement will be made along the longitudinal centerline complete and accepted in-place.
 - 2. Payment for TBM Tunnel Excavation and Initial Support Classes – SC I TBM, SC II TBM, SC I E TBM, and SC II E TBM in Permanent Lining Designated Areas will be made at the Contract Unit Price per Linear Foot for Item No. 3 which price shall include excavation, initial support, any additional initial support required, transportation of excavated muck to the rail yard or truck loading area and disposal off-site, and the cost of all work, labor, materials, including all variable and indirect costs, required by various sections under Divisions 2 through 16 as referenced therein, and all the Contract Documents including other work, labor, and materials necessary therefore or incidental thereto; including associated indirect costs and profit.
 - 3. Incidental stoppage time for the TBM(s) resulting from the installation of additional initial support will not be measured or paid for separately, but will be deemed included in the cost of Item No. 7.
 - 4. Probe drilling and filling the probe holes with grout, as indicated in the Contract, will not be measured or paid for separately, but will be deemed included in the cost of Item No. 7.
 - 5. Welded wire fabric for surface protection shall be incidental to the tunnel excavation and will not be measured or paid for separately, but will be deemed included in the cost of Item No. 7.
- H. Item No. 8 - TBM Tunnel Excavation and Initial Support Class – SC III TBM in Permanent Lining Designated Areas:
- 1. Measurement for TBM Tunnel Excavation and Initial Support Classes – SC III in Excavation in Permanent Lining Designated Areas will be made per Linear Foot, measured to the limits specified. Measurement will be made along the longitudinal centerline complete and accepted in-place.
 - 2. Payment for TBM Tunnel Excavation and Initial Support Classes – SC III TBM in Permanent Lining Designated Areas will be made at the Contract Unit Price per Linear Foot for Item No. 8 which price shall include excavation, initial support, any additional initial support required, transportation of excavated muck to the rail yard or truck loading area and disposal off-site, and the cost of all work, labor, and materials required by various sections under Divisions 2 through 16 as referenced therein, and

all Contract Documents including other work, labor, and materials necessary therefore or incidental thereto; including associated indirect costs and profit.

3. Incidental stoppage time for the TBM(s) resulting from the installation of additional initial support will not be measured or paid for separately, but will be deemed included in the cost of Item No. 8.
4. Probe drilling and filling the probe holes with grout as indicated in the Contract will not be measured or paid for separately, but will be deemed included in the cost of Item No.8.
5. The TBM excavation Initial Support Class – SC III in the proximity of the IRT No. 7 Line shall be constructed without steel mat lagging as shown on the Contract Drawings. The omission of the steel mat lagging will not be measured or paid for separately. Installation of the Initial Support Class – SC III will be paid for at the Contract Unit Price specified.

H. Item No. 9 – Tunnel Permanent Lining in TBM Excavation Areas:

1. Measurement for Tunnel Permanent Lining in TBM Excavation Areas will be made per Linear Foot. Measurement will be made along the longitudinal centerline complete and accepted in-place for pre-cast or CIP concrete lining of TBM Tunnels to the specified limits as indicated on the contract drawings.
2. The cost for furnishing and installation of precast concrete segments and/or CIP concrete lining including reinforcement, waterproofing and drainage will not be measured or paid for separately, but will be deemed to be included in the cost of Item No. 9.
3. The cost of any labor, materials and equipment used for concrete repairs and/or leak remediation of either precast segments or CIP lining shall not be paid separately and is deemed to be included in this item.

I. Item No. 10 – Standby Time:

1. Measurement for Stand-by Time due to coordination with other contracts during blasting operations will be made per Crew Hour for each affected TBM, defined as an hour of time for labor and equipment.
2. Measurement of crew hours for Standby Time shall begin when Contractor is directed by the Resident Engineer to cease operations in the lower TBM tunnels within the future GCT Cavern and/or tail tracks to allow for blasting operations to take place under a separate contract within the GCT Caverns. Measurement of crew hours for Standby time shall end when it is deemed safe to resume Work as directed by the resident Engineer, plus an additional 1/2 hour per occurrence to allow for remobilization of Contractor's personnel and equipment.
3. During this disruption, the Contractor shall cease all operations in these areas and transport personnel to a location north of the blasting area within the caverns.

4. It is anticipated that the disruption will last less than one hour per occurrence. However, in those instances where the time exceeds one hour, the contractor will be paid the additional time in half-hour increments.
5. Blasting will be coordinated between the contractors by the Resident Engineer to minimize the impact on CM009 operations. In addition, at no time will blasting take place during the actual placement of concrete.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for construction progress documentation specified herein.

1.02 REFERENCED SECTIONS

- A. Section 01330 – Submittal Procedures

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. The CPM Schedule shall be submitted in the following formats:
 - 1. Preliminary Schedule: No later than 14 calendar days after Notice to Proceed, submit a CPM Time-Scaled Network Diagram defining Contractor's planned activities during the first 90 calendar days. The Preliminary Schedule shall contain in detail Contractor's proposed schedule of work to be commenced within the first 90 working days after the Notice of Award. This Preliminary CPM shall include, in a summary format, the balance of Work leading to the Project's Substantial Completion. The Preliminary Schedule shall conform in all respects to the criteria set forth in this specification both for content and updating purposes. Contractor agrees that this schedule accurately represents Contractor's plan for the timely completion of the Work scheduled herein.
 - 2. Baseline Contract Schedule: No later than 45 calendar days after Notice to Proceed, submit the complete CPM Schedule documents. The Baseline Contract Schedule submittal shall incorporate the entire scope of the Work as awarded by the MTA. Upon approval by the Resident Engineer, the Baseline Contract Schedule shall be the Schedule of Record. Contractor agrees that this schedule or submission shall accurately represent Contractor's initial construction plan for the timely completion of the Work scheduled herein.

3. Summary Schedule: Submit a Summary CPM Schedule along with the approved Baseline Schedule of Record and all subsequent monthly schedule updates for the duration of the Contract. The summarized CPM schedule shall reflect the current schedule status of the Project with each submission. The format and level of detail will be in accordance with the Contract's major areas of work to be agreed upon with the Resident Engineer after the award of the Contract. Contractor agrees that this schedule or submission accurately represents Contractor's current plan for the timely completion of the Work scheduled herein.
 4. Updated Current Contract Schedule (Monthly): No later than the seventh (7th) workday of the month following the report period, submit an update of the CPM schedule. This schedule shall be derived from the Baseline Contract Schedule and include progress of the Work as agreed to each month. Contractor agrees that this schedule or submission accurately represents the progress of the Work to date and balance of the Work to be completed. Logic and duration changes are not permitted to the Baseline CPM Schedule or subsequent updates unless submitted to the Resident Engineer for approval prior to their insertion into the schedule.
 5. As-Built Schedule: Submit the As-Built Schedule as one of the prerequisites to the receipt of Final Payment. The As-Built Schedule shall cover all work performed under the Contract. Contractor agrees that this As-Built Schedule accurately represents the actual dates, activities, durations and logic and the manner in which the Contract was executed.
 6. Electronic Copies: The Preliminary, Baseline, Summary and Current Updated Schedules, in detail and in summary format, shall be submitted on Microsoft Windows compatible CD-ROM medium in Primavera Project Planner (P3) Version 3.1, or later, format. Upon approval by the Resident Engineer, Contractor may use 3-1/2-inch floppy disk instead of CD-ROM. MTA reserves the right to request conversion to "Primavera Enterprise" at a future date.
- B. Payment Requisition: Each month, no later than the second workday of the month following the reporting month, submit their Payment Requisition in accordance with the requirements of the General Terms and Conditions, Chapter 7, "PRICING AND PAYMENT".
- C. Schedule Control Specialist's Resume: Within 10 calendar days of Contract award, submit the Schedule Control Specialist's resume of experience. Resident Engineer has right to reject the Schedule Control Specialist based upon lack of experience as required herein. If Resident Engineer does not accept the person proposed by Contractor, submit another person(s) meeting experience requirements.
- D. Detailed Cost Breakdown (DCB): Not later than 30 calendar days from Notice of Award, submit a DCB with all Lump Sum, Unit Price and Allowance Items reflecting the Total Contract Amount.

1.07 DELIVERABLES

- A. Progress Photographs and Video Footage: Take photographs and video footage as required to document the progress of the Work, and as per the specific requirements of the Resident Engineer. The photographs and video shall show in detail the initial condition of the Work Site, the monthly progress of the Work, and unusual or special conditions that may develop throughout the duration of the Contract. The video and photographs shall be provided monthly and shall be representative of all major elements of work in progress during the month.
- B. Photographs:
 - 1. Photographs shall be taken with a digital camera that is capable of producing color prints with a minimum 3.3-megapixel resolution.
 - 2. Provide an electronic and typed description of each photograph indicating the number; the date/time and location; the camera position; the direction faced; and a brief description of what is being photographed.
 - 3. A minimum of 15 photos shall be taken each month.
- C. Video Footage:
 - 1. Video footage shall be taken using a digital video camera that is capable of producing mini digital video (dv) footage.
 - 2. Provide an electronic and typed shot log that indicates the shot date/time and location; type of shot (e.g., close-up, pan left or right), and a brief description of what is being filmed.
- D. Photograph and Video Ownership: All photographs and video footage, including all digital cassettes, shall become the property of the MTA. The cassettes or cartridges and typed descriptions/shot logs, along with one 8-inch by 10-inch print copy of each photograph, shall be delivered to the Resident Engineer within two weeks of date taken. Photos shall be printed on glossy premium photo paper. Electronic copies of all photographs shall also be provided via e-mail or CD-ROM.
- E. Six Week Look Ahead Schedule: As part of the weekly Job Progress Meetings to be held on a day mutually agreed to by the Resident Engineer and Contractor, provide a progress schedule listing activities completed and in progress for the previous week and the activities scheduled for the succeeding five weeks based on the Current Contract Schedule. The Six Week Look Ahead Schedule shall be on 11- by 17-inch paper and shall be provided from the Current Contract Schedule, and include all activities scheduled including: activity ID, description, early start and early finish, total float, original duration, remaining duration, percent complete, performance of the activity, and pertinent remarks as to activity status.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION**3.01 GENERAL SCHEDULE REQUIREMENTS**

- A. CPM Schedule: The Work shall be monitored by a detailed Critical Path Method Scheduling System (hereinafter "CPM Schedule"). The scheduling of all design, submittals, procurement, and construction is the responsibility of Contractor. The requirement for the CPM Schedule is included to assure adequate planning and execution of the Work and to assist MTA in appraising the reasonableness of the proposed schedule, as well as its compliance with Contract requirements.
- B. Progress Payment: The monthly CPM schedule submission, showing updated activities and status in accordance with requirements of this Section shall be conditions precedent to the start of the progress payment cycle.
- C. Purpose: The CPM Schedules shall be used by the MTA and Contractor for the following purposes as well as where the issue of time is relevant:
 - 1. To communicate Contractor's current plan for carrying out the Work;
 - 2. To identify work paths critical to the timely completion of the Work;
 - 3. To identify upcoming activities on the critical path(s);
 - 4. To evaluate the best course of action for mitigating the impact of unforeseen events;
 - 5. To support the basis of progress payments to Contractor;
 - 6. As the basis for analyzing the time impact of changes in the Work (see General Terms & Conditions Chapter 6, PROVISIONS RELATING TO TIME);
 - 7. To prioritize the MTA review of submittals;
 - 8. To document the actual progress of the Work;
 - 9. To evaluate resource requirements of Contractor and the MTA;
 - 10. To identify all Force Account work;
 - 11. To integrate the Work with MTA's operational requirements;
 - 12. To facilitate efforts to complete the Work in a timely manner.

- D. Time is of the essence in the performance of all Work under this Contract including but not limited to providing the necessary schedule information required herein. The CPM Schedule shall at all times accurately reflect Contractor's current plan for the Work and shall be updated as required herein, in a timely manner. The CPM Schedule shall be the primary tool utilized by Contractor to accurately document the progress of the Work and to communicate its plan for the timely completion of the Work.
- E. Float: Float is not for exclusive use or benefit of either MTA or Contractor, but is an expiring resource available to both parties. Float is used by either party, as needed, to meet Contract milestones and Contract completion dates, or to cover changes to the Contract. Should work be delayed on the Critical Path. Contractor may not use any float created by such delay on any other path without the approval of the Resident Engineer. Approval for use of float shall be in advance of its use in order for the Resident Engineer to evaluate the option of maintaining non-critical path(s), while recovering time to the Contract Milestone(s).
- F. Float Suppression: Pursuant to float sharing requirements of this Section, use of float suppression techniques such as preferential sequencing or logic, special lead/lag logic restraints, and extended activity times or durations are prohibited. The use of negative lags or the use of any other float suppression techniques is also prohibited from use in the CPM Schedule. Approval of any Schedule Submission by MTA shall not preclude later correction of float suppression techniques or of any other deficiency by the MTA.
- G. Early Completion Schedule: While the Contract Documents indicate a specific Contract time for completion of the Work, if Contractor elects to propose an Early Completion Schedule, such schedule shall not violate any interim Milestones specified in the Contract Documents.
1. Early Completion Schedules are subject to General Terms and Conditions Article 6.05 B, "SCHEDULE ANALYSIS PRINCIPLES". In such case, the Early Completion Schedule, once approved by MTA, may become the revised Baseline Contract Schedule subject to the conditions in Article 6.05.
 2. If Contractor includes an activity or milestone in their schedule that represents Substantial Completion, such activity will only be acceptable if it meets all the requirements of the General Terms and Conditions Chapter 6, "PROVISIONS RELATING TO TIME".
- H. Required Schedule Controls Staff: Employ a schedule controls specialist with five years experience in the use of Primavera Project Planner (P3), for the purpose of monitoring and maintaining Contractor's detailed schedule system utilizing Primavera Project Planner (P3). The schedule controls specialist shall attend all job progress review, schedule update and any other meetings as requested by the Resident Engineer.

- I. Scheduling Kickoff Meeting: Upon Notice of Award, Contractor and MTA will conduct a scheduling Kickoff Meeting to review the requirements herein and any related Contract Documents. This meeting shall be attended by Contractor's Authorized Representative, Contractor's Schedule Controls Specialist, representatives from major subcontractors, MTA's Program Management Staff including the MTA Project Scheduler and Resident Engineer. Specific items to be covered, as a minimum, will include Contract schedule requirements, intermediate milestones, workday calendars, activity coding, update cycle timing, and progress payment process.
- J. No Waiver of Rights: Review and approval of Contractor's schedule shall not waive any rights under this Contract, expressed or implied or any other contract requirements.
- K. Detailed Cost Breakdown (DCB):
 - 1. The DCB shall be consistent with the General Terms and Conditions CHAPTER 7, "PRICE AND PAYMENTS" but shall be in lieu of requirements to furnish Cost-Loaded Activities (CLA) in the schedule.
 - 2. The DCB for each lump sum item shall include its proportionate share of overhead, profit, premium on bond, insurance and all other expenses involved, be in proper balance, and subject to approval of the Resident Engineer.
 - 3. Upon approval by the Resident Engineer, the approved DCB shall be used in the Payment Requisition for determining progress payments each month based on earned value and in accordance with the General Terms and Conditions Chapter 7, Price and Payments.
 - 4. The DCB shall be consistent with the Bid Item Breakdown as indicated in Book No. 1, Appendix C unless otherwise approved by the Resident Engineer.

3.02 DETAILED SCHEDULE REQUIREMENTS

- A. Type of CPM: The CPM Schedule shall be prepared in the Precedence Diagram Method (PDM) format based on the Critical Path Method (CPM) technique.
- B. Schedule Detail: The CPM Schedule shall contain sufficient construction activities to represent the Work, subject to the approval of the Resident Engineer, with a means to monitor and follow progress of all phases of work; comply with limits imposed by scope of work, with contractually specified interim milestones and completion dates; and with constraints, restraints, or sequences included in the Contract. Schedule detail required shall be to the satisfaction of the Resident Engineer. Factors which must be considered, but not limited to are as follows:
 - 1. Organization by the Contract's major areas of work as agreed upon with the Resident Engineer.

2. Type of work to be performed, including sequences. This shall include Force Account work to be done by MTA's own forces and any other railroad agency. This work shall include the General Orders (G/O), Work Train Requirements (WT) as well as Flagging Requirements (FL) and be coded in the schedule as noted.
3. Purchases, master list of submittals, submittal reviews, manufacture, tests, delivery, and installation activities for major materials and equipment. Each submittal included in the Resident Engineer-approved submittal list shall be represented in the CPM Schedule by submittal activities. Descriptions in the submittal list shall correspond to activity descriptions in the CPM Schedule and shall be of sufficient detail to identify the unique scope of the submittal. Whenever possible, like items shall be combined in a single submittal. When it is discovered that a submittal required by the Contract documents has not been included in the Resident Engineer-approved submittal list, the CPM Schedule shall be corrected by the addition of the required submittal activities. When multiple items are included in a single submittal, that submittal shall be represented in the schedule by an activity in accordance with the following conditions:
 - a. The "Review" activity for that submittal shall be a predecessor to every activity representing the fabrication and delivery of any of the materials submitted.
 - b. When the submittal receives a partial proceed and that partial proceed is sufficient to enable the commencement of a successor activity, then the original submittal activity shall be broken down into multiple activities, as necessary to accurately reflect the logic of Contractor's current plan.
4. As part of the monthly update procedure, submittal activities shall be reviewed and modified to ensure that the scope and logic of the activities are consistent with Contractor's current plan.
5. Deliveries of MTA furnished equipment and/or materials in accordance with dates or schedule windows of such times set forth in the Contract or furnished by the MTA. As part of the monthly update procedure during the progress review meeting, a discussion of delivery activities shall be reviewed and modified to ensure that the scope and logic of delivery activities are consistent with Contractor's current plan. Activities representing the delivery of materials or equipment for more than one installation activity will be permitted in accordance with the following conditions:
 - a. The material delivery activity shall be a predecessor to each activity representing the installation of that material in each area.
 - b. When partial deliveries are received and those deliveries are adequate to enable the commencement of some, but not all, successor activities, then the original delivery activity shall be broken down into multiple activities, as necessary to accurately reflect the logic of Contractor's current plan.

6. Preparation, submittal and approval of shop and/or working drawings and material samples showing a 30-day minimum time specified for the Resident Engineer's review of normal or routine submittals, so identified in the Specifications (see Section 01330). If Resident Engineer or MTA requires a re-submittal, such extra activity shall be added to the updated Current Contract Schedule with a 30-day minimum review time.
7. Approvals required by regulatory agencies or other third Parties.
8. Schedules for subcontract work at similar levels of detail.
9. Milestones or Access Restraints for completion of certain portions of the Work or access and availability to work areas.
10. Identification of interfaces and dependencies with preceding, concurrent, and follow-on Contractors and utilities, typically shown as milestone type of activities.
11. Actual tests, submission of test reports, and review process of test results.
12. Inspections, start up, testing, training, and assistance required under the Contract.
13. Planning for phased or total handover to the MTA.
14. Punch list and final cleanup.
15. Identification of manpower, material, or equipment restrictions, as well as any activity requiring unusual shift work, such as two shifts, six day weeks, specified overtime, or work at times other than regular days or hours.
16. Activity Code Structures: Activities shall be coded for the following categories: submittal, submittal review, procurement, fabrication, delivery, change order, construction, installation, testing, payment item, major areas of work, responsibility etc.
17. Resource Loading: Resource allocation against each P3 activity identifying the physical quantity of material to be installed (cubic yards of concrete, linear feet of pipe, etc.). Activities containing unit price items as specified in Contractor's bid proposal shall total in amount to the quantity specified in the Contract.
18. The CPM schedule shall contain only a single "start" activity (milestone) and a single "finish" activity (milestone) to which all paths in the network are tied. All activities with the exception of these work start and end nodes shall have predecessors and successors. The start of an activity shall have a start-to-start or finish-to-start relationship with preceding activities. The completion of an activity shall have a finish-to-start or finish-to-finish relationship with a succeeding activity.

19. Calendars: Develop activity calendars commensurate with Contractors workweek plan. Calendars shall include all non-working days, such as weekends, holidays, or other periods when Contractor plans not to work. Calendar(s) shall be reviewed by Resident Engineer as part of the Baseline Contract Schedule submittal and will be monitored on the updated Current Contract Schedule submittals.
 - a. The planning unit for the Contract shall be days.
 - b. Calendars shall contain all union holidays, as listed in applicable labor agreements.
 - c. Every activity shall be assigned a working day calendar that takes into account when the activity is planned to occur and when it is contractually permitted to occur. Define and submit working day calendars for approval by the Resident Engineer that are necessary for completion of work in accordance with the requirements of the Contract Documents.
 20. Activities representing work or participation by MTA or Resident Engineer staff shall be assigned to 5-day workweek calendars. Contractor's schedule shall not anticipate or require weekend or holiday work periods for MTA or Resident Engineer unless specifically agreed to by the MTA's Authorized Representative.
- C. Material and Equipment Procurement: Include following activity sequence for major material and equipment procurement: Submittal Preparation; Review; Fabricate and Deliver. Divide procurement items that may contain multiple submittals occurring at different time intervals into separate sequences that can be tracked on an individual basis. Include a minimum original duration of 30 days for review activities. Include a minimum duration of 30 days for re-review.
- D. Logic and Durations: Logic and activity time durations shall be established by Contractor consistent with Contract requirements and reflective of proper coordination between trades, definitive resource planning and on-site work conditions. Logic shall show how the start of a given activity is dependent on the completion of preceding activities, and its completion restricts the start of following activities. Activities shall not have a duration greater than 15 work days without approval from the Resident Engineer.
- E. Restraints and Milestones: The start date of the CPM Schedule shall be the Contract Notice to Proceed date. The completion date of the CPM Schedule shall be the Contract completion date as specified in this Chapter, which shall be entered into P3 as the "Project Must Finish No Later Than" date. All intermediate restraints and milestones required in the Contract shall be shown in proper logical sequence and input as "Start-No-Earlier-Than" or "Finish-No-Later-Than" dates, respectively.
- F. Schedule Dates: Whenever the term "schedule" or "scheduled date" is used, it shall mean the "early start" and "early finish" dates in the CPM schedule. The "late" dates are for purposes of calculating float and do not represent the schedule dates.

- G. Activity Descriptions: Activities shall be described such that the Work is readily identifiable for assessment of start and completion, as well as intermediate status. Descriptions shall utilize identifiers for physical locations such as column lines, stations, and elevations where possible to define the Work. The activity description shall identify the scope of the activity. There shall not be any two activities with the same activity description.
- H. Working Days: While contract times are expressed in calendar days, the CPM Schedule shall be calculated in working days.
- I. Weather Allowances: Seasonal weather conditions shall be considered in the planning and scheduling of all work such that the all work will be completed within the allotted Contract time. All weather allowances shall be stated in the baseline narrative.
- J. Submittal and Review Periods: The review period shown in the Schedule for submittals shall conform to the provisions of Article 2.01 of the General Terms and Conditions "SUBMITTALS".
- K. Constraints: The schedule shall include all work constraints indicated by MTA or Resident Engineer in the original Contract or as added with a Contract modification. Other activity Constraints shall not be used unless approved by the Resident Engineer.

3.03 COMPUTER PROGRAM REQUIREMENTS

- A. Software: Scheduling software shall be "Primavera Project Planner" (P3), Version 3.1 or later, a proprietary computer program of Primavera Systems, Inc. MTA reserves the right to request conversion to "Primavera Enterprise" at a future date.
- B. Settings: Within Primavera Project Planner (P3), ensure that the following settings be used for consistency across the Project, when reporting schedule information:
 - 1. Auto Cost Rules: Do not link remaining duration and percent complete.
 - 2. Schedule Calculation:
 - a. Use Retained Logic: If an activity is started before completion of its predecessor, revise logic such that the tie between the predecessor and the out-of sequence activity is removed and a tie be added between the predecessor and any of its successors if that logic tie is required to reflect the sequence of the Work.
 - b. Calculate total float as Finish Float.

3.04 COMPUTER REPORTS

- A. Prepare definitions and designs for reports and/or layouts in P3 in accordance with requirements detailed herein. These will allow the Resident Engineer to produce reports meeting MTA requirements.

- B. Sort Orders: Schedule Reports shall be provided in the following sort orders:
1. Activity number.
 2. Total float, then early start.
 3. Grouped by responsibility, then by early start.
 4. Grouped by location, then by early start.
 5. Grouped by major work areas, then by early start.
- C. Information on Reports: The minimum activity information required in each of the above reports shall include the following:
1. Activity ID.
 2. A description of the Work represented by the activity.
 3. Location code identification.
 4. Work responsibility code identification.
 5. Original activity duration and remaining duration in working days.
 6. Early and late start and finish dates calculated according to CPM principles.
 7. Total float.
 8. Historical dates for activities completed or underway shall replace the appropriate calculated dates.
 9. Percent complete.
- D. No Activity ID Changes: Once assigned, activity numbers (Activity ID) shall not be changed without prior approval of the Resident Engineer.
- E. Time-scaled Network Diagrams:
1. Network Detail: The schedule displayed on the Network Diagram shall depict the exact detail of the CPM Schedule Reports.
 2. Precedence Diagram: The Network diagram shall be of the precedence type and drawn by using early dates.
 3. Activity Bar Content: The activity display shall include the following for each activity bar:
 - a. Activity description.
 - b. Activity number.

- c. Activity duration.
 - d. Activity total float.
 - e. Activity early start and finish dates.
- 4. Grouping: The activities that are displayed on the Network Diagram shall be grouped as approved by the Resident Engineer. The title of these components shall appear on the left hand side of the plot.
 - 5. Critical Path Display: The critical path shall be identified on the plot in such a manner that it will be clearly distinguishable from other activities.
 - 6. Grid Lines: Vertical lines indicating the start and the end of each month shall be drawn.
 - 7. Data Date: The data date shall be indicated on the plot. This shall be done in the activity display and in the title at the top or bottom of the plot.
 - 8. Progress Display: Completion of activities shall be indicated on the plot.
 - 9. Contract Title: The Contract title shall be displayed on the plot.
 - 10. Legend: A legend shall be provided which indicates the various symbols used and their meanings.
 - 11. Milestone Symbols: Contract milestones shall be indicated by a distinct and prominent symbol.

3.05 REVIEW AND APPROVAL

- A. Reviews of Contractor's schedule submissions will be in accordance with Section 01330, unless noted otherwise herein.
- B. Preliminary Schedule Review: Resident Engineer will review and respond to Contractor's Preliminary Schedule submittal within 7 calendar days after submittal. After review by the Resident Engineer, if changes or additional information are required, the Preliminary Schedule shall be revised and resubmitted as required within 7 calendar days. Review, revision, and resubmission shall continue until the Resident Engineer's approval is achieved.
- C. Baseline Schedule Review: Resident Engineer will review and respond to Baseline Contract Schedule submittal within 30 calendar days after submittal. After review by the Resident Engineer if changes or additional information are required, the Baseline Schedules shall be revised and resubmitted as required within 15 calendar days. Review, revision, and resubmission shall continue until the Resident Engineer's approval is achieved.

- D. Update Reviews: Resident Engineer will review and respond to update scheduling submittals within 7 calendar days after submittal, unless a different review period is expressly identified elsewhere in the Specifications or other Contract Documents. After review by the Resident Engineer if changes or additional information are required, submit a revised schedule within 7 calendar days. Review, revision, and resubmission shall continue until the Resident Engineer's approval is achieved.

3.06 BASELINE CPM SCHEDULE NARRATIVE

- A. As a component of the Baseline CPM Schedule, submit a narrative to describe the procedures, general approach and the means and methods it will use to complete the Work under the conditions described and in accordance with the Contract documents.
- B. Submit the narrative described herein along with the Baseline CPM Schedule. Any review, acceptance, or approval of a Baseline narrative or schedule submission cannot revise or amend any contract provision and does not represent MTA agreement to any conclusion, interpretation, indication, method or description contained therein.
- C. The narrative shall describe and demonstrate that Contractor's proposed means and methods meet the specified Contract requirements. The narrative shall include:
1. Drilling and blasting, as well as excavation and initial support installation for the approach tunnels, TBM assembly chamber if the Contractor chooses to build it, starter tunnels, cross passages, central instrument room, and wye caverns. Anticipated drilling and blasting production rates.
 2. TBM assembly and launch operations including details of the TBM assembly chamber, TBM disassembly, back-out and reassembly, TBM final disassembly and removal.
 3. Description of proposed TBM and trailing gear, including TBM operational characteristics, equipment details, safety provisions, means for cutter replacement, routine and major TBM equipment component maintenance.
 4. TBM excavation operations, including initial support installation and testing.
 5. Sequence of TBM tunnel drives and widening of wye caverns in relation to the TBM drives.
 6. Anticipated TBM advance rates.
 7. Probe drilling.
 8. Grouting ahead of the tunnel face and from within excavated tunnels and caverns.
 9. Tunnel water control, collection, and removal.

10. Monitoring and control of tunnel alignment.
11. Geotechnical instrumentation in excavated tunnels and caverns and existing NYCT tunnels.
12. Handling and disposal of muck from TBM and drill and blast operations.
13. Test blasts for the approach tunnels and wye caverns.
14. Installation of waterproofing, placement of CIP concrete lining in wye caverns.
15. Reframing of structural columns at Queens Bellmouth.
16. Installation and construction of medium voltage power substation.

3.07 UPDATING AND REVISION

- A. Updating: Update Contract Schedule monthly, with Data Date as of the first day of the following Month.
 1. Use updated Current Contract Schedule for subsequent planning, scheduling, managing, statusing of the master list of submittals, and execution of work to be accomplished. If an update evidences delay to the Baseline Schedule, one of the goals of the planning process shall be mitigation of that delay, in accordance with and subject to the provisions of General Terms and Conditions Chapter 6.
 2. Submittal and approval of schedule updates shall be a condition precedent to making monthly payments as referenced in the General Terms and Conditions Chapter 7.
 3. For otherwise excusable or compensable delays, the MTA shall not be liable for delays to Contractor's work that occur during a time when Contractor has failed to provide a schedule update in accordance with the requirements of the Contract Documents.
 4. Update the CPM Schedule monthly, whether or not the Resident Engineer has approved the prior updated schedule, to reflect actual construction progress. The update shall include the historical record of actual start and finish dates for activities completed. For in-progress activities, the update shall include percent complete based on a unit of measure and remaining duration based on the amount of workdays required to complete the activity.
 5. Default (automatic) updating of the schedule is prohibited. Actual Start and Finish dates shall not be automatically updated by default mechanisms that may be included in the CPM scheduling software systems.

- B. Progress Review Meeting: A monthly progress review meeting shall be held within two working days of the Data Date inclusive, unless designated otherwise by Resident Engineer. MTA reserves the right to change the monthly cut-off dates in the future for its sole convenience. This meeting shall be attended by the Resident Engineer, Contractor's schedule controls specialist, and subcontractors' representatives. The purpose of this meeting shall be to obtain joint agreement on work progress as well as to discuss schedule related problem areas, proposed logic changes, revisions to previously established productivity rates and other schedule issues. At this meeting, all progress during the calendar month shall be addressed and reviewed for incorporation into the schedule by Contractor.
- C. Update Submittal: The monthly schedule update submittal shall consist of three copies of the following:
1. Updated CPM Tabular Reports.
 2. Updated Time-Scaled CPM Network Diagram.
 3. CPM Narrative Progress Report.
 4. A comparison report showing all changes made to the schedule since the last update as approved by the Resident Engineer. This report shall include the reasons for these changes.
- D. Progress Narrative: The CPM Progress Narrative Report submitted as part of the update analysis shall include, but not be limited to:
1. Description of cost and schedule status.
 2. Discussion of current and anticipated delaying problem areas and their estimated impact, including off-site activities such as submittal preparation, fabrication, and deliveries.
 3. If the Work is behind schedule, include discussion of schedule slippage and/or progress along the critical path in terms of days ahead or behind the allowable dates and discussion of progress along other paths with negative float. This shall also include a proposed recovery plan.
 4. Logic changes and an explanation of the revisions. Revisions to activities not worked on during the period, including changes in duration; revisions to activity relationships; and revisions to constraints on activities; are all to be considered logic revisions. Similarly, this shall include description and explanation of reason for any changes to calendars being used in P3 as well as any changes to calendar assignments of activities.
 5. Identification and justification of all activities worked out of sequence. Out-of-sequence activities shall not be left as such in the schedule and shall be corrected in logic revisions before submittal of the updated Current Contract Schedule.

6. A summary of planned equipment utilization for the Project, identifying each type of operated equipment to be used on the Contract, the planned quantity of each type of operated equipment utilized each month, and all changes to the criteria for mobilizing and demobilizing each piece of equipment to and from the Work Site.
 7. A summary of planned labor utilization for the Contract, identifying the average and maximum number of workers on-site each month. Identify actual and potential labor resource limitations. A summary of the actual labor utilization used over the past month.
 8. Identification and discussion of Force Account work including General Orders, Work Trains, and Flagging.
 9. List and Description of Elective Changes: An elective change is defined as a revision to logic or duration(s) by Contractor to effectively use labor and resources that has no adverse affect on Contract Milestones. The Resident Engineer may also use this section to request a change in the schedule. Mutual agreement on the change shall be gained to implement such request. The elective change narrative shall contain the following information.
 - a. Identification of the activities changed.
 - b. A description of the scope of the elective change and identification of the advantages and disadvantages of implementing the change. Identify all driving resources, if any. Identify key constraints influencing Contractor's approach to the Work.
 10. Identification of outstanding RFIs including discussion of their cost and/or schedule impact.
- E. Recovery Schedule: Recovery Schedules are required as provided in General Terms and Conditions Article 6.02D. In addition, when, in the Resident Engineer's opinion, the CPM Schedule fails to reflect Contractor's actual plan and method of operation, the Resident Engineer may require Contractor to submit for review within 2 weeks, a revised CPM Schedule for completion of the remaining work within the Contract completion date.

3.08 EXTRA WORK

- A. To insure that the CPM Schedule shall continue to accurately reflect Contractor's plan for the Work and that it incorporates the impact of all Extra work as soon as the Work scope can be defined, the following procedure shall be followed to incorporate Extra work in the Schedule.
1. When a Change Proposal is submitted by Contractor in accordance with the requirements of the General Terms and Conditions Chapter 8, "CHANGES TO THE CONTRACT", identify, as part of the required Time Impact Analysis (See Article 6.06 – "TIME IMPACT ANALYSIS") in a CPM-type sketch, additional or changed work required because of the proposal and its interrelationship to the CPM Schedule. This Time Impact Analysis shall show all activities, logic revisions, and duration changes for performing the Work in question.

2. Upon execution of a Contract Modification, incorporate the revisions into the Baseline Contract Schedule and the Current Contract Schedule at the next Schedule update.
- B. No additional compensation will be paid Contractor for preparing these revisions.
 - C. Any request for Extension of Time shall be verified by Time Impact Analysis and be in accordance with General Terms and Conditions Chapter 6, "PROVISIONS RELATING TO TIME".

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for Submittal procedures indicated on the Contract Drawings and specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Submittals schedule. See Table at end of this Section and Paragraph 3.01A.
- B. Initial Submittal of the Project Drawing List.
- C. Within 30 days of the date of Notice of Award, submit a test sample of a CADD drawing file prepared by Contractor to assure compatibility with the Resident Engineer's CADD system. Layering and other required CADD conventions will be supplied to Contractor by the Resident Engineer.

1.07 DELIVERABLES

- A. Updated Project Drawings Lists and hard copies of updated Record Drawings and entries/revision logs.
- B. Electronic set of final Project Drawing List and all Record Drawings (both in CADD format and as image files, such as ".tiff", ".jpg", or ".pdf") and all Shop Drawings.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION**3.01 GENERAL**

- A. Submit Shop Drawings, drawings, calculations, samples, catalog cuts, and related items (identified in the Contract Drawings and elsewhere in these Specifications), and all Other Submittals, in accordance with this Section. See also general requirements and provisions relating to Submittals in General Terms and Conditions Article 2.01 "SUBMITTALS".
- B. All submittals shall be clearly labeled with the Specification section designation for the subject submittal. Contractor's transmittal shall also clearly indicate the Specification section designation for the submittal to be reviewed. Submittals that do not include the Specification section designation will be returned to Contractor without review.
- C. A Submittals listing is provided at the end of this Section for Contractor's convenience. This listing is for information only and should not be considered as full and complete. Submittals other than those listed may be required and it is Contractor's responsibility to include in its Submittals schedule (as required in General Terms and Conditions Paragraph 2.01A) and to provide all Submittals required in the Contract or otherwise necessary to perform the Work.
- D. Except for those Submittals for which a specific process, procedure or additional requirements are set forth in other paragraphs of this Section or in other Contract Provisions, all Submittals shall be submitted and will be reviewed in accordance with Article 3.04 below. Whenever the term "review" is used in these Technical Specifications with respect to any submittal, it shall refer to the process, procedures and requirements identified in General Terms and Conditions Article 2.01 "SUBMITTALS", and in this Section and in any Contract provisions referenced herein. Schedule Submittals shall be submitted and reviewed in accordance with General Terms and Conditions Article 6.02 "CONTRACTOR'S SCHEDULES" and Section 01320 of these Technical Specifications.
- E. Review by the Resident Engineer of Submittals will not relieve Contractor of responsibility to comply with all Contract requirements, for the adequacy of their design, construction, and use, nor for the safety of persons and property by reason thereof, nor for the safety and successful execution and completion of the Work.

3.02 CONTRACT DRAWINGS

- A. The Contract Drawings referred to in this Contract are signed by the General Engineering Consultant (GEC), are part of the Contract Documents for this Project, and are designated or numbered in the index of the Contract Drawings.
- B. The sections and dimensions indicated on the Contract Drawings are typical sections and dimensions that should be applicable to the greater part of the work. If required, the MTA will clarify the Contract Drawings under the provisions of the General Terms and Conditions Chapter 2, "SUBMITTALS". In such cases, drawings clarifying the Contract Drawings will be furnished to Contractor by the Resident Engineer and shall be considered as part of the Contract Drawings.

- C. In order to assist Contractor in the preparation of drawings by Contractor, the Resident Engineer will furnish Contractor one full-size, hard copy set of the Contract Drawings.
- D. In order to assist in the preparation of Computer Aided Drafting and Design (CADD) generated drawings for the Project, the Resident Engineer will furnish Contractor with CADD-generated Contract Drawings in MicroStation J “.dgn” format, of the Contract Drawings prepared by the MTA for this Project that can be used as background reference files. These drawing files will be provided on CD-ROM.

3.03 DRAWINGS PREPARED BY CONTRACTOR

- A. Drawings prepared by Contractor shall include certain Design Drawings, all Shop Drawings, and all Record Drawings as described herein.
- B. The format for hard copies of drawings, whether they are hand-drafted or CADD-generated, that are submitted by Contractor shall be standard “D” size with outside cut line dimensions 22-inches by 34-inches. Drawings shall conform to East Side Access CADD Standards Manual and Configurations. These drawings shall be arranged in systematic order and numbered consecutively.
- C. Hard copies of drawings submitted by Contractor shall be on high-quality paper with the line work and text of such quality that will allow digital reproduction and that will allow readable prints to be obtained from both the original prints, copies and digitized files.
- D. CADD drawings files, if submitted by Contractor, shall be vectorized computer-generated drawing files in MicroStation J “.dgn” format that are editable. Each Submittal shall include the ESA Project Standard Cell and Font Libraries and reference files used to generate the CADD drawing files. Each Submittal shall be provided on CD as specified herein. Each CD shall be properly labeled and shall include Contractor’s name, date, Project name, Contract Number, description of contents, and CADD format. Vendor and Shop Drawings for systems work (signals) shall use AutoCAD 2000 to be compatible with design software Promise “E” used by the LIRR.
- E. In addition to requirements for CADD drawing files, all Contractor and Vendor Design, Shop Drawings and Record Drawings shall be processed into electronic images (“JPG” or “JPEG” files) and provided in accordance with ESA Document Control Requirements.

3.04 SHOP DRAWINGS AND OTHER SUBMITTALS

- A. “Shop Drawings” are as defined in General Terms and Conditions Article 1.02 “DEFINITIONS AND ABBREVIATIONS” and include any design drawings and working drawings Contractor is required to prepare. “Other Submittals” are all Submittals other than Shop Drawings, including but not limited to any other Project data, Work plans, procedures or other information required to be provided to the Resident Engineer by Contractor or, through Contractor, by a Subcontractor, manufacturer, supplier, or distributor to illustrate some portion of the Project.

- B. When preparing Shop Drawings and Other Submittals, perform the following:
1. Check and verify all field measurements.
 2. Review for completeness and for conformance to the Contract Drawings.
 3. Review and coordinate the work shown on the Shop Drawings and Other Submittals with the work of Subcontractors and suppliers.
 4. Check that all Shop Drawing Submittals contain the applicable Specification Section and Contract Drawing number(s).
- C. Prepare all Shop Drawings based on the requirements of the Contract Drawings, the Specification Sections, clarifying drawings, and the conditions of the existing structure, surface, subsurface, and overhead structures, and adjoining structures. Such drawings shall be full-size and shall be drawn to scale showing in detail all dimensions, kind and quality of materials, and Specifications. The Shop Drawings shall also provide such information as may be required to permit the fabrication and erection or installation of the Work covered.
- D. All Shop Drawings and Other Submittals required shall be submitted to the Resident Engineer for review.
- E. Give express and unambiguous written notice of each deviation from the requirements in the Contract Documents in its letter of transmittal, as provided in General Terms and Conditions Sub-Article 2.01D, "VARIATIONS FROM CONTRACT DOCUMENTS". Shop Drawings and Other Submittals showing each deviation shall be submitted. Shop Drawings may not be used for proposed substitutions, "or equals", or arrangement changes. See General Terms and Conditions Paragraph 2.01D.
- F. The following Shop Drawings and Other Submittals shall be signed by and shall bear the seal of a Professional Engineer registered in the State of New York. Such Shop Drawings shall be submitted for review by the Resident Engineer.
1. Drawings showing plant and temporary structures required for the Project and other data showing the method to be used for sheeting, for bracing, for protecting and securing the existing structure, for sheeting, bracing, and decking of trenches, for the sequential demolition of the existing buildings, and for supporting utilities.
 2. Design loads and stresses, calculations, and procedures shall accompany such drawings or be shown thereon. Such drawings shall show complete design details, types of materials, and locations at which the structures will be used.
 3. Shop Drawings or Other Submittals indicating modifications to the permanent structure as proposed by Contractor.
- G. Review by the MTA of such drawings and proposed methods will not relieve Contractor of responsibility for the adequacy of their design, construction, and use, nor for the safety of persons and property by reason thereof, nor for the safety and successful execution and completion of the work.

- H. Shop Drawings and Other Submittals requiring review by the Resident Engineer shall be scheduled on the Schedule Documents in accordance with General Terms and Conditions Article 6.02 – “CONTRACTOR’S SCHEDULES” and Section 01320. Submittal of Shop Drawings and Other Submittals shall be scheduled in advance of the scheduled dates for installation and use in order to allow for the time required for reviews, for securing necessary reviews, for possible revisions and resubmittals, and for placing orders and securing delivery.
- I. Submit eight white prints of all Shop Drawings and Other Submittals to the Resident Engineer. Where samples are to be submitted, six of each will be submitted to the Resident Engineer and they shall be accompanied by eight copies of a transmittal providing full identification as required above.
1. When full “D” size drawings are submitted, at least one half-size (11 x 17) drawing set shall be provided in addition to the copies required herein.
 2. All Shop Drawings and Other Submittals shall be checked by Contractor, Subcontractors, and suppliers and shall be so indicated in the “Title Block” of Shop Drawings or on the face of Other Submittals before submitting to the Resident Engineer for review.
 3. The prints shall be free of all extraneous pencil, ink, crayon, or other markings and shall be of a quality that will produce clear and legible copies.
- J. The Resident Engineer will record the Submittal and forward it to the appropriate parties for review. Within 30 days of receipt by the Resident Engineer, or such longer period in accordance with General Terms and Conditions Article 2.01, the Resident Engineer will return one copy to Contractor stamped with a review code as identified below, with comments and required revisions noted thereon.
- K. Except where the Resident Engineer determines otherwise, the Resident Engineer will use the following review codes to indicate the review status of the Shop Drawing or Other Submittal:
1. “PROCEED”;
 2. “PROCEED AS NOTED”;
 3. “PROCEED AS NOTED – RESUBMIT”;
 4. “REVISE AND RESUBMIT”.
- L. Where the assigned review code is indicated as “PROCEED” or “PROCEED AS NOTED”, no resubmission is required, but Work shall conform to any comments or notations. Where it is “PROCEED AS NOTED - RESUBMIT” or “REVISE AND RESUBMIT”, make the revisions indicated and resubmit to the Resident Engineer the same number of prints and/or samples and in the same form and format as originally required. Within 30 days of receipt by the Resident Engineer or such longer period in accordance with General Terms and Conditions Article 2.01, the Resident Engineer will return one copy of the resubmittal to Contractor stamped with a review code as identified herein with comments and required revisions noted thereon.

- M. No changes or corrections other than the changes and corrections noted by the Resident Engineer shall be made to any "PROCEED" or "PROCEED AS NOTED" Shop Drawing or Other Submittal except by resubmittal with revisions appropriately noted. The submission shall be accompanied by justification for the changes and corrections including necessary design calculations.
- N. No Work shall commence on the portion of the Work included in the Submittal until Contractor has received from the Resident Engineer Shop Drawings or Other Submittals stamped with the review code "PROCEED", "PROCEED AS NOTED", "PROCEED AS NOTED - RESUBMIT", or equivalent express written direction from MTA.

3.05 RECORD DRAWINGS

- A. Record Drawings (As-Built Drawings) are a record of the completed Project depicting as-built facilities as actually installed or constructed because of field conditions, clarification drawings issued by the Resident Engineer, or by additional work ordered during construction or otherwise. They shall include, but not be limited to, the following:
 - 1. Updated Contract Drawings.
 - 2. Requirements for Record Drawings as contained in the Contract Drawings and Specifications.
 - 3. "PROCEED" and "PROCEED AS NOTED" Shop Drawings that include details of as-built conditions not shown on the Contract Drawings. Where the Contract Drawings are generally schematic and are not intended to portray the precise physical layout making it impractical to mark-up, the "PROCEED" or "PROCEED AS NOTED" Shop Drawings shall be marked-up to show the actual as-built installation.
- B. Image files of Contract Drawings shall be used by Contractor as background reference files to prepare CADD-generated Record (As-Built) Drawings. Alternatively, redline the image files by hand-drafting or by using software that supports redlining.
- C. Prepare, update, and maintain the Record Drawings throughout the progress of the Work.
 - 1. A full-size hard copy set of Contract Drawings shall be kept at Contractor's field office. All changes to these drawings resulting from the actual installation or construction, or as-built conditions, shall be entered by hand-marking on the hard copy set as soon as practicable after the changes have occurred. This hard copy set shall be used only for the entry of such changes. All entries shall be dated and attention called to each entry by a "cloud" drawn around the area affected. This hard copy set shall be properly identified.

2. Periodically transfer all entries/revisions from the hard copy set to Record Drawing files. At a minimum, this transfer shall be done at the end of each month. All entries shall be dated and attention called to each entry by a “cloud” drawn around the area affected. Maintain a log of entries/revisions made to the Record Drawing files.
 3. In addition, make entries to these Record Drawing files as soon as practicable after Modifications have been issued to Contract Drawings. Entries/revisions shall be made without calling attention to each entry by a “cloud” drawn around the area affected. However, maintain a log of entries/revisions made to the Record Drawing files.
- D. Beginning four months after the date of Notice of Award and at intervals of two months thereafter until Substantial Completion, submit an updated Project Drawings List along with a hard copy of updated Record Drawings and entries/revision log.
1. The Project Drawing List shall be generated in the format required herein. The Project Drawing List shall identify the drawing number, the drawing’s revision/issue, the drawing title description, the completion date of the drawing, the type of drawing as “REC” indicating it is a record drawing, and the CADD file name, if applicable.
 2. The initial Submittal of the Project Drawing List shall identify all Record Drawings scheduled to be made by Contractor throughout the progress of the work. Each subsequent Submittal shall be updated to show any additional records added to the list since the previous Submittal and the date of drawing files completed since the previous Submittal.
- E. Record Drawings, both the hard copy set (and the CADD files set, if applicable) along with the updated Project Drawing List, will be subject to review by the Resident Engineer at any time to assure that entries are being made as changes occur. Contractor is responsible for the accuracy of all entries.

3.06 ELECTRONIC RECORD SETS PREPARED BY CONTRACTOR

- A. Furnish two complete drawing sets on CD before Final Completion. Each set shall contain the final Project Drawing List and all Record Drawings and all Shop Drawings. Each set shall contain both CADD drawing files (if applicable), including all background and reference files, and document image “jpg” files.

SUBMITTAL REVIEWS

Section No.	Paragraph No. 1.06	Submittal
01140	A	Plans for material storage adjacent to Railroad
01160	A	Railroad Work Plans
	B	Engineering data
	C	Railroad crossings
	D	Flag protection requirements
01320	A	CPM Schedules
	B	Payment requisition
	C	Schedule Control Specialist's Resume
	D	Detailed Cost Breakdown (DCB)
01330	A	Submittal schedule
	B	Initial submittal of Project Drawings
	C	Test sample of CADD drawing file
01380	A	Code Compliance Liaison
	B	Code Compliance Plan
	C	Seismic Design QA Plan
	D	Wind Design QA Plan
	E	Qualifications of special inspectors
01450	A	Quality Program
	B	Resumes
	C	Inspection & testing plan
	D	Inspection & testing procedures, checklists, report forms
	E	Qualifications of third party testing laboratories
01515	A	Plans for maintaining existing communication for 63 rd Street Tunnel & furnishing and installing new communications system
01520	A	List of furnishings/equipment for RE office
	B	Plans & details for Resident Engineer & Contractor Employee Parking Area
01540	A	SSHP
	B&C	Resumes – Safety engineer, Supervisors, & Representatives
	D	Proposed duty tours
	E	Qualifications of personnel
01545	A	Site-specific Construction Safety & Health Plan (CSHP)
	B	Resumes of Safety Supervisors
	C	Resumes of Safety Representatives, duty tours & schedules
	D	Safe Work Plan (SWP)
01555	A	MPT Plan
01568	A	Qualifications - Security Representative
	B	Security Requirements Outline (SRO)
01570	A	Contract-Specific Environmental Compliance Plan
	B	Stormwater Pollution Prevention Plan
	C	Haul routes
	D	Qualifications - Environmental Coordinator
01572	A	Noise & vibration control plan
	B	Shop & working drawings, computations, etc.
	C	Materials data
	D	Equipment Sound Level Data Reporting Form

Section No.	Paragraph No. 1.06	Submittal
01592	A	Site & building layout
	B	Alternate layouts
	C	Shop Drawings & design calculations
01720	A	Qualifications for land survey personnel
	B	Detailed description of methods, etc.
	C	Control station materials & methods
	D	Mathematical materials pre-analysis
01730	A	Proposed O&M data
02105	A1	SHP/SWP
	A2	Laboratory qualifications
	A3	Sampling plan
02145	A	Groundwater Treatment System Schematic Diagram
	B	Groundwater Treatment System Shop Drawings & Catalog Cuts
	C	Operation & monitoring plan
	D	CSHP
	E	NYCDEP & NYSDEC Periodic Monitoring Reports
	F	Groundwater Treatment System Monitoring Plan
02220	A	Plan including construction sequence; permits; releases
	B	Shop Drawings
	C	Demolition removal procedures
	D	Closeout procedures
02239	A	Working drawings and design data
	B	Subcontractor's name, qualifications and evidence of work experience
02254	A	Qualifications
	B	Shop & working drawings
02269	A	Samples
	B	Manufacturer's information
	C	Shop Drawings
02270	A	Samples
	B	Manufacturer's information
	C	Shop Drawings
02290	A	Evidence of valid permits, licenses, certifications
	B	Disposal facility permits & compliance documentation
	C	Disposal manifests
	D/E	Installation procedures
	F	Well abandonment procedures
	G	Developing/re-developing procedures
02300	A	MPT plan
	B	Samples
	C	Design for support of excavation
	D	Material test reports
02372	A	Proposed method of erosion control
	B	Stormwater Pollution Prevention Plan
02406	A	Resumes & training certificates for proposed personnel
	B	Working Drawings & details
	C	Contingency plans

Section No.	Paragraph No. 1.06	Submittal
02407	A	Qualifications/resumes
	B	Resumes of proposed supervisors, drillers, miners
	C	Working drawings, work plan, system description, schedule of operations, protection measures, "break-out" procedures, contingency plan, configuration & layout, layout, configuration, catalog cuts, methods of controlling line & grade of shotcrete lining, etc.
	D	Selected method & equipment for as-built survey
02410	A	Shop Drawings & work plan
	B	Written description of removal & disposal procedures
	C	Manifests, receipts, scale tickets
02413	A	Detailed TBM data/information
	B	Product data
	C	Work plans, methods, details
	D	Survey methods/instructions; maintenance schedule;)&M manuals
02414	A	Shop Drawings
	B	Product data
	C	Quality control requirements
	D	Pre-construction surveys
	E	Vibration & air overpressure monitoring
02427	A	Material manufacturers, facility locations, shop Drawings, design details, certifications, design & test data, material specifications, qualifications, Work plans & procedures, samples, notices, gasket performance, repair procedures
02495	A	Contingency plans
	B	Resumes
	C	Installation procedures
	D	Manufacturer's product data
	E	Product data
	F	Method of grouting/fixing anchor points
	G	Instrument maintenance
	H	Proposed power sources & layouts
	I	Proposed wireless signal transmission, if applicable
02820	A	Product data
	B	Shop Drawings
02950	A	Shop Drawings
	B	Product data
	C	Design mix
03100	A	Details of pre-engineered metal forms
03200	A	Shop Drawings
	B	Manufacturer's catalog cut and product data
	C	Quality Control Sheet (form)
03300	A	Product data, working drawings, samples, procedures & methods, shipment/delivery information
	B	Design mixes
	C	Concrete repair methods

Section No.	Paragraph No. 1.06	Submittal
03305	A	Details & methods; test data; design mixes
	B	Manufacturer's data, technical information, & samples
	C	Concrete repair methods
03370	A	Product data, samples, certifications, design mixes
	B	Resumes, ACI certifications, test reports, curing procedures
03375	A	Samples, shop drawings, procedures, calculations
03605	A	Experience resumes, Working Drawings, descriptions, calculations, procedures, forms; mixes; grout mix & procedures; product data
04200	A	Product data
05120	A	Mill orders
	B	Shop Drawings
	C	Product data
	D	Design drawings & calculations
	E	Contractor-designed structural steel
07122	A	Resumes
	B	Product data & catalog cuts
	C	Shop Drawings
	D	Waterproofing plan & details
	E	Manufacturer's recommendations & procedures
	F	Installer certification
	G	MSDS
	H	Material samples
	I	Field samples
	J	Leak remediation plan
07124	A	Product data, manufacturer's instructions, Shop Drawings, locations, identification systems, & designs
08130	A	Shop Drawings
	B	Manufacturer's instructions & procedures
	C	Certifications
	D	Calculations
10290	A	Rodent control program
13115	A	Instrument lists, layout, hook-up, qualifications
13280	A	LBP Management Plan
13430	A	Shop Drawings
	B	Product data
	C	Detail theory - control panel operation
	D	Factory test plan
15205	A	Product information & data
	B	Shop Drawings
16050	A	Materials list
	B	Shop Drawings
	C	Coordination data - fuses
16060	A1	Final engineering drawings
	A2	Shop Drawings
	A3	Certification - test reports
16062	A	Shop Drawings, product data, test procedures, welding qualifications

Section No.	Paragraph No. 1.06	Submittal
16120	A	Product data
	B	Test reports
16154	A	Shop Drawings; catalog cuts
16210	A	Product data
	B	Certification
	C	Test reports and data
	D	MPT plan
	E	Final engineering design drawings
	F	Factory production test reports
16240	A	Manufacturer's description, catalog data, information, arrangement, wiring, detail drawings, design calculations
16270	A	Shop Drawings
	B	Product data
	C	Factory test results
16340	A	Detailed sequence of operation
	B	Shop Drawings, catalog cuts, samples, calculations, O&M manuals
16950	A	Test procedures & reports

Notes:

1. This Table does not include reviews for "or approved equal" proposals. Reviews for "or approved equal" proposals are covered in the General Terms and Conditions Article 2.01 "SUBMITTALS".

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for obtaining a Construction Permit, performing Special Inspections, scheduling and providing access for inspections by others, obtaining a Code Compliance Certificate, obtaining a Temporary Approval for Occupancy, Stop Work Orders and Revocation of Permits and Certificates as required by the BCNYS and the Energy Conservation Construction Code (Code).

1.02 REFERENCED SECTIONS

- A. Section 01320 - Construction Progress Documentation
- B. Section 01330 - Submittal Procedures

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. No physical Work at the Work Site shall begin until a Construction Permit is issued.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)
 - a. Part 1221 - Building Code of New York State
 - b. Part 1240 - Energy Code of New York State
- B All Special Inspections shall be performed to the quality standards as set forth in the Referenced Standards called out in the BCNYS.

1.06 SUBMITTALS

- A. Code Compliance Liaison: Within 20 days after Notice of Award, designate a Code Compliance Liaison and submit the name and resume for this position. Contractor's Code Compliance Liaison shall be Contractor's single point of contact for all Code Compliance issues.
- B. Code Compliance Plan: Within 30 days after the date of the Notice of Award, furnish for review the Code Compliance Plan (CCP) by which Contractor proposes to implement the requirements of this Section. The CCP shall include the following:
 - 1. Identity of Contractor's Superintendent.

2. Identity of third-party testing lab(s).
 3. A schedule that includes Permits and application submission date, Special Inspections, Inspections to be performed by others, Record Drawings/close-out documentation and a Code Compliance Certificate. Schedule shall be consistent with the requirements of Section 01320.
 4. Identity of Contractor's designer/engineer and any elements of the Contract Work that will be designed by Contractor's designer/engineer.
- C. Seismic Design Quality Assurance Plan and statement of responsibility, if applicable.
- D. Wind Design Quality Assurance Plan and statement of responsibility, if applicable.
- E. Qualifications of Special Inspectors.

1.07 DELIVERABLES

- A. All Permit Applications, including Construction Permit Application.
- B. Initial Special Inspection Application, Statement of Responsibilities.
- C. Monthly status reports of non-conforming Special Inspections.
- D. Final Special Inspection Reports, with all required documentation.
- E. Record Drawings (As-Built Drawings) - see Section 01330.
- F. Request for Final Inspection.
- G. Application for Code Compliance Certificate.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Contractor's designated Code Compliance Liaison shall act as Contractor's main coordinator/liaison for all Code Compliance issues. The Code Compliance Liaison's duties and responsibilities, at a minimum, shall include:
 1. Coordinate Code Compliance activities between Contractor's designers and construction supervision, the Resident Engineer's staff, and the MTA's Code Compliance Unit.
 2. Monitor and control Contractor's Code Compliance activities.

3. Insure Contractor's conformance with Code Compliance requirements.
- B. The Resident Engineer will conduct a Code Compliance Introductory (kick-off) Meeting within 30 days after the Notice of Award. Contractor's Project Manager, Project Engineer, Code Compliance Liaison and each principal designer shall attend.
- C. Copies of all permit applications shall be concurrently provided to the Resident Engineer.
- D. Seismic Design:
 1. Where Contractor designs any required seismic systems, a Quality Assurance Plan shall be prepared by Contractor's designer of record as described in BCNYS Section 1705.
 2. Contractor responsible for construction of a seismic-force-resisting system, designated seismic system, or component listed in the quality assurance plan shall submit a written Contractor's statement of responsibility to the MTA Code Compliance Manager prior to the commencement of Work on the system or component.
- E. Wind Design:
 1. Where Contractor designs any required wind resistant structures, a Quality Assurance Plan shall be prepared by Contractor's designer of record as described in BCNYS Section 1706.
 2. Contractor responsible for construction of a main wind force-resisting system or wind-resisting component listed in the quality assurance plan shall submit a written contractor's statement of responsibility to the MTA Code Compliance Manager prior to the commencement of Work on the system or component.

3.02 CONSTRUCTION PERMIT

- A. Apply for a Construction Permit (see Attachment 1) at the office of the MTA Code Compliance Unit located at ESA's Main Project Office at 469 Seventh Avenue, 11th Floor, New York, New York 10018.
- B. The Construction Permit Application shall be completed by Contractor and contain the reason for the filing, location and description of Work, information about Contractor, type of Permit, certification by the applicant as to the correctness and completeness of the application and the identity of the Superintendent of Construction.
- C. The Initial Special Inspection Report, Statement of Responsibilities shall be filled out by Contractor's Special Inspector or third-party testing laboratories. All proposed inspectors and laboratories shall meet the requirements of BCNYS Chapter 17.

- D. Upon satisfactory completion of the Construction Permit Application and Initial Special Inspection Application a Construction Permit will be issued by the MTA Code Compliance Manager within five days.

3.03 PLAN EXAMINATION

- A. Any elements of the Contract Work, temporary or permanent that will be designed by Contractor's designer/engineer, shall be filed for Plan Examination prior to applying for a Construction Permit for that element of the Work (see Attachment 2).
1. A complete set of design documents including plans, specifications calculations and proposed Special Inspections shall be submitted to the MTA Code Compliance Unit for Plan Examination.
 2. Upon submission for plan examination and approval of the design documents by the MTA Code Compliance Manager, the construction permit process for these elements of the Work can begin.

3.04 SPECIAL INSPECTIONS

- A. The MTA has determined that the following Special Inspections are required:
1. Concrete.
 - a. Concrete mix designs.
 - b. Reinforcement.
 - c. Cement grout.
 - d. Resin grout.
 - e. Shotcrete mix design.
 2. Soils.
 - a. Backfill.
 3. Off-Site Fabrication.
 4. Wood.
 5. Structural Steel.
 - a. Excavation support members and internal bracing
 - b. Rock dowels and rock bolts, including end hardware (bearing plate, beveled washers, anchor nut and steel cap)
 - c. Lattice girders
 6. Seismic Resistance QA.

7. Seismic Resistance Inspection.
- B. Contractor's designer-of-record of temporary Work shall provide a listing of special inspections for the following:
 1. Temporary power substation.
 2. Construction utilities.
 3. Conveyor structures.
- C. Contractor's Special Inspector, as identified on the Initial Inspection Report, Statement of Responsibilities (see Attachment 3), shall perform special inspections in accordance with the BCNYS Chapter 17.
- D. The Special Inspector shall be a qualified person who shall demonstrate competence (in accordance with code requirements), to the satisfaction of the MTA Code Compliance Manager for inspection of the particular type of construction or operation requiring a special inspection.
- E. Special Inspectors shall keep records of inspection and shall furnish inspection reports to the Resident Engineer. Reports shall indicate that Work inspected was done in conformance to the Contract Documents and approved construction documents. Discrepancies shall be brought to the immediate attention of Contractor for correction. If the discrepancies are not corrected, the discrepancies shall be brought to the attention of the Resident Engineer and MTA Code Compliance Manager prior to the completion of that phase of the Work.

3.05 OTHER INSPECTIONS

- A. In addition to special inspections, other types of inspections as required by the BCNYS shall be performed during the course of construction.
- B. These types of inspections shall include observation of any of the following elements that may be included in the Contract:
 1. Foundation.
 2. Framing.
 3. Superstructure.
 4. Electrical systems.
 5. Plumbing systems.
 6. Heating/ventilating/air conditioning system.
 7. Fire protection and detection system.
 8. Exit features.

- C. The Construction Permit will identify the required inspections.
- D. Identify hold points within the construction schedule (see Section 01320) for all required inspections.
- E. Provide access and personnel to permit these observations and/or inspections to be performed.

3.06 REQUEST FOR FINAL INSPECTION

- A. At the conclusion of Work as required by the Contract, or a portion thereof, complete a Request for Final Inspection.
- B. The Request for Final Inspection shall include the following:
 - 1. Record Drawings (As-Built Drawings):
 - a. Provide a copy of the approved Record Drawings to the MTA Code Compliance Manager.
 - b. The Record Drawings shall include any substantive changes to the Contract Drawings.
 - c. The Record Drawings will be used by the MTA Code Compliance Manager to check the final Work as constructed.
 - 2. Final Special Inspection Reports: As certain aspects of the project are completed, receive from the Special Inspector all reports and required backup to demonstrate to the MTA Code Compliance Manager and the Designer of Record that all Work covered by the special inspection was performed in accordance with the Contract Documents, the Code, and Referenced Standards.
 - 3. Evidence of required Other Inspections.
- C. Upon receipt of an acceptable Request for Final Inspection, the MTA Code Compliance Manager will perform the Final Inspection in anticipation of issuance of the Code Completion Certificate.

3.07 CODE COMPLIANCE CERTIFICATE

- A. A Code Compliance Certificate will be issued for all Work covered by the Code when a Final Inspection is conducted which:
 - 1. Indicates substantial completion of any Work for which a Construction Permit has been issued; and
 - 2. Reveals no uncorrected deficiency or material violation of the Code within the area or Work for which the Certificate is issued.

- B. The Code Compliance Certificate signifies that a building or structure may be occupied or that any Work performed pursuant to a Construction Permit may be safely put to the use for which it is intended. This Certificate closes out the Construction Permit.
- C. A Temporary Approval for Occupancy can be issued at the discretion of the MTA Code Compliance Manager if it is determined that a building or structure or a designated portion of a building or structure is sufficiently complete so that it may be safely occupied, or that Work performed pursuant to a construction permit may safely put to the use for which it is intended. A Temporary Approval for Occupancy does not eliminate the need for a Code Compliance Certificate when all the Work as described herein has been satisfied.

3.08 STOP WORK ORDER AND REVOCATION OF PERMITS

- A. The MTA Code Compliance Manager may suspend or revoke a Construction Permit, a Code Compliance Certificate, or a Temporary Approval for Occupancy, or issue a Stop Work Order halting construction, if violations of the Code are discovered and it is determined to be in the best interests of Public Safety or of the State of New York to do so.

ATTACHMENT 1



Long Island Rail Road
East Side Access

CCU CONSTRUCTION PERMIT APPLICATION

FORM CCU/P
Form Must Be Legible

Package Number:

Note: CCU/P Form must be accompanied with 'Special Inspection Form' CCUTR-1 with the "Identification of Responsibilities" (first column) and other pertinent sections completed

- 1 TYPE OF FILING**
- ☐ Initial, "Base Package" (complete all sections) Expected Job Start Date:
- ☐ Subsequent, Design/Build (complete all sections) Expected Job Start Date:
(must be accompanied by form CCU/A completed by the designer-of-record and the construction documents reviewed and approved by the "Base Package" designer-of-record)
- ☐ Renewal with change (complete all sections)

2 LOCATION & DESCRIPTION OF WORK

Borough:

Street Address:

Brief Description of Work in this Application:

3 APPLICANT/CONTRACTOR

Last Name:

Fist Name:

M.I:

Business Name:

Business Phone: ()

Address:

City:

State:

ZIP:

- ☐ License Type (circle one): P.E., R.A. Lic. No:
- ☐ General Contractor
- ☐ Demolition, Contractor
- ☐ I shall perform the responsibilities required of a Superintendent of Construction for this job.

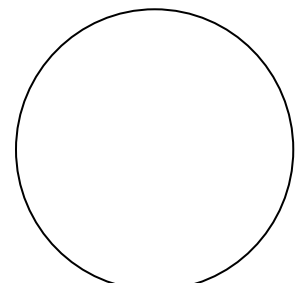
4 TYPE OF PERMIT (INCLUDING ALL WORK TYPES)

New Building	Alteration	Boiler	Standpipe
Demolition & Removal	Plumbing	PA	Fire Alarm
Foundation	Curb Cut	Fuel Burning:	Fire Suppression System
Earthwork	Construction Equipment	Fuel Storage	Mechanical/HVAC
		Sprinkler	

Other:

5 STATEMENT & SIGNATURE – must be completed by all applicants

I hereby state that the above information is correct and complete to the best of my knowledge.



Seal (if applicable)

Applicant Name

Title

ATTACHMENT 1

**Long Island Rail Road
East Side Access****CCU CONSTRUCTION PERMIT APPLICATION**FORM CCU/P
Form Must Be Legible**Package Number:**

Signature

Date

6 SUPERINTENDENT OF CONSTRUCTION

I, the undersigned, agree to take responsibility for superintending the use of materials and their incorporation into the work to be performed for this job and any renewal permits as long as such renewals certify no change to Superintendent of Construction.

Last Name:

Fist Name:

M.I:

Business Name:

Business Phone: ()

Address:

City:

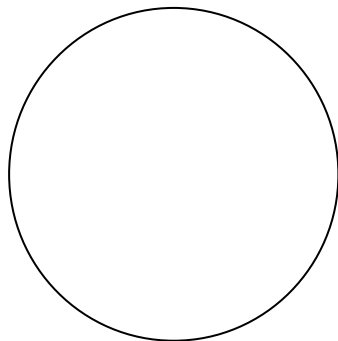
State:

ZIP:

Check one:

☐ P.E.☐ R.A.☐ General Contractor☐ Demo Contractor

Lic. No.



Seal (if applicable)

Name

Signature

Date

ATTACHMENT 2



Long Island Rail Road
East Side Access

**CCU PLAN REVIEW APPROVAL/
APPLICATION FORM CCU/A**

FOR CCU USE			Internal CCU Use
<input type="checkbox"/> PRE-SCHEMATIC SUBMISSION	Received at CCU (date)	_____	Package Number
<input type="checkbox"/> SCHEMATIC SUBMISSION	Received at CCU (date)	_____	
<input type="checkbox"/> 30% SUBMISSION	Received at CCU (date)	_____	Application Must Be Typed
<input type="checkbox"/> 60% SUBMISSION	Received at CCU (date)	_____	
<input type="checkbox"/> 90% SUBMISSION	Received at CCU (date)	_____	
<input type="checkbox"/> 100% SUBMISSION	Received at CCU (date)	_____	
<input type="checkbox"/> FINAL SUBMISSION/APPROVAL	Received at CCU (date)	_____	
<input type="checkbox"/> OTHE R _____	Received at CCU (date)	_____	
<input type="checkbox"/> SUBSEQUENT FILING, DESIGN/BUILD for APPROVAL (also submit Form CCU/P for PERMIT)	Received at CCU (date)	_____	

1 FILING STATUS (Select one and complete sections indicated)			
Initial Filing 2, 3, 4, 5, 6, 7, 10	Initial Filing Resubmission (30%, 60%, 90%, etc.) 2, 3, 5, 6, 7, 10	Subsequent Filings (Additional Jobs, same Package, such as 'Design-Build') 2, 3, 5, 6, 7, 9, 10	Changes
Number of Structures	Additions I am the original applicant applying for additional approvals.		Amendments
I am a subsequent applicant taking responsibility for the items specified herein. (Additional Jobs, same Package, such as 'Design-Build')			
2 LOCATION			
Address:		Street Name:	Borough :
3 DESIGNER-OF-RECORD			
Last Name:		First Name:	M.I:
Business Name:		Business Phone: ()	
Address :		City :	State: ZIP:
<input type="checkbox"/> P.E. <input type="checkbox"/> R.A. <input type="checkbox"/> Other :		Lic. No:	
4 INITIAL FILING (Complete sections and schedules indicated to the right of only one selected type)			
New Structure 5, 6, 7, 8, 9, 10			
Alteration to existing structure 5, 6, 7, 8, 9, 10			
Demolition to existing structure 5, 6, 7, 8, 9, 10			

ATTACHMENT 2 (Cont)**5 SCOPE OF WORK JOB DESCRIPTION** *(Required for all work)*

☐ Tunnel Work
 ☐ Site Work
 ☐ Building Work
 ☐ Station Work
 ☐ Other
 ☐ Demolition

☐ There will be Design/Build work in this Package filed under subsequent applications.

☐ Structural Stability will not be affected by this application.

6 PLANS SUBMITTED (types)

Architectural AR	Plumbing PL	Electrical EL
Structural ST	Foundation FO	Other OT
No Plans NP	Mechanical ME	

7 DESCRIPTION OF WORK**8 CONSTRUCTION EQUIPMENT**

Sidewalk Shed	Scaffold	Chute	Fence	Other
---------------	----------	-------	-------	-------

Material of Construction _____ Sidewalk Shed/Linear Feet _____

9 COMMENTS**10 Statements and Signatures****Designer-of-Record's Statement** (Complete if applicable and sign below.)

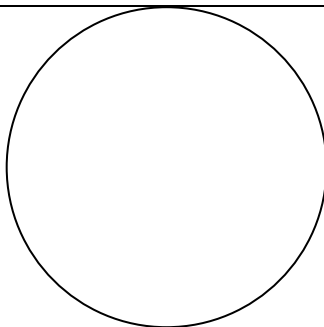
I prepared or supervised the preparation of the plans and specifications herewith submitted and to the best of my knowledge and belief, the plans and work shown thereon comply with the provisions of NY State Code.
Except as set forth in the accompanying documents.

Name

Date

Signature

Seal (P.E. or R. A.)



Package Manager's Signature		
I have authorized the applicant to file this application for the work specified herein and all future amendments.		
Last Name	First Name	M.I.
<hr/>		
Title		
Agency		
Address		
City		
State	ZIP	Phone ()
Signature		Date
<hr/>		

Approvals (<i>Internal CCU Use Only</i>)			
	Examined and Recommended for Full Approval		
Approved for:		Foundation	Earthwork Only
CCU Examiner Name			
CCU Examiner Signature			Date
Limitation(s): (To appear on permit)			
Other Approvals			
CCU Examiner Name			
CCU Examiner Signature			Date
Approved			

ATTACHMENT 3



**Long Island Rail Road
East Side Access**

FORM CCUTR-1 SPECIAL INSPECTIONS

“Special Inspection Report”	CCU Number (CCU Internal Use)
Statement of Responsibilities	Package Number

1. FILING PURPOSE					
Identification of Responsibilities			Withdrawal of Responsibility		
Certification of Completed Inspections/Tests					
2. LOCATION & DESCRIPTION OF WORK					
Borough:		Street Address:			
Description of Work Under This Application:					
3. INSPECTOR-OF-RECORD (Responsible for inspections, or for inspections by qualified individuals under his or her direct supervision)					
Last Name		First Name		M.I.	
Business Name		Business Phone			
Address		City		State	
s				Zip	
P.E.		R.A.		Lic. No.	
		Other			
4. ITEMS REQUIRING SPECIAL INSPECTION (as listed on the contract documents by the Designer-of-Record)					
Inspections & Tests (NYS Code 2002 Pertinent Sections & Tables)		Identification of Responsibilities (will conduct the inspection)		Certification of Completed Inspections (has completed the inspection)	
		Initials & Date		Initials & Date	
<input type="checkbox"/>	1. CONCRETE (Section 1704.4 & Table 1704.4) INCLUDING REINFORCING, ANCHOR BOLTS, DESIGN MIX, CONC. TESTS, PLACEMENT, CURING, PRECAST, PRESTRESSED, POSTTENSIONED.				
<input type="checkbox"/>	2. SOILS (Section 1704.7) INCLUDING SOIL TYPES, CONDITION, BEARING CAPACITY, & FILL.				
<input type="checkbox"/>	3. PIERS (Section 1704.9)				
<input type="checkbox"/>	4. EXT. INSULATION SYSTEMS (EIFS) (Section 1704.12)				

ATTACHMENT 3 (Cont.)

<input type="checkbox"/>	5. OFF-SITE FABRICATION (Section 1704.2)				
<input type="checkbox"/>	6. PILES (Section 1704.8)				
<input type="checkbox"/>	7. MASONRY (Section 1704.5, Table 1704.5.1 & Table 1704.5.3) INCLUDING MORTAR MIX, ANCHORS, REINFORCING, & PLACEMENT.				
<input type="checkbox"/>	8. WOOD (Section 1704.6)				
<input type="checkbox"/>	9. WALL PANELS (Section 1704.10)				
<input type="checkbox"/>	10. STRUCTURAL STEEL (Section 1704.3 & Table 1704.3) INCLUDING HIGH STRENGTH BOLTS, STEEL MATERIAL, WELDING, JOINT DETAILS.				
<input type="checkbox"/>	11. SPRAY-ON FIREPROOFING (Section 1704.11)				
<input type="checkbox"/>	12. SMOKE CONTROL (Section 1704.14)				
<input type="checkbox"/>	13. WIND LOADS QA (Section 1706)				
<input type="checkbox"/>	14. SEISMIC RESISTANCE QA (Section 1705)				
<input type="checkbox"/>	15. SEISMIC RESISTANCE INSP. (Section 1707)				

ATTACHMENT 3 (Cont.)**5. STATEMENTS AND SIGNATURES**

Inspector of Record	Owner's Representative (Resident Engineer)
<p align="center">Identification of Responsibilities</p> <p>I have assumed responsibility for the items specified above. I personally, or where permitted by The NYS Code 2002, qualified personnel under my direct supervision will perform the required inspections and tests as per the qualification, certification, licensing, and methodology requirements of NYS Code 2002 and its referenced documents. All inspection and test reports shall be signed and filed with the ESA/CCU via the Resident Engineer.</p>	<p>I acknowledge that I have read and complied with all instructions pertaining to this application and supplementary schedules submitted.</p> <p>I certify that the Special Inspections listed on page 1 of this form are as listed by the designer-of-record on the construction documents.</p> <p>Name _____</p> <p>Signature _____</p> <p>Date _____</p>
<p align="center">Change of Inspector-of-Record</p>	
<p>I, _____, am a newly designated individual responsible for the items specified herein and I hereby state that;</p>	
<p>None of the Special Inspections/tests indicated herein have been performed to date by the previously designated individual.</p>	
<p>Some of the Special Inspections/tests indicated herein have been performed by the previously designated individual, as indicated in the attached report.</p>	
<p align="center">Certification of Completed Inspections/Tests</p>	
<p>I have completed the items specified herein and certify the following:</p>	
<p>All work has been performed in accordance with the NYS Code 2002 and other designated references, rules, and regulations</p>	
<p>All work and materials conform to the approved plans and specifications, except as indicated in the attached report.</p>	
<p align="center">CCU Violation Removal</p>	
<p>The following CCU violations were corrected as a result of work performed under the job/application number referenced herein. Therefore, I respectfully request the removal of these violations:</p>	
<p>List violations & dates issued here;</p>	
<p align="center">Withdrawal of Responsibility/Inspector-of-Record</p>	
<p>I am withdrawing responsibility for the items of Special Inspection indicated herein and herewith submit the results or status of the work performed to date.</p>	
<p>Inspector-of-Record Signature</p>	
<p>Name</p>	
<p>Signature _____ Date _____</p>	

ATTACHMENT 3 (Cont.)

Seal (P.E. or R.A. as required by NYS Code 2002 Chapter 17)

ESA/CCU "Special Inspection Form CCUTR-1" INSTRUCTIONS

This "**Special Inspection**" form shall be filed for all inspections/tests required for the related job, in accordance with the NYS Code 2002, Chapter 17.

For all items, a pre-permit identification of Responsibilities shall be submitted. Upon satisfactory completion of the inspections/items, a Certification of Completed Inspections/Tests, as well as any supplementary Technical Reports, shall be submitted for all required inspections/tests.

Provide the **Package Number** of the work associated with this filing.

Section	Instructions
1. Filing Purpose	<p>Check (X) the appropriate box for purpose of filing. Only one box may be checked (X).</p> <p>Identification of Responsibilities: The P.E., R.A., or F.S.C. responsible for supervising performing inspections and tests shall check (X) this box for Permit filings.</p> <p>Certification of Completed Inspections/Tests: Check (X) this box when all or a portion of the items previously specified have been completed and a final inspection has been performed. For CCU Certificate of Compliance or Certificate of Occupancy.</p> <p>Withdrawal of Responsibility: Check (X) this box if the Inspector-of-Record must withdraw his responsibilities either partially or entirely, prior to Certification of Completed Inspections/Tests.</p>
2. Location & Description of Work	<p>Provide the house number and street name (if available) or Block and Lot. Provide a brief description of the work to be covered under this application.</p>
3. Applicant	<p>Provide the last name, first name, middle initial, business name, phone number and address of the Inspector-of-Record.</p> <p>Check (X) the appropriate box to indicate whether the applicant is a PE, R.A.</p>
4. Items	<p>Check (X) the items of inspection or tests that the particular filing pertains to:</p> <p>Identification of Responsibilities: If a filing purpose indicated is 'Identification of Responsibilities' (Permit Filing) then the Inspector-of-Record must provide the date and his initials in the column labeled "Identification of Responsibilities".</p> <p>Certification of Completed Inspections: If the filling purpose is 'Certification of Completed Inspections' then the Inspector-of-Record must provide the date of the last inspection and his initials in the column labeled "Certifications of Completed Inspections".</p> <p>Withdrawal of Responsibility: If filing purpose is 'Withdrawal of Responsibility', then the Inspector-of-Record should check all items which they will no longer be responsible for.</p> <p>The total number of sheets submitted, including forms and reports must be indicated in the last line.</p>
5. Statements and Signatures:	<p>Statements and Signatures shall be completed as follows for each filling status:</p> <p>Identification of Responsibilities: Inspector-of-Record must check(X) this statement of a Permit filing.</p> <p>If the Inspector-of-Record who completed the Identification of Responsibilities statement is superseding another professional, then the Change of Applicant statement must be checked (X) also.</p>

5. Statements and Signatures:
(continued)

Change of Inspector-of-Record: Check (X) if the inspector is superseding another professional. Check (X) to indicate if none or some of the controlled inspections/tests have been performed to date by the previous inspector. If so, specify in an attached report.

Certification of Completed Inspection/Tests: Inspector-of-Record shall check (X) the appropriate box within the section labeled Certification of Completed tests/Inspections.

Removal of CCU Violations: If the work involves the removal of CCU violation(s), then the Inspector-of-Record should specify the CCU violation number(s) and package number.

Withdrawal of Responsibility: Inspector-of-Record shall check (X) the box labeled Withdrawal of Applicant.

Inspector-of-Record Signature:

Applicant listed in section (3) of this form must provide their name, signature and affix their seal (if applicable, see NYS Code 2002, Chapter 17) within this box.

Owner's Representative: Owner's Representative (Resident Engineer) must complete the section labeled "Owner's Representative" identifying the 'Special Inspections' required by the Designer-of-Record in the construction documents and directing the Inspector-of-Record to perform those inspections specified. **Owner's Representative's authorization is required for both Initial Inspector or Change of Inspector filing.**

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. This Section defines the responsibilities of Contractor in the management of quality in the construction of the Project to achieve an end product conforming to the level of quality required by the Contract Documents.
- B. Establish, implement, and maintain a Contractor Quality Program (CQP) to assure that the Work complies with the requirements of the Contract Documents.
 - 1. The CQP shall consist of plans, procedures, and the organization necessary to assure adequate control and assurance of quality for materials, equipment, workmanship, fabrication, and operations covering both on-site and off-site Work by Contractor including its subcontractors, suppliers, technical laboratories, and consultants. The CQP shall meet the requirements of the FTA QA/QC Guidelines.
 - 2. The CQP shall also include training for personnel performing activities that affect and insure quality.

1.02 REFERENCED SECTIONS

- A. Section 01330 – Submittal Procedures.
- B. Section 01380 – Code Compliance
- C. Section 01570 – Environmental Compliance.

1.03 CITED STANDARDS

- A. ESA Project Quality Manual
- B. FTA Quality Assurance and Quality Control Guidelines (FTA-IT-90-50001-021, dated February 2002)
- C. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Acceptance of CQP: Acceptance of the CQP is conditional and will be predicated on satisfactory performance during construction. Implementation of the CQP requirements shall be subject to audit by the MTA.
- B. The CQP shall meet the requirements of the FTA QA/QC Guidelines.

1.06 SUBMITTALS**A. Quality Program:**

1. Within 30 days after the date of the Notice of Award, furnish for review the Quality Program by which Contractor proposes to implement the requirements of this Section. The CQP shall be signed by a principal of the firm, the Project Manager and Contractor's Quality Manager (CQM).
 - a. If Contractor fails to submit an acceptable CQP within the prescribed time, the Resident Engineer will not allow the Work to continue unless an acceptable interim plan is provided. The interim plan will only be acceptable for 60 days after Notice of Award.
2. Failure to comply with these submittal requirements within the prescribed times may result in the Resident Engineer directing Contractor to stop all Work on the Project.
3. Subcontractor/Supplier Quality Plans used in lieu of the CQP that have been reviewed and approved by the CQM.
4. Review the CQP on a semi-annual basis for continued adequacy to meet the requirements of the Contract Documents. All proposed changes to the CQP are subject to the prior review.

B. Resume of CQM and the Quality Management Team for review;**C. Inspection and testing plan including hold points;****D. Inspection and testing procedures, checklists and report forms;****E. Qualifications of third party testing laboratories 30 days prior to being used on the Project.****1.07 DELIVERABLES**

- A. Copies of all quality documents within 7 days from the time they are prepared by CQM, and upon request by the Resident Engineer.
- B. Monthly Certification Report;
- C. Audit schedule for internal and external audits;
- D. Special Inspection Reports as required by the Designer of Record;
- E. Construction Work Plans (CWPs) for specific Work activities 10 days prior to Readiness Review Meeting;
- F. Schedule for materials and equipment fabricated off-site 30 days prior to start of fabrication identifying fabrication, inspection and testing dates;
- G. Quality look-ahead schedule presented at each progress meeting;

- H. Monthly status report of non-conformance reports.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 IMPLEMENTATION OF CONTRACTOR QUALITY PROGRAM (CQP)

- A. Organization, Staffing, and Responsibilities:
1. The CQP shall describe Contractor's Project organization including major subcontractors and suppliers, and shall include an organization chart showing names, titles, contact information lines of authority, and the inter-relationship of those involved in managing and directing the Project. Provide the qualifications, duties, responsibilities, and functions of its on-site and off-site management team for the Contract as part of the CQP.
 2. Assign a CQM exclusively to this Project beginning 10 days after Notice of Award until its Final Completion. The CQM shall be responsible to manage and to act upon all quality matters for the Project on behalf of the Contractor.
 - a. The CQM shall not be subordinate to Contractor's personnel that directly perform, supervise, or progress the Work. The CQM shall have direct access to the upper management of Contractor. The CQM shall possess a minimum of 5 years of related QA/QC experience.
 - b. The resume of the CQM shall include a description of the duties, responsibilities, and the QA/QC record of assignments that establishes the candidate's experience as a Quality Manager. The CQM's qualifications shall be submitted for review and the CQM shall be available for interview. The CQM shall participate in developing the CQP for this Project.
 3. Adequate staff and resources shall be provided to perform all QA/QC activities for all trades to assure Contract compliance whether the Work is performed by Contractor's own forces or by subcontractors. Contractor's own QA/QC staff may, if qualified and identified in the CQP, perform QA/QC activities for subcontractors. Individuals performing quality control/quality assurance activities shall not be responsible to perform or supervise the Work. The Resident Engineer may direct Contractor to provide additional staff and resources to the CQM if, in its sole opinion, there are significant deficiencies in implementing the CQP requirements.

B. Submittal Management and Control of Documents and Document Changes:

1. The CQP shall provide for establishing and maintaining a submittal management system that schedules, manages, and tracks all submittals required by the Contract Documents including those of subcontractors and suppliers. The submittal schedule shall indicate all submittals due far enough in advance (especially for long lead time items) of the scheduled dates for installation to allow for the time required for reviews, for possible revisions and resubmittals, and for placing orders and securing delivery. The submittal schedule shall be updated as required and submitted.
 - a. Review submittals prepared by its subcontractors and suppliers for compliance with the Contract Documents and all submittals shall be signed by the CQM before submission to the Resident Engineer.
2. All Shop Drawings required for the Work, shall be prepared by Contractor, subcontractors, or suppliers and shall be reviewed by Contractor to verify all materials and field measurements are checked and coordinated to assure that the information contained on the Shop Drawings, product data, and samples conforms to the requirements of the Contract Documents as required in Section 01330.
 - a. No portion of the Work requiring these Shop Drawings shall be commenced until this review and coordination has been performed by Contractor and signed by the CQM. Copies of these shop drawings and any other documentation that demonstrate Contractor's compliance with the Contract Documents shall be kept at Contractor's office and shall be available for inspection and audit by the Resident Engineer. Drawings shall be maintained (redlined) as changes occur and drawing electronic files updated as required in Section 01330.
3. The CQP shall also provide for establishing and maintaining a document control system for control of Project documents and data such as Contract and Shop Drawings, Specifications, calculations, calibration records, inspection procedures, test procedures, inspection and test results, CWPs, special work instructions, and operational procedures.
 - a. The document control system shall provide assurance that the Work is performed to the latest reviewed Contract Drawings and Specifications and that these documents are made available at each Work location before the start of the Work to all users who require them. Obsolete documents shall be promptly eliminated from each Work location. Any superseded documents retained for the record shall be clearly identified as such.
4. All changes to documents shall be processed in writing and records maintained of changes as they are made and require the same review/approval process as the original document. The Project Contract Drawing List as described in Section 01330 shall identify the revised data for each Contract Drawing that is revised.

C. Receiving, Handling, Storage, and Control of Materials and Equipment:

1. The CQP shall contain provisions for verification that material and equipment meet specified quality and Contractual requirements and that they are properly received, stored, handled and maintained to ensure that the quality is not degraded. Establish and maintain documented procedures that ensure that all materials and equipment are positively identifiable and traceable to a specified origin point.
2. Purchased items entering the construction site shall be inspected including their supporting documentation for verification that subcontractors and suppliers have met the appropriate quality requirements of the Contract Documents. Certificates of compliance and/or conformance shall be submitted for materials as required in the various sections of the Specifications.
3. The CQP shall include procedures, inspections, and reports to confirm compliance with all environmental requirements. See Section 01570.
4. Materials for which required certifications have not been received shall be identified, segregated and not incorporated into the Work.

D. Subcontractor and Supplier Control:

1. The CQP shall assure that items and services are procured from subcontractors and suppliers capable of meeting all requirements of the Contract Documents. Review its agreements with subcontractors and suppliers to insure inclusion of all applicable quality requirements.
 - a. All subcontractors and suppliers shall comply with CQP and shall provide written notification of their intent to comply with the program or their own program. If the subcontractors and suppliers elect to submit their own CQP, it shall be reviewed as meeting the requirements of this Section by CQM.
2. Source inspection shall be performed at the subcontractor's/supplier's plants. The source inspection activities shall be concurred with the Resident Engineer
3. Perform external audits of its subcontractors and suppliers to assess compliance with the requirements of the CQP and Contract Documents.
 - a. Submit an external audit schedule to the Resident Engineer within 60 days after the date of the Notice of Award. Make appropriate changes to the audit schedule when warranted due to changed conditions or when directed by the Resident Engineer. Submit the revised schedule to the Resident Engineer within 30 days of the change.

- b. The Resident Engineer shall be notified in writing 14 days (45 days if the audit is to be conducted more than 50 miles from the Work Site) in advance, of the date, time, and location of each audit. An MTA representative designated by the Resident Engineer may participate in such audits. The audit results shall be documented and shall be used to correct deficiencies and prevent their recurrence.

E. Inspection and Testing Plan:

- 1. Contractor's CQP shall include an inspection and testing plan subject to review. The detailed Inspection and Testing Plan (ITP) shall be submitted within 45 days of Notice of Award and shall provide the following information for each identified inspection and test:
 - a. List of inspections and tests to be performed;
 - b. Identify the specification paragraph containing the inspection or test requirements;
 - c. Identify if Contractor, subcontractor, or supplier is responsible for each type of test;
 - d. Schedule of inspections and tests.
 - e. Identification of independent test laboratories to be used;
 - f. List specialized equipment and/or personnel training or qualifications required.
 - g. Identify the characteristics to be inspected, examined, and tested at each activity point;
 - h. Specify inspection and test procedures and acceptance criteria to be used;
 - i. Identify inspection checklists and test reports;
 - j. Identify hold points as described herein below.
- * Contractor's ITP shall be reviewed before any activity inspection or test takes place and shall include test requirements, acceptance criteria, and test conditions. During the life of the Contract, update the plan to reflect any changes in the ITP.
- 2. Personnel performing inspections and tests shall possess a demonstrated competence in the specific area of interest and shall have an adequate understanding of the requirements. Written guidelines shall be established in the ITP to assure that suitable education, experience, and technical qualifications are maintained for personnel performing inspections and tests. Copies of these qualifications shall be maintained by the CQM.

3. A listing of hold points shall be established as part of the ITP. The hold points may also be used by the Resident Engineer to perform verifications of Contractor's work and/or that required inspection and testing has been performed and quality records completed.

F. Control of Construction Processes:

1. Ensure that the Work complies with the Contract Documents and shall provide written records indicating that the results obtained for the various phases described below are documented and maintained. The controls shall include a minimum of 3 phases of control for all definable features of Work as follows:
 - a. Preparatory Phase: This phase occurs before beginning any Work on any definable feature of Work. It shall include, but not be limited to, the following:
 - 1) A review of the Contract requirements.
 - 2) A CWP has been prepared and a Readiness Review Meeting held.
 - 3) All required submittals have been completed.
 - 4) A check to assure that all materials and/or equipment have been tested, submitted, and reviewed.
 - 5) A check to assure that provisions have been made to provide required control inspection and testing.
 - 6) Examination of the work areas to ascertain that all preliminary Work has been completed.
 - 7) A physical examination of materials, equipment, and sample Work to assure that they conform to reviewed shop drawings or submitted data and that all materials and/or equipment are available.
 - b. Initial Phase: This phase shall be accomplished at the beginning of a definable feature of Work and shall include, but not be limited to, a check of preliminary Work (first item inspection) to:
 - 1) Verify full compliance.
 - 2) Establish acceptable levels of workmanship.
 - 3) Resolve all discrepancies.
 - c. In-Process Phase: Daily checks shall be performed to assure continuing compliance with Contract requirements and shall include, but not be limited to, the following:

- 1) In-process inspection activities shall be planned and performed to ensure the quality of the finished Work. Any non-conforming conditions shall be documented and corrected before continuing.
 - 2) Suitable maintenance of equipment used in construction to ensure continuing process capability.
2. Ensure that the Work is performed in accordance with the applicable codes, standards, specifications, or other special Contractual requirements using qualified personnel and/or equipment.
 - a. Code compliance shall be documented through the use of Special Inspection Reports as required by the Designer of Record. See Section 01380.
 - b. For Contractor-designed elements, Contractor's design professional shall identify all required Special Inspections.
3. Distinguish between inspected and accepted items and non-accepted items by using suitable control devices through installation to operation of the constructed Work.

G. Control of Measuring and Testing Equipment:

1. The CQP shall describe the methods for ensuring that equipment used for measuring and testing is in calibration or condition to provide accurate test and inspection results. At intervals established to ensure continued validity, measuring devices shall be verified or calibrated against certified standards that are traceable to recognized industrial standards or naturally occurring physical constants.
2. Use methods to assure proper handling, storage, and care of measuring and testing equipment to maintain the required accuracy of such equipment. Material and testing equipment that are considered found to be out-of-calibration or have been subjected to possible damage shall be identified as non-conforming and shall be removed from service, replaced, or repaired according to the manufacturer's instructions.
3. Ensure that all measuring and testing equipment selected for measurements, tests, or calibration is of the proper range, type, and is controlled, adjusted, and maintained at specified intervals identified in the CQP or before use to assure conformance to the established requirements or predetermined accuracy.
 - a. The equipment shall have some indication affixed attesting to the current calibration status and shall indicate the name of the individual responsible for the last calibration and the date (or other basis) that inspection or recalibration is next required.
4. Contractor's measuring and testing equipment shall be made available for use by the Resident Engineer. Make personnel available for operation of the equipment if requested by the Resident Engineer.

H. Preventive Action and Control of Non-Conforming Conditions:

1. The CQP shall contain provisions for implementing preventive and corrective actions and identifying, recording, controlling, and correcting non-conforming items including provisions for reinspecting and retesting of repaired and reworked items to the original requirements. Any “use as-is” or “repair” determinations shall require review by the Resident Engineer.
2. Investigate the cause of non-conformance and take appropriate corrective actions to prevent recurrence. These actions taken shall be documented on a non-conformance report.

I. Documentation by Quality Records:

1. The CQP shall contain provisions for identification of types of quality records to be maintained, their retrievability and retention periods and shall include a sample or blank copy of all quality records and checklists to be used on this Project.
 - a. Maintain quality records as evidence that all of its activities and those of its subcontractors and suppliers comply with the requirements of the CQP. Additionally, maintain records as evidence that:
 - 1) All deliverables and Work meet the requirements of the Contract Documents;
 - 2) Personnel, procedures, and equipment for special construction processes are qualified;
 - 3) Surveillance of subcontractors and suppliers are performed;
 - 4) Corrective action and action taken to prevent recurrence is being taken for non-conforming conditions.
2. Additional Types of Records to be Maintained:
 - a. Contractor internal and external audit records including, but not limited to, the following:
 - 1) A schedule of Contractor and subcontractor/supplier audits;
 - 2) Quality programs, plans, and procedures audited;
 - 3) Items, services, and activities for which audit was performed;
 - 4) Results obtained;
 - 5) Analyses of audit data for use in corrective action.

- b. Inspection and test records that include:
 - 1) Completed inspection checklists signed by the CQM;
 - 2) Identification of any deficient or non-conforming items;
 - 3) Inspector or data recorder;
 - 4) Date of inspection or test;
 - 5) Reference drawing number and specification reference;
 - 6) Applicable requirements;
 - 7) Special Inspection Reports;
 - 8) Specific inspections or tests performed and results.
 - c. Daily Quality Summary Reports: Prepare a report for all Work on a daily basis. The report shall contain a brief description of the Work performed and whether or not an inspection of the Work was performed. If an inspection or test was performed, a copy of the inspection or test record shall accompany the report.
 - 1) The report shall be forwarded to the Resident Engineer's office by the end of the next business day. The report shall be filed for each day including days in which no Work was performed. The report shall be signed and dated by the CQM.
 - 3. Quality records shall be maintained for both conforming and non-conforming Work.
 - 4. Unless otherwise required by the Resident Engineer or by law, retain all quality records for a period of 3 years after Final Completion and shall make them available to the Resident Engineer upon request.
 - 5. Provide a Monthly Certification Report, which clearly identifies Work completed for the month and the status of this Work. The report shall identify inspection and testing completed for the month and shall also identify any Work that has been found to be in nonconformance. The Monthly Certification Report shall be provided within 10 days from the end of the month.
- J. Contractor Internal Audit:
- 1. Perform internal audits of its own Quality Management System.
 - 2. The audits shall be performed on a minimum semi-annual basis and shall begin within 6 months of the Notice of Award.

3. An internal audit schedule shall be submitted to the Resident Engineer within 60 days after the date of the Notice of Award. Change the schedule when warranted because of changed conditions or when directed by the Resident Engineer. Submit the revised schedule to the Resident Engineer within 30 days of the change.
 4. The Resident Engineer shall be notified in writing 14 days in advance of the date, time, and location of each audit. The Resident Engineer or its designee may participate in all such audits. The audit results shall be documented and used to correct deficiencies and prevent their recurrence.
- K. Training:
1. Provide training in the requirements of the CQP to its management team. Such training shall occur within 90 days after Notice of Award.
 2. Notify the Resident Engineer at least 7 days in advance of the date, time, and location of the above training. The Resident Engineer and its designee will have the option of attending the training. Records shall be kept of the above training documenting the date, time, duration, location, attendees, trainer's name and qualifications, and the items discussed. Copies of these records shall be forwarded to the Resident Engineer no later than 7 days after such training course.
 3. This training requirement is in addition to other training requirements contained in this Contract, if any.
- L. Statistical Analysis: Where appropriate, identify the need for statistical techniques to verify the acceptability of construction process capabilities and Work characteristics. These include, but are not limited to, control charts, sampling plans, and trend analyses of non-conformances.
- M. Design Process Control:
1. Procedures shall be established, documented, implemented, and maintained to control the preparation, and review of design work required by this Contract, if any. Design work includes, but is not limited to, the preparation of shop drawings, record drawings ("as-built" drawings), working drawings, design details, and engineering analyses/calculations, as well as software development.
 2. The procedures shall include methods to identify and document input requirements relating to the scope of design work to reflect applicable statutory, regulatory, and Contractual requirements as well as nationally recognized industrial codes or MTA requirements, if any.
 3. The procedures shall state how design work outputs shall be documented, verified against the design input requirements, and validated as part of the review process.

4. The procedures shall contain a formal program of in-process design work review(s) that shall identify the stages of design at which work review(s) shall occur, the representatives of all concerned functions that shall participate in the review(s), and the document of the review(s) results.
5. The procedures shall include methods to identify, document, and review changes, revisions, and/or modifications to the original design work before resubmittal for review.

3.02 READINESS REVIEWS

- A. The Resident Engineer will conduct readiness reviews prior to all key Work activities. Contractor and each involved subcontractor shall participate in readiness reviews.
- B. Subjects for readiness reviews will be determined by the Resident Engineer. At a minimum, readiness reviews will be held for the following activities:
 1. Communication power substation and property line manhole construction;
 2. Drill-and-blast excavation;
 3. TBM assembly;
 4. TBM operation, cutter changes, and muck removal;
 5. Grouting and ground water control;
 6. Initial support: installation
 7. Construction of muck conveyor over Northern Boulevard;
 8. Reframing at Bellmouth;
 9. Concrete invert at Bellmouth;
 10. 63rd Street Tunnel Invert reconstruction.
- C. Readiness reviews will evaluate the preparedness for accomplishing designated construction operations or activities and will include the following items:
 1. Safety procedures and Safe Work Plans;
 2. Review of the CWP;
 3. Permits and approvals;
 4. Traffic and pedestrian access and maintenance;
 5. Any other relevant issues.
- D. As part of the review session, outline the sequence of Work, planned hold points, and contingency plans in place.

- E. Prior to the readiness review, complete a Construction Work Plan (CWP) for the specific Work activity and shall distribute copies of the CWP to all readiness review attendees at the start of the readiness review meeting. At a minimum, CWP's shall include the following:
1. Overall description of the specific Work activity, including the schedule and sequence of Work;
 2. Construction methods to be used, including key pieces of equipment;
 3. References to applicable Safe Work Plans;
 4. Responsibilities of key Contractor personnel;
 5. List identifying applicable Contract Specifications and Drawings;
 6. Required submittals and disposition of review comments;
 7. Shop and Working Drawings to be used;
 8. List of prerequisite activities that shall be progressed or completed;
 9. Material and equipment delivery methods and schedule;
 10. Methods of verifying that Work meet Contract requirements, including inspection and testing requirements and planned hold points;
 11. Checklist to be used for inspections and identify those responsible for acceptance of the Work;
 12. Identify special processes to be used (e.g. welding, NDT, etc.);
 13. Tolerances for Work;
 14. Identify how completed Work will be protected from follow-on Work activities;
 15. Special measures to address impacts to traveling public, including pedestrians and railroad operations.
- F. The Work being reviewed shall not proceed until the Resident Engineer has indicated acceptance of the CWP and satisfactory conclusion of the readiness review, either by issuance of meeting minutes or subsequent correspondence. The CWP will be attached to the readiness review meeting minutes.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for tunnel communications indicated on the Contract Drawings and/or specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Before commencement of the Work, submit plans for maintaining existing communications for 63rd Street Tunnel, and furnishing and installing new communications system between the tunnel headings, switching locations, bottom and top of Queens open-cut and at the Security Control Center (SCC) in the Resident Engineer's Office on Northern Boulevard.

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION**3.01 EXISTING 63rd STREET TUNNEL COMMUNICATIONS**

- A. A special 63rd Street tunnel telephone system has been installed with telephones at 500-foot spacing between 63rd Street and 2nd Avenue and the Queens open-cut at the existing bellmouth. The telephones can only dial to MTA-PD, NYPD, 911, and NYCT's RTO Operations Center. Protect the existing system for the duration of the Contract.

3.02 COMMUNICATIONS REQUIREMENTS

- A. Provide the following, including but not limited to:
1. Protect the existing telephone system as described herein above in good operating condition throughout the duration of the Contract.
 2. Install and maintain a battery powered mine telephone system in the tunnels, caverns, and chambers with telephones located as follows:
 - a. Resident Engineer's office
 - b. Contractor's office
 - c. Security station (near main Work Site entrance)
 - d. First aid office
 - e. Top and bottom of Queens open-cut
 - f. Along tunnel, spaced not to exceed 1,000-feet so that employees will not have to travel more than 500-feet to the nearest telephone.
 - g. In tunnel at each end of California switches
 - h. At each TBM, a minimum of three locations
 - i. At other locations to be determined by Contractor and in accordance with the Site Security Plan
 3. Install a conventional hard-line telephone system. These telephones shall be an extension of Contractor's primary external telephone system. At a minimum, telephones shall be located as follows:
 - a. On the TBMs
 - b. At all California switches
 - c. Top and bottom of Queens open-cut
 - d. Main security entry/exit gate
 - e. First aid office
 - f. Underground construction power substation
 - g. At locations to be determined by Contractor and/or in accordance with the Site Security Plan

4. Install a radiax cable and maintain a working radio communication system between the tunnel and the Queens open-cut. Radio units shall be required in the heading and at the bottom of the Queens open-cut. Locomotives shall be equipped with radios for use in emergency situations. Additional radios may be required at the first aid office or other locations as determined by Contractor and/or in accordance with the Site Security Plan.
5. Install closed circuit television (CCTV) cameras at each California switch and on the trailing gear with monitors to be located at the bottom of the Queens open-cut and at the SCC. Additional coverage may be required as determined by Contractor and/or in accordance with the Site Security Plan.
6. All communications systems and CCTV systems in the tunnel shall be required to be maintained in good working order and will become the property of the MTA at the end of the Contract.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 DESCRIPTION OF WORK**

- A. Requirements for providing construction site facilities, including Contractor's Office Facilities, Resident Engineer's Field Trailer, office equipment, and furnishings for the Resident Engineer's Main Office and Field Trailer. The general details of construction and the locations of the Work are indicated more particularly on the Contract Drawings.
- B. Requirements for Contractor to take assignment of existing temporary systems and upgrade for Contractor's use during construction.
- C. Requirements for Contractor to transfer assignment of temporary systems, equipment, and/or facilities in satisfactory condition to MTA by Substantial Completion.

1.02 REFERENCED SECTIONS

- A. Section 01515 – Tunnel Communications
- B. Section 01570 – Environmental Compliance
- C. Section 01580 – Project Identification
- D. Section 02145 - Groundwater Treatment System
- E. Section 02239 - Tunnel Dewatering

1.03 CITED STANDARDS

- A. Business and Institutional Furniture Manufacturer's Association (BIFMA) International.

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Submit Resident Engineer's office furnishings/equipment list, and details before procuring and installing items.
- B. Submit plans and details for Resident Engineer's Parking and Contractor's Employee Parking Area.

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION**3.01 MOBILIZATION AND DEMOBILIZATION**

- A. Mobilization: Subsequent to receipt of Notice to Proceed, establish required construction plant at the Work Site, complete in place, and ready for commencement of the Work.
1. Erect fencing and barricades as required.
 2. Install construction signage (see Section 01580).
 3. Provide Contractor's field offices including toilet facilities and 2 hot water/cold water showers.
 4. Maintain Contractor's field offices.
 5. Deliver required construction equipment, tools, and appurtenances for commencement of the Work. Construction equipment shall be of the appropriate type, capacity, quality, and function for the performance of the Work.
 6. Provide equipment, furnishings, and services for Resident Engineer as described herein.
- B. Existing temporary systems to be taken over from MTA:
1. Provide, operate and maintain a complete dewatering and groundwater treatment/control system to collect water from within the tunnels, caverns, chamber, cross passages, central instrument room, cross flue and existing 63rd Street Tunnels, convey it to the Queens open-cut access area, and suitably treat it before discharge in accordance with Section 02145 and 02239. The existing tunnel drainage system shall be upgraded, maintained, and extended throughout the Contract working areas, as necessary, to support construction. Design any upgrades or modifications to the existing system and submit to the Resident Engineer for review. Take over the existing groundwater treatment system and upgrade the system, as necessary, to handle the water flow from the various excavation areas including 63rd Street Tunnels in a manner that prevents damage to the tunnels and surrounding property in accordance with Section 02239 and all applicable Federal, State, local regulations and industry standards. Refer to the Supplemental Terms and Conditions for available Reference Documents.

2. Design, furnish, install, operate and maintain a temporary lighting system in all underground and other working areas in strict compliance with all applicable Federal, State, local regulations and industry standards. The system shall provide a minimum light level in accordance with OSHA requirements. Take over the existing temporary lighting in the existing 63rd Street Tunnels and the Queens open-cut access area. Upgrade, maintain, and extend the existing system throughout the Contract working areas, as necessary, to support construction. Refer to the Supplemental Terms and Conditions for available Reference Documents. In case of failure of the lighting system, provide an emergency lighting system in all work areas in strict compliance with all applicable Federal, State, and local regulations, and industry standards.
 3. Design, furnish, install, operate and maintain temporary ventilation during all phases of construction complying with all applicable Federal, State, local regulations and industry standards. Take over the existing temporary ventilation equipment and ducts and existing 63rd Street Tunnels. Upgrade, maintain and extend the existing system throughout the Contract working areas, as necessary, to support construction. Design any upgrades or modifications to the existing system and submit to the Resident Engineer for review. Refer to the Supplemental Terms and Conditions for available Reference Documents.
- C. Demobilization: Unless otherwise specified, upon completion of construction remove excess materials and temporary facilities including field offices and other structures, utilities, signage, barricades, and fencing. Unless otherwise specified, leave improved areas broom clean and restore unimproved areas to original condition.
- D. Temporary Construction Equipment to be Left in Place:
1. The following items shall be left in place and transferred to the MTA by Substantial Completion. At the time of the transfer, all systems and components shall be in good condition and satisfactory operating condition. Before the transfer of the ownership to the MTA, Contractor's representative in charge of the systems and components shall inspect all equipment to be transferred. Replace non-functioning and poorly functioning equipment before transfer and prove proper functioning of the entire system and all components to the satisfaction of the MTA:
 - a. All compressed air pipe, valves, etc.
 - b. TBM tunneling ventilation plant including scrubbers, ventilation fans, fan line, ducts, all appurtenant equipment, and electrical service and controls. No TBM-mounted backup scrubbers or ductwork is required to be left in place that is not needed for the completion of work as part of this Contract.
 - c. Medium voltage underground power substation at 63rd Street and 2nd Avenue and all of the electrical power distribution system.
 - d. All mine power cables, transformers, etc.

- e. All temporary lighting within tunnels, caverns, chamber, shafts and at surface.
- f. All construction water supply lines, valves, and hoses.
- g. All dewatering discharge lines, valves, pumps and fittings.
- h. All tunnel communication systems and closed circuit television (CCTV) (see Section 01515).
- i. All construction rail system and railroad facilities including, but not limited to rails, switches, and rail supports. No rolling stock or locomotives are to be left.
- j. The dewatering and groundwater treatment/control systems, plants, settling ponds, basins, etc.
- k. Noise barrier walls and/or fences.
- l. Personnel hoist and/or emergency stairs.
- m. Contractor's trailers, offices, change house facilities, shops, and other related facilities and other temporary structures constructed on MTA property. Offices, trailers, change house facilities, and shops shall be left with furniture, lockers, fixtures, and utilities in place and functional. No hand tools or portable equipment are to remain.

3.02 CONTRACTOR'S OFFICE FACILITIES

- A. Establish Contractor's office at the Work Site or within two blocks of the site (29-85 Northern Boulevard).
 - 1. Contractor's office shall include a conference room suitable for seating up to 20 participants that shall be made available for Project meetings.
 - 2. If Contractor's offices are established off-site, provide adequate on-site trailers for Contractor's field supervision to work on-site and to communicate with the off-site offices.
- B. On-site Parking: Control and minimize the parking of vehicles on-site in accordance with the requirements of Section 01570. On-site parking for employee-owned vehicles shall be limited. Visitor parking shall be in designated marked spaces only and shall be in a secure area, away from construction activities, subject to the Resident Engineer's review and acceptance.
- C. Resident Engineer's Parking: Provide three secure, 24-hour accessible parking spaces solely for use by the Resident Engineer and its representatives.
 - 1. If these parking spaces are provided off-site, they shall be located within two blocks of the Queens Area offices at 29-76 Northern Boulevard, subject to the Resident Engineer's review and acceptance.

2. If these parking spaces are provided within the site, they shall be in designated marked spaces only and shall be in a secure area, away from construction activities, subject to the Resident Engineer's review and acceptance.

3.03 RESIDENT ENGINEER'S FACILITIES

- A. All office equipment, including accessories, supplies and all maintenance and service contracts provided by Contractor, shall be handed over to the MTA upon completion of the Work.
- B. Warranty and maintain Contractor-provided equipment, including maintenance contracts, from the date of delivery to the issuance of Final Completion.
- C. All items shall be furnished new and shall be subject to the initial and continuing acceptance by the Resident Engineer.
- D. Boot Wash: Prior to commencement of Work at the Work site, provide a boot wash facility just inside the pedestrian entrance gate on Northern Boulevard and any other pedestrian gate and maintain them for the duration of the Contract. Boot wash facility(s) shall consist, at a minimum, of the following:
 1. Water hose.
 2. Two boot brushes.
 3. Minimum 8-feet by 10-feet open metal grating area. Grating area shall meet with existing sidewalk at pedestrian gate. Provide minimum 6-in clearance under metal grating, with the ability to raise grating and periodically remove accumulated debris. Provide drainage from beneath grating away from sidewalk, into site drainage system.

3.04 RESIDENT ENGINEER'S MAIN OFFICE

- A. The Resident Engineer's main office has been established by the MTA and is located within existing MTA offices adjacent to the Work Site (at 29-76 Northern Boulevard, 5th Floor). This office is located within a designated area of existing rented office space. Before starting any physical Work, provide equipment for the Resident Engineer's main office as listed herein.
- B. Furnishings and Office Equipment: Provide the following furnishings and equipment shall be delivered to the Resident Engineer's main office within 15 days of Notice to Proceed:
 1. Two metal file cabinets; full suspension letter size 4-drawer, lockable, 12-inches wide by 52-inches high.
 2. One FireKing Fireproof 2-drawer vertical file cabinet; full-suspension letter size, lockable, or approved equal.
 3. One metal supply cabinet, 5-shelf, (heavy-duty, commercial-quality, lockable, fire resistant), meets BIFMA shelf standards; 18-inches deep by 36-inches wide by 72-inches high.

4. Four bookcases, metal, 34-1/2-inches wide by 12-5/8-inches deep by 71-inches high with five adjustable shelves.
5. Four bookcases, metal 34-1/2-inches wide by 12-5/8-inches deep by 41-inches high with two adjustable shelves.
6. Two bulletin boards, 72-inches by 48-inches, wall-mountable, metal edged.
7. Six extendable arm desk lamps.
8. Twelve chairs, swivel, with arms.
9. Conference table, 48-inches by 144-inches.
10. Eight Nextel i860 cellular telephones with full Nextel service (unlimited direct connect, nationwide coverage, and up to \$200.00 usage per month per phone), or approved equal, including eight AC adapters, eight Nextel carry holsters with swivel belt clip, eight desktop charging stands, eight USB data cable kits, eight Nextel ruggedized headsets, and eight extra batteries.
11. One Dell 2300MP Multimedia Projector, minimum 2000 (ANSI) lumens, with remote control and spare lamp/bulb, or approved equal.
12. One Kodak Easy ShareOne Digital Camera, 4.0-mega-pixels, 256-MB internal memory, or approved equal, with Camera Dock Series 3 Cradle, 1-GB secure digital memory card, USB cable, AC adapter, camera bag, and extra Li-Ion battery and charger.
13. As requested, thirty - 20-sheet boxes, maximum, HP Premium Photo Paper, 8-11 1/2-inch by 11-inch glossy, or approved equal.
14. Two whiteboards, 60-inches by 30-inches, wall-mountable, with two sets of whiteboard markers and eraser for each board.
15. One - 21-inch combination TV, VCR, and DVD player.
16. One GBC Shredmaster 75X Cross-Cut Shredders, or approved equal.
17. One conference room speakerphone, Polycom Voice Station 100, or approved equal.
18. Two desktop calculators, electronic with tape.
19. Three surveyor's tapes, 100-foot fiberglass.
20. Two electric pencil sharpeners, AC powered.
21. Two - 3-hole punch, ACCO Model 450, or approved equal.
22. One - 15-inch heavy-duty paper trimmer, capable of cutting up to twenty - 11-inch by 17-inch sheets.

23. Four year maintenance contract for existing Xerox DocuColor 12-color photocopier, Serial No. FU2005545. The maintenance contract shall include all services, repairs, ink/toner, staples, and related supplies (excluding paper).
24. Four year maintenance contract for existing Xerox Document Centre 440DC photocopier, Serial No. NNO-131860B. The maintenance contract shall include all services, repairs, ink/toner, staples, and related supplies including paper.
25. Four year maintenance contract for existing Xerox Synergix 8855 Engineering Printer (drawing plotter), Serial No. EIN867100. The maintenance contract shall include all services, repairs, ink/toner, and related supplies including paper.
26. Four year maintenance contract for existing Canon image Class Fax/Copier D680.
27. One copy machine, Konica Minolta BizHub 7145 Digital Copier/Scanner, or approved equal, including four year maintenance contract covering all services, repairs, ink/toner, staples, and related supplies including paper.
28. One copy machine, Brother DCP-8045D Digital copier, or approved equal, including four year maintenance contract covering all services, repairs, ink/toner, staples, and related supplies including paper.
29. Two plain paper multi-function fax machines, Brother MFC-420CN, or approved equal, with USB cable and ten sets of additional Brother replacement ink cartridges.
30. One - 220-volt–110-volt step-up/step-down transformer; rated 3,000-watts.
31. Five - 350-wa uninterruptible power supply (UPS); with minimum eight outlets.
32. Two - 700-wa uninterruptible power supply (UPS); with minimum four outlets.
33. One - 22-KVA uninterruptible power supply (UPS); capable of supporting two HP ML370 servers.
34. Six surge protectors (for PCs, monitors, printers and other related accessories).
35. One Dymo label maker.
36. Twelve clothes lockers, single-tier, 72-inches without legs, 18-inches by 18-inches.
37. Office consumables (for approximately 20 people) on a weekly basis including, as a minimum, first aid supplies, bottled water, coffee, tea, disposable coffee cups, paper towels, toilet paper, and hand soap.

- C. Computer Equipment: The following computers and associated equipment shall be delivered to the Resident Engineer's main office within 15 days of Notice to Proceed. Computers shall be provided with all necessary cables for network connections, power cords, and related accessories.
1. Provide fourteen Dell 630m with either Intergrated Intel Pro Wireless or Dell Internal Wireless Solution, or approved equal, equipped with minimum 2.0-GHz-M processor, 1-GB DDR2 533-MHz SDRAM 2 DIMMS, 80-GB hard disk 9.5-MM and 7,200-RPM, 14-inch SXGA display; MS Windows XP Professional OS with SP1, 8-24-10-24X SWDVD/CDRW combo drive, 1.44-MB floppy drive, 10/100-Mbps Ethernet NIC, internal 56K modem, integrated speakers, USB optical mouse; D/Port Port Replicator, D/Monitor Stand; Dell 2001FP 20.1-inch flat panel LCD monitor, universal carrying case, performance USB keyboard, AC adapter, spare Li-Ion battery, docking stations, portable notebook surge suppressor; and Kensington slim microsaver lock and cable. All units shall include three-year extended warranty, next business day parts, and labor on-site service response.
 2. Provide 14 desktop computers, Dell OptiPlex GX620 Minitower Pentium 4 640/3.2-Ghz, or approved equal, 2M, 800FSB Hyper threading, 1.0-GB, 533-MHz, DDR2 memory, USB Enhanced Multimedia Keyboard, flat panel LED 19-inch color monitor, 256-MB graphics video card, 80-GB SATA hard drive, 7,200-RPM with burst cache, 3.5-inch 1.44-MB floppy drive, USB 2-button optical mouse, Windows XP Professional Service Pack 2. Eight computers shall be equipped with 48X SWDVD/CDRW. Six desktop computers shall be equipped with 48X CD-ROM; all units shall include three year extended warranty, next business day parts, and labor on-site service response.
 3. Provide one HP Design Jet 5500ps plotter, or approved equal, with four year maintenance contract, which shall include all services, repairs, ink/toner, and related supplies including paper as requested by the Resident Engineer.
 4. provide one GEI MFP 8400 44-inch color copier system consisting of Canon Colortrac 4080e Color Scanner and Canon 8400 Color Plotter and associated software or approved equal.
- D. Field Equipment: The following general field equipment and supplies shall be delivered to the Resident Engineer's main office within 15 days of Notice to Proceed.
1. Provide up to 100 hard hats during life of contract; MSA V-Guard with "FasTrac" suspension; cap style; each included with Reflective Strips; or approved equal; color as determined by the Resident Engineer.
 2. Provide up to 25 hard hats during life of contract: MSA V-Guard with "FasTrac" suspension; full-brim style; each included with reflective strips; or approved equal; color as determined by the Resident Engineer.
 3. Provide up to 100 hard hat winter liners during life of contract: OccuNomix, shoulder length, or approved equal.

4. Provide up to 200 rubber gear {rain suits} during life of contract; Neese bib overalls and Neese jackets with hoods; various sizes; or approved equal.
5. Provide thirty safety vests; OccuNomix, high-visibility yellow, or approved equal.
6. Provide five - 200-count boxes of hearing protection; Howard Leight "MAX" NRR 33 rated earplugs, without cords; or approved equal.
7. Provide one - 100-count box of hearing protection; Howard Leight "MAX" NRR 33 rated earplugs, with cords; or approved equal.
8. Provide 50 Crews Safety Glasses Model "Storm", or approved equal, clear lens.
9. Provide 50 Crews Safety Glasses Model "Storm", or approved equal, amber lens.
10. Provide 50 Crews Safety Glasses Model "Storm", or approved equal, gray tinted lens.
11. Provide 50 pairs clear, hard, plastic clip-on side shields, from Safety Glasses USA Inc., or approved equal.
12. Provide 20 steel-toe rubber/neoprene mining boots, Walker Style, Tingley MB921, or approved equal, various sizes.
13. Provide 100 steel-toe rubber/neoprene mining boots of various sizes as requested by the Resident Engineer during the Contract duration.
14. Provide 100 flashlights, Koehler Bright Star during life of contract, or approved equal, two "D" cell, permissible flashlights with carry case (belt) and batteries.
15. Provide two industrial first-aid kits; Johnson and Johnson Model F40-162, or equal.
16. Provide one Haz-Dust EPAM Monitor Model HD-1033, or approved equal.
17. Provide 200 Moldex 2200 N95 Particulate Respirators during life of contract, or approved equal.
18. Provide six Noise Meters Quest Q300, Castle GA-111, or approved equal, with data logging capability.
19. Provide four SESVA-SC-20E, Larson Davis-820 Sound Level Meters, or approved equal, with data logging capability.
20. Provide three environmental kits for outdoor monitoring.

3.05 RESIDENT ENGINEER'S FIELD TRAILER

- A. Provide a separate field office trailer located at 29-85 Northern Boulevard for the exclusive use of the Resident Engineer. This field office trailer shall be established and powered-up within 10 days of the establishment of Contractor's offices.
- B. The Resident Engineer's Field Trailer shall be at least 12-feet by 60-feet and shall be provided with appropriate lighting, heating, air conditioning; water supply, and private restroom. The trailer shall be erected on a raised crushed stone area, with appropriate drainage. The trailer shall be outfitted with drinking water cooler with hot and cold water supply; coffee maker; first aid cabinet; and fire extinguishers.
- C. Provide cleaning, janitorial service and trash removal on a twice-weekly basis. Provide ongoing maintenance of the heating, air conditioning, water supply, plumbing, lighting fixtures, and wiring, including replacement light bulbs.
- D. The following furnishings and equipment shall be delivered to the Resident Engineer's Field Trailer within ten days of the trailer's erection and power hook-up.
 - 1. Provide one desk, flat top, double pedestal with center drawer, 60-inches by 30-inches, with suspension guides for double drawers.
 - 2. Provide one desk chair, swivel, with arms.
 - 3. Provide one office table, with drawer, 60-inches by 30-inches.
 - 4. Provide eight clothes lockers, single-tier, 72-inches without legs, 18-inches by 18-inches.
 - 5. Provide one bookcase, metal, 34-1/2-inches wide by 12-5/8-inches deep by 71-inches high with five adjustable shelves.
 - 6. Provide one rolling vertical plan file with arms.
 - 7. Provide one metal file cabinet; full-suspension letter size 4-drawer, lockable, 12-inches wide by 52-inches high.
 - 8. Provide six folding office chairs, padded.
 - 9. Provide one metal supply cabinet, 5-shelf, (heavy-duty, commercial-quality, lockable, fire resistant), meets BIFMA shelf standards; 18-inches deep by 36-inches wide by 72-inches high.
 - 10. Provide one bulletin boards, 72-inches by 48-inches, wall-mountable, metal edged.
 - 11. Provide one whiteboards, 60-inches by 30-inches, wall-mountable, with a set of whiteboard markers and eraser for each board.
 - 12. Provide one wall clocks.

- 13. Provide two wastebaskets.
- E. Upon establishment of the field office and delivery of the furnishings and equipment, provide no less than 15 keys to the Resident Engineer.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for Safety Planning and Supervision specified herein.

1.02 REFERENCED SECTIONS

- A. Section 01160 – Work Affecting the Railroad
- B. Section 01165 – Railroad Construction Safety
- C. Section 01545 – Construction Safety and Health

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Physical work at the Work Site shall not commence until Contractor's site-specific Construction Safety and Health Plan (CSHP) has been approved by the MTA.
- B. Physical work at the Work Site shall not commence until Contractor's Safety Engineer/Supervisor/Representative has been submitted to and approved by the MTA in writing and is physically on the Work Site during all work activities.
- C. Personnel shall not work on MTA property until they have attended the required Contractor Safety Orientation and Training, which is site specific to this contract.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Code of Federal Regulations (CFR):
 - a. 29 CFR 1910 - Safety and Health Regulations for General Industry (OSHA)
 - b. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)

1.06 SUBMITTALS

- A. Within 15 days after Notice of Award, and in any event before commencing any physical work performed on the work site, submit the site-specific Contractor's CSHP. The CSHP shall include Emergency Action Plans, which shall be revised/updated as conditions change on the project. All revisions shall be submitted.

- B. Within 15 days after the Notice of Award, and in any event before commencing any physical work performed on the work site, submit a resume documenting qualifications of Contractor's proposed Safety Engineer. The Safety Engineer shall have successfully completed the 30-hour OSHA course on Construction Safety and Health (29 CFR 1926). The Engineer may accept other safety certifications or safety training in lieu of the foregoing. The Safety Engineer shall have not less than 10-years of safety or safety related experience, must be familiar with underground work being performed, and shall be a professional member of the American Society of Safety Engineers (ASSE), or other recognized Professional Safety Society. Contractor shall submit a resume documenting the qualifications of the proposed candidate to the Resident Engineer for approval. The Resident Engineer, prior to approval, may interview the candidate Safety Engineer. The resume must include for a 10-year period, a description of the duties, responsibilities, accomplishments and safety record of preceding assignments from which the candidate has gained underground safety engineering experience.
- C. Within 30 days after the Notice of Award, and in any event before commencing any physical work performed on the work site, submit resumes of proposed Safety Supervisors and Safety Representatives who shall have successfully completed the 30-hour OSHA course on Construction Safety and Health (29 CFR 1926).. The resumes shall show a minimum of five years, or as approved by the Resident Engineer, experience as a heavy construction Safety Representative, including a description of the duties, responsibilities, accomplishments, and safety record (including statistical data) of preceding assignments from which the candidate has gained underground safety engineering experience.
- D. Along with the resumes, submit proposed duty tours showing how Contractor proposes to schedule the Safety Engineer, the Safety Supervisor and Safety Representative(s) to provide the required safety services.
- E. Submit for approval, the names and qualifications of proposed competent person(s) as required for the work.

1.07 DELIVERABLES

None Listed

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION**3.01 GENERAL REQUIREMENTS**

- A. To promote safety, hold safety meetings, properly train new employees, and monitor Work Site safety via inspection during each day's work shift(s). In addition, correct and report any safety violations and attend the MTA's investigative meetings that follow accidents the MTA designates as serious.
- B. Contractor has sole responsibility for planning and implementing compliance with all requirements for site safety.
- C. At a minimum, the Safety Engineer, a Safety Supervisor or a Safety Representative shall be present on the site whenever physical work is being performed.
- D. Monthly Job Hour and Injury Summary: A Monthly Job Hour and Injury Summary shall be prepared and provided on or before the fifth day of the following month and submitted to the MTA. The hours shown on this report shall be based on Contractors and subcontractor's Weekly Certified Payroll Reports.
- E. Emergency Action Plan Implementation: Should an emergency occur, Contractor shall immediately secure the area, implement the Emergency Action Plan, notify the Resident Engineer, and provide information regarding the emergency only to the Resident Engineer and any regulatory agency responding to the emergency. The press and media shall be referred to the Resident Engineer for information.

3.02 CONTRACTOR'S CONSTRUCTION SAFETY AND HEALTH PLAN (CSHP)

- A. Develop and maintain, a Contract-specific, effective, Construction Safety and Health Plan (CSHP) to protect the lives and health of all persons, prevent damage to property and materials, and to avoid work interruptions due to accidents.
- B. The CSHP shall be generally organized as follows, including but not limited to:
 - 1. Cover page with name of Contractor, title of Contract, and Contract number. Include plan revision number, date of revision, name and signature of Safety Engineer.
 - 2. Table of contents listing each section and exhibit that clearly identifies the revision number and date of each section and exhibit.
 - 3. Policy Statement signed by an Officer of Contractor,
 - 4. Organization chart of Contractor and subcontractor personnel responsible for implementing the CSHP and their duties and responsibilities. The chart shall show the reporting relationship and integration of the Safety Engineer with all personnel, including top-level managers, responsible for implementing the CSHP.

5. Description of Safety Engineers, Safety Supervisor's and Safety Representatives' duties and responsibilities, including the Safety Responsibilities of Contractor's Project Management Team and designated competent persons.
6. A site inspection procedure to ensure that a walk-through of the site is conducted daily for each work shift and recorded in a Daily Safety Report. Include copy of Report form.
7. An accident investigation procedure including a decision chart for identifying root causes.
8. Emergency Action Plans, including the following:
 - a. A plan for safe and effective response to medical emergencies. Emergency medical services shall include first aid treatment, including all necessary qualified personnel and supplies, and ambulance service or other standing arrangement for the immediate transport of injured workers to medical treatment. Include a map of local routes to medical treatment facilities.
 - b. An evacuation plan that designates one or more assembly areas for personnel and ensures that each person is accounted for in case of fire or other such emergency.
 - c. A list of emergency telephone numbers that identify the proper numbers to call for all emergencies including fire, police, medical (hospital, clinic, ambulance), disruptions of train service, and the release of contaminants into the environment. Identify the location of all telephones available for emergency notification.
 - d. Emergency Action Plans shall be compatible with local police and fire department procedures and shall address all foreseeable emergencies including, but not limited to: injuries, property damage, fire, tunnel collapse or flooding, natural disasters, exposures to hazardous substances, loss of tunnel ventilation, and bomb or terrorist threats.
9. Disciplinary procedures for violations of safety rules.
10. A detailed safety orientation plan for Contractor and subcontractor personnel including, at a minimum:
 - a. Description of the Work;
 - b. Review of Safety Policy Statement;
 - c. Discussion of general safety rules with a copy of the rules distributed to each employee;
 - d. Procedure for reporting all accidents, injuries and incidents;
 - e. Location of First Aid and medical facilities;

- f. Surface and Underground Training Requirements
 - g. Specific Work Site hazards and safe work practices;
 - h. Review of public safety concerns;
 - i. Attendance requirements at Worker Safety Meetings/Briefings;
 - j. Personal Protective Equipment requirements;
 - k. Substance abuse policy and program;
 - l. Fire prevention requirements;
 - m. Review of hazard communication program;
 - n. Housekeeping requirements;
 - o. Construction equipment safety;
 - p. Vehicle safety;
 - q. Warning devices and safety postings;
 - r. Disciplinary procedures;
 - s. Safety awards program, and;
 - t. Non-Harassment Plan
 - u. Requirements for Safe Work Plans
11. Outline of general safety rules and procedures for the performance of the work. Ensure that all applicable safety regulations are addressed and included in this Section. These written programs shall be included in Contractor's CSHP. Examples for inclusion in this Section are as follows:
- a. A written Hazcom Program,
 - b. A written Hearing Conservation Program,
 - c. A written Respiratory Protection Program,
 - d. A written Confined Space Program,
 - e. A written Lockout/Tagout Program,
 - f. Use and storage of compressed gases.
 - g. A written Fall Protection Plan.
12. Outline of site-specific safety rules and procedures for the performance of the work. Examples for inclusion in this Section are as follows:
- a. Plans for safe ingress and egress,
 - b. Traffic control plans,
 - c. Public protection,
 - d. Plans for fire protection and emergency response,

- e. Plans for Lead and Asbestos Abatement,
 - f. Site Security: Refer to Section 01568,
 - g. “Back Injury Prevention” program,
 - h. Training of workers for Surface and Underground Work.
- C. Each subcontractor shall agree to (in writing) and be required to comply with Contractor’s approved CSHP and to take corrective Safety directions from the Safety Engineer, Safety Supervisor or Safety Representative.

3.03 DAILY SAFETY REPORT

- A. A Daily Safety Report shall be prepared by: the Safety Engineer, the Safety Supervisor and each Safety Representative and shall include:
- 1. A header stating;
 - a. Title of Contract and Contract Number,
 - b. Date,
 - c. Time of shift,
 - d. Work area(s) inspected,
 - e. Weather conditions, and
 - f. The location, time and results of all air quality (O₂, CO, Oxides of Nitrogen, H₂S, and LEL) and air quantity (LFM) tests, as is required to maintain a safe and healthful workplace
 - g. Accidents or Near Misses
 - 2. An entry for each safety deficiency that includes;
 - a. Location, severity and nature of deficiency,
 - b. Time noted,
 - c. Names of persons and firms that were notified* of the deficiency including time notified; and
 - * Notification shall include at a minimum the parties exposed to the safety hazard, the parties responsible for creating the deficiency, and the parties responsible for correcting the deficiency.
 - d. Time and nature of corrective action(s).
 - 3. An entry for each deficiency that was not corrected on the prior shift’s Daily Safety Report until the deficiency is corrected;
 - 4. A 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;

5. Notation of Safety Meetings conducted and attended including type of meeting;
6. A notation of visits by safety representatives of the MTA, Federal, State, and local authorities including name and phone number of representative, time of visit, and department or authority represented, and results of visits (i.e. citations, penalties, etc.); and
7. Printed name and signature of person completing the report.

3.04 SAFE WORK PLAN (SWP)

- A. Safe Work Plans (SWP) are written work plans that identify tasks to be performed, the method of work for performing each task, the associated work hazards, and the corresponding equipment and methods that will be used to prevent accidents. Each SWP shall define a plan of action for each identified hazard including comprehensive prevention methods for exposures to workers, the public, property, and the environment. At a minimum, each SWP shall include the following categories:
 1. Key Job Steps: Briefly describe the steps taken for this work.
 2. Potential Hazards (JHA): List potential hazards anticipated during the execution of the work.
 3. Equipment and Tools: List anticipated tools and equipment that will be used during the execution of the work.
 4. Hazard Prevention and Hazard Abatement Procedures: List the procedures and methods to eliminate the potential hazardous conditions.
- B. Based on the six-week Look-ahead Schedule, prepare SWPs for the upcoming major tasks. When drafting an SWP, obtain input from the supervisor who will be responsible for the work involved. Each SWP shall be reviewed and submitted by the Safety Engineer not less than two weeks before the scheduled start of each task. Work on the task shall not commence until the SWP is reviewed and accepted.
- C. Take immediate action to prevent the reoccurrence of any incident or accident. Review and, if necessary, revise the SWP to address the corrective action necessary to prevent the reoccurrence of the incident or accident.
- D. At the start of any operation requiring the submittal and approval of a SWP, Contractor shall review the SWP at the daily toolbox meeting or at a special Worker Safety Meeting. The purpose is to inform the affected employees of the potential hazards and the preventative and/or abatement procedures that shall be utilized to eliminate the hazard(s) identified in performing this work including, but not limited to, the following:
 1. Operations or tasks involving new equipment, machinery or procedures;
 2. Operations involving environmental remediation;
 3. Operations that have resulted in a significant incidence of accidents or

- near misses;
 - 4. Danger of striking against or being struck by;
 - 5. Potential injury from burns, including chemical, thermal and or radiation;
 - 6. Potential oxygen-deficient environments, limited access or exit conditions;
 - 7. Potential of being caught in, on, or between objects;
 - 8. Potential injury from strain by pushing, pulling, or lifting;
 - 9. Potential exposure to toxic/radioactive gases, vapors, mists, dusts, heat, cold or other physical stress agents;
 - 10. Potential for property damage or loss of functions (i.e., critical lifts, power outages, etc.);
 - 11. Any change in process or procedures that effect the crews operation;
 - 12. Potential fire hazards.
- E. SWP Training: The SWP serves as an operating procedure and shall be made available to all personnel performing the Work. A copy of the accepted SWP shall be provided to all supervisors and carried by the foreman performing the work. Personnel involved with the operation shall be informed as to the hazards involved and instructed in the methods required to eliminate the hazards, including emergency action to be taken in the event of an accident.

3.05 SAFETY AND HEALTH BULLETIN BOARD

- A. Maintain a bulletin board in an area near Contractor's field office that is accessible to all workers. Items such as, but not limited to, the following shall be posted on the bulletin board:
- 1. Emergency Action Plans, including emergency/evacuation procedures,
 - 2. Emergency phone numbers,
 - 3. OSHA poster,
 - 4. Notice of Workers' Compensation Carrier,
 - 5. OSHA 300 summary (updated monthly).

3.06 SAFETY ENGINEER SAFETY SUPERVISOR AND SAFETY REPRESENTATIVE

- A. Assign a full-time Safety Engineer exclusively to this Project to its completion. The Safety Engineer's sole responsibility shall be the management of all safety matters specified.
- 1. The Safety Engineer shall participate in the development of Contractor's CSHP, shall review/approve the Plan (evidenced by its signature) for use on this Contract, continually monitor Contractor's adherence to the Plan, and review and revise the Plan on a yearly basis or as needed.

2. It is imperative that effective safety coverage be provided for all work activities on this project including safety coverage that is required for all shifts.
 3. On multiple shift work, the Safety Engineer shall primarily work on the day shift in order to be accessible to MTA needs and activities or meetings that may require his attendance and participation. The Safety Engineer shall have a Safety Supervisor or Safety Representative assigned to work on all other shifts while work is in progress. The Safety Engineer may find it necessary to overlap his time and duties into another shift as needed; in order to communicate Contractor's safety plans, aid in safety coverage and/or assist with project compliance issues in correlation with the Safety Supervisor or Safety Representative or crew, of the overlapped shift.
 4. The Safety Supervisor shall have not less than 5-years of safety or safety related experience, must be familiar with underground work being performed, The Safety Engineer shall supervise all Shift Safety Supervisors and Safety Representatives. Submit for review safety supervision coverage where weekend or holiday work is scheduled.
- B. The proposed Safety Engineer, Safety Supervisor and Safety Representatives shall maintain current certifications in first aid and CPR.
- C. The Safety Engineer shall report directly to the Corporate Director of Safety or a Corporate Officer and not be subordinate to Contractor's personnel on the Project site. Upon discovery of an unsafe condition, the Safety Engineer or Safety Supervisor and each Safety Representative shall order the work to be stopped and the unsafe condition immediately corrected.
- D. Failure to have a Safety Engineer, a Safety Supervisor or Safety Representative on the Contract Site when any work is being performed may result in a stoppage of work (which shall be deemed non-excusable delay) until the Safety Engineer, Safety Supervisor or a Representative is physically on the contract Work Site. The Resident Engineer shall receive a written report explaining the reason for Contractor failing to provide the Safety Representative, prepared by a principal of Contractor, within five working days of such occurrence.
- E. Three working days before the start of a railroad track outage, Contractor's Safety Engineer shall certify to the Resident Engineer that all required safety equipment and materials are available at the site of the work, have been inspected and found to be in working order and in good condition. For extended track outages, such certification shall be reaffirmed on a weekly basis.
- F. Do not change the approved Safety Engineer, the Safety Supervisor or Shift Safety Representative without prior written consent of the Resident Engineer.

- G. Contractor's Safety Engineer, Safety Supervisor/Representative shall, at a minimum:
1. Maintain a safety library including at a minimum, a current copy of CFR29, Parts 1910 and 1926; 30CFR, Contractor Safety and Health Plan; Contractor's Corporate Safety and Health Program; and copies of each Subcontractor Safety and Health Plan.
 2. Perform and document daily safety inspections of the jobsite(s) and public areas contiguous and adjacent thereto. Initiate immediate corrective action(s) to eliminate unsafe acts and/or conditions.
 3. Provide relevant material for use in conducting weekly Worker Safety Meetings.
 4. Review and maintain files of the weekly Worker Safety Meeting reports to ensure adequacy of training as well as subject matter. Periodically attend or conduct these meetings.
 5. Coordinate and participate in the development of Safe Work Plans, ensuring quality and timely submittals. Coordinate training of work crews and first line supervision affected by each SWP.
 6. Conduct accident and incident investigations and preserve accident/incident sites until the investigation is completed.
 7. Develop and implement effective safety-training programs for supervisors and employees.
 8. Ensure that employees receive prompt medical treatment for occupational injuries or illnesses.
 9. Obtain or perform industrial hygiene monitoring/testing applicable to the hazards, potential or otherwise, which may be encountered on the site. Written records of such tests shall be kept at the work site and made available to an authorized MTA representative upon request.
 10. Maintain a record of equipment certifications and testing.
 11. Ensure that all subcontractor employees at any tier comply with jobsite safety rules and regulations; and that each subcontractor safety and health reports are completed.
 12. Review Emergency Action Plans monthly to ensure that Contractor personnel are familiar with the proper actions to take, and that emergency telephone numbers are current.
 13. Maintain liaison with FDNY throughout project duration.

H. Use of a Designated Safety Representative (DSR):

1. Sick, Personal or Emergency Leave: Inform the Resident Engineer immediately upon the absence of the Safety Engineer, Safety Supervisor or Safety Representative and provide a copy of the Alternate Safety Coverage Request indicating the approved person who will act as DSR during the absence. If the sick, personal or emergency leave extends more than 14 calendar days, provide a qualified Safety Supervisor or Representative.
2. Vacation Leave: Provide a copy of the Alternate Safety Coverage Request indicating the approved person who will act as DSR during the absence no less than one week prior to the planned absence. If the vacation extends more than 14 calendar days, provide a qualified Safety Engineer or Safety Supervisor.
3. Termination or Resignation of Safety Engineer, Safety Supervisor/Representative: In the event that a Safety Engineer, Safety Supervisor or Representative is either terminated or resigns, immediately inform the Resident Engineer, assign a DSR, and provide a copy of the Alternate Safety Coverage Request.
4. Small Work Crews (Only for Weekends, Holidays or Irregular shifts): A DSR may be substituted for the regular safety personnel only where a small crew of 15 employees or less, including all supervisory and subcontractor employees, is involved in work on an extended shift, weekend work or irregular shift work provided the following conditions are met:
 - a. Prepare a SWP and identify how the DSR will provide adequate and appropriate safety coverage.
 - b. Submit the SWP, and provide a copy of the Alternate Safety Coverage Request indicating the approved person who will act as DSR during the work, no less than four working days prior to the planned work.

I. When the contract involves underground work, Contractor's Safety Engineer, Safety Supervisor/Representative shall have the following added responsibilities:

1. Ensure that all equipment used in underground work has required approvals and is properly maintained.
5. Ensure that timely and accurate records are kept by the gas tester(s). These records shall be maintained at the work site, available to the RE.

3.07 ACCIDENT AND INCIDENT NOTIFICATION

- A. Immediately notify the Resident Engineer of accidents and incidents in accordance with notification procedures. Transmit copies of the required Accident Investigation Report(s) to the Resident Engineer within 24 hours of each accident or incident. Notify the Insurance Carrier immediately, and cooperate fully with it's investigators and adjusters.
- B. In the event of a Serious Accident, the Safety Engineer shall convene an Accident Investigation Meeting for the purpose of determining the cause of the accident and actions to prevent a reoccurrence of such an accident. Notify the Resident Engineer and permit the MTA to attend this meeting.
- C. A Serious Accident shall be defined as follows:
 - 1. Fatality.
 - 2. Spinal cord injuries.
 - 3. Burns to 10% or more of the body.
 - 4. Amputations or crushing injuries.
 - 5. Eye injuries resulting in partial or total loss of sight.
 - 6. Injuries resulting in loss of hearing.
 - 7. Severe head injuries.
 - 8. Any occupational disease.
 - 9. Any injury resulting in more than 24 hours hospitalization.
 - 10. Any accident resulting in more than \$5,000 in property damage.
 - 11. Any accident involving the public
- D. Notification Procedures: Notification to the Resident Engineer is required for the following accidents and/or incidents:
 - 1. Any event deemed to be an emergency, requiring a report to the "911" agency or intervention of emergency first responders such as fire, rescue, or ambulance (other than ambulance for personal illness).
 - 2. Any injury or illness resulting in a fatality, in-patient hospitalization, requiring ambulance transport, or medical treatment beyond first aid.
 - 3. Any lost-workday injury or illness case.
 - 4. Any illness resulting from job-related exposures that could worsen significantly.
 - 5. Any electrical shock.
 - 6. Property Damage: Explosion or violent uncontrolled chemical reaction; or fire beyond the incipient stage that requires trained firefighters to extinguish.

7. Exposure to Toxic Materials, Harmful Physical Agents, or Radiological Events; including personal contamination case (uptakes) in excess of regulatory standards and/or penetrating radiation exposures greater than the project limits.
 8. Near Misses / Near Hits; including any event where the potential for an injury or death existed had the conditions changed slightly, any excavation collapse where employee or equipment was exposed to potential injury or damage, any confined space incident where employees were injured or exposed to chemicals, or any fall from elevations greater than 4 ft.
- E. Accident and Incident Investigations: All accidents/incidents shall be thoroughly investigated without delay.
1. Issue standing orders/protocol; to all supervisors directly in charge of operations that the scene of an incident shall not be disturbed, except for rescue or other emergency measures. Contractors' personnel, either witnessing or party to the incident, shall be detained at the site to provide detailed accounting of facts in the form of a written, signed statement. All statements as well as a preliminary investigation into the facts conducted by contractor management personnel, including drawings and pictures, shall be provided to the Resident Engineer within 24 hours of the incident.
 2. The MTA may conduct an independent investigation of serious incidents and injuries. All contract employees, regardless of tier, shall make themselves available to the MTA at the MTA's convenience for interviews regarding the incident under investigation.
 3. Preserve the incident scene in an undisturbed condition until advised by the MTA that work may continue.
 4. Analysis and Corrective Action: Corrective action can only be taken when specific factors of an incident have been accurately developed and the resulting recommendations have been disseminated to responsible persons. In preparing written reports of an incident, statements and comments shall be confined to facts.
- F. Reporting Procedures: Within 24 hours of an incident, provide a report for each incident. Prepare the New York State C-2 form based on the information provided by the injured employees' supervisor. Additional required information to complete the C-2 form may be obtained from either the injured employee or the injured employee's personnel record. The injured employee's supervisor is to complete the MTA's "Supervisor's Report of Bodily Injury and Property Damage" Form.
- G. Photographs shall be taken in conjunction with investigations of any incident involving serious personal injury, all non-project personnel injuries, substantial property damage (including motor vehicle), equipment or material failure, and all incidents that may, even remotely, involve third party action. Photographs shall be sufficient in number to adequately reflect the general area as well as pertinent

details from a variety of angles. Photographs shall be taken as soon as possible following the incident. Identify each print on its reverse as follows: name of injured (if equipment damage, type; if property damage, location); date of incident; photographer's initial, and time photographs taken (date if different from occurrence), direction facing, and brief description of photo.

- H. Telephone Reports: Designate a responsible person to make emergency calls. Should a serious incident occur resulting in damage to public or MTA property; or bodily injury to the public or employees of MTA, its consultants, contractors, or their subcontractors, it shall be reported immediately by phone to the Resident Engineer.

3.08 SAFETY ORIENTATION

- A. Before working on the Work Site, each employee, including all subcontractor employees, shall undergo Contractor's safety orientation program as outlined in the CSHP. Each safety orientation shall be documented, including a list of all participants.

3.09 SAFETY MEETINGS

- A. Worker Safety Meetings:
1. Worker Safety Meetings shall be held weekly, at a minimum, in accordance with the requirements of the CSHP. Each employee of Contractor and each Subcontractor working at the Work Site shall attend these meetings.
 2. An employee failing to attend a Worker Safety Meeting shall not be permitted to perform any work that requires safety precautions that were discussed in the Worker Safety Meeting, until the employee has received the same instruction.
 3. Notify the MTA of each Worker Safety Meeting. A record of each Worker Safety Meeting including the topics covered and a signed list of attendees shall be maintained by Contractor's Safety Engineer.
 4. Each Worker Safety Meeting shall include instruction and discussion of safe working methods and applicable rules required for the safe performance of the upcoming work. Subject matter shall cover specific safety procedures pertinent to the crew's on-going activity, including procedures outlined in the SWP. Topics shall also include proper use and care of PPE, location of safety equipment and supplies, Emergency Action Plans and specific emergency/evacuation procedures. The MTA reserves the right to direct Contractor to cover additional safety related information in these meetings.
 5. The Worker Safety meeting shall be conducted by the Safety Engineer, the Safety Supervisor or Safety Representative or Contractor's supervisor, or by a supervisor of the subcontractor. The Safety Engineer shall approve the content of each subcontractor Worker Safety Meeting.

- B. Pre-Construction Safety Meeting: The MTA Safety Manager will conduct a pre-construction safety meeting before work commences on the contract. Required attendees are Contractor's Project Manager, Safety Engineer, Safety Supervisors and a representative of each major subcontractor.
- C. Safety Briefings: A Safety Briefing shall be held at the start of each work shift to instruct all employees in safety precautions applicable to that day's work. Safety briefings shall be documented.
- D. Management Safety Meeting: The Resident Engineer will conduct a Monthly Management Safety Meeting either as part of another regularly scheduled meeting or as a separate meeting as safety concerns warrant. Contractors Project Manager, General Superintendent, and Safety Engineer shall attend.
- E. Project-Wide Monthly Management Safety Meeting: The MTA will conduct a monthly Management Safety Meeting. Contractor's Project Manager, Safety Engineer and a representative from each major subcontractor actively working on the contract shall attend.
- F. Railroad Worker Protection (RWP) Safety Meeting: A RWP Safety Meeting shall be held each day that crews may infringe on the "foul area" established by the Railroads (See Section 01160). Any employee failing to attend the RWP Safety Meeting shall not be permitted to perform any work that requires safety precautions that were covered in the meeting until the employee has received the same instruction. RWP Meetings shall be documented, including an attendance list signed by the attendees. The meeting shall include instruction and discussion of safe working methods and applicable safety rules required for the safe performance of the work.

3.10 MAINTENANCE OF SAFETY RECORDS

- A. Maintain the following Project Safety Records on site for the duration of the contract and make them available for review by the MTA upon request. In addition, maintain these records for six years after final completion of the contract.
 - 1. Contractors Construction Safety and Health Plan (CSHP);
 - 2. Safe Work Plans (SWP's);
 - 3. Daily Safety Reports;
 - 4. Worker Safety Meeting records;
 - 5. Training records and Certification Cards including, Safety Orientation, Roadway Worker Protection, NYCT Track Safety, and all other training provided to employees;
 - 6. Submitted and Approved Competent Person Designations;
 - 7. Material Safety Data Sheets (MSDS);

8. Accident/Incident reports including; Report of Injury, (C-2), Accident Investigation Report, LIRR Form Accident Report Non-Employee (ARNE);
9. OSHA Form 300 for Contractor and each Subcontractor;
10. Written notice of Citations, Suits, or Complaints; and
11. Other compliance records as required by City, State, and Federal Agencies.

3.11 FIRST AID FACILITY AND STAFF

- A. Provide a Type I First-Aid Facility meeting the following requirements:
 1. The location, size, furnishing and equipment shall have the acceptance of the MTA and be capable of providing quiet, private communications, as well as adequate ventilation, light, heat, hot and cold running potable water, toilet facilities and electrical outlets and telephone(s).
 2. The First Aid Station shall be connected to the mine phone system and equipped with the following: an automated external defibrillator, medical oxygen, first-aid kit suitable to service the number of personnel assigned to the project and acceptable to Contractor's consulting physician, paper towels and paper cups, a blood pressure cuff and stethoscope, a cot or an equivalent resting place, and other items as required by Contractor's consulting physician.
- B. The MTA, under the Owner Controlled Insurance Program (OCIP), will provide the necessary EMT's for the Contract duration. The EMT shall coordinate with the Resident Engineer and Contractor's Safety Engineer or Safety Supervisor.
- C. Contractor and subcontractor supervisors, first-line supervisors (forepersons, shifters, etc.) and two other Contractor employees in each work area shall be currently certified in first-aid and CPR. Copies of the current certificates shall be provided to the Resident Engineer.
- D. Off-site medical treatment of employee injuries shall be performed at medical facilities acceptable to the MTA-OCIP.

END OF SECTION

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for site-specific Contractor's Construction Safety and Health Plan (CSHP) specified herein.
- B. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary to support the removal of hazardous and contaminated materials, as defined herein

1.02 REFERENCED SECTIONS

- A. Section 01160 – Work Affecting the Railroad
- B. Section 01165 - Railroad Construction Safety
- C. Section 01540 - Safety Planning and Supervision

1.03 CITED STANDARDS

- A. American Conference of Governmental Industrial Hygienists (ACGIH)
- B. American National Standards Institute (ANSI)
 - 1. B30.5 - Mobile and Locomotive Cranes
 - 2. B30.9 - Slings
 - 3. Z49.1 - Safety in Welding and Cutting
 - 3. Z87.1 - Occupation and Education Eye and Face Protection
 - 4. Z89.1 - Requirements for Industrial Head Protection
- C. Compressed Gas Association (CGA)
- D. Factory Mutual (FM)
- E. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC)
 - 2. 130 - Fixed Guideway Transit and Passenger Railway Systems
 - 3. 704 - Identification of the Fire Hazards of Materials for Emergency Response (Hazard Warning System - NFR Diamond)
- F. Underwriters' Laboratory (UL)

1.04 NOTED RESTRICTIONS

- A. Exposure limits for all workers shall be the current ACGIH Threshold Limit Values (TLV).

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Building Code of the City of New York (NYC)
 - a. RS-16 - Plumbing and Gas Piping
 - 2. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)
 - 3. Code of Federal Regulations (CFR):
 - a. 29 CFR 1900.1200 -Labor
 - b. 29 CFR 1910 - Occupational Safety and Health Administration (OSHA)
 - c. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)
 - d. 36 CFR 1911, Appendix A - ADA Accessibility Guidelines for Buildings and Facilities
 - 4. New York City Department of Environmental Protection (NYCDEP)
 - 5. New York State (NYS):
 - a. Department of Environmental Conservation (NYSDEC).
 - b. Industrial Code
 - 6. U.S. Environmental Protection Administration (USEPA)
 - 7. Other applicable rules and regulations of authorities having jurisdiction.

1.06 SUBMITTALS

- A. Within 90 days after the Notice of Award or prior to starting tunnel construction, whichever occurs first, submit a Tunnel Ventilation Plan. The plan shall be jobsite specific.

1.07 DELIVERABLES

- A. Crane certification, crane operator license, crane configuration and crane manufacturer's load chart, and certification of ground support.
- B. Lifting gear certification.
- C. Rolling Stock: proof of training for locomotive operator(s).

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION**3.01 GENERAL REQUIREMENTS**

- A. Safely perform the work in accordance with this Section and as further defined and detailed in Contractor's CSHP (See Section 01540).
- B. Safety of passengers and other persons, property, MTA employees, and of all employees of Contractor and subcontractors working on the Work Site shall be a primary concern and responsibility of Contractor. Assume the full responsibility and obligation to provide and maintain a safe working environment at all times and a clean, and healthy Work Site.
- C. Comply with the applicable provisions of OSHA, FRA, 49 CFR 214, ANSI, USEPA, NYSDEC, NYCDEP, NFPA, including the NEC, BCNYS, NYS Industrial Code, Rules and Regulations of LIRR, Amtrak, and NYCT, and all other applicable rules and regulations (See Section 01165).
- D. Prior to commencement of work, the Project Manager, Superintendent(s), Safety Engineer and Safety Supervisor(s) shall attend an ESA safety indoctrination and coordination conference.
- E. All government promulgated safety regulations are minimum standards. Additional safeguards may be required to ensure worksite safety, and prevent losses.
- F. Site Visitors and Group Tours: A high degree of protection shall be afforded all persons on authorized tours of construction jobsites. The Resident Engineer shall be advised of any tour in a timely manner prior to the tour-taking place. All visitors shall comply with contractor safety requirements. Tour guides shall familiarize their group(s) with the hazards to be encountered on the tour prior to entering the work site. Coordinate the following with the individual or organization requesting the tour:
 - 1. Number of Visitors: Tour groups in non-work areas shall be limited to no more than twenty-five persons per tour guide. Tour groups in work areas will be limited based upon the specific conditions to be encountered by the tour group.
 - 2. Clothing: Visitors entering the work areas are required to wear pants or slacks, shirt or blouse, and sturdy leatherwork shoes. Sneakers, high-heeled shoes, lightweight-hiking footwear, steel-toed athletic or casual footwear are prohibited.
 - 3. Minors: Persons under 18 years of age are not permitted on project tours.
 - 4. Protective Equipment: Hard hats, eye protection, earplugs, flashlights, self-rescuers and other protective devices shall be required as necessary.

5. Release and Hold Harmless Agreement: Each visitor shall be required to sign a release and hold harmless agreement prior to the commencement of the tour. The Resident Engineer will provide a sample Visitor's Release and Hold Harmless Agreement.
 6. Tunnels: Personnel touring tunnels shall be effectively trained in the unique hazards of underground construction, the use of self-rescuers, and other emergency procedures.
- G. Fitness for Duty: Do not permit a worker whose ability or alertness is impaired because of drugs, fatigue, illness, intoxication, or other conditions to work at the Work Site. Comply with MTA's Zero-Tolerance Policy that will be provided by the Resident Engineer.
- H. Employee Conduct: The MTA reserves the right to refuse access to the Work Site or require immediate removal from the Work Site any individual violating site safety or security regulations.
- I. Electrical Safety: Ground fault circuit interrupters (GFCI) designed for personnel protection shall be used on all electrical services used by workers. Assured grounding may only be used for temporary light circuits. All other power sources, including portable generators (regardless of wattage), as well as extension cords plugged into permanent power sources, shall be protected by GFCI.
- J. Powder-Actuated Tools: All operators of powder-actuated tools shall be trained by the manufacturer (Hilti, Ramset, etc.). In addition, a FDNY Certificate of Fitness shall be required for work within the New York City limits. The Safety Engineer shall maintain a copy of each employee's certificate in the safety files.
- K. Storage and Office Trailers: Trailers shall be fully chocked and tied down to prevent overturning in high wind conditions. Storage and office trailers shall be equipped with auxiliary supports at each corner.

3.02 UNSAFE CONDITIONS

- A. 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 Work Site, work shall be stopped in the affected area until the condition is corrected. If Contractor does not take corrective action immediately, or within the time period specified by the MTA, the MTA reserves the right to take whatever action it determines necessary to correct the Unsafe Condition (up to and including withdrawal of affected workers from the area) and back charge Contractor for the cost incurred.
- B. Whenever an unsafe condition is determined, Contractor will be notified verbally and/or in writing to correct the unsafe condition. Within 24 hours of receiving a written notice, respond in writing as to the immediate corrective action taken to eliminate the unsafe condition. In addition, include in this written response, the procedures implemented to prevent the recurrence of similar unsafe conditions.

3.03 PERSONAL PROTECTIVE EQUIPMENT (PPE)

- A. Eye Protection: Eye protection shall be worn at all times and meet the requirements of ANSI Z87.1.
- B. Hard Hats: Hard hats shall be worn at all times and shall be SEI Certified in accordance with ANSI Z89.1 or ANSI Z89.2 requirements for Type I Class E protection. Metal or aluminum hard hats are prohibited. Hard hats shall be worn and maintained in accordance with the manufacturers specifications.
- C. Safety Vests: Safety vests shall be worn at all times and shall be flame-retardant, 360-degree reflective, high visibility orange, and 100-percent rip away.
- D. Foot Protection: Foot protection shall be worn at all times. Work shoes shall be at least 6-inches high, preferably leather, and be completely laced or buckled. The shoe shall have definite heels that are no more than 1-inch high. Hiking shoes, dress shoes, sneakers or other recreational shoes including deck shoes, high-heeled shoes, sandals and opened-toed shoes are not permitted on the work site.
- E. Work Clothing: Work clothing shall be worn at all times and shall include full-length pants, free of holes and made of durable material. An employee shall not be permitted to wear work clothing that has been saturated with any flammable or combustible substance. Shirts shall completely cover the shoulders and mid-section to the waist. Athletic, sleeveless, tank top, or fishnet type shirts shall not be permitted. The minimum shirt allowed will be a standard T-shirt.
- F. Provide other PPE as required by safety and health standards, (hearing protection, and effective respiratory protection, including self-rescuers).
- G. Employees working on or near NYCT active tracks shall be equipped at all times with the following:
 - 1. High-visibility vests as required in NYCT Safety Regulations (Ref: Item No. 702-Con manufactured by “The Industries for the Blind of New York State”, Telephone 518-456-8617, Fax 518-456-3587, or approved equal). Note: “The Industries for the Blind of New York State” has been designated as a “preferred source” for this item pursuant to NYS Finance Law Section 163.
 - 2. One 2-cell, size “D” permissible flashlight.
- H. Perform regular field inspections to ensure effective PPE compliance. Non-compliance of the PPE requirements shall lead to disciplinary action up to the removal of the personnel from all Project Work Sites.

3.04 UTILITY MARKOUT

- A. Take all necessary precautions to identify, locate and avoid contact with existing utilities. A minimum of one week before excavating, notify:
 - 1. The local “Call Before You Dig” or “One Call Center” to allow member agencies to mark locations of underground utilities (1-800-272-4480, or other applicable contact number).

2. In addition, notify the affected Railroads.

3.05 BLASTING

- A. Before blasting, all necessary precautions shall be exercised by Contractor as required by the applicable ordinances and regulations of New York City and the New York City Fire Department (FDNY). This shall include complying with all FDNY Rules and Regulations concerning blasting and obtaining all necessary permits issued by FDNY.

3.06 CRANE OPERATION

- A. Cranes shall meet the requirements of ANSI B30.5.
- B. Notify the MTA and transmit copies of the following documentation before putting the crane into use.
 1. Certification of Inspection.
 2. License of crane operator.
 3. Crane manufacturer's load chart for the model and configuration of the crane
 4. Certification (approved by Professional Engineer licensed in the State of New York) of ground support and submittal of grillage and design of ground support
- C. Do not hoist over a building without notification and permission of the building owner. Do not allow public vehicular and/or pedestrian traffic to pass beneath the boom of any crane. If the boom of a crane shall be placed over a street or pedestrian walkway, stop or reroute the vehicular and/or pedestrian traffic.
- D. Modifications or additions that affect the safe operation of a crane shall not be made without the Manufacturer's written permission.
- E. All cranes assembled at the Work Site shall be inspected and tested by the crane supplier or qualified personnel with proof of inspection and testing transmitted to the MTA. All lifting devices shall be engineered and tested in the configuration for a safe working load. Permanently attach or affix, clearly and visibly, the capacity chart of the lifting device.
- F. All critical lifts require a Safe Work Plan (SWP), (See Section 01540). A lift shall be designated as a critical lift under any of the following circumstances:
 1. The item being lifted is unique and, if damaged, would be irreplaceable or not repairable and is vital to a system, facility, or project operation.
 2. The cost to replace or repair the item being lifted, or the delay in operations of having the item damaged would have a negative impact on the project, organizational, or Contractors budget to the extent that it would affect program commitments.
 3. The item, although non-critical, is to be lifted above or in close proximity to a critical item or component.

4. The load being lifted is 95-percent or more of a mobile crane's chart rating for the maximum radius that will be experienced.
 5. Two mobile cranes are lifting the load and the load share equals more than 70-percent of one or both crane's chart rating for the maximum radius that will be experienced
 6. Lifts without the use of outriggers using on-rubber tire load charts; lifts where the center of gravity could change;
 7. Any lift that the lift or crane operator believes should be considered critical.
- G. Where any crane is operated in such a location that any part of the crane or its load in any position of boom or swing may come within 10-feet of a live power line or contact rail, comply with Railroad safety requirements (see Section 01160) and NYCT Safety Regulations.
- H. Ensure that all loads are secure and that all loose material is removed before the load is lifted.
- I. Boom Trucks: If the manufacturers rated capacity of the lifting device is three tons or greater, the lifting device shall be inspected annually in accordance with current ANSI standards.
- J. Crane and boom truck operators shall be licensed by the City of New York and/or the State of New York for the equipment type to be operated. Re-certification is required for any crane or boom truck involved in an incident and/or subjected to any overloading, side pulling, or shock loading of the boom.

3.07 RIGGING

- A. Rigging shall meet the requirements of the ANSI B30.9. For reference on best practices see Department of Energy – RL-92-36 “Hanford Site Rigging Manual”.
- B. Only qualified riggers, one of which shall be designated as the competent person for rigging, shall be employed when hoisting is in progress. The competent person for rigging shall be capable of identifying existing and predictable conditions that may be hazardous or dangerous to employees both in the surroundings and in the working conditions and shall have the authorization to take prompt corrective measures to eliminate these conditions. The designated competent person for rigging is, at a minimum, responsible for and shall ensure the following:
1. Compliance with applicable OSHA standards including State, County, and City regulations applicable to rigging.
 2. Rigging hardware and materials are inspected before use, configured correctly, and properly attached to the lifting equipment.
 3. Assigned lift personnel in the rigging process are complying with all applicable standards, requirements, and safe practices.
 4. Review rigging activities being performed for all daily routine light and

- medium lifts.
5. Substandard or unsafe equipment or methods are immediately reported to supervision and are not used to move loads.
 6. All loads are dogged-off (positive hoist latching device engaged) until unsafe equipment is repaired or methods are revised so that the lift can be completed in a safe manner.
 7. Rigging crew, prior to the lift, understands any job specific procedures required for daily lifting operations.
 8. Rigging is properly stored after use.
- C. Contractor's lifting attachments, chains, and fiber slings shall have the manufacturer's safe working load identified and attached to each item. Each sling shall be inspected and certified as prescribed by law and regulations. Before and as often is necessary during use, a competent person shall inspect slings. Defective slings and lifting devices shall be taken out of service and repaired or destroyed.
- D. All lifting hooks shall be equipped with properly functioning safety latches.
- E. The use of chains, including alloy steel chains, for lifting any load is prohibited unless prior, task specific, written approval by the MTA is obtained.

3.08 WELDING AND CUTTING

- A. Welding and cutting equipment and operations shall meet the requirements of the ANSI Z49.1, and the requirements of this Section.
- B. Gas welding and cutting equipment shall be listed by UL or FM.
- C. Before any welding, cutting, burning, or any other spark-producing operations in any work area, provide or obtain the necessary "Hot Work Permit(s)".
- D. Welding apparatus and equipment shall be inspected daily, before use. Defective apparatus and equipment shall not be used and shall be removed from service until repaired or replaced.
- E. Whenever the operator leaves the work area cylinder valves shall be closed.
- F. Torch valves shall be checked for leaks at the start of each shift.
- G. Only friction lighters or other approved devices shall be used to light torches.
- H. Splices or repaired insulation on arc welding cables shall not be permitted within 10-feet of the electrode holder. Cables shall be positioned so as not to interfere or create obstructions on walkways, scaffolds, stairs, or ladders. Splices shall be equal to or greater than the original insulation on the cable.

- I. Portable welding screens or shields shall be used to protect other workers and/or the public in the immediate area.
- J. A live domestic water supply or fire extinguishers rated at 10 ABC or larger shall be in the immediate area whenever welding or cutting is being carried out.
- K. A fire watch shall be assigned to all welding, cutting, burning, or heating operations. A Fire Watch shall be maintained for a minimum of 30 minutes following the completion of any cutting or welding, burning or heating operation. Fire watch personnel shall be trained in the use of fire extinguishing equipment and have a current certificate of fitness issued by the FDNY and shall be familiar with methods of sounding an alarm in the event of a fire.

3.09 COMPRESSED GAS CYLINDER STORAGE

- A. All compressed gas cylinders shall be stored, used, and handled in accordance with the CGA guidelines, NFPA standards, and the requirements of this Section.
- B. Each compressed gas cylinder shall be considered to be in transport, storage, or use.
 - 1. Compressed gas cylinders shall be transported and used in portable welding carts with the cylinders securely chained to the cart.
 - 2. An operable dry chemical fire extinguisher, rated not less than 2-3/4-pounds, shall be mounted on each portable welding cart, available for instant use.
 - 3. Valve protector caps shall be in place except when the cylinders are in use.
 - 4. Compressed gas cylinders in storage (full or empty) shall; be separated by a minimum 1/2 hour rated fire wall or separated by a minimum of 20-feet, be chained or secured in an upright position on a firm base, have the proper protective cap in place, and be protected from sources of heat.
 - 5. Mixed gases shall not be stored together.
 - 6. Improperly stored cylinders shall be immediately removed from the work area.
 - 7. Excessive or unreasonable storage of cylinders on the Work Site is prohibited.

3.10 FIRE PROTECTION AND PREVENTION

- A. Open flames and smoking shall be prohibited within 100-feet of flammable materials.
- B. In addition to notifying the MTA, the written permission of the water utility shall be obtained before shutting off water servicing a fire hydrant.
- C. Prior written permission of the MTA shall be obtained before blocking roadways, hydrants, post indicator valves, or access to fire fighting equipment.

- D. The Safety Engineer shall designate, as required, appropriately trained personnel to act as Firewatchers. Firewatchers shall be familiar with hazards that exist in the work area, and be trained in the operation of each type of fire extinguisher on the Work Site. Firewatchers shall have a current certificate of fitness from the FDNY.
- E. Flammable liquids shall be stored in FM-approved safety cans equipped with self-closing lids and flame arrestors.
- F. Storage of flammable materials in or near Railroad structures shall be prohibited.
- G. Work stoppage and shutdown of equipment shall be mandatory upon alarm of fire or other emergency. Personnel shall immediately report to the designated assembly area(s).
- H. Each temporary structure shall be constructed of clearly marked, fire rated material.
- I. Comply with the recommendations of the National Fire Protection Association and applicable regulations of the FDNY.
- J. Perform daily, documented, fire hazard inspections of the entire project. Immediate correction of substandard conditions is mandatory.
- K. The operation and maintenance of temporary heating equipment shall be authorized by the Resident Engineer and not create fire hazards. The use of solid fuel salamanders is prohibited. Placing on or near heaters shall not be permitted to dry clothing.

3.11 FALL PROTECTION

- A. Provide fall protection for all workers exposed to any fall greater than 6-feet. Excavations 6-feet or greater in depth with slopes steeper than 45-degrees shall also be provided with fall protection.

3.12 CONFINED OR ENCLOSED SPACES

- A. Adhere to the requirements for entering a confined space as listed in 29 CFR 1926.21(b)(6)(i) including a timely submittal of Contractor's written Confined or Enclosed Space program to the Resident Engineer addressing the following, at a minimum:
 - 1. Documentation of training and periodic refresher training for working in confined or enclosed spaces,
 - 2. Perform documented, air quality testing prior to and during entry,
 - 3. Provide required escape equipment or means of escape for employees working in a confined or enclosed space,
 - 4. Provide an effectively trained entry/exit attendant at all times when employees are working in a confined or enclosed space,
 - 5. Prepare and submit to the Resident Engineer 2 weeks prior to proceeding with the work, Safe Work Plans for working in specific confined or enclosed spaces listed in 29 CFR 1926.21(b)(6)(ii), and;

- B. The MTA has adopted the requirements of CFR 1910.146 “Permit-required confined spaces”, and will use these requirements as the guidelines for acceptance of the Contractor’s Confined or Enclosed Space program. Prior to entry into a permit-required confined space, submit a Safe Work Plan to the Resident Engineer addressing procedures for working in the specific “permit-required confined space”.
- C. No employee shall enter a confined space without the prior completion of a Safe Entry Permit or similar checklist by a competent person.
- D. Work between the cutterhead and face is considered a non-permit confined space.
 - 1. When working between the cutterhead and face:
 - a. Submit a safe work plan for acceptance prior to the start of work.
 - b. Document training and periodic refresher training for this operation.
 - c. Perform air quality tests prior to entering and while working in this area.
 - d. Provide a trained entry/exit attendant at all times when working in this area; this person may be the person operating the jog motor.
 - e. Provide means of direct communication between worker(s) and entry/exit attendant.
 - f. If cutting and/or burning are required, provide a fire extinguisher and fire watch in the work area.

3.13 HAZARDOUS SUBSTANCES AND SPILL PREVENTION

- A. Inspect all equipment for leak free operation on a daily basis. Drip pans or absorbent diapers shall be used to catch and collect leaking fluids. Any spillage shall be cleaned up promptly to prevent any release into the environment. Spill kits, adequate for the amount of materials stored or used, shall be maintained on site. Report all spills of hazardous materials including petroleum products to the authority having jurisdiction and the MTA immediately.
- B. Provide a list of hazardous substances that will be used in their work-site operations. This list shall be updated and re-submitted whenever a new substance or product is added. Copies of all Material Safety Data Sheets and other documentation shall be maintained at the work site.
- C. Comply with the requirements of “Chemical and Hazards Safety and Health Plan” as per 29 CFR 1910.120 as it applies to the handling of hazardous wastes. All hazards, including chemical, physical, and biological, shall be included in the Contractor's CSHP.

- D. All exposures to hazardous substances that are potentially above the current ACGIH Threshold Limit Values (TLV's) shall be immediately reported to the Resident Engineer in writing. A qualified person shall determine if follow up with monitoring is required.
- E. Hazardous Material Labeling and Storage: Ensure that each hazardous material is clearly marked or labeled in accordance with either the NFPA 704 (NFR Diamond) or the new color bar format (HMIG labels) as specified in 29 CFR 1900.1200. Each Hazardous material shall be stored in accordance with the manufacturer's recommendations.

3.14 MOTOR VEHICLES AND MOBILE CONSTRUCTION EQUIPMENT

- A. Vehicle and equipment operators shall effectively inspect and test essential controls, safety equipment, and safety devices before placing the vehicle or equipment in use. If found unsafe, construction equipment, whether owned, leased, or rented, shall be removed from service and a signed, Do Not Operate Tag placed on it, until it is repaired and made safe.
- B. Modification of construction equipment affecting its safe operation shall not be performed unless approved in writing by the manufacturer.
- C. All motor vehicle and equipment operators shall be effectively trained for the type of equipment they operate.
- D. Vehicles and equipment shall not block access for emergency responders.
- E. Pedestrians shall have the right-of-way at all times. The speed limit on MTA property is 5-miles per hour unless otherwise posted.
- F. Contractor Vehicles: Company identification shall be clearly displayed on each vehicle.

3.15 PROTECTION OF THE WORKPLACE AND THE PUBLIC

- A. Contractor shall provide substantial, durable, and effective protective devices including but not limited to guardrails, barricades, fences, bridging, ramps, floor coverings, road plates, sidewalks, guide rails, lights, traffic control devices, warning signs and signals, and other protective devices as required by the Work or elsewhere in the Contract.
- B. Protective devices shall be designed to protect the public and others on or adjacent to the Work Site from potential exposures created by the work. Such protective devices shall include but not be limited to; the use of welding screens to protect against welding flash, the use of solid barricades or tarps to protect against flying objects created by cutting, chipping or grinding, or the use of full sealed enclosures to protect against exposures to hazardous vapors, fumes, or dusts.
- C. Protective devices shall be designed to withstand the reasonably anticipated forces in or around the work area including but not limited to wind, vibration, runoff, and other natural or man-made conditions.

- D. Protective devices shall be maintained in a clean and smooth condition so as not to cause cuts, nicks, splinters, or snag clothing.
- E. Remove each protective device when the device is no longer required.
- F. Each protective device shall be constructed of properly identified fire rated materials.
- G. Barricades and fences shall be a minimum of 4-feet in height and be maintained in a continuous unbroken line along the work area. Barricades or fences eight feet or higher shall be provided along work areas with moderate to heavy pedestrian traffic or along work areas where site security is required.
- H. Barricades and fences shall be continuously maintained and be rigid and capable of preventing unauthorized entry into the work area. Caution tape or unsupported fencing shall not be considered a rigid barricade.
- I. Covers, plates, ramps, temporary walkways and bridging shall be constructed to minimize potential slip and trip hazards; secured against movement; and installed in accordance with ADA Accessibility Guidelines for Buildings and Facilities (Appendix A to 36 CFR Part 1911). All such covers, plates, ramps, temporary walkways and bridging shall be solid and coated with slip-resistant materials so that the surface is at least as slip resistant as the surrounding walking surfaces. The perimeter of floor covers and plates shall be painted yellow or another contrasting color approved by the Railroad.

3.16 HOUSEKEEPING

- A. Each piece of equipment, tool, material, facility, or apparatus shall be stored, stacked, located, or placed, in such a manner as will render an injury highly improbable and gives the direct and obvious impression of a clean and orderly work place. This applies to all areas of the Work Site. Material and equipment shall be stored or parked in an orderly manner.
- B. When a work crew begins work in an area, that crew is responsible for the housekeeping of that area, regardless of whether the area was left disorderly by a previous work crew.
- C. Rubbish and debris shall be cleaned and removed to acceptable containers at the end of each shift. Trash containers shall be placed in appropriate locations for the disposal of all trash, debris and rubbish. Trash containers shall be emptied on a regularly scheduled basis or when full.

3.17 SCAFFOLDS

- A. In addition to the requirements of CFR 29, Part 26, Subpart L – Scaffolds, the following Scaffold Tagging requirements shall apply. The use of this scaffold tagging procedure is mandatory. Untagged scaffolds shall be “off limits” to all personnel not authorized to erect, dismantle or make repairs to scaffolds.

- B. Scaffold Competent Person: The scaffold competent person shall ensure that scaffolds are built per requirements, are properly tagged, and that all erected scaffolds are inspected at the start of each shift.
- C. All scaffolds shall comply with Federal OSHA, State, and local requirements. Scaffolds shall be designed by a qualified person and shall be constructed and loaded in accordance with that design. Scaffolds shall be erected, moved, dismantled or altered only under the supervision of a competent person qualified in scaffold erection, dismantling, moving, or alteration. Only experienced and trained employees selected for such work by the competent person shall perform such activities.
- D. Scaffold Inspection: Scaffolds and scaffold components (including stairtowers), shall be inspected for visible defects by a competent person before each work shift, and after any occurrence that could affect a scaffold's structural integrity. Any defective components shall be immediately discarded. Before erecting and while dismantling scaffolds, inspect scaffold components. Scaffold components shall be straight and free from bends, kinks, dents, and severe rusting. Inspections shall include the following components:
 - 1. Handrails, midrails, cross bracing and steel tubing for nicks and other damage, especially near the center span.
 - 2. Weld zones on the scaffold frame for cracks.
 - 3. Ends of tubing for splits or cracks.
 - 4. Manufactured decks for loose bolts or rivet connections and bent, kinked, or dented.
 - 5. Plywood surfaces for softening due to rot or wear and for peeling at the edges or laminated layers.
 - 6. Scaffold planks for rot, cracks, cuts, and other external damage.
 - 7. Tie rods or bolts and angle iron cleats.
 - 8. Cams, springs, threaded connections, toggle, pins, or other quick connecting devices.
 - 9. Casters for rough rolling surfaces, sticky swivels, and defective locks.
- E. Scaffold Tagging Procedures: The scaffold tagging system is mandatory. A competent person shall tag all scaffolds. Scaffold tagging procedures shall not be used as a substitution to build a complete scaffold. The scaffold tagging system shall include, at a minimum, the following:
 - 1. Green Tag: To be placed on scaffolds by the designated competent person at all access points that the completed scaffold complies with all regulatory requirements.

2. Yellow Tag: To be placed on all scaffolds by the designated competent person that are structurally sound, but an accessory such as a handrail cannot be installed due to the location of the scaffold, or the nature of the work to be performed. Fall protection is required on all yellow-tagged scaffolds.
 3. Red Tag: To be placed on scaffolds by the designated competent person on scaffolds that are damaged, defective, being constructed or dismantled where no access is permitted by personnel not authorized to erect, dismantle or make repairs to scaffolds and in a visible location, preferably at the access points.
- F. Employees shall be prohibited from working on scaffolds covered with snow, ice, or other slippery material except as necessary for removal of such materials. Work on or from scaffolds is prohibited during storms or high winds unless a competent person has determined that it is safe for employees to be on the scaffold and those employees are protected by a personal fall arrest system or windscreens. Windscreens shall not be used unless the scaffold is secured against anticipated wind forces imposed.
- G. Scaffolds shall be cleaned off upon completion of daily work by the craft using the scaffold. Tools or materials shall be removed or secured so they cannot fall or roll off when a scaffold is moved. The responsible supervisor using the scaffold shall ensure tools, materials, and debris does not accumulate in quantities that create a falling objects or tripping hazard.
- H. Scaffolds shall not block or prevent access to fire protection and/or safety equipment. Personnel shall be prohibited from using any untagged scaffold. Scaffold erectors shall comply with the 6-foot fall protection requirements.
- I. Falsework shall not be constructed prior to the submission and acceptance of a written Safe Work Plan for the construction with detailed drawings and calculations signed by a Professional Engineer. The Safe Work Plan shall also include inspection and maintenance procedures to be completed during the utilization of the falsework structure. Prior to construction, demolition or stripping of falsework, a written Safe Work Plan shall be submitted describing how the contractor intends to perform the work safely. Protective sheeting or netting to prevent debris from falling shall be installed along railing where falsework spans a public street or pedestrian walkway.

3.18 UNDERGROUND WORK

- A. Adhere to all the requirements for underground construction as listed in 29 CFR 1926.800. The following requirements shall apply to the work including but not limited to:
1. Smoking shall be strictly prohibited underground.
 2. Gasoline-engine driven machinery/equipment shall not be used underground.

3. Fuels (diesel etc), compressed gas cylinders (full or empty) and any other hazardous materials shall not be stored underground.
 4. Adhere to all the requirements for lasers as listed in 29 CFR 1926.54.
- B. Air Quality Testing:
1. Contractor's underground Work areas shall be effectively ventilated as required in accordance with an accepted Tunnel Ventilation Plan.
 2. During tunnel excavation operations, Contractor's Safety Engineer, Safety Supervisor or Shift Safety Representative shall perform air quality tests as often as required to maintain a safe and healthful workplace. Records shall be maintained of all air quality tests performed.
 3. Contractor's employees who may be exposed to silica shall be provided with approved respirators and instructed in their proper use.
- C. Underground Safety Training
1. Contractor shall provide safety training to all new workers for underground work before the worker is assigned work duties.
 2. Instruction shall be given by qualified instructor(s) and cover the following topics:
 - a. Authority and responsibility of supervisors. The course shall include instruction in the description of the line of authority of supervisors and an introduction to the Contractors safety rules and the procedures for reporting hazards.
 - b. Self-rescue and respiratory devices. The course shall include instruction and demonstration in the use, care, and maintenance of self-rescue and respiratory devices used at the facility. Training in the use of self-contained self-rescue devices shall include complete donning procedures in which each person assumes a donning position, opens the device, activates the device, inserts the mouthpiece or simulates this task while explaining proper insertion of the mouthpiece, and puts on the nose clip. The course shall be given before the new worker goes underground.
 - c. Entering and leaving the facility; transportation; communications. The course shall include instruction on the procedures in effect for entering and leaving the facility; the check-in and checkout system in effect at the facility; the procedures for riding on and in facility conveyances; the controls in effect for the transportation of workers and materials; and the use of the facility communication systems, warning signals, and directional signs.

- d. Introduction to the work environment. The course shall include a visit and tour of the facility, or portions of the facility, which are representative of the entire facility. A method of mining utilized at the facility shall be observed and explained.
- e. Facility map; escape ways; emergency evacuation. The course shall include a review of the facility map; the escape way system; the escape, firefighting, and emergency evacuation plans in effect at the facility. Also included shall be a description of restricted or secured areas that the workers may not enter.
- f. Roof or ground control and ventilation plans. The course shall include an introduction to and instruction on the roof or ground control plan in effect at the facility and procedures for roof and rib or ground control; and an introduction to and instruction on the ventilation plan in effect at the facility and the procedures for maintaining and controlling ventilation.
- g. Health. The course shall include instruction on the purpose of taking dust, noise, and other health measurements, and any health control plan in effect at the facility shall be explained. The health provisions of the safety plan and warning labels shall also be explained.
- h. Housekeeping/Cleanup. The course shall include instruction on the purpose of cleanup and housekeeping standards in effect at the facility, where applicable.
- i. Hazard recognition. The course shall include the recognition and avoidance of hazards present in the facility, particularly any hazards related to explosives where explosives are used or stored at the facility.
- j. Electrical hazards. The course shall include recognition and avoidance of electrical hazards.
- k. Security. The course shall include instruction in required project security procedures.
- l. Facility gases. The course shall include instruction in the detection and avoidance of hazards associated with potential underground gases.
- m. Health and safety aspects of the tasks to which the new worker will be assigned. The course shall include instruction in the health and safety aspects of the tasks to be assigned, the safe work procedures of such tasks, and the mandatory health and safety standards pertinent to such tasks.

- n. Methods, including oral, written, or practical demonstration, to determine successful completion of the training shall be included in the training plan. The methods for determining such completion shall be administered to the worker before s/he is assigned work duties.
 - o. The Resident Engineer based on circumstances and conditions at the facility may require other courses as is deemed necessary.
 - 3. Records of training:
 - a. Upon a worker's completion of the approved training program topics, the Contractor shall record and certify on a suitable form/certificate that the worker has received the specified training.
 - b. A copy of the training form/certificate shall be given to the worker at the completion of the training.
 - c. The training certificates for each worker shall be available at the facility site for inspection by an MTA authorized representatives.
 - d. When a worker leaves the Contractor's employ, upon request, he worker shall be entitled to a copy of his training forms/certificates.
- D. Tunnel Safety Inspections: Inspect the tunnel roof, face and ground support system at the beginning of each shift and thereafter as often is required to maintain safe working conditions. Any loose or dangerous ground shall be adequately supported. At a minimum, the Contractor's Safety Engineer, or Safety Supervisor or Safety Representative shall make a documented, daily shift inspection of all tunnel work areas.
- E. Transportation and Haulage:
 - 1. Trains shall not be operated at a speed that will endanger any employee.
 - 2. Two riders are permitted to ride on a locomotive only while seated in seats.
 - 3. Trains carrying passengers shall not be put into motion until the Operator is satisfied that no one will be endangered, before moving the machine.
 - 4. All locomotives shall be equipped with lights, front and rear, an audible warning device (horn, bell or siren) a fire extinguisher and self-rescuers.
 - 5. All locomotives and cars shall be safety inspected at the beginning of each shift.
 - 6. Any defects affecting the safe operation of the equipment shall be corrected before its use.
 - 7. All cars shall be equipped with safety chains that are connected between cars/locomotives when in use.
 - 8. All trains shall slow down and use extreme caution when passing over switches or when personnel are alongside the track.

9. All other personnel transported by the locomotive shall be seated in a man-car.
10. At no time shall personnel ride on the outside of the locomotive.
11. The operator in the completion of his/her duties shall be allowed to stand.
12. No train shall be moved until the operator has first given a warning by sounding a bell, horn or siren.
13. All standing trains and cars shall be blocked or otherwise secured to prevent movement.
14. All materials being transported by train shall be adequately secured against shifting.
15. Only cars equipped with seats, overhead protection, non-skid floors, adequate headroom, enclosed sides and entrance gates at sides of the car shall be provided and used to transport personnel.
16. In the event that oil, water or other conditions render track slippery, sand or other effective means shall be used to treat the affected areas to provide for adequate traction. Sanding mechanisms on locomotives, if so equipped, shall be maintained in working condition.
17. Locomotives shall be equipped with both manual and emergency braking systems. Braking systems shall be kept in serviceable condition at all times. They shall also be equipped with a deadman control system, which will be kept serviceable at all times.
18. All locomotives shall be equipped with a stokes stretcher and a first aid kit.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for the maintenance and protection of vehicular and pedestrian traffic in and about the vicinity of the Work, and for the maintenance of the Work Site including storage areas, all as required by the Contract Documents and as directed by the Resident Engineer.
- B. The general details of construction and the locations of the Work are indicated more particularly on the Contract Drawings.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. D6.1 - Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)

1.04 NOTED RESTRICTIONS

- A. Conditions of Operation: In order to minimize interference with the usual use of the roadways and sidewalks in the area of the Project, Contractor's operations shall be conducted in accordance with Contractor's Work Permit issued by the NYCDOT and the following provisions:
 - 1. The roadways along the line of the Project shall be kept free from Contractor's plant, from structural or other materials, and from working operation that would cause interference with the usual use of the roadways by the public except to the extent absolutely necessary to install decking and as specified in Contractor's Work permit issued by the NYCDOT.
 - 2. Materials shall not be stored on the roadways and sidewalks.
 - 3. The necessary access for fire apparatus shall be maintained at all times of the day and night.
 - 4. Excavated areas must be barricaded during working hours and decked at the end of the working period.
- B. Bridges to Buildings: No building shall be deprived of means of access thereto without the consent of the owner or occupant and without notice to the Resident Engineer; and where streets are open, suitable bridges shall be built and maintained to permit owners and occupants to reach their premises.

C. Notice of Work Affecting Street Traffic:

1. Give the MTA at least 15 days notice in writing, exclusive of Sundays and legal holidays, before beginning any Work necessitating the closing of any street. Such notice shall state the days and hours when such Work is to begin and end.
2. Give four working days' notice through the Resident Engineer to the NYC Department of Traffic before working in a metered zone. The NYC Department of Traffic will arrange for the removal of parking meters, exclusive of stanchions, in the area affected and for the removal or change of "Parking Zone Restriction" signs.

D. NYCDOT Holiday Embargo Periods:

1. All routine work shall be suspended during an embargo period unless an approval for work is granted by the NYCDOT Office of Construction Mitigation and Coordination (OCMC). Such suspension shall not apply to emergency work, for which an emergency number shall be obtained from the NYCDOT. Information regarding embargo periods is on file at each Borough permit office.
2. Contractor will not be permitted to close lanes on Memorial Day, Independence Day, Labor Day, the day before Thanksgiving through the Sunday following Thanksgiving, the day before Christmas Day, Christmas Day, the day before New Years Day and New Years Day.
3. Permissible lane closing are as follows:
 - a. If a holiday is on Friday, no lane closures are allowed from 12:00 PM of Thursday preceding the holiday until 6:00 AM of the Monday following the holiday.
 - b. If a holiday is on a Saturday, Sunday or Monday, no lane closures are allowed from 12:00 PM of Friday preceding the holiday until 6:00 AM of the Tuesday following the holiday.
 - c. For holidays falling on all other days, no lane closures are allowed from 12:00 PM of the day before the holiday until 6:00 AM of the day after the holiday.

1.05 QUALITY CONTROL

A. Regulatory Requirements:

1. New York City Department of Transportation (NYCDOT) Standard Specifications.

1.06 SUBMITTALS

- A. MPT Plan: Within 30 days after the date of the Notice of Award of the Contract, submit for review by the Resident Engineer an MPT Plan with schedule showing planned procedure for all construction activities and indicating facilities to be provided to maintain vehicular and pedestrian traffic.

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS**2.01 BARRICADES**

- A. Temporary lighted barricades for all storage, work areas, and other areas indicated on the Contract Drawings shall be completely enclosed and shall conform to the details and requirements indicated on the Contract Drawings, and as otherwise required. Barricades for the channelization of traffic shall be as required by the NYCDOT.

2.02 SIGNS

- A. Signs shall conform to the general requirements of the NYCDOT and the MUTCD and shall bear inscriptions advising the public of the interference with vehicular and pedestrian traffic. Signs shall be erected and maintained per the MPT Plan and as required on the Contract Drawings and specified herein and at all approach intersections of cross streets, roads, etc., that are affected by the Work.
- B. Signs identifying steel plates or decking covering excavations in areas subject to vehicular traffic shall be furnished, erected, and maintained at appropriate locations. Signs shall be 3-feet square by 3/4-inch thick exterior grade plywood mounted diagonally. The signs shall be painted with three coats of paint and shall have black inscriptions and border on an orange field. The inscriptions shall be 6-inches high placed diagonally and shall read: **"RAISE PLOW AHEAD"**.

2.03 DRUMS AND CONES

- A. Drums and cones shall conform to the MUTCD as to material, size, and color.

2.04 TIMBER PEDESTRIAN BARRICADES

- A. Timber pedestrian barricades shall conform to NYCDOT requirements as to material, size, and paint colors.

PART 3 EXECUTION**3.01 GENERAL**

- A. In addition to general requirements of Work, safety requirements, etc., conduct the Work in a manner to reduce to a minimum the encumbrance of the streets with construction material, plant, and waste material.

3.02 STREET TRAFFIC

- A. Furnish all necessary facilities for the benefit of street traffic, both on longitudinal and cross streets.
- B. Wherever the Work of taking up pavement, decking, or paving the street surface is being done, maintain access for traffic in the blocks and street intersections adjoining such Work.
- C. Except where working shafts are located, keep the street intersections open for traffic at all times.

3.03 ROADWAY AND SIDEWALKS TO BE DECKED

- A. In order to minimize interference with traffic and inconvenience to abutting property owners during the performance of the Work hereunder, deck and cover over the roadway and sidewalks wherever excavated, and take every precaution to keep traffic free from interruption. Maintain decking in such condition that it will not present a slipping or skidding hazard to pedestrian and vehicular traffic. Where the decking is temporarily removed from any part of the street, protect the opening by barricades and bridging, and lighted where required.

3.04 STREET CROSSING TO BE KEPT CLEAN

- A. Maintain all street crossings on the lines of the sidewalks in a clean and neat condition, bridging gutters and low places where water might collect. At all times keep gutters open for surface drainage. Provide all facilities and equipment necessary to maintain surface drainage.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Concept of operation for Work Site security, the parties involved and their responsibilities for management and coordination, and for furnishing all labor, materials, tools, equipment, and performing all operations necessary for construction security, as specified herein.

1.02 REFERENCED SECTIONS

- A. Section 02414 – Controlled Blasting

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)
 - 2. Code of Federal Regulations (CFR):
 - a. 49 CFR - Federal Railroad Administration (FRA)
 - 3. Other applicable rules and regulations of authorities having jurisdiction.

1.06 SUBMITTALS

- A. Within ten days after Notice of Award, designate a Security Representative and submit the name and resume for this position. The Security Representative may have other responsibilities. Contractor's Security Representative will be subjected to a background check coordinated by the ESA Construction Security Manager. Contractor's Security Representative shall be required to pass the Background Check before being considered for approval.
- B. Within 30 days after Notice of Award, and before commencing any physical work on the Work Site, submit a Security Requirements Outline (SRO), which shall present Contractor's plan for internal security and control. The SRO shall include, as a minimum, the following elements:
 - 1. Cover page with Contractor's name and contact information, title of Contract, and Contract number. Include revision number, date of revision, name and signature of the Security Representative.

2. Table of contents listing each section and exhibit that clearly identifies the revision number and date of each section and exhibit.
3. Organization chart of personnel responsible for implementing or supporting Contractor's Work Site security measures, and a description of the duties and responsibilities of Contractor's designated Security Representative.
4. A Work Site drawing indicating the locations of combustible and flammable materials, oxygen/acetylene storage, other hazardous or toxic materials, all temporary buildings, trailers, and storage units. Contractor shall update this drawing as Work Site conditions are modified or changed.
5. Description of Contractor's internal security accountability system, lock and key controls, etc.
6. Control of special equipment and material, high-value items, break-in and entry tools such as bolt-cutters, cutting torches, etc.
7. Areas, buildings, equipment, materials, and work-in-progress that require special security attention, such as more frequent guard tours, checks of vehicles, equipment, building doors, tool cages, and container locks.
8. Special security requirements for dangerous items such as explosives, flammable liquids and gasses, etc.
9. Reporting procedures for security incidents.
10. Special security-related work rules, coordinating instructions and resolution of security problems.
11. Provide any additional information identified as being essential to construction security planning.
12. Method and manner of implementation, and Contractor-personnel responsible for implementation of requirements assigned to Contractor.
13. Drawings showing details of security guard booth(s) and suggested locations.

1.07 DELIVERABLES

- A. Personnel Roster: Within 30 days after the Notice of Award, and before commencing any physical work on the Work Site, submit a Personnel Roster indicating Contractor personnel requiring access to the Work Site.
 1. The Personnel Roster shall be annotated with any special restrictions for time of day, duration of access, limitations of Work Site access (interior Work Site areas), and related requirements.

2. The Personnel Roster shall be updated and resubmitted as required to remain current. At a minimum, the Personnel Roster shall be updated on a monthly basis. Failure to maintain a current Personnel Roster will result in Contractor's personnel being restricted access to the Work Site.
 3. The Personnel Roster shall be clearly labeled with the Contract Number, Roster Revision Number and Date of Revision. Once Work Site access badges are issued to employees, the badge numbers and company affiliation shall be included on the Personnel Roster.
- B. Vehicle and Equipment Controls: Within 30 days after the Notice of Award, and before commencing any physical work on the Work Site, submit a Vehicle and Equipment Access/Control Plan. At a minimum, the Vehicle and Equipment Access/Control Plan shall include the following:
1. A listing of all vehicles authorized for entry to the Work Site.
 2. A vehicle entry/exit pass system for vehicular access control. The pass system shall include blocks of sequential pass numbers, and authorized signatures, to be used for the first time period.
 3. Description and plans for parking of vehicles within the Work Site, including visitor parking areas.
 4. Plans for access and Work Site controls of equipment, tools, and materials.
 5. The Vehicle and Equipment Access/Control Plan shall be updated and resubmitted as required to remain current.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 CONSTRUCTION SECURITY - GENERAL REQUIREMENTS

- A. Security of all Work Site personnel, critical operations, facilities, and equipment tools, materials and work-in-progress is an essential project requirement.
- B. The MTA will provide an ESA Security Services Contractor, who will have responsibility for Work Site access control and for any special security requirements included in the Site Security Plan (SSP).
- C. The ESA Construction Security Manager will coordinate the following security related services:
 1. Identification and distribution of applicable security regulations, policies and directives, and any special requirements for addressing concerns regarding general and/or Work Site-specific construction security operations and performance standards.

2. Interface with Metropolitan Transportation Authority Police Department (MTA-PD), New York City Police Department (NYPD), Joint Infrastructure Task Force (JITF), and other appropriate agencies relative to the provision of adequate patrol of the Work Site's exterior environment; response s to incident reports and assistance calls; transportation of explosives to the Work Site; provision of criminal investigative support; and conduct of no-notice contraband inspections.
 3. Preparation, implementation and maintenance of the Project-wide Construction Security Plan.
 4. Oversight of ESA Security Services Contractor performance.
 5. Oversight of the installation, operation, and maintenance of technical security systems and equipment, and all other security management programs.
 6. Implementation of no-notice contraband inspections with the MTA-PD and with Contractor. Efforts will be made to preclude undue interference with scheduled Work.
- E. The ESA Security Services Contractor will provide Work Site access control. These services will include day-to-day management of construction security including Site Security Supervisors, Security Officers, Security Console Operators, a Security Control Center (SCC), and security systems' installation, maintenance, and central monitoring.

3.02 CONSTRUCTION SECURITY REQUIREMENTS

- A. Exercise primary responsibility for its own internal security and control to include: establishing and maintaining systems for issue and accountability for tools, equipment and materials; and providing for their storage, to include appropriate lock and key control.
- B. Contractor's designated Security Representative shall act as Contractor's main coordinator/liaison for all security related issues. The Security Representative's duties and responsibilities, at a minimum, shall be:
1. Coordinate security activities between Contractor's internal security program and the security services provided by other MTA contractors or consultants or by the MTA.
 2. Supervise Contractor's own Work Site security forces, if applicable.
 3. Monitor and control Contractor's support of the MTA-provided security badge program.
 4. Insure Contractor's compliance with the Site Security Plan (SSP).
- C. Actively participate in security planning efforts and implement appropriate action. Contractor's designated Security Representative shall meet with the ESA Construction Security Manager on at least a monthly basis.

- D. Within 15 days of Award, the Security Representative shall meet with the ESA Construction Security Manager to review and discuss the Contractor's preparation of the Security Requirements Outline (SRO). Consult with the ESA Construction Security Manager as necessary during the preparation and implementation of the SRO and SSP, including the identification of Work Site security requirements and adequate security countermeasures to address them.
- E. Report immediately any security incidents and infractions of security-related work rules to the Construction Security Manager. Emergency security assistance and serious incident reports may be made directly to MTA-PD or NYPD with subsequent timely notification to the Resident Engineer and Site Security Supervisor, including copies of any incident reports.
- F. Non-Disclosure: Do not disseminate any Contract Drawings, Specifications, Reports, or related documents to any outside agency, Contractor, or individual without prior written permission from the Resident Engineer.
- G. Explosives: The transportation and handling of explosives shall conform to the requirements of Section 02414, and shall be subject to special Work Site security measures in accordance with SSP. Explosives deliveries to the Work Site may be subject to escorts by MTA-PD or NYPD. Within the Work Site, the access to explosives shall be closely controlled and shall be restricted to designated employees only.

3.03 CONSTRUCTION SITE SECURITY PLAN (SSP)

- A. Following review of Contractor's Security Requirements Outline (SRO), the ESA Construction Security Manager will prepare a draft Site Security Plan (SSP). The ESA Construction Security Manager will meet with Contractor's Security Representative to review the draft SSP before it is finalized. Contractor shall actively participate in development process of the SSP. The final SSP will be signed by the ESA Construction Security Manager and Resident Engineer and shall also be signed by Contractor's Project Manager and Security Representative. Following the signatures, the Resident Engineer will issue the final SSP for implementation by Contractor and the ESA Security Services Contractor.
- B. The SSP will establish the protected perimeter, access-controlled portals, security guard work areas, systems for access control, intrusion detection, surveillance and alarm assessment. The SSP will also include:
 - 1. Site Security policy statement.
 - 2. Organization chart of personnel responsible for SSP implementation, including a description of the duties and responsibilities of Contractor's designated Security Representative; the ESA Construction Security Manager; and the ESA Security Services Contractor.
 - 3. Description of Contractor's security requirements, from the SRO, including internal security accountability systems, lock and key controls, and controls of special equipment, materials and high-value items.
 - 4. Special security measures for dangerous items such as explosives, flammable liquids and gasses.

5. Site security systems, closed circuit television (CCTV), access control, intrusion detection, and central monitoring, as determined appropriate.
 6. Contractor-installed security guard booths, fencing and security lighting.
 7. Personnel badging, vehicle decals, and gate passes for equipment, tools and materials, as determined appropriate.
 8. Contraband identification and control (deterrence, denial and detection).
 9. Reporting procedures and responsibilities for security incidents.
 10. Police (MTA-PD and NYPD) support and coordination; including process for requests for investigative and other support.
 11. Planned responses to emergency situations: fire, natural disaster, civil disruption, terrorism, work-place violence, and other serious incidents.
 12. Special coordinating instructions and resolution of security problems.
 13. Security-related work rules, including prohibited activities and items.
 14. A Work Site drawing indicating the locations of combustible and flammable materials, oxygen/acetylene storage, other hazardous or toxic materials, all temporary buildings, trailers and storage units. Contractor shall update this drawing as Work Site conditions are modified or changed.
 15. Controlled access and physical security to the office, warehouse, material, and equipment sites.
 16. Control of material and equipment packaging, transportation, and delivery to the Work Site.
 17. Accountability procedures for storage, requisition and issue of material and equipment.
 18. Process for reporting of security-related incidents, including trespassing, loss, theft or vandalism.
- C. Following the issuance of the SSP, consult with the ESA Construction Security Manager on the SSP implementation, as required.
- D. Failure of Contractor to provide sufficient and effective Work Site security, in accordance with the SSP, will result in MTA's implementation of corrective security measures at Contractor's cost.

3.04 CONTRACTOR EMPLOYEE DOCUMENTATION

- A Contractor's Personnel Roster will be utilized by the ESA Security Services Contractor, who will incorporate it into the security badging and access control system.

- B. All Contractor employee's, including all subcontractor personnel, shall read and sign a "Confidentiality and Non-Disclosure Agreement" before being permitted to work on-site. The Resident Engineer will provide the Confidentiality and Non-Disclosure Agreement forms within seven days from Notice to Proceed. The Confidentiality and Non-Disclosure Agreement will require that employees do not discuss, copy or otherwise disclose information concerning the Project and will require that employee's keep secure all Project-related documents and computer files at all times.
- C. Background checks will be required for Contractor's key management personnel, as well as all Contractor employees, including all subcontractor personnel, who handle explosives, perform security functions and perform or review structural designs. Background checks will be coordinated by the ESA Construction Security Manager and will meet minimum DOT requirements.
- D. While on-site, all Contractor's employees, subcontractors, suppliers and vendors shall carry their badge at all times. Badges shall be returned immediately when Work Site access is no longer required, such as employee relocation or termination. Special badges will be required for personnel handling or transporting explosives or hazardous materials.

3.05 WORK SITE SECURITY REQUIREMENTS

- A. In accordance with requirements in Contractor's SRO, the final SSP will detail areas and buildings that ESA Security Services Contractor will not normally enter for reasons of safety, privacy, or lack of necessity. This will not preclude no-notice inspections for contraband that may be conducted by the MTA-PD, with or without canines, anywhere on the Work Site.
- B. Provide in accordance with the SSP: perimeter and interior security fencing, portals, gates, locks; perimeter and interior security lighting; its own required secure buildings, trailers, tool cages, enclosures, vehicle and equipment locks, and related security items.
- C. For all civil construction contracts building line section(s) for future track construction, whether in bored tunnel, cut-and-cover excavation or at grade, the applicable track stationing shall be marked and maintained throughout the contract period. At a minimum, this stationing shall be clearly marked at least every 100-feet along the alignment. This stationing will be used during safety or security incidents in order to guide emergency responders to the correct location.

3.06 SECURITY INSTALLATIONS

- A. Furnish and install security guard booths and all Work Site security fencing and lighting as specified in the Contract Documents and as required in accordance with the final SSP.
- B. Guard Booth(s): Provide and maintain security guard booths at each entry/exit gate, including pedestrian gates. Guard booths shall meet the following minimum requirements:
 - 1. Minimum 40-square-feet floor area. Furnished with desk, chair and 2-drawer file cabinet.

2. Booth(s) shall include windows on all four sides and shall be positioned on a platform raised at least 3-feet off the ground. Steps shall be provided.
 3. Booth(s) shall be equipped with power receptacles, lighting, and heat.
- C. Fencing: Security fencing shall be provided and maintained in accordance with the final SSP. Protective Barriers are required around the Work area perimeter in the Existing Rail Yard. A 5'-3" high Chain Link Fence is required on top of the protective barriers.
- D. Lighting: Security lighting shall be required at Work Site access gates, entry/exit portals, CCTV locations, sensitive storage or equipment areas, explosives magazines, and related security-sensitive locations. Be responsible for the installation and maintenance of security lighting in accordance with the requirements of Contractor's SRO and SSP.
1. Security lighting for general area surveillance, trespass/intrusion detection, and related purposes shall provide at least three-foot-candle illumination.
 2. At gates, entry/exit portals, and related access points, security lighting shall be adequate for facial recognition, badge reading, and identification purposes. For these purposes, the security lighting shall provide at least four foot-candles illumination.
 3. Allow the ESA Security Services Contractor to tap lighting installations for power needed for security equipment, such as CCTV, alarms or access control systems. All costs for such security equipment power shall be borne by Contractor.

END OF SECTION

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Certain requirements that supplement Federal, State, and local regulatory conditions and permits. These requirements are consistent with the Project's goal of protecting environmental resources and minimizing adverse effects on communities in the Project area.

1.02 REFERENCED SECTIONS

- A. Section 01140 - Work Restrictions
- B. Section 01572 - Noise and Vibration Control
- C. Section 01555 - Maintenance and Protection of Traffic

1.03 CITED STANDARDS

- A. None Cited

1.04 NOTED RESTRICTIONS

- A. Comply with Work restrictions specified in Section 01140 and elsewhere herein.
- B. The Contractor shall be responsible for management of environmental issues and implementation of mitigation measures ranging from protection of cultural resources to waste management.
- C. The Contractor shall be responsible for compliance with all environmental regulatory requirements applicable to their specific activities, including the protection of wetland resources; cultural resources; air quality; implementation of effective noise and traffic controls; and proper management of soils, water, hazardous materials, and waste.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. New York State Department of Environmental Conservation (NYSDEC) - 6 NYCRR Part 703, Surface Water and Groundwater Quality Standard and Groundwater Effluent Limitations, Section 703.5, Water Quality Standards for Taste-, Color-, and Odor-Producing Toxic and Other Deleterious Material.
- B. Implement and maintain an environmental quality control program as part of construction operations, including daily environmental quality control inspections and monitoring to confirm compliance with environmental requirements.

1.06 SUBMITTALS

- A. Contract-Specific Environmental Compliance Plan: Within 30 days after Notice of Award, and before commencing any physical Work on the site, submit an Environmental Compliance Plan (ECP) that outlines in detail the measures to be implemented by Contractor to minimize adverse impacts to the environment and nearby communities and to comply with this Section and the above-listed sections, and all applicable laws, regulations, and permits, and all other Contract requirements. The ECP shall include:
1. Hazardous materials management plan.
 2. Spill prevention and control plan.
 3. Dust control plan, including odor control plan.
 4. Traffic and parking management, including pedestrian access and flow.
 5. Control of diesel emissions.
 6. Protection of archaeological, cultural and historical resources.
 7. Compliance with State and Local permits.
 8. Waste management plan.
 9. Recycling plan.
- B. Stormwater Pollution Prevention Plan: Within 30 days after Notice of Award, and before commencing any physical Work on the site, Contractor shall submit a Stormwater Pollution Prevention Plan (SWPPP). The Resident Engineer, or an MTA-designated representative, shall sign the SWPPP when it is determined that that plan addresses all of the elements of General Permit 02-01, Part III. Additionally, per Part III.A.3, no Work shall commence on site until the SWPPP is approved, Contractor submits the Notice of Intent, and all appropriate stormwater control measures are in place.
- C. Submit haul routes to NYCDOT 30 days before required date.
- D. Environmental Coordinator: Within 30 days after Notice of Award, designate an Environmental Coordinator and submit the name and resume for this position. The Contractor's Environmental Coordinator shall be the Contractor's single point of contact for all environmental performance, coordination and reporting issues. The Environmental Coordinator shall have a Bachelor's degree from an accredited college; a minimum of 10-years experience in the environmental industry; current 40-hr HAZWOPER certification; and knowledge of Federal, State and New York City environmental regulations and standards.

1.07 DELIVERABLES

- A. Provide copies of permits for street and/or pedestrian walkway closures or detours.
- B. Combined Sewer Discharge Monitoring Report: Contractor is responsible for

negotiating the terms of the discharge permit with the oversight agency, NYCDEP. Provide sufficient information to demonstrate to the Resident Engineer the monitoring report requirements. Contractor shall then provide the monitoring reports to the Resident Engineer in a timely fashion.

- C. Provide copies of truck haul routes submitted to NYCDOT.
- D. Approved Haul Route(s): Contractor is responsible for development and implementation of a Maintenance and Protection of Traffic Plan (MPT Plan) for removal of excavated materials from the Work Site by truck (see Section 01555). Further to the MPT Plan requirements, Contractor shall provide the truck haul route(s) as approved by NYCDOT.
- E. Environmental Performance Report: Provide an Environmental Performance Report every six (6) months. This report shall include a copy of Environmental Performance Records for the reporting period and shall also detail of environmental issues of significance.
- F. Provide an outline of all environmental-related training and the log of personnel trained, prior to commencement of physical Work.

PART 2 - PRODUCTS

2.01 DUST SUPPRESSION

- A. Dust suppression wetting agents shall be water soluble, non-toxic, non-reactive, non-volatile, and non-foaming.

2.02 DIESEL FUEL

- A. All diesel-powered heavy equipment used on the site during the execution of this Contract shall use ultra low-sulfur diesel fuels.

2.03 MATERIALS USED IN CONSTRUCTION

- A. The following environmental requirements apply to materials used for temporary construction, and to effects of materials used in the permanent works (such as off gassing).
- B. Spoils:
 - 1. Beneficial re-use of spoil is to be given priority. Where silica content is high, spoil re-use as aggregate is not permitted.
 - 2. Where practicable, stockpile and reuse non-contaminated, non-hazardous on-site excavated materials. Use off-site fill material when on-site sources are exhausted. This will only be allowed when off-site material meets criteria specified in the Contract and off-site material is deemed not contaminated or hazardous.

3. Prevent loss of soil during construction by storm water run-off and/or wind erosion, including protecting excavated soil stockpiled for reuse.
4. Prevent sedimentation of storm sewer of receiving streams and/or air pollution with dust and particulate matter.
5. Use only environmentally-acceptable soil conditioners.

C. Concrete:

1. The use of flyash in concrete shall meet product specifications, as available, listed in the U.S. Environmental Protection Agency's Comprehensive Procurement Guideline for Procurement of Products Containing Recovered Materials 65 Fed. Reg. 3,070 (final, January 19, 2000 codified at 40 CFR 247.1). "EPA CPG" Specifications available at <http://www.epa.gov/cpg>. Flyash cannot be obtained from facilities where hazardous waste materials are included in the fuel mix used to create the ash.
2. Contractor shall record Pulverized Fly Ash (PFA) and Ground Blast Furnace Slag (GBFS) contents in concrete and grouts in the Environmental Performance Records.
3. Maximize recycled scrap steel content in reinforcing bars.
4. Use only non-hazardous bond breakers, curing compounds, and form release agents. All bond breakers, curing compounds and form release agents shall be composed on non-petroleum based, non-hazardous (i.e., without chlorinated solvents or heavy metals) ingredients.

D. Formwork:

1. Formwork made from expanded polystyrene shall be manufactured without the use of chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs).
2. Do not use solder with lead content in any site potable water lines or chilled-water piping systems.
3. Use maximum 350g/L VOC content in liquid membrane-forming curing and sealing compounds.

E. Metals:

1. Structural Steel: Framing steel shall maximize the use of recycled steel.
2. Millwork and casework adhesives shall be water-based, formaldehyde-free, low-VOC adhesives, maximum 50g/L.
3. Steel studs, runners, and channels for framing shall maximize recycled steel content.

4. Contractor shall maximize use of recyclable content in the following materials or products:
 - a. Reinforcing Steel in Concrete.
 - b. Reinforcing Bars in Precast Concrete.
 - c. Reinforcing Bars in Concrete Unit Masonry.
 - d. Framing steel.
- F. Timber: Use of chromate copper arsenate (CCA) as a wood treating material is not permitted. Use of ammonium copper quat (ACQ) is acceptable.
- G. Joint Sealants:
 1. Interior sealant shall not contain mercury, butyl rubber, neoprene, SBR (styrene butadiene rubber), or nitrile.
 2. Silicone sealant shall be low VOC content, maximum 50g/L.
 3. Polyurethane sealant containing mercury shall not be used.
 4. Compressible foam joint fillers, polyester polyurethane foam impregnated with neoprene rubber or acrylic ester styrene copolymer shall not be manufactured with CFC blowing agents.
 5. Sealants formulated with aromatic solvents (organic solvent with a benzene ring in its molecular structure), fibrous talc or asbestos, formaldehyde, halogenated solvents, mercury, lead, cadmium, hexavalent chromium, or their components shall not be used.
 6. Without sacrificing cost or product performance all joint compounds shall be low VOC content, maximum 50g/L and shall not contain any antifreeze.
 7. Only paper joint tape (no fiberglass tape) shall be used.
- H. Paints:
 1. Water-based paints formulated with aromatic hydrocarbons (organic solvent with a benzene ring in its molecular structure), formaldehyde, halogenated solvents, mercury or mercury compounds, or tinted with pigments of lead, cadmium, chromium VI and their oxides, shall not be used. Water-based paints shall have a maximum VOC content of 50g/L and shall have a flash point of 61 degrees C or greater.
 2. Where it is necessary to use solvent-based paints, they shall be formulated for low VOC emissions, maximum 350g/L, and shall not be formulated with formaldehyde, halogenated solvents, mercury or mercury compounds, or tinted with pigments of lead, cadmium, chromium VI and their oxides, nor formulated with more than 10% aromatic hydrocarbons by weight.

3. The following shall have a maximum VOC content as listed below and shall not be formulated with aromatic hydrocarbons (organic solvent with a benzene ring in its molecular structure) formaldehyde, halogenated solvents, mercury or mercury compounds, or tint with pigments of lead, cadmium, chromium VI and their oxides:
 - a. High performance water-based acrylic coatings, VOC 250g/L.
 - b. Pigmented acrylic sealers, VOC 50g/L.
 - c. Catalyzed epoxy coatings, VOC 380g/L.
 - d. High performance silicone grafted epoxy coatings, 380g/L.
4. Paint containing more than 0.06% lead is prohibited.
5. Interior and Exterior Paints - Chemical exclusions and low volatile organic compound (VOC) content: Unless it can be justified by life-cycle hazard analysis that other systems are defensible, interior and exterior paints used as topcoats must meet the product-specific performance and environmental requirements of Green Seal's Standard for Architectural Coatings (GS-11 - First edition, May 20, 1993) and Green Seal's Choose Green Report on Architectural Paints (December, 1999) Green Seal, 1001 Connecticut Avenue, NW, Suite 827, Washington, DC 20036 (<http://www.greenseal.org>). In the case that requirements are not met (after justification) appropriate precautions shall be taken.
 - I. Solder: Use solder that does not contain lead.
 - J. Ozone Depletants: Use no CFC refrigerants, insulation or solvents.
 - K. Ductwork: Comply with New York State "low VOC" requirements. Confirm the use of low VOC materials and record actual VOC content in the Environmental Performance Records.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Be responsible for compliance with all environmental regulatory requirements applicable to their specific activities. Contractor is required to cooperate fully in implementing Project-specific procedures and guidelines developed with regard to environmental compliance. Communicate in a timely manner any environmental problems to the Resident Engineer.
- B. Environmental Training:
 1. Train personnel to be thoroughly familiar with spills, waste handling and emergency procedures. Ensure that employees handling universal wastes are thoroughly familiar with the proper handling and emergency procedures related to their responsibilities.
 2. For those personnel whose duties are to handle hazardous wastes,

- additional training such as the Occupational Safety and Health Administration's (OSHA) 40-Hour Hazardous Waste Site Operation, shall be required.
3. Conduct "tool box" talks with all labor forces to explain and highlight aspects of environmental compliance relevant to their site and activities. Such efforts shall especially be employed when work is proceeding towards areas of environmental sensitivity (e.g., cultural resources, sensitive communities).
 4. Provide for supervisor/foreperson attendance at Environmental Awareness Training conducted by the Resident Engineer.
- C. Evaluate in advance the need for site-specific mitigation measures, and tailor mitigation measures to the need before initiating construction activities. Initiate timely corrective actions to protect communities and environmental resources.
- D. Incorporate environmental issues into daily planning, in a similar way as done for safety planning (e.g. include environmental compliance issues in readiness review meetings and daily "tool box" talks).
- E. Do not commence physical construction activities on the site until the Environmental Compliance Plan (ECP) has been submitted, reviewed and accepted.
- F. Environmental Performance Records: Maintain a record of environmental performance, including materials logbook, and obtain verification that materials used have been reviewed for environmental considerations as required herein. These records shall include the usage of local materials in compliance with the "Buy America" program.
1. The records shall provide documentation of compliance with the environmental requirements for materials used in construction, as specified herein.
 2. Each section shall be labeled with the specification section number and shall record the VOC content, the recycled content, and other environmental specifications of the material. The section will also include the Materials Safety Data Sheet (MSDS), product label and or manufacturer's data verifying conformance with the applicable environmental specifications; and shall identify in general terms where the product is to be used in the Work.
 3. These records shall include compliance reports for non-road diesel equipment.
 4. These records shall be maintained weekly.
 5. The environmental performance records shall be accessible to the Resident Engineer at all times, and shall be submitted periodically as part of the Environmental Performance Report.

- G. Comply with the following environmental performance commitments:
1. Select products that minimize consumption of non-renewable resources due to their manufacture packaging or transportation that consumes reduced amounts of energy and minimizes amounts of pollution produced, and employs recycled and or recyclable materials.
 2. Communicate in a timely manner on any environmental problem to the Environmental Coordinator and Resident Engineer.
 3. Initiate timely corrective actions to protect communities and environmental resources.
 4. Minimize the impact to the environment from waste and sanitation collection generated by construction activities.
 5. Conserve water.
- H. Environmental Coordinator: Contractor's designated Environmental Coordinator shall act as Contractor's main coordinator/liaison for all environmental-related issues. The Environmental Coordinator's duties and responsibilities shall include:
1. Coordinate, review and oversee in preparation of all environmental plans, records and reports.
 2. Monitor and control Contractor's environmental-related Work activities, including compliance with recycling and waste management plans.
 3. Ensure Contractor's compliance with environmental requirements.
 4. Participate during spot checks and environmental compliance inspections performed by the Resident Engineer. This joint inspection process will be used to help ensure communication, and timely action at the worksite.
- I. Environmental Coordination Meetings: In addition to the requirement for environmental plans, records and reports, regular coordination meetings will be held with the Resident Engineer to review environmental issues, including implementation of waste management plans, and monitor the status of Environmental Performance Records and Environmental Performance Reports.
- J. In instances where the Resident Engineer observes and reports environmental non-compliance, immediately implement and maintain corrective actions.
- K. Monitor all Work daily to confirm compliance with environmental requirements. Adjust and deploy mitigation measures based on observations made during inspections and upcoming scheduled activities.
- L. Community Relations: Support the Resident Engineer in providing communications to the community. Such support may include attending meetings, advising of the Contractor's progress and performance, and Contractor conformance to its permits and obligations.

3.02 VEHICLE EMISSION CONTROL

- A. All motor vehicles and construction equipment (both on-highway and non-road) shall comply with all pertinent State and Federal regulations relative to exhaust emission controls and safety.
- B. Establish truck-staging zones for vehicles waiting to load or unload material at the Work Site. Such zones shall be located where diesel emissions have the least impact on abutters and the general public.
- C. Idling time shall be limited to three consecutive minutes for delivery and dump trucks and all other diesel powered equipment except as follows:
 - 1. When a “mobile source” is forced to remain motionless because of traffic conditions or mechanical difficulties over which the operator has no control;
 - 2. When it is necessary to operate heating, cooling or auxiliary equipment installed on the “mobile source” when such equipment is necessary to accomplish the intended use of the “mobile source”;
 - 3. To bring the “mobile source” to the manufacturer’s recommended operating temperature;
 - 4. When the outdoor temperature is below twenty-five (25) degrees Fahrenheit;
 - 5. When the “mobile source” is being repaired.
- D. Ensure that diesel emissions do not cause harmful effects to adjacent sensitive receptors. Sensitive receptors include but are not limited to hospitals, schools, daycare facilities, elderly housing, and convalescent facilities.
- E. Ensure that diesel powered engines are located away from fresh air intakes, air conditioners, and windows.
- F. Equipment shall prominently display a clean exhaust message such as: “Machine is equipped with an air pollution control device and uses Ultra Low Sulfur Diesel fuel”.

3.03 OFF-ROAD VEHICLE EMISSION CONTROL

- A. All Contractor and Sub-Contractor non-road vehicles, on road vehicles with auxiliary power source and construction equipment powered by an internal combustion engine with gross engine horse power rating of 50hp and above that are on the Project or are assigned to the Contract shall be Minimum Tier 2 certified diesel engines (emissions meeting Tier 2 standards), fitted with retrofit technology such as Diesel Particulate Filter (DPF) or better that removes greater than 90% particulate matter without increasing Nox, and uses Ultra Low Sulfur diesel fuel with 15 parts per million (ppm) maximum of sulfur.

- B. The retrofit technology / retrofit emission control device shall be included on the US Environmental Protection Agency (EPA) Verified Retrofit Technology List or Certified by the US EPA or Certified by California Air Resources Board (CARB) or have satisfactorily met all the criteria of VERT and recommended for use on construction equipment
- C. All Contractor diesel powered off-road construction equipment planned for use on site with engine horsepower ratings of 50-horsepower and above, shall be retrofitted with emission control devices and use ultra-low sulfur diesel fuel (maximum 15 parts per million) in order to reduce diesel emissions.
- D. The reduction of emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM) shall be accomplished by installing retrofit technology. Retrofit technology can be:
 - 1. Diesel oxidation catalysts or diesel particulate filter;
 - 2. Engine upgrade;
 - 3. Early engine replacement; or
 - 4. Combination of above.
- E. The retrofit technology/retrofit emission control device for non-road equipment shall be included on the U.S. Environmental Protection Agency (EPA) Verified Retrofit Technology List or certified by the EPA to achieve emission reduction of 50- to 90-percent Hydro Carbon (HC), 40- to 90-percent Carbon Monoxide (CO), and 20- to 50-percent Particulate Matter without increasing NOx.
- F. Maintain a list of non-road diesel powered construction equipment that will be or have been retrofitted. The list is to be included in the Environmental Performance Records and shall include:
 - 1. Contractor/subcontractor name/address/contact person;
 - 2. Equipment type, model, serial number;
 - 3. Engine serial number, make, model, year of manufacture; and
 - 4. Retrofit type, make, model, manufacturer, EPA verification number, and installation date
- G. Maintain copies of fuel deliveries identifying source of supply, quantity of fuel, and quality of fuel. These copies shall be available for review by the Resident Engineer.
- H. Contractor will be issued a Notice of Non-Compliance when any diesel powered non-road construction equipment is in non-compliance with this specification. Non-compliance shall be required to be corrected within a 24-hour period. After the 24-hour period, if the non-complying equipment has not been corrected, remove from the Work Site.

3.04 DUST CONTROL

- A. At a minimum, wet suppression shall be used to provide temporary control of dust. Several applications per day may be necessary to control dust depending upon meteorological conditions and Work activity. Apply wet suppression on a routine basis as necessary to control dust.
 - 1. Wet suppression consists of the application of water or a wetting agent in solution with water. Ensure wetting agent is not used on plantable soils.
 - 2. Wet suppression equipment shall consist of sprinkler pipelines, tanks, tank trucks, or other devices capable of providing regulated flow, uniform spray, and positive shut-off.
- B. Provide wind-screens and wind barriers in locations where they would be effective in minimizing wind erosion and spread of dust. Locations shall be submitted as part of Contractor's dust control plan. Keep wind-screens and barriers in good repair for the life of the Contract.
- C. Use the following measures to control dust on public roadways:
 - 1. For trucks hauling soil or rock (muck), the truck bed shall be completely covered with a tarp or similar protective cover before the truck leaves the site. The truck bed shall remain covered until the truck reaches the disposal site.
 - 2. Before any vehicle leaves the Work Site, the vehicle body and/or wheels shall be cleaned of mud and dirt to control tracking. Gravel cover shall be applied to soil (unpaved) surfaces where they will be regularly traveled at egress and ingress routes from/to Work sites.
 - 3. Vehicle mud and dirt carryout, material spills, and soil washout onto public roadways and walkways and other paved areas shall be cleaned up immediately.
 - 4. Contractor is responsible for daily clean up of public roadways and walkways affected by Work of this Contract. A wet spray power vacuum sweeper or similar equipment shall be used on paved roadways. Dry power sweeping is prohibited.
- D. Use the following methods to control dust and wind erosion of active and inactive stockpiles:
 - 1. Wet suppression without wetting agent during active stockpile load-in, load-out, and maintenance activities.
 - 2. Soil stabilizers applied to the surface of inactive stockpiles.
 - 3. Plastic tarps on stockpiles, secured with sandbags or an equivalent method to prevent the cover from being dislodged by the wind. Repair or replace covers whenever damaged or dislodged.

- E. Use the following measures to minimize dust from earthwork activities:
 - 1. During batch drop operations (i.e., earthwork with front-end loader, clamshell bucket, or backhoe) the free drop height of excavated or aggregate material shall be reduced as practical to minimize the generation of dust.
 - 2. To prevent spills during transport, freeboard space shall be maintained between the material load and the top of the truck cargo bed rail.

3.05 TRAFFIC MANAGEMENT

- A. Make every effort to transport materials by rail rather than truck.
- B. Employ the following methods to minimize adverse impacts to pedestrians and traffic:
 - 1. Advance public notice to motorists of the nature, extent, and duration of lane closings and detours;
 - 2. Place detour signage in strategic locations, and use appropriate warning signs;
 - 3. Perform construction activities that impact traffic during off-peak hours, whenever feasible;
 - 4. Minimize disruption of access to residences and businesses; maintain at least one entrance to a property where multiple entrances exist;
 - 5. Coordinate with other projects in the area that have potential to impact roadways and create cumulative effects;
 - 6. Select truck routes to limit roadway and traffic impacts;
 - 7. Adopt a parking policy for construction workers that will minimize impacts to residents and businesses;
 - 8. Install signage and barriers to protect and guide pedestrians.

3.06 TRANSPORTATION OF EXCAVATED MATERIALS

- A. Rail Transport: Rail access is available under this contract and materials can be transported by rail without work-hour restrictions. The Contractor is responsible for all necessary arrangements for rail transportation, including provisions for on-site rail infrastructure. The placement of appropriate spur tracks may be required in the Existing Rail Yard to accommodate the removal of excavated materials by rail.
- B. Truck Transport: Where excavated materials are removed by truck, such methods will be subject to NYCDOT approval, stringent environmental requirements and community restrictions, as detailed herein and elsewhere in these specifications, and in accordance with all applicable laws, regulations, and permits.

1. Haul trucks shall be equipped with diesel particulate filters.
2. The hours of operation for off-site transport and disposal of excavated material using trucks may be limited by local community restrictions.
3. Trucks hauling excavated material shall be subject to the following restrictions:
 - a. Haul trucks shall enter and exit the existing rail yard only through the Queens Street access road. Use of the Private Drive Access Road for the transport of excavated materials is undesirable and will only be permitted with prior written acceptance from the Resident Engineer.
 - b. Submit haul routes to NYCDOT 30 days before required date.
 - c. Once on Northern Boulevard, laden trucks shall enter Jackson Avenue and proceed directly to the Long Island Expressway (LIE) using one of the following designated truck routes only:
 - 1) East on Jackson Avenue, right turn onto Queens Boulevard (south), right turn onto Van Dam Street (south), left turn onto Hunterspoint Avenue (east) and proceed to LIE entrance from Hunterspoint Avenue
 - 2) West on Jackson Avenue and proceed directly to LIE entrance near the Midtown Tunnel plaza

Upon exiting the Long Island Expressway, select truck routes to limit roadway and traffic impacts and utilize designated truck routes to the greatest extent feasible.
 - d. Empty haul trucks returning to the Work Site shall use the same designated truck routes.

3.07 ENVIRONMENTAL PERMIT COMPLIANCE

- A. Further to Supplemental Terms and Conditions Article 14.12 - "PERMITS AND APPROVALS", the permits listed herein will be obtained by Contractor and issued by the NYSDEC or NYCDEP to the MTA. The Contractor is responsible for execution of the Permits and complying with all of the terms of each Permit. The Contractor shall immediately notify the Resident Engineer of any deviations from any Permit conditions, along with recommendations for correction and/or mitigation.
- B. Combined Sewer Discharge Permit: This permit is required by NYCDEP for the groundwater treatment system discharge. Due to the groundwater contaminant plumes in the Existing Rail Yard, the treatment process equipment shall be functionally maintained at all times. Make every effort to maintain the functionality of the process system, collect system and effluent monitoring samples in a timely fashion, and optimize the operation of the system.

- C. SPDES General Permit for Stormwater Discharges from Construction Activities: This permit is required by NYSDEC for sediment and erosion control due to stormwater run-off. Make every effort to comply with the SPDES General Permit and the SWPPP, update the SWPPP as the Work site changes, and maintain erosion control features.
- D. Contractor is advised that failure to comply with the permit requirements, including the timely submission of periodic monitoring reports, may result in the required shutdown of the dewatering system. In such cases, the Contractor shall be wholly responsible for any added costs and/or delays associated with the dewatering shutdown.

3.08 WASTE MANAGEMENT

- A. Adopt processes that generate the least amount of waste.
- B. Minimize the impact to the environment due to waste production from construction activities, including finding beneficial uses for excavated materials. Waste disposal in landfills or incinerators shall be minimized.
- C. Waste materials that are generated shall be salvaged for reuse and or recycled to the greatest extent practicable, subject to the waste management provisions within the approved Contract-Specific Environmental Compliance Plan.
- D. Waste Management Plan: Contractor's waste management plan shall identify waste types; quantity by weight and volume; methods for handling and disposal; and transportation procedures. Plan shall include proposed methods for waste salvage, reuse, and disposal, including the name of applicable salvage, reuse and disposal subcontractors and/or facilities.
- E. Recycling Plan: Contractor's recycling plan shall outline the materials chosen to be recycled on- or off-site and include methods employed to recycle those materials, identify the off-site receiver of those materials, and details the ultimate use of those materials by the receiver. Include methods that will be used for separating recyclable waste.
- F. Recycling and waste bin areas shall be kept neat and clearly marked to avoid comingling of materials.
- G. Include in material purchase agreements a waste reduction provision requesting that materials and equipment be delivered in packaging made of recyclable materials, that they reduce the amount of packaging, that packaging be taken back for reuse or recycling, and to take back all unused product. Ensure that subcontractor require the same provisions in their purchase agreements.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for eliminating or minimizing noise and vibration generated by all construction activities including temporary ventilation with the exception of blasting (which is addressed in Sections 02407 and 02414) and of complying with applicable regulations, specification requirements, and noise and vibration limits specified within this Section.
- B. Definitions
 - 1. Air-Overpressure (Airblast): Fluctuating changes in ambient air pressure caused by blasting. Air-overpressure is expressed in units of linear-scale decibels (dBL). Microphones that measure blast-induced air-overpressure have flat frequency response from 2- to 250-Hertz.
 - 2. A-Weighted Noise Levels: Decibels (referenced to 20-micro-Pascal) as measured with A-weighting network of standard sound level meter, abbreviated dBA.
 - 3. Daytime: The period from 7:00 AM to 10:00 PM local time daily, except Sundays and legal holidays as defined in local ordinances.
 - 4. L_{eq} : Equivalent sound level.
 - 5. L_{max} : Maximum measured sound level.
 - 6. Nighttime: Other than daytime and includes Sunday and legal holidays as defined in local ordinances.
 - 7. Noise Level Measurements: Unless otherwise indicated, the use of A-weighted and "slow" response of instrument complying with Type 2 requirements of ANSI S1.4.
 - 8. Vibration: Maximum peak particle velocity (PPV) levels in inches/second (in/sec). The maximum of the ground motion velocities measured in the vertical, longitudinal, and transverse directions. PPV is not the vector sum of the three components of motion.
 - 9. Vibration Measurements: The use of a vibration transducer, amplifier, peak detector, and frequency band filters complying with ANSI S2.4.
 - 10. Noise and Vibration Sensitive Locations: Historic structures, residences, hotels, institutions, hospitals, and other locations so named herein
 - 11. Surface Level Vibration: Vibration measured outside of surface structures at ground level.

12. Work Site: For purpose of noise and vibration control requirements, the Contract limits of construction. This includes Right-of-Way lines, property lines, construction Easement Boundary or property lines and Contractor staging areas outside the defined boundary lines, used expressly for construction.

1.02 REFERENCED SECTIONS

- A. Section 01520 – Construction Facilities
- B. Section 02407 – Tunnel and Cavern Excavation by Drill and Blast
- C. Section 02414 – Controlled Blasting
- D. Section 02495 - Geotechnical and Structural Instrumentation

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI):
 1. S1.4 - Sound Level Meters
 2. S1.13 – Methods of Measurement of Sound Pressure Levels
 3. S2.4 - Method for Specifying the Characteristics of Auxiliary Analog Equipment for Shock and Vibration Measurements
- B. International Electrotechnical Commission (IEC):
 1. 179 - Precision Sound Level Meters
- C. Society of Automotive Engineers (SAE):
 1. J994 - Alarm - Backup - Electric Laboratory Performance Testing
 2. J1446 - On-Machine Alarm Test and Evaluation Procedure for Construction and General Purpose Industrial Machinery

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Regulatory Requirements: Verify compliance with the following codes and regulations:
 1. Code of Federal Regulations (CFR):
 - a. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)

2. City of New York: Department of Buildings Technical Policy and Procedure Notice No. 10/88 (Vibration Limits for Historical Structures)
 3. Regulatory Requirements: Fire Department of the City of New York (FDNY) Blasting Regulations
- B. Responsibilities of Contractor:
1. Perform Work within the permissible noise and vibration levels, work schedule limitations, and procedures provided for in this Section and applicable Federal, State, and local laws and regulations.
 2. Other than those provided herein, be responsible for obtaining, at Contractor's own expense, permits, variances, equipment certifications, and other documents required by this Section and by applicable Federal, State, and local laws and regulations.
 3. With regard to noise and vibration monitoring, include the following:
 - a. Provide access to the Resident Engineer to collect and measure noise and vibration monitoring data.
 - b. Implement noise and vibration control measures as required by this Section, based on Resident Engineer's noise and vibration monitoring data and nuisance conditions reported by the Resident Engineer.
- C. Responsibilities of Resident Engineer: The Resident Engineer will measure background noise and vibration levels to determine ambient baseline conditions and provide this information to Contractor before construction operations commence.
- D. Designate a staff member as the Noise and Vibration Control Representative.

1.06 SUBMITTALS

- A. Submit a Noise and Vibration Control Plan as specified in this Section to the Resident Engineer for review no later than 30 days after NTP. Prepare plan using an Acoustical Engineer experienced in the preparation of Noise and Vibration Control Plans. Do not operate noise or vibration generating construction equipment either at surface or below ground level at the Work Site until the Noise and Vibration Control Plan has been submitted and accepted.
- B. Shop and Working Drawings, computations, material data and other criteria, for noise and vibration control measures, identified in the Noise and Vibration Control Plan.
- C. Materials data as required.

1.07 DELIVERABLES

- A. Provide vibration and noise measurement equipment models and calibration certificates.

- B. As requested by the Resident Engineer have available the Equipment Sound Level Data Reporting Form (see Paragraph 3.05A.3 and Figure 1) for each item of equipment to be used.

PART 2 PRODUCTS

2.01 INSTRUMENTS AND METERS

- A. Provide instruments that are in compliance with the criteria for a geophone and seismograph as defined in the current revision of ANSI S2.4 to perform vibration measurements.
- B. Provide sound level meters (SLM) listed in Section 01520, in compliance with the Type 2 (Precision) requirements as defined in the current revision of ANSI S1.4.
- C. SLM to be capable of measuring the L_{\max} and ten-minute to one-hour L_{eq} on the A-Weighted scale required by regulatory criteria and Ground-Borne Noise Level Limits.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Perform Work within the permissible noise and vibration levels, Work schedule limitations, and procedures provided for in this Section and applicable Federal, State, County, and Municipal codes, regulations, and standards.
- B. Conduct noise and vibration measurements as necessary to ensure compliance with the requirements herein. Provide access to the Resident Engineer to collect and/or review noise and vibration monitoring data.
- C. Designate staff member as Noise and Vibration Control Representative.

3.02 VIBRATION LEVEL LIMITS

- A. Buildings and Above Ground Structures:
 - 1. The maximum peak particle vibration velocity (PPV) level limits, in any direction, for all construction activities excluding blasting and pile driving is a maximum vibration level limit of 1.92-inches per second PPV.
 - 2. Surface Level Vibration at Historical Buildings (as indicated in the drawings): Blast-induced vibration measured in any one of three mutually perpendicular directions shall not exceed 0.5-inch per second.
 - 3. Surface Level Vibration at All Other Buildings: Blast-induced vibration measured in any one of three mutually perpendicular directions shall not exceed 1.92-inches per second.

B. Underground Structures:

1. Blast induced vibration in MNR tunnels, structures, and facilities shall not exceed 1.0-inch per second measured in any one of three mutually perpendicular directions above ambient vibration levels in these structures as measured by the Resident Engineer.
2. Vibration in NYCT tunnels, structures, and facilities shall not exceed strain levels as follows:
 - a. An Alert strain level shall be 500-microstrains;
 - b. A Review strain level shall be 150-microstrains.
3. Upon reaching Alert and Review strain levels, actions required are specified in Section 02495.

3.03 GROUND-BORNE NOISE

- A. If muck is hauled by rail within the newly excavated tunnels, caverns, and/or existing 63rd Street Tunnel, noise generated from muck haul operations shall not be permitted to exceed the specified ground-borne noise levels. The ground-borne noise levels within building structures due to the muck trains and other underground and tunneling construction activities is limited to the Leq noise levels, as measured over a 10-minute period, listed in the Table 1.
- B. The ground-borne noise will be measured by the Resident Engineer, subject to permission and access by the building owner, at the interior of the nearest occupied building to the construction activity. Measurements shall be conducted once a day during both daytime and nighttime hours to measure ground-borne noise levels at the building location from underground construction activities. Noise measurements shall also be conducted at the closest occupied level of the nearest building to the construction activity as specified in Paragraph 3.05A of this Section. The ground-borne noise level limits will be adjusted to ambient plus 5-dBA at those receivers where the interior background noise levels are higher than the levels listed in Table 1. The maximum adjustment in noise level limits is 5-dBA above any applicable limit.

Table 1		
Ground-Borne Noise Level Limits – Leq (dBA)		
Category of Land Use	Daytime (7 am to 10 pm)*	Nighttime (10 pm to 7 am)
Residential	55 dBA	40 dBA
Hotel	55 dBA	45 dBA
Offices	55 dBA	N/A
Commercial Spaces	60 dBA	N/A

Notes: Ground-borne noise limits do not apply to blasting or TBM operations.

N/A – Nighttime hours are not applicable to these land uses.

- * If at any one receiver, construction activity is anticipated to be noticeable for 60 days or less, the daytime noise levels may exceed the limits by 5-dB. The maximum adjustment in noise level limits is 5-dBA above any applicable limit.

3.04 AIR-BORNE EXTERIOR (ABOVE-GROUND) NOISE LEVELS LIMITS

- A. Sound levels for public exposure to noise shall comply with the following noise level restrictions in all areas:
1. In no case expose the public to construction noise levels exceeding 90-dBA on "slow" response or to impulsive noise levels exceeding 125-dBA maximum transient level "fast" response as measured on a general purpose sound level meter.
 2. Conduct construction activities in such a manner that the noise levels 200-feet from construction limits or at the nearest affected building, whichever is closer, do not exceed the levels listed in Table 2.
 3. In areas outside of construction limits and not designated as a special construction site or special zone, prevent stationary noise sources, parked mobile sources or any other source or combination of sources from producing repetitively scheduled or long-term noise lasting more than 10-percent of the construction duration from exceeding the limits of Table 2.
- B. Test the equipment and demonstrate compliance with noise limits specified in Article 3.05.
- C. Perform the work in a manner to minimize nuisance conditions such as noise that exhibits a specific audible frequency or tone (e.g., back-up alarms, unmaintained equipment, brake squeal) or impact noise (e.g. jack hammers, hoe rams).

TABLE 2 CONSTRUCTION NOISE LIMITS		
Land Uses	Noise Level – Leq (dBA) (whichever is greater)	L _{max} Level (dBA, slow)
DAYTIME (7 AM TO 6 PM)		
Residences and buildings where people normally sleep	75 or Background + 5*	85* 90 (impact equipment)
Commercial Areas	80 or Background + 5*	None
Industrial Areas	85 or Background + 5*	None
EVENING (6 PM TO 10 PM)		
Residences and buildings where people normally sleep	Background + 5	85
Commercial Areas	None	None
Industrial Areas	None	None

NIGHT-TIME (10 PM TO 7 AM)		
Residences and buildings where people normally sleep If Background < 70-dBA If Background \geq 70-dBA	Background + 5 Background + 3	80 80
Commercial Areas	None	None
Industrial Areas	None	None

- * Noise from impact equipment is exempt from the Leq requirement, however is subject to a lot-line L_{max} limit of 90 dBA.

Note: All measurements will be taken at the affected lot-line in accordance with Article 3.05.

Noise level limits are averaged over 20-minute intervals.

L_{max} noise level limits are the maximum noise level that occurs over 20-minute intervals

3.05 NOISE AND VIBRATION CONTROL PLAN

- A. Noise and Vibration Control Plan: Include the following for construction activities that may occur at the Work Site.
 1. Site Drawing: Prepare a scaled drawing of the Work Site indicating the following:
 - a. Contract name and number
 - b. Contractor's name
 - c. Date
 - d. Scale
 - e. Direction of North
 - f. Noise and vibration-sensitive buildings near the Work Site.
- B. Equipment Inventory: Prepare an inventory of equipment used to perform the construction.
- C. Vibration Calculations: Prepare calculations of the maximum peak particle velocity vibration level expected at the nearest residential, institutional, and commercial building.
- D. Noise Calculations: Prepare calculations of one-hour Leq noise levels expected at the nearest residential and commercial buildings.
- E. Update the Noise and Vibration Control Plan at three month intervals from the initial acceptance date and re-submit the Plan within 10 days of the start of each quarterly period.

- F. Noise and Vibration Reduction Methods: To the extent required to meet the ground vibration PPV, ground-borne noise (interior) limits, and airborne (exterior) noise level limits specified by this Section, modify construction operations to reduce noise and vibration.

3.06 EQUIPMENT NOISE CERTIFICATION

A. Requirements for Construction Equipment:

1. Ensure that Contractor and Subcontractor equipment, of the types listed in Table 3 and used at the surface of the Work Site is tested for compliance with the stated noise emission limits during the first day of use on the Work Site or at an alternative site, with compliance data available to the Resident Engineer for review.
2. Retest equipment as described above at six-month intervals while in use on-site, and certify new equipment before being placed into service at the site.
3. For each piece of equipment used, provide an Application for Certificate of Equipment Noise Compliance (see Figure 1). Ensure that the equipment identification number used for the Certificates is consistent with the identification number used in the Noise Control Plan. Do not use equipment on-site without valid certificates of noise compliance.

B. Test Procedures for Construction Equipment:

1. Operate engine-powered equipment by Contractor at maximum governed rpm under full load conditions during the tests.
2. Test portable and mounted impact hammers, such as hoe rams and jackhammers to be used for concrete breaking, during the first day of actual operation at the Work Site under maximum load conditions as rated by the equipment manufacturer.
3. Noise Certification Measurements: Use an acoustic calibrator of the type recommended by the sound level meter manufacturer before measurements.
4. As specified in Paragraph 3.05C of this Section, take measurements at two locations: two feet from the right and left sides of the equipment casing, at a distance of 50-feet and a height of 5-feet above ground level, with the equipment operating at maximum governed rpm under full load conditions for a minimum period of one minute. Reduce measurements made at less than 50-feet, because of space limitations at the test site by the values given in Table 4 to estimate the 50-foot sound level.

TABLE 3
CONSTRUCTION EQUIPMENT 50-FOOT NOISE EMISSION LIMITS

Equipment Category	L _{max} Level (dBA, slow)	Impact/Continuous
Arc Welder	73	Continuous
Auger Drill Rig	85	Continuous
Backhoe	80	Continuous
Bar Bender	80	Continuous
Boring Jack Power Unit	80	Continuous
Chain Saw	85	Continuous
Compressor	70	Continuous
Compressor (other)	80	Continuous
Concrete Mixer	85	Continuous
Concrete Pump	82	Continuous
Concrete Saw	90	Continuous
Concrete Vibrator	80	Continuous
Crane	85	Continuous
Dozer	85	Continuous
Excavator	85	Continuous
Front End Loader	80	Continuous
Generator	82	Continuous
Generator (25 KVA or less)	70	Continuous
Gradall	85	Continuous
Grader	85	Continuous
Grinder Saw	85	Continuous
Horizontal Boring Hydro Jack	80	Continuous
Hydra Break Ram	90	Impact
Impact Pile Driver	95	Impact
In situ Soil Sampling Rig	84	Continuous
Jackhammer	85	Impact
Mounted Impact Hammer (hoe ram)	90	Impact
Equipment Category	L _{max} Level (dBA, slow)	Impact/Continuous
Paver	85	Continuous
Pneumatic Tools	85	Continuous
Pumps	77	Continuous
Rock Drill	85	Continuous
Scraper	85	Continuous
Slurry Trenching Machine	82	Continuous
Soil Mix Drill Rig	80	Continuous
Street Sweeper	80	Continuous
Tractor	84	Continuous
Truck (dump, delivery)	84	Continuous
Vacuum Excavator Truck (vac-truck)	85	Continuous
Vibratory Compactor	80	Continuous
Vibratory Pile Driver	95	Continuous
All other equipment with engines larger than 5 HP	85	Continuous

TABLE 4 ADJUSTMENTS FOR CLOSE-IN EQUIPMENT NOISE MEASUREMENTS	
<u>Distance (Feet)</u>	Measurement Values to be Subtracted from Measured Sound Level to Estimate Sound Level at 50 Feet (dBA)
19-21	8
22-23	7
24-26	6
27-29	5
30-33	4
34-37	3
38-42	2
43-47	1
48-50	0

C. Noise Certification Compliance

1. Complete and maintain a noise report for each item of equipment used of the types listed in Table 3 with certification that equipment noise emissions do not exceed those prescribed in Table 3.
2. If the noise levels obtained during the tests exceed those specified in Table 3, remove such equipment from use until such equipment is modified and retested, or substitute other equipment to meet the noise level requirements.
3. Equipment will be subject to spot noise level testing at the Resident Engineer's discretion to determine that the equipment in use meets the requirements specified in this Section. If such tests are requested by the Resident Engineer, locate and operate the equipment at the designated site to facilitate the measurements.

3.07 CONSTRUCTION METHODS - EQUIPMENT

- A. Minimize the use of impact devices, such as jackhammers, pavement breakers, and hoe rams. Where possible, use concrete crushers or pavement saws rather than hoe rams.
- B. Pneumatic impact tools and equipment used at the Work Site shall have intake and exhaust mufflers recommended by the manufacturers thereof, to meet relevant noise ordinance limitations.
- C. Equip noise producing equipment i.e. jackhammers and pavement breakers with acoustically attenuating shields or shrouds recommended by the manufacturers thereof, to meet relevant noise ordinance limitations.
- D. Line or cover hoppers, conveyor transfer points, storage bins, and chutes with sound-deadening material.
- E. Provide mufflers or shield paneling for other equipment including internal combustion engines recommended by manufacturers thereof.

- F. As required to meet the noise limits specified in this Section, use alternative procedures of construction and selection of proper combination of techniques that generate least overall noise and vibration. Such alternative procedures include the following:
 - 1. Employ prefabricated structures instead of assembling on-site
 - 2. Solar powered arrow boards
 - 3. VMS message signs
- G. Use construction equipment manufactured or modified to dampen noise and vibration emissions.

3.08 CONSTRUCTION METHODS - OPERATIONS

- A Operate equipment to minimize banging, clattering, buzzing, and other annoying types of noises, especially near residential areas during the nighttime hours.
- B Configure the Work Site in a manner that keeps noisier equipment and activities as far as possible from noise sensitive locations and nearby buildings. Particular attention should be given to operations, associated muck removal, conveying, and secondary handling operations at the Queens open-cut.
- C. Furnish equipment operated by Contractor, vendors, suppliers, and subcontractors on the Work Site with back-up alarms with either audible self-adjusting back-up alarms or manual adjustable alarms. The self-adjusting alarms shall automatically adjust to a minimum of 5-dBA and a maximum of 10-dBA over the surrounding background noise levels and have an operating range between 77- to 97-dBA. Set the manual adjustable alarms at the low setting, 87-dBA. Installation and use of alarms shall be consistent with the performance requirements of the current revisions of SAE J994, SAE J1446, and OSHA regulations.
- D. In no case shall the above restrictions limit Contractor's responsibility for compliance with applicable Federal, State, and local safety ordinances and regulations and other sections of these Specifications.
- E. Maximize physical separation, as far as practicable, between noise generators and noise receptors. Separation includes following measures:
 - 1. Provide enclosures for stationary items of equipment and barriers around particularly noisy areas on-site.
 - 2. Locate stationary equipment to minimize noise and vibration impact on the community, subject to acceptance by the Resident Engineer.
- F. Minimize noise-intrusive impacts during most noise sensitive hours.
 - 1. Plan noisier operations during times of highest ambient noise levels.
 - 2. Keep noise levels relatively uniform; avoid excessive and impulse noises.
 - 3. Turn off idling equipment.

4. Phase in start-up and shutdown of site equipment.
- G. Select truck routes for muck disposal so that noise from heavy-duty trucks will have minimal impact on sensitive land uses (e.g., residential).
1. Conduct truck loading, unloading and hauling operations so noise and vibration are kept to a minimum.
 2. Route construction equipment and vehicles carrying soil, concrete, and other materials over streets and routes that will cause least disturbance to residents in vicinity of Work.

FIGURE 1 - EQUIPMENT SOUND LEVEL DATA REPORTING FORM**APPLICATION FOR CERTIFICATE OF EQUIPMENT NOISE COMPLIANCE**

Contractor Name: _____

Contract Name & Number: _____

Equipment Type: _____

Manufacturer & Model Number: _____

Identification Number: _____

Rated Power & Capacity: _____

Operating Condition during Test: _____

Measured Sound Levels at 20 to 50 feet: _____

Measured Values and Distance:

Right Side: dBA (SLOW), at _____ -feet

Left Side: dBA (SLOW), at _____ -feet

Estimated Values at 50-Foot Distance:

Right Side: dBA (SLOW).

Left Side: dBA (SLOW).

Maximum Values Allowed for this Equipment:

_____ dBA (SLOW) at 50 feet

_____ -dBC (FAST) at 50 feet

If equipment sound level exceeds maximum value allowed, indicate action taken to achieve compliance:

_____Name, Address, & Telephone No.
of Acoustical Engineer_____

Authorized Signature:

_____ Date _____

CONTRACTOR'S APPROVAL:

Authorized Signature:

_____ Date _____

ENGINEER'S CONCURRENCE:

Authorized Signature:

_____ Date _____

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for Project identification indicated on the Contract Drawings and specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Advertisements Forbidden: The use of fences and buildings for advertising purposes, other than the name and address of Contractor, is forbidden.

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

None Listed

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS**2.01 PROJECT IDENTIFICATION SIGNS**

- A. The MTA will provide Contractor with Project identification signs for each site entrance gate, 3-feet wide by 4-feet high by 0.125-inch thick, manufactured of rigid acrylic or similar material.

2.02 CONTRACTOR SIGNS

- A. Provide temporary signs 3-feet wide by 2-feet high, with minimum 1-inch lettering, to include Contract number and title, Contractor's company name, address of Contractor's field office, and 24-hour emergency telephone numbers.

PART 3 EXECUTION**3.01 GENERAL REQUIREMENTS**

- A. Install the signs within one week of commencement of physical work. Install to resist vandalism and theft. Construction signs shall not obscure traffic or public information signs. Signs shall be placed at site entrance gates where the public can see them readily. Signs shall not impede pedestrian or vehicular flow.
- B. Maintain and clean signs regularly. All markings, soot, and steel dust shall be removed with soap and water or common solvents without harm to the sign's surface.
- C. At a minimum, Project identification signs and Contractor signs shall be installed at the following locations:
 - 1. Northern Boulevard site entrance
 - 2. 40th Road site exit
 - 3. 41st Ave. site fence
 - 4. 2nd Avenue and 63rd Street

3.02 PROJECT IDENTIFICATION SIGNS

- A. Exact sign locations shall be reviewed by the Resident Engineer before installation.
- B. Replace signs as supplied by the MTA if the condition of the signs becomes unsatisfactory.
- C. Remove the signs upon Substantial Completion. Return all signs to the MTA upon removal.

3.03 CONTRACTOR SIGNS

- A. Install Contractor signs at each site entrance gate, security guard booth, and at Contractor's field office.
- B. Prominently display Contractor signs for the duration of the Contract. Remove the signs upon vacating the Work Site.

3.04 IDENTIFICATION OF CONTRACTOR'S TOOLS AND EQUIPMENT

- A. Permanently inscribe all tools, equipment, and other personal property belonging to Contractor or its subcontractors with a clearly visible mark identifying the property as belonging to Contractor or such subcontractors, as applicable. The mark shall consist of at least three characters and may be any combination of numbers and letters. The same identifying mark shall be used on all tools and equipment used in the prosecution of the Work for the duration of the Contract. Maintain a listing of all such tools and equipment by mark and serial number.

- B. The requirements of this Article do not impose any responsibility or liability on the MTA with respect to such tools and equipment.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Design, construct, and maintain modular buildings to be located on MTA property at 63rd Street and 2nd Avenue. Requirements are as specified herein and/or shown schematically on attached sketch SK-1. Alternate site and building layouts are acceptable but must meet the intent of this Section to provide MTA and Contractor's facilities with an acceptable aesthetic appearance to the public. Alternates to conceptual layout shall meet all requirements and be submitted for approval.
- B. The newly constructed facilities shall incorporate an existing structure on site that will be accessible to the public. New modular buildings shall house MTA offices, Contractor's facilities should the Contractor choose to use this site, as well as a security guard booth. If the Contractor chooses not to use the site, the Contractor shall coordinate with the Resident Engineer, develop, and submit a revised site layout without Contractor's dedicated spaces, showing the existing building and modular buildings for MTA's use. The modular construction provided shall be in keeping with the existing structure's architectural character and have in general the appearance of one continuous structure.
- C. At completion of the Contract, the Contractor shall leave in place all constructed and/or furnished facilities, buildings, site improvements, plantings, listed office furnishings and equipment, utilities and service connections in good repair as approved by the Resident Engineer; and remove Contractor's equipment, tools, materials, field offices and/or containers.
- D. Contractor shall provide maintenance of the site and facilities and make repairs as necessary for the Contract duration.
- E. Contractor shall arrange for and/or install the necessary utilities, pay for all utility connection fees and pay for all utility services for the duration of the Contract including monthly telephone, water, sewage and electrical service charges.

1.02 REFERENCED SECTIONS

- A. Section 01450 - Quality Control Procedures
- B. Section 01570 – Environmental Compliance
- C. Section 01572 – Construction Noise and Vibration Control

1.03 CITED STANDARDS

- A. Regulatory Requirements:
 - 1. Americans with Disabilities Act Accessibility Guidelines (ADAAG)
 - 2. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)

3. FDNY, NYCDOT, NYCDEP, and other applicable rules and regulations of authorities having jurisdiction

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Follow quality control procedures as per Section 01450.
- B. All materials and systems installed in the modular building units shall be new and installed in accordance with applicable codes and regulations and in accordance with manufacturer's recommendations.
- C. Contractor shall obtain all necessary agency approvals and construction permits required to develop the site and occupy the MTA facilities for office use.

1.06 SUBMITTALS

- A. Submit site and building layout and manufacture for approval and prior to procurement of modular units, graphic illustrations of office structure and guard booth to show general consistency with architectural character of existing building.
- B. Submit any alternate layouts of site and buildings.
- C. Submit shop drawings and design calculations signed and sealed by a New York State Professional Engineer or Registered Architect; manufacturer's data sheets or other descriptive data, as applicable, describing the size, type, construction details of modular building units, gages and finishes of materials, services characteristics of components, capacities, fittings, accessories, and any other pertinent information regarding the modular buildings and systems.

1.07 DELIVERABLES

- A. Provide warranties as specified at completion of work under this Section.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Modular Building Products and installation shall conform to the BCNYS. Use specified manufacturers, or approved equal:
 1. Tanglewood Conservatories (manufacturer of existing building)
2300 Perkins Place
Silver Spring, Maryland 20910
Telephone: 301-565-2925
Fax: 301-565-2014

2. Kullman Industries
381 Blair Road
Avenel, New Jersey 07001
Telephone: 908-636-1500
Fax: 908-636-1813
3. Williams Scotsman, Inc.
8211 Town Center Drive
Baltimore, Maryland 21236
Telephone: 800-782-1500
E-mail: info@willscot.com
4. GE Capital Modular Space
967 Conklin Street
Farmingdale, NY 11735
Telephone (631) 752-9421
Fax: (631) 752-9665
E-mail: stephanie.stranick@gecapital.com

2.02 MODULAR BUILDING CONSTRUCTION FOR MTA'S USE

- A. Provide modular buildings with a minimum of approximately 1,400-square feet of office space for MTA's use.
- B. Furnish, install on site, and/or modify as necessary, complete with functioning utilities one doublewide modular unit 24-feet by 60-feet in plan; or two joined singlewide units to provide equivalent minimum of 1,400-square feet of office space.
- C. The façade exposed to public view shall be finished in keeping with the existing structure's architectural character to have an acceptable appearance to public view.
- D. Provide the following features and amenities, including but not limited to:
 1. One fully equipped handicapped accessible half bath.
 2. Coffee bar, base cabinet for storage of kitchen supplies, and plumbed sink.
 3. Configure modular unit(s) with main office of 12-feet by 34-feet in plan; four private offices, 12-feet by 12-feet in plan with two of the offices to have 4-feet wide by 3-feet deep closets, shelf and lockable doors; and private conference room approximately 12-feet by 20-feet in plan.
- E. Structural frame and flooring substrate designed to support a live load of at least 50-psf, with insulation having a total R-value of not less than 19, the floor edge insulation having a total R-value of not less than 8.
- F. All exterior walls and roof system shall be braced as required to meet applicable structural, wind, and seismic loadings.

- G. Frame windows with muntins (applied to exterior of glass if real divided lights are not used). Muntins and lights of similar appearance to those at existing building.
- H. Frame stile and rail entry doors with glass panel. Muntins (applied to exterior of glass if real divided lights are not used) and lights shall be of similar appearance as those at existing building.
- I. Roof shall have mansard or pitched style as approved and insulation with a minimum "R" value of 19.
- J. Tie downs shall be provided to ensure structures are secured to site foundations.
- K. Each module's lifting points and/or hitch to be concealed or detached for module's use at the site.
- L. Provide and install skirting to match finish of exterior siding to within 2-inches of grade.
- M. Once modular units are set in place, fill any spaces between modular units with finished materials to match adjacent exterior appearance.
- N. Provide central HVAC system including heating, ventilation and air conditioning complete with associated items as required for year round use of modular building office spaces.
- O. Provide sufficient interior light levels appropriate for office work at desktop level.
- P. Electric panel and service sized to support all electrical requirements in accordance with NFPA 70 and brought to modular office block.
- Q. Guard Booth with exterior finish appearance of other buildings, approximately 25 square feet, equipped with electrical receptacle and lighting.
- R. Exterior lighting shall be installed to adequately illuminate walkways and building entrances.
- S. Install duplex data port at each of the four MTA office spaces and three in the main office space.
- T. Interior wall surfaces shall be paneling, vinyl clad or painted white.

2.03 FACILITIES FOR CONTRACTOR'S USE

- A. If the Contractor so chooses, the Contractor is permitted to occupy approximately 800 square feet of space on MTA property at 63rd Street and 2nd Avenue to house an emergency generator, store generator fuel, store materials/tools, and/or locate a small field office at this site in accordance with the following requirements:
 - 1. The generator shall be housed in a sound attenuated metal container, have two-hour rating and located in an unobtrusive location as suggested at location on the attached sketch SK-1. Meet environmental requirements of Sections 01570 and 01572.

2. Generator and small tool fuel storage, and/or general material/tool storage shall be housed in steel containers with two-hour fire-rated construction, separated from the other structures on site, and located in an unobtrusive location as suggested on the attached sketch SK-1.
3. Locate field office for the switchgear maintainer or other personnel at this site, as suggested on the attached sketch SK-1.
4. Contractor's storage and generator containers and switchgear maintainer's facilities shall be hidden from view along the westerly side by constructing a solid plywood fence with solid access doors, finished with materials to approximate a similar appearance to exterior siding of new modular units and the existing building, and constructed with a similar style and roof color of the modular units.
5. The Contractor will be permitted, if Contractor so chooses, to occupy approximately 140-square feet of MTA office space during installation of instrumentation on surface structures.
6. The Contractor is permitted to park two automobiles or light trucks at this site.

2.04 SITE DEVELOPMENT

- A. Demolish existing 18-inch raised area, garden pool, and walkway; clear and grub site.
- B. General site paving shall be concrete and designed to adequately support loading from automobile and light trucks. Plant Kentucky Blue Grass in any unpaved areas.
- C. Provide five parking spaces for automobiles or light trucks as noted on Sketch SK-1.
 1. Stripe parking spaces.
 2. Furnish and install five precast concrete parking blocks.
- D. Furnish and install new gates as shown to access site. Gates shall be galvanized chain link, full height, swing gates, to match existing in finish, wire gauge, and wire mesh. Match diameter of existing gateposts and rails. Concrete footings for gateposts to be 3-feet-6-inches deep minimum; 1-foot-0-inch around minimum. Gates shall be lockable. All frame corners and connections to be welded.
- E. Repair existing chain link fences and gates to the satisfaction of the Resident Engineer.
- F. Plantings:
 1. Shrubs, sod and lawn seed shall be from local nursery familiar with urban context and climatic zone. Provide shrubs balled or burlapped.

2. Box hedge shrubs shall be 2 to 6-feet high shrubs similar to those planted at the street front perimeter of the site See Sketch SK-1 for locations of plantings.

2.05 MISCELLANEOUS ITEMS

- A. Furnish and install single 24-inch by 36-inch framed bulletin board made for outdoor use.
 1. Damp proof exterior grade painted plywood case with a sealed, hinged glass lockable door.
 2. Equipment for mounting at exterior location inside fence but visible from public sidewalk with bottom at 48-inch above grade.
- B. Furnish and install fire extinguishers as per code.
- C. Furnish and install window shades with sunscreen shade cloth that meets federal requirements for fire retardance, Antimicrobial without topical treatment, NYS Fire-Gas Toxicity Text, ASTM E 84, Flamespread 17, Smoke Density Index 118.

PART 3 EXECUTION

3.01 SITE WORK

- A. Clear the site of all previous tenant's property; remove and dispose of debris and an existing recessed pool at site. Shut and cap any utilities connected to garden pool. The existing wood and glass structure shall remain intact, on site.
- B. Retain the existing box hedge inside the property line and outside the fence; plant new shrubs as shown on attached sketch SK-1.
- C. Level the site as much as possible to meet the elevation of the existing sidewalks at the west and north perimeters and to meet the floor elevation of the existing building with a slope away from the building to carry water runoff to surface drains.
- D. Utility Service:
 1. Retain the existing building's telephone, electricity, potable water and sewage connection services.
 2. Install a new electric breaker panel at the modular office unit(s) to provide sufficient electricity to power the interior lighting for the offices and storage units, exterior lighting, HVAC system, all required electrical and electronic equipment.
 3. Install new T1 line, computer network router, rack, equipment and lines to serve the four private offices and at three locations in the main office space. Contractor's option to install more lines for Contractor's use.

4. Provide potable water service to the modular office units for the bathroom, kitchen pantry fixtures and to an outdoor spigot.
 5. Site surface drainage, piped roof drainage, and sanitary piping shall connect to city sewer system in accordance with NYCDEP requirements.
- E. Landscaping:
1. The site shall be cleared, graded, paved with concrete that is designed to support vehicular loading and properly sloped for drainage. Unpaved portions of the site shall be landscaped for aesthetic appeal. No gravel shall be used as finished paving material.
 2. Follow good seeding, fertilizing, and watering procedures.
 3. Plant hedges where indicated on attached sketch SK-1.

3.02 MAINTENANCE AND REPAIRS

- A. Maintain site including:
1. Removal of debris two times per week.
 2. Remove snow and ice from site and adjoining sidewalks.
 3. Water, weed and maintain plantings and grass weekly.
 4. Replace dead shrubs in a timely manner.
 5. Maintain pedestrian paths clear and safe at all times.
 6. Clean glass on all buildings each week.
 7. Keep all buildings free of graffiti at all times.
 8. Repaint as necessary to maintain appearance of all buildings.
- B. Provide housekeeping services for new and existing MTA facilities on site twice per week including mop/sweep/vacuum floors, empty trash, clean all bathrooms.
- C. Provide office supplies as required; including printer and photocopier cartridges and paper, miscellaneous kitchen and bathroom supplies such as paper towels, toilet tissue, and soap.
- D. Maintain interior and exterior of all modular buildings for MTA's use and for Contractor's use including all necessary repairs to the constructed facilities and their mechanical, electrical and plumbing systems for the Contract duration.
- E. For the newly constructed MTA facilities, and just prior to Contract substantial completion, make repairs as necessary to restore to new condition interior and exterior surfaces of the modular units.
1. If walls were originally painted, repair and repaint interior surfaces

2. If walls are paneling or vinyl covered, repair any wall damage and/or replace wall coverings as necessary.
 3. Repair/replace damaged doors, windows; and exterior siding.
 4. Regardless of condition replace carpet throughout MTA modular units; and replace any broken or discolored floor or ceiling tile.
- F. After performing the initial site work, provide the following for the existing building:
1. Paint exterior walls and clean windows.
 2. Paint interior walls and ceiling.
 3. Furnish and install commercial grade indoor/outdoor carpet

3.03 WARRANTIES

- A. Provide 10-year warranty on roof.
- B. Provide 5-year warranty of HVAC compressor
- C. Provide manufacturer's warranties and owner's manuals on all electronic equipment and furnished items upon delivery.

3.04 SITE DEMOBILIZATION

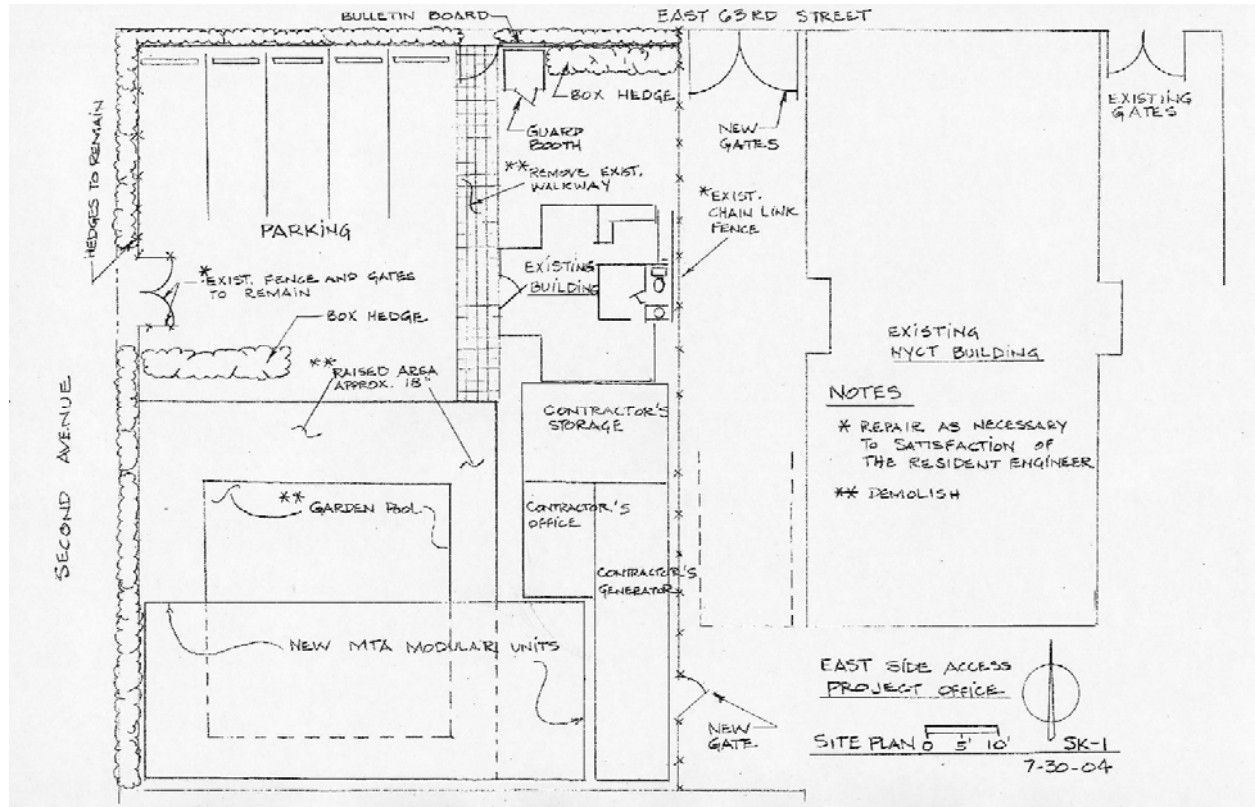
- A. Contractor shall remove Contractor's containers and any associated solid fence/siding, Contractor's equipment, fuel storage tanks, materials and tools.
- B. Cap and terminate utility services to Contractor's facilities.
- C. Restore any adjoining adjacent surfaces to existing and/or new MTA facilities that were damaged during demobilization of the site.
- D. Clear and sweep site of debris from demobilization operations.

3.05 LIST OF EQUIPMENT AND FURNISHINGS

- A. Provide equipment, furniture, warranty and maintain Contractor-provided equipment from the date of delivery to completion of the Contract. The equipment and furniture to be furnished shall be in satisfactory condition subject to the initial and continuing acceptance of the Resident Engineer. All office equipment, including accessories, supplies, maintenance and/or service contracts, furnished by Contractor, shall be handed over to the MTA upon completion of the work; and consists of the following items:

Item	Quantity
"L" Workstation, 66" X 30" desk with 42" X 24" return. Two box and two file drawers. Center drawer	8
Managerial mid back swivel/tilt chair	10
Stacking chair	12
Conference Table, 48" X 120"	1
Bookcases, metal, 34-1/2"w x 12-5/8"d x 47"h with 3 adjustable shelves	4
File Cabinet; full suspension letter size 4-drawer, 12"w x 52"h	8
Rolling vertical plan file with arms; Refrigerator with freezer compartment, 16-cubic feet	1 Each
Supply cabinet (heavy-duty, lockable, fire resistant), 18"d x 36"w x 72"h	1
Item	Quantity
Wastebasket	10
Bulletin Board, 72" X 48", metal edge, glass encased, lockable, for outdoor use	1
Whiteboard, 60" X 30", wall-mountable, with whiteboard markers and eraser	2
Digital Copy Machine, Xerox Document Centre 432 Digital Copier, or approved equal, with collator and stapler attachments, including service and supplies (toner, paper and staples) for the duration of the Contract	1
Fax Machine (telecopier), Xerox WorkCentre Pro 655, or approved equal, plain paper operated, including maintenance, service and supplies for the duration of the Contract	1
Lockers: 12" x 12" x 60"	8
Microwave; 21" TV; VCR; 20' power chord extension and TV/VCR Cart on wheels	1 Each
Hewlett-Packard Laserjet Printer 2200DN, or approved equal	4
Dell Precision Workstation 530, or approved equal, 2.4 Ghz or latest processor, 256-MB memory, 20-GB hard drive, MS Windows 2000 Professional,, 20/48X CD-ROM, 1.44-MB floppy drive, integrated 3Com 10/100 Mbps Ethernet network card, Harmon/Kardon 206 speakers and all necessary cables for network connections, power cords, surge protectors and related accessories; Dell 21" computer monitor, minimum 0.24-mm dot pitch, or approved equal	4
One high speed T-1 line and monthly service charges; necessary network ports for four computer work stations, seven phone lines with one dedicated line for a fax machine.	As noted
Phone instruments equipped for voice mail, conference call capability and intercom speakerphone, including monthly phone service charges for above services.	6

**Conceptual Layout
East Side Access Project Office
(Not to Scale)**



END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for establishing and maintaining survey control points and baselines necessary to control the tunnel alignment (vertically and horizontally) and all parts of the Work within the specified tolerances, as indicated on the Contract Drawings, Specifications referenced herein, and in other sections of these Specifications.
- B. Be responsible for the development and implementation of a surveying program capable of satisfying all Project survey and accuracy requirements. This program shall be subject to the review of the Resident Engineer before commencement of the Work. The review shall in no way release Contractor of liabilities associated with or dependent on this part of the Work.

1.02 REFERENCED SECTIONS

- A. Section 02406 – Tunnel Excavation by TBM
- B. Section 02407 – Tunnel and Cavern Excavation by Drill and Blast
- C. Section 02413 – Tunnel Boring Machine (TBM)
- D. Section 03300 - Cast-in-Place Concrete

1.03 CITED CODES, STANDARDS, AND PROJECT SYSTEMS

- A. National Spatial Data Infrastructure, Geospatial Positioning Accuracy Standards, Federal Geodetic Control Subcommittee, Federal Geographic Data Committee, Document FGDC-Std-007-1998
- B. NAD83 - North American Datum of 1983 (State Plane Coordinate System-Long Island Zone)
- C. NAVD88- National American Vertical Datum of 1988

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Planning and execution of this Work shall be supervised by a Land Surveyor licensed in the State of New York using only qualified personnel.
- B. The party chief shall have a minimum of five years experience (or as approved by the Resident Engineer) in at least two projects of similar magnitude in high-precision surveys acceptable to the Resident Engineer.
- C. As-built surveys shall be signed and sealed by Land Surveyor licensed in the State of New York.

- D. Furnish skilled labor, instrument platforms, ladders, other temporary structures, special lights or group of lights and electric power, as necessary, for making and maintaining points, lines, and grades in connection with the surveys performed by the Resident Engineer.

1.06 SUBMITTALS

- A. Qualifications of land survey supervisor(s) with detailed references made to projects requiring application of similar surveying procedures and techniques.
- B. Detailed description of proposed survey method, network diagrams, and equipment type accompanied by manufacturer's literature specifying probable accuracies, calibration procedures, requirements, and frequencies.
- C. Control station materials and methods of installation, preservation, and recovery.
- D. Mathematical pre-analysis to demonstrate that the required accuracies can be achieved using the proposed methods.

1.07 DELIVERABLES

- A. Results of all surveys and measurements and of all verification, incremental control, and recovery surveys made accompanied by updated network diagrams.
- B. A complete and accurate log of control and survey work as it progresses.
- C. As-built location survey records including, but not limited to, control diagrams, field notes, computer printouts, working sketches, and final drawings.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 SURVEY ACCURACY REQUIREMENTS

- A. It is the intent to obtain survey accuracy sufficient to ensure that the work as described on the Contract Drawings and in Sections 02406, 02407, 02413, and 03300 as determined by the survey, shall, in fact, be within the tolerances shown on the Contract Drawings and as specified.
- B. The combined errors of land and underground surveys shall result in a lateral breakthrough error (at right angle to the tunnel centerline) no greater than 1.00-foot; a longitudinal breakthrough error (parallel to tunnel centerline) no greater than 0.5-foot; and a vertical breakthrough error no greater than 1.0-foot.
- C. Tolerances of the work are specified in other Sections of these Specifications.
- D. The accuracy requirement for land survey shall be of first order.

- E. The survey shall be performed according to the following precision:
 - 1. Horizontal precision for points controlling alignment or grade, for reference points, and for benchmarks: 0.01 foot
 - 2. Horizontal precision for points defining general topography and subsurface features: 0.01 foot
 - 3. Vertical precision of points defining alignment or grade, for reference points, and for drainage structures: 0.01 foot
 - 4. Vertical precision of points defining general topography and subsurface features: 0.01 foot

3.02 SURVEY REFERENCES

- A. The Resident Engineer has established basic survey control and reference points. Examine and verify locations of survey control points, and notify the Resident Engineer of any discrepancies discovered within 48 hours of discovery and before starting the work.
- B. Establish, verify, and maintain all such additional survey points required for the work.
- C. At all times, protect, preserve, and maintain survey control points used for the work. Report to the Resident Engineer the loss, destruction, or relocation of any survey control point, and replace survey control points based on original survey control.
- D. Use equipment and implementation techniques such as forced centering at control stations as necessary to achieve required accuracies.
- E. Control datum for the survey is indicated on the Contract Drawings. The horizontal datum is the NAD83 and its associated reference ellipsoid is the GRS80. The horizontal datum for the land-based activities is the Project grid.
- F. Vertical datum is East Side Access Project Datum, which is 300.00-feet below NAVD88.
- G. The coordinate system is the New York State Plane Coordinate System, Lambert Conical Conformal Projection with the NAD83 transformation parameters.

3.03 NETWORK DESIGN

- A. Design and implement a functional underground network, and determine all required measurements and the required accuracy of each measurement including horizontal angles, zenith angles, azimuths, distances, and height differences. Include analysis of required redundancy and measure of internal reliability associated with each planned observation.

- B. Design and implement a functional surface control network, stations, positions, measurements, and accuracies. Measurements may include Global Positioning System (GPS) vectors, horizontal and zenith angles, azimuths, distances, and height differences. Include analyses of required redundancy and measure of internal reliability associated with each planned observation.

3.04 VERIFICATION

- A. Every 1,000-feet or ten instrument stations along the alignment, whichever is less, verify location and elevation using independent measurement of equal or better accuracy.
- B. The Resident Engineer may conduct its own verification from time to time. Assist the Resident Engineer in such verification, allow the Resident Engineer access to all survey points, and provide transportation for workers and materials to and from the survey point locations.

3.05 CALIBRATION AND DATA PROCESSING

- A. Calibrate all instrumentation as required and as recommended by instrument manufacturer.
- B. Data reduction shall incorporate calibrations and meteorological correction, and reduction of measurements to the ellipsoid and thence to the New York State Plane Coordinate System. Correct distance measurements by electro-optical distance measurement instrument (EODMI) for scale, cyclic error, zero error, and meteorological effects. Correct azimuths using the Laplace correction and include the effect of the deflection of the vertical components on angles and azimuth measurements.
- C. Data processing shall include least squares adjustments, as required. Employ data outlier detection. Determine horizontal and vertical confidence intervals.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for preparing and submitting operation and maintenance data for mechanical, electrical, and other specified equipment.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Proposed Operation and Maintenance Data: Format including a table of contents not less than 90 days before acceptance tests and final inspection.

1.07 DELIVERABLES

- A. Completed Operation and Maintenance Data Manual in final form 30 calendar days before acceptance tests and final inspection.
- B. Six copies of Operation and Maintenance Manual within ten calendar days after acceptance tests and final inspection.
- C. Continuous Updating Program: Furnish one copy of letter indicating suppliers have been notified to provide updated operation and maintenance data, service bulletins and other information pertinent to equipment, as it becomes available.

PART 2 PRODUCTS**2.01 GENERAL**

- A. Document Size: 8-1/2-inches by 11-inches.
- B. Paper: White bond, at least 20-pound weight
- C. Text: Printed, typewritten or word-processed.
- D. Printed Data: Manufacturer's catalog cuts, brochures, and operation and maintenance data. Clear reproductions will be acceptable.

- E. Drawings: 8-1/2-inches by 11-inches, preferably bound in with text. Larger drawings are acceptable, provided they are folded to fit into a pocket inside rear cover of manual. Reinforce edges of large drawings.
- F. Prints of Drawings: Black on white, sharp in detail and suitable for making reproductions.
- G. Flysheets: Separate each portion of the manual with colored, neatly prepared flysheets briefly describing contents of the ensuing portion.
- H. Document Covers: 40-to 50-mil thick, clear plastic, front and back covers for each manual.
- I. Bindings: Conceal binding mechanism inside manual; three-ring binders will be acceptable. Binding is subject to acceptance of the Resident Engineer.

PART 3 EXECUTION

3.01 GENERAL

- A. Assemble operation and maintenance manual using manufacturer's latest standard commercial data.
- B. Include the following information on cover and on inside cover sheet:

OPERATION AND MAINTENANCE INSTRUCTIONS

(OPERATION AND MAINTENANCE DATA OF STRUCTURE OR FACILITY)

(TITLE AND NUMBER OF CONTRACT)

(ADDRESS)

(City, State)

(General subjects of this Manual)

Contractor (or its Operation and Maintenance organization designee)

Issue Date

- C. Contents of Manual: Include following:
 - 1. Index of volumes, in each volume of multiple volume systems.
 - 2. Index, in and for each volume. List and combine the literature, for each system, in sequence of operation.
 - 3. Names, addresses and telephone numbers of Contractor, suppliers, and installers.

4. Names, addresses and telephone numbers of manufacturers' nearest service representatives.
5. Names, addresses and telephone numbers of local parts vendor and service agency.
6. Description of system and component parts.
7. Pre-operation check or inspection list.
8. Procedures for starting, operating and stopping equipment.
9. Post-operation check or shutdown list.
10. Inspection and adjustment procedures.
11. Emergency operating instructions.
12. Accepted test data.
13. Maintenance schedules and procedures.
14. One copy of each wiring diagram.
15. One copy of each piping diagram.
16. One copy of each duct diagram.
17. One copy of each accepted Shop Drawing.
18. Manufacturers' parts lists with catalog names, numbers, and illustrations.
19. Exploded view of each piece of equipment with part designations.
20. List of manufacturers' recommended spare parts, prices and quantities for two years of operation.
21. List of special tools and test equipment required for the operation, maintenance, adjustment, testing and repair of the equipment, instruments and components.
22. Scale and corrosion control procedures.
23. Dismantling and reassembly instructions.
24. Troubleshooting and repair instructions.
25. Calibration procedures.
26. Ordering information.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for sampling and analysis of soil (and other applicable materials) stockpiles using the sampling methods specified herein.
- B. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for sampling and analysis of groundwater and any wastewater as required by the New York State Department of Environmental Conservation (NYSDEC) Long Island Well Permit and/or the New York City Department of Environmental Protection (NYCDEP) Sewer Discharge Authorization as per 15 Rules of the City of New York (RCNY) Chapter 19 - Use of Public Sewers.
- C. Recommended stockpile classifications and number of stockpile samples.
- D. Suggested stockpile analytical parameters or as directed by MTA-approved disposal facility.

1.02 REFERENCED SECTIONS

- A. Section 01545 – Construction Safety and Health

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Verify that soil, other applicable site materials, and groundwater and any wastewater analytical results are consistent with applicable regulatory standards and permit restrictions.
- B. A qualified Safety Supervisor/Representative shall be present at the Work Site at all times.
- C. Display or have available at the site at all times a copy of the approved Contract-specific Construction Safety and Health Plan (CSHP) and Safe Work Plan (SWP), in accordance with Section 01545.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. NYCDEP:
 - a. NYCDEP Sewer Use Regulations - 15 RCNY Chapter 19
 - 2. New York Code of Rules and Regulations (NYCRR):
 - a. 6 NYCRR Part 360, Solid Waste Management Facilities

- b. 6 NYCRR Part 371, Identification and Listing of Hazardous Waste
 - c. New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP)
3. NYSDEC:
- a. Spill Technology and Remediation Series (STARS) Memo No. 1, Petroleum Contaminated Soil Guidance Policy, Division of Construction Management, Bureau of Spill Prevention and Response, August 1992
 - b. Technical Administrative Guidance Memorandum (TAGM) 4046 - Determination of Soil Cleanup Objectives and Levels
 - c. NYSDEC Consolidation Memo, Determination of Soil Cleanup Levels, from Michael J. O'Toole Jr., Director, Division of Environmental Remediation, December 20, 2000
 - d. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, Division of Water Technical and Operational Guidance Series (TOGS)
 - e. Record of Decision (ROD) – Amtrak, Sunnyside Yard Operable Unit 1 (OU-1): Proposed High Speed Train Facility (HSTF) Building, Queens, New York, Site Number 241006, 1997, revised in 1998
 - f. Long Island Well Permits issued to MTA and Long Island Well Permit Conditions requested by MTA
 - g. Division of Environmental Remediation – Sampling Guidelines and Protocols
4. Code of Federal Regulations (CFR):
- a. 29 CFR 1910 – Occupational Safety and Health Standards (OSHA)
 - 1) 29 CFR 1910.120 – Hazardous Waste Operations and Emergency Response
 - b. 40 CFR Part 261 - Identification and Listing of Hazardous Waste
 - c. 40 CFR Part 761 – Polychlorinated biphenyls (PCBs) Toxic Substances Control Act (TSCA)
5. United States Environmental Protection Agency (USEPA):
- a. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 42 U.S.C. s/s 9601 et seq
 - b. Resource Conservation and Recovery Act (RCRA) 42 U.S.C. s/s 321 et seq

- B. Verify that soil, groundwater, or other sampling activities are performed in accordance with applicable regulatory protocols and referenced standards and regulations referenced herein above.
- C. Verify that the MTA has approved proposed treatment or disposal facility and verify that facility has approved the sampling and analytical methods and procedures contained in this Section.
- D. Verify laboratory-provided results and documents include all requested analytical parameters prior to submission to the Resident Engineer.
- E. Contractor is responsible for assuring compliance with all applicable federal and state regulations and policies in place at the time of sample collection. This includes, but is not limited to, any state or federal modifications to the sampling or analytical methods, standards, or policies specified herein.

1.06 SUBMITTALS

- A. Submit the following for review by the Resident Engineer:
 - 1. Contract-specific SHP/SWP as required in Section 01545 and as related to proposed chemical sampling and handling of potentially hazardous and contaminated material in this Section and in accordance with applicable OSHA standards including 29 CFR 1910.120(b).
 - 2. Laboratory Qualifications: Analytical laboratory shall provide certification under the NYSDOH ELAP for all chemical analyses required.
 - 3. Sampling Plan: Sampling and analysis plan within 21 days prior to implementing sampling activities in accordance with the requirements described in this Section and cited regulatory requirements in Article 1.05.

1.07 DELIVERABLES

- A. Laboratory Data: Applicable analytical laboratory data and completed chain-of-custody forms shall be submitted to the Resident Engineer within 21 calendar days of the sampling event. The laboratory data shall accompany a drawing that depicts the sampling locations, which corresponds to the appropriate laboratory data.
- B. Laboratory data requirements shall comply with Long Island Well Permit conditions. Category B QA/QC Data Package. Deliverables shall be required.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION**3.01 STOCKPILING GUIDELINES**

- A. Classify and segregate excavated material into stockpiles for sampling as follows:

Stockpile Classification	Defined as:
Hazardous Material	Excavated material from areas where analytical results exceed Resource Conservation and Recovery Act (RCRA) and/or TSCA hazardous waste regulatory levels for at least one target compound including Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), RCRA or Total Metals, polychlorinated biphenyls (PCB), Pesticides and Herbicides.
Contaminated, Non-Hazardous Material	Excavated material from areas where analytical results exceed NYSDEC soil cleanup objectives of TAGM# 4046, or STARS Memo No. 1. for VOCs, SVOCs, RCRA Metals, Total Metals, PCB, Pesticides and Herbicides but below RCRA and/or TSCA hazardous waste regulatory levels.
Petroleum-Contaminated Material	Excavated materials from areas where field observations suggest petroleum contamination, which has not been confirmed by laboratory analysis.
Non-Contaminated Material	Excavated materials from areas where either field observations and/or analytical results do not indicate the presence of contamination as identified in the above 3 categories.
Rock/Construction Debris	Rocks which are greater than or equal to 4 inches in diameter and/or other miscellaneous construction demolition debris.
Unidentified Impacted Material	Suspected contaminated material or hazardous waste, which has not been previously identified.

3.02 SAMPLING PROTOCOL FOR SOIL

- A. Collect samples from the soil (and other applicable material) stockpiles for waste characterization purposes as directed by MTA-approved disposal facility. The recommended number of samples per stockpile is included below as directed in NYSDEC STARS Memo No 1:

Contaminant Sample Type Soil Quantity (Cubic Yards)	Semi-Volatiles		Volatiles	
	Grab	Composite	Grab	Composite
0-50	1	1	1	1
50-100	1	2	2	1
100-200	1	3	3	1
200-300	1	4	4	1
300-400	2	4	4	2
400-500	2	5	5	2
500-800	2	6	6	2
800-1000	2	7	7	2
>1000	Proposed sampling plan should be submitted to Resident Engineer for review on a site-specific basis			

- B. Samples (soil and other applicable material) shall be collected for laboratory analysis and should include a minimum of the following parameters:

Analytical Parameters	EPA Method
TCLP VOCs	8260C
TCLP SVOCs	8270C
TCLP Metals	1311/6010/7471
PCBs	8082
TCLP Pesticides	1311/8081
TCLP Herbicides	1311/8151
Ignitability	1020
Corrosivity	9045
Reactivity	SW 846, Ch.7.3

- C. Submit stockpile samples to the Laboratory for analysis by the analytical parameters suggested above or as directed by the MTA or approved treatment or disposal facility. Samples shall be submitted in Laboratory provided containers and within prescribed holding times and conditions.
- D. Furnish laboratory analytical results and copies of chain-of-custody forms to the Resident Engineer within 21 calendar days of the sampling event.
- E. Provide additional analytical results as required by the disposal or beneficial use facility.
- F. No extra payment shall be made for additional sampling and analysis for waste characterization as required by the MTA-approved treatment or disposal facility.

3.04 SAMPLING PROTOCOL FOR GROUNDWATER/WASTEWATER

- A. Collect groundwater and any wastewater samples in accordance with the conditions set forth in all applicable permits and relevant regulations including NYSDEC's TOGS, NYSDEC Long Island Well Permit Conditions and NYCDEP's 15 RCNY Chapter 19 – Use of Public Sewers.
- B. Submit samples to laboratory and analyze for parameters as specified in all applicable permits and relevant regulations.
- C. Samples shall be collected for laboratory analysis and should include a minimum of the following parameters (unless otherwise specified):

Analytical Parameters	EPA Method
TCL VOCs	624/8260B
TCL SVOCs	625/8270C
TCL PCBs	8082
TAL Metals Unfiltered	6010
TAL Metals Filtered	6010
Temperature	Standard Method (in situ)
pH	9045C (in situ)
Total Suspended Solids	160.2
Flash Point	1010

3.05 GROUNDWATER CORROSIVITY TESTING

- A. Corrosivity of the groundwater shall be measured with a probe at the face of the TBM. The groundwater parameters to be measured are Dissolved Oxygen, pH, Specific Conductance, Hydrogen Sulfide, Total Dissolved Solids, Alkalinity (Total), Sulfate, Hardness as CaCO₃ and Chloride.
- B. Do not exceed 20 sampling events during this Contract at locations directed by the Resident Engineer.
- C. Submit samples to laboratory and analyze for parameters as specified.
- D. Samples shall be collected for laboratory analysis and shall include a minimum of the following parameters:

Analytical Parameters	EPA Method
Dissolved Oxygen	In-Situ
pH	In-Situ
Specific Conductance	In-Situ
Hydrogen Sulfide	In-Situ
Total Dissolved Solids	160.1
Alkalinity, Total	300
Sulfate	300
Hardness as CaCO ₃	6010
Chloride	300

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for groundwater treatment systems to be provided by Contractor for treatment of groundwater, tunnel seepage (from both existing and tunnels constructed under this Contract), stormwater and tunneling operation process water before discharge to the New York City Department of Environmental Protection (NYCDEP) sewers, as specified herein.
- B. The Work shall consist of controlling, handling, treating, and disposing of groundwater, tunnel seepage (from both existing and tunnels constructed under this Contract), stormwater, and tunneling operation process water as required for performance of the Work as well as Work necessary to repair or replace property damaged because of groundwater disturbance.
- C. Requirements for operating, maintaining, and upgrading (as necessary) the existing groundwater treatment provided by the MTA and described in Sections 01520 and 02254.
- D. The dewatering and groundwater treatment/control system referenced in Section 02239 includes the groundwater treatment system described herein and the following elements within the proposed working areas and existing tunnels:
 - 1. Grit chambers and sumps.
 - 2. Pumping and control systems.
 - 3. Tunnel drains, inlets, and associated piping.
 - 4. Pumping stations.
 - 5. Discharge points to sewers.

1.02 REFERENCED SECTIONS

- A. Section 01520 - Construction Facilities
- B. Section 01545 – Construction Safety and Health
- C. Section 02105 - Chemical Sampling and Analysis
- D. Section 02239 – Tunnel Dewatering
- E. Section 02254- Maintenance, Protection, and Support of Existing Shafts, Tunnels, Facilities, Structures and Utilities
- F. Section 02372 – Soil Erosion and Sedimentation Control
- G. Section 02406 – Tunnel Excavation by Tunnel Boring Machine (TBM)

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Maintain access and vehicular movement within the tunnels, caverns, and chamber.
- B. Trace concentrations of petroleum products and other contaminants may be present in groundwater at various locations; these conditions are described in the Environmental Reports for the Manhattan Tunnels.
- C. Contractor is responsible for controlling the pH of the water from the tunnels, caverns, and chamber, which may be high due to Contractor's grouting or other activities involving cement.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. New York State Department of Environmental Conservation (NYSDEC):
 - a. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, Division of Water Technical and Operational Guidance Series (TOGS).
 - b. Long Island Well Permits issued to MTA and Long Island Well Permit Conditions requested by MTA.
 - 2. New York City Department of Environmental Protection (NYCDEP):
 - a. 15 Rules of the City of New York (RCNY) Chapter 19 - Use of Public Sewers.
 - 3. New York City Department of Transportation (NYCDOT)
 - 4. Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120
- B. Verify groundwater treatment systems meet discharge permit requirements for both water flow rate and water quality. Complete laboratory analysis of effluent samples using NYSDEC and United States Environmental Protection Agency (USEPA) approved methods by an Environmental Laboratory Accreditation Program (ELAP)-certified laboratory as required in Section 02105.
- C. Verify compliance with referenced standards and regulations.

1.06 SUBMITTALS

- A. Submit Groundwater Treatment System Schematic Diagram and Design Calculations, including location, description, and sizing of temporary and permanent sumps, piping, pumps, sedimentation tanks, oil/water separators, pH adjustment systems, controls, valves, instrumentation, backup equipment, and alternate power supply. Include design flow rate and removal efficiency calculations demonstrating adequacy of selected components. Design shall also include provision for installation and connection of filtration systems in the event they become necessary. The pH adjustment system design shall include the type of reagent, storage location, and delivery and protection requirements; monitoring and reagent dosing devices; and associated piping, valves, and controls.
- B. Submit Groundwater Treatment System Shop Drawings and Catalog Cuts.
- C. Submit Operation and Maintenance (O&M) Plan to include provisions for removal of accumulated oil, if any, and settled solids from collection devices and piping as well as replacement of oil absorbent materials from sumps and sedimentation tanks. The plan shall also include contingencies for changes in influent concentrations or pH, changes in influent flow rate, system component malfunction and replacement, and other foreseeable potential occurrences. The O&M Plan shall include operation, maintenance, and revision (as necessary) of the treatment system provided by the MTA. The O&M Plan shall indicate the method for monitoring pH reagent supply and associated replenishment.
- D. Submit Construction Safety and Health Plan (CSHP) and Safe Work Plan (SWP) as required in Section 01545 and pursuant to 29 CFR 1910.120 specific to the operation and maintenance of the treatment system, including provisions for handling and removal of any absorbent materials, accumulated oil, and settled solids. The plans shall include specific discussion of the pH reagent to be utilized and associated handling and spill control requirements. The plans shall also include a spill containment and control plan, which incorporates provisions for air monitoring in the working spaces of the tunnel surrounding a potential spill. Maintain copies of these plans and the overall Project Construction Safety and Health Plan for the tunneling operations regarding air monitoring and provisions for emergency evacuation, ventilation, and lighting on Work Site. Provide the telephone numbers of emergency services and Work Site personnel in chain of command to all key personnel and the Resident Engineer and post at main treatment system components. Verify tunnel communication system has been incorporated in spill response plan.
- E. Submit NYCDEP and NYSDEC Periodic Monitoring Reports (as required).
- F. Submit Groundwater Treatment System Monitoring Plan to include methods for sample collection and analysis from various treatment system components to assess influent and effluent concentrations, flow rates, and treatment system removal efficiency and in accordance with all applicable NYCDEP and NYSDEC permits. Such methods shall include state-certified laboratory analysis for Volatile Organic Compounds by EPA Method 8260 using appropriate field sample collection techniques and preservation.

1.07 DELIVERABLES

- A. Provide all permits obtained by the MTA and/or Contractor necessary to conduct groundwater treatment and discharge to City sewer.
- B. Provide proof of approval from all regulatory agencies having jurisdiction before full construction service activation.
- C. Provide permits and licenses of waste receiving facilities. Provide copies to the Resident Engineer for approval prior to any transport of waste. Such wastes shall include recovered waste oil, settled solids, and used absorbent materials.
- D. Provide local permits, as required, for storage of reagents for pH adjustment systems and provide copies to the Resident Engineer.
- E. Provide Groundwater Treatment System As-Built Drawings.
- F. Provide all system monitoring data in an approved format to the Resident Engineer within 24 hours of data collection. Data shall include but not be limited to: influent and effluent flow rates and water quality and an overall performance evaluation noting key issues such as potential equipment problems or flow rates approaching maximum equipment limits.
- G. In accordance with Section 02406, collect probe-hole in-flow measurements continuously during the operation of the TBM and provide to the Resident Engineer, in an approved format, within 24 hours of data collection. Provide this data to the treatment system operator.

PART 2 PRODUCTS**2.01 GENERAL**

- A. The groundwater treatment system shall consist of gravity settling tanks, oil/water separators, filtration, pH adjustment, carbon absorption, or other industry accepted treatment system components necessary to handle all water encountered and generated during the construction and to meet applicable discharge limits established in the NYCDEP 15 RCNY Chapter 19. Operate all equipment on a 24-hour continuous basis; provide necessary equipment to facilitate repair and service of each system component without disrupting overall system operation. The groundwater treatment system includes the existing groundwater treatment facility provided by the MTA.
- B. Reinforced concrete slab, or equivalent solid surface to place groundwater treatment system equipment (as required).
- C. Protect all equipment exposed to the weather from freezing through such methods as heat-tape with insulation, air circulators, or covered buildings.
- D. Heating and ventilation system, lighting, water supply and all other necessary amenities to treatment building (as required).
- E. Provide power (and back-up emergency power) for all pumps and controls as well as treatment system building (as required).

- F. Piping and all other accessories to bring groundwater from the Work Site to the treatment system and from the treatment system to the city sewer.
- G. Valves, sampling ports, meters, gauges, controls, and control panels, as needed for the treatment system and associated pumps. Locate all meters, sampling ports, and gauges at sufficient distance from piping bends, tees, and valves as suggested by the manufacturer for accurate measurements.
- H. Hydrophobic petroleum absorbent pads, socks, and booms of sufficient size and durability for use in construction dewatering environments (high flow, high solids); manufactured by 3M, SPC, or approved equal. Provide ropes, ties, and other connectors for easy retrieval and also to secure the absorbent materials to sump or sedimentation tanks and prevent contact with pump intakes or effluent piping.
- I. Provide watertight containers for collection and removal of used absorbent materials. Containers shall comply with the NYCDOT requirements for transport via tunnel vehicles or conveyance systems as well as surface transport requirements.
- J. A pH adjustment system, as required to meet the discharge limits. Provide secondary containment and weatherproof enclosures for storage of acid reagents, if utilized. The system shall incorporate pH monitoring, reagent metering, dosing, and mixing devices as necessary to assure compliance with the discharge limits. Acid-based systems shall include non-metallic piping from the reagent dosing through the mixing stages of the water treatment stream. Mixing tanks and internal components shall also be of non-metallic materials.
- K. Contractor's groundwater treatment system design shall provide, to the satisfaction of the Resident Engineer, sufficient back-up capacity in the event of essential treatment system equipment malfunctions or temporary maintenance shut downs are necessary. Sufficient back-up capacity shall be demonstrated by Contractor through installed parallel treatment trains; storage of spare equipment on Work Site to effect prompt repair of the treatment system; or by on-call service agreements with approved subcontractors to provide temporary treatment capabilities.

PART 3 EXECUTION

3.01 PREPARATION

- A. Submit to the permitting authority the information required in the special condition section of the permit. The analytical screening requirements for groundwater are outlined in Section 02105. Dewatering and discharging activities may only commence upon the approval by the permitting authority under the general permit requirements and any additional Project-specific conditions.

- B. Design, install, operate, and maintain a groundwater treatment system to reduce identified contaminant concentrations and concentrations inherent to the construction activities (such as high pH levels from grouting operations) to required levels stipulated in applicable discharge permit(s) from the NYSDEC and/or NYCDEP.

3.02 DESIGN

- A. Design the groundwater treatment system to meet discharge criteria as stipulated in the applicable NYSDEC or NYCDEP discharge (and/or effluent limitations) permits and supplemental requirements as may be stipulated in these permit(s). The groundwater treatment system shall also meet applicable Long Island Well Permit requirements.
- B. Design the groundwater treatment system to operate continuously, without interruption and provide adequate removal efficiency to meet the discharge permit requirements. The system must not, in any way, cause any delay in water removal from the tunnel segments and must, at all times, be capable of handling all water encountered and generated during the Project. Design the system to provide backup for key system components that may require periodic isolation for maintenance and/or repair. The system design shall also consider the effects of potential variability in flow rate and contaminant, pH, and metals concentrations. The use of duplicate or multiple smaller treatment units (i.e. sedimentation tanks, oil/water separators, and pH adjustment systems) running in parallel may be considered on the basis of meeting the variable system flows and avoiding overall system failure.
- C. Construct all sedimentation tanks, oil/water separators, pH adjustment systems, and oil collection tanks of industry-accepted materials for use in heavy equipment, high flow, high solids, outdoor environments. Sedimentation tanks and oil/water separators shall be of sufficient size to handle the flow rates and provide sufficient residence time within the tanks for settlement of solids and separation of oil. Install all inlet and outlet piping to maximize the residence time and minimize flow through or short-circuiting. Design tanks for easy removal of oil absorbent materials, oil, and settled solids.
- D. The incorporation of a pH adjustment system may be necessary to reduce the pH of seepage water from grouted and cemented areas of the tunnel construction. The reference drawings include a typical pH treatment system. Acid-based systems shall include provisions for secondary containment for acid storage and downstream monitoring to assure the pH is within the acceptable range. The system shall include mixers of sufficient size and design to assure adequate mixing of reagent and water stream at the water flow rates encountered. The reference design includes automated controls for pH monitoring and corresponding reagent delivery; such controls are recommended to minimize reagent usage and contractor labor costs while also assuring compliance with discharge limits.
- E. Any and all additional system components such as filtration systems, metals sequestering systems, and carbon adsorption units shall be of sufficient size to handle the flow rates and provide sufficient treatment. Design of all such components shall meet the 100-percent continuous operation requirements of the treatment system.

- F. Design the groundwater treatment system components (i.e. pumps, piping, etc.) within the tunnel segments to minimize potential volatilization of contaminants out of the water and into the air of the tunnels. Cover all interim sumps to the extent possible to minimize migration of vapors from the water. The use of open-top or uncovered sedimentation ponds or tanks within the tunnel is discouraged for these reasons.
- G. Verify installation complies with manufacturer's instructions and standards.
- H. The design shall also consider the presence of various metals, including iron, manganese, sodium, and calcium in the groundwater. The presence of these metals in water passing through the treatment system may cause precipitates and scaling requiring treatment system maintenance. Conduct the installation or use of metals filtering or sequestering systems in accordance with the Work Site permits and all applicable local, state, and federal regulations and discharge limits. Design all sumps and pumping systems to minimize the intake of solids into the system piping and components.
- I. At a minimum, the design shall incorporate meters and sampling ports for the measurement of flow rate, total flow, and influent and effluent concentrations. Electronic automated data recorders are recommended to reduce labor costs and provide continuous monitoring to assure compliance with discharge limits.
- J. Overflow alarms are required on deep sump pits, sedimentation tanks, and oil collection tanks. Set alarms below the overflow levels with sufficient warning to treatment system operator for preventing spillage.

3.03 INSTALLATION

- A. Locate, operate, and maintain the groundwater treatment system and associated components such that all utilities within the area are protected from damage.
- B. Protect all benchmarks, survey control points, boring locations, monitoring wells, and piezometers from damage or displacement during groundwater treatment activities at the Work Site.
- C. Protect any on-site drainage basins, outfalls, and connections thereto from damage, accumulation of silts, sediments or other solids from groundwater conveyed within or discharged from the Work Site in accordance with Section 02372.
- D. Protect all treatment system equipment, especially in tunnel areas, from damage from passing vehicles and conveyance equipment.
- E. Install and maintain erosion and sedimentation controls around all sumps to limit sediment infiltration of the sumps.
- F. Install the sump pit pumps, piping, sedimentation tanks, oil/water separators, and oil collection tanks.

- G. Install inlet piping to sedimentation tanks to maximize the flow pathway (i.e. residence time) within the tank for settling of solids. Fit the outlet pipe with a strainer and placed above the bottom of the tank to allow for settled solids containment. The use of baffles or weirs within the tank will further provide for solids containment.
- H. All system components, piping, and connections shall be water-tight. All sump, pump, and piping configurations shall be made to minimize the release of vapors from system components within the tunnel areas; such configurations shall include, but not be limited to, covering sumps and interim sedimentation basins within the tunnel.
- I. Install all level alarm controls securely. Wire level alarms for automatic switching to back-up power in the event of standard power failure.
- J. Install posts and connections on sump pits and sedimentation tanks as necessary for retrieval and securing of absorbent materials within these units. Install all connection points, and lengths of ropes and ties to absorbent materials to prohibit contact of absorbent media with pump inlets and effluent piping.
- K. Place a supply of absorbent pads and booms for spill containment and control near all sedimentation basins and tanks; similar emergency spill control kits are recommended at sumps and interim sedimentation basins within the tunnel.
- L. Locate the reagent storage for the pH adjustment system in a secure low-traffic area and protected from damage from passing equipment. Acid storage areas shall have secondary containment and appropriate ventilation and signage. Reagent storage shall be in close proximity to the treatment system to minimize piping. Protect all reagent piping and controls from damage and weather conditions.

3.04 START-UP AND TESTING

- A. Operate the groundwater treatment system in accordance with manufacturer's operating procedures and applicable permit requirements.
- B. Conduct initial treatment system start-up and testing to verify compliance with discharge limitations. Analysis of the groundwater treatment effluent must be provided and acceptable to the Resident Engineer before full system activation.
- C. Provide the requisite personnel with appropriate training and certification to operate the groundwater treatment system as required in the discharge permit(s).
- D. Maintain the treatment system and its various components in accordance with the manufacturers' recommended maintenance routines and procedures.
- E. Reagent dosing levels for pH adjustment shall be set based on initial measurements, but also to provide for precipitation events (dilution, lower influent pH) and worst-case conditions (limited dilution, higher influent pH). The reference design includes automated controls to activate reagent dosing for high influent pH levels and increase dosing if effluent pH indicates additional reagent is necessary. Adjust the dosing level settings accordingly based on actual influent flow rates and pH levels. While the pH levels will vary due to construction grouting and cementing activities and periodic dilution from precipitation and

run-off events, Contractor is responsible for adjusting the reagent dosing levels to assure compliance with the discharge limits during all flow conditions.

3.05 OPERATION

- A. Operate the groundwater treatment system in accordance with manufacturer's operating procedures, design considerations, and applicable permit requirements.
- B. Keep a Groundwater Treatment System Log Book to document all measurements of system performance including flow rates, pH, temperatures, concentrations, and total volumes. Incorporate printouts from any electronic data recorders into the Log Book.
- C. Provide the requisite personnel with appropriate training and certification to operate the groundwater treatment system as required in the discharge permit(s).
- D. Maintain the treatment system and its various components in accordance with the manufacturers' recommended maintenance routines and procedures.
- E. Inspect system components daily for the presence of oil, ice, settled solids accumulation, flow rates, and effluent color and appearance. Clean and replace system components and re-inspect as needed.
- F. Remove settled solids upon significant accumulation (i.e. 10- to 20-percent of sedimentation tank volume). Handle solids in accordance all applicable Federal, State, and local regulations. Similarly, maintain the erosion controls around the sumps and deep sump pits to limit sediment infiltration of the sumps, and remove any sediment in the sumps as needed. Diligent recovery and removal of settled solids from the temporary drainage system components (all interim sumps and finally the sedimentation tank) by Contractor will reduce the pH buffering capacity of the drainage water and associated use of pH reagent.
- G. Remove oil from all sumps and collection tanks. Maintain and replace oil absorbent pads and/or booms as necessary in the influent side of all sedimentation tanks and as necessary in sumps or interim sedimentation basins. Handle any accumulated oil in accordance with all applicable Federal, State, and local regulations for waste oil disposal. Remove absorbent materials and replaced as necessary and properly containerized and disposed. Maintain the supply of absorbent pads and booms for spill containment and control at all sedimentation basins and tanks, and re-stock, as needed; with similar emergency spill control kits is recommended at sumps and interim sedimentation basins within the tunnel.
- H. Monitor pH reagent supply levels and refill as needed. Monitor the effluent pH as required by the discharge permit and adjust reagent dosing levels as necessary. The pH adjustment system may cause precipitation of cement compounds and other metallic scaling on the mixers, mixing tank, downstream piping, and monitoring probes; maintain or replace as necessary.
- I. Install and operate additional treatment components as necessary to maintain the flow rates necessary for de-watering and to assure compliance with the effluent limitations. Such components may include, but are not limited to, additional sedimentation tanks, metals removal or sequestering systems, carbon adsorption units, or complete additional treatment lines for increased flows.

- J. Provide adequate ventilation of treatment system building/enclosure, if installed, especially during system maintenance. Repair any liquid or vapor leaks in equipment and piping. Keep all openings to the sedimentation tanks and other components closed.

3.06 TRANSFER OF EQUIPMENT

- A. Transfer the operating groundwater treatment system together with all instrumentation to the MTA upon completion of this Contract.
- B. The groundwater treatment system and all instrumentation shall remain in place upon Substantial Completion and ownership of all components of the groundwater treatment system and all instrumentation including, but not limited to the instruments, readout units, and special equipment provided for maintenance of the instrumentation shall be transferred to the MTA at that time.
- C. The groundwater treatment system and the instrumentation will be required for long-term use up to ten years. At the time of transfer, all components of the groundwater treatment system and the instrumentation shall be in good condition and satisfactory operation condition. Before the transfer of ownership, Contractor's groundwater treatment personnel in charge of the system and instruments shall inspect all equipment to be transferred. Replace non-functioning and poorly functioning equipment before transfer and prove proper functioning of all components of both the groundwater treatment system and the instrumentation to the satisfaction of the MTA.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all work necessary for demolition and removal of existing structures specified herein below within the 63rd Street Tunnel structure.
- B. The Work shall include, but not be limited to, the following:
 - 1. temporary removal of metal grating walkway including supports at 12th Street, if it is in interference with Contractor's operations;
 - 2. removal of three steel beams attached to the ceiling at 12th Street;
 - 3. demolition and removal of the Control Room LIRR Temporary Ventilation Plant located at Second Avenue and East 63rd Street inside the underground enclosure identified as LIRR traction power substation, which is a vacant facility. Remove and dispose of all equipment in the Control Room including conduits leading to the LIRR fan work area and to the service end box beneath the 63rd Street ventilation gratings. Remove and dispose of the air duct, including an exhaust fan, leading from the Control Room to the 63rd Street ventilation gratings. Remove CMU wall, as required, for construction power conduits;
 - 4. partial removal of the floor slab and installation of temporary support directly above LIRR track at existing First Avenue cable vault and cross passageway; and
 - 5. demolition of the existing structure of the Bellmouth at the 63rd Street Tunnel (Queens access Work Site).

1.02 REFERENCED SECTIONS

- A. Section 01160 – Work Affecting the Railroad
- B. Section 02254 – Maintenance, Protection, and Support of Existing Shafts, Tunnels, Facilities, Structures, and Utilities
- C. Section 10290 - Rodent Control
- D. Section 13280 - Lead Paint Management

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. No blasting will be permitted for any demolition items.

- B. No demolition of the floor slab above the LIRR trackway at First Avenue until Contractor's Shop Drawings on temporary support have been reviewed by the Resident Engineer.
- C. Protection and Restoration: Prevent damage to pipes, conduits, wires, cables, and structures within the 63rd Street Tunnel structure that are not designated for removal. Repair or replace damaged items.
- D. See Section 01160 for coordination requirements with NYCT during Bellmouth wall demolition.
- E. See Section 02254 for further maintenance and protection requirements.
- F. See Section 13280 for lead paint management before removal of steel beams at 12th Street.
- G. Before demolition of LIRR temporary ventilation plant control room, Contractor's temporary ventilation system must be operational.

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Submit the following documentation 30 days before start of demolition work:
 - 1. Plan including construction sequence for demolition and reconstruction works.
 - 2. Permits and releases from each owner of property where demolition debris shall be deposited absolving the MTA of responsibility in connection with such disposal.
- B. Shop Drawings: Indicate demolition and removal sequence; and location and construction of barricades, fences, and temporary work including temporary support. Drawings and design calculations shall be prepared by a Professional Engineer licensed in the State of New York.
- C. Describe demolition removal procedures.
- D. Closeout procedures.

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION**3.01 PREPARATION**

- A. Provide, erect, and maintain temporary facilities as needed to perform the demolition work for protection of the MTA and Contractor's employees.
- B. Protect appurtenances and structures that are not to be demolished.

3.02 PROCEDURES

- A. Construct, maintain, and remove, upon completion of the Work, temporary structures, where required, for protection of the MTA and Contractor's employees in accordance with applicable codes to ensure a safe working environment.
- B. Conduct demolition with minimum interference with adjacent structures.
- C. Cease operations immediately if adjacent structures appear to be in danger. Notify the Resident Engineer. Do not resume operations until directed by the Resident Engineer.
- D. Sprinkle Work with water to minimize dust. Provide hoses and water connections for this purpose.
- E. Keep traffic areas free from debris and spillage of materials.
- F. Continuously clean up and remove demolished materials from the Work Site. Do not allow materials to accumulate within the 63rd Street Tunnel structure or on the Work Site.
- G. Do not burn or bury materials on site. Leave Work Site in clean condition.

3.03 SCHEDULE

- A. Remove items as follows:
 - 1. Remove debris resulting from demolition work off-site.
 - 2. Dispose of debris off-site only with permission of the MTA where such debris is to be deposited and in accordance with Federal, State, and local codes and regulations of authorities having jurisdiction.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations and design necessary for dewatering to control groundwater of the existing tunnels and during construction of the tunnel, cavern, and chamber sections as indicated on the Contract Drawings and as specified herein.
- B. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for excavating tunnel sections by TBM are specified in Section 02406. Excavation of the tunnel, cavern, and chamber sections, consisting of the TBM Assembly Chamber and adjoining Starter Tunnels, GCT 5 Wye Caverns and adjoining Starter Tunnels, GCT 3 Wye Caverns, Cross Passages, Central Instrument Room, and Cross Flue are specified separately in Section 02407.
- C. Specific requirements for treatment of groundwater prior to discharge are specified in Section 02145.

1.02 REFERENCED SECTIONS

- A. Section 02105 - Chemical Sampling and Analysis
- B. Section 02145 - Groundwater Treatment System
- C. Section 02406 - Tunnel Excavation by TBM
- D. Section 02407 – Tunnel and Cavern Excavation by Drill and Blast
- E. Section 02495 – Geotechnical and Structural Instrumentation
- F. Section 03605 - Tunnel Grouting

1.03 CITED STANDARDS

- A. American Water Works Association (AWWA):
 - 1. C704 - Flow Meters

1.04 NOTED RESTRICTIONS

- A. Subsurface site conditions, including groundwater conditions, are described in the Geotechnical Baseline Report (GBR) and the Geotechnical Data Report (GDR) for the Manhattan Tunnel Alignment.
- B. Maintain train, pedestrian, and vehicular traffic.
- C. Groundwater and other effluent treatment requirements shall be in accordance with Section 02145.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. New York City Department of Environmental Protection (NYCDEP):
 - a. 15 Rules of the City of New York (RCNY) Chapter 19 – Use of Public Sewers
 - 2. New York State Department of Environmental Conservation (NYSDEC):
 - a. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, Division of Water Technical and Operational Guidance Series (TOGS)
 - b. Long Island Well Permits issued to MTA and Long Island Well Permit Conditions requested by MTA
- B. Assign only personnel having a minimum five years experience (or as approved by the Resident Engineer) in tunnel dewatering and groundwater treatment/control systems that includes groundwater treatment design and operations as presented herein and in Section 02145. Supervisor(s) assigned to oversee the Work shall have a minimum of five years experience (or as approved by the Resident Engineer) being in charge of dewatering similar to the Work proposed herein.
- C. Provide necessary upgrade of the existing groundwater treatment system provided by the MTA as specified in Section 02145.

1.06 SUBMITTALS

- A. Before installation of dewatering and groundwater treatment/control system, submit working drawings and design data showing the following items within 30 days following Notice to Proceed for review by the Resident Engineer:
 - 1. Submit employment and work experience records of above specified person(s). Do not commence dewatering work until workforce qualifications have been reviewed by the Resident Engineer.
 - 2. Design calculations demonstrating adequacy of the selected upgrade of the existing dewatering system and equipment to achieve dewatering and groundwater treatment in accordance with the requirements of Section 02145. The calculations shall be signed and sealed by a Professional Engineer licensed in the State of New York.
 - 3. Arrangement, location, and depths of components of system(s) in accordance with Section 02145.
 - 4. Complete description of equipment and materials to be used, with installation, operation, and maintenance procedures in accordance with Section 02145. Submit operation and maintenance manuals for all equipment furnished.

5. Standby equipment and power supply.
 6. Location and size of berms, dikes, sediment removal ponds, observation wells, sumps and discharge lines, including their relation to discharge locations (manhole connecting to City sewer system) in accordance with Section 02145.
 7. Procedures for cleaning and disposal of sediment to be removed from sediment removal ponds and settling basins, and floating matter and grit or other settled matter from oil/water separators in accordance with Section 02145.
 8. Types and sizes of groundwater treatment system components, in accordance with Section 02145.
 9. Instrumentation and monitoring including flow meters and other measuring devices, and water, soil and rock particle content sampling outlets to be installed on the dewatering system(s), including calibration procedures for each measuring device and instrumentation.
 10. Submit product data including manufacturer's catalogs, material specifications, installation instructions, performance characteristics, and other pertinent data for all manufactured components used in the dewatering and groundwater treatment system.
 11. Design calculations demonstrating adequacy of the selected dewatering system and equipment to achieve dewatering and groundwater treatment in accordance with Section 02145. The calculations shall be signed and sealed by a Professional Engineer licensed in the State of New York.
 12. Copies of all necessary permits obtained by Contractor to conduct dewatering and sediment disposal in accordance with Section 02145.
 13. Obtain approval from regulatory agencies having jurisdiction and notify the Resident Engineer before full construction service activation.
 14. Resubmit the above information, as appropriate, if the system or system components are modified during installation or operation.
 15. Copy of NYCDEP discharge permit.
- B. If the Work is to be subcontracted, submit within 30 days following Notice to Proceed, Subcontractor's name, qualifications, and evidence of work previously performed of an equal nature. Do not commence dewatering work until Subcontractor has been accepted by the Resident Engineer. The following criteria shall be met:
1. Subcontractor shall have a minimum five years recent continuous experience (or as approved by the Resident Engineer) performing tunnel dewatering/groundwater control work similar to that specified herein.

2. Substantiate this experience with a minimum of five case histories of major projects comparable to this Project within the past ten years, and successfully completed.

1.07 DELIVERABLES

- A. As-built drawings and operation and maintenance (O&M) manuals for all systems and system components to be left in place, and to be handed over to the MTA by Substantial Completion.
- B. Provide data and records as specified herein elsewhere.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Equipment for Monitoring Soil and Rock Particles in Discharge Water: Furnish to the Resident Engineer a Rossum Sand Content Tester as manufactured by Roscoe Moss Company, or approved equal.
- B. Dewatering: When water is known or expected to be encountered, and Contractor has chosen sump pumps, then pumps of sufficient capacity to handle the flow shall be maintained at the Work Site. When operating, sump pumps shall be monitored on a 24-hour basis.

PART 3 EXECUTION

3.01 GENERAL

- A. The Work shall consist of the collection and removal of water from the existing tunnels and the new tunnel, cavern and chamber excavations, treatment of the collected groundwater to meet permit requirements for discharge, and discharge of the treated water in accordance with permit requirements. The dewatering and groundwater treatment/control system shall be operational at all times during the course of the construction including holidays and weekends and during periods of work stoppages, and shall have adequate backup systems to accomplish control of water.
- B. For operation, maintenance, and protection of NYCT-owned permanent groundwater control systems, refer to Section 02254.
- C. The method of control, handling, and disposal of groundwater shall be by whatever means are necessary and in conformance with the provisions of this Section, and to obtain satisfactory working conditions and maintain the progress of the Work. All applicable permit conditions and regulations shall be followed.

- D. All required drainage, pumping, and disposal shall be done without damage to adjacent property or structures, and without interference with the operations of other contractors, or the rights of public and private property owners, or pedestrian and vehicular traffic. Modify the dewatering and groundwater treatment/control system at no cost to the MTA, if after installation and while in operation, it causes or threatens to cause damage to adjacent property or to existing buildings, structures, or utilities.
- E. Promptly repair to the Resident Engineer's satisfaction, any damage, disruption, or interference to adjacent property, existing buildings, structures and utilities resulting directly or indirectly from dewatering operations at no cost to the MTA.
- F. Design Requirements:
 - 1. Provide a dewatering and groundwater treatment/control system that will:
 - a. be capable of controlling the maximum potential instantaneous tunnel face inflow and sustained groundwater inflows in the excavations, as described in the GBR, construction service water, as well as water inflows in the existing tunnels. The system must be effective in keeping the muck transportation equipment/system, the drill-and blast equipment, and TBM operational without shutdown, or damaging components of such equipment.
 - b. be compatible with existing dewatering systems.
 - c. provide the groundwater treatment specified in Section 02145, with a system handling capacity appropriate for, or exceeds, the inflow estimates as given in the GBR. The groundwater treatment system shall meet NYCDEP effluent limitations.
 - 2. Locate groundwater treatment and flow discharge facilities where they will not interfere with utilities and construction work to be performed by others.
 - 3. Modify dewatering procedures that cause, or threaten to cause, damage to new or existing facilities. Determine and make the modifications necessary at no additional cost to the MTA.
 - 4. Comply with the requirements of Federal, State, and local requirements, regulations, ordinances governing the discharge of construction water. Obtain necessary permits from NYCDEP for discharging into City sewer system.
 - 5. Provide separate measuring devices at probe holes, at the TBM face, at the portal of each tunnel and cavern excavation, and at other such locations as may be required for the conduct of the Work and as required to document instantaneous and sustained groundwater inflows for tunnel sections identified in the GBR.
 - 6. Monitor the discharge of the system with totalizing type water flow meters conforming to AWWA C704, reading in cubic feet or gallons, and meeting the requirements specified herein.

7. For the discharge components of the dewatering systems, provide a configuration that meets the water flow meter manufacturer's requirements for lengths of straight discharge pipe upstream and downstream of the flow meter. Placement of the flow meters shall provide for an unobstructed view of the flow meter duct for monitoring purposes, and the flow meter shall be protected from damage and vandalism.
8. Provide dewatering systems that include on each discharge line, a valve controlled bypass that will permit samples to be taken for soil and rock particle content determinations and chemical analyses of treated groundwater.

3.02 PREPARATION

- A. Determine the existing groundwater elevations, patterns, permeability rates characteristic of the local subsurface geologic profile, and potential fluctuations in order to satisfactorily plan and provide material and equipment for an adequate dewatering system.
- B. Assume operation, maintenance, control of existing dewatering systems at the Queens open-cut. Modify and upgrade the existing system, as necessary, and as required.
- C. Permits: Make arrangements with the governing agency for permission to discharge pumped water into the existing drainage systems after the flow has passed through the groundwater treatment system specified in Section 02145 and shown on the Reference Drawings. Before discharging more than 10,000-gallons per day of water from all dewatering systems used for the Work under this Contract into storm sewers, obtain a discharge permit from the NYCDEP as required by 15 RCNY Chapter 19.

3.03 MONITORING

- A. Monitor the quantity of soil and rock particles in the water discharged from dewatering systems during construction using testing equipment specified herein. Data obtained from soil and rock particle content measurements shall be submitted to the Resident Engineer.
- B. Monitor the groundwater quality before and during dewatering operations. Groundwater samples shall be collected for chemical analysis provided in Section 02105 and in conformance with all applicable Federal, State, and local permit requirements.
- C. Provide access for the Resident Engineer to all flow meters installed and maintained for the dewatering system(s). The Resident Engineer will take frequent and random readings of the flow meters independent of Contractor's readings. The Resident Engineer's data will be available upon request.
- D. Observe the dewatering system in operation and record the discharge volume, average flow rate, and the time of operation of each pump used in the system. Submit data on an accepted form.

- E. Dispose of all groundwater collected by dewatering operations in accordance with Federal, State, and local agency permits. Submit copies to the Resident Engineer of any data required by the permits. A record of discharges on a daily basis shall be made and provided to the Resident Engineer.
- F. Check the calibration of all flow meters at least once a month. Record the data of these calibration tests and submit to the Resident Engineer. Replace or repair within 48 hours any flow meter that is found to be working improperly.

3.04 INSTALLATION

- A. Select necessary upgrade of the existing dewatering and groundwater treatment/control system and install a dewatering system designed to successfully execute all excavation work under this Contract. Install dewatering and groundwater control system(s) in accordance with reference drawings. Groundwater treatment systems must control amount of soil and rock particles to enable the system to be functional and the discharges to meet permit requirements.

3.05 OPERATION

- A. Dewatering:
 - 1. Maintain continuous and complete effectiveness of the dewatering and groundwater treatment/control system installation. Comply with all requirements of all agencies having jurisdiction.
 - 2. Dispose of pumped water from the excavations and dewatering and groundwater treatment/control systems, in accordance with the following requirements:
 - a. The discharge point for the dewatering and groundwater treatment/control system is the discharge sump pit at the Queens open-cut.
 - b. All groundwater removed from the Work Site shall be discharged through pipes. The conveying of groundwater in open ditches or trenches will not be allowed. Groundwater shall be discharged in a manner that will not cause soil erosion at the discharge point.
 - c. Control discharge of water so that quantity is not greater than the limits set in permits from governing agencies.
 - d. Quality of discharge water must comply with permit conditions. Use settling tanks, filtration, activated carbon absorbers, and/or other acceptable treatment processes, in accordance with the requirements of Section 02145, to obtain quality required by permits and as specified herein.

- e. Clean the sediment removal ponds or settling basins to maintain sedimentation capability and dispose of sediment in accordance with Contractor's reviewed submittal and Section 02145. Discharge from settling basins or ponds shall not cause siltation or flooding in any stream, storm sewer, or on adjacent properties. Settling basins shall be cleaned of solids as necessary to maintain efficiency.
 - f. Dispose of precipitation and subsurface water away and clear of the work area.
 - g. Prevent surface drainage from flowing onto adjacent streets.
 - h. Provide water to flush sewers and drains.
 - i. Promptly remove deposits from sewer, drain, catch basin, or gutter receiving pumped water from the Work Site, partially or entirely filled with sediment.
- 3. Provide to the Resident Engineer any schedule or information concerning any proposed changes in the status of dewatering system and groundwater treatment components that are essential to the Resident Engineer to schedule the necessary instrumentation readings.
 - 4. Discharges to the City sewer system shall meet the requirements of the NYCDEP 15 RCNY Chapter 19 - Use of Sewers.
 - 5. All oily waters shall be collected and provided adequate treatment through an oil/water separation device before discharge to public waters or storm sewers leading to public waters or water treatment facilities in accordance with Section 02145. Floating matter and settled matter shall be removed as necessary from oil/water separation devices to assure their efficient operation at all times. All floating matter and grit or other settled matter removed from the oil/water separator or otherwise collected at the Work Site shall be disposed of in accordance with Contractor's reviewed submittal.

3.06 TRANSFER OF EQUIPMENT

- A. Transfer the operating dewatering and groundwater treatment/control system to the MTA by Substantial Completion, including, but not limited to, the following:
 - 1. The dewatering, groundwater treatment/control, and flow discharge systems including pumps in the completed tunnel, cavern, and chamber excavations.
 - 2. All geotechnical instrumentation used for monitoring the performance of the dewatering system and the response of the Project area and adjacent areas to construction operations.
 - 3. All documentation regarding installation, operation, and maintenance of all dewatering system components, measuring devices, and geotechnical instrumentation.

- B. The entire dewatering system shall remain in place upon completion of this Contract and ownership of all components of the dewatering system shall be transferred to the MTA by Substantial Completion. The amount of water being pumped, as measured at the final discharge point from the Work Site shall be in accordance to the limits specified in Section 03605.
- C. The dewatering and groundwater control system(s) will be required for long-term use up to ten years. At the time of transfer, all components of the dewatering and groundwater treatment system shall be in good condition and satisfactory operation condition. Before the transfer of ownership, Contractor's dewatering personnel in charge of the system shall inspect all equipment to be transferred jointly with the Resident Engineer. Non-functioning and poorly functioning equipment shall be replaced before transfer and Contractor shall prove proper functioning of all components of both the dewatering and groundwater treatment system to the satisfaction of the MTA.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment and performing all operations necessary to maintain, protect, and support existing shafts, tunnels, facilities, structures, and utilities in the vicinity of the Project affected by the Work hereunder.

1.02 REFERENCED SECTIONS

- A. Section 01160 - Work Affecting the Railroad
- B. Section 01520 - Construction Facilities
- C. Section 01555 – Maintenance and Protection of Traffic
- D. Section 02290 - Environmental Monitoring
- E. Section 02495 – Geotechnical and Structural Instrumentation
- F. Section 03300 - Cast-in-Place Concrete
- G. Section 05120 - Structural Steel

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Employ a superintendent for this Work with experience in responsible charge of similar operations immediately preceding start of construction.
- B. Provide upgrade of existing groundwater treatment system at the Queens open-cut. Upgrading work shall be designed by a Professional Engineer licensed in the State of New York.
- C. The Work shall be in conformance with applicable Federal, State, and local regulatory requirements.
- D. Take all necessary precautions for the protection of personnel and perform the Work in a manner to prevent settlement of, or damage to, adjacent roadways, sidewalks, walls, utilities, ducts, sewers, facilities, shafts, tunnels, foundations, and structures on the properties contiguous to the Work Site.

1.06 SUBMITTALS

- A. Qualification: A minimum of 60 days before commencement of the Work, submit documentation for review to the Resident Engineer demonstrating that the assigned superintendent proposed to perform the work items covered by this Section, meet requirements specified herein.
- B. Shop and Working Drawings: A minimum of 45 days before commencement of the Work, submit the shop and working drawings for review to the Resident Engineer. Shop and Working Drawings shall include, but not be limited to, the following:
 - 1. Method, staging, and necessary details for maintenance, protection, and security measures including existing track, which will remain in place.
 - 2. Proposed modifications to LIRR facility, rooms, shaft, and plenum areas within the existing MTA 2nd Avenue Ventilation Building.
 - 3. Computations: Submit design computations to support Shop and Working Drawings.
 - 4. Copies of permits required and to be obtained by Contractor.

1.07 DELIVERABLES

None Listed

PART 2 PRODUCTS

- A. Provide materials conforming to the requirements of Section 03300 and 05120 of the Specifications for each system for which they are required or, if not specified, conform to the requirements of the respective utility or building owner.
- B. All lumber and plywood used for the protection of existing structures and facilities must be fire retardant.

PART 3 EXECUTION**3.01 GENERAL REQUIREMENTS**

- A. Verify in the field all dimensions, locations, and elevations of existing structures shown on the Contract Drawings, on as-built drawings and/or data supplied by the Resident Engineer on existing facilities, structures or installations before commencement of any Work that may require modification of these facilities. Notify the Resident Engineer of any discrepancies that may exist before performing related work.
- B. Assume financial responsibility for repairs to be made by the utility company for damage caused by Contractor's operation. Do not make repairs to utility facilities without written direction from the Resident Engineer and facility owner.

- C. If any structure is damaged by Contractor, it shall be repaired by replacement with the same materials in place, subject to the approval of the owner and the Resident Engineer, and at the expense of Contractor.
- D. Notify the Resident Engineer and the utility owner of utilities that are not indicated on the Contract Drawings or marked in the field.
- E. Permit utility owners, and personnel engaged by them, access to the Work Site of the work in order to maintain, relocate or inspect their facilities, and cooperate with them in performing this work. Allow access to their facilities at all times.
- F. Provide and maintain safeguards necessary to protect persons and property from injury or damage during the performance of the Work. This includes protective fencing as shown on the Contract Drawings and as may be required by the operating railroads.
- G. Before the start of construction, verify the location of Project control markers and obtain sufficient information to confirm coordinate and elevation values of each Project control marker. Protect and maintain Project control markers during construction.
- H. Conduct the Work so that no equipment, material, or debris will be placed on or be allowed to fall upon private property in the vicinity of the Work unless he or she has first obtained approval from the MTA and the owner of the adjacent property.
- I. Refer to Section 01160 for maintenance and protection of railroad traffic for additional maintenance and protection requirements.
- J. During construction, all affected pedestrian and vehicular traffic crossings shall be maintained and protected as indicated in Section 01555 and as shown on the Contract Drawings.
- K. Conveyors, cranes, loaders, excavators, and other equipment used in the vicinity of NYCT elevated structures shall be isolated both structurally and electrically from the elevated structure.
- L. Maintain, clean, and sweep all pedestrians walkways and vehicular roadways adjacent to the Work Site, as required.
- M. For temporary system requirements, refer to Section 01520.

3.02 MAINTENANCE AND PROTECTION OF EXISTING SHAFTS, TUNNELS, FACILITIES, STRUCTURES, UTILITIES, AND QUEENS STAGING AND ACCESS AREAS

- A. Maintain, protect, and support the following:
 - 1. Queens open-cut at existing Bellmouth and Lot 1 Site, Block 403: The lot west of Northern Boulevard shall be used as a staging area by Contractor for the duration of the Contract. Be responsible for the maintenance of the entire staging and access area including the existing site fencing, gates, noise barrier walls, site lighting, cable railing at top of open-cut, and wood hand rails. In addition, be responsible for the maintenance of the entire Queens open-cut for the term of the Contract including, but not limited to

the following equipment: Stair tower and/or hoist, lighting, electrical services, construction water supply lines, ventilation ducts, dewatering discharge lines, submersible pumps, and communication systems.

2. Protect from damage all existing instrumentation, piezometers, pumping wells, or other installed geotechnical monitoring devices within the working area.
3. The 29th Street Ventilation Building, adjacent to the Queens open-cut area, is an NYCT facility and is not available to Contractor.
4. Excavation Support and Groundwater Cut-Off Walls: Maintain the existing excavation support and groundwater cut-off walls at the Queens open-cut. This includes slurry walls, sheet-pile walls, and associated internal bracing and tiebacks for the term of the Contract. Do not compromise the integrity or water tightness of existing support of excavation and structures.
5. Dewatering System for Seepage and Rainfall at the Queens Open-Cut Area: Take over the existing dewatering system, and operate and maintain the existing dewatering system for the duration of the Contract. Install additional drainage/treatment systems, as necessary, to handle the flow from the tunneling operations and the existing 63rd Street Tunnels.
6. Contractor will be provided with an area within the existing rail yard including the use of a former NYAR Maintenance Shop, as shown on the Contract Drawings. Contractor is responsible for general cleanup of the yard in the vicinity of NYAR Shop and inside the shop including, but not limited to, removal of drums, scrap metal, batteries, and miscellaneous debris. Arrange for utility services and pay for all fees and monthly charges for utility services.
7. Be responsible for maintaining the staging and access area used within the existing rail yard for the term of the Contract. Install and maintain tracks and switches, as necessary, if muck will be hauled by rail from the existing stub track at Queens Street. Existing tracks to remain shall be protected from damage.
8. Locate and protect existing wells at the Queens open-cut working area for the duration of the Contract, in accordance with Section 02290 and the Contract Drawings.
9. Be responsible for protecting the existing structures and facilities, and to repair any damage caused by Contractor's construction activities.
10. Existing Two-Track Tunnel from approximately 170-feet west of Second Avenue West Building Line, south of East 63rd Street in Manhattan to Queens Open-Cut:
 - a. Be responsible for the maintenance of the existing LIRR tunnels between the Queens open-cut and existing tunnel face at Second Avenue for the term of the Contract including, but not limited to the following existing construction equipment and utilities: Ventilation equipment and ducts, lighting, electrical services,

- construction water supply lines, dewatering discharge lines and submersible pumps, and communication systems.
- b. Protect the existing 4-inch diameter Cablevision fiber optic communications conduit and Cablevision pull boxes in the existing westbound tunnel from Second Avenue to 29th Street for the term of the Contract.
 - c. Protect the existing telephone system including telephone lines, as required, for the term of the Contract. The system will be maintained by NYCT. Any damage will be repaired and replaced by NYCT personnel. All necessary repair and replacement cost are to be paid by Contractor.
 - d. Protect, maintain, and clean the existing 63rd Street Tunnel drainage system.
11. Existing Pumping Stations Serving the LIRR Level of the 63rd Street Tunnel:
- a. The existing Second Avenue Pump Room shall be assigned to Contractor. An independent pumping system may be installed for the term of the Contract. All effluent is to be discharged, after treatment, into NYCDEP sewer system. The electrical power tie-in with NYCT electrical system will remain for the term of the Contract. Be responsible for maintenance and protection of the existing equipment and piping. If an independent pumping system is installed by Contractor, replacing the existing pumps, deliver the removed pumps to NYCT facility within the City limits.
 - b. Operate and maintain the two existing sump pumps (one in each track way) 370-feet west of Vernon Boulevard shaft. Coordinate with the Resident Engineer to remove the electrical power tie-in with NYCT electrical system and provide an independent source of electrical power. Be responsible for maintenance and protection of the existing equipment and piping leading from the sump pits or replace with equipment of Contractor's choice. Submit for review of the Resident Engineer, if substitute equipment is used. All necessary repair and replacement cost are to be paid by Contractor.
 - c. The three remaining Existing Pumping Stations serving the LIRR at Roosevelt Island, Vernon Boulevard, and 12th Street are not assigned to Contractor and remain under the jurisdiction of NYCT.
12. Contractor may utilize the unoccupied LIRR facility rooms, shaft and plenum areas within the existing MTA 2nd Avenue Ventilation Building for installation of a construction power substation, construction drainage system and for construction ventilation purposes. Minimize modifications to the existing structure to meet Contractor's needs.

13. Existing and Newly Constructed Tunnel Drainage System Within the Existing 63rd Street Tunnels and TBM Tunnels, Caverns, and Chamber: Upgrade the existing tunnel drainage system, as necessary. Be responsible to maintain and protect the existing and new tunnel drainage system for the term of the Contract. In addition, clean up both systems before final handover to the MTA. All necessary repairs and replacements shall be Contractor's responsibility.
14. LIRR Water Meter Rooms: The NYCT shall operate and maintain the seven LIRR water meter rooms at Second Avenue, FDR Drive, Roosevelt Island, Vernon Boulevard, 12th Street, 23rd Street, and 29th Street.
15. On a weekly basis, maintain the site within fenced area of Block No. 1437, Lot No. 49 at 63rd Street/Second Avenue for the duration of the Contract. Maintenance shall include watering of plants, trimming of hedges, cutting grass, and removal of cuttings, leaves, snow, and debris. Access to the fenced-in site shall be coordinated through the Resident Engineer.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for installation of permanent rock anchors with Double Corrosion Protection as indicated on the Contract Drawings and specified herein. These requirements establish minimum standards and material requirements for the performance of the work. Contractor is responsible for the design, furnishing, fabrication, installation, stressing, and testing of the anchors.
- B. The Work shall consist of:
 - 1. furnishing of materials and equipment for installation of permanent rock anchors to carry the design loads;
 - 2. furnishing drilled holes for the anchors and pre-grouting where required;
 - 3. furnishing and installing anchor heads for all anchors including grouting;
 - 4. pretensioning of permanent rock anchors as specified on the Contract Drawings;
 - 5. testing of permanent rock anchors as specified. Contractor shall provide safe and secure access for observing and witnessing all testing of permanent rock anchors;
 - 6. permanent rock anchors shall not be installed until the Resident Engineer has reviewed the sequence of installation for all such anchors.
- C. Definitions:
 - 1. Anchorage: Portion of the permanent rock anchor including anchor nut or head, anchor plate and protective cap that is used to transfer load from the rock wall to the permanent rock anchor.
 - 2. Bonded Length: Portion of permanent rock anchor that transfers the tensile force from the permanent rock anchor to the rock.
 - 3. Double Corrosion Protection System: Sheathed and grouted rock bolts or rock anchors to provide corrosion protection (referred to as Class I corrosion protection by the Post Tensioning Institute, Phoenix, Arizona).
 - 4. Permanent Rock Anchor: A high strength steel bar fitted with anchorage along the entire length of the bar permitting force transfer between the anchor and the rock. The use of strands instead of bars shall not be permitted.

1.02 REFERENCED SECTIONS

- A. Section 02270 – Rock Reinforcement and Initial Support for Shaft and Tunnel Stub Excavation

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. A 36 - Carbon Structural Steel
 - 2. A 325 - High-Strength Steel Bolts
 - 3. A 416 - Steel Strand, Uncoated, Seven-Wire for Prestressed Concrete
 - 4. A 572 - High-Strength Low-Alloy Columbium-Vanadium Structural Steel
 - 5. A 615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 - 6. A 722 - Uncoated High-Strength Steel Bar for Prestressing Concrete
 - 7. A 775 - Epoxy-Coated Reinforcing Steel Bars
 - 8. C 150 - Portland Cement
 - 9. C 109 - Compressive Strength of Hydraulic Cement Mortars
 - 10. D 3350 - Polyethylene Plastic Pipe and Fitting Materials
 - 11. D 4101 - Polypropylene Plastic Injection and Extrusion Materials

1.04 NOTED RESTRICTIONS

None Noted.

1.05 QUALITY CONTROL

- A. Design and Performance Requirements: All work in this Section shall be supervised by a technical specialist with at least five years of continuous experience in the design, installation, and testing of prestressed rock anchors.
- B. Supervision: A qualified representative of the manufacturer of Double Corrosion Protection System anchors shall supervise the installation and testing of the first 10 anchors.
- C. Orientation and Tolerances:
 - 1. Anchors shall not deviate more than the lateral tolerances shown on the Contract Drawings.
 - 2. The alignment of anchors shall not deviate from the required orientation by more than 2-percent.
- D. Testing of Grout: Random sampling and testing of cement grout for test anchors shall be performed as required by the Engineer to verify Strength. Test procedure shall be in accordance with ASTM C 109.

1.06 SUBMITTALS

- A. Samples:
1. At least 30 days before the purchase of permanent rock anchors with double corrosion protection system,, obtain two samples from the normal stock of the manufacturer of each of the various sizes and types of rock anchors components to be used. Furnish samples of each type of rock anchors including end hardware to the Resident Engineer who will arrange for testing by an independent testing agency designated by the Resident Engineer.
 2. In case of failure of the anchors being tested, provide new samples for testing at no cost to the MTA until it can be demonstrated that the anchors scheduled for delivery meet the specified requirements.
- B. Manufacturer's Information: A minimum of 30 days before beginning anchor installation work, submit the following:
1. Applicable literature from the manufacturer of the permanent rock anchors with double corrosion protection, including their recommended installation procedures for this specific Project.
 2. Manufacturer literature for anchorage fittings and accessories.
- C. Shop Drawings: A minimum of 30 days before beginning anchor installation work, submit the following:
1. Typical pattern of rock anchors is to be used.
 2. Spacing, type, size, and length of rock anchors together with type of hardware accessories and surface covering.
 3. Installation procedures related to grouting.
 4. Sequence and timing of installation and vertical and horizontal distance from last anchor installation.
 5. Testing procedures

1.07 DELIVERABLES

- A. Provide the following:
1. Certified mill test reports for anchor steel and head assembly.
 2. Grout mix, including non-shrink additives and compressive strength test results from a certified testing laboratory.
 3. Complete description of the drilling and grouting equipment.
 4. Shop drawing(s) of the anchor showing details and dimensions, and corrosion protection.

5. One - 5-foot length of anchor having the double corrosion protection system indicated on the drawings.
6. A complete description of the stressing and testing equipment and their arrangement, including but not limited to electronic load cell, hydraulic jack, jacking frame and reference frame with dial gauge(s).
7. Certified calibration curves for load cells and hydraulic jacks for both loading and unloading cycles for range of specified testing.
8. The proposed sequence of anchor installation and testing.
9. As-built drawings of installed anchors.

1.08 DELIVERY, STORAGE AND HANDLING

- A. All permanent rock anchors and components shall be handled and stored in such a manner as to avoid corrosion and physical damage.
- B. Damage, such as abrasions, cuts, nicks, welds, weld spatters or heavy corrosion and pitting, will be a cause for rejection of the anchor. Rejected anchors shall be replaced at no cost to the MTA in terms of either material replacement or resulting time delays.

1.09 PROJECT CONDITIONS

- A. Contractor is responsible for installing permanent rock anchors that will comply with the acceptance criteria specified herein.
- B. Do not install anchors until the Resident Engineer has reviewed all materials, equipment, installation, and test procedures.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Permanent Rock Anchors with the Double-Corrosion Protection System: Each anchor shall consist of:
 1. A single, deformed bar for prestressing steel encased in PVC or HDPE corrugated sheathing.
 2. The deformed bar shall be centered in the corrugated sheathing and the annular space between the bar and the sheathing shall be filled with cement grout.
 3. The PVC or HDPE sheathing shall form a gas and water-tight barrier around the prestressing steel bar.
 4. A steel hexagonal nut with round head shall fit into the counter sunk hole in the bearing plate.

5. Both the steel hexagonal nut and bearing plate with welded seamless pipe shall have factory-applied epoxy coating.
 6. A plastic cap and plastic nut filled with mastic corrosion inhibitor will encapsulate the hexagonal nut for corrosion protection.
- B. Prestressing Bar: The prestressing bar shall be threaded, Grade 150-ksi conforming to ASTM A 722, Type II, cold-stretched and stress relieved after threading process. Each bar shall be proof stressed to a minimum of 80% of tensile strength after the threading operation.
- C. Plastic Sheathing:
1. Corrugated plastic sheathing shall be PVC, having a minimum tensile strength of 7,000-psi. Material shall be free of water-soluble chlorides and other ingredients that might enhance corrosion, hydrogen embitterment or stress corrosion of the prestressing steel. The plastic shall be non-reactive with grout and its ingredients. The PVC sheathing shall be gas and water tight, resistant against chemical attacks and aging.
 2. Sheathing for unbonded length of anchors shall consist of seamless polypropylene tubing having minimum wall thickness of 60-mils, plus or minus 10-mils, and conforming to ASTM D 4101, cell classification PP210B55542-11. Encapsulation of anchor bond length shall consist of grout filled, corrugated high density polyethylene (HDPE) tubing having a minimum wall thickness of 30 mils and conforming to ASTM D 3350, cell classification 334413.
- D. Accessories:
1. Steel bearing plates shall conform to ASTM A 572.
 2. Nuts shall be hexagonal, heavy-duty type with round head, conforming to ASTM A 325 or to the prestressing bar manufacturer's specification.
- E. Miscellaneous:
1. Grease for the stressing head assembly shall be a mastic corrosion inhibitor, waterproof, non-corrosive, non-hardening sealing compound.
 2. Epoxy coating shall conform to ASTM A 775.
- F. Cement Grout:
1. Grout shall be a non-shrink neat cement mix, or an approved alternate. Neat cement grout shall have a water-cement ratio of 0.4. The cement grout shall have sufficient strength to guarantee the load transfer between the threaded bar and the corrugated sheathing. Cement for grout shall consist of Portland cement conforming to ASTM C 150 (Types I, II or III).
 2. An approved additive shall be mixed with the grout as an expanding agent.

- G. Corrosion-inhibiting grease shall consist of Viscosity Oil Company “Visconorust 3166”, or approved equal.
- H. Coat fusion bonded epoxy elements in accordance with ASTM A 775, except that film thickness shall be 15-mils.
- I. Steel elements, such as plates, stiffeners, etc., shall consist of steel conforming to ASTM A 36.
- J. Spacers and centralizers shall be fabricated from approved plastic and shall allow for a free flow of grout.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Drilling:
 - 1. Drill to the diameter, length, line, and tolerances specified in the Contract Drawings or specified by the manufacturers.
 - 2. Drill the holes as shown on the Contract Drawings.
 - 3. Flush clean all holes with either high-pressure water or air.
 - 4. Drill the holes to an angle tolerance of 3-percent of their planned direction and in any 10-foot section of the hole, the maximum deviation between the ends shall not exceed 1.0-inch.
- B. Water Tightness Test: Before installation of the anchor, test the drilled hole for water tightness by a suitable testing method. The permeability of the drilled hole should be less than 10^{-5} cm/sec. If test results show higher permeability, grout the hole to achieve the specified permeability and re-tested.
- C. Insertion of Anchor:
 - 1. Handle prefabricated anchors using appropriate strong-backs and sufficient pick locations to preclude detrimental bending. Anchors exhibiting any permanent deviations shall be rejected and replaced at no cost to the MTA.
 - 2. Inspect each anchor before installation by the Resident Engineer in the field to ensure conformance with shop drawings.
 - 3. All equipment use for placing the anchor shall be such that it will not damage the corrugated sheathing.
 - 4. Insert the anchor in the hole and attach accessories to both ends.
 - 5. Stress the anchor to the required load, as shown on the Contract Drawings.

D. Grouting:

1. As shown on the Contract Drawings, anchors shall be installed first, stressed, and subsequently grouted using a grout tube attached to the bottom of the bond length of the anchor.
2. Mix grout by continuous mixing equipment and pump using a positive displacement piston-type pump.
3. Place grout in anchor holes in a continuous operation. If an interruption should occur, the grout shall be recirculated through the pump. The minimum volume placed shall be the theoretical volume of the hole reduced by the volume of installed anchor elements.
4. Fit pressure-injected anchors with tube and manchettes along their bond lengths. Establish the number and spacing of the grouting points based on his experience and the results of the performance tests. After each injection of pressure grout, flush clean the grout tube(s) to allow for subsequent stages of grouting.
5. Determine the criteria for grouting pressure and grout quantities for each stage of pressure grouting.

3.02 FIELD TESTS**A General**

1. Use a certified, calibrated hydraulic jack and to apply the test load. The jack and pressure gauge (100-psi increments or less) shall be used to measure the applied load. In addition, provide a certified, calibrated electric resistance load cell and read out to measure all test loads.
2. Place stressing and load cell equipment over the anchor in such a manner that the jack, bearing plates, load cell, and stressing anchorage are axially aligned with the anchor and the anchor is centered within the equipment.
3. Perform performance, proof, and creep tests by incrementally loading and unloading anchors in accordance with the loading schedule(s) shown in Paragraphs 3.02B and C.
4. For both performance and proof tests, record each increment of loading or unloading with a micrometer dial gauge accurate to 0.001-inch, and maintain loading increments until the rate of movement is either zero or the change in the last five minutes is less than 0.004-inch.
5. Unless otherwise shown on the Contract Drawings, establish an independent reference system to determine the amount of movement the stressing system imposes on the structure.
6. The Resident Engineer will select anchors for lift-off testing as indicated on the Contract Drawings. Perform these lift-off tests after anchor lock-off as indicated on the Contract Drawings. Adjust the lock-off load to compensate for losses as indicated by the lift-off tests.

7. Perform all field-testing in the presence of the Resident Engineer and shall be subject to his review and approval.

B. Performance Tests

1. Performance tests shall be carried out on five anchors as directed by the Resident Engineer.
2. The anchors for performance testing shall be identical to working anchors designed and constructed for the specified design working loads.
3. The maximum test load for performance test shall be 1.5 times the design load (P), as shown on the Contract Drawings, but not more than 80-percent of the ultimate tensile strength.
4. The Alignment Load (Ta) shall be selected between 0.1P and 0.2P. The test loads shall be applied in increments of the Design Load (P).
5. Loading cycle shall follow the following pattern: Ta, 0.25P, Ta, 0.25, 0.5P, Ta, 0.25P, 0.5P, 0.75P, Ta, 0.25P, 0.5P, 0.75P, 1.0P, Ta, 0.25P, 0.5P, 0.75P, 1.0P, 1.25P, Ta, 0.25P, 0.5P, 0.75P, 1.0P, 1.25P, 1.5P
6. At 1.5P hold for creep test before locking off the load.
7. Record the movement measurement at Alignment Load Ta to the nearest 0.001 inch.
8. At each load, the movement measurement shall be made before proceeding to the next load level.
9. Hold each anchor subjected to performance test at final load of 1.5P for duration of ten hours. Record anchor creep under the constant load of 1.5P with respect to a fixed reference point. The recordings shall be taken at 0, 1/2, 5, 10, 15, 30, 60 minutes and 2, 3, 4, 5, 6, 7, 8, 10 hours. If load relaxation occurs because of anchor creep, adjust the jack pressures to 1.5P immediately before recording the anchor displacements at the prescribed intervals. Correct changes in the test load due to temperature variations. Plot the anchor displacement versus log time in minutes and the creep coefficient (K) shall be determined. The creep coefficient (K) is defined as the slope of the anchor displacement versus log time curve.
10. At the conclusion of the creep test anchor load shall be reduced and locked-off at 100-percent of design load (P).

C. Proof Tests

1. Perform Proof Test on all anchors.
2. The Alignment Load (Ta) shall be selected between 0.1P and 0.2P. The test loads shall be applied in increments of the Design Load (P).
3. Loading cycle shall follow the following pattern: Ta, 0.25P, 0.5P, 0.75P, 1.0P, 1.25P, 1.5P

4. Hold each load except maximum test load long enough to obtain the movement reading.
5. The maximum test load $1.0P$ shall be held for ten (10) minutes. Total movement relative to fixed reference point shall be recorded at 1, 2, 3, 4, 5, 6, 10 minutes.

D. Lift-off Test

1. Perform lift-off test on all anchors. The lift-off test shall comprise an initial test following transfer of the stressing load to the anchor assembly and prior to removal of the jack. Perform a second lift-off test if directed by the Resident Engineer or its designee seven days after.
2. Increase loading of the anchor until elongation of the anchors occurs. When elongation occurs, hold the load long enough for the jack pressure and load cell to be read.
3. Do not cut-off anchor protrusions until the Resident Engineer or its designee has determined no further lift-off tests shall be performed.

E. Acceptance Criteria:

1. The creep rate for anchors shall be less than 0.004-inch in last five minutes for proof and/or performance tests.
2. The measured elastic extension of anchors shall not exceed the extension computed assuming the stressing length plus 50-percent of the bond length, or be less than the elastic extension computed assuming ninety percent of the stressing length.
3. The measured elastic extension of anchors shall not exceed the extension computed assuming the stressing length plus 25-percent of the bond length, or be less than the elastic extension computed assuming ninety percent of the stressing length.
4. The creep rate does not exceed 0.080-inch per logarithmic cycle of time during the final log cycle of the proof or creep test regardless of tendon length and load.
5. The initial lift-off shows an anchor load within 5-percent of the specified lock-off load.

F. Inspection:

1. The Resident Engineer may inspect anchors at the fabrication plant, after shipment, and before and during installation. The Resident Engineer will inspect all anchor installations and testing.
2. Cooperate with the Resident Engineer and furnish services as he may require for these inspections and obtain data.

3. The Resident Engineer will keep a record of each anchor installed including, but not limited to, the following:
 - a. Dates of drilling, installation, and grouting
 - b. Anchor designation
 - c. Type and size of anchor
 - d. Location and inclination of anchor
 - e. Drill type and size
 - f. Type and volume of grout used
 - g. The time anchor grouting is started, interrupted, resumed and stopped
 - h. Description of any unusual circumstances affecting the installation of the particular anchor
 4. The Resident Engineer will keep a record of all field tests specified herein above.
- D. Corrections and Deficiencies:
1. Notify the Resident Engineer immediately, in writing, of the failure of an anchor to meet any requirement of this Section. Such written notification shall include all information required for the evaluation of remedial measures, including all information required for redesign.
 2. Replace all anchors not meeting the acceptance criteria, and provide any additional redesigned items resulting from the anchor replacement, at no cost to the MTA.
 3. All abandoned drill holes and anchors shall be fully grouted.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for installing and testing rock reinforcement in the tunnel, cavern, and chamber excavations. Rock reinforcement and rock support consists of the elements shown on the Contract Drawings and specified herein.
- B. Determine that the types, sizes, and amounts of rock reinforcement and initial support indicated in the Contract Drawings are adequate to maintain stability of the excavation under the rock conditions that may be encountered.
- C. Definitions:
 - 1. Additional Initial Support: See Sections 02406 and 02407.
 - 2. Initial Support: See Sections 02406 and 02407.
 - 3. Lattice Girder: See Section 03375.
 - 4. Length of a Rock Dowel or Rock Bolt: The length of the steel bar or Glass Reinforced Polymer rod (also referred to as GRP for the purposes of this Contract) that is embedded within the rock with tolerances, as shown in the Contract Drawings.
 - 5. Pattern Rock Reinforcement: A prescribed pattern of rock dowels or bolts as shown on the Contract Drawings.
 - 6. Rock Bolt: A tensioned rock reinforcement element installed in a percussion-drilled hole fully encapsulated with resin or cement grout.
 - 7. Rock Dowel: An untensioned rock reinforcement element installed in a drilled hole fully encapsulated with resin or cement grout.
 - 8. Rock Reinforcement: Rock dowels and rock bolts and related support elements that reinforce the in-situ rock and increase the capacity of the rock to support itself.
 - 9. Rock Reinforcement as Part of Additional Initial Support: Rock reinforcement not shown on the Contract Drawings, but required to support the rock mass, used in areas where no pattern reinforcement is indicated or where the indicated pattern does not supply adequate support, and as required by actual ground conditions encountered or as directed by the Resident Engineer.
 - 10. Rock Surface Protection: Reinforcement placed on the exposed rock surface to support or contain loosening, raveling, or falling rock from between rock dowels. Rock surface protection includes welded wire fabric, steel mat lagging, mine straps, and channels.
 - 11. Shotcrete: See Section 03370.

12. Pre-Support Spiling: An untensioned rock reinforcement element installed for pre-support spiling in a drill hole at a low angle to the longitudinal axis of the tunnel without end hardware. Pre-Support Spiling may be deformed steel reinforcing bars, or self-drilling grouted bars.
13. Steel Mat Lagging: A prefabricated panel consisting of a grid of welded wire or steel bars, used to support or contain loosening, raveling, or falling rock between steel ribs installed in the tunnel.
14. Steel Rib: A rolled structural steel section with connecting plates, nuts, bolts, tie rods, and miscellaneous hardware.

1.02 REFERENCED SECTIONS

- A. Section 02406 – Tunnel Excavation by TBM
- B. Section 02407 – Tunnel and Cavern Excavation by Drill and Blast
- C. Section 03300 – Cast-In-Place Concrete
- D. Section 03370 – Shotcrete
- E. Section 03375 – Shotcrete Lining
- F. Section 05120 – Structural Steel

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI):
 1. 440.1R-01 – Guide for the Design and Construction of Concrete Reinforced with FRP Bars
- B. American National Standards Institute (ANSI):
 1. B1.1 - Unified Inch Screw Threads
- C. ASTM International (ASTM):
 1. A 36 - Carbon Structural Steel
 2. A 185 - Welded Steel Wire Fabric for Concrete Reinforcement
 3. A 436 – Austenitic Gray Iron Castings
 4. A 563 - Carbon and Alloy Steel Nuts
 5. A 569 – Steel, Carbon, Hot-Rolled Sheet and Strip, Commercial Quality
 6. A 615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 7. A 706 – Low-Alloy Steel Deformed Bars for Concrete Reinforcement

8. A 775 – Epoxy-Coated Steel reinforcing Bars
9. A 4435 –Rock Bolt Anchor Pull Test
10. C 579 – Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing and Polymer Concretes
11. C 1107 –Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
12. D 638 Tensile Properties of Plastics
13. D 3916 - Tensile Properties of Pultruded Glass-Fiber – Reinforced Plastic Rod

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Qualifications of Manufacturer: Resin used as grout for rock reinforcement shall be the product of an established manufacturer who has been regularly engaged in production of these products for use with rock reinforcement for at least five years.
- B. The drilling of holes and the installation of rock reinforcement shall be under the direct supervision of an individual with experience in accordance with Section 02407.
- C. Installation of rock reinforcement shall be in accordance with the recommendations of the grout and rock reinforcement manufacturer and this Specification. When such recommendations differ from the requirements of this Section, this Section governs.
- D. Pull tests shall be performed in accordance with the requirements of ASTM D 4435 and as specified herein.
- E. Calibrations by an independent certified testing laboratory shall be made of jacks and gauges used for pull tests.
- F. The first 30 resin encapsulated rock bolts shall be installed in the presence and under the supervision of the resin grout manufacturer's representative who shall submit a report of satisfactory initial installation. The resin encapsulated rock bolts shall be tested to 80-percent of their capacity. Manufacturer shall inspect installation procedures once per month, thereafter for the first six months.
- G. The resin encapsulated steel rock dowels shall be tested to 80-percent of their capacity.
- H. The GRP rock dowels shall be tested to 27.5-kips as specified herein.
- I. Rock reinforcement shall not extend more than 6-inches into the theoretical excavation line.

1.06 SUBMITTALS

- A. Samples: Submit the following:
1. At least 30 days before the purchase of rock dowels and bolts, obtain two samples from the normal stock of the manufacturer of each of the various sizes and types of rock reinforcement components to be used. Furnish, upon request, samples of each type of rock reinforcement including end hardware to the Resident Engineer. The Resident Engineer may arrange for testing of furnished samples by an independent approved testing agency designated by the Resident Engineer. Furnish samples of resin cartridges for each setting period to be used. Any cost related to the sample testing shall be paid by Contractor.
 2. In case of failure of the bolts and resin grout being tested, provide new samples for testing at no cost to the MTA until it can be demonstrated that the bolts and resin scheduled for delivery meet the specified requirements.
- B. Manufacturer's Information: Submit applicable literature from the dowel/bolt hardware and resin manufacturers, including their recommended installation procedures for this specific Project for dowels/bolts and resin along with material samples specified herein above.
- C. Shop Drawings: A minimum of 30 days before beginning rock reinforcement work, submit the following to the Resident Engineer for review:
1. Typical pattern when pattern rock reinforcement is to be used.
 2. Spacing, type, size, and length of rock reinforcements together with type of hardware accessories and surface protection.
 3. Installation procedures related to resin set time.
 4. Sequence and timing of installation and vertical and horizontal distance from last bolt installation.
 5. Testing procedures.
 6. Shop Drawings for ribs, mine straps, channels, ties, and steel mat lagging.

1.07 DELIVERABLES

- A. Certificates: Provide the following:
1. Certificates stating that samples for testing are from normal stock.
 2. Certified mill reports of the steel bars and manufacturer's certified test results and/or ISO certificates for the GRP rock dowels and the end hardware.
 3. Manufacturer's certified test results of gel time and working strength for each type of resin grout to be used.

4. Pull test equipment calibrations and pull test results.
- B. Provide as-built information regarding layouts of rock bolts, rock dowels, and other reinforcement installations.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General: An adequate supply of rock reinforcement materials shall be maintained on the Work Site to prevent delay in the Work.
- B. Steel Rock Dowels and Bolts:
 1. Rock Bolt sets shall consist of rock bolts along with standard end hardware. Rock bolts can be a deformed steel reinforcing bar with a threaded end, or a continuously threaded steel bar. End hardware consists of a bearing plate, one or more beveled washers as required, a flat steel washer, an anchor nut, and a hexagonal nut.
 2. Rock dowel sets shall consist of the rock dowel along with end hardware, and conform to the requirements of Paragraph 2.01.B.1.
 3. Rock dowels and rock bolts shall be either deformed steel bars, threaded on one end, or all-thread type, both conforming to the requirements of ASTM A615 or A706, Grade 75. Bars shall meet the minimum size, length, and tolerance requirements as shown on the Contract Drawings and allow for the installation of end hardware. Threads on the exposed end shall be ANSI B1.1, coarse thread series with Class 2A tolerances. Threads on the embedment end shall be manufacturer's standard for the type and size of dowel/bolt. Capacity shall be as shown on the reviewed shop and working drawings. Tension capacity shall be available through the weakest cross-section at the threads.
 4. The length of bolts shall be as shown on the reviewed shop and working drawings except as specified elsewhere herein.
 5. Dowels/bolts shall have tips shaped as recommended by the resin manufacturer. If no shape is recommended, ends shall be square cut. Ends of dowels/bolts shall be so formed as to facilitate spinning the bolt during placement, for attaching the end hardware of the bolts where required, and for attaching the wire mesh keeper plates.
 6. All steel rock dowel and bolt sets shall be epoxy coated according to ASTM A775.
 7. All rock dowels and bolts used for initial support are considered to be permanent for the purposes of this Contract.
 8. Friction type bolts of any type will not be permitted to be installed for the purpose of initial support.

D. Glass Reinforced Polymer (GRP) Rock Dowels:

1. The GRP rock dowels shall be solid bar type, Weldgrip "Gripforce Reinforcement System", or approved equal.
2. The GRP rock dowels shall be reinforced with E-glass fibers and Hybrid Vinylester resin with a minimum of 2.3-percent elongation at break.
3. GRP rock dowels shall be deformed or have their surface intentionally roughened to have a good bonding characteristics at the interface between the rod and the resin to produce a resin-grouted dowel of the required capacity.
4. The rock dowels shall have a minimum bar dimension of 1- plus or minus 1/64-inch in diameter and shall have their exposed end threaded.
5. The guaranteed tensile strength of the rock dowels, as defined in ACI 440.1R-01, shall be 152-ksi by ASTM D638 or D3916.

E. Resin Grout:

1. Resin shall be unaffected by mild acids, mild alkalis, or by the formation water. Resin shall reach 80-percent of its ultimate strength within a time interval equal to five times the gel time. Strength of mixed and cured resin when tested in accordance with ASTM C 579 shall be:
 - a. Compressive Strength: 17,000-psi
 - b. Tensile Strength: 7,500-psi
 - c. Shear Strength: 4,800-psi
2. Resin shall be supplied in cartridge form, and shall have a casing constructed of saturated polyester providing optimum resistance to moisture, but easily fractured to enable complete mixing during installation.
3. Resin cartridge shall contain two distinct fractions of unsaturated polyester resin and catalyst with or without an intervening mechanical membrane.
4. Resin shall be high strength unsaturated polyester with a predominance of non-reactive inorganic filler.
5. Catalyst shall contain peroxide with non-reactive inorganic filler.
6. Gel and cure time of fast-set resin shall be sufficient to permit bolt tensioning within ten minutes or as recommended by manufacturer for the particular application, but in no case shall the gel time be more than 2 minutes.
7. Gel time of slow-set resin shall be 20 to 30 minutes.

8. Resin shall reach 80-percent of ultimate strength within a time interval equal to five times the gel time.
 9. The materials shall have thixotropic and viscous properties to permit adequate mixing of the materials by manipulation of the rock dowels and rock bolts and to prevent the mixture from running out of the hole after mixing.
 10. The mixture shall be prevented from running out of the hole.
 11. Resin cartridge shall have a shelf life of not less than six months as dated on the container, and shall be used within that stated shelf life.
- F. Cement Grout:
1. Cement for grout shall be as specified in Section 03300.
 2. Non-shrink Grout shall conform to ASTM C1107.
 3. Compressive Strength of the grout shall be not less than 1,000-psi at one day.
 4. Cement grout shall be supplied in cartridges form with a casing constructed of saturated polyester providing optimum resistance to moisture or may be pumped via grout tubes.
 5. Where cement grout is used spacers shall be provided to centralize the rock bolts and dowels.
 6. The cement grout shall completely encapsulate the steel rock dowels and bolts without any air pockets.
- G. End Hardware for Steel Bolts and Dowels:
1. Steel bearing plates shall be square, of sufficient thickness to limit bending stresses to $0.6-F_y$ under design loading, but not less than 0.375-inch thick, having not less than 6-inch by 6-inch square bearing area, and shall conform to ASTM A 36. Hole in steel bearing plate shall be of sufficient size to eliminate binding of the bolt.
 2. Steel washers shall be spherical washers, 2-inches minimum in diameter. Flat washers shall be quenched and tempered steel and shall conform to ASTM A 436. Washers shall be of appropriate diameter for use with a specific size rock bolt with the center hole 0.125-inch larger in diameter than the bolt with which it is to be used. Flat washers shall be a minimum of 0.125-inch thick.
 3. Nuts shall be hexagonal head, heavy-duty type, capable of developing an ultimate strength of not less than 125-percent of the minimum yield strength of the bolt bar and conforming to ASTM A 563 or, for upset thread bars, conforming to the bar manufacturer's special specifications.

- H. End Hardware for GRP Dowels:
1. End plates shall be minimum 6-inch square or 6-inch diameter round, GRP or approved equal.
 2. The nuts shall be GRP or approved equal.
 3. The breaking load capacity of the end assembly of the GRP dowels shall be 13.5-kips minimum.
- I. Protective grease shall be of the type used for bilge protection containing rust-inhibiting compounds, factory applied to threads of rock bolts and entire surface of nuts and washers of steel bolts, dowels and their end hardware.
- J. Lubricant for threads and washers shall be molybdenum disulfide base such as Alpha Molykote Corporation "Molykote G", or approved equal.
- K. Threads of steel bolts, dowels, and nuts shall be protected by a plastic type molded protector that can be easily stripped off just before installation.
- L. Steel Ribs and Accessories:
1. Steel ribs shall be wide flange shapes conforming to requirements of Section 05120, and to the minimum section size and shape shown on the Contract Drawings.
 2. Steel ribs shall be furnished complete with bolts, nuts, washers, plates, hanger rods, tie rods, spreaders, and other accessories required for installing the ribs.
 3. A supply of 10-percent of the total estimated quantities of steel ribs and accessories of all types as shown in the Contract Drawings shall be maintained on hand at all times while tunnel excavation is in progress. When, in the opinion of the Engineer, the excavation is sufficiently complete that such quantities are not considered necessary, the quantities may be reduced.
- M. Blocking and Lagging:
1. The material used for blocking shall be steel, hard wood, grout bags or shotcrete.
 2. Steel mat lagging shall be fabricated of welded wire sheets conforming to ASTM A 185, or steel bars conforming to ASTM A 36, as shown on the Contract Drawings and bent as required to fit the excavated diameter of the tunnel.
- N. Pre-Support Spiling:
1. Pre-Support Spiling shall be deformed steel bars conforming ASTM A 615 Grade 60 or self-drilling type.

2. Bars shall meet the minimum size and length requirements shown on the Contract Drawings.
 3. Bars shall be furnished in full length. Splicing shall not be permitted.
 4. Self-drilling Pre-Support Spiling shall be Dywidag Systems International Hollow Bolt Type "MAI", R32N, or approved equal.
- O. Channels and Mine Straps:
1. Channels shall conform to the requirements of ASTM A 36.
 2. Mine straps shall conform to the requirements of ASTM A 569.
- P. Welded wire fabric:
1. Welded wire fabric shall conform to the requirements of ASTM A 185.
 2. Mesh opening shall be six inches by six inches and wire size shall be W4.0x W4.0.

PART 3 EXECUTION

3.01 GENERAL

- A. Install rock dowels and bolts in accordance with Sections 02406 and 02407, and as shown on the Contract Drawings.
- B. Provide rock reinforcement and initial support of exposed rock surfaces that is adequate at all times to maintain safety of personnel and construction operations. Maintain all initial support and additional initial support throughout the length of the Contract. Periodically inspect all exposed rock areas in the excavations and install additional initial support, as required.
- C. As excavation advances, the rock condition shall be assessed by Contractor and submitted to the Resident Engineer for concurrence on rock reinforcement and initial support requirements. The rock reinforcement and initial support, as shown on the Contract Drawings, shall then be applied and supplemented by additional initial support as required by actual ground conditions encountered or as directed by the Resident Engineer.
- D. Provide additional initial support consisting of rock dowels, steel ribs and mine straps for TBM tunnels as specified in Section 02406, and rock dowels, rock bolts, pre-support spiling, welded wire fabric and shotcrete (reinforced by steel fibers) as specified in Section 02407, to maintain stability and integrity of the tunnels, caverns and chambers
- E. Rock dowels and rock bolts shall be set in polyester resin grout. Cement grout or cartridges of cement with micro-encapsulated water may be substituted for polyester resin grout subject to review by the Resident Engineer. Written request for substitution shall be accompanied by appropriate descriptive material, procedure details, comparison test results, and a Work Site demonstration test.

3.02 INSTALLATION

A. Resin Grouted Rock Dowels and Rock Bolts:

1. Percussion drill the hole for each rock dowel and rock bolt in accordance with the type of initial support as shown on the Contract Drawings to a uniform diameter recommended by the manufacturer for the entire length. The borehole must be compatible with the diameter of the rock dowel and/or rock bolt, and the cartridge diameter specified. For GRP rock dowels, the borehole diameter shall not be more than 3/8-inch larger than the dowel diameter. Holes shall be drilled 2-inches longer than the design embedded lengths of rock reinforcement shown on the reviewed shop drawings. Clean holes of all drill cuttings, sludge, and debris by air flushing or wet drilling.
2. After drilling and cleaning of rock holes has been completed, insert resin cartridges in accordance with manufacturer's recommendations for anchorage conditions. Carefully insert individual resin cartridges into the hole to avoid rupture and place in position with tamping rods. For rock dowels, use resins of the same gel time for the full length of the drill hole as shown on the Contract Drawings. For rock bolts, a minimum of 2-feet shall be of fast-gel type, gelling in not more than two minutes at 50- to 65-degrees Fahrenheit, followed by cartridges of slow-gelling, gelling in not less than 20 minutes at 50- to 65-degrees Fahrenheit sufficient to fully encapsulate the entire bolt. Provide the minimum number of cartridges per hole as recommended by the manufacturer for the hole and bar size combination used to ensure complete encapsulation of the bar. If manufacturer's recommendations are based on theoretical hole sizes, add one additional cartridge for each ten cartridges recommended or fraction thereof. Count-out and place in a single group the cartridges for each hole for each gel time before filling of the hole begins. Use of the manufacturer's recommendations does not relieve Contractor of its responsibility to provide a bolt of the required capacity with complete encapsulation.
3. Ensure that all threads are free of rust and burrs, and remove foreign matter from all threads immediately before installation of the rock dowels and rock bolts. Remove protective grease from the threads and nuts.
4. To rupture the cartridge and mix the resin, insert the rock dowel or rock bolt in the hole rotating it at a uniform penetration and rotation rate through the cartridge. Ensure that the threads on the projecting end of the bolt are not damaged during installation.
5. Ensure that the resin does not run out of the hole. Promptly clean any excess resin from any surface that will receive shotcrete.
6. Apply lubricant to the threads. Use lubricant between the washer and the nut.
7. Set the bearing surface of the nut perpendicular to the bolt by the use of spherical washers between the bearing plates and nuts.

- B. Cement Grouted Rock Dowels and Rock Bolts, and Mechanically Anchored Rock Bolts:
 - 1. Percussion drill the hole for each rock dowel and rock bolt in accordance with the type of initial support as shown on the Contract Drawings to a uniform diameter recommended by the manufacturer for the entire length. The borehole must be compatible with the diameter of the rock dowel and/or rock bolt, and the cartridge diameter or the specified grouting method.
 - 2. Pack or seal holes between the end plate and rock to retain the grout in the hole.
 - 3. Mechanically anchored rock bolts shall be fully grouted after completion of tensioning.
- C. Pre-Support Spiling: Pre-Support Spiling shall be installed where indicated as pre-support and where required by actual ground conditions as part of additional initial support.

3.03 TENSIONING ROCK BOLTS

- A. Tension the rock bolt by direct pull using center-hole hydraulic jacks and accurate calibrating techniques to 60-percent of the bolt yield strength, and the nut tightened to retain the bolt tension. If the bolts are resin-encapsulated, do not begin tensioning until the fast gelling anchor cartridges have reached their working strength as determined from certified tests by the manufacturer for the approximate temperature at which installation occurs. Complete tensioning before gelling of the remaining cartridges begins. Upon completion of the tensioning, lock the force by tightening the nut. Use 1/4-turn method.
- B. While tension is being applied, the operators shall stand to the side of the equipment and shall prohibit anyone from standing in the line of the bolt within 25-feet.
- C. If due to the nature of the rock, it is not possible to obtain the required tension, advise the Resident Engineer immediately so that a modified procedure can be determined.
- D. After tensioning of the bolt has been completed, do not relax the tension for any purpose.

3.04 PULL TESTS FOR ROCK BOLTS AND DOWELS

- A. Maintain the equipment to be used for performing pull tests in good working condition.
- B. Store equipment in a secure, dry area.
- C. Equipment provided shall consist of a suitably sized hollow ram jack, an adjustable bearing truss for aligning the direction of pull with the centerline of the bolt, an extension bar for attaching the jack to the bolt, a hydraulic jack with a gauge calibrated to read directly in pounds for the ram being used, a dial gauge which reads in increments of 0.001-inch, a magnetic or independent dial gauge mounting, and all other necessary accessories recommended by the manufacturer.

- D. Calibrate the pump gauge while connected to the jack by a uni-axial testing machine before performing pull tests and at subsequent times, as per manufacturer's recommendations, during the period of construction. Calibration shall be done by an independent, certified testing laboratory as specified herein.
- E. Keep in stock, or have ready access to, spare parts for the testing equipment, especially the gauges and pump seals, so that the work is not delayed.
- F. Before installation of production rock bolts, perform pull tests to capacity on a minimum of three test rock bolts at locations designated by the Resident Engineer to verify that the specified tension can be sustained. If any of these rock bolt pull tests fail, install additional rock bolts using modified installation procedures, and repeat pull tests until the rock bolt passes the pull test.
- G. First ten rock bolts and the first ten rock dowels shall be tested. Thereafter rock bolts will be selected at random by the Resident Engineer for testing. A minimum of three percent of each type installed shall be tested. Perform tests not less than one or more than three days after installation.
- H. Test rock bolts/dowels to 80-percent of their respective yield strength.
- I. The bolt/dowel tested shall be considered to have failed and shall be replaced at no cost to the MTA if the total movement exceeds 0.5-inch or if movement occurs and continues to occur below or at the indicated test load. Test up to five additional bolts/dowels adjacent to a failed bolt/dowel. Replace the failed bolts/dowels at no additional cost to the MTA and retest the replacement bolts/dowels.
- J. The GRP rock dowels shall be tested at random as selected by the Resident Engineer after one but not more than three days after installation as follows:
 - 1. First ten dowels.
 - 2. Twenty percent of first 100 dowels.
 - 3. Three percent of the remaining dowels.
- K. The GRP rock dowels shall be tested to 27.5-kips. The test shall be considered acceptable if the test load of 27.5-kips is held by the dowel for five minutes and the total movement of the bolt is less or equal to 0.5-inch. Test up to five additional GRP rock dowels adjacent to a failed GRP rock dowel. Replace the failed GRP rock dowels and retest the GRP rock dowels.
- L. The results of rock bolt and rock dowel tests shall be submitted to the Resident Engineer within 24 hours of the completion of each test or inspection.

3.05 UNACCEPTABLE ROCK REINFORCEMENT

- A. If it is found that any rock reinforcement is defective, loose, or improperly installed or will not take the required load in a pull test without slip, install another rock reinforcement in a new hole drilled in the immediate vicinity of the unsatisfactory bolt.

- B. Bolts or dowels that will not take the required tension without anchorage slip of less than 0.5-inch shall be replaced by an additional bolt or dowel as specified herein above.
- C. If rock reinforcement has been damaged or made ineffective by construction operations, repair the damage and, if necessary, install additional rock reinforcement to replace the damaged or ineffective ones.

3.06 PLACEMENT OF WELDED WIRE MESH, CHANNELS, AND MINE STRAPS

- A. Welded wire fabric shall be placed and secured against the excavated or shotcreted surface (as shown on the Contract Drawings). The fabric shall be anchored to follow the excavated or shotcreted surface contours and additional pins shall be provided if necessary to hold mesh in contact with the excavated surface or shotcrete.
- B. Welded wire fabric shall not be used with fiber-reinforced shotcrete.
- C. Channels and mine straps shall be installed with dowels or bolts and securely bolted to them with end hardware.

3.07 STEEL RIBS AND BLOCKING

- A. Steel Ribs: Install the steel ribs to the proper lines and grades and maintain the ribs in the proper condition and within tolerances for alignment throughout the duration of this Contract. Ribs that are improperly installed, damaged, or displaced, shall be repaired or replaced within 48 hours after notification by the Resident Engineer.
- B. Blocking:
 - 1. Steel ribs shall be securely blocked and braced against rock surfaces, and against distortion and lateral displacement.
 - 2. Place blocking in the form of open cribbing. Cribbing shall be arranged to permit the ready flow of future final lining concrete through and around cribbing.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for protecting and constructing monitoring wells (in case of damage by Contractor) as indicated on the Contract Drawings and specified herein. Included in the Work are the construction (in case of damage by Contractor), protection, maintenance, and abandonment of damaged environmental monitoring wells as shown in the Contract Drawings.

1.02 REFERENCED SECTIONS

- A. Section 01545 – Construction Safety and Health
- B. Section 02105 – Chemical Sampling and Analysis

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. C 778 - Standard Sand
 - 2. D 1785 - Poly Vinyl Chloride (PVC) plastic pipe, Schedule 40
 - 3. D 5092 - Design and Installation of Ground Water Monitoring Wells in Aquifers
 - 4. D 5299 –Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
 - 5. D 6286 - Selection of Drilling Methods for Environmental Site Characterization

1.04 NOTED RESTRICTIONS

- A. A Contractor's Safety Supervisor/Representative shall be present at the Work Site at all times.
- B. Display or have available at the Work Site at all times a copy of the approved Contract-specific Construction Safety and Health Plan (CSHP) and Safe Work Plan (SWP).

1.00 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Railroad Safety Regulations and Rail Safety Training (as required).

2. Code of Federal Regulations (CFR):
 - a. 29 CFR 1910 - Occupational Safety and Health Administration (OSHA)
 - b. 49 CFR 214 - Roadway Worker Protection
 3. New York State Department of Environmental Conservation (NYSDEC):
 - a. Division of Water - Water Well Program
 4. Other applicable rules and regulations of authorities having jurisdiction.
 5. Approved NYSDEC Long Island Well Permit Conditions (or application if permit is not available).
- B. Review the details of all monitoring wells to be used and prepare the procurement list for all items required for installation and maintenance for the duration of the Work.
- C. The driller shall have at least four years (or as approved by the Resident Engineer) of direct field experience with similar projects.
- D. The driller must have all appropriate New York State Licenses and must be approved as a well driller with NYSDEC.
- E. Verify compliance with standards and regulations and Section 01545.
- F. Ensure compliance with Section 02105 for characterization of drill cuttings and purged water.
- G. When directed by the Resident Engineer, verify proper operation of monitoring wells by means of recharge test or equivalent procedure reviewed by the Resident Engineer.

2.00 SUBMITTALS

- A. Submit evidence of current valid permits, licenses, and certifications including, as a minimum, the following:
1. Training certificates (current Hazardous Waste Operations and Emergency Response [HAZWOPER] 40-hour or 8-hour Refresher) of all workers, to be engaged in Work under this Section, including Contractor's Safety Supervisor/Representative in accordance with OSHA standards.
 2. Valid off-site transportation and disposal permits and licenses from the waste hauler and treatment, storage and disposal (TSD) Facility.
 3. Written verification by a Certified Industrial Hygienist (CIH) of approval of the Contract-specific SHP and SWP as required in Section 01545.
 4. Name, location, telephone number and all required permits of all facilities to be used for disposal.

- A. Submit disposal facility permits and regulatory compliance documentation.
- B. Submit disposal manifests.
- C. Submit detailed step-by-step procedure for installation of all monitoring wells, including samples of the installation record sheets and logs.
- D. Submit installation procedures including, but not limited to, the following:
 - 1. Manufacturer and model of drill rig.
 - 2. Method to be used for cleaning/decontaminating the inside of casing or augers and other materials and equipment that are exposed to contaminated soil.
 - 3. Method for checking and verifying depth to bottom of well and method for the removal of fines for all wells.
 - 4. Specifications for proposed grout mixes, including commercial names, proportions of admixtures and water, mixing sequence, mixing methods and duration, pumping methods and tremie pipe type, size, and quantity.
 - 5. Drill casing or auger type and size.
 - 6. Depth increments for backfilling boreholes with sand and granular bentonite.
 - 7. Method of sealing joints in pipes to prevent ingress of grout.
 - 8. Method(s) for protecting monitoring wells from damage.
 - 1. Method for collection, containerization, and disposal of well cuttings, development, and purged water.
- E. Submit detailed step-by-step procedure for well abandonment, including material list, and handling and disposal of all wastes and materials. Within 30 days, submit abandonment logs indicating details of well abandonment (well ID, location, depth, quantities of materials utilized, documentation of materials removed, and documentation of materials left in place).
- F. Submit detailed step-by-step procedure for developing and re-developing wells, including handling and disposal of wastes and waste-water generated during development. Within five days of well development or redevelopment, submit records of proceedings, including volumes utilized and any additives; note the use of any and all additives must be reviewed by the Resident Engineer prior to use.

1.07 DELIVERABLES

- A. Within five days after installing each monitoring well, provide the installation record sheet for that well including the surveyed as-built location and reference elevation as specified herein. Within 30 days of the installation, submit boring/well construction logs for each well, including depth, types of materials and all other construction details. As each well is installed, prepare an installation record sheet including appropriate items from the following list:

1. Project name.
2. Contract name and number.
3. Planned/actual location in horizontal position and elevation.
4. Planned/actual orientation.
5. Planned/actual thickness and volumes at backfill.
6. Personnel responsible for installation.
7. Plant and equipment used including diameter and depth of any drill casing or augers used.
8. Date and time of start and completion of installation.
9. A geologic log of subsurface data indicating the elevations of strata changes encountered in the borehole. Strata soil nomenclature shall be based on profiles and boring logs contained in the Geotechnical Data Report. Soils shall be classified for lithology using the United Soil Classification System (USCS).
10. Type of backfill used.
11. As-built location in horizontal position and elevation including:
 - a. Elevation referenced to the MTA Project Elevation Datum together with the location of the point used for the elevation measurement.
 - b. Horizontal position referenced to the Project horizontal control system together with the location of the point used for horizontal position measurement.
 - c. A location sketch showing the instrument number, taped horizontal distances to the instrument, measured to an accuracy of plus or minus 1-foot from permanent physical features in the field. A sufficient number of taped measurements shall be included on the sketch to establish a unique horizontal position for the instrument. If such features are removed, provide a new sketch before removal with taped measurements to other features.
12. As-built orientation.
13. As-built volumes of backfill.
14. Weather conditions at the time of installation.
15. Notes of importance on the installation including problems encountered, delays, unusual features of the installation (i.e., sheen, odors, floating product), and details of any events that may have a bearing on instrument behavior.

1.08 PROJECT CONDITIONS

- A. Some portions of the Work may require closure of adjacent tracks, de-energizing of adjacent third rail, de-energizing of catenary and flag protection. Coordinate all such actions through the Resident Engineer. No Work shall occur in rail track areas without MTA flagman and by individuals without current Railroad Safety Training Certificates in accordance with Amtrak Safety Regulations and 49 CFR 214.

PART 2 PRODUCTS**2.01 GENERAL**

- A. All materials shall be new. Whenever materials are specified by brand name and model numbers, any request from Contractor for consideration of a substitution shall clearly state the nature of any deviation from the product specified.
- B. The Resident Engineer may approve the use of a substituted material or product.
- C. Furnish all installation tools, materials, and miscellaneous components.
- D. Materials used shall not contribute to or remove contaminants from the groundwater. Materials and equipment that have contact with soil must be decontaminated between well installations.
- E. Solvents or glues must not be used.
- F. Each monitoring well shall be permanently marked on the well cap with a unique identification number.
- G. Well riser shall be 2-inch diameter, Schedule 40 PVC plastic pipe and comply with ASTM D 1785.
- H. Well screens shall be 2-inch diameter, Schedule 40 PVC plastic pipe, ten feet long, with 0.02-inch slots.
- I. Provide riser pipe with end cap and a vented top cap. Riser pipe shall be two-inch, Schedule 40 PVC with self-sealing flush joints and shall comply with ASTM D 1785. Joints shall either have modified pipe threads or O-rings such that they sustain an internal water pressure of 50-pounds per square inch. Standard square threads without appropriate O-rings are not acceptable.
- J. Surface protection shall be flush with the ground surface in paved or other areas and shall consist of an 8-inch diameter, 12-inch depth limited access watertight manhole manufactured by PEMCO (Model No.1038 x 12) or approved equal. A locking lid shall be provided.
- K. Granular bentonite shall be Wyo-Ben, Inc. "Enviroplug Medium"; Baroid Division, Petroleum Services, Inc. "Holeplug"; Cetco "PureGold Medium Chips"; Polymer Drilling Systems Company "Pel-Plug TR30" or "TR-60"; or approved equal. Compressed bentonite pellets shall not be used.

- L. Filter sand shall conform to ASTM C 778 for 20-30 sand.

PART 3 EXECUTION

3.01 GENERAL

- A. The Resident Engineer may take samples or data from the wells installed by Contractor.
- B. Responsibilities:
1. Abandon wells as directed by the Resident Engineer (See Article 3.05)
 2. Protect from damage and maintain all monitoring wells as shown on the Contract Drawings and as directed by the Resident Engineer.
 3. Prior to commencing construction, verify depth to bottom for all wells within limits of Work area. Clean wells as necessary of any accumulated sediment.
 4. Existing wells shall be protected. Repair or replace damaged or non-functioning wells in a timely manner (within 72 hours) or as directed by the Resident Engineer.
 5. Provide the Resident Engineer with access to the wells as requested.

3.02 GENERAL INSTALLATION PROCEDURES

- A. Install monitoring wells one per borehole, at the locations, to the elevations and in the manner shown on the Contract Drawings, and as directed by the Resident Engineer.
- B. Installation procedures for monitoring wells shall be such that all steps in the procedure are in accordance with quality assurance requirements specified herein including ASTM D 5092, ASTM D 6286 and as shown on the Contract Drawings. Volumes of each increment of backfilling with sand and granular bentonite shall be small enough that no bridging occurs. The depth to the top of each increment shall be checked after placement. Place granular bentonite in depth increments not exceeding 2-feet.
- C. Place grout using a tremie method with side discharge ports on the tremie pipe.
- D. Before installing wells through drill casing or augers, thoroughly remove all material adhering to the inside of the casing or augers and all cuttings.
- E. Whenever withdrawing drill casing or augers during instrumentation installation in a borehole, take care to minimize the length of unsupported borehole and the rate of casing or auger withdrawal. Do not allow collapse of the borehole. Do not allow backfill material to build-up inside the casing or auger such that the instrument is lifted as the casing or auger is withdrawn. Withdraw the casing or auger without rotation.

- F. Do not leave partially completed well installations overnight or longer without prior written permission of the Resident Engineer.
- G. Monitoring wells (partially or fully completed) must not allow foreign objects to enter the riser pipe.
- H. Monitoring well as-built locations and elevations shall be surveyed by a New York State Licensed Land Surveyor.
- J. After installation, roadway boxes shall be free-draining. Repair or replace roadway boxes that are not free-draining at no additional cost to the MTA.

3.03 INSTALLATION OF MONITORING WELLS

- A. Boreholes must be hand augered or vacuum excavated to a minimum depth of 5 feet.
- B. Drill boreholes required for monitoring wells to depths specified on the Contract Drawings.
- C. Install well screens at elevations shown on Contract Drawings.
- D. Do not install a monitoring well less than five feet from an existing monitoring well.
- E. Check depth to the top of each increment of granular bentonite using a cylindrical sounding hammer. Do not tamp the granular bentonite.
- F. Joints, caps, and end plugs must be secured through the use of welds, threads with Teflon tape or force fittings.
- G. The space between the borehole and the well casing above the well screen must be sealed (using bentonite) to prevent contamination of groundwater and samples.
- H. Decontaminate all equipment that contacts the soil.
- I. Develop the monitoring wells by surging with compressed air or water columns or other reviewed methods.
- J. The top of the riser pipe must be permanently marked to establish a datum for future water level measurements.
- K. After completion of installation, determine the as-built location in horizontal position to an accuracy of 0.1-foot and in elevation to an accuracy of plus or minus 0.01-foot (i.e., well cap, top of casing, screen, and bottom of well).
- L. Dispose of drill cuttings and development and purged water in accordance with applicable Federal, State and local regulations.
- M. Restore all surfaces affected by installation of instruments to the original condition before completion of the Work.

3.04 MAINTENANCE AND PROTECTION

- A. Maintain and protect new and existing wells from damage or deterioration due to constructions activities, weather, traffic, and vandalism. If unable to protect any well(s) from damage for any reason, abandon the well(s) as directed in Article 3.05 and replace as directed by the Resident Engineer.
- B. Maintain and, where necessary or as directed by the Resident Engineer, construct access to all monitoring wells to ensure accessibility.
- A. If a monitoring well is damaged or becomes inoperative, repair or replace the damaged or inoperative well within 72 hours. The Resident Engineer will be the sole judge of whether repair or replacement is required. The Resident Engineer may impose a work stoppage in the vicinity of the damaged or inoperative well until it is again operational. All damaged or inoperative wells must be decommissioned in accordance with NYSDEC and/or industry accepted requirements (See also Article 3.05).
- A. Extend or reduce installed monitoring wells and reinstall roadway boxes as necessary as grade changes occur and revise reference elevations as necessary.
- B. Sound each well on a monthly basis to ensure that soil particles are not accumulating in the riser pipe. Maintain depth to bottom by cleaning out as necessary.
- C. Maintenance and protection of monitoring wells is exclusively the responsibility of Contractor. Contractor is hereby forewarned that conditions (foreseen or unforeseen) affecting the operability of monitoring wells will provide no relief to Contractor with respect to Contractor's obligation to protect wells in order that reliable groundwater data be provided at the locations and frequencies given in the Long Island Well Permits for Contract CQ026 and Contract CQ028 and as required in the Contract Documents.

3.05 ABANDONMENT

- A. Abandon monitoring wells as directed by the Resident Engineer.
- B. Every appropriate precaution must be taken to avoid introducing contaminants into a borehole. All monitoring wells, which are abandoned, must be fully sealed in a manner appropriate for the geologic conditions to prevent contaminant migration through the borehole.
- C. Remove the riser casing to the greatest extent possible. All riser casing and well installations in the upper five feet of the boring or within five feet of the proposed level of excavation must be removed.
- D. Sealing by pressure injection with cement bentonite grout using a tremie pipe or other method acceptable to the Resident Engineer must extend the entire length of the boring to five feet below the ground surface or the proposed excavation level. Where the surrounding geologic deposits are highly permeable, alternate methods of sealing may be required to prevent the migration of the grout into the surrounding geologic formation. The upper five feet must be backfilled with appropriate native materials and compacted to avoid settlement.

- E. The sealed site must be restored to a safe condition. Any pits shall be backfilled and the area shall be left clean. Proper and accurate documentation of procedures and materials shall be required. Reporting procedures defined by state regulation must be followed. The Work Site must be inspected periodically after sealing for settlement or other conditions, which require remediation.
- F. If a monitoring well is to be installed to replace a non-functioning well, It is Contractor's responsibility to do so no later than 72 hours after the abandonment is complete.
- G. Contractor is responsible for all corrective measures such as repaving in the event of settlement.
- H. Maintain an accurate written log and record the abandonment details for each monitoring well including but not limited to the well depth, the amounts of Portland cement and bentonite utilized, and the gallons of water used in the mixture.

3.06 DISPOSITION OF WELLS

- A. All monitoring wells shall become the property of MTA.
- B. Before conclusion of Work, verify depth to bottom for all wells as directed by the Resident Engineer. Clean wells if necessary.
- C. Upon completion of the Work and before transfer all monitoring wells in satisfactory operation condition for continuation of monitoring by others. Replace all equipment that is damaged, non-functional, or in poor condition.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for earthwork activities associated with the property line manholes at 63rd Street and Second Avenue including, but not limited to, the following:
1. Preparing subgrades for slabs-on-grade, walks and pavements
 2. Excavating and backfilling for structures, including basins and mechanical or electrical utility structures.
 3. Drainage course for slabs-on-grade
 4. Subbase course for concrete walks and pavements
 5. Base course for asphalt paving
 6. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures including hand excavation
 7. Dewatering required to protect subgrades and foundation soils
 8. Excavation Support and Protection for open excavations exceeding 5-feet
- B. Definitions:
1. Backfill: Soil materials used to fill an excavation
 - a. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - b. Final Backfill: Backfill placed over initial backfill to fill a trench.
 2. Base Course: Layer placed between the subbase course and asphalt paving.
 3. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.
 4. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
 5. Drainage Course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.
 6. Excavation: Removal of material encountered above subgrade elevations
 7. Additional Excavation: Excavation below subgrade elevations as directed by Resident Engineer. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 8. Bulk Excavation: Excavations more than 10-feet in width and pits more than 30-feet in either length or width.

9. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by the Resident Engineer. Unauthorized excavation, as well as remedial work, shall be without additional compensation.
10. Fill: Soil materials used to raise existing grades.
11. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
12. Subbase Course: Layer placed between the subgrade and base course for asphalt paving, or layer placed between the subgrade and a concrete pavement or walk
13. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
14. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.02 REFERENCED SECTIONS

- A. Section 02950 – Street and Site Restoration

1.03 CITED STANDARDS

- A. ASTM International (ASTM)
 1. D448 - Sizes of Aggregate for Road and Bridge Construction
 2. D698 - Laboratory Compaction Characteristics of Soil Using Standard Effort
 3. D1556 - Density and Unit Weight of Soil in Place by the Sand-Cone Method
 4. D1557 - Laboratory Compaction Characteristics of Soil Using Modified Effort
 5. D2167 - Density and Unit Weight of Soil in Place by the Rubber Balloon Method
 6. D2487 - Classification of Soils for Engineering Purposes
 7. D2922 - Density of Soil and Soil-Aggregate in Place by Nuclear Methods
 8. D2937 - Density of Soil in Place by the Drive Cylinder Method
 9. D2940 - Graded Aggregate Material for Bases or Subbases for Highways or Airports
 10. D3740 - Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

11. E329 - Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
12. E548 - General Criteria Used for Evaluating Laboratory Competence

1.04 NOTED RESTRICTIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Resident Engineer and then only after arranging to provide temporary utility services according to requirements indicated. Plate over excavations and restore full width of roadway at the end of each shift. Do not restrict access by Consolidated Edison Company of New York (ConEd) to property line manholes at any time.
 1. Notify Resident Engineer not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Resident Engineer's written permission.
 3. Contact utility-locator service for area where Project is located before excavating.
- B. Work Hours: Contractor shall be permitted to close one traffic lane on 63rd Street on Saturdays and Sundays from 9:00 AM to 2:00 PM, in order to install property line manholes and ducts.

1.05 QUALITY CONTROL

- A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E329 to conduct soil materials and rock-definition testing, as documented according to ASTM D3740 and ASTM E548.

1.06 SUBMITTALS

- A. Maintenance and Protection of Traffic Plan (MPT): Submit to the Resident Engineer for review, the proposed Maintenance and Protection of Traffic Plan (MPT). No street work will be permitted before a MPT Plan has been approved by NYCDOT.
- B. Samples: Submit 30-pound samples, sealed in airtight containers, of each proposed soil material from on-site or borrow sources.
- C. Support of Excavation Design: Submit a Support of Excavation design prepared by, and signed and sealed by a Professional Engineer licensed in the State of New York.
- D. Material Test Reports: Submit material test reports from a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 1. Classification according to ASTM D2487 of each on-site or borrow soil material proposed for fill and backfill.

2. Laboratory compaction curve according to ASTM D698 for each on-site or borrow soil material proposed for fill and backfill.
- E. Submit laboratory compaction curve according to ASTM D1557 for each on-site or borrow soil material proposed for fill and backfill.

1.07 DELIVERABLES

None Listed

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D2487 soil classification groups GW, GP, GM, SW, SP, and SM, or a combination of these group symbols; free of rock or gravel larger than 3-inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: ASTM D2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, and PT, or a combination of these group symbols.
 1. Unsatisfactory soils also include satisfactory soils not maintained within two-percent of optimum moisture content at time of compaction.
- D. Backfill and Fill: Satisfactory soil materials.
- E. Subbase: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90-percent passing a 1-1/2-inch sieve and not more than twelve-percent passing a No. 200 sieve.
- F. Base: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 95-percent passing a 1-1/2-inch sieve and not more than eight-percent passing a No. 200 sieve.
- G. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90-percent passing a 1-1/2-inch sieve and not more than twelve-percent passing a No. 200 sieve.
- H. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; except with 100-percent passing a one-inch sieve and not more than eight-percent passing a No. 200 sieve.
- I. Drainage Fill: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100-percent passing a 1-1/2-inch sieve and zero to five-percent passing a No. 8 sieve.

- J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100-percent passing a 1-inch sieve and zero to five-percent passing a No. 4 sieve.
- K. Impervious Fill: Clay, gravel, and sand mixture capable of compacting to a dense state.

PART 3 - EXECUTION

3.01 GENERAL

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials, as necessary.
- C. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.02 DEWATERING

- A. Prevent surface water and groundwater from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Re-route surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
 - 2. Install a dewatering system to keep subgrades dry and convey groundwater away from excavations. Maintain until dewatering is no longer required.
 - 3. Dispose of water removed from excavations in a manner to avoid endangering public health, property, and portions of Work under construction or completed. Dispose of water in a manner to avoid inconvenience to others. Provide sumps, sedimentation tanks, and other flow control devices as required by NYCDEP and any other authorities having jurisdiction.

3.03 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.04 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavation to subgrade elevations of materials above rock regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, and obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials, replace with satisfactory soil materials.

3.05 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus-or-minus 1-inch. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus-or-minus 1-inch. Do not disturb bottom of excavations intended for bearing surface.

3.06 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

3.07 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12-inches higher than top of pipe or conduit, unless otherwise indicated.
 1. Clearance: 12-inches on each side of pipe or conduit
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
 1. For pipes and conduit less than 6-inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
 2. For pipes and conduit 6-inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
 3. Excavate trenches 6-inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.08 APPROVAL OF SUBGRADE

- A. Notify Resident Engineer when excavations have reached required subgrade.
- B. If Resident Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
 - 1. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- C. Proof roll subgrade with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Resident Engineer.

3.09 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used when approved by Resident Engineer.
 - 1. Fill unauthorized excavations under other construction or utility pipe as directed by Resident Engineer.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation
 - 2. Surveying locations of underground utilities for record documents
 - 3. Inspecting and testing underground utilities
 - 4. Removing concrete formwork and waiting for required concrete curing time
 - 5. Removing trash and debris
 - 6. Removing temporary shoring and bracing, and sheeting as required
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls

3.12 UTILITY TRENCH BACKFILL

- A. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- B. Backfill trenches excavated under footings and within 18-inches of bottom of footings. Fill with concrete to elevation of bottom of footings.
- C. Provide 4-inch-thick concrete-base slab support for piping or conduit less than 30-inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4-inches of concrete before backfilling or placing roadway subbase.
- D. Place and compact initial backfill of subbase material, free of particles larger than one-inch, to a height of 12-inches over the utility pipe or conduit.
 - 1. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
- E. Coordinate backfilling with utilities testing.
- F. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.
- G. Place and compact final backfill of satisfactory soil material to final subgrade.
- H. Install warning tape directly above utilities, 12-inches below finished grade, except six-inches below subgrade under pavements and slabs.

3.13 FILL

- A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.
- B. Plow, scarify, bench, or break up sloped surfaces steeper than one vertical to four horizontal so fill material will bond with existing material.
- C. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use nursery-grade soil material
 - 2. Under walks and pavements, use engineered fill
 - 3. Under steps and ramps, use engineered fill
 - 4. Under building slabs, use engineered fill
 - 5. Under footings and foundations, use engineered fill

3.14 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within two-percent of optimum moisture content.
 - 1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by two-percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF BACKFILLS AND FILLS

- A. Place backfill and fill materials in layers not more than 8-inches in loose depth for material compacted by heavy compaction equipment, and not more than 4-inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil to not less than the following-percentages of maximum dry unit weight according to ASTM D698:
 1. Under walkways, scarify and re-compact top six-inches below subgrade and compact each layer of backfill or fill material at 92-percent.
 2. Under lawn or paved areas, scarify and re-compact top six-inches below subgrade and compact each layer of backfill or fill material at 85-percent.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 1. Lawn or Unpaved Areas: Plus or minus 1-inch
 2. Walks: Plus or minus 1-inch
 3. Pavements: Plus or minus 1/2-inch
- C. Grading Inside Building Lines: Finish subgrade to a tolerance of one-half-inch when tested with a 10-foot straightedge.

3.17 SUBBASE AND BASE COURSES

- A. Install separation fabric on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
- B. Under pavements and walks, place subbase course on prepared subgrade and as follows:
 1. Place base course material over subbase.

2. Compact subbase and base courses at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95-percent of maximum dry unit weight according to ASTM D1557.
 3. Shape subbase and base to required crown elevations and cross-slope grades.
 4. When thickness of compacted subbase or base course is six-inches or less, place materials in a single layer.
 5. When thickness of compacted subbase or base course exceeds six-inches, place materials in equal layers, with no layer more than six-inches thick or less than three-inches thick when compacted.
- C. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12-inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95-percent of maximum dry unit weight according to ASTM D1557.
- D. Restore street, sidewalk and curb per Section 02950.

3.18 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor shall engage a qualified independent geotechnical engineering testing agency to perform field quality control testing.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed Work comply with requirements.
- C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design-bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Resident Engineer.
- D. Testing agency shall test compaction of soils in place according to ASTM D1556, ASTM D2167, ASTM D2922, and ASTM D2937, as applicable. Tests will be performed at the following locations and frequencies:
1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2,000-square-feet or less of paved area or building slab, but in no case fewer than three tests.
 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for each 100-feet or less of wall length, but no fewer than two tests.
 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for each 150-feet or less of trench length, but no fewer than two tests.

- E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required. Re-compact and retest until specified compaction is obtained.

3.19 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Resident Engineer. Reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Project site.
- B. Disposal: Transport surplus satisfactory soil to designated storage areas on the Project site.
- C. Remove, stockpile, or spread soil as directed by Resident Engineer.

3.21 RESTORATION

- A. Contractor shall restore the street, sidewalk, sidewalk ventilation plenums, and curbs in accordance with Section 02950.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES:**

- A. Requirements for temporary measures to control soil erosion and water pollution during construction activities.

1.02 REFERENCED SECTIONS

- A. Section 01545 - Construction Safety and Health

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Work shall not commence until coverage under New York State Department of Environmental Conservation (NYSDEC) State Pollutant Discharge Elimination System (SPDES) General Permit GP-02-01 is granted and Stormwater Pollution Prevention Plan is produced and implemented.
- B. A qualified Safety Supervisor/Representative shall be present at the Work Site at all times.
- C. Display or have available at the Work Site at all times a copy of the approved Contract-specific Construction Safety and Health Plan (CSHP) and Safe Work Plan (SWP) as required in Section 01545.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. NYSDEC:
 - a. NYSDEC SPDES General Permit for Stormwater Discharges from Construction Activity (GP-02-01).
 - b. New York State Guidelines for Urban Erosion and Sediment Control and Draft New York Standards and Specifications for Erosion and Sediment Control.
 - 2. New York State Department of Transportation (NYSDOT) Standard Specifications
 - 3. United States Environmental Protection Agency (USEPA):
 - a. Best Stormwater Management Practices
- B. Ensure compliance with all regulatory requirements.

1.06 SUBMITTALS

- A. Submit proposed method of erosion control.
- B. Submit Stormwater Pollution Prevention Plan including Erosion and Sediment Control Plan (ESCP) in accordance with NYSDEC, NYSDOT and USEPA regulatory requirements (See Article 1.05).

1.07 DELIVERABLES

- A. Provide Notice of Intent (NOI) for SPDES General Permit for Stormwater Discharges from Construction Activities.

PART 2 PRODUCTS**2.01 CRITERIA**

- A. Conform to NYSDOT Standard Specifications including Section 209-2.
- B. Conform to New York State Guidelines for Urban and Sediment Control and NYSDEC, NYSDOT and USEPA regulatory requirements.

2.02 SILT FENCE

- A. Mirafi Silt Fence, or approved equal.

2.03 STOCKPILE COVERS

- A. 4-mil polyethylene sheeting shall be used to cover all soil and debris stockpiles.
- B. Sandbags or other non-puncture weighted materials to keep cover in place.

2.04 GENERAL

- A. Install and maintain all necessary products to conform to the requirements of this Section and the NYSDEC SPDES Permit. Such products may include, but are not limited to, hay bales at storm drain inlets and catch basins; dewatering pump inlet bags or sediment traps; temporary slope stabilization materials such as stone rip-rap, fabric filters, geo-textiles, degradable blankets, seeding, planting, or mulching; and sedimentation tanks to treat run-off where Work Site space is limited.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Initiate all erosion controls required during construction to prevent siltation of any affected collection basins, inlets, manholes, channels, combined sewers, or storm sewer systems as shown on the Contract Drawings, in accordance with NYS Guidelines for Urban Erosion and Sediment Control, New York Standards and Draft Specifications for Erosion and Sediment Control. Prevent sediment from flowing onto public right-of-way.

- B. Installation of the temporary soil erosion and water pollution controls shall be in accordance with NYSDOT Standard Specifications, Section 209-3, Construction Details in addition to USEPA's Best Stormwater Management Practices, New York State Guidelines for Urban Erosion and Sediment Control and NYSDEC, NYSDOT, and USEPA regulatory requirements.

3.02 OPERATION, MAINTENANCE, AND REPAIR

- A. Inspect all erosion and sediment controls, especially before, during, and after storm events, for indications of failure, malfunction, or sediment buildup in accordance with State Guidelines.
- B. Remove sediment buildup from all controls to maintain functional capacity. All sediment shall be properly handled and managed in accordance with the NYSDEC SPDES Permit. Any contaminated sediment shall be handled and managed according to the applicable Section.
- C. Repair and replace any malfunctioning or failing erosion and water pollution controls in accordance with State Guidelines, the NYSDEC SPDES permit.
- D. Keep and maintain a stockpile of materials at the Work Site to supplement, replace, or repair all erosion and sedimentation controls. Typical materials to be utilized include silt fence, straw bales, mulch, mesh/blanket matting, and crushed stone/rip-rap.

3.03 DUST CONTROL

- A. Maintain appropriate covers on all soil stockpiles to prevent wind erosion as well as storm-water run-off.
- B. Provide and apply water and other dust control measures as necessary to all open or un-stabilized excavations and roadways to minimize dust generation.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for excavating tunnels by tunnel boring machine (TBM), constructing interfaces with Cross Passages and Caverns, and installation of initial support and additional initial support.
- B. Furnishing and installing one-pass permanent tunnel support consisting of bolted and gasketed precast concrete segments as specified in Section 02427, if the precast segment lining option is selected by the Contractor. The concrete segments are referred to herein after as the “lining” or “liner”.
- C. Furnishing and placing backfill grout behind precast concrete linings to fill the annular space between lining extrados and excavated surface in accordance with Specification Section 03605.
- D. Furnishing and placing pre-excavation and post-excavation grout in accordance with Specification Section 03605.
- E. Requirements for furnishing and placing cast-in-place concrete liners in the tunnels are specified in Section 03300.
- F. Installing and maintaining temporary drainage, lighting, power, water, communications and ventilation in the excavations.
- G. Excavation of Approach Tunnels, TBM Assembly Chamber and adjoining Starter Tunnels, GCT 3 Wye Caverns, GCT 5 Wye Caverns and adjoining Starter Tunnels, Cross Passages, Central Instrument Room, Cross Flue, and Sump Pump Chamber are specified separately in Section 02407.
- H. Requirements for new or refurbished tunnel TBMs for use in excavation of portions of the tunnels are specified in Section 02413.
- I. Definitions:
 - 1. Additional Initial Support in TBM Excavated Tunnels: This includes rock dowels, mine straps, and steel ribs in addition to the initial support types and quantities for the Support Classes as shown on the Contract Drawings. Additional initial support measures are installed in a systematic or non-systematic manner, for local stabilization during tunneling.
 - 2. Initial Support in TBM Excavated Tunnels: This is support installed immediately behind the TBM cutterhead support and while the rock is restrained by the finger shield, to the extent practicable, to minimize ground movement and loosening, and to maintain stability of the excavated ground. Initial support includes rock dowels, welded wire fabric, mine straps, channels, steel ribs, and steel mat lagging as shown for the support classes on the Contract Drawings.

3. Tunnel Excavation by TBM: This consists of the performance of all operations for excavating the running tunnels by TBM and supporting the running tunnels in whatever ground conditions are encountered conforming to the indicated geometry, and line and grade tolerances. This also includes installation of precast segment lining, if the precast concrete segment lining option is selected by the Contractor.

1.02 REFERENCED SECTIONS

- A. Section 01520 – Construction facilities
- B. Section 01545 – Construction Safety and Health
- C. Section 01720 – Surveying and Layout
- D. Section 02145 - Groundwater Treatment System
- E. Section 02239 - Tunnel Dewatering
- F. Section 02270 – Rock Reinforcement and Initial Support
- G. Section 02407 – Tunnel and Cavern Excavation by Drill and Blast
- H. Section 02410 – Muck Handling and Disposal
- I. Section 02413 – Tunnel Boring Machine (TBM)
- J. Section 02427 – Precast Concrete Tunnel Lining
- K. Section 02495 – Geotechnical and Structural Instrumentation
- L. Section 03300 – Cast in Place Concrete Lining
- M. Section 02414 – Controlled Blasting
- N. Section 03605 – Tunnel Grouting
- O. Section 07122 – Waterproofing – Cavern Structures and Tunnels

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Do not begin TBM tunnel excavation until the following conditions have been met:
 1. Required submittals have been made and the Resident Engineer has reviewed submittals.

2. Pre-construction surveys near the TBM tunnel excavation have been completed by the Resident Engineer and pre-construction documents have been provided to Contractor.
3. Installation of geotechnical and structural instrumentation at any specific location for surface structures, NYCT subway structures and Air-Right Structures above GCT, in accordance with Section 02495, shall be completed and initialized before the advancing TBM face reaches within 200-feet of that location.
4. All issues related to health and safety have been met and all submittals have been made in accordance with OSHA requirements, Section 01545, and other applicable codes and regulations of Federal, State, and local agencies having jurisdiction.
5. Required personnel with qualifications specified herein and in Section 02407 are available at the Work Site to perform Work and training specified in Section 02413 has been completed.
6. Temporary construction power substation has been installed and tested in accordance with the Division 16 specifications.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 1. Code of Federal Regulations (CFR):
 - a. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)
- B. The Work shall be performed under the direct supervision of an experienced project manager with a minimum of 15 years (or as approved by the Resident Engineer) in civil -and heavy construction of which a minimum of five years experience (or as approved by the Resident Engineer) is in tunnel construction, including a minimum of two projects with full face, hard rock TBMs of comparable size to the Project TBMs.
- C. The Work shall be performed under the direct supervision of an experienced tunneling superintendent and tunneling supervisors with experience requirements in accordance with Section 02407. In addition, the tunneling superintendent experience shall include at least one project with full face, hard rock TBMs of a comparable size to this Project within the previous ten years (or as approved by the Resident Engineer). Duties of the tunneling superintendent and tunneling supervisors shall include the requirements set forth in Section 02407.
- D. Substitutions for the project manager or the tunnel superintendent during the Contract period shall not be made without prior written acceptance by the Resident Engineer. Substitute personnel must have the same qualifications specified herein for the position to be held.

- E. TBM operators and TBM mechanics shall have at least ten years (or as approved by the Resident Engineer) of demonstrated experience in operating hard rock TBMs.
- F. Tunneling shall not be performed unless the tunneling superintendent, tunneling supervisors, TBM operators and TBM Mechanics meeting the above experience requirements are on Work Site and in actual control of this portion of the Work.
- G. Contractor's safety supervisor and safety representative shall be experienced in TBM tunnel construction, and meet the requirements of tunnel construction safety as specified in Section 01545.

1.06 SUBMITTALS

- A. Submit the following for review to the Resident Engineer:
 - 1. Resume of proposed project manager.
 - 2. Resume of the proposed tunneling superintendent within 30 days of the date given in the Notice to Proceed.
 - 3. Resumes of the proposed tunneling supervisors at least 60 days before commencing tunnel excavation.
 - 4. Training certifications as required by the provisions of Section 02413 and/or resumes of TBM operators and mechanics, experienced in operating and maintaining TBMs suitable for the Project conditions, at least 60 days before TBM assembly or excavation commences.
 - 5. Resumes of safety supervisor and safety representative in accordance with Section 01545.
- B. At least 60 days before commencing TBM excavation, submit the following:
 - 1. Detailed working drawings of excavation sequence, initial support and additional initial support, a schedule of operations and methods of construction, including sequence and methods for mobilizing each TBM to Assembly Chamber, launching TBMs in Starter Tunnels, partial or complete disassembly, backing up and re-assembling TBMs at Wye Caverns and re-launching in Starter Tunnels for subsequent tunnel drives.
 - 2. If the precast segment lining option is selected by the Contractor, details of the seals to be used at the structure walls and other measures to be taken to minimize loss of ground and to provide groundwater control while the TBM advances sufficiently to complete the installation of several liner rings and to facilitate complete backfill grouting (see Section 03605).
 - 3. Details for tunnel and cross passage and tunnel and cavern interfaces.
 - 4. Complete working drawings and system description of proposed equipment, ventilation, materials and method for handling water within the tunnel, measurement of pumped water, and disposal methods.

5. A work plan covering access to the tunnel face in front of the TBM cutterhead. This shall include, but not limited to safety procedures, work plans, and methods of supporting and securing the unsupported portion of the heading and face when workers are in front of the TBM cutterhead during cutter changing, inspection or removal of manmade obstructions, and all other required cutterhead maintenance and repair activities.
 6. A work plan covering temporary support of tunnel face due to unplanned stoppages and planned weekends and holidays.
 7. Overall operational procedures for the TBM, including on-site assembly testing before start-up, identification of consumable materials and sources of each, and operational details of all TBM components.
 8. A work plan for rectifying water leakage in to the finished tunnel.
- C. Contingency Plans:
1. Submit contingency plan for additional initial support of pillars with signs of instability or if excessive ground deformations are detected.
 2. Submit contingency plan for providing additional initial support of tunnel sidewalls and advancing TBM if rock mass has insufficient bearing capacity to support required gripper pressure.
 3. Measures to be implemented if commercial electric power to TBMs and support system is interrupted.

1.07 DELIVERABLES

- A. Continuous Monitoring Data of TBM Performance: Provide to the Resident Engineer on a real-time basis for the duration of TBM excavation via data logger, as specified in Section 02413.
- B. While tunnel excavation is in progress, submit to the Resident Engineer a daily as-built survey record showing line, level, and grade of centerline of tunnel at the invert relative to the theoretical alignment and profile and actual excavated tunnel cross-sections compared to the theoretical cross-sections shown on the Contract Drawings. Submit the line and grade TBM guidance system information, both in hard copy and in electronic form. The hard copy shall show the current data, while the electronic file shall contain both the current and historic data. The initial submittal shall also detail the Contractor's complete procedures on the operation of the guidance system, frequency of setups on tangents and in curves, bringing the line and grade into the tunnel and independent verification measures to check the accuracy of the surveys.
- C. Within 60 days of completion of excavation of each tunnel, provide a complete record in electronic form, in tabular form and drawing form, the as-built survey data. Data must be presented in the form of station, offset from the baseline track (as stated in the contract documents, or design centerline for untracked structures) and elevation, and include cross section diagrams that show the variance of the as-built from design with values of maximum differentials indicated. Data points and a best-fit surface shall be shown with any anomalies explained. Survey data, including graphical cross sections, shall be presented at regular intervals not to

exceed 100-feet (except on curves, where the data shall be presented at regular intervals not to exceed 20-feet); also at each side of abrupt changes in cross section and at other points. Contour-type diagrams shall be produced as developed plans/sections for the entire surface of each tunnel indicating deviation from the design (showing extra clearance positive).

- D. Maintain daily records as excavation progresses and provide one copy of such before 12:00 PM of the following workday. Keep such other records as deemed necessary. The following data shall be included in the daily record for each tunnel heading:
1. Station of tunnel heading faces at start and end of each work shift.
 2. Type, quantity, and location of initial support and additional initial support installed.
 3. Evaluation of in-tunnel monitoring results.
 4. Probe hole records as specified herein.
 5. Number of workers employed per shift for each workday categorized by union trade, idle equipment, active equipment, and site visitors.
- E. Daily shift reports on TBM operation and performance data shall be prepared commencing on the first day of TBM assembly and cover a continuous period until the TBMs are removed from the tunnel. One copy of the shift reports, signed by Contractor's representative, shall be provided to the Resident Engineer before 12:00 PM the following workday. Data collection shall be accomplished both manually and by automatic recording systems in accordance with Section 02413. The following information, as a minimum, shall be included in the shift reports for each tunnel heading excavated by TBM:
1. TBM performance information, including stations of each advance of the TBM, the TBM clock time at the start and end of each shift.
 2. For each shove or stroke of the TBM, the date, time and tunnel station at start of shove, the duration and length of shove.
 3. TBM and excavation system downtime, including classification, details, and duration. Details shall include the impact on excavation progress. Categories of downtime may include, but not be limited to, TBM repair, cutter changes, installation of initial support and additional initial support, groundwater inflow, gas inflow, power outages and electrical repair, downtime of backup equipment, muck disposal system delays, hydraulics repair, gripper problems, alignment survey, waiting time due to lack of grout, initial support elements, etc., and routine maintenance.
 4. Cutter changes, including time, date, and reason for replacement, cutter position, or number.
 5. TBM clock record of utilization and penetration rates.
 6. Air quality and gas monitoring data.

7. Line and grade survey reports.
8. Water inflows, if any, with locations and estimates of rates.
9. Overbreak.
10. Any other geotechnical and/or unusual features such as faults, shears, crushed or soft zones, and raveling areas.
11. If the precast concrete segment liner option is selected by the Contractor, then include lining ring data, as specified in Section 02427 and time of erection starts and finishes.
12. Number of precast concrete segment rings erected during the shift.
13. For each erected ring, the following information shall be included:
 - a. Summary of all data automatically recorded by the TBM Guidance, Alignment Control, and TBM Monitoring System (see Section 02413).
 - b. Orientation of lining ring (position of key).
 - c. Grout pressures and quantities (backfill and check grout).
 - d. Measurements of horizontal and vertical diameters for each tunnel support ring at the completion of each ring and as specified in Section 02427. Complete records of measurements, with records of grouting for each ring daily.
 - e. Delays during shoving or lining erection.
 - f. Problems encountered such as water seepage.
 - g. Damages to lining segments or gaskets during erection or after start of shoving for the next ring, and as specified in Section 02427. Correction of such damage or replacement of damaged liner or gasket; changes to means or methods to prevent recurrence.
14. Records of deformation and/or damage for each lining element including repairs affected, water inflows, etc.
15. Results of strength tests for the injected tail void (backfill) grout.
16. The quantity and location of all initial support and additional initial support installed in the tunnel.
17. The quantity and location of all instrumentation installed during the shift.
18. Grouting reports as specified in Section 03605.

- E. On a weekly basis, provide comparison between As-Built and design tunnel centerline for rings built in the previous week, in a format reviewed by the Resident Engineer.
- F. Provide the no load drive motor current and TBM drag from propel cylinder pressure.
- G. Provide maintenance records of the TBM, the mucking system, and all associated equipment on a monthly basis.
- H. To comply with all applicable health and safety reporting requirements, provide reports as and when required by public authorities, and provide a copy of each such report prepared to the Resident Engineer at the same time that each is sent to the appropriate public authorities and, in all cases, within 24 hours following preparation of each report.

1.08 ACCESS BY THE RESIDENT ENGINEER

- A. Provide reasonable access for the Resident Engineer and its representatives to inspect and observe the work, to perform independent line and grade surveys, to take measurements, to check ring build quality, to check gauges and instruments used to monitor TBM parameters, to check for leaks and to ensure safe working practice, and for geologic mapping, as deemed necessary by the Resident Engineer. Such inspections are considered part of the Work at no additional cost to the MTA for such access.

PART 2 PRODUCTS

2.01 TUNNEL BORING MACHINES

- A. Tunnel boring machines and ancillary equipment shall be in accordance with Section 02413.

2.02 GROUT

- A. Grout shall be in accordance with Section 03605.

2.03 PRECAST CONCRETE SEGMENTS

- A. Precast concrete segments shall be in accordance with Section 02427.

2.04 MATERIALS

- A. Rock dowels and resin shall be in accordance with Section 02270.
- B. Welded wire fabric, ribs, tie rods and steel mat lagging shall be in accordance with Section 02270.
- C. Miscellaneous steel consisting of mine straps, welded wire fabric, ties, channels, or similar members that are attached to the rock surface by means of rock dowels shall comply with Section 02270.

PART 3 EXECUTION**3.01 TEMPORARY SYSTEMS**

- A. Provide, operate, and maintain all required temporary utility and ventilation systems in accordance with the requirements of Section 01520.
- B. Design, furnish, install, operate, and maintain for the duration of the Contract, a complete tunnel dewatering and groundwater treatment/control system in accordance with the requirements of Sections 02239 and 02145.

3.02 GENERAL REQUIREMENTS

- A. Work shall be performed in a manner that minimizes safety hazards and exposure of personnel and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements and Contractor's Safety and Health Plan.

3.03 EXCAVATION

- A. Excavation shall be to the lines, grades, and dimensions shown on the Contract Drawings and as specified. Surfaces of excavation shall not extend within the theoretical excavation line shown on the Contract Drawings. Methods shall be used and precautions shall be taken to minimize removal, loosening, and raveling of material beyond the minimum excavation necessary to satisfy all criteria.
- B. Coordinate the operation of the two TBMs in such way that both TBMs and related equipment are not started at the same time so that the surge supply limitations of ConEd are not exceeded.
- C. Do not advance the TBMs at any time when the TBM guidance system, as specified in Section 02413, is out of order.
- D. Validate line and grade continually with survey control being undertaken by qualified survey personnel in accordance with Section 01720.
- E. Detailed construction sequencing shall be the responsibility of Contractor, consistent with the requirements of these Specifications and those shown on the Contract Drawings. Refer to Contract Drawings and general notes for suggested tunnel excavation sequence.
- F. TBM tunnel excavation shall be staged such that no two active headings are within 100-feet of each other.

3.04 EXCAVATION WITH THE INSTALLATION OF PRECAST CONCRETE SEGMENT LINER

- A. Continuously backfill grout the tail void as the machine advances. Grouting through grout holes in segments will not be accepted as the primary method of backfill grouting.
 - 1. Adjust grout set-up times for compatibility with machine progress rates and planned or unplanned work stoppages.

2. As the segment ring is pushed in place, continuously pump grout at sufficient pressure and in sufficient volume to ensure complete and total filling of the annular void and to support the surrounding ground.
 3. Grout pressures shall be controlled to prevent damage to the tunnel lining, and ground deformation exceeding allowable limits.
 4. If buoyancy of the tunnel lining in the annular grout causes damage, distortions or excessive vertical movement, remedial measures and adjustments in grout mixes and injection procedures shall be proposed for review by the Resident Engineer. See Section 03605.
- B. As the TBM advances, continuously inject tail seal grease under pressure to minimize risk of groundwater or grout intrusion.
- C. Immediately stop the TBM(s) and secure the tunnel(s) when the computerized guidance system fails or is not functioning correctly. Do not resume advance of the TBM(s) until the computerized guidance system is functioning correctly.
- D. Immediately stop the TBM(s) and secure the tunnel(s) when the automatic backfill grouting system fails or is not functioning correctly. Do not resume advance the TBM(s) until the automatic backfill grouting system is functioning correctly.
- E. Erect precast concrete segment liner in accordance with Section 02427
- F. Perform backfill and check grouting in accordance with Section 03605.
- G. As the excavation progresses, the Resident Engineer will perform periodic inspection and geologic mapping of the tunnels. Lighting and access shall be provided for close inspection of the exposed excavated surfaces, as directed by the Resident Engineer. Where necessary, the excavated surfaces shall be cleaned by air or water jets to provide surfaces suitable for mapping, as directed by the Resident Engineer, provided, however, such cleaning shall be minimal in areas where softer materials can be gouged out to greater than 3-inches. Adjust TBM operations to the extent necessary to permit such mapping as directed by the Resident Engineer. Such work will be coordinated by the Resident Engineer in a manner to minimize disruption to Contractor's operations.
- H. Remove excavated material from each tunnel heading in accordance with Section 02410.
- I. Any blasting work that may be incidental to TBM operations shall be in accordance with requirements set forth in Section 02414.
- J. Precast Concrete Tunnel Lining: See Section 02427
- K. Backfill and Check Grouting: See Section 03605.
- L. Cast in Place Concrete Lining: See Section 03300

3.05 INITIAL SUPPORT

- A. Support Classes and Support Class Ranges:
1. All stations indicating limits of typical support classes referenced herein or as shown on the Contract Drawings are only approximate and may vary due to geological and hydrological conditions actually encountered in the field. TBM tunnel support classes, as shown on the Contract Drawings, are the minimum to be installed and shall be adjusted above and beyond the said minimum based on the actual ground conditions and shall be determined in the field in consultation between Contractor and the Resident Engineer.
 - a. Each support class defines installation of a specific initial support system. The support elements are as specified in Section 02270 and as shown on the Contract Drawings.
 - b. Initial support measures have been derived based on anticipated ground conditions and the need to provide stabilization of the tunnel openings for enlargements to cavern size openings under this Contract or future contracts.
 - c. Excavation and support measures delineated hereafter are typical and shall be supplemented by additional initial support measures as required by ground conditions actually encountered or as directed by the Resident Engineer. To minimize ground movement, the initial support shall be installed following each TBM shove or stroke directly behind the cutterhead support and as close to the face as practical in accordance with Section 02413.
 2. Three support classes have been identified and are shown on the Contract Drawings. They are Support Class I (SC I-TBM), Support Class II (SC II-TBM) and Support Class III (SC III-TBM). In addition, Support Classes I-E (SC IE-TBM) and II-E (SC IIE-TBM) are shown on the Contract Drawings to accommodate future enlargements.
 3. Contractor shall be responsible for maintaining the initial support and additional initial support for the duration of the Contract.
- B. No tunnel section (shove or stroke) may be advanced without initial support.
- C. Install initial support and additional initial support elements in accordance with Section 02270 and as shown on the Contract Drawings.

3.06 PROBE HOLES

- A. Provide a probe hole ahead of the tunnel face for the entire length of the first TBM run. Provide probe holes for a minimum of 50-percent of the remaining total lengths of the remaining TBM runs. Locations of these subsequent probe holes shall be determined by consultation between the Contractor and the Resident Engineer. The maximum probe hole length to be maintained ahead of any of the TBM headings shall be 250-feet.

- B. Where the TBM heading is within 200 horizontal feet of adjacent or overlying NYCT or other structures (as shown on the Contract Drawings), the length of the probe hole shall be limited to 100-feet and maintain a minimum separation of 5 feet between these structures and the probe hole.
- C. When excavating on a curve, the probe hole length shall be suitably limited such that the probe hole remains within 10 feet of the theoretical excavation line.
- D. Maintain a minimum of 30-feet of probe hole ahead of the active tunnel face at all times. Probe hole shall be within or above the projected tunnel face. For probe holes drilled above the tunnel face, provisions of this subsection are to be met. Drilling and maintenance of probe holes shall be a routine part of, and incidental to the tunnel excavation, and not as a substitute for any holes drilled for grouting.
- E. In zones where pre-excavation grouting may be required, as indicated on the Contract Drawings, drill three probe holes in approximately 9, 12, and 3 o'clock positions. The length of probe holes shall be limited to 80-feet. Probe drilling with three probe holes shall start 50-feet before reaching the respective zone and shall be continued to 50-feet beyond it.
- F. Maintain logs of all probe holes drilled. The logs shall include the following: date, time, location, orientation, drilling rate (and changes in drilling rates), and drilled length of each probe hole; the location, nature, and quantity of any water inflows; loss of drilling water; indications of any weak zones; and any other drilling or geological anomalies.
- G. If groundwater inflow from a probe hole exceeds the requirements set forth in Section 03605, or if the condition of the rock as revealed during tunneling, in the opinion of the Resident Engineer, indicates the need, grout the rock with a cement-based grout in accordance with Section 03605 before advancing the tunnel excavation further.

3.07 GROUTING

- A. Conduct pre-excavation and post-excavation grouting in accordance with Section 03605 and as shown on Contract Drawings.

3.08 MAINTAINING PILLAR STABILITY

- A. Install rock dowels in pillars where the pillar width measured at springline is less than or equal to 12-feet, as shown on the Contract Drawings.

3.09 WATERTIGHTNESS OF FINISHED TUNNEL

- A. For watertightness criteria in tunnels that receive a cast-in-place concrete liner see Specification Section 07122.
- B. If the precast concrete segment liner option is selected by the Contractor, then watertightness criteria and procedures for remedial action shall be as specified herein:

1. After the segmental lining has been completed, water inflow into the tunnel shall not exceed 100-gallons per any 1,000-feet of tunnel per day and 10-gallons per any 30-feet of tunnel per day.
2. Leakage shall be restricted to damp patches on the face of the concrete at radial joints and to minor weeping of circumferential joints. Damp patches shall be defined as wet areas with no visible film of water.
3. Where water leakage rates into the tunnel exceed the specified limits, Contractor may propose to rectify this by treating the rock mass behind segment joints or by other means to stop leakage for review of the Resident Engineer. Treatment of the rock mass shall comply with the requirements of this Section, and Section 03605. Undertake any required remedial measures as reviewed by the Resident Engineer.
4. Establish grout injection pressures for sealing leaks by means of an on site demonstration. Do not damage the lining.
5. Caulking of grooves shall only be conducted after failure of all grouting efforts, as reviewed by the Resident Engineer. Caulking materials shall be used in accordance with the manufacturer's instructions.
6. Prior to caulking, all caulking grooves shall be thoroughly cleaned by means of an air jet or water jet or both under high pressure and by scraping, if required.
7. All caulking grooves below bench and future track slab concrete level shall not be caulked, but shall be maintained as open channels to prevent water under pressure from acting to lift the track slab. Caulking grooves behind the bench may be kept open by the installation of channeling or by some other means. The final methods and details shall be as reviewed by the Resident Engineer.

3.10 DISPOSAL OF EXCAVATED MATERIALS

- A. Remove and dispose of excavated material from each bored tunnel in accordance with Sections 02410 and 02145.

3.11 SURVEYING AND ALIGNMENT CONTROL

- A. Surveying to be in accordance with Section 01720 and as specified herein.
- B. If the precast concrete segment liner option is selected by the Contractor, then additional survey work during tunneling and segment erection shall be as specified hereunder:
 1. Immediately following the installation of each ring of the tunnel lining, accurately survey ring as-built profile and compare to design alignment.
 2. Eight points shall be surveyed and recorded. The data obtained shall be presented in terms of coordinates (station, offset and ESA level) relative to the design track alignment. The points surveyed shall be; one in the crown, one in the invert, one at each horizontal axis and one at each end of the diagonals at 45 degrees to the vertical axis. All measurements shall be taken on the leading edge of the ring and at the intrados of the lining rather

than at the pockets or grooves in the segments. The tunnel centerline shall be calculated from the surveyed points and the produced values will be coordinates (station, offset, ESA Eastings, ESA Northings and ESA level).

3. Following the initial readings, select one ring every 100 foot section of the tunnel for additional measurements. Measurements as indicated above shall be taken in the selected ring three days after the selected ring was erected, then weekly for four weeks and at monthly intervals thereafter until movement stops.
4. Advance and verify all underground tunnel control after every 500-feet of tunnel advance.

C. Final As-Built Tunnel Survey of Precast Concrete Segment Liner:

1. A tunnel survey shall be conducted upon completion of the precast concrete tunnel lining installation and prior to any subsequent concreting work, to verify final as-built line, level, grade and internal clearances.
2. Fix permanent reference points in the crown of the tunnel at maximum intervals of 200-feet on straights and 100-feet on curves. Reference points shall be disks set in ceilings stamped "Horizontal/Vertical Control, ESA Project". Such reference points shall be accurately coordinated and shall be installed to not conflict with any part of the permanent structures, and shall be left in place for the following contract.
3. Every fifth ring shall be surveyed at eight points as specified herein. The final as-built survey shall show locations of all reference points, openings to shafts, cross passages and open-cut structures.
4. The final survey shall be based on one closed traverse for each tunnel.
5. Paper and electronic copies of survey data, calculations and graphical representations showing any deviations against the design alignment shall be submitted to the Resident Engineer, in a format acceptable to the Resident Engineer. Demonstrate that the as-built tunnel is acceptable for the design track alignment.
6. Identify out-of-tolerance sections and re-survey at closer ring intervals as required to refine limits. Demonstrate that the design track alignment is acceptable for the out-of-tolerance sections. If not acceptable, design and propose modifications as specified in Section 02427 that will achieve required vehicle clearance envelope and rail operating parameters. Upon review of proposed modifications by the Resident Engineer, perform modifications.

3.12 INSTRUMENTATION AND MONITORING

- A. Install all geotechnical instrumentation, as specified in Section 02495, and as shown on the drawings.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for excavating and installing the initial support to tunnel sections, caverns and chamber by means other than tunnel boring machine (TBM) including Approach Tunnels, TBM Assembly Chamber and adjoining Starter Tunnels, GCT 3 Wye Caverns, GCT 5 Wye Caverns and adjoining Starter Tunnels, Cross Passages, Central Instrument Room, and Cross Flue.
- B. Excavation of the running tunnel sections by TBM shall be undertaken in accordance with Section 02406.
- C. Definitions:
 - 1. “Additional Initial Support” in tunnels excavated by means other than TBM includes rock bolts and dowels, shotcrete (reinforced by steel fibers), welded wire fabric, and pre-support spiling installed in addition to the initial support. Additional initial support measures are installed in a systematic or non-systematic manner, for local stabilization during tunneling.
 - 2. “Flashcrete”: See Section 03375.
 - 3. “Initial Support” in tunnels excavated by means other than TBM includes those measures required to maintain the inherent strength of the ground surrounding the tunnel openings and to enhance stress redistribution within the rock while preventing unnecessary loosening. Support measures include rock bolts and dowels, welded wire fabric, and reinforced shotcrete lining as shown on the Contract Drawings.
 - 4. “Length of Round”: Length of unsupported exposed ground opened during one excavation increment.
 - 5. “Line Drilling”: See Section 02414.
 - 6. “Overbreak”: The amount of ground unintentionally dislocated beyond the theoretical excavation line.
 - 7. “Over-Excavation”: Excavation of ground beyond the theoretical excavation line.
 - 8. “Pre-Support Spiling”: Reinforcement without end hardware installed at the tunnel heading ahead of the tunnel excavation face to pre-support the ground.
 - 9. “Shotcrete Lining”: See Section 03375.
 - 10. “Staged Excavation”: Sequence of excavation by which the final excavation is divided into a group of smaller drifts, also referred to as slashes, and cuts.

11. “Support Class”: Method of excavation and initial support defined in the Contract Drawings for use at a particular location.
12. “Theoretical Excavation Line”: Theoretical line of excavation inside of which no rock or surrounding ground should protrude.
13. “Water Sheet and Drain Hose”: Sheets and hoses used to collect and drain off ground water from areas at either the excavated surface behind the shotcrete lining or to collect and drain seepage through the shotcrete lining.

1.02 REFERENCED SECTIONS

- A. Section 01545 - Construction Safety and Health
- B. Section 01520 – Construction Facilities
- C. Section 01572 - Construction Noise and Vibration Control
- D. Section 01720 - Surveying and Layout
- E. Section 02145 - Groundwater Treatment System
- F. Section 02239 - Tunnel Dewatering
- G. Section 02270 - Rock Reinforcement and Initial Support
- H. Section 02406 - Tunnel Excavation by TBM
- I. Section 02410 - Muck Handling and Disposal
- J. Section 02414 - Controlled Blasting
- K. Section 02425 – CIP Concrete Liner
- L. Section 02495 - Geotechnical and Structural Instrumentation
- M. Section 03300 - Cast-in-Place Concrete
- N. Section 03370 - Shotcrete
- O. Section 03375 - Shotcrete Lining
- P. Section 03605 - Tunnel Grouting

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 1. A 185 - Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

1.04 NOTED RESTRICTIONS

- A. Do not begin excavation until the following conditions have been met:
 - 1. Required submittals have been made and the Resident Engineer has reviewed the submittals.
 - 2. Pre-construction survey in the vicinity of drill-and blast excavation has been completed by the Resident Engineer and pre-construction documents have been provided to Contractor.
 - 3. Installation of geotechnical and structural instrumentation at any specific location for surface structures, NYCT subway structures, and Air-Right Structures above GCT shall be completed and initialized before the advancing drill-and-blast excavations reach within 200-feet of that location.
 - 4. All issues related to health and safety have been met and all submittals have been made in accordance with OSHA requirements, Section 01545, and other applicable codes and regulations of Federal, State, and local agencies having jurisdiction.
 - 5. Required personnel with qualifications specified herein are available at the Work Site to perform the Work.
 - 6. All necessary equipment and materials required to perform the Work are at the Work Site, in sufficient quantity and in good working order along with the personnel qualified to install them.
- C. Further restrictions in the execution of the TBM Assembly Chamber and Wye Caverns are as specified elsewhere herein.
- D. Restrictions on drilling and blasting operations shall be in accordance with Section 02414.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Code of Federal Regulations (CFR):
 - a. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)
- B. Tunneling superintendents and supervisors shall have a minimum of 15 years (or as approved by the Resident Engineer) of comparable experience in supervising the excavation and support of tunnels in similar ground conditions using similar construction methods, and shall have all necessary licenses and permits required by local agencies or others having jurisdiction. Comparable experience shall encompass at least two projects involving full and partial-face drill and blast tunnel excavation, rock reinforcement, and shotcrete support. Duties of superintendents and supervisors shall include the following:

1. Supervising excavation to ensure safety and quality of construction.
 2. Meeting daily with the Resident Engineer at the tunnel face to discuss ground conditions encountered and corresponding excavation and support requirements including additional initial support and keeping record thereof.
 3. Devising and implementing additional initial support measures as required by ground conditions or as directed by the Resident Engineer, coordinating remedial measures when ground loss at mined tunnel heading or instability of mined tunnel occurs, or appears likely to occur.
 4. Be available at the Work Site at all times during tunnel excavation activities.
- C. Drill-and-blast supervisor shall have a minimum of ten years (or as approved by the Resident Engineer) of comparable experience with at least one project on full-face drill and blast tunnel excavation and initial support installation as specified.
- D. Drillers and miners shall have a minimum of five years (or as approved by the Resident Engineer) of comparable experience with at least one project on full-face drill and blast tunnel excavation and shotcrete support.
- E. Tunneling shall not be performed unless the tunneling superintendent and supervisors, meeting the experience requirements, are at the Work Site and in actual control of the Work.
- F. Survey control of line and grade shall be undertaken by qualified survey personnel in accordance with Section 01720.
- G. Determine the amount of over-excavation around the tunnel circumference to accommodate tunnel construction tolerances dictated by the excavation methods and equipment selected.
- H. Drawings and computations shall be certified by a Professional Engineer licensed in the State of New York who has experience in drill-and-blast rock excavation with shotcrete support.
- I. Construction noise and vibration control shall be in accordance with Section 01572.

1.06 SUBMITTALS

- A. Submit resumes of tunneling superintendent, and supervisors in accordance with Section 02406.
- B. At least 60 days before commencing excavation, submit resumes of proposed drill-and-blast supervisors, and drillers and miners for review by the Resident Engineer.
- C. At least 60 days before commencing excavation, submit for review by the Resident Engineer:

1. Detailed working drawings showing layout, configuration, construction sequence (showing distance between headings and partial drifts/slashes) and initial support including rock reinforcement, pre-support spiling, shotcrete lining, and initial support at headwalls for (inclusive of headwalls and transitions between the different structures):
 - a. Approach Tunnels
 - b. TBM Assembly Chamber and adjoining Starter Tunnels including any adjustment in size to suit Contractor's operation
 - c. GCT 3 Wye Caverns
 - d. GCT 5 Wye Caverns and adjoining Starter Tunnels
 - e. Cross Passages
 - f. Central Instrument Room
 - g. Cross Flue
2. Work Plan inclusive of working drawings showing excavation and support sequence for:
 - a. Controlled blasting including line drilling and "Smoothwall Blasting", in accordance with Section 02414.
 - b. Controlling line and grade of shotcrete linings.
3. Working drawings and system description for proposed equipment, materials and method of handling, measuring and disposing of water from within the excavation areas.
 - a. Proposed equipment, materials, and methods for shotcrete operations.
 - b. Proposed equipment, materials, and methods for ventilation.
 - c. Proposed equipment, materials, and methods for control of respirable dust to remain within Federal, State, and local regulations specified herein.
4. Further information as necessary inclusive of location, layout, configuration, construction sequence and initial support for any temporary niches, cross adits, temporary or future pump sump pits and other temporary openings along with proposed methods for their backfill and sealing before Contract completion, unless otherwise directed by the Resident Engineer.
5. Schedule of operations, methods of construction and manufacturer's literature for mechanical excavation, drilling, mucking, transporting equipment, and ventilation.

6. Measures to protect the existing 63rd Street tunnel lining and invert, and reconstructed invert areas during construction operations.
 7. Procedures for “break-out” from existing 63rd Street Tunnel Structure.
 8. Contingency plan to be implemented for excavation and initial support in the event that monitoring of blasting operations in accordance with Section 02414 indicate vibrations exceeding response values defined or monitoring of settlements in accordance with Section 02495 indicate exceedence of response values defined therein.
 9. Configuration and layout of line drilling proposed by Contractor at any given location, in accordance with Section 02414.
- D. At least 60 days before commencing the as-built survey and digital scan, submit for review by the Resident Engineer the selected method and equipment to be used.

1.07 DELIVERABLES

- A. Maintain daily records as excavation progresses and provide one copy of such records to the Resident Engineer before noon of the following workday. Keep such other records, as deemed necessary for Contractor’s purposes. The following data shall be included in the daily record:
1. Station of tunnel, cavern and chamber heading faces and benches at start and end of each work shift.
 2. Type, quantity, and location of initial ground support and additional initial support installed.
 3. Reporting requirements for evaluation of in-tunnel monitoring results in accordance with Section 02495.
 4. Water inflows, if any, with locations and estimates.
 5. Overbreak.
 6. Any other geotechnical and/or unusual geologic features such as faults, shears, crushed or soft zones, and raveling areas.
 7. Other information deemed relevant from the daily meetings at the tunnel face between Contractor and the Resident Engineer.
 8. All blasting related data as specified in Section 02414.
- B. Within 60 days of completion of excavation of each wye cavern, tunnel, chamber, cross passage, central instrument room, cross flue, and at least 30 days prior to commencement of waterproofing installation in the wye caverns and central instrument room, provide a complete record in electronic form, in tabular form and drawing form, the as-built survey data. Data must be presented in the form of station, offset from the baseline track (as stated in the contract documents, or design centerline for untracked structures) and elevation, and include cross section diagrams that show the variance of the as-built from design with values of maximum differentials indicated. Data points and a best-fit surface shall be

shown with any anomalies explained. Survey data, including graphical cross sections, shall be presented at regular intervals not to exceed 20-feet; also at each side of abrupt changes in cross section and at other points directed by the Resident Engineer. Contour-type diagrams shall be produced as developed plans/sections for the entire surface of each shotcreted structure, indicating deviation from the design (showing extra clearance positive).

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Store all materials in accordance with the suppliers' specifications. Maintain materials in a clean and undamaged condition. Replace damaged or destroyed materials.

PART 2 PRODUCTS

2.01 SAFETY EQUIPMENT

- A. Provide safety equipment and monitoring instruments in accordance with Section 01545 and the Construction Safety and Health Plan.
- B. Provide personal protective equipment for protection against respirable dust, and all other protective measures that may be deemed necessary for dust control as per Federal Requirements.

2.02 MATERIALS

- A. The digital tunnel scanner system shall be as manufactured by Dibit Messtechnik GmbH, or approved equal.
- B. Rock dowels, bolts, and spiling shall be in accordance with Section 02270.
- C. Welded wire fabric for the shotcrete lining shall be 6x6-W4xW4, as specified in Section 02270.
- D. Blasting products shall be as specified in Section 02414.
- E. Lattice girders and shotcrete lining shall be as specified in Section 03375.
- F. Shotcrete materials shall be as specified in Section 03370.
- G. Water Sheet and Drain Hoses as part of temporary construction measures to drain off local water inflows:
 - 1. PVC sheet, system AKWA Drain , or approved equal, for application at exposed ground surface or shotcrete surface.
 - 2. Flexible PVC hose with end couplings as required.

PART 3 EXECUTION**3.01 TEMPORARY SYSTEMS**

- A. For temporary system requirements, refer to Section 01520.

3.02 GENERAL REQUIREMENTS

- A. Work shall be performed in a manner that minimizes safety hazards and exposure of personnel and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements and Contractor's Construction Safety and Health Plan, in accordance with the provisions of Section 01545.
- B. The method and means of tunnel construction shall minimize ground movement at the tunnel face and in the surrounding excavation, and shall prevent ground loss, subsidence, and movement in surface features, overlying structures, and utilities above and around the vicinity of the tunnel excavation. Detection of movement shall be undertaken in accordance with Section 02495.
- C. Detailed construction sequencing shall be the responsibility of Contractor, consistent with the requirements of these Specifications and those shown on the Contract Drawings.
- D. Propose additional subdivision of excavation areas and face stabilization by means of shotcrete, or other means, wherever ground conditions dictate.
- E. Before the commencement of the next shift, submit for review by the Resident Engineer the selected method for additional subdivision of excavation areas and means of face stabilization wherever ground conditions dictate.
- F. In case of stoppages, maintain on duty, qualified personnel to monitor conditions that may threaten stability of the heading. Detection of movement shall be in accordance with Section 02495.
- G. In the event that monitoring of ground vibrations, air blast, and/or ground deformations indicate vibration levels, noise levels, or ground deformations exceeding response levels as defined under Sections 02414 and 02495, adjust procedures for excavation and initial support installation in accordance with the accepted Contingency Plan to reduce the levels to within acceptable limits.
- H. Maintain sufficient quantities of all initial support elements, including shotcrete materials at the Work Site, ready for immediate installation or application, during the entire excavation period. Excavation will not be permitted without this requirement being met.
- I. As the excavation progresses, the Resident Engineer will perform inspection and geologic mapping of the excavated areas. Lighting and access shall be provided for close inspection of the face. Such work will be coordinated by the Resident Engineer in a manner to avoid disruption to Contractor's operations.

- J. Sequence and Direction of Construction: Sequence and direction of tunneling shown on the Contract Drawings are suggested. The excavation sizes and sequences may be adjusted by Contractor, based upon the actual ground conditions encountered and proximity to adjacent and overlying structures, while not exceeding the vibration and deformation response levels defined in Sections 02414 and 02495. Develop a modified construction sequence plan based on the predicted conditions presented in the GBR and submit to the Resident Engineer for review, prior to actually performing any drill-and-blast excavation.
- K. Temporary niches, cross adits, temporary or future pump sump pits and other temporary openings:
 - 1. Excavate these temporary openings conforming to excavation and support criteria of this section and as reviewed by the Resident Engineer.
 - 2. Seal all temporary openings with 4,000-psi 28-day strength concrete in accordance with Section 03300 when no longer needed, before Contract completion and as reviewed by the Resident Engineer.

3.03 EXCAVATION

- A. Excavation shall be to the lines, grades, and dimensions shown on the Contract Drawings and as specified herein. The surface of an excavation shall not extend within the theoretical excavation line shown on the Contract Drawings. Methods shall be used and precautions taken to prevent removal, loosening, and raveling of material beyond the minimum excavation necessary to satisfy all criteria.
- B. Excavation of each round shall be followed by the installation of initial support, as specified herein.
- C. Line and grade shall be continually validated with survey control being undertaken by qualified survey personnel in accordance with Section 01720.
- D. Excavate to lines, grades and dimensions as shown on the Contract Drawings and as specified herein including tolerances and deformations to accommodate shotcrete or other linings.
- E. Equipment:
 - 1. Equipment shall be capable of being directionally controlled to the desired line and grade whilst minimizing over-excavation, overbreak, and loss of ground, and be capable of excavating the ground materials encountered.
 - 2. Equipment and methods shall be used that satisfy the requirements of this Section while preserving and protecting the inherent strength of the ground material surrounding the tunnel.
- F. Blasting, including test blasting, and line drilling shall be undertaken in accordance with Section 02414.
- G. Excavated material from each heading shall be removed and disposed in accordance with Section 02410.

- H. Distance Between Headings and Partial Slashes:
1. Top Heading - Multiple Face Slashes: Apply partial drifts/slashes in top heading as shown on the Contract Drawings. The actual sequence may be adjusted by Contractor as specified herein.
 2. Bench Excavation – In Rounds:
 - a. Excavate bench following completion of the top heading excavation as shown on the Contract Drawings.
 - b. Alternatively, bench excavation may follow top heading excavation in an alternating sequence as reviewed by the Resident Engineer.
 - c. Apply bench excavation in rounds as shown on the Contract Drawings.
 - d. The actual sequence of bench excavation may be adjusted by Contractor as specified herein.
 3. Distance Between Headings: Maintain distance between the closest active headings as shown on the Contract Drawings.

3.04 INITIAL SUPPORT

- A. Continuously backfill grout the tail void as the precast rings are installed. Grouting through grout holes in segments will not be accepted as the primary method of backfill grouting.
- B. As the precast rings are installed, continuously inject tail seal grease under pressure to minimize risk of groundwater or grout intrusion.
- C. The initial support, shown on the Contract Drawings, is the minimum required. Contractor may propose alternate initial support systems. In such a case, Contractor shall submit to the Resident Engineer for review, calculations demonstrating that the proposed alternate initial support system is equivalent to that shown on the Contract Drawings, prior to actually excavating each of the different caverns and tunnels.
- D. The initial support shall be supplemented with additional initial support elements, as shown on Contract Drawing CM009-GT-2000, if actual ground conditions encountered so dictate, or if directed by the Resident Engineer.
- E. Tunnel shotcrete lining shall be installed to the clearance lines shown on the Contract drawings, and in accordance with Sections 03370 and 03375.
- F. A new round of excavation shall only be opened up following the installation of initial support and additional initial support of the previous round and for a length not exceeding the maximum length of unsupported excavation shown on the Contract Drawings. Round length and initial support spacing may require reduction, if actual ground conditions encountered so dictate, or if directed by the Resident Engineer.

G. Pre-Support:

1. Pre-support spiling shall be installed as indicated on the Contract Drawings and as specified herein.
2. Pre-support spiling shall be installed in pre-drilled holes. Alternatively, self-drilling, grouted bars may be used as pre-support spiling depending on ground conditions actually encountered, or as directed by the Resident Engineer.

H. Field Quality Control:

1. Initial support systems shall not encroach on clearance lines shown on the Contract Drawings. Consider inaccuracy of construction, material tolerances, and shotcrete lining deflection to determine dimensions of actual excavation and all support -and pre-support elements.
2. Field Testing and Correction of Defective Work: For shotcrete lining, see Section 03375.

I. Face Support for Stoppages:

1. A minimum 5-inches reinforced shotcrete shall be mandatory for stoppages longer than 48 hours in the GCT 5 wye caverns and adjoining starter tunnels. Contractor may propose an alternate method of securing the heading faces, based upon the ground conditions and as reviewed or directed by the Resident Engineer prior to actually performing the Work.
2. A minimum 2-inches plain shotcrete shall be applied for stoppages longer than 48 hours dependent on the field conditions and as reviewed by the Resident Engineer in the TBM assembly chamber and adjoining starter tunnels, GCT 3 wye caverns, cross passages, central instrument room and cross flue. Contractor may propose an alternate method of securing the heading faces, based upon the ground conditions and as reviewed or directed by the Resident Engineer prior to actually performing the Work.

J. Excavation and Support:

1. Evaluation of the ground conditions and of the excavation and support shall be made at the face and in the top heading, as applicable, with the consideration of the anticipated subsurface conditions ahead of the face and in the bench/invert area.
2. Review of the proposed excavation and support sequence by the Resident Engineer or his failure to call attention upon improper or inadequate application of the related excavation sequence and/or tunnel support and/or pre-support and/or face support or to require respective change shall not relieve Contractor of its responsibility for the integrity and safety of the tunnel support or the proper execution of the Work.

3. Excavation and support measures delineated hereafter are typical and may have to be supplemented by additional initial support measures as required by ground conditions actually encountered or as directed by the Resident Engineer.
4. Round lengths for blasting shall not exceed the maximum shown on the Contract Drawings, unless Contractor can demonstrate through test blasts at each of the specified locations, in accordance with the requirements of Section 02414, that vibration and deformation limits as specified in Sections 02414 and 02495, respectively, are maintained, and is consistent with the initial support requirements, to the satisfaction of the Resident Engineer. Notwithstanding the above, round lengths may require reduction, if actual ground conditions encountered so dictate, or if directed by the Resident Engineer.

K. In-Tunnel Water Control:

1. Before application of the shotcrete or cast in place concrete lining, collect all seeping groundwater or local groundwater inflow by means of temporary measures, such as drain hoses and/or water sheets to prevent build-up of hydrostatic pressure behind the shotcrete or final concrete lining and deterioration or reduction of the strength properties of the fresh shotcrete or concrete. Use water sheets to collect water seepage through shotcrete and drain away by means of drain hoses. Contractor may conduct post excavation grouting as required, in accordance with Section 03605, prior to placement of concrete or shotcrete lining for water control to meet specified requirements.
2. For tunnel dewatering see Section 02239.
3. For cast-in-place concrete liner installation requirements see Section 02425.

L. Support Types: Each support type defines a specific length of excavation round, either full face or split into drifts/slashes, support measures, and excavation and support sequence for the ground conditions anticipated in the Geotechnical Baseline Report (GBR). Support types in the vicinity of existing surface and subsurface structures have been laid out with respect to their round lengths to aid in limiting the vibration impact by drill-and-blast excavation using controlled blasting techniques in accordance with the requirements of Section 02414. The support types for the individual structures are as shown on the Contract Drawings. Alternate initial support systems may be installed and alternate round lengths may be used as specified elsewhere herein.

M. Special Requirements Before and During Excavation:

1. Approach Tunnels:
 - a. Excavation of these tunnels shall be either by full face or top heading and bench excavation methods, as required by the ground conditions and the proximity of the existing NYCT operating tunnels. The excavation sequences shown on the Contract Drawings are suggested methods of accomplishing the Work. Contractor may propose alternate means and methods as specified herein.

- b. Round lengths and initial support shall be as specified herein.
- 2. TBM Assembly Chamber:
 - a. The minimum distance between the assembly chamber and NYCT subway tunnel shall be 20-feet. Subject to this restriction, Contractor may adjust the size of the assembly chamber to suit his operations.
 - b. Excavation of the assembly chamber shall be performed in stages, with the number and size of stages, and the limits on dimensions of the top heading, slashes, and benches being as suggested in the Contract Drawings. Where Contractor has adjusted the size of the assembly chamber, the excavation sequence and size of slashes may be adjusted within these limits and as shown on the Contract Drawings. Contractor may use alternate sequences of excavation as specified herein.
- 3. GCT 3 and 5 Wye Caverns:
 - a. Excavation of the caverns shall be performed in stages as shown on the Contract Drawings.
 - b. Where TBM tunnels have been constructed in advance of the enlargement to a cavern the following shall apply:
 - 1) Smoothwall blasting or mechanical excavation methods shall be used for excavating rock between cavern theoretical excavation line and driven TBM tunnel perimeter in order to minimize overbreak.
 - c. Enlargement operations shall be in stages, with consideration to initial support installed during the TBM excavation, such that stability of excavations is not compromised.
- 4. Cross passages, cross flue and central instrument room shall be excavated in a similar manner as shown on the Contract Drawings for the excavation of GCT 3 and 5 wye caverns.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for muck disposal as indicated on the Contract Drawings and specified herein.
- B. The Work consists of handling and disposal of muck from: Approach tunnels, TBM assembly chamber and adjoining starter tunnels, GCT 3 wye caverns, GCT 5 wye caverns and adjoining starter tunnels, cross passages, central instrument room and cross flue, excavated by tunnel boring machine and drill-and blast methods. Facilitate loading, transportation, hoisting, unloading, stockpiling, and final disposal of the muck. The muck shall become the property of Contractor and shall be disposed in accordance with Federal, State, and local regulations. Remove the muck to an off-site disposal area or beneficial re-use location.
- C. Be responsible for the transportation of the muck through the new tunnels, wye caverns, chamber, and existing LIRR 63rd Street tunnel to the existing Queens open-cut. Use construction rail equipment, conveyor system, rubber-tired vehicles, or a combination thereof.
- D. Be responsible for the vertical transportation or hoisting of the muck to the surface at the existing Queens open-cut.
- E. Use an overhead conveyor system over Northern Boulevard and beneath the NYCT BMT elevated transit structure to transport muck from the existing Queens open-cut to the Existing Rail Yard.
- F. Be responsible for the design, planning, manufacturing, delivery, installation, and maintenance of the hauling system(s). This includes, but is not limited to rubber-tired vehicles, rail systems, horizontal and vertical conveyance systems, vertical hoisting systems, and crushing equipment.
- G. If a rail transportation system is installed within the existing and newly constructed tunnels, caverns and chamber, it shall be handed over to the MTA by Substantial Completion.
- H. Acquire all permits, approvals, and registrations necessary for handling, transportation, and disposal at accepted recycling (i.e., beneficial use) or disposal facilities.
- I. Definitions:
 - 1. “Muck” consists of rock materials generated in excavating tunnels, wye caverns, cross passages and chambers. This material will be TBM rock and drill and blast rock, but may also contain grout, shotcrete, and other construction or tunneling debris. Rock and concrete are classified by 6 NYCRR Part 360-1.2(b)(38) as “construction and demolition debris.” and may be beneficially re-used as per 6 NYCRR Part 360-1.15(b)(11) as a substitute for conventional aggregate, or other beneficial use on a case-specific basis and approved by the NYSDEC as per 6 NYCRR Part 360-1.15(d).

1.02 REFERENCED SECTIONS

- A. Section 01570 - Environmental Compliance
- B. Section 01572 - Construction Noise and Vibration Control
- C. Section 02105 - Chemical Sampling and Analysis

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Temporary placement of materials at other locations not specified on the Contract Drawings for the convenience of Contractor will be allowed only with the written approval of the Resident Engineer and materials shall be reused or removed and placed within the designated areas before final completion of the Work.
- B. Obtain required permits before start of trucking operations.
- C. Any muck contaminated from Contractor's excavation processes, handling procedures, or stockpiling methods are not considered extra costs. All costs incurred for handling, temporary storage, transportation, sampling, laboratory analyses, and disposal of muck contaminated by Contractor's operations shall be the sole responsibility of Contractor.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. New York City Department of Transportation (NYCDOT) regulations.
 - 2. NYSDEC:
 - a. Division of Solid Waste, 6 NYCRR Part 360.
 - b. Division of Solid Waste, Technical Administrative Guidance Memorandum (TAGM) SW-89-2002 - Construction and Demolition Debris (December 26, 1989)
- B. Comply with the applicable ordinances, codes, statutory rules, and regulations of the Federal, State, and local authorities.
- C. Screen all muck for visual and olfactory indications of contamination. Based on visual and/or olfactory indications, suspected contaminated material will be sampled as early as possible after excavation, segregated at the rail yard until expedited laboratory analysis completed, and properly classified for disposal.

- D. If at any time during the course of construction, Contractor deems any muck to be contaminated, immediately notify the Resident Engineer. The Resident Engineer will take the appropriate action to identify the muck as "contaminated", either by field examination for possible contamination (i.e., discoloration, odors, etc.), or by taking a representative composite sample for laboratory analysis. Upon determination by the Resident Engineer that the suspect muck is contaminated, Resident Engineer shall authorize Contractor to dispose of the material as specified herein.

1.06 SUBMITTALS

- A. Submit evidence of current valid permits, licenses, and certifications of disposal facilities including, but not limited to, the following:
1. Valid off-site transportation and disposal permits and licenses from the waste handler and reuse or disposal facility..
 2. Written verification by a Certified Industrial Hygienist (CIH) of acceptance of the site-specific Construction Safety and Health Plan (CSHP), and a copy of the report.
 3. Name, location, telephone number, and all required permits necessary for disposal.
- B. Submit the muck handling, transportation, and disposal plan with Shop Drawings and work plans, signed and sealed by a Professional Engineer licensed in the State of New York, for review by the Resident Engineer at least 60 days before start of excavation. Include as a minimum a listing of all required permits, noise control measures, Work Site restoration plans, and detailed information regarding the selected means and methods to be used for the muck transportation in the tunnels and from the Queens shaft/open-cut to the Existing Rail Yard.
- C. Written description of removal and disposal procedures, list of tasks, and statement of qualifications for waste materials management including names, addresses, and telephone numbers of responsible individuals (all subject to review by the Resident Engineer before initiation of the Work).

1.07 DELIVERABLES

- A. Provide muck disposal countersigned bills of lading, receipts, and scale tickets to the Resident Engineer no later than 30 Working Days following disposal or recycling at the permitted facility.
- B. Provide any other documentation to the Resident Engineer, as requested, to conform or comply with all applicable laws, codes, ordinances, and regulations.

PART 2 PRODUCTS**2.01 MATERIALS**

- A. Conveyors, crushers, and hauling systems shall be designed to operate safely and quietly while withstanding all design, operating and wind loads. The systems shall be designed to minimize dust, spillage, and noise in accordance with other permitting agency requirements.

PART 3 EXECUTION**3.01 OVERHEAD CONVEYOR SYSTEM**

- A. Coordinate access and installation (footing locations, construction, repair, and maintenance) with adjacent Contracts through the Resident Engineer.
- B. Where the system crosses Northern Boulevard, the conveyor system must be elevated to clear traffic and other construction activities. The conveyor system shall not project below the bent framing of the existing elevated structure along Northern Boulevard.
- C. The location and spacing of vertical support members for the elevated portion of the system shall be coordinated with the Resident Engineer to clear concurrent installation of utilities by others. Typical spacing of vertical support members shall be at 100-foot intervals, but Contractor must be prepared to span as much as 150-feet in some locations. Coordinate and obtain approval of NYCDOT and NYCT for the elevated conveyor crossing Northern Boulevard.
- D. Design and construct the system to minimize noise and dust as specified in Sections 01570 and 01572.
- E. Spillage must be minimized by proper design of the system. Special precautions such as total enclosure, safety netting, or shields shall be employed along the elevated portions of the system. Clean up any spillage immediately.
- F. Keep spare parts for the overhead conveyor system available on Work Site for the duration of the muck transport.

3.02 CLEANING

- A. Remove all waste materials and restore all temporary disposal sites and corridors to the satisfaction of the Resident Engineer.
- B. At the completion of the Work, temporary fill areas accepted by the Resident Engineer shall have a neat appearance and shall be graded to drain to accepted drainages to prevent erosion.
- C. If rail transportation system is utilized for muck handling, the tunnels, wye caverns, and chamber are to be cleaned and free of all construction -and rock debris down to the top surface of rail ties by Substantial Completion.

3.03 REMOVAL, HANDLING, AND DISPOSAL OF MUCK

- A. The muck shall become the property of Contractor and shall be disposed in accordance with Federal, State, and local regulations. Remove the muck to an off-site disposal facility or beneficial re-use location.
- B. If at any time during the course of construction non-hazardous contaminated muck is encountered, the following procedure shall be followed:
 - 1. Remove non-hazardous contaminated muck and other material from the areas without mixing with foreign materials.
 - 2. Stockpile excavated non-hazardous contaminated muck and other material in designated storage area until waste characterization is completed. Determine the storage area subject to review by the Resident Engineer.
 - 3. Stockpiles shall be of manageable size and designed to protect the non-hazardous contaminated tunnel muck and other material from precipitation, stormwater runoff, and erosion. Be responsible for the sizing and the design of the stockpiles.
 - 4. Storage areas shall be designed to prevent leakage from the stockpiled materials from entering surrounding surface soils or waters. Line and cover stockpiled areas with 4-mils thick impervious, polyethylene sheeting.
 - 5. Provide appropriate berms, sumps, or ditches around the storage area to prevent stormwater runoff from contacting the stockpiles and to prevent infiltrating water from discharging off the stockpile area.
 - 6. Provide a drainage system to collect accumulated liquids from all stockpiled areas and divert the liquids to an appropriate water collection, storage, and/or treatment system.
 - 7. Collect muck and other material samples from the stockpiles for waste characterization purposes. Proposed analytical parameters and appropriate methods are presented in Section 02105.
 - 8. All non-hazardous contaminated muck and other material shall be properly disposed of, following the Resident Engineer's receipt and written notice of sampling, analysis, and characterization.
 - 9. Disposal options for non-hazardous contaminated muck and other material shall include:
 - a. Disposal at an off-site authorized facility or landfill.
 - b. Off-site re-use or recycling under specific NYSDEC Beneficial Use Determinations (BUDs).
 - c. On-site treatment.

10. No muck shall be removed from the Work Site unless authorized by the Resident Engineer. On the day of off-site shipment, the Resident Engineer shall sign the waste manifest and retain one copy.
11. The disposal of non-hazardous contaminated muck and other material at the off-site facility shall include all time incurred for queuing, weighing, and tipping at the facility.
12. Deliver all scale tickets to the Resident Engineer for confirmation of quantities.
13. Submit all countersigned bills of lading, receipts, and scaled tickets for each load of non-hazardous contaminated muck and other material removed from the Work Site.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for new or refurbished tunnel boring machines (TBMs) including trailing gear, for use in excavating the tunnels are specified in this Section.
- B. All TBMs proposed for the Work shall conform to the minimum requirements specified in this Section. The TBMs shall be designed to be suitable for excavation, installation of initial support of the tunnels, in accordance with the requirements set forth in the Contract.
- C. If the precast concrete segment lining option is selected by the Contractor, then all TBMs shall also be capable of installation of precast concrete segment lining, in accordance with the requirements set forth in the Contract.
- D. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for excavating tunnel sections by TBM are specified in Section 02406.

1.02 REFERENCED SECTIONS

- A. Section 01110 - Summary of Work
- B. Section 01545 - Construction Safety and Health
- C. Section 01720 - Surveying and Layout
- D. Section 02270 - Rock Reinforcement and Initial Support
- E. Section 02406 - Tunnel Excavation by TBM
- F. Section 02407 – Tunnel and Cavern Excavation by Drill and Blast
- G. Section 02410 – Muck Handling and Disposal
- H. Section 02414 - Controlled Blasting
- I. Section 03605 – Tunnel Grouting
- J. Section 02427 – Precast Concrete Tunnel Linings
- K. Section 03300 – Cast in Place Concrete Lining

1.03 CITED STANDARDS

- A. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC)

1.04 NOTED RESTRICTIONS

- A. Do not begin TBM tunnel excavation until required submittals have been made and the Resident Engineer has reviewed submittals.
- B. The TBMs shall be designed such that all work using TBM(s) are performed in accordance with Section 01545, all applicable OSHA requirements, and all current applicable regulations and codes of Federal, State, and local agencies having jurisdiction.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Code of Federal Regulations (CFR):
 - a. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)
- B. Qualifications:
 - 1. TBM manufacturer (or, refurbisher) shall have a minimum of ten years experience (or as approved by the Resident Engineer) in the design, manufacture and rebuilding of hard rock TBM(s) equipped with precast concrete segment erectors. It shall have supplied at least two TBM(s) of a comparable size (or greater) and type in the last 15 years.
 - 2. Provide proof of recent successful experience using full-face hard rock TBMs equipped with precast concrete segment erectors.
 - 3. For Contractor personnel qualification requirements, refer to Sections 02406 and 02407.
 - 4. Contractor shall have the TBM manufacturer's (or refurbisher's) representative on-site during assembly, reassembly, and startups of the TBMs, as a minimum.
 - 5. The TBM manufacturer (or refurbisher) shall provide an on-site training course for the operators and mechanics of the TBM based on the TBM operation and maintenance manual. Manufacturer's recommendations for preventive maintenance and repairs, and instructions on steering and operating the TBM in the type of ground anticipated on this Project shall be covered. A minimum of twelve of the Contractor's personnel, including six TBM operators and six TBM mechanics, shall attend. Training certifications of TBM operators and TBM mechanics for each shift shall be submitted to the Resident Engineer.
- C. Certifications:
 - 1. TBM drawings and calculations certified by a licensed Professional Engineer, preferably licensed in the State of New York, with a minimum prior experience in responsible design of two TBMs of the type to be used in the Work.

2. Manufacturer certification that TBMs, as assembled, meet specification requirements, are ready for operation, and that TBM operators are qualified to operate, and TBM mechanics are qualified to maintain and repair TBMs and back-up systems.
 3. Certification of main bearing design: employ an independent reviewer who has been in responsible charge of at least five similar designs to review main bearing design including seals, for compatibility with expected tunneling conditions.
 4. All TBM electrical systems shall be configured and certified in accordance with the NEC. Hydraulic oil used on the machine and back up systems shall be certified fire-retardant.
- D. For survey and layout information, see Section 01720.

1.06 SUBMITTALS

- A. Submit the following information for each TBM within 30 days of Notice to Proceed:
1. Type of TBM(s) to be used, including whether new or refurbished TBM(s) are to be employed.
 2. Manufacturer's technical information for the TBMs, all backup and ancillary equipment, and systems required for machine operation, including, but not limited to, the design, dimensions, method of operation, cutterhead, cutter type, size and arrangement of cutters, thrust, articulation, and steering systems, drive system, muck system, all bearings and bearing seals, tail seals, alignment control/guidance system, probe hole drilling system, initial support installation system, tunnel liner grouting system, gas monitoring system, fire suppression system, schematic electrical system, ventilation system, segment erector, ring former and the interface of TBMs with the segmental lining system elements, and muck transport system, all described in sufficient detail to clearly demonstrate that all aspects of the requirements of these Specifications are met. The description shall include TBM spare parts specified elsewhere herein.
 3. Detailed narrative, supported with sketches, demonstrating the suitability of the TBMs and backup for tunneling in the ground conditions given in the Geotechnical Baseline Report (GBR). Include as a minimum; cutterhead horsepower and drive system details; torque, variable rotation speed and reversibility; machine thrust.
 4. Schedules for shipment of the TBM(s) and backup equipment for each TBM to the Work Site.
- B. Product Data: Submit product data for TBM(s) within 90 days of the receipt of Notice to Proceed. Include the name of the manufacturer of each TBM, the model number, and the following information:

1. Manufacturer's technical specifications and all working drawings for each TBM and ancillary equipment, including, but not limited to the design, dimensions, method of operation, face control capability, cutterhead, cutter type, size and arrangement of cutters, cutter replacement details, propulsion system, initial support installation systems, back up equipment, and alignment control systems, tunnel liner grouting system, schematic electrical system, segment erector, ring former and the interface of TBMs with the segmental lining system elements. The TBM manufacturer's Shop Drawings shall be to scale and at a scale to show sufficient detail. There shall also be sufficient vertical and horizontal sections at tunnel axis and cross sections to clearly identify the different components of the TBMs and backup equipment and systems
2. Description of TBM features designed or selected to be compatible with expected rock mass and groundwater conditions including cutterhead, grippers, and muck bucket design. Include cutterhead horsepower and drive system details; torque, rotation speed and reversibility; machine thrust; thrust per cutter; propulsion system including thrust mechanisms.
3. Details of main bearing, main bearing seals, and tail seals, including calculations and drawings to demonstrate the design procedure used for the design of the main bearing and seals. The calculations shall contain the design assumptions for the specified life of the main bearing.
4. Detailed description of initial support installation systems.
5. Description of backup equipment, lighting and ventilation systems, dust control systems, probe drilling and proposed water control and monitoring provisions, including positions of ports for grouting through or around the cutterhead.
6. Excavated material (muck) handling system on the TBMs, described in sufficient detail to clearly demonstrate that all aspects of the requirements of these Specifications are met.
7. Description and drawings of the arrangement of the dust control system, continuous gas monitoring system, fire suppression system, safety systems, air quality monitoring systems, and other ancillary equipment and/or systems.
8. Detailed description of temporary and back-up power systems.
9. Written certification from TBM manufacturer of full and complete design coordination between TBM manufacturer, backup equipment manufacturer, segment erector manufacturer and segment lining manufacturer. Include a written certification by Contractor and manufacturers affirming the compatibility of TBM and backup equipment with lining, segment erector, and continuous backfill grout injection system.
10. Location of spare main bearing and drive gear, and list of spare parts to be maintained on-site.

11. Description of procedures and schedules for TBM initial assembly and launch, disassembly and reassembly within the tunnels and caverns (in locations indicated on the Contract Drawings), and final demobilization and removal from tunnels.
 12. Program for fire prevention and mitigation.
 13. Certifications attesting to the fact that all hydraulic oil used on the machine and back up systems is fire-retardant
 14. Estimated average liner erection rate in minutes per complete ring.
 15. If refurbished TBMs are proposed by Contractor, submit for each refurbished TBM the following information in addition to the information required above:
 - a. The year of original fabrication of the TBM and release for operation.
 - b. The name of the current owner, including location, phone number and contact person.
 - c. Experience record of the proposed TBMs, including project names, excavated diameter, total operated hours, hours on main bearing, utilization, actual advance and penetration rates achieved, and rebuild records of major components and modifications.
 - d. Machine manufacturer or refurbisher certifications for the cutterhead; drive train, including motors, clutches, gear boxes, pinion gears, bull gear and other components; main bearing and main bearing seals; segment erector and ring former, backfill grouting system; hydraulic system, including pumps, pistons, cylinders, seals, and other components; electrical system; segment erector, ring former, muck buckets and muck removal system. Certifications shall include a statement by the manufacturer or the refurbisher that the TBM has been completely refurbished to like-new conditions equivalent to current industry standards.
- C. Submit the following information for each TBM at least 120 days before start-up of each TBM:
1. Methods for monitoring the rate at which material is excavated and removed from the face.
 2. A contingency work plan covering unanticipated disassembly, reassembly and/or removal of TBM(s) and back-up equipment.
 3. Detailed description of proposed TBM guidance system including how the guidance system interfaces with conventional laser, how the control is brought underground, how it is used by the TBM operator to monitor machine performance, how it interfaces with specified TBM operational systems and lining ring placement and grouting sequence to minimize deviations from the theoretical tunnel alignment, how it will be used to

correct misalignment, and format of data to be provided to the Resident Engineer. Include detailed descriptions of survey methods and instruments for line and grade control and the methods and computer program for correcting tunnel alignment if the specified driving tolerance is exceeded.

4. Detailed description of the backfill and check grout mixes, methods, and procedures proposed, demonstrating that they provide the required strength, deformation and set time characteristics while driving the tunnel. Include a description of the grouting system to demonstrate the capability of complete, immediate, and uniform filling of the annular tail void through the tail of the machine, as the TBM advances, and how grout set time is designed to ensure consistency with the planned rates of advance of the TBM. Describe how the TBM is prevented from advancing when primary backfill grouting is not being done. Describe method of measuring grout volumes and pressures and logic used to determine grout composition and pressures as a function of tunnel depth, rate of advance, ground, and groundwater conditions.
 5. Submit for acceptance and provide any recommended changes to segment joints, geometry, seals, compression packing, gaskets, gasket materials or other items required by the selected means, methods, procedures, or equipment to successfully retain and complete the grouting operations.
 6. Details of the TBM and backup system, gas detection system, its equipment interlocks, alarms, set points, and operating logic network diagram. Also provide description of calibration data for gas detection instruments to be provided and procedures for operation.
 7. A work plan detailing the special precautions and the inspection procedures to be taken when stopping the machine for repair, weekends, holidays, and other scheduled and unscheduled stoppages to ensure that face stability is maintained during the shutdown including contingency measures to be implemented if problems develop in ground or groundwater control or if power is lost.
 8. Methods of measuring each lining ring and of correcting lining ring non-planarity and/or non-circularity that may cause segment or gasket damage or leakage if not detected and corrected, and corrective measures to be taken should specified tolerances be exceeded.
 9. Details of the mechanisms by which the load distribution pads and the thrust jacks will be kept in their intended positions on the lining segments so as not to introduce any eccentric or excessive loads to the segments or gaskets creating a potential for damage, and intended corrective measures to be taken if jack misalignment or liner or gasket damage should occur.
 10. Product data and injection system means and methods for seal grease.
- D. Submit the following information, prior to start of tunneling.
1. A maintenance schedule for all TBMs.

2. Three complete sets of TBM manufacturer's operations and maintenance manuals and TBM drawings.

1.07 DELIVERABLES

- A. Provide for the use of the Resident Engineer a complete automatic PC-based TBM performance monitoring system for each TBM. This system shall be suitably hard-wired such that all TBM performance data can be viewed and recorded in real time. The available data shall include, but is not limited to, the items specified in Paragraph 2.03Z of this Section. The system shall be installed in the Resident Engineer's field office before start-up of each TBM, and maintained in proper working condition at all times throughout the TBM boring period. Such equipment shall be repaired or replaced within 24 hours of notice to Contractor by the Resident Engineer.
- B. Before start of tunneling, and as required during operations, provide calibration certificates for gas detection system, TBM guidance system, thrust jacks, and annular backfill grout pressure gauges. Provide these certificates every 30 days during which TBM tunneling is taking place.

1.08 PROJECT CONDITIONS

- A. Geotechnical conditions expected are as presented in the Geotechnical Baseline Report (GBR) and the Geotechnical Data Report (GDR).
- B. Rock material mechanical properties as tested and rock mass properties as determined by laboratory tests and field information are presented in the GBR and the GDR.
- C. Drillability indices as tested are as presented in the GBR and GDR.
- D. The largest single component unit of the TBM(s) shall pass through the existing lower level of the 63rd Street Tunnel. For dimensions and details of the lower level of the 63rd Street tunnel refer to the Contract Documents.

PART 2 PRODUCTS

2.01 GROUT

- A. Grout shall be as specified in Section 03605.

2.02 FINAL CONCRETE LINER

- A. Precast concrete segments for the final liner of tunnels shall be as specified in Section 02427.
- B. Cast-in-place concrete final liner shall be as specified in Section 03300.

2.03 INITIAL SUPPORT

- A. Initial support shall be as specified in Section 02270.

2.04 TUNNEL BORING MACHINES (TBMs) DESIGN REQUIREMENTS

- A. The tunnel boring machines provided for the Work covered by this Contract, in accordance with Section 01110, shall conform to the requirements of this Section and all applicable sections of both the general and technical provisions of the Contract Specifications and all applicable Contract Drawings. Two TBM(s) will be required.
- B. The TBM(s) used for the work specified shall be full-face, hard rock machine(s) designed and built or refurbished for the entire range of ground conditions indicated in the GBR and GDR. The TBM(s) shall be selected and designed to have the capability of excavating the rock with properties ranging from 90-percent of the minimum tested values to 110-percent of the maximum tested values of strengths, mechanical properties, abrasivity indices, mineral contents, and drillability indices as indicated in the GBR and the GDR. The TBM(s) shall have all backup and ancillary or support equipment required for the excavation of tunnels, installation of initial support and additional initial support, and installation of precast concrete segments (if this option is selected by the Contractor) in the rock indicated in the GBR and the GDR. All of the various components and systems that constitute each TBM and its backup, ancillary and support equipment shall be new or refurbished to be like new so that the machine is ready to operate upon installation at the Work Site. This includes, but is not limited to, cutterhead, cutters, spare parts, main bearing and seal assembly, main frame, segment erector, ring former, tunnel liner grouting system, hydraulic system, electrical system, gearboxes and motors. The TBM(s) shall be able, with excess capacity and within the Project timeframe established for this Contract, to handle the range of ground and water conditions and ground support requirements indicated in the Contract, including the GBR and the GDR. The TBM tunnels shall be excavated to a diameter required to produce a finished tunnel diameter of 19-foot 6-inches, with a precast concrete segment or cast-in-place concrete final liner, as shown on the Contract Drawings. The minimum tunnel clearances shown on the Contract Drawings and construction tolerances specified herein shall be maintained.
- C. Design each TBM for and fit it with 17-inch or larger single disc cutters. Low profile type muck buckets are required. The Contractor is responsible for controlling gage cutter wear to maintain the minimum tunnel excavated diameter specified.
- D. Design the TBM(s) drive train, cutterhead assembly, main bearing, frame, and grippers for sustained operation and for the maximum and minimum ranges of ground conditions indicated in the Contract including the GBR and the GDR. The grippers shall be designed to maintain the integrity of the pillar between adjacent TBM driven tunnels as indicated in the GBR. The primary means of propulsion shall be through the use of grippers. Thrust cylinders that react against the installed segmented liner shall be provided for the compression of gaskets between the precast concrete segments. These thrust cylinders, in combination with the grippers, can be used as a secondary means for forward propulsion in areas where ground conditions so require, and as directed by the Resident Engineer. The precast concrete segments, in these areas shall be capable of withstanding the reaction due to the forward thrust, as per the requirements of Section 02427.

- E. Design the TBM(s) with such sufficient drive motor horsepower that the machines are not torque limited for 110% of the maximum and minimum range of ground conditions indicated in the GBR and GDR.
- F. Provide TBM(s) with the capability of starting the cutterhead at a minimum of 125-percent of the rated full torque. Clutches or hydraulic assist shall be provided for an electric drive, or a variable speed hydraulic drive system may be used.
- G. The TBM(s) and all associated machinery and equipment shall be designed with waterproof components at all locations exposed to flowing and ponding groundwater. Protect the cutterhead, main bearing seals, main drive units, segment erector and ring former against dust and water intrusion. The muck disposal system shall be designed for a wet environment.
- H. The TBM(s) shall be designed to allow for replacement of the cutterhead main bearings and seals from within the tunnel. In case blasting is necessary to access the cutterhead components, such blasting shall be conducted in accordance with Section 02414.
- I. Design the guidance system to provide continuous location, position and attitude (yaw, tilt and roll) data in real-time including comparison between design tunnel centerline and driven tunnel centerline. The real time comparison shall be graphically displayed to the machine operator at all times on an electronic display terminal. If the precast concrete segment liner option is selected by the Contractor, then data presented shall also include, for every segment ring interval along tunnel centerline: design centerline stationing values, as-driven coordinates and elevation values, horizontal and vertical offsets from design tunnel centerline to the driven tunnel centerline, horizontal and vertical attitude of TBM compared to theoretical and forecasted position of the TBM at a distance 10-rings in front of the face. The guidance system shall be equipped with an alarm to alert the TBM Operator in the event the driven tunnel exceeds tolerances and shall have the capability to forecast the composition and orientation of the subsequent 10-rings to get back on target. The system shall operate unattended and shall record all data electronically to a database, which shall be automatically backed up to prevent loss of As-Built data for later use. The database shall be in Microsoft Excel or Microsoft Access file format.
- J. Do not exceed tunnel horizontal and vertical tolerances of plus or minus 2-inches. When a variation from specified line or grade occurs, immediately take action to return the excavation within the specified design line and grade shown on the Contract Drawings. In zones where the actual alignment lies outside of the theoretical design by more than the plus or minus 2-inch tolerance specified herein, remedy the area of underbreak such that a finished, stable tunnel within the specified spatial envelope is provided at hand-over to the Resident Engineer.
- K. The TBM(s) shall have provisions for the installation of all initial support elements immediately behind the cutterhead support and while the rock is restrained by the finger shield (as specified herein), to the extent practicable, and without interfering with the TBM operation or trailing equipment. The TBM(s) shall be designed to permit installation of initial support as specified in Section 02270 and in the Contract Drawings, including, but not limited to, the following:

1. Rock dowels of types, sizes and at spacings specified in Section 02270 and as shown in the Contract Drawings. The TBM shall be capable of installing the dowels immediately behind the cutterhead support.
 2. Full circle steel ribs and steel mat lagging of sizes and at spacings specified in Section 02270 and as shown in the Contract Drawings. The TBM shall be equipped with a steel rib erector capable of erecting steel ribs of specified sizes immediately behind the cutterhead support.
 3. The TBM shall be able to develop the required forward thrust without damage to previously installed initial support. Provide a roof shield (finger shield) to provide sufficient coverage during support installation.
- L. Design the TBM with provisions for probe drilling up to 250 feet ahead of the TBM cutterhead. The equipment mounted on the TBM for this purpose shall be capable of drilling probe holes either through or above the cutterhead oriented up to 20-degrees in any direction of the longitudinal axis.
- M. Design the TBM with provision for drilling holes ahead of the tunnel face for grouting in at least four positions through the cutterhead and eight positions equally spaced around the perimeter of the TBM cutterhead. Each TBM shall be equipped for pre-excavation grouting ahead of the plane of the tunnel face a minimum of 100-feet measured along the drill hole. Drills shall be selected for rapid percussion or rotary drilling ahead of the TBM and shall be mounted at a convenient location behind the cutterhead and be capable of drilling the perimeter holes at a minimum inclination of 4 degrees and a maximum of 8-degrees to the tunnel axis. Grouting shall be performed in accordance with the provisions of Section 03605.
- N. Size the trailing gear and backup equipment of the TBM to allow the equipment to negotiate the curves on the alignment (as shown on the Contract Drawings) and pass by full ring steel sets installed behind the cutterhead without damaging them.
- O. If a conveyor is to be used to remove excavated material through the tunnel from the TBM, provide a crusher as part of the backup system for the TBM(s).
- P. Equip the TBM with a ventilation system to allow a continuous and sufficient supply of fresh air to the areas of the TBM that are occupied by personnel. Provide air flow quantities that conform to OSHA requirements.
- Q. Equip the TBM with a pumping and discharge system of sufficient capacity, to handle all water inflows as indicated in the GBR, as a minimum.
- R. Equip the TBM with a fire suppression system and hand-operated fire extinguishers.
- S. Equip the TBM with a dust suppression system of sufficient capacity to maintain dust levels in the working areas below the maximum levels specified by OSHA.
- T. Equip the TBM with a continuous monitoring system for noxious and explosive gases. Include audible and visual alarms at each end of the TBM that will be triggered if threshold levels, as specified by OSHA, are reached at any point along the TBM.

- U. Equip the TBM with a power interruption system that will automatically shut down power to the TBM upon detection of levels of noxious or explosive gases in excess of OSHA standards or in the event of a fire. Design this power interruption system so that power for lighting and ventilation within the excavation area is not also shut down.
- V. Keep available one spare main bearing assembly and seals, and one spare main drive gear (bull gear) for each type of TBM for replacement of the corresponding parts provided with the TBM in case those parts fail. These spare parts shall be available for the duration of the TBM excavation and shall be deliverable to the Project site within three weeks from the time that the need for parts is determined. One spare main drive units including pinions, gearboxes and motors shall be provided for each type of TBM.
- W. Maintain an inventory of and a location for manufacturer's recommended spare parts for the TBM(s), all backup, and muck-handling systems.
- X. Equip the TBM with suitable safety systems in accordance with applicable OSHA requirements for underground construction equipment, including equipment classified as a "Rapid Excavation Machine". Before use on this Project, all TBM electrical systems shall be configured and certified in accordance with the NEC. Hydraulic oil used on the machine and back up systems shall be fire-retardant, and certifications attesting to this property shall be submitted to the Resident Engineer.
- Y. Design the TBM and back up equipment to allow disassembly and complete removal through the driven and supported tunnel including curves, with steel ribs, rock bolts, and precast segmented liner installed as shown on the Contract Drawings. The TBM and back up equipment shall be capable of being reassembled within the tunnel at locations and with dimensions as shown on the Contract Drawings.
- Z. Make provisions for automatic recording and transmission of TBM performance data in real time to an internet-based system which shall be accessible to the Resident Engineer, for unlimited users. Real time shall mean that the time lag from which the data is generated to being accessible on the internet-based system is no greater than one (1) minute. Process and generate, automatically by computer, separate plots of all parameters of TBM performance. Use automatic recording systems for data collection. Data to be collected for each shove or stroke of the TBMs shall include, but not be limited to the following:
 - 1. Date, time and tunnel station at start of shove, duration and length of shove.
 - 2. Time lining erection started and finished.
 - 3. Drive motor current or hydraulic pressure continuously recorded for cutterhead.
 - 4. Propel cylinder pressures.
 - 5. Rotational speed, torque, and direction of the cutterhead.

6. Instantaneous advance rate of TBM during shove.
 7. Information from guidance system including the location of each ring as compared to theoretical alignment and target.
 8. Mode of operation; tail grout volumes and pressures; tail seal grease volume.
 9. Mucking rate and volume of excavated material.
- AA. Maintain accessibility for all gauges and instruments used to monitor TBM parameters to allow the Resident Engineer to verify readings taken during construction.
- AB. Remove the excavated material from each tunnel heading to locations indicated in Section 02406 and 02410 and/or on the Contract Drawings.
- AC. Grouting:
1. Backfill Grouting: Provide an automatic computer operated grouting system linked to TBM systems to calculate grout quantities and continuously adjust grout injection rate and pressure on the basis of the TBM advance rate, prevailing pressures and other data, and in accordance with the provisions of Section 03605. Provide an interlock system so that the TBM cannot be advanced unless the tail grouting systems are operational and capable of providing the required grout, and conducting grouting.
 2. Check grouting shall be as specified in Section 03605.
 3. Pre-excavation grouting shall be as specified in Section 03605.
 4. Grouting ports shall be fitted with suitable glands and valves to withstand the pressures envisaged.
- AD. Segment Erector
1. Design the segment erector to be compatible with the machine and liner system to ensure safe and efficient segment installation.
 2. Design the erector to be actuated in the axial, radial, and circumferential directions and in the three articulation angles corresponding to the six degrees of freedom. Design the erector to grip and erect the segments so that they are positioned accurately, so that segments are aligned within the required tolerances, so that gaskets are compressed, and so that no damage or distortion of the segments or gaskets occurs.
 3. Provide an erector and segment installation system that installs tunnel rings in true shape and ensures tunnel ring faces are planar, and provides for mating of subsequent rings true and planar as well. This system shall include a ring orientation computer program that is linked to the TBM guidance system to optimize segment/curve alignment. Check and correct ring planarity and circularity indicated for segment tolerances.

4. Equip TBMs with positioning device to indicate correct radial and circumferential location of the segments. This device shall continuously measure the gap between segments and tail shield to supply data for the ring orientation computer program which is linked to the guidance system.
 5. Provide special construction bars, framework, lockout devices, or other supports, as required, to assure safety for workers during erection of segments and to ensure that segments cannot be released during handling and installation.
 6. Design the TBM segment erector so as to be able to retrieve segments for replacement if damage is incurred within the first 12 inches of shove.
- J. Machine – Liner Interface
1. Equip TBM to allow continuous, complete backfill grouting of the annulus between the concrete segments and excavated surface.
 2. Design TBM to grout the tail void using pipes or channels designed by the TBM manufacturer. Uniformly space grout pipes with a redundant pipe at each location for use in the event that the first pipe becomes blocked. Use minimum of six sets of pipes (minimum twelve pipes total) during grout injections. Provide means of clearing blocked pipes of grout. Grouting through grout holes in segments will not be accepted as the primary method of backfill grouting.
 5. Coordinate the tail seal and the liner system design, fabrication, and operation to ensure a competent seal.
 6. Tail seal grease shall be compatible with the liner system gaskets and materials, shall be inert, shall not contaminate the surrounding ground or groundwater and shall not in any way cause the long term deterioration of the liner concrete, the joint connectors, the gaskets, seals or joint packers. As the TBM advances continuously inject tail seal grease under pressure to minimize groundwater or grout intrusion.
 7. Equip TBM with ring reformer to ensure shape/circularity of each ring is maintained until the lining has been grouted and the ring is stabilized.
 8. The TBM and its backup equipment shall be equipped to drill and perform check grouting within 20-feet of the tail shield.

PART 3 EXECUTION

3.01 GENERAL

- A. Operation of the TBM shall be in accordance with the provisions of Section 02406.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for the use of explosives in drill-and-blast operations for all Work involving the excavation of rock for the construction of tunnel sections, caverns, chamber, and openings required in this Contract. This Section covers the use of explosives for drill and blast operations to excavate the following areas including, but not limited to, the following:
 - 1. Approach tunnels
 - 2. TBM assembly chamber and adjoining starter tunnels
 - 3. GCT 5 wye caverns and adjoining starter tunnels
 - 4. GCT 3 wye caverns
 - 5. Cross passages
 - 6. Central Instrument Room
 - 7. Cross Flue
 - 8. Additional rock excavation within the open-cut excavation at the Queens Bellmouth
- B. This Section also covers procedures for test blasts at the following locations:
 - 1. Approach tunnels at 63rd Street
 - 2. GCT 3 wye cavern (upper level single level wye at Park Avenue and 49th/50th Streets)
 - 3. GCT 5 wye cavern (single level at 58th/59th Streets)
 - 4. Open-cut excavation at the Queens Bellmouth
- C. The Work covered in this Section includes, but is not limited to, blast design, blast limitations, materials, equipment, labor, supervision for the transportation and storage of explosives, drilling and loading of blast holes, protection of existing structures and facilities, Test Blasts, blast-effects monitoring, pre-blast and post-blast inspections, and damage repairs.
- D. Definitions:
 - 1. Air-Overpressure (Airblast): Fluctuating changes in ambient air pressure caused by blasting. Air-overpressure is expressed in units of linear-scale decibels (dBL). Microphones that measure blast-induced air-overpressure have flat frequency response from 2- to 250-Hertz.

2. Blaster(s)-in-Charge: The trained and qualified person(s) in charge and responsible for all matters regarding the safe use of explosive materials once they are received from the Magazine Keeper. The Blaster-in-Charge is also responsible for filling out necessary explosive use or blasting report forms, and is responsible for returning all unused explosive materials to the Magazine Keeper.
3. Buffer Holes: Holes with reduced energy charges drilled adjacent to smoothwall holes or line-drilled holes at the perimeter of the excavation. The explosive charge in buffer holes is generally between 50- and 75-percent of the charge used in normal production blastholes. Buffer holes are usually drilled parallel to adjacent holes at the excavation perimeter.
4. Burden/Spacing Ratio: The ratio value calculated to evaluate the effectiveness of smoothwall blast designs. The ratio value is determined by dividing the burden (distance between smoothwall perimeter holes and the first-row-in blastholes) by the spacing distance between perimeter holes. For example, if perimeter holes are spaced 18-inches apart and the burden distance to the adjacent row of blastholes is 24-inches, the burden/spacing ratio is 1.33 (24/18).
5. Controlled Blasting: Excavation of rock in which the various elements of the blast, i.e., perimeter drilling, hole size, depth, spacing, burden, charge size, distribution, delay sequence, are carefully balanced and controlled to reduce overbreak and lessen damage to rock remaining beyond desired excavation limits and to reduce ground-borne noise and vibration energy transfer associated with blasting. Blasts incorporating effective smoothwall blasting, or line-drilling measures would be considered controlled blasts.
6. Line Drilling: A method of controlling overbreak and reducing ground-borne vibration energy transfer, in which a series of very closely spaced holes are drilled at the perimeter of the excavation. Line holes are generally not loaded with explosives; however, in some applications alternating holes may be loaded with light charges using detonating cord.
7. Magazine Keeper: The person(s) employed by Contractor, who are named in FDNY permits as those responsible for receiving explosive deliveries and maintaining all explosive inventory and usage records, and providing safe and secure storage of all explosive materials, as required by FDNY rules.
8. Maximum-Charge-Weight-per-Delay: For purposes of vibration control, any charges firing within any 8-millisecond time period are considered to have a cumulative effect on vibration and air-overpressure effects. Therefore, the maximum charge per delay equals the sum of the weight of all charges firing within any 8-millisecond period.
9. Peak Particle Velocity (PPV): The maximum of the ground motion velocities measured in the vertical, longitudinal, and transverse directions. PPV is not the vector sum of the three components of motion. Velocity units are expressed in inches per second (in/s).

10. Powder Factor: Explosive distribution expressed in pounds of explosive per cubic yard of rock shot.
11. Primary Initiation: The method whereby the blaster initiates the blast(s) from a remote and safe location.
12. Production Blast: Production Blasts are blasts detonated following Test Blasts in a given project area with designs based upon the results reviewed by the Resident Engineer of Test Blasts in that area, with normal review procedures in effect.
13. Production Holes: Blast holes in the main body of the rock mass being removed by drilling and blasting.
14. Residential Area: An area containing structures where people normally sleep, including hotels as well as residences, as shown on the Contract Drawings.
15. Scaled Distance: The distance from a blast measured in feet, divided by the square root of the charge per 8-millisecond delay period measured in pounds. These "square root" scaled distance values are used in calculations to limit charge-weight-per-delay for controlling the intensity of blast-induced ground motion. Scaled distance values are expressed in units of feet pounds^{-0.5}.
16. Smoothwall Blasting (Trim Blasting): A form of controlled blasting used in tunnel, trench, and other underground excavations. With this method, appropriately designed, small diameter, lightly loaded uniform continuous charges are placed in relatively close-spaced holes and timed to fire such that a well-relieved open face provides excellent relief when removing the final burden of rock in front of trim holes drilled at the excavation limits. Smoothwall trim blasts can be fired as separate blasts after mass rock has been blasted and removed or the trim blast can be integrated with adjacent mass blasts if delay timing and other blast design factors ensure that adequate free-face relief is provided for the final rock burden against perimeter charges.
17. Stemming: Crushed stone, sand, or other inert material placed in the unloaded collar area of blastholes for the purpose of confining explosive charges and limiting rock movement and air-overpressure.
18. Subdrilling: The portion of a blasthole that is drilled below or beyond the desired excavation depth or limit. Subdrilling is generally required to prevent the occurrence of high or tight areas of unfractured rock between blastholes.
19. Test Blast: Test Blasts are blasts that are required in a project area to determine (a) vibration and airblast impacts on neighboring structures, facilities and the appropriate Scaled Distance, (b) effectiveness of fragmentation, and (c) overbreak.

1.02 REFERENCED SECTIONS

- A. Section 01572 - Construction Noise and Vibration Control
- B. Section 01720 - Surveying and Layout
- C. Section 02407 - Tunnel and Cavern Excavation by Drill and Blast
- D. Section 02495 - Geotechnical and Structural Instrumentation

1.03 CITED STANDARDS

- A. International Society of Explosives Engineers (ISEE) Guidelines and Practices for Blasting Seismographs

1.04 NOTED RESTRICTIONS

- A. Do not begin drilling and blasting works until the following conditions have been met:
 - 1. Required submittals have been made and the Resident Engineer has reviewed submittals.
 - 2. Pre-construction survey in the vicinity of drill and blast excavation has been completed by the Resident Engineer and pre-construction documents have been provided to Contractor.
 - 3. Installation of geotechnical instrumentation and monitoring program in the area of drill- and-blast excavation has been completed and initialized in accordance with Section 02495.
 - 4. Required personnel with qualifications specified herein are available at the Work Site to perform Work.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Bureau of Alcohol Tobacco and Firearms (BATF)
 - a. Title XI, Regulation of Explosives (18 U.S.C. Chapter 40; 84 Statute 952), of the Organized Crime Control Act of 1970 (84 Statute 922) and 27 CFR 55
 - 2. City of New York:
 - a. Department of Buildings (DOB) Technical Policy and Procedure Notice #10/88 (Vibration Limitations for Historical Structures)
 - b. Fire Department (FDNY) Blasting Regulations and General Vibration Limitations

3. Code of Federal Regulations (CFR):
 - a. 29 CFR 1926 - Safety and Health Regulations for Construction (OSHA)
 - b. 49 CFR 106, 107, 171-179, 383, and 390-399 (Department of Transportation (DOT))
- B. Qualifications and Participation:
 1. Blasters-in-Charge shall have a minimum of ten years of experience (or as approved by the Resident Engineer) in similar excavations, rock and controlled blasting techniques, directly related to underground tunneling and controlled blasting work. All Blasters-in-Charge shall document the completion of at least three projects of similar scope and complexity.
 2. All Blasters-in-Charge, blasters, and supervising shift forepersons shall be properly qualified and licensed in accordance with applicable Federal, State, and FDNY regulations.
 3. Retain the services of an experienced independent Blasting Consultant(s) with at least 20 years experience (or as approved by the Resident Engineer) in preparing controlled blasting designs for underground tunneling operations occurring near critical structures and sensitive neighborhoods. The Blasting Consultant shall also have thorough knowledge of all blasting methods used to control overbreak and damage to rock remaining in walls and roofs around underground openings. Blasting plans, test-blasting plans, and revisions to any of these plans will be reviewed by the Blasting Consultant(s), and covered with a signed review letter by the Blasting Consultant(s). The Blasting Consultant will not be required to sign the individual blast plans provided they are signed by an on-site Blaster-in-Charge.
 4. All Blasters-in-Charge, blasters, magazine keeper and all persons involved in blasting shall undergo training, at Contractor's expense, on blasting techniques as required by BATF, FDNY, OSHA, and other regulatory agencies. The training shall also address the safety issues related to the use of explosives.
 5. All persons with access to NYCT tunnels or MNR tunnels, structures, and facilities shall undergo training, at Contractor's expense, regarding safety instructions and procedures for such facilities before they begin Work on Project.
- C. Notify the Resident Engineer before each blast to confirm that all installations and operations required for the blast herein have been completed and are in accordance with the blasting plans, except as otherwise specified herein.
- D. Construction noise and vibration control shall be in accordance with Section 01572.
- E. For additional survey and layout information, see Section 01720.

- F. Contractor is solely responsible for the safety, design, stability, and integrity of the excavation and all existing structures, facilities, utilities and railroad infrastructure.

1.06 SUBMITTALS

A. Shop Drawings:

1. Prepare and submit a Blasting Safety Plan that includes, at a minimum, the following:
 - a. A complete description of the clearing and guarding procedures that will be employed to ensure personnel, staff, visitors, and all other persons are restricted to safe locations during blasting. This information will include details regarding visible warning signs or flags, audible warning signals, method of determining blast areas (all areas affected by any potentially harmful blast effects), access blocking methods, guard placement and guard release procedures, primary initiation method, control of potential radio frequency interference, and the system by which the Blaster-in-Charge will communicate with Work Site security guards.
 - b. Detailed description of how explosives will be safely stored, transported, and used at the various Work Sites. Plans shall explain how storage magazines and explosive transport boxes and vehicles will satisfy all applicable FDNY and BATF regulations, MNR/LIRR/NYCT regulations and safety plan. This plan will also indicate how explosives will be inventoried, secured, and guarded to prevent theft or unauthorized use of explosives.
 - c. Detailed contingency plans for handling of misfires caused by cut-offs or other causes.
 - d. Detailed plans for ventilation to meet applicable OSHA requirements.
 - e. Fire prevention plan details, including smoking policies, procedures, and limitations for work involving any open flames or sparks, description and location of all fire fighting equipment, and fire fighting and evacuation plans.
 - f. Initial and ongoing blasting and fire-safety training programs, including regular tool-box blasting safety meetings attended by all workers handling and using explosives in any given work shift.
 - g. Description of the personal protective equipment that will be used by Contractor's personnel, including but not limited to safety glasses, hard-toe footwear, hard hats, and gloves.
 - h. An outline of the initial blasting safety and applications training program that will be attended by all persons directly involved with blasting operations including supervisors, blasters, drillers, and helpers.

- i. Contact list with phone and cell phone numbers for Contractor's personnel, first responders, MTA, MNR, NYCT, Blast Consultant, and Resident Engineer to be used in case of safety or security related events.
2. Obtain copies of all applicable codes, regulations, and ordinances, and keep readily accessible copies in the Project field office at all times. Contractor's Safety Supervisor or Safety Representative shall ensure that ongoing blasting work complies with all applicable regulations.
3. Submit a General Blasting Plan to the Resident Engineer not less than 60 days before commencing any blasting for this Contract, or at any time Contractor proposes to change the drilling and blasting methods. Contractor's Blasting Consultant shall be responsible for the development and review of this plan, submitted under a signed letter from the Blasting Consultant. Review of the General Blasting Plan by the Resident Engineer shall not relieve Contractor of his responsibility for the accuracy and adequacy of the plan when implemented in the field. New blasting plans, as required, shall be submitted 30 days before use. For all planned excavations, the General Blasting Plan shall include:
 - a. Methods of drilling, including equipment descriptions, hole alignment techniques, and measures that will be used to prevent excessive blasthole deviation.
 - b. Shop Drawings showing typical hole locations, diameter and spacing for burn-cut and relief holes, production blastholes, and for line-drilled, or smoothwall holes at the excavation perimeter in plan.
 - c. Additional Shop Drawings showing typical firing sequence for explosively loaded holes, including delay periods and delay times in plan.
 - d. Additional Shop Drawings indicating how typical firing sequence will be implemented using the chosen initiator system in plan.
 - e. Description of methods to assure proper implementation of initiator sequence, including placement of appropriate detonators into boreholes, connection of individual detonators, and connection to the initiation system (blasting machine or other initiator).
 - f. Vertical section drawings for typical production blastholes, and for line-drilled or smoothwall holes, showing typical diameter and length, and location, distance, and direction of existing nearby structures relative to line drilling.
 - g. Shop Drawings showing vertical sections for explosively-loaded holes shall indicate hole-charging methods, including detonator and primer location and make-up, charge placement, and stemming length and type. Shop Drawings should also indicate tamping or non-tamping of charges along length of explosive column.

- h. Vibration Control Calculations: A detailed description of how blasts will be conducted in conformance with limitations described herein, based upon test blasts and resultant calculations.
 - i. Methods for preventing spills or losses of explosives, drilling fluids, oil, or any other pollutants to the ground during all handling and hole charging operations. Include details of all containment and contingency plans for quickly and effectively cleaning up any spilled materials.
 - j. Methods of safe and approved (FDNY) disposal of all explosive packaging materials.
 - k. Methods of addressing unusual circumstances, including cutoffs, misfires, substantial changes in ground conditions, loss, or misplacement of explosives.
5. Individual Blast Plans, signed by Blaster-in-Charge, shall be submitted to the Resident Engineer for each blast at least 24 hours before drilling any blast holes. Supply the format of Individual Blast Plans to the Resident Engineer for review 60 days before any drilling and blasting is to be conducted. Individual Blast Plans shall include the following information:
- a. Proposed date and time of the blast.
 - b. Shop Drawings showing the location, orientation, and number of blastholes relative to specific stations, slopes, and elevations in scaled plan view.
 - c. Shop Drawings for excavation rounds showing the location, orientation, and number of line-drilled, or smoothwall holes drilled at excavation perimeters in scaled section view.
 - d. Shop Drawings for tunnel rounds showing detonator quantities, types, delays, firing times, and connections in scaled section view.
 - e. Shop Drawings showing the borehole diameter, and amount, type, weight, and linear loading density of explosive in all blastholes in scaled cross section view.
 - f. A table showing the weight of explosive per hole, total weight of each explosive used, maximum charge weight per delay, and powder factor.
 - g. Scaled Distance to nearest surface structure, and whether such structure is designated historic or residential, and nearest subsurface structure such as MNR tunnels or NYCT tunnels, structures, and facilities.
 - h. If required, submit information deemed pertinent by the Resident Engineer such as measures to control flyrock, vibration, air-overpressure, or other blast effects.

6. Blast Reports of excavation work shall be maintained and signed by the Blaster-in-Charge. The Resident Engineer shall be provided with one copy of the Blast Reports for each blast detonated during each day's work on the following workday. Supply the format of Blast Reports to the Resident Engineer for review 60 days before any drilling and blasting is to be conducted. The following data shall be included in the Blast Reports:
 - a. Tunnel, cavern or chamber station of the shot.
 - b. Unusual occurrences including rock falls, unstable ground, groundwater problems, work delays, equipment malfunction, and the station of each occurrence.
 - c. Complete description of each blast including:
 - 1) Date, time, and limits of blast by location and station number for tunnels.
 - 2) Amount of each type of explosive used by weight and number of cartridges, as well as total explosive weight used.
 - 3) Total number of delays used and number of holes used for each delay.
 - 4) On a diagram of accepted blast pattern, indicate each hole not drilled, drilled but not loaded, changes in spacing or in pattern delays, or in loading holes.
 - 5) Total number of holes, maximum charge per hole, and corresponding hole number.
 - 6) Evaluation of blast indicating tights, areas of significant overbreak, and recommended adjustment for the next blast.
 - 7) Blast monitoring recording times.
 - 8) Peak particle velocities for all seismograph recordings.
7. An updated regression calculation that adds the current vibration and scaled distance data to previous data and that of the Test Blasts must be calculated by the Blasting Consultant and supplied to the Resident Engineer weekly.
8. If Contractor intends to blast within 100-feet of cast-in-place concrete that is aged less than 28 days, a plan prepared and signed by Blasting Consultant indicating details of controlled blasting techniques that will be used to prevent damage to the concrete shall be submitted to the Resident Engineer. These plans shall indicate the age of the concrete at the time of blasting, and shall include calculations indicating levels of expected strain in the concrete. Plans shall also indicate how strain levels in the concrete generated by such blasting will be monitored and reported to the Resident Engineer.

9. An Emergency Response Plan indicating types of explosive materials, storage locations and quantities shall be submitted to and approved by FDNY. The approved Emergency Response Plan will be submitted to the Resident Engineer before explosives are allowed on the Work Site.
- B. Product Data: Manufacturer's product information sheets and Material Safety Data Sheets (MSDS) for all explosives, blasting agents, primers and initiator products, blasting devices, lightning detectors, blasting mats, and all other blasting equipment and specific details about hazardous communications programs for employees.
- C. Quality Control Submittals: At least 60 days before commencing drilling and blasting, submit to the Resident Engineer for review:
 1. A detailed description of the education, training, and experience of all proposed persons that will be immediately in charge of drilling and blasting operations. Separate qualifications shall be submitted for each supervising Blaster-in-Charge. Contractor's submittal shall include names, addresses, and telephone numbers of at least three persons who can verify such prior successful experience. Copies of valid NYC blasting licenses shall also be submitted for all Blasters-in-Charge.
 2. Any changes to Blaster-in-Charge or Blasting Consultant must be submitted to the Resident Engineer for review a minimum of 30 days before Blaster-in-Charge or Blasting Consultant begin work on the Project.
 3. The name and qualifications of a recognized independent Blasting Consultant(s) whom Contractor plans to retain to facilitate the development or review of all blasting designs and blast-effect control measures. The qualifications of the Blasting Consultant(s) shall meet or exceed the specified requirements. The Blasting Consultant shall be retained for the duration of the Project. The Blasting Consultant shall also be on site during Test Blasting.
 4. Submit copies of certificates of training for all personnel involved in the blasting as specified herein above.
 5. Copies of required FDNY Explosive Use and Storage licenses, and individual blaster licenses.
 6. Copies of blaster licenses for Blasters-in-Charge and all blasters.
 7. Copies of any required regulatory variances.
- D. Pre-Construction Surveys:
 1. The Resident Engineer will conduct a pre-construction survey to document the condition of all property located within the area of influence of blasting areas prior to commencement of blasting activities. Pre-construction survey documents will be provided to Contractor.

2. The Resident Engineer will document existing conditions of exposed utilities within transit and rail tunnels that may be affected by blasting. Contractor may have additional surveys performed at their own cost. Provide copies of any such surveys conducted by Contractor to the Resident Engineer.
- E. Vibration and Air-Overpressure Monitoring: The Resident Engineer will perform all primary compliance monitoring, as well as specialized monitoring of the response of structures in areas close to blasts (i.e. NYCT and MNR Tunnels, and buildings above the wye caverns). Such monitoring will be done with blast monitoring equipment that conforms to ISEE Guidelines, and Practices. Instrumentation will be furnished and installed by others. Copies of all monitoring records will be provided to Contractor. If desired, Contractor can perform additional monitoring, provided that blast monitoring equipment complies with the ISEE Guidelines and Practices. In order for the data to be acceptable, submit copies of monitoring records collected by Contractor to the Resident Engineer within one month of collection. Only qualified and properly trained persons shall operate blast monitoring equipment on behalf of Contractor, and training certificates for such persons shall be provided.
- F. General: Unless otherwise indicated, make required submittals at least 60 days before conducting any blasting operations, and before any explosives, blasting agents, primers, or initiators are delivered to the Work Site.

1.07 DELIVERABLES

- A. Test Blasts:
 1. Blast Reports as specified herein above.
 2. Regression calculations as determined by Blasting Consultant from charge weight, distance and seismograph data for Test Blasts.
 3. Additional records taken by Contractor.
- B. Production Blasts:
 1. Blast Reports as specified herein above.
 2. Weekly regression calculations as specified herein above.
 3. Additional records taken by Contractor.

1.08 PERMITS

- A. Obtain and pay for all permits and licenses from the applicable Federal, Local and State agencies in connection with all drill and blasting operations. Copies of all such permits and licenses shall be supplied to Resident Engineer. These permits include, but are not limited to, the following:
 1. FDNY permit to use, transport, and store explosives
 2. Individual blaster licenses

3. NYC DEP tunnel permits
4. BATF
5. Procure all other permits required in accordance with the General Terms and Conditions, the Supplemental Terms and Conditions, and Division 1 - General Requirements.

1.09 SCHEDULING AND SEQUENCING

- A. To facilitate compliance monitoring work, notify the Resident Engineer of the planned times and locations of all blasts at least 24 hours before they are scheduled to occur. If blasts are cancelled, or the time scheduled for a blast is delayed more than one hour, the Resident Engineer shall be notified of the cancellation or rescheduled time by telephone immediately. For each blast, sufficient time must be provided for Resident Engineer to set up monitoring equipment at all desired structures or locations. Contractor may not blast until Contractor has received a telephone or radio notice to proceed from Resident Engineer. All delays caused by Contractor's failure to provide adequate blasting notification to the Resident Engineer will be at Contractor's expense. Notify the Resident Engineer immediately upon completion of the blasting.
- B. MNR Trains run at scheduled intervals and must not be stopped by construction operations. The following procedures shall be followed when blasting is within 200 feet of MNR tunnels:
 1. No blasting shall be conducted within 200-feet of existing MNR tunnels, structures, or facilities during the morning and late afternoon rush hours, as follows:
 - a. 5:00 AM to 9:45 AM inclusive
 - b. 3:00 PM to 8:00 PM inclusive
 2. Communications shall be set up between Contractor, Resident Engineer and MNR rail operations. Obtain a MNR flagger at all times during blasting operations so that communication is kept open between or MNR, the Resident Engineer, and Contractor. Through the Resident Engineer, provide a representative to communicate with the flagger.
 3. Give specific notice to Resident Engineer 24 hours before blasting is anticipated within 200-feet of MNR tunnels. Notification requirements are as specified herein.
 4. Following contact with MNR, the Resident Engineer will notify Contractor and provide a time window consistent with the train schedule intervals, acceptable to MNR, within which Contractor must complete his blast.

5. Notify the Resident Engineer at least one hour prior to each blast to be detonated within the approved window. Do not blast until such clearance is given by the Resident Engineer. If for any reason, Contractor fails to complete his blast within this time window, then another hour of notification time shall be necessary before conducting the blast.
 6. Following the blast, Contractor, Resident Engineer, and a representative of MNR shall conduct visual inspection of MNR tunnels, structures and facilities to assess any damages resulting from blasting. If damages occur, blasting shall be suspended, and the blast design shall be modified to preclude further damage. Damages shall be repaired to the satisfaction of the Resident Engineer and MNR before drilling the next round.
- C. NYCT Trains run at scheduled intervals and must not be stopped by construction operations. The following procedures shall be followed when blasting is within 100 feet of NYCT tunnels:
1. No blasting shall be conducted within 100 feet of existing NYCT tunnels, structures, or facilities during the morning and late afternoon rush hours, as follows:
 - a. 6:30 AM to 9:00 AM inclusive
 - b. 4:30 PM to 7:00 PM inclusive
 2. Communications shall be set up between Contractor, Resident Engineer and NYCT rail operations. Obtain a NYCT flagger at all times during blasting operations so that communication is kept open between or NYCT, the Resident Engineer, and Contractor. Through the Resident Engineer, provide a representative to communicate with the flagger.
 3. Give specific notice to Resident Engineer 24 hours before blasting is anticipated within 100-feet of NYCT tunnels. Notification requirements are specified elsewhere herein.
 4. Following contact with NYCT, the Resident Engineer will notify Contractor and provide a time window consistent with the train schedule intervals, acceptable to NYCT, within which Contractor must complete his blast.
 5. Notify the Resident Engineer at least one hour prior to each blast to be detonated within the approved window. Do not blast until such clearance is given by the Resident Engineer. If for any reason, Contractor fails to complete his blast within this time window, then another hour of notification time shall be necessary before conducting the blast.
 6. Following the blast, Contractor, Resident Engineer, and a representative of NYCT shall conduct visual inspection of NYCT tunnels, structures, and facilities to assess any damages resulting from blasting. If damages occur, blasting shall be suspended, and the blast design shall be modified to preclude further damage. Damages shall be repaired to the satisfaction of the Resident Engineer and NYCT before drilling the next round.

- D. No blasting shall be conducted within 200-feet of Residential Areas between the hours of 10:00 PM to 8:00 AM inclusive, unless Contractor can prove to the Resident Engineer (either through additional test blasts or otherwise) that noise and vibration levels can be maintained below limits specified in Section 01572 at all times.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Contractor is responsible for knowledge of and compliance with applicable Federal, State, and FDNY regulations, applicable to the purchase, transportation, storage, handling, and use of explosives, blasting agents, primers, initiators, and ancillary equipment and materials in accordance with 49 CFR 106, 107, 171-179, 383, and 390-399.
- B. Transportation: Contractor has responsibility of satisfying FDNY regarding transportation procedures, and supplying Resident Engineer confirmation of such satisfaction.
- C. On-Site Storage: Contractor has responsibility of satisfying FDNY regarding on-site storage and security procedures, and supplying Resident Engineer confirmation of such satisfaction.

1.11 PROJECT CONDITIONS

- A. Blasting in close proximity to operating NYCT tunnels and MNR tunnels, structures and facilities, and all commercial and residential buildings, shall be conducted safely and in accordance with the vibration and air-blast limitations specified in Section 01572, as revised herein, and the Contract Drawings. Owing to these concerns, the Resident Engineer will examine carefully the qualifications of every person whose knowledge and skills may bear on the outcome of the work. In addition, the Resident Engineer will reject any persons who are deemed unqualified for any tasks that may be required.
- B. Contractor's Blasting Consultant must remain aware of operations and oversee relevant decisions so that Project can be conducted in a safe and timely manner. If Resident Engineer determines that Blasting Consultant is non-responsive, the Resident Engineer can require Contractor to engage a new Blasting Consultant.
- C. Contractor is advised that reasonable predictability of overall blasting results is mandatory, including overbreak, fragmentation, and movement of muck, and ground vibration. Construction methods, including hole location and delay, detonator type, explosive charge distribution, perimeter hole placement, overbreak control, and scaling must be chosen such that the Resident Engineer and concerned parties may be confident that the results of blasting will be within specified bounds, and that modifications for any reason will reasonably approach the desired results.
 - 1. Specifically, the use of electronic detonators, which have been approved by FDNY for use in New York City, has been shown to be effective in (a) safety, (b) security, and (c) accuracy, resulting in reduced overbreak, improved fragmentation, and predictability and control of resultant vibration, relative to standard non-electric pyrotechnic detonators. While not mandating means and methods for Contractor, Contractor must

demonstrate that the initiation system selected is appropriate to the requirements described herein.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN

- A. Design Criteria: The following shall apply to blasting in all areas specified herein above.
1. The firing systems for the general blast holes shall be controlled by the use of electronic or non-electric delay detonators approved by FDNY. Explosives used for a single period delay shall be the minimum required for effective fragmentation, consistent with blast vibration requirements.
 2. Blast designs shall include measures that prevent all forms of misfires and ensure complete detonation of all explosives. If any products or methods are causing excessive cutoffs or other forms of misfires, suspend the use of problematic products or methods. New blasting plans shall be submitted as required. All associated costs of redesigned blasts or delays caused by this action will be at Contractor's expense.
 3. Underground Blast Rounds:
 - a. Excavation to final rock surfaces shall be carried out using line drilling, or smoothwall-blasting methods. Pre-split blasting and channel drilling shall not be used.
 - b. The diameter of all holes charged with explosives shall not exceed 2.25-inches.
 - c. Only fixed-cartridge or packaged explosives approved by FDNY shall be used.
 - d. When smoothwall blasting methods are used, the design and implementation shall conform to the following requirements:
 - 1) Spacing between parallel holes drilled at the excavation perimeter shall not exceed 18-inches. Justification for Contractor's proposed hole spacing shall be based on the Resident Engineer's opinion that Test Blasts have produced satisfactory results.
 - 2) The main explosive charge, not including the primer stick or a small charge tamped against the decoupled charge at the collar of the hole, shall be uniform, continuous, and decoupled from the wall of the hole.
 - 3) The linear charge weight of the decoupled explosive column shall not exceed 0.29-pound per foot. The weight of the primer stick and tamped collar charge shall each not exceed 0.88-pound (one - 1-1/2-inch by 12-inch cartridge).

- 4) Burden/spacing ratio for perimeter holes must be between 1.3 and 1.5; e.g., for spacing of 18-inches, burden must be between 23.4- and 27-inches.
 - e. The advance length of blasted rounds, not including subdrilling, shall not exceed round length and as shown on the Contract Drawings.
 - f. Subdrilling shall not exceed 2-feet. Holes shall be backfilled, as appropriate, to ensure proper charge placement for smoothwall breakage.
 - g. If air-overpressure caused by any blasting exceeds 127-dBL at any surface location, or levels of air-overpressure adversely impact any underground facilities, at least 1.5-feet of stemming shall be tamped into the collars of blastholes and at least 1-foot of stemming shall be tamped into the collars of smoothwall perimeter holes to control air-overpressure.
- B. Vibration and Air-Overpressure Limitations:
- 1. Air-Overpressure: In no case shall air-overpressure measured at any surface location exceed 133-dBL.
 - 2. Vibration limitations shall be as specified in Section 01572.

2.02 EXPLOSIVE MATERIALS

- A. Only FDNY-approved blasting systems shall be used. Electronic detonators are permissible with FDNY approval. Cap and fuse method or standard electric pyrotechnic initiators shall not be used.
- B. Only explosives approved by FDNY, and designed and manufactured for smoothwall (trim) blasting shall be used for the primary column charges in perimeter holes.
- C. Explosives, blasting agents, primers, initiators, and ancillary blasting materials shall be kept in original packaging with clearly marked date codes. All explosives and initiating devices used shall be less than one year old or within manufacturer's shelf life limits, whichever are more stringent.
- D. If Contractor, Blaster-in-Charge, Blasting Consultant, or Resident Engineer determines that a blasting product appears to be in a damaged or deteriorated condition, the suspect product shall not be used. Products found to be damaged or in a deteriorated condition shall be immediately returned to the supplier for safe disposal.

PART 3 EXECUTION**3.01 PREPARATION AND PROTECTION**

- A. Establish fail-safe procedures and protection devices that ensure that all persons are at safe locations before any blasting. FDNY-approved procedures shall be followed, including, but not limited to, the following:
 - 1. Signboards displaying blast clearing and guarding procedures shall be displayed in lunchrooms, change rooms, and other locations where workers and visitors to tunnel areas can clearly see them.
 - 2. The blaster-in-charge shall direct all clearing and guarding operations and blasting shall be performed only after ensuring that all people and equipment have been removed to a safe location.
 - 3. A "tag out" procedure will be utilized to ensure that all persons are out of the blasting area before a blast.
 - 4. A notification procedure to rail/transit agencies and public.
- B. Flyrock Control: Methods and procedures shall be used as required to protect instrumentation, utilities, personnel, this work, and equipment from flyrock.
- C. Scaling and Stabilization: All rock on the cut face that is loose, hanging, or that creates a potentially dangerous condition shall be removed or stabilized and as directed by the Resident Engineer during or upon completion of the excavation in each round. Drilling of the next round will not be allowed until this work has been completed.
- D. Contractor must review the pre-construction survey documents of NYCT tunnels and MNR tunnels, structures and facilities including duct banks, track slabs, and utilities, and determine loose elements such as tiles, brackets, decorative ornaments, etc., that can fall during blasting. These elements must be secured and tightened by Contractor before initiating blasting so that the maximum expected vibration due to blasting will not dislodge the elements. Particular attention must be paid to the safety and security of any personnel within these areas. Contractor shall coordinate railroad protection (flagging) or track outages with NYCT and MNR through the Resident Engineer.

3.02 TEST BLASTS

- A. Before any production blasting, a series of Test Blasts shall be performed to collect required data as specified herein.
 - 1. To determine minimum scaled distances for design of production blasts
 - 2. To determine means, methods, and procedures to limit potential blast impacts on critical facilities such as MNR tunnels, structures and facilities, and NYCT tunnels
 - 3. To evaluate the reduction in ground-borne vibration achieved using line drilling

- B. Contractor's Blasting Consultant(s) and at least one qualified technical representative from the explosive supplier and a representative of the FDNY shall be on Work Site to facilitate test-blasting activities at Contractor's expense.
- C. A minimum of three Test Blasts will be conducted in each of the following areas:
1. Approach Tunnel (EB2) near East 63rd Street
 2. GCT 5 Wye Caverns (WB1 or WB3) near East 58th/59th Street
 3. GCT 3 Wye Caverns (WB1 or EB2) at Park Avenue near 49th/50th Streets
 4. Open-Cut excavation at the Queens Bellmouth
- D. Other Test Blasts shall be detonated as directed by the Resident Engineer under the following conditions:
1. An area of the project, which has not previously been blasted.
 2. Following a substantive change in blast design or methods, whether by choice of Contractor or upon recommendations of the Resident Engineer.
 3. When there are substantive changes in ground conditions (as in entering a shear zone).
- E. Test Blasts shall use the following procedure:
1. A Test Blast Plan and location for each area shall be submitted and reviewed by the Resident Engineer before drilling for Test Blasts.
 2. The round length for Test Blasting shall not exceed 4-feet.
 3. Test Blasts shall be of Contractor's design unless described specifically by Resident Engineer.
 4. Maximum charge weights per 8-millisecond delay shall be chosen, as close as practicable, to be 0.25, 0.5, and 1.0 times the charge weight determined from:
 - a. The vibration regression equation: $PPV = 300 SD^{-1.6}$ where SD (Scaled Distance) equals $D/W^{0.5}$, where this equation is based upon blasting results in Manhattan.
 - b. D is distance from blast in feet, and W is charge weight per delay. Distance shall be calculated from the closest surface monitoring point.
 - c. The vibration level, PPV, determined by the Resident Engineer and NYCT, MNR, or FDNY to be appropriate for such tests.

5. A regression equation shall be calculated for the mean and 95-percent confidence limits for the Test Blasts.
 6. This regression equation shall be used to determine Initial Minimum Design Scaled Distance for blast plans to produce, at the closest location, either the mean level vibration, or a vibration 0.75 times the vibration predicted by the 95 -percent confidence level, whichever is lower.
- F. The Test Blast plan will be reviewed by the Resident Engineer, Blasting Consultant, and NYCT/MNR as appropriate. The Resident Engineer, Blasting Consultant, and NYCT/MNR will review the Test Blast results and monitoring data and evaluate the effectiveness of initially specified blasting controls before allowing full-scale blasting in various excavations. At the direction of the Resident Engineer, coordinate the Test Blasting firing times to accommodate additional structural response monitoring that might be performed by the Resident Engineer. Test blast scheduling and sequencing shall be as specified herein.
- G. Whenever practical, Test Blasts shall also be designed to evaluate the results of smoothwall blasting or other accepted measures intended to minimize overbreak. The effectiveness of tested control measures shall be reported in Test Blast reports. Video and/or photographic documentation of effectiveness shall be supplied to Resident Engineer.
- H. Allow adequate time for executing Test Blasts. Full scale production blasting will not be allowed until the Resident Engineer, Blasting Consultant, and NYCT/MNR have reviewed all Test Blast data and Contractor's proposed blast-effect control methods, as appropriate. The Resident Engineer's review of the Test Blasting plans does not relieve Contractor's responsibility for any damages that might result from blasting.

3.03 PRODUCTION BLASTING

- A. Conduct blasting operations in a manner to keep air-overpressure and ground motion near critical on-site structures, adjacent transit facilities, and private structures within the specified limitations. If blast-induced air overpressure or vibration levels exceed the performance requirements specified herein, suspend blasting in the affected excavation(s) until a re-designed blasting plan is submitted to and reviewed by the Resident Engineer.
- B. Production blasting shall be conducted in accordance with the designs determined from the Test Blasting.
- C. Limitations:
1. Blasting shall not be permitted when in the opinion of the Resident Engineer it may be detrimental to existing installations. The Resident Engineer's decision will be final.
 2. Controlled blasting techniques shall be used to minimize overbreak and minimize rock damage in all excavations. Blast patterns shall be designed so that the explosive energy is not directed into the back and sidewalls of the excavation but, instead, towards the developed free face.

3. Whenever, in the opinion of the Resident Engineer, proposed blasting may cause harm to persons, cause damage to structures, or create unacceptable rock instability, cease blasting immediately and review the blast design. Contractor may resume excavation of the rock with either a re-designed blast plan submitted to and reviewed by the Resident Engineer, or by mechanical means.
- D. Misfires and Dangerous Conditions: After a blast has been fired, the Blaster-in-Charge and one assistant under his direct supervision shall make a careful inspection of the blast area. The Resident Engineer may be present for this inspection. Inspections shall determine whether there are any indications that misfires might have occurred or whether the blast created any other imminent dangers such as unstable ground conditions. If misfires or other dangerous conditions are found, the Blaster-in-Charge shall immediately notify the Resident Engineer, secure the area and properly correct all hazards before any other work is allowed in the affected area. The all clear signal, allowing other work to resume in the area, shall not be given until affected blast sites are clear of all hazards.
- E. Review and Modification Methodology: If vibrations exceed or approach the limitations specified herein above and explosive weights need to be reduced, or if vibrations are significantly below limitations specified herein above and Contractor would like to increase charge weight, Contractor must establish a modified Design Scaled Distance and submit it for review by Resident Engineer according to the following procedures:
 1. Review data for accuracy.
 2. Review current regression equation and modify.
 3. Modify Minimum Design Scaled Distance to determine revised design charge weight as 75-percent of the 95 -percent confidence level.

3.04 SUSPENSION OF BLASTING

- A. Blasting operations may be temporarily suspended by the Resident Engineer for any of the following reasons:
 1. Contractor's safety precautions are inadequate.
 2. Air-overpressure and ground vibration levels exceed specified limits.
 3. Excavation by drill and blast results in excessive overbreak or over-excavation.
 4. Blasting endangers the stability of or causes damage to adjacent facilities.
 5. The results of the blasting, in the sole opinion of the Resident Engineer, are not satisfactory.
- B. Blasting operations shall not resume until the Resident Engineer has reviewed Contractor's revised blasting plan with modifications correcting the conditions causing the suspension.

- C. Existing NYCT and MNR tunnels within 100-feet and 200-feet, respectively, of drill and blast excavation shall be observed for structural integrity following operations. Should any conditions indicate instabilities of the tunnel opening and its initial support, the drill and blast excavation shall be temporarily suspended and remedial measures submitted to the Resident Engineer for review.

3.05 DAMAGE REPAIR

- A. If blasting operations damage existing structures and facilities, off-site properties, or a portion of the work, or material surrounding or supporting the work, promptly repair or replace damaged items to the condition that existed before the damage, to the satisfaction of the Resident Engineer. The Resident Engineer and MTA shall be notified immediately of any damage or settlement.
- B. Nothing contained herein shall relieve Contractor of its responsibility for claims arising from its construction operations.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for cast-in-place concrete lining installation as indicated on the Contract Drawings and specified herein. This Section supplements the requirements of Sections 03100, 03200, 03300, 03605 and 07122.

1.02 REFERENCED SECTIONS

- A. Section 03100 – Concrete Formwork
- B. Section 03200 – Concrete Reinforcement
- C. Section 03300 – Cast-in-Place Concrete
- D. Section 03305 – Steel Fiber Reinforced Concrete
- E. Section 03605 – Tunnel Grouting
- F. Section 07122 – Waterproofing System - Cavern Structures and Tunnels

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI):
 - 1. 309 – Guide for Consolidation of Concrete
 - 2. 318 – Building Code Requirements For Structural Concrete
- B. ASTM International (ASTM):
 - 1. C 39 – Compressive Strength of Cylindrical Concrete Specimens
 - 2. C 94 – Ready-mixed Concrete
 - 3. C 109 –Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
 - 4. C 143 – Slump of Hydraulic Cement Concrete
 - 5. C 494 – Chemical Admixtures for Concrete
 - 6. C 618 – Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
 - 7. D 1785 –Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

C. U.S. Army Corps of Engineers, Concrete Research Division (CRD):

1. CRD-C572 Polyvinylchloride Waterstops.

1.04 NOTED RESTRICTIONS

A. Do not begin lining installation until required submittals have been made and have been reviewed by the Resident Engineer.

1.05 QUALITY ASSURANCE

A. Qualifications

1. Personnel in charge of placing concrete, and personnel who place concrete, shall have at least five years of verifiable experience (or as approved by the Resident Engineer) in placing concrete in the type of work specified herein.
2. Personnel in charge of formwork and falsework system shall have at least five years of verifiable experience (or as approved by the Resident Engineer) in assembling, disassembling, reassembling, operating and maintaining of such systems.
3. For multi-use formwork and falsework system supported off a traveler the manufacturer shall have at least 10 years of verifiable experience (or as approved by the Resident Engineer) in the design, manufacture, and setting-up of such systems.
4. Contractor shall have a formwork and falsework system manufacturer representative on-site during initial assembly and start-up and shall remain on-site until concrete is poured behind second set-up of the system.

1.06 SUBMITTALS

A. Submittal requirements shall be in accordance with the provisions of Sections 03300, 03100 and 03605.

1.07 DELIVERABLES

A. As-Built Drawings: Provide As-Built Drawings for contact grouting pipes as follows:

1. Location and elevation of contact grouting pipes and ports
2. Date of pipe installation
3. Date of concreting

B. All other deliverables shall be in accordance with the provisions of Sections 03300, 03100 and 03605.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Load, transport, unload, and store structural materials to keep them clean and free from damage.
- B. Store materials on platforms, skids, or other supports above the ground and ensure proper drainage and protection from corrosion.

PART 2 PRODUCTS**2.01 MATERIALS**

- A. Materials shall conform to the applicable requirements of the referenced Sections.
- B. Grout constituents shall comply with the applicable requirements of Sections 03300 and 03605.

2.02 FORMWORK

- A. Design formwork and falsework to satisfy the criteria in Section 03100.
- B. Formwork spacer pins (spuds) shall not bear against the waterproofing membrane. Buoyancy of the formwork shall be resisted by other means.

2.03 GROUT PIPES FOR CONTACT GROUTING

- A. Contact Grout Pipes: 3/4-inch nominal pipe size polyvinyl chloride (PVC) pipe schedule 40; ASTM D 1785, length as shown on the Contract Drawings or as reviewed by the Resident Engineer, but not to exceed 30-feet. Furnish with inside thread and removable plug, perforated at rubber sleeves. Rubber sleeves at nominal 6-foot centers for distribution of grout. Provide a hydrophilic O-ring, 12-inches from the grout plug.

2.04 GROUT MIX FOR CONTACT GROUTING

- A. Grout for contact grouting shall consist of one part Portland cement, one part fine aggregate, and admixture or equivalent reviewed by the Resident Engineer.
- B. Minimum compressive strength: 100-psi within 24 hours and 4,000-psi at 28 days when tested according to ASTM C 109.
- C. Water-cement ratio shall be compatible with pumping and placing requirements.
- D. Testing requirements shall be in accordance with Section 03605.

2.05 WATERPROOFING

- A. Material shall conform to the applicable requirements of Section 07122.

2.06 REINFORCING STEEL AND STEEL FIBER REINFORCEMENT

- A. Material shall conform to the applicable requirements of Section 03200 and Section 03305.

2.07 WATERSTOPS

- A. Waterstops Type-A and Type-B:
1. Waterstops Type-A and Type-B shall be molded or extruded polyvinylchloride conforming to the requirements of U.S. Army Corps of Engineers Specification CRD-C572. Size, configuration, dimensions, and tolerances shall be as indicated on the Contract Drawings.
 2. Filed splices shall be made by heat sealing the square cut ends of the waterstop. Field splices shall develop water tightness equal to that of the unspliced material and shall have a tensile strength of not less than 100% of the unspliced material.
- B. Hydrophilic Waterstops: Hydrophilic waterstops shall be based on modified chloroprene rubber, shall have a delayed swell action to prevent premature expansion prior to concreting and shall have a volumetric increase of not less than 120-percent. Miscellaneous materials: adhesive, mastic, and accessories shall be supplied by, or as recommended by, the waterstop manufacturer.

PART 3 EXECUTION**3.01 PREPARATION**

- A. Initial support or additional initial support elements shall not encroach within the design line shown on the Contract Drawings, except for Support Class II and III within the bored tunnels, as shown on the Contract Drawings.
- B. Water inflows shall be excluded from the space to be filled with concrete in accordance with Section 07122.
- C. Install hydrophilic waterstops just before concreting and place as near as possible to the face subject to hydrostatic pressure in accordance with the manufacturer's requirement of minimum edge distance. Cutting, splicing and adhesion shall be in accordance with the manufacturer's instructions.
- D. Grout pipes shall be securely fixed to the waterproofing membrane, parallel with the membrane surface, in such a manner that the membrane is not over-stressed or damaged. Ends of grout pipes shall be securely fixed perpendicular to the concrete surface and flush with the concrete surface. The ends of the grout pipes shall be suitable plugged to prevent entrance of concrete or mortar. Grouting vent pipes shall not be positioned through holes drilled in the finished lining.

3.02 PLACEMENT

- A. General: Concrete shall be placed in accordance with Section 03300, Section 03305, and the following requirements:

1. Concrete in the arch shall be placed by pumping or other accepted non-pneumatic methods.
 2. The placing equipment and the method of its operation shall permit introduction of the concrete into the forms without high velocity. Placing equipment and methods shall force concrete into all irregularities in the initial support surfaces and to completely fill the lining and crown. A slick line shall not be used behind the formwork except where a back-face reinforcing bar mat is used.
 3. Joints at the ends of each lining placement shall be vertical. Joints at ends of placements shall be cleaned and treated as shown on the Contract Drawings and as specified in Section 03300.
- B. Consolidation: Concrete shall be consolidated to the maximum practicable density, so that it is free from pockets of aggregate and entrapped air, and closes snugly against all surfaces of forms and embedded materials. Concrete shall be consolidated in accordance with ACI 309. Except for the crown pour, concrete shall be consolidated by internal vibration only. The location of form vibrators at the crown, position of the end of the slick line or the delivery snorkel, operation of the immersion vibrators, and discharge of concrete shall be coordinated so as to obtain maximum filling of the crown with concrete and so as to avoid settlement and flow of concrete away from the filled crown due to improperly positioned and timed vibration.
1. Form vibrators shall be located and operated to fully consolidate concrete but shall not cause segregation or excess water and mortar rising to the surface.
 2. At least three each spare immersion type and form type vibrators in operable condition shall be available at the Work Site at all times when concrete is being placed.
 3. When concrete is placed in horizontal lifts, insert the vibrator rapidly to the bottom of the layer, and at least 6-inches into the underlying layer, hold it there stationary for several seconds, and then withdraw it slowly, at the rate of about 3-inches per second. Conduct vibration to produce concrete that is uniform in texture and appearance, free of honeycombing, air and rock pockets, streaking, cold joints, and visible lift lines.

3.03 SURFACE FINISH

- A. Surface finish shall be as specified in Sections 03300 and 03305.

3.04 CURING

- A. Concrete shall be cured by the water method or curing compound method in accordance with the requirements of Section 03300.
- B. Spray curing compound shall not be used without the Resident Engineer's acceptance.

3.05 TOLERANCES

- A. Tolerances shall be as specified in section 03300.

3.06 WATERTIGHTNESS

- A. Requirements for watertightness and leakage infiltration rates, where applicable, are specified in Section 07122.

3.07 CONTACT GROUTING

- A. For general grouting procedures see Section 03605.
- B. Clean out grout holes or pipes that become obstructed before grouting.
- C. Perform contact grouting through contact grouting pipes with such quantity and pressure to fill all voids behind concrete lining. Contact grouting in the crown of the form shall be performed from the lower end (based on top of rail or slope of working line) to the higher end.
- D. Grout shall be pumped until a minimum pressure of 18-psi is reached. Pressure shall not exceed 20-psi.
- E. Contact grouting shall not be undertaken until concrete lining has attained 28-day strength.
- F. No remedial grouting as specified in Section 07122 shall be undertaken until contact grouting operations in a structure are complete.
- G. During contact grouting operations flush the sidewall drainage pipes (see Section 07122) with water to prevent clogging by incidental contact grout material or protect side wall drain pipes from clogging by other means as reviewed by the Resident Engineer.
- H. After completion of grouting operations, fill grout holes/pipes and vent pipes with dry pack or thick grout, to produce a smooth finished surface.
- I. In areas of the crown where no contact pipe is indicated on the Contract Drawings, control-and-grouting pipes shall be grouted in accordance with Section 07122, whether or not leakage is apparent.

3.08 FIELD QUALITY CONTROL

- A. Field quality control procedures for lining concrete shall conform to the requirements of Section 03300.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and services for performing all operations necessary for manufacturing, testing, transporting, handling, storing, delivering and installing precast concrete tunnel linings in accordance with the requirements set forth in the Contract Drawings and as specified herein.
- B. Requirements for labor, products, equipment and services necessary for loading, transportation to and offloading of linings at the Work Site, storage on the Work Site, repair or replacement of damaged segments and other incidental and related Work necessary for erection of the concrete lining in bored tunnels at locations as shown on Contract Drawings and as specified herein.
- C. Requirements for ensuring compatibility of lining design with selected construction methods and for performing any design modifications.
- D. Definitions:
 - 1. Gasket: A continuous, deformable, elastomeric element located in a segment joint groove surrounding each segment to provide permanent watertightness for the erected tunnel lining.
 - 2. Packing: Load-distributing elements attached to the segment joints, to distribute compressive stresses across the segment joints without affecting the ability of the segment gasket to withstand existing hydrostatic pressures. The term “packing” does not mean “shimming” as used herein.
 - 3. Precast Concrete Segment: A precast structural element cast in an arc shape, which when installed in the tunnel with other segments, forms a continuous ring forming the tunnel lining and supporting the surrounding ground.
 - 4. Precast Concrete Segmental Tunnel Lining: A one-pass structural lining consisting of bolted, gasketed precast reinforced concrete segments grouted in place. This concrete segmental lining is called the “lining” or “liner”.
 - 5. Shim or Shimming: Placing materials between segments to correct for misalignments, incorrect ring build, or any purpose other than “packing”. Shimming shall not be permitted; tapered rings shall be used to negotiate horizontal and vertical curves and to correct for line and level.

1.02 REFERENCED SECTIONS

- A. Section 02406 - Tunnel Excavation by TBM
- B. Section 02413 - Tunnel Boring Machine (TBM)
- C. Section 03200 - Concrete Reinforcement
- D. Section 03300 - Cast-in-Place Concrete

E. Section 03605 – Tunnel Grouting

1.03 CITED STANDARDS

A. American Concrete Institute (ACI):

1. 301 - Structural Concrete
2. 309 - Consolidation of Concrete
3. 517 - Accelerated Curing of Concrete at Atmospheric Pressure

B. ASTM International (ASTM):

1. A 36 - Carbon Structural Steel
2. A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. A 307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
4. A 563 - Carbon and Alloy Steel Nuts
5. A 615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcing
6. C 33 - Concrete Aggregates
7. C 39 - Compressive Strength of Cylindrical Concrete Specimens
8. C 150 - Portland Cement
9. C 156 - Water Retention by Concrete Curing Materials
10. C 171 - Sheet Materials for Curing Concrete
11. C 192 - Making and Curing Concrete Test Specimens in the Laboratory
12. C 618 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
13. C 666 - Resistance of Concrete to Rapid Freezing and Thawing
14. C 1166 - Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories
15. C 1202 - Electrical Indication of Concretes Ability to Resist Chloride Ion Penetration
16. D 395 - Rubber Property - Compression Set
17. D 412 - Vulcanized Rubber and Thermoplastic Elastomers Tension
18. D 471 --Rubber Property - Effect of Liquids

19. D 518 - Rubber Deterioration – Surface Cracking
 20. D 573 - Rubber – Deterioration in an Air Oven
 21. D 1149 - Rubber Deterioration – Surface Ozone Cracking in a Chamber
 22. D 2240 - Rubber Property – Durometer Hardness
 23. F 436 - Hardened Steel Washers
- C. National Institute of Standards and Technology (NIST)
1. PS1 - Construction and Industrial Plywood
- D. Precast/Prestressed Concrete Institute (PCI):
1. MNL 116: Manual for Quality Control for Plants and Production of Structural Concrete Products. All segments shall contain reinforcing steel cages conforming to the requirements.

1.04 NOTED RESTRICTIONS

- A. Do not begin segment mold or precast concrete segment production until the required submittals have been made and the Resident Engineer has reviewed submittals.
- B. Do not begin segment repairs until the required submittals have been made and the Resident Engineer has reviewed submittals.

1.05 QUALITY CONTROL

- A. Qualifications of Manufacturers
1. Employ qualified firms (including mold manufacturer, precast concrete manufacturer, gasket manufacturer, joint connector systems manufacturer) regularly engaged in manufacture and fabrication of precast concrete tunnel lining segments or accessories (as applicable) of similar dimensions and tolerances to those specified, and who has provided precision tunnel rings or accessories (as applicable) for at least two projects comparable to Work of this Contract in size and type, in the last five years. Comparable work shall include bolted, gasketed tunnel lining segments installed as permanent lining below the groundwater table in similar subsurface conditions.
 2. Employ personnel experienced in the manufacturing and installation of gasketed and mechanically connected precast segmented tunnel liner.
- B. Inspection and Testing:
1. Employ an independent testing laboratory to prepare the design of mixes for the requirements of concrete as indicated on the Contract Drawings and as specified herein. Tests and trial mixes shall be performed in accordance with Section 03300, ASTM C 192 and ASTM C 39.

2. Casting:
 - a. Provide the Resident Engineer with sufficient office space, communications, labor, assistance, and equipment for performing inspections and reports at the segment casting yard/factory throughout the duration of the segment production. The Resident Engineer may reject finished segments not found to be in accordance with these Specifications.
 - b. The first segment cast in any mold shall be checked for compliance with the tolerances specified; thereafter as a minimum, check every twentieth segment from each mold. As a minimum, ensure that one segment from each mold is checked weekly for dimensions and tolerances. When any variation in segment quality is found, the number of segments checked shall be increased to that required to re-establish the accuracy and consistency of production. If any out of tolerance segment is found, do not use that segment in the Work or any other segments from the mold found to be out of tolerance. Check all segments cast from that mold since that mold was last checked. Remove and do not use any segments that fail to comply with requirements for dimensions and tolerance.
 - c. Maintain full time inspection personnel at the casting yard/plant who shall be responsible for ensuring that the specified quality is being achieved and reviewed procedures are being implemented at all stages of the segment production process. Provide adequate equipment including substantial steel templates (master and working), gauges, and calipers to determine accuracies for the control of the segment production.
 - d. Provide three certified test results each, by a qualified independent laboratory, demonstrating, in embedded condition, that the pullout (yield) capacity of circumferential joint connector assemblies and the pullout (yield) capacity of radial bolt assemblies meet the specified requirements. Include actual joint connector assemblies. Tested segments shall not be incorporated in the Work.
- C. Molds/Formwork: The molds shall be fully checked and certified by an accredited testing/survey authority for compliance with the requirements for dimensional tolerance and the results reviewed by the Resident Engineer before the molds are shipped to the precast concrete plant.
- D. Casting Tolerances
 1. Fabricate segments to dimensions and tolerances indicated in the Contract Drawings. Use tighter tolerances if necessary for erection or watertightness.
 2. Contractor may propose more stringent tolerances as may be required to suit his chosen construction means and methods.

3. Provide written notice at least 30 days before starting manufacture of segments, to allow the Resident Engineer to inspect and accept plant and means and methods of fabrication.
4. The segment manufacturer shall design and implement a tolerance measurement system to account and adjust for thermal, moisture, and ambient temperature influences.
5. Ensure segments of common design and cast in different molds and at different times are interchangeable.

E. Tunnel Liner Ring Installation Construction Tolerances

1. After grouting, the ring of the tunnel lining shall conform to the following tolerances:
 - a. As shown on Contract Drawings.
 - b. The center of the ring of segments shall not deviate from its design position by more than two-inches.
 - c. The internal diameter of the erected liner ring shall not differ from the design diameter by more than one-inch.
 - d. The internal profile of the lining shall not deviate from its design position by more than 2.5-inches (combining b and c above).
 - e. The square and plumb (yaw and pitch) of the lining shall not differ by more than 0.8-inch from the design value measured over the internal diameter horizontally and vertically or by more than 0.8-inch from the attitude of the shield.
 - f. The leading edge of the lining shall not be out-of-plane by more than 0.25-inch.
 - g. The roll of each ring in relation to the previous ring shall be no greater than can be accommodated within the limitations of bolt hole & dowel clearances. The absolute roll, measured by deviation of the crown dowel hole from the tunnel centerline, shall be within plus or minus 0.75-degrees (plus or minus 1.5-inches) of the theoretical ring position.
 - h. Lips and steps between segments at radial and circumferential joints shall not exceed 0.2-inch.
2. A non-conformance report shall be submitted by Contractor for any ring which is found to be out-of-tolerance after erection and grouting. Any ring or part of a ring which does not satisfy these tolerances shall be removed and rebuilt by Contractor.

3. At the locations of cross passages and other works where there is the possibility of additional deformation during breakout and subsequent construction, support the lining so that the tolerances are not exceeded and the lining is not damaged. Acceptability of breaking out precast segments shall be subject to the requirements stated elsewhere in the Contract Documents.

F. Re-Alignment of Out-of-Tolerance Lining

1. Propose immediate remedial actions to bring the tunnel drive into tolerance. The Resident Engineer will exercise a Stop Work Order in the event the tunnel drive is out-of-tolerance and no satisfactory remedial action is proposed or the remedial action is not implemented in a timely manner or is not effective.
2. Contractor may propose a re-alignment to the future operational tracks to correct an out-of-tolerance tunnel drive for minor deviations from the theoretical alignment. In exercising this option, it is the responsibility of Contractor to demonstrate that:
 - a. Clearances indicated on the Contract Drawings are maintained between the dynamic envelope and tunnel, bench, systems and furniture. Minimum clearances for a rectangular walkway envelope and for the track support slab must also be achieved.
 - b. The re-alignment does not in any way change the intended operational characteristics of the line.
3. Segment grinding is not permitted.

G. Trial Liner Assembly

1. In order to check on the matching and spacing of bolt holes, dowels and interchangeability of bolted segments before bulk manufacture is commenced, assemble and bolt/dowel together on a flat level base, segments to form three rings from any mold set in the presence of the Resident Engineer. The Resident Engineer will select the segments to be used for the trial liner assembly.
 - a. Furnish a 15-day written advance notice to the Resident Engineer before the start of the trial liner assembly.
 - b. Assemble the entire trial liner rings at the Work Site or another accepted location above ground. The rings are to be built one above the other and the radial joints staggered by one third of a segment. No packing or gaskets are to be used in the joints between segments in these trial rings.
 - c. Maintain trial liners intact until tolerances of completed rings are verified and removal of liners is authorized by the Resident Engineer. The lowest ring shall be retained as a master ring for the duration of the Contract. Use dismantled segments for lining tunnel, if undamaged and accepted by the Resident Engineer.

- d. If trial liners are not accepted, dismantle liners, adjust forms, cast new segments and erect new trial liners for acceptance. Continue this procedure until trial liners are acceptable.
 - e. Unacceptable trial liner segments, and other segments cast from the same molds, shall be rejected.
 - f. At a minimum frequency 1 per every 100 segments manufactured from each mold shall be picked at random by the Resident Engineer and assembled on the master ring to ensure that tolerances and interchangeability of segments are being maintained. Unacceptable segments, and other segments cast from the same molds, shall be rejected.
- 2. Ensure availability of trial liner rings in the appropriate time frame to allow sending completed rings to the TBM manufacturer for use in performance testing of the TBM as specified herein and in Section 02413.
- H. Production Units: Do not commence bulk production manufacturing before obtaining Resident Engineer's written acceptance of the trial liners.
- I. Markings: Markings such as logos, trademarks and proprietary information, except panel identification markings, are prohibited on surfaces of tunnel liner segments. Required markings are specified elsewhere herein.
- J. Acceptance
 - 1. All segments containing honeycombing will be rejected. Segments containing cracks will be rejected.
 - 2. Segments not meeting tolerance requirements, minimum strength requirements or other requirements of this specification and contract drawings will be rejected.
 - 3. Rejected segments shall be indelibly marked on the inner (concave) face, permanently removed from the Work Site, and not used in the Project.
- K. Segment Repair
 - 1. Segments to which damage has occurred that can not be repaired in accordance with the accepted Contractor's repair procedures will be rejected.
 - 2. A non-conformance report shall immediately be raised by Contractor for any segment or ring which is found to be damaged after erection. Should the Resident Engineer deem that an installed segment is in a state beyond repair or that the damage is sufficient to compromise the integrity of the lining or its long term function or durability, remove it from the permanent lining and propose remedial works to the Resident Engineer for acceptance.
- L. Chloride Ion Penetrability: As determined by ASTM C 1202. Test mix designs and field cured specimens representing each 1,000 segments fabricated.

1.06 SUBMITTALS

- A. Within 60 days of Notice to Proceed, submit the following:
1. Name and location of the mold, segment, dowel and gasket manufacturers; names and experience of personnel directly managing the production, and list of comparable tunnel projects and names and telephone numbers of client contacts where the manufacturer's products have been used.
 2. Location of segment precasting facility.
 3. Shop Drawings of each type of segment showing complete details of molds/ formwork, reinforcement, mechanical joint connection assemblies, joint reliefs, gasket grooves, gaskets, inserts and accessories necessary for manufacture, transportation and erection. No segments shall be cast until Shop Drawings are reviewed by the Resident Engineer.
 4. Design and detail the liner segment reinforcement based on the design load criteria presented on the drawings, grouting pressures, gasket loads and the contractor's handling, transportation, stacking, erector arm and segment erector jack loads; and if the TBM may advance by reacting off segments, TBM thrust jack loads. Segment design modifications listed below may be proposed. Calculations and Shop Drawings shall be provided, which demonstrate that the proposed design, including any modifications, meets or exceeds all structural requirements. Calculations and Shop Drawings shall be prepared and certified by a Professional Engineer registered in the State of New York with prior experience in design of precast concrete segmental tunnel liners for at least two tunnel projects in the last five years of a similar type and size to be used in the Work. Modifications to the following may be proposed subject to review by the Resident Engineer:
 - a. Internal Diameter: Increase in design internal diameter.
 - b. Segment Geometry: Change in ring width, segment shape and segment arcs. If rectangular segments are proposed, bolts must be used instead of dowels between rings.
 - c. Segment Thickness: Increase in segment thickness.
 - d. Ring Taper: Change in ring taper (e.g. left, right, and tangent ring types) instead of Universal ring (i.e. left ring only). Contractor may propose a moderate ring taper increase.
 - e. Lifting Eye/Grout Hole: Alternative segment lifting arrangement. Segment grout holes are required but Contractor may propose alternative details. If vacuum lifting proposed, use shoe-locating recesses.
 - f. Dowels: Change in geometry of dowels and dowel holes. Contractor may propose to replace dowels with bolts and sockets.
 - g. Bolts: Change in geometry of bolts and sockets.

- h. Modifications are unlikely to be acceptable for concrete, packers, polypropylene fibers and gasket width. All costs related to such modifications shall be included in the bid price.
- 5. Written certification from the precast concrete segment manufacturer of full and complete design coordination between the TBM manufacturer and the precast concrete segment manufacturer. Include a written certificate by both manufacturers affirming the compatibility of the TBM and the liner systems.
- 6. Concrete mix design and test data, including information required in Appendices A and B herein, certified by a Professional Engineer registered in the State of New York.
- 7. Material specifications for components of joint connection systems and specification describing pullout capacity and material properties of the assemblies.
- 8. Name, certificates, qualifications, and record of experience:
 - a. Mold Manufacturer
 - b. Gasket Manufacturer
 - c. Precast Concrete Manufacturer
 - d. Independent Testing Laboratory(s)
 - e. Joint Connection System Manufacturer
- 9. Work Plans and Procedures
 - a. Detailed description of quality control procedures for manufacturing, casting, curing, identification, handling, transporting, delivering, storing, erecting, and repairing segments. Include procedures to control shrinkage and temperature cracking of segments.
 - b. Calculations demonstrating capability of mold to provide rigidity and strength required to maintain manufactured and construction dimensions and tolerances specified.
 - c. Gasket manufacturer's quality control plan ensuring consistency of gasket material, dimensions and installation.
 - d. Detailed design for segment lifting and handling devices. Allow for complete removal of lifting and handling devices intruding into tunnel space. Lifting and handling devices includes all devices used for handling segments; in tunnel, in shaft and at shaft top.
 - e. Details showing layout of facilities for casting, curing and storing segments.

- f. Details of joint connections for pullout capacity testing.
 - g. Details of tolerance measurement system, including equipment details, master and working template configurations and layout, types and numbers of gauges, calipers and theodolites used to determine accuracies and tolerances.
- 10. Samples of Contractor proposed items:
 - a. Gasket: 5-linear-feet and three corner assemblies.
 - b. Adhesive: One pint of each type proposed.
 - c. Lifting/grouting insert assembly: Two each.
 - d. Compression packing: 3-linear feet
 - e. Radial and circumferential joint connector assemblies: Two each
 - f. Reinforcement spacers and chairs: Three each.
 - g. Lubricant: 1-pint of each type proposed.
- 11. Manufacturer's product data and material safety data sheets.
- 12. Notice that segment production plant is ready for Resident Engineer inspection, prior to segment production.
- 13. Notice of start of trial liner assembly prior to that assembly.
- 14. Methods to protect segments and gaskets from direct sunlight and weather if stored outside.
- 15. Gasket Performance: Submit a report demonstrating that the proposed gasket, gasket groove and surrounding concrete meet the specified criteria for the design life of the structure. The report shall additionally include a list of substances known to be deleterious to the gasket, together with an analysis of the risk of contact with such substances.
- 17. Segment repair procedures and rejection criteria (by Contractor's Design Engineer), which shall include descriptions of the type, location and extent of the damage, and their associated repair procedure, or basis for rejection of segments.

1.07 DELIVERABLES

- A. Prepare, maintain, and provide the following records after each shift during segment production and TBM bored tunnel excavation in addition to the requirements of Sections 02406 and 03605. All records shall be in a format acceptable to the Resident Engineer and shall include identification of each segment, and ring if applicable:
 - 1. Quality records of manufactured segments.

2. Quality records of segments delivered to the Work Site consisting of bills of lading (shipping statements)
3. Quality records of all damaged and repaired segments, including rejected segments.
4. Quality records of as-built lining ring data:
 - a. Diametric dimension of the lining: vertically, horizontally and diagonally (2 No).
 - b. Maximum size of steps at each radial joint.
 - c. Maximum size of steps at each circumferential joint with arc length for any step exceeding 0.2-inch.
 - d. Position of key.
 - e. Deviation of the crown dowel hole from the tunnel centerline, to nearest 0.25 inch.
 - f. Position, dimension and description of any crack.
 - g. Position and description of any other damage.
 - h. The information shall be recorded for each ring when it is no more than 100-feet from the last ring built.
5. Non-conformance reports including:
 - a. Out-of-tolerance tunnel liner ring installation.
 - b. Segments or rings that are found to be damaged after erection.

1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Transport, store, and handle units to avoid damage and prevent excessive stresses developing within segments.
- B. Use supports for storing segments to avoid damage; do not subject segments to undue loading.
- C. Prevent damage to all segment surfaces during handling and storage. Keep wire ropes, chains and hooks from direct contact with all segment surfaces, joint assemblies, mating surfaces, gaskets, and joint packings.
- D. If universal rings are not adopted, select and deliver combinations of left and right tapered segments to provide specified tunnel geometry, and for making alignment corrections as necessary during construction.
- E. Replace gaskets and joint packings that have deteriorated through exposure.

- F. During cold weather, prevent water from filling the pockets and recesses of the segments, and freezing.
- G. Ensure segments have attained the specified 28-day design strength prior to transportation.
- H. Inspect completed segments before loading. Discard defective and damaged segments; repair minor damage in accordance with procedures reviewed by the Resident Engineer.
- I. Shipped segments shall be in units of complete rings, all properly identified.

PART 2 PRODUCTS

2.01 GENERAL

- A. The segments and components shall resist decomposition from sulfates, chlorides and contaminated materials described in the Environmental Finding Report Summary.
- B. Materials and products shall be fire retardant and shall not give off toxic fumes in the event of fire.

2.02 CONCRETE

- A. Cement shall be Type II and shall conform to the requirements of ASTM C 150.
- B. Concrete compressive strength shall be 6,000-psi minimum at 28 days as determined by ASTM C 39.
- C. Maximum Water/(Cement+Ash) Ratio: 0.38. An accepted superplasticizer may be incorporated into the mix to ensure that the minimum possible water/cement ratio consistent with Contractor's workability requirements is achieved.
- E. Silica Fume: 5- to 7-percent of total cementitious material content
- F. Fly Ash: Maximum 25-percent of total cementitious material content. Fly ash shall conform to the requirements of ASTM C 618, Class F. Sulfur Trioxide (SO₃) content shall not exceed 4-percent. The loss on ignition shall not exceed five-percent. Fly ash shall not be used with blast furnace slag.
- G. Water Permeability (40 Days): 100×10^{-15} -fps maximum
- H. Chloride Ion Penetrability: Average 700-coulombs charge or less and in no case shall exceed 1,000-coulombs, as determined by ASTM C 1202
- I. Air Entrainment: Minimum percentage required to meet freeze-thaw test per ASTM C 666.

- J. Aggregates:
 - 1. 1/2- to 3/4-inch, conforming to ASTM C 33 and shall consist of natural sand, gravel, crushed gravel or crushed rock. Aggregates shall not contain a total mass of reactive alkali greater than 5-pounds per cubic yard or any other matter likely to affect the long-term durability of the concrete.
 - 2. Water absorption shall not exceed 2-percent.
- K. Admixtures containing chlorides, nitrates or other corrosive agents shall not be used.
- L. Only 100-percent virgin polypropylene monofilament fiber containing no reprocessed materials shall be used.
- M. The dosage of polypropylene fiber shall be between 2.6- and 3.5-pounds of 0.5-inch long 6-denier fiber per cubic yard of concrete.
- N. Water used for mixing concrete shall be potable fresh water.

2.03 REINFORCING STEEL

- A. Reinforcing steel shall conform to the requirements of Section 03200, with the following additions:
 - 1. Bars: ASTM A 615, Grade 60, deformed bars.
 - 2. All spacers shall be concrete from the same concrete mix design as the segments, and compacted and cured to the same standards as the segments. Plastic and metal spacers are not to be used.
 - 3. All reinforcement shall be cold bent. Rebending or heating shall not be permitted.
 - 4. Cages shall fully tied or welded.
 - 5. Tying wire shall be 1/16-inch diameter soft annealed mild steel, and when fixed shall not project into the concrete cover.

2.04 INSERTS, ANCHORS, BOLTS, DOWELS, AND ACCESSORIES

- A. Inserts and anchors shall be ASTM A 36 steel, zinc coated (hot-dip galvanized) in accordance with ASTM A 123. Nuts shall be ASTM A 563, hot-dipped galvanized. Washers shall be ASTM F 436, hot-dipped galvanized. Bolts shall be ASTM A 307, hot-dip galvanized.
- B. Bolts: Required pullout capacity shall be determined by calculation, sufficient to resist gasket forces in a fully closed radial joint with fully tightened bolts after erector arm is disengaged. Stiffness shall be as determined by calculation to maintain sufficient gasket compression to meet specified gasket requirements.

C. Dowels:

1. Performance:

- a. Pullout Capacity; as required by calculation to resist gasket forces in a completed segmental ring, initially with full joint closure. Assuming all TBM jacks have been retracted.
- b. Shear Capacity; as required for segment erection forces.
- c. Design Life: 120-years.

2. Geometry:

- a. Diameter; greater than 2-inches.
- b. Overall Length; greater than 7-inches.

D. Grommets will not be permitted.

E. Grout Holes:

1. One grout hole shall be provided in each tunnel lining segment at the location indicated on the Contract Drawings, which may also be utilized for segment handling/lifting. These grout holes shall terminate short of the outer surface of the segment and shall be used in the event of temporary malfunction of tail shield grouting system and for secondary backfill and check grouting in accordance with Section 03605.
2. Each grout hole shall include a threaded socket cast into the segment and a threaded grout plug with hydrophilic washer. The washer shall be included irrespective of whether the hole is used by Contractor for grouting. The socket shall be arranged such that the grout plug in its final position does not protrude into the tunnel beyond the inner surface of the segment. The head of the plug shall incorporate suitable means by which it can be tightened and removed, but shall be of a design that it will not trap water when inserted below axis level. The design of the socket, plug, washer, and any ancillary materials such as grease or other coating to the threads shall be to the acceptance of the Resident Engineer. The assembly shall be capable of withstanding the groundwater pressure and any additional pressures caused by grouting without leakage and have a design life of not less than 120 years.
3. The clear distance between the grout socket or hole and the reinforcing bars in the segments shall be not less than the specified concrete cover to the reinforcement.

F. Segment Identification

1. The following minimum information shall be incorporated on a bar code fixed permanently to the circumferential joint face of each segment. The bar code shall be located on a non-bearing surface on the leading edge of each segment and flush with the concrete surface.

- a. Concrete specification.
 - b. Ring type.
 - c. Segment type.
 - d. Manufacturer's name or initials.
 - e. Date of production.
 - f. Serial number; Resident Engineer will designate series.
 - g. Mold number.
2. Each segment shall also be identified on the inside surface of the liner segment. The following information shall be identified:
 - a. Segment type designation with match marks, as indicated on Contract Drawings.
 - b. Drilling locator dimples shall be provided to identify locations of no reinforcing steel, where holes may be drilled into the lining for temporary or permanent attachment of tunnel services or concrete dowels. Three circular rows of dimples shall be provided around every segmental ring, with a dimple every 7.5 degrees, except where reinforcement is present. Except within 12-inches of radial joints, reinforcing bars shall be located to remain clear of drilling locator dimples. The highest row of dimples shall be offset 3.75 degrees from the tunnel centerline.
 3. The materials and system for bar coding shall be to the acceptance of the Resident Engineer and shall not result in any material that may be deleterious to the long -term durability of the segment.
 4. Supply and maintain a bar code reader for the Resident Engineer's use for the duration of the Contract.

2.05 GASKETS

- A. All segments shall be provided with a water sealing system consisting of an elastomeric gasket on all mating faces. Gaskets fabricated from hydrophilic material will not be accepted.
- B. The elastomeric gasket material shall be an EPDM (Ethylene Propylene Diene Monomer), manufactured by Phoenix, Dätwyler, Trelleborg (Heinke) or approved equal, formulated to provide good retention of elasticity and low stress relaxation properties, which shall be free from blisters, porosity, pittings, inclusions or flow marks and other manufacturer's defects, manufactured as a continuous frame (loop) with fully molded, mitered gasket corners to the appropriate corner angles of segments, and vulcanized to provide uniform gasket thickness along entire length of mating surface. Each segment type shall have a gasket frame specifically designed for the dimensions and geometry of the segment. Each gasket shall be lightly tensioned to ensure that it grips the segment and fits snugly into the gasket grove.

- C. The fitted gaskets shall be designed to initially resist a minimum water pressure of 140-psi above atmospheric, at maximum permissible joint gaps and offsets.
- D. The gaskets shall be approximately 2-inches wide.
- E. Test of Material Properties of fabricated gasket shall meet the following minimum requirements:
 - 1. Tensile Strength: ASTM D 412, greater than 1,500-psi
 - 2. Elongation: ASTM D 412, greater than 300-percent
 - 3. Hardness: ASTM D 2240, Durometer A; 65 plus or minus 5
 - 4. Compression Set: ASTM D 395; Method B:
 - a. Short Term Test: Less than 15-percent compression set after 25-percent initial vertical compression at 70-degrees Centigrade for 22 hours.
 - b. Long Term Test: Less than 25-percent compression set after 25-percent initial vertical compression at 23-degrees Centigrade (room temperature) for 70 hours.
 - 5. Not Used
 - 6. Aging: ASTM D 573, 70 hours at 100-degrees Centigrade. Limit changes in material properties as follows:
 - a. Tensile Strength: Less than 10-percent decrease.
 - b. Elongation: Less than 15-percent decrease.
 - c. Hardness: Less than six units increase
 - 7. Water Absorption: ASTM D 471, 48 hours at 70-degrees Centigrade, maximum 10-percent increase by weight. Use distilled water for the standard test.
 - 8. Oil Absorption: ASTM D 471, 70 hours at 70-degrees Centigrade, Oil No. 3, maximum change in weight 110-percent.
 - 9. Ozone Resistance: ASTM D 1149, by method described in ASTM D 518 Procedure A, with the following stipulation: No surface cracking of un-tensioned specimen (zero-percent elongation) when immersed in a 200-parts per 100,000,000, ozone solution for 100 hours at room temperature and 55-percent humidity.

10. Stress Relaxation:

- a. For material sample tested at room temperature and 40-percent vertical deflection, with two minute measured stress set equal to 100-percent, residual stress shall be greater than 85-percent after 14 continuous days of testing.
- b. Show by long-term test, accelerated tests or both, that residual contact stress after 120 years is greater than 60-percent of the measured stress after 15 minutes at 40-percent vertical deformation at room temperature. After 120 years, the remaining stress shall be more than 50-percent of that originally applied.

F. Performance:

1. Gasket Groove Loads: Demonstrate through a combination of engineering analysis and laboratory experiments that gasket will be watertight and will not exert a load that may damage the concrete gasket groove of concrete tunnel liner under any combination of manufacturing and installation tolerances.
2. Groove Casting Quality: Gasket grooves must be checked and shall be fully formed; there shall be no cracks and chipping damage. The groove corners shall have no flaws or porous zones. Only individual occurring pores up to 1/32-inch diameter and 1/32-inch depth are permissible in the groove zone. Edges and corners shall be repaired and pores must be properly filled in accordance with the reviewed Work Plan.
3. Gasket Groove Design: Design gasket grooves for selected gaskets. Design shall account for compressed packers in circumferential joints and no packers in radial joints to prevent over-compression of gaskets and to create approximately uniform gasket compression. Gasket groove shall be smooth, and free of spalls, fractures, and imperfections.
4. Watertightness: Demonstrate by laboratory testing that watertight seals can be provided even when complete closure of concrete tunnel liner segments is not possible because of manufacturing and installation tolerances. Tests will be witnessed by the Resident Engineer. The gasket-mounting surfaces of the test rig platens shall be fabricated or finished in cement mortar and shall incorporate grooves of the same dimensions as those on the lining segments. Provide 1/8-inch plywood packers between cement mortar bearing surfaces, as shown in the Contract Drawings. The gaskets shall be installed in the same manner as those on the lining segments using similar adhesives and installation procedures. A straight joint and a 'T' joint shall be tested such that it can accurately simulate the combination of gaps and offsets defined herein. The gap between the faces of the test pieces, representing gaps in the joints of the tunnel lining, shall be 0.2-inch greater than the theoretical value calculated from the shape of the joint surfaces and from the thickness of any packing which is to be used. The tests shall be performed with a lateral offset of 0.4-inch at the groove in the following configurations:
 - c. Straight joint: one side offset

- d. 'T' joint: one corner side of intersecting joint offset
- c. Resist water pressure of at least 95-psi above atmospheric in these configurations for four continuous weeks, without visible signs of leakage.
- 5. Gasket material shall not suffer any adverse effects when exposed to groundwater at pressures up to 70-psi gauge.
- 6. Chemical Resistance: The gasket shall be resistant to Work Site-specific concentrations of compounds in the ground and groundwater as stated in the Environmental Finding Report Summary. The gasket shall be resistant to alkalinity of the tunnel lining concrete and tunnel grout.
- 7. Future Performance: Demonstrate by combination of engineering analysis and measured performance of gaskets that the installed gasket is expected to perform its intended function over a design life of 120-years.
- G. Gasket Adhesive: As recommended by gasket manufacturer to secure gasket to groove. Apply adhesive to groove in accordance with the gasket manufacturer's recommendations.
- H. The selected gasket shall have a proven reputation for satisfactory performance in tunnels with similar groundwater pressure.

2.06 COMPRESSION PACKING

- A. Marine Grade Plywood, NIST PS-1, Grade A-A, compression joint packers shall be provided as shown on the Contract Drawings. The compression packing shall extend no closer than 1/4-inch from inside edge of gasket groove and fully compress against abutting segments.

2.08 MOLDS/FORMWORK

- A. Molds shall be fully fabricated from machined steel and shall be of strong and rigid construction, with smooth machined steel mating surfaces to provide true and sound concrete surfaces to the dimensions and tolerances indicated.
- B. All inserts used to form bolt pockets, bolt holes, grout holes etc., shall be made of steel or accepted material with a coefficient of thermal expansion similar to that of concrete.

PART 3 EXECUTION**3.01 GENERAL**

- A. Maintain full responsibility for the safety of the Work as related to the production, transportation, storage, erection, and repair of the tunnel segmental lining.
- B. Install tunnel liner continuously with tunnel excavation in accordance with Sections 02406 and 03605.
- C. Coordinate tunnel excavation and installation of lining in accordance with:
 - 1. Tunnel liner ring installation construction tolerances as specified herein.
 - 2. Additional requirements as may be required by Contractor's means and methods for performing tunnel excavation, installation of lining and ancillary work.

3.02 WORKMANSHIP

- G. Install fully tightened bolts in every bolthole and fully compress dowels in every dowel hole.
- H. Grout Holes:
 - 1. At the time that the lining is erected each grout plug shall be fully screwed into place. When the grout plug is in place, no water or grout shall seep into the tunnel from around the outside of the socket, from between the grout plug and the socket or through the grout plug.
 - 2. When a grout hole is used for grouting it shall be extended through to the exterior surface of the segment by drilling in a manner that does not cause damage to the concrete beyond the intended diameter of the hole. The diameter of the drilled hole and the means of drilling shall be subject to the acceptance of the Resident Engineer.
 - 3. Upon completion of the Contract, leave each grout hole in a condition in which the grout plug can be removed without damage to it or any part of the socket or the tunnel lining segments, the grout hole can be drilled out, grouting can be carried out and the grout plug replaced such that all leaks are sealed.

3.03 MOLDS/FORMWORK

- A. Clean and coat forms with non-staining release agent before each reuse.
- B. Ensure smooth surfaces for application of adhesive in accordance with manufacturer's of both segments and adhesive.
- C. Accurately place reinforcing steel with tolerances in accordance with Section 03200. Cages shall be sufficiently rigid to prevent deformation during manufacturing process.

3.04 CASTING PREPARATION

- A. Fix concrete spacers so that the reinforcement is held firmly in the correct position within the mold with all the cover as specified and with the spacers rigidly fixed to the reinforcement to prevent displacement. If the spacers are wired on, the end of the wires are turned into the unit.
- B. Do not use spacers in the circumferential or radial joint regions. The joint regions are the areas up to a distance of 4-inches from the joint surface.
- C. Saturate all spacers with clean water prior to use. Spacers shall not be allowed to dry out after being fixed to reinforcement cages before the concrete is cast.
- D. Securely anchor inserts and embedded items to mold.

3.05 SEGMENT CASTING

- A. Segment production and quality control shall meet the requirements of Precast/Prestressed Concrete Institute MNL 116.
- B. Produce segments under controlled plant conditions with production areas protected against rain, dust, and direct sunlight. Protect all concrete from hot and cold weather and rapid temperature changes at all times during productions.
- C. Consolidating: ACI 309. Consolidate concrete into complete contact with forms and embedded items. Consolidate concrete adjacent to side forms and along the entire length of forms to ensure a smooth surface finish after stripping of formwork.
- D. Surface Finishes:
 - 1. Formed Surfaces: Smooth form finish. Ensure that the maximum local irregularity on formed surfaces does not exceed a rounded protrusion of 1/64-inch above the general concrete surface form.
 - 2. Extrados: Finish segments by steel float with only the minimum of surface working being employed, consistent with the requirement to achieve a smooth level uniform surface and free from blemishes. The local maximum irregularity shall be a rounded protrusion of 1/16-inch above the general surface.
- E. Keep a record of all the units cast in each mold. Withdraw from service any mold that becomes distorted or that casts faulty units until it is proved to be corrected to the satisfaction of the Resident Engineer.
- F. Check reinforcement cages and other embedments within each mold.
- G. Test to determine the in-place strength of concrete prior to lifting and for proving the attainment of design strength.
- H. Verify that the segments have attained the design strength prior to shipping through a combination of in-place strength testing and comparison with strength gain-maturity curves. Verify results with cylinder tests from concrete cured with segments.

- I. Verify that the segments are delivered to the Work Site in an undamaged condition.
- J. Replacement Segments: Sufficient number of segments shall be cast to replace without delay loss by damage or other causes.

3.06 SEGMENT CURING

- A. All precast concrete segments shall be cured using moist curing, curing compounds or curing at elevated temperatures, or a combination of these systems. Curing shall be undertaken in accordance with the detailed Work Plan reviewed by the Resident Engineer.
- B. Moist Curing:
 - 1. Where moist curing is used all exposed concrete surfaces shall be covered with absorptive mats of fabric kept thoroughly wet throughout the process. Alternatively a fog/mist spray may be used or waterproof sheet materials conforming to ASTM C 171 laid in contact with the wet concrete. Other proposals may be made by Contractor for the review of the Resident Engineer but the adopted method shall keep the surface of the concrete continuously moist until cured.
 - 2. Moist curing shall be accomplished in such a way that excess water shall be available to the concrete throughout the curing process. It shall be carried out in an enclosed environment that protects the segments from the drying effect of wind and sun.
 - 3. Segments shall be moist cured in accordance with the requirements of Article 3.05A, but for no less than five days after casting.
- C. Curing Compounds: Where used, curing compounds shall be applied only and immediately after demolding the segment and shall meet the requirements of ASTM C 156. Moist curing shall be continued until the first coat of curing compound is applied to all surfaces.
- D. Low Pressure Steam Curing: Steam curing at atmospheric pressure shall be in accordance with ACI 517, and meet the following additional requirements:
 - 1. Where used, segments shall be steam cured while in molds. Immediately after segments have been cast, place molds in a sealed, vapor-tight enclosure to prevent escape of moisture and heat, but large enough to allow complete circulation of steam.
 - 2. Protect the segments from thermal shock. Utilize blankets/covers to minimize thermal shock. Provide sufficient steam jets or steam-entry points to ensure that a substantially uniform temperature is maintained under steam blankets/covers, such that the difference in air/steam temperature between any two points adjacent to the concrete mass is not more than 18-degrees Fahrenheit. Trials of full sized segments shall be conducted with suitable instrumentation to demonstrate conformance with the temperature gradients specified herein.

3. Under no circumstances during steam curing shall steam jets be allowed to impinge upon any part of the concrete mass or of a test specimen or of their formwork or molds nor shall any steam delivery pipe be attached directly to any formwork or molds in such a manner as may cause localized overheating of the concrete.
 4. Steam blankets/covers shall be placed over the concrete mass immediately following concrete finishing operations to prevent the segment from drying out. The concrete shall remain undisturbed and shall not be exposed to steam until it has reached a minimum initial stiffness of 75-psi penetration resistance. During this period, the temperature at the surface of the concrete mass shall not exceed 100-degrees Fahrenheit. All concrete shall have an initial maturity of one hour before steam may be admitted to the steam blankets/covers except that, where necessary, a small amount of steam may be used to maintain the concrete at the temperature at which it was placed.
 5. Enclosure Ambient Temperature: Do not exceed 100-degrees Fahrenheit for first two hours of curing; then maintain temperature between 90- and 150-degrees Fahrenheit until curing strength is achieved, which shall be demonstrated to the satisfaction of the Resident Engineer.
 6. When required strength is attained, allow segments to cool slowly, do not allow rate of temperature change to exceed 30-degrees Fahrenheit per hour. The temperature of the curing system shall not exceed 150-degrees Fahrenheit.
 7. Following steam cure, moist-cure segments for five days after casing. Curing compound is not permitted in lieu of moist-curing.
- E. Demolding: Segments shall not be demolded until the concrete has achieved sufficient strength to prevent damage to the segment, as determined by Contractor. The Resident Engineer reserves the right to require increased compressive strength before segments are demolded if there is any evidence of distortion, cracking, spalling or similar damage that could have occurred during handling and storage of segments that were of insufficient strength.

3.08 CONCRETE TESTING

- A. Test concrete in accordance with Section 03300, with the following additional requirements:
1. Before start of segment production, establish concrete mix that will produce concrete of specified compressive strength.
 2. After acceptance of the initial mix design has been obtained, make six cylinders from a single batch of concrete. Mix shall incorporate specified dosage of polypropylene fibers.
 3. Obtain prior acceptance from the Resident Engineer for change in mix design during manufacture of segments.

4. Prepare cylinders before start of manufacture. Cylinders shall be cured exactly the same as the proposed methods for the segments and shall be removed in pairs at appropriate time intervals during curing, and tested immediately upon removal to establish correct curing duration.
5. For cylinders prepared because of change in mix design:
 - a. Follow same procedures specified for cylinders prepared before start of manufacture.
 - b. Obtain acceptance of test results from the Resident Engineer before manufacture of segments using a new or modified mix design.
6. Production Test Cylinders
 - a. Test cylinders in accordance with Section 03300, and as specified herein.
 - b. Prepare three cylinders and cure as specified for each work shift or for every 150-cubic yards of concrete used, whichever is more frequent.
 - c. Test cylinders for compressive strength as follows: one cylinder after 7 days and the remaining cylinders after 28 days.
 - d. At weekly intervals during segment manufacture, prepare two cylinders from same concrete batch and cure in same manner as segments; demonstrate minimum strength for form removal is being attained before such removal occurs. If average strength of two cylinders is less than required, cure related tunnel liner segments for a longer time, as reviewed; demonstrate minimum cured strength is met.

3.09 REPAIR OF DEFECTS

- A. Repair or replace damaged and misaligned segments or any component of the lining system.
- B. Damaged segments shall be repaired in accordance with ACI requirements to maintain the structural integrity, durability, and watertightness of the segmental lining system.
- C. Segments that show excessive crazing, voids, change, or defects will be investigated by Contractor and the Resident Engineer to determine the cause. Segregate and identify segments accepted for repair as to the class of defect(s).
- D. Major damage or irregularities to a concrete segment, which impair structural integrity or performance, will be cause for rejection of a segment.
- E. All projecting fins of hardened grout that may occur at the joints between the sides and base of the mold shall be removed by grinding.

- F. Damage occurring to segments at any stage prior to erection shall be repaired in accordance with the reviewed Contractor's Work Plan. Repair shall be completed sufficiently early to allow time for repair agents to cure fully prior to taking the segment into the tunnel.
- G. Care shall be taken to ensure good color match with the segment concrete.
- H. All repairs shall be recorded and reported to the Resident Engineer.

3.10 INSTALLATION OF GASKETS

- A. Prior to installation, gaskets shall be stored under cover in a dry storage area in an undeformed, relaxed condition at moderate temperatures and protected from direct sunlight. They shall be protected from circulating air and shall not be stored near equipment that can generate ozone (such as electric motors). The gaskets shall be kept clean, particularly avoiding contact with metals, solvents, oil, and grease.
- B. State in the Work Plan the type of wrapping and containers proposed for gaskets and the conditions under which they will be stored. All containers shall be marked with the date of production and gaskets shall be used in the order received to minimize storage times.
- C. Use gasket adhesive as recommended by gasket manufacturer.
- D. Place gasket into groove provided around segments in accordance with manufacturer's recommendations and reviewed Contractor's Work Plan.
- E. Fitting of the gasket frame shall commence at the radial joint surface by neatly pressing the gasket into the groove by hand. The circumferential joint surfaces shall then be fitted starting from the middle and working towards the two corners on each face. Care shall be taken to ensure that the gasket frame is accurately located and that the corners are neither distorted nor loose. The gasket frame may be lightly hammered into position using a rubber hammer and shall then be pressed onto the surface for a minimum period of five minutes until the adhesive has hardened.
- F. Each completed segment shall be inspected for correct seating of the gasket frame and uniform adhesion prior to storage. If segments have not been installed in the tunnel within six months of applying gasket frames, segments shall be protected from precipitation and sunlight. The gasket frame shall be re-inspected prior to the segment installation within the tunnel.

3.11 ERECTION/INSTALLATION OF TUNNEL LINING

- A. Use only methods of lining erection which have been certified in writing by both the TBM and the segment manufacturer and which have been reviewed by the Resident Engineer.
- B. Refer to Sections 02406, 02413, and 03605 for additional requirements for installation and erection of the lining.
- C. Inspect concrete segments, joint connection assemblies, joint packings and gaskets before being taken underground and just before erection. Bring

- imperfections and damage to attention of the Resident Engineer; repair or replace as required.
- D. Apply compression packings before tunnel lining installation.
 - E. The segmental lining shall be erected to the correct line and grade, in true circular form to preserve the circular form of tunnel.
 - F. Determine the sequence and rotation of each ring that shall form the tunnel lining, which shall be established after each excavation cycle and prior to erection of the next ring.
 - G. Provide bedding if required to prevent ring from dropping or deflecting after it has left ring assembly area. Provide blocking or other means to properly hold and center the ring in the design location.
 - H. Install segmental tunnel lining system to dimensions and tolerances for line, grade and circularity indicated on the Contract Drawings and specified herein; for joint and structural performance.
 - I. Segment positions shall be maintained by the TBM thrust jacks during erection and after completion of the ring build.
 - J. After the excavation cycle is complete, the thrust jacks shall be left locked onto the previously built ring. Only enough thrust jacks will be removed to allow the installation of one segment at any one time.
 - K. Keep invert in the ring assembly area clean and free of soil and water before erection of each ring. Satisfactorily clean joint surfaces of previously installed segments and new segments immediately before erection.
 - L. Each time a segment is placed, any correction required because of the tunnel alignment and build checks, shall be carried out before the segment bolts are tightened and the thrust jacks put back onto the segments. Segment bolts and thrust jacks shall be used to provide compression of the gaskets and compression packing and maintain optimum joint closure tolerances during erection of subsequent rings.
 - M. The bolts in the lining shall be permanent and shall be tightened to the fullest extent necessary to ensure the lining structure functions as designed, with proper contact between faces of gaskets. Retighten all of the lining bolts on a ring after erection.
 - N. Radial joints in adjacent rings shall be staggered so that there are no continuous joints.
 - O. Tapered rings shall be used to negotiate horizontal and vertical curves and to correct for line and level. Shims, packing of variable thickness or more than one packing material shall not be used for this purpose.
 - P. Do not apply loads or eccentricities to segments or gaskets that are detrimental to lining system during erection sequence (including thrust jacks, segment erector and ring reformer).

- Q. At all times during the ring building process, great care shall be taken to avoid causing damage to the tunnel segments, and gaskets. After the completion of the building process, the integrity of every ring and all gaskets must be checked before the next advance begins.
- R. Replace segments that are damaged during the first 12-inches of shove.
- S. Should any new cracks or concrete defects occur in the erected tunnel lining, or an existing crack or defect becomes enlarged, then TBM operation shall be immediately suspended and the following reviewed with the Resident Engineer:
 - 1. Grout records.
 - 2. Jack thrust records and jack selection.
 - 3. TBM operational parameters, and changes if required to the acceptance of the Resident Engineer.
- T. Hangers for utility lines necessary for construction of tunnel may be connected to concrete segments, which shall not interfere with proper erection of each ring. Cast holes or embedded anchorages may be used as reviewed by the Resident Engineer. Holes may only be drilled in non-reinforced zones, identified by drilling locator dimples. Drilling in all other areas shall require prior acceptance by the Resident Engineer. Maximum depth of drilled holes shall not exceed 4-inches.
- U. Each installed ring shall be uniquely identified using a consecutive numbering system. Every fifth ring shall have its identification number marked using 6-inch high stenciled numerals near its leading edge at springline.
- V. Backfill Grouting: Grouting of segmental lining shall be in accordance with Sections 02406 and 03605.

3.12 FINISHING OF INSTALLED TUNNEL LINING

- A. Temporary Holes Drilled into the Lining: Clean and fill with mortar after final tunnel grouting. Trowel mortar into place and pack to produce a dense mortar.
- B. Cast bolt pockets and grout holes shall not be filled with mortar. Leave cast grout holes in a condition as specified herein.
- C. Upon completion of the Work, clean tunnels to remove any water, debris, and sediment.

3.13 WATERTIGHTNESS

- A. Completed Tunnels: Watertightness as specified in Section 02406.

APPENDIX A

CONCRETE MIX DESIGN SUBMITTAL

PROJECT

DATE

1. Trial Mix Designed by:

2. Specified Strength (f'c):

3. Concrete Supplier:

4. Materials (by Brand):

a. Cement:

b. Fine Aggregate:

c. Coarse Aggregate:

d. Admixtures:

1) Air Entrainment
Agent:

2) Water Reducer

3) High Range
Water Reducer:

4) Water Reducing
Set Retarding

5) Pozzolan

a) Fly Ash

b) Silica
Fume

6) Others (if any)

5. Gradations:

	Fine Aggregate (Percent)	Coarse Aggregate (Percent)
1"		
3/4"		
3/8"		
No. 4		
No. 8		
No. 16		
No. 30		
No. 50		
No. 100		
Fineness Modulus		
Specific Gravity		

6. Batch Weights per Cubic Yard Trial Mixes:

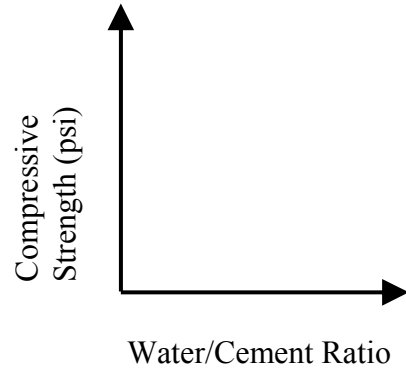
	#1	#2	#3	#4
Cement, lbs.				
Sand, lbs.				
Stone, lbs.				
Total Water, Gals.				
Admix. Air Entrainment, lbs.				
Admix. Water Reducer, lbs.				
Air Content, %				
Initial Slump, in.				
Final Slump, in.				
Unit Weight, pcf				
W/C Ratio, lbs/lbs				

7. Compressive Strengths Trial Mixes:

	#1	#2	#3	#4
7-Days:				
• Psi				
• Average				
28-Days				
• Psi				
-				
-				
• Average				

Recommended Mix #_ for f'_c plus 25-percent

8. Chloride Ion Penetrability Tests Results: as determined by ASTM C 1202.
9. Graph:



APPENDIX B

PROJECT _____

MIX# _____

Number of Test Cylinders
Evaluated _____

Standard Deviation (S) _____

F'cr (required average
Compressive strength in psi) = $f'_c + 1.34S$
or = $f'_c + 2.33S - 500$
whichever is larger

Refer to ACI 301 for increased deviation factor when fewer than 30 tests are available.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing, installing, and maintaining geotechnical and structural instrumentation (surface, in-ground, tunnels, caverns, and existing structures); protecting instrumentation from damage; monitoring instruments inside new tunnels under construction; removing instruments, and interpreting Contractor's Data and monitoring data provided by the Resident Engineer. It also includes additional instrumentation and data collection that Contractor deems necessary to ensure the safety of personnel and the Work. Contractor shall implement required remedial and precautionary measures based on the instrumentation data.
- B. Definitions:
1. "Acceptance Reading": Post-installation reading performed for each completed instrument by Contractor to confirm that the instrument is functional.
 2. "Additional Contractor's Data": Data resulting from Contractor's monitoring of any instrument external to new tunnels under construction, including those installed by Contractor in addition to those specified herein.
 3. "Alert Level": The second and greater instrument reading that stops the construction and necessitates mitigative action to halt settlement and avoid damage to existing structures.
 4. "Baseline Reading": The reading that is based on a series of formal initial readings and agreed to by the Resident Engineer as being the one with which all subsequent readings shall be compared to determine levels of change.
 4. "Central Data Storage" (CDS) Unit: Data storage and handling unit purchased, operated, and maintained by the Resident Engineer.
 5. "Datalogger": Data collection unit to collect, pre-evaluate, and transfer data readings from various instruments. The datalogger transfers this data to an intermediate data storage (IDS) unit via direct connection (short-haul modem) or telephone modem.
 6. "Facility": An existing building, roadway, railroad, element of a utility system, or structure other than a new tunnel or related ancillary structure to be built under this Contract.
 7. "Formal Initial Reading": The reading that is closest to the average of three readings taken soon after the installed instrument is confirmed to be functional. These readings shall be taken over a period of one month and shall be used to establish the baseline readings with the Resident Engineer.
 8. "Intermediate Data Storage (IDS) Unit": Data storage unit that receives data from datalogger and transfers it to the CDS.
 9. "Response Levels": Comprised of "Alert Levels" and "Review Levels".

10. “Review Level”: The first and lowest instrument reading that will trigger the implementation of mitigative action to avoid damage to existing structures.
 11. “Verification Reading”: Reading occasionally taken by Resident Engineer on in-tunnel instruments being monitored by Contractor to ensure continuing agreement with accuracy of data.
- C. Purposes of the Geotechnical and Structural Instrumentation Program include but are not limited to providing:
1. Pre-construction baseline data for comparison with construction and post-construction data.
 2. Monitoring of movements of ground, groundwater level, and facilities during and after construction, to determine whether they have been affected by construction activities.
 3. A forewarning of unforeseen conditions and trigger actions required when “Review Level” and/or “Alert Level” have been reached.
- D. The MTA is not responsible for the safety of the Work based on geotechnical or structural instrumentation data.
- E. Responsibilities of Contractor:
1. Furnish components of instrumentation that are to be installed during construction as specified herein.
 2. Furnish portable readout units for the Resident Engineer's use as specified herein.
 3. Install instruments and the automated data acquisition systems including dataloggers and IDSs required to monitor them. Coordinate with the Resident Engineer to configure the automated data acquisition systems to monitor the instruments on the schedules indicated herein.
 4. Protect from damage and maintain instruments installed by Contractor, and existing instruments installed by others. Repair or replace damaged or inoperative instruments.
 5. In addition to the data provided by the Resident Engineer, interpret the following that Contractor deems necessary to ensure the safety of personnel and the work: supplementary data that Contractor chooses to collect from Contract instruments; and data from instruments additional to Contract instruments that Contractor chooses to install and monitor.
 6. Provide to the Resident Engineer safe access to any part of the Work for data collection.
 7. Implement response actions from all CM009 instruments including those installed by others.

8. Carry out Acceptance Readings after instrument installation of each instrument as soon as practicable, as soon as any encasing grout has reached its final set. Acceptance Readings are not required for tunnel deformation monitoring instruments in new tunnels under construction.
9. Obtained baseline readings for all installed instruments and confirmed such readings with the Resident Engineer. Submit these readings.
10. The Liquid Level Survey System (LLSS) Specialist shall assist in the preparation of the submittals specified elsewhere herein, and shall supervise all tasks specified elsewhere herein.
11. The Automated Motorized Total Station (AMTS) Specialist shall assist in the preparation of submittals specified elsewhere herein, and shall supervise tasks specified elsewhere herein.
12. Contractor shall provide on-site training sessions for the Resident Engineer on the operation of the automated data acquisition systems after they are installed and fully operational.
13. The Contract Drawings show conceptual layout of the proposed liquid level survey system (LLSS), automated motorized total station (AMTS), and dynamic strain gauge (DSG) monitoring systems. Upon inspection of NYCT subway tunnels, and surface area above alignments, Contractor shall finalize the layout and design, and develop details of support and installation of each system including determination of the number and locations of required AMTS theodolites. Contractor shall submit the detailed design along with reliable and maintainable cables, power and communications to the Resident Engineer for review, including conduit for lines where it is required by code. The Resident Engineer, in coordination with NYCT will provide necessary input to Contractor for finalization of the design and installation details.
14. Contractor shall coordinate with the Resident Engineer to engage the NYCT Force Account personnel in arranging telephone lines for modems and electrical power for dataloggers and intermediate data storage units. Contractor shall also ensure continuous back-up electrical power (batteries, etc.) in case of failure of the primary systems, which fall within Contractor's area of responsibility.
15. Contractor shall be responsible for cable installations, telephone charges, and with the exception of those specified elsewhere herein, telephone line installations.
16. Contractor may explore wireless methods of signal transmission. Methods shall satisfy all requirements for data transmission as specified elsewhere herein. Contractor shall take into account the possibility of cellphone shutdown in NYCT tunnels and cellphone failure elsewhere, and provide systems or procedures to ensure that signals are not interrupted.
17. Groundwater level and tunneling deformation monitoring.

- F. Monitoring Role of Resident Engineer: The Resident Engineer will baseline the noise and vibration levels. The Resident Engineer will also confirm baseline readings for other instruments collected by Contractor, and upon acceptance of the fully functional instrumentation, continue to monitor and take readings (except groundwater level and deformation of the new tunnel) from the instrumentation and immediately inform Contractor if any response levels are exceeded, however, this shall not relieve Contractor of responsibility for the safety of the works.

1.02 REFERENCED SECTIONS

- A. Section 01160 - Work Affecting the Railroad
- B. Section 01572 - Construction Noise and Vibration Control
- C. Section 01720 - Surveying and Layout
- D. Section 02414 - Controlled Blasting

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. C 778 - Standard Sand
- B. Deutsches Institut für Normung (DIN):
 - 1. 18723 - Field Procedure for Precision Testing of Surveying Instruments
- C. International Society of Explosives Engineers (ISEE) Guidelines and Practices for Blasting Seismographs
- D. National Geodetic Survey (NGS)
- E. National Institute of Standards and Technology (NIST)

1.04 NOTED RESTRICTIONS

- A. Contractor shall coordinate access to public and private facilities for installation of instrumentation through the Resident Engineer. MTA will be responsible for obtaining permission from abutters to install instruments on or in their facilities.
- B. If Contractor chooses to use radio or cellphone data transmission systems, they shall be designed to avoid interference with the communications and signal systems of NYCT. Such data transmission systems shall be designed to ensure against interruptions in the flow of data if NYCT shuts down cellphone service in their facilities, or if cellphone service is interrupted in any part of the Contract area for any reason.

1.05 QUALITY CONTROL

- A. A factory calibration shall be conducted on all instruments before shipment. Certification shall be provided to indicate that the test equipment used for this purpose is calibrated and maintained in accordance with the test equipment manufacturer's calibration requirements and that, where applicable, calibrations are traceable to the NIST.
- B. Contractor shall provide the manufacturer's warranty for each unit of equipment furnished by Contractor.
- C. Qualifications of Contractor's Instrumentation Personnel:
 - 1. Contractor's instrumentation personnel who are responsible for furnishing and installing all geotechnical and structural instrumentation, maintaining instrumentation, as required, and interpreting data shall have the qualifications specified herein. These personnel may be employed by Contractor or may be employed by a specialist instrumentation subcontractor/consultant.
 - 2. Contractor's instrumentation personnel shall include a qualified Geotechnical Instrumentation Engineer (GIE) who is a Professional Engineer registered in the State of New York, who has a minimum of a Bachelor of Science degree in Civil Engineering, and who has at least one year of experience (or as approved by the Resident Engineer) in the logging of rock core and six years of experience (or as approved by the Resident Engineer) in installation and monitoring of the types of instruments specified herein and in interpreting instrumentation data. An Engineering Geologist at the same experience level is also acceptable as the Geotechnical Instrumentation Engineer. The Geotechnical Instrumentation Engineer shall:
 - a. Prepare detailed step-by-step procedures and schedule with bar charts for the installation of all instruments specified herein.
 - b. Be on-site to inspect and log the rock core from the first five boreholes where in-ground instruments are to be installed and provide training to Contractor personnel to ensure that all subsequent boreholes are logged to include core recovery percentages, RQDs, and descriptions and strata nomenclature based on profiles and boring logs contained in the Geotechnical Data Report.
 - c. Be on-site, supervise, and conduct the pre-installation and post-installation acceptance tests of each type of instrument.
 - d. Be on-site and supervise at least the first five installations of each type of instrument.
 - e. Supervise interpretations of geotechnical instrumentation data.
 - 3. Contractor's engineer designing the layout for optically surveyed instrumentation shall be under the responsible charge of a Land Surveyor registered in the State of New York with a minimum of three years experience (or as approved by the Resident Engineer) in design work of the types and accuracy specified herein.

4. Contractor's instrumentation personnel shall include Superintendent(s) who will be in responsible charge full-time on site during the geotechnical and structural instrumentation program. The Superintendent(s) shall have at least six years of direct field experience (or as approved by the Resident Engineer) in installation and monitoring of the types of instrumentation specified herein, and shall have supervised instrumentation programs of similar magnitude in similar subsurface conditions. The Superintendent(s) shall be available to supervise all instrument installations, pre-installation and post-installation acceptance tests, collection of baseline readings, new tunnel deformation and groundwater monitoring and instrumentation data interpretations when illness or other insurmountable circumstance prevents the GIE from performing these functions. The Superintendent(s) shall also be prepared at all times to supervise the installation of any instrument after the GIE has supervised the installation of the first five of any type.
 5. Substitutions for the GIE or the Superintendent(s) during the Contract period shall not be made without prior acceptance by the Resident Engineer. Substitute personnel shall have the same qualifications specified herein for the positions to be held.
 6. Contractor's personnel shall include an LLSS Specialist who shall perform and is qualified to perform the following tasks related to the LLSS as specified herein.
 - a. Plan and configure the system including dataloggers, IDS units, and database software.
 - b. Detail the overall configuration and appurtenant hardware and installation procedures for the entire LLSS including final locations of the components, some of which are approximated on the Contract Drawings.
 - c. Perform pre-installation and post-installation acceptance tests.
 - d. Supervise installation of the system in its entirety.
 - e. Collect, reduce, process, plot, evaluate data to prove functionality, and obtained baseline readings before turning system over to the Resident Engineer.
 - f. Oversee replacement and repair of damaged components until the system is no longer required for the collection of data for this Contract.
 7. The LLSS Specialist shall have previous experience in the planning, configuration, installation, monitoring, maintenance, and data interpretation of at least two similar open channel type LLSSs.
- D. If Contractor collects Additional Data, either from additional instruments or from specified instruments, Contractor's personnel shall be as follows:

1. Installations shall be supervised by the GIE or the Superintendent as specified herein above.
 2. Data collection, reduction, plotting, and reporting, except for survey data, shall be supervised by the GIE or the Superintendent.
 3. The person in responsible charge of the surveyors shall be a Land Surveyor registered in the State of New York with a minimum of three years of experience (or as approved by the Resident Engineer) in deformation measurements of the types and accuracies specified herein. The field survey party chief shall have a minimum of one year of experience (or as approved by the Resident Engineer) in deformation survey measurements of the types and accuracies specified herein.
 4. Interpretations of data shall be supervised by the GIE.
 5. Instrument installation and data collection shall be as specified herein.
- E. Contractor's instrumentation personnel including qualifications of the GIE, the Superintendent(s), Registered Land Surveyor, and field survey party chief shall be subject to the review of the Resident Engineer.
- F. All personnel working within the NYCT tunnels will be required to take NYCT safety training before they are permitted to enter the underground working areas.
- G. Contractor's personnel shall include a qualified AMTS Specialist who shall perform and who is qualified to perform the tasks related to the AMTS as specified herein. The AMTS Specialist shall have previous experience in the installation, monitoring, and data interpretation of at least two AMTS systems in similar applications including previous experience in active subway tunnels. The AMTS Specialist shall perform the following tasks:
1. Detail the overall configuration and appurtenant hardware and installation procedures for the entire AMTS system including final locations of the components, some of which are approximated on the Contract Drawings because of restricted access to existing facilities during the design phase.
 2. Perform pre-installation and post-installation acceptance tests.
 3. Supervise installation of the system in its entirety.
 4. Collect, reduce, process, plot, evaluate data to prove functionality, and obtained baseline readings before turning system over to the Resident Engineer.
 5. Oversee replacement and repair of damaged components until the system is no longer required for the collection of data for this Contract.
 6. Perform routine maintenance, including regular checks of residuals as well as changes to the model parameters for the least square model to compensate for obstruction of targets, suspect reference targets, and optimization of atmospheric corrections.

- H. Contractor's personnel shall include a qualified DSG Specialist who shall perform and who is qualified to perform the tasks related to the dynamic strain gauges as specified herein. The DSG Specialist shall have had previous experience in the design, installation, monitoring, maintenance, and data interpretation of at least two projects involving dynamic strain measurement on concrete. The DSG shall be subject to review by the Resident Engineer. The DSG Specialist shall perform the following tasks:
1. Design the strain gauge data collection system.
 2. Perform pre-installation and post-installation acceptance tests.
 3. Supervise installation of the system in its entirety.
 4. Demonstrate that the system will collect, reduce, process, plot, evaluate data to prove functionality, and obtain baseline readings before turning system over to the Resident Engineer.
 5. Supervise replacement and repair of damaged components until the gauges are no longer required for the collection of data for this Contract.

1.06 SUBMITTALS

- A. At least 30 days before beginning any excavation, Contractor shall submit for the Resident Engineer's review contingency plans to be implemented in case any Response Level as specified elsewhere herein is reached. The contingency plans shall be positive measures by Contractor to do any or all of the following, as applicable.
1. Limit further excavation-induced structure and ground movement.
 2. Limit further decrease in groundwater and piezometric levels.
 3. Control vibrations.
 4. Maintain the structural integrity of adjacent structures and utilities.
 5. Implement corrective, mitigative actions including changing means and methods of construction as necessary.
- B. Within 30 days after the Notice to Proceed, submit the following for review:
1. Resumes of Geotechnical Instrumentation Engineer, Superintendent(s), senior technicians, field survey party chief, and LLSS, AMTS, and DSG Specialists, sufficient to define details of relevant site experience requirements specified herein.
- C. Within 90 days of Notice to Proceed, submit layout plans and details of installation of LLSS and AMTS systems based on the conceptual layout in Contract Drawings and actual field verification of same.

- D. At least 60 days before commencing installation of the first of each type of instrument, submit to the Resident Engineer for review the following items pertaining to that instrument type:
1. Detailed step-by-step procedure for installation, together with a sample installation record sheet. The installation procedures shall include appropriate content from the following list:
 - a. The method of forming boreholes, including the procedure for advancing casing, shall be submitted to the Resident Engineer for review before commencement of the Work.
 - b. The method to be used for cleaning the inside of casing or augers, and for disposing of drill water and cuttings.
 - c. Proposed grout mixes, including commercial names, proportions of admixtures and water, mixing sequence, mixing methods and duration, pumping methods and tremie pipe type, size and quantity.
 - d. Drill casing or auger type and size.
 - e. Depth increments for backfilling boreholes with sand and granular bentonite.
 - f. Locations of IDS units and dataloggers for tiltmeters, in-place inclinometers, multiple position borehole extensometers (MPBXs), and LLSS, indicating which instruments are to be connected to their own individual datalogger, and which are to be grouped and connected to a common datalogger.
 - g. Method for overcoming buoyancy of instrumentation components during grouting.
 - h. Method of sealing joints in pipes, MPBX, and inclinometer casing to prevent ingress of grout.
 - i. Method for conducting post-installation acceptance test.
 - j. Method for protecting instruments from damage.
 - k. For LLSS, AMTS, and DSG monitoring systems, drawings showing final layout and design, support, installation details, and wiring diagrams including reliable and maintainable cables, power and communications requirements, with conduit for lines where it is required by Code.
 - l. For LLSS and AMTS, the algorithm used to calculate displacement as measured by the systems, and samples of LLSS and AMTS data presentation.
 - m. For seismographs, method for mounting seismograph geophones on building columns, rock, pavement, and soil.

- n. The method of tremie grouting horizontally installed instruments so that each is fully grouted for its entire length.
 - o. Plans for equipment primary electrical power, back-up power, and telephone lines for data transmittal.
 - 2. If Contractor collects Additional Contractor's Data using survey methods, the detailed step-by-step procedures for conducting all optical survey measurements to the specified accuracies shall include types of surveying instruments, all as specified herein, and data reduction procedures. The manufacturer's stated accuracy and the field procedures shall be such that the resulting accuracies meet the specified accuracies at a minimum 95-percent level of confidence.
 - 3. Contractor shall submit resumes of the Land Surveyor, field survey party chief, and surveyors.
 - 4. A bar chart indicating the proposed schedule of instrument procurement, installation, and testing.
- E. At least 30 days before purchase, submit manufacturer's product data describing all specified instruments including requests for consideration of substitutions, if any, together with product data and instruction manuals for requested substitutions.
- 1. Product data for the LLSS shall include documentation to indicate that the LLSS has been proven to have the performance and accuracy specified herein in an active subway or railroad.
 - 2. Product data for the AMTS system shall include documentation to indicate that it has been proven to have the performance and precision specified herein in at least one active subway or railroad tunnel, and also for monitoring the deformation of structures other than tunnels at a minimum of one project, all as specified herein.
 - 3. Product data for in-place inclinometer shall include results of testing by a testing laboratory that is independent of the manufacturer and acceptable to the Resident Engineer, and that demonstrates that the in-place inclinometers have the performance characteristics specified herein.
 - 4. Product data for tiltmeters shall include performance or test data, acceptable to the Resident Engineer that demonstrates that the tiltmeters have the performance characteristics specified herein.
- F. Method of grouting or fixing individual anchor points of MPBXs at least 30 days before installation.
- G. Instrument Maintenance:
- 1. Contractor shall provide information pertinent to the maintenance requirements of the instruments proposed.

2. The information shall include, but not be limited to, frequency and duration of maintenance and required track outages as well as equipment and spare parts required for performing the maintenance.
 3. At least 60 days before installation of any first instrument, submit detailed maintenance plan for all instruments of that type proposed to be installed.
- H. Submit proposed power sources and layouts of power and signal cables for all instruments.
- I. If applicable, submit proposed wireless methods of signal transmission.

1.07 DELIVERABLES

- A. Within ten working days of installing each instrument, provide the following, in a single package:
1. A copy of factory calibration, manufacturer's test equipment certification, completed copy of quality assurance checklist, and warranty for each portable readout unit.
 2. Completed pre-installation acceptance test record form for that instrument.
 3. The installation record sheet for that instrument, including as-built coordinates as specified.
- B. Provide soil and rock samples as specified herein.
- C. Provide data as specified.
- D. Every four weeks, provide updated as-built instrument location plans unless no instruments were installed since the last post-installation acceptance test.
- E. Provide baseline readings as specified herein comprising a minimum of three consistent readings taken at least one day apart before subject to any effects from construction.

1.08 SCHEDULING WORK

- A. Stage the Work to ensure that the earliest installations are in the vicinity of 63rd Street where tunnel excavation is scheduled to begin.
- B. Install instruments, obtain and agree with Resident Engineer on baseline readings in accordance with the following schedule:
1. Deep benchmarks shall be installed and baseline readings obtained and agreed on at least 60 days before the start of any construction that would be affected by the collection of settlement data.
 2. Open standpipe piezometers shall be installed and baseline reading of groundwater levels obtained and agreed upon at least 90 days before the excavation reaches the instrument location.

3. Inclinometers and vertical borehole extensometers shall be installed and baseline readings obtained and agreed on before any excavation for a tunnel within 200-feet of the instrument.
4. As defined elsewhere herein, movement monitoring points (S1, S2, SM) shall be installed and baseline readings obtained and agreed on at least 30 days before any tunnel excavation within 200-feet of the instrument.
5. At least 60 days before commencement of any tunnel construction activity, submit detailed instrumentation location plan and proposed method of reading of tunnel deformation monitoring instruments including details of installation procedures and timing.
6. To permit the collection of representative baseline data, the AMTS shall be installed so baseline readings can be taken at the earliest practicable time before excavation can influence the instrument. Unless otherwise directed or approved by the Resident Engineer, a baseline reading period of one month duration before any excavation within 200-feet of the instrument is required. Building facade instruments (those external to the GCT) shall have the highest priority and the AMTS likely to be affected by the approaching tunnels shall be installed before other instruments in the same general location.
7. The installation of the AMTS for building facade monitoring shall be sequenced so that the installation commences at 63rd Street and progresses southward along the tunnel alignment.
8. The LLSS shall be installed so baseline readings can be taken and confirmed a minimum of 90 days before any excavation within 200-feet of the instrument, or any dewatering.
9. Dynamic strain gauges shall be installed with sufficient cure time for bonding epoxy in accordance with manufacturer's recommendations before baseline readings can be collected and confirmed. Gauges shall be ready for monitoring the blasting.

1.09 STORAGE AND SERVICING OF INSTRUMENTS

- A. All instrumentation materials, after receipt at the Work Site and before installation, shall be stored in an indoor, clean, dry, and secure storage space. Instruments shall not be exposed to temperatures outside the manufacturer's stated working temperature range.

PART 2 MATERIALS

2.01 GENERAL

- A. All materials shall be new and shall have a design life of at least seven years.

- B. Any request from Contractor for consideration of a substitution shall clearly state the nature of the deviation from the product specified. Each request for substitution shall be the subject of a letter transmitted for review before purchase of equipment as specified herein elsewhere. It will not be considered acceptable for substitutions to be seen by the Resident Engineer for the first time when Shop Drawings are received.
- C. Specified readout units, together with associated calibration devices and software, shall be furnished to the Resident Engineer no later than one week before commencing installation of the first of each type of instrument. In addition to specified readout units for the Resident Engineer's use when collecting data, Contractor shall provide Contractor's own readout units as needed for making pre-installation and post-installation acceptance tests, for taking any required readings during installation and the collection of baseline readings. Such readout units shall be identical to the specified readout units.
- D. A factory calibration shall be conducted on all instruments at the place of manufacture before shipment. Each factory calibration shall include a calibration curve with data points clearly indicated, and a tabulation of the data. Each instrument shall be marked with a unique identification number. Quality assurance procedures during factory calibration shall be as specified.
 - 1. Factory calibration of seismograph vibration monitors shall be performed using a shake table and a reference sensor traceable to the NIST. Factory calibrations of overpressure sensors shall be performed using a piston calibrator traceable to the NIST. Seismographs shall be calibrated yearly. Contractor shall provide for adequate supply of comparable instrumentation during calibration to ensure against delay of Project.
- E. Surface protection for vertically installed instruments shall be flush with the ground surface in paved or other areas. For all instruments, surface protection shall consist of a Tyler Pipe Model 26T-6855 LF Top Only Roadway Box, or approved equal, with a plain 5-1/4-inch lock-lid, a Bresnahan Foundry Model 00068 Roadway Box with latching lock lid, or approved equal. Roadway boxes for inclinometers shall either have a diameter adequate to allow attachment of cable support assembly or shall allow for attachment of an inclinometer casing extension while manual readings are being taken. Tunnel deformation and roof leveling devices and LLSS instruments will not require roadway box protection. LLSS sensors may require special protection if they are installed on the tunnel benches or where they are subject to damage by railroad personnel or equipment.
- F. For each instrument type, provide an instruction manual that shall include the following:
 - 1. A description of the purpose of the instrument.
 - 2. Theory of operation.
 - 3. Step-by-step procedures for:
 - a. Pre-installation acceptance test when instruments are received on site, to ensure the instruments are functioning correctly before installation.
 - b. Calibration of readout units.

4. A list of calibration equipment required for vibrating wire instruments, and recommended frequency of calibration.
 5. Step-by-step instrument installation procedure including materials, tools, spare parts, and any borehole requirements, and post-installation acceptance tests.
 6. Maintenance procedure.
 7. Step-by-step data collection procedure.
 8. Software requirements and instructions, data reduction, processing, and plotting procedures.
- G. If not stated otherwise, all graduations shall be in U.S. Customary Units, for example, feet, inches, pounds.
- H. Dataloggers shall be provided to collect data from tiltmeters, in-place inclinometers, multiple-position borehole extensometers and LLSSs. The dataloggers shall be capable of retaining setup information and measurements in memory for a minimum of 72 hours in case of power failure or power interruption. The dataloggers shall have the ability to communicate with the IDS units by short-haul or telephone modem. The dataloggers shall be Geokon Inc. "Micro-10 Dataloggers", or approved equal.
- I. IDS units shall be provided to serve as buffers between the dataloggers and the CDS. The IDS units shall receive monitoring data from the dataloggers attached to them, consolidate this data, and transfer it to the CDS by telephone modem. Contractor shall provide IDS units that are suitable for performing the required function. As a minimum, the hardware shall include an Intel-based PC with Microsoft Windows XP operating system, 2.0-GHz or higher processor, 256-MB SDRAM, and 30-GB hard disk. Each IDS shall be equipped with a CD drive and a 56-K modem for remote access.
- J. Software shall be provided for the IDS units to control and program the dataloggers. A method of programming this software shall be provided, which uses menu-oriented fill-in-the-blanks, or equally easy-to-understand techniques. No special knowledge of computer languages shall be required to program the IDS. The IDS software shall be capable of transferring the monitoring data to the CDS in a comma-separated ASCII format to be used by the Resident Engineer's database program. The IDS software shall be Geokon, Inc. "MultiLogger Software, or approved equal.
- K. Each IDS unit shall be provided with software to enable remote control and operation of the IDS from the CDS. The remote control software shall be Symantec Corporation "pcAnywhere Version 10.5", or approved equal.
- L. Cables to connect instruments with the datalogger/IDS shall be shielded to protect against the effect of stray current and electrical induction, water, and weather, and shall be resistant to vandalism and rodent attack.
- M. For most instruments, dataloggers and IDS units may, with the concurrence of abutters and approval of appropriate agencies, be installed inside buildings or in public spaces. Equipment shall be housed in secure cabinets that are protected

against theft, vandalism, rodents, and the effects of weather.

2.02 DEEP BENCHMARKS

- A. A deep benchmark shall comprise a sleeved steel pipe grouted into undisturbed bedrock
- B. The inner pipe shall be 1-1/2-inch, Schedule 40 steel pipe, threaded and coupled. The couplings shall have 45-degree tapered shoulders across the full coupling wall thickness at both ends. The top of the pipe shall be fitted with a hemispherical stainless steel knob.
- C. The outer casing shall be 3-inch Schedule 40 steel pipe, threaded and coupled.
- D. The centralizers shall consist of PVC pipe sized to provide a tight fit on the inner pipe and spring-formed with longitudinal cuts to a larger diameter to provide a loose fit in the outer pipe. They shall be spaced on 10-foot vertical centers.
- E. Cement grout shall be ordinary Portland cement and water.
- F. Caulking compound shall be silicone based commercial grade.
- G. Bentonite slurry shall consist of bentonite and water.
- H. Surface protection shall be flush with the ground surface in paved areas and incorporate a lockable 8-inch cast iron top box into a concrete block as shown on the Contract Drawings. The outer pipe shall be sleeved through the base of the block with a 12-inch length of 4-inch diameter PVC pipe. In areas that are not paved, the surface protection shall normally be flush but, where directed by the Resident Engineer, the surface protection shall project above ground surface.

2.03 OPEN STANDPIPE PIEZOMETERS

- A. Provide open standpipe piezometers with slotted pipe, bottom caps, and vented top caps as indicated on the Contract Drawings. The slotted pipe shall be 5-feet long, 1-1/4-inch, Schedule 80 PVC pipe with three rows of 0.01-inch wide slots on 120-degree centers, with a slot length to leave 0.25-inch between rows. The standpipe shall be 1-1/4-inch, Schedule 80 flush-joint PVC pipe. If accepted by the Resident Engineer, boreholes as small as NQ size and standpipes as small as 1-inch may be used.
- B. Filter sand shall conform to ASTM C 778.
- C. Electrical water level indicator shall have a 100-foot long graduated cable with graduations at 0.02-foot or smaller intervals.
- D. Granular bentonite shall be Wyo-Ben, Inc. "Enviroplug Medium; Petroleum Services, Inc., Baroid Division "Holeplug"; or approved equal.

2.04 SURVEYING INSTRUMENTS FOR TUNNEL DEFORMATION MONITORING

- A. Instruments used for tunnel deformation monitoring shall have a minimum accuracy of plus or minus 3.0-arc seconds (standard deviation in accordance with DIN 18723), and a minimum display reading less than or equal to the accuracy. Distances greater

than 30-feet shall be measured with an Electro-Optical Distance Measuring Instrument (EDM). Electronic pointing shall be used to minimize error due to possible misalignment of the EDM axis and telescope. Centering shall be accomplished using high precision optical plummets or mechanical centering devices.

- B. EDM equipment used for horizontal movement monitoring shall, after calibration, have a minimum accuracy of plus or minus 0.2-inch plus 5-ppm.

2.05 MOVEMENT MONITORING

- A. Movement monitoring points will be used to monitor vertical and horizontal deformation of various facilities at selected locations shown on the Contract Drawings.
- B. The following types of monitoring points shall be used to monitor deformation:
 - 1. Surface Monitoring Point Type 1 (S1) shall consist of a 1-inch diameter steel pipe that extends at least 2-feet below the bottom of paving and a surface roadway box split pipe at tip for 1-foot as shown on the Contract Drawings.
 - 2. Surface Monitoring Point Type 2 (S2) shall consist of a 1/4-inch diameter, 1-inch long stainless steel bolt with an identification tag. It shall also have an indent in the center of its rounded head to receive a surveyor's plumb bob. The identification tag shall be 1-1/2-inch diameter by 3/32-inch thick with a punched number for identification. The bolt shall be placed through the central hole in the identification tag and driven into a surface on the facility such that the identification tag lies directly between the instrumented surface and the head of the bolt with the identification number facing up so it can be read.
 - 3. Structure Monitoring:
 - a. Structure monitoring points, survey prisms (SP), shall be suitable for installation in vertical surfaces such as steel, concrete, masonry, and mortar joints. For anchorage of instruments, use a sleeve, an anchor, and a bolt as shown on the Contract Drawings or redesigned as appropriate, and reviewed by the Resident Engineer. Anchor sleeves and anchors can be obtained from Hilti and ITW Ramset/ Red Head; or approved equal, as recommended by the instrument manufacturer.
 - b. Structure monitoring points shall be for tilt, horizontal movement, and settlement monitoring of structural elements, columns, facades, walls, and pillars.
 - c. Use two vertically offset survey prisms as shown for optical structure monitoring of horizontal movement, settlement and tilt, or biaxial tilt meters for electronic tilt monitoring.
 - d. For structural monitoring of buildings using optical methods, use automated motorized total stations (AMTS) as specified herein.

- e. Survey prisms installed in existing subway tunnels and stations will be monitored by the Resident Engineer through the use of a portable total station theodolite.
 - f. For structural tilt monitoring using electronic methods, use tilt meters as specified herein and as shown on the Contract Drawings.
 - g. For settlement monitoring at vertical surfaces, use structural monitoring point on vertical masonry or concrete surface (SM) as shown on the Contract Drawings to facilitate the reception of the leveling staff. The SM shall consist of a bolt of similar materials as described herein above, but shall protrude from the vertical surface and shall have a round head mounted perpendicular to the bolt.
- C. For tilt monitoring of structures, use tiltmeters as specified herein below.
- 1. Tiltmeters include those vertically mounted instruments shown on the Contract Drawings.
 - 2. Each tiltmeter shall be biaxial and shall incorporate tilt transducers that are electrolytic levels (also referred to as electro-levels), vibrating wire transducers, accelerometers, or magneto-resistive transducers. A temperature sensor shall be incorporated into each tiltmeter.
 - 3. The tiltmeters shall have been proven by data obtained during a minimum of three project applications similar to the specified application, or by laboratory testing, all of which are acceptable to the Resident Engineer, to have the performance characteristics specified herein
 - a. Minimum angular range plus or minus 1-degree.
 - b. Operating temperature range plus 33- to plus 100-degrees Fahrenheit.
 - c. Static repeatability of plus or minus 2-arc-seconds or better.
 - d. Maximum temperature sensitivity throughout the entire angular range and operating temperature range of plus or minus 40-arc-seconds.
 - e. Zero stability over a minimum period of 90 days at a constant temperature of plus or minus 5-arc-seconds or better.
 - 4. The tiltmeter electrical cable shall be as recommended by the manufacturer of the tiltmeters and shall be shielded with a waterproof jacket.
 - 5. Portable readout units and dataloggers shall be as recommended by the manufacturer of the tiltmeters. Each tiltmeter shall be connected to a datalogger. The portable readout unit shall be for use during installation and for subsequent duplicate readings.
 - 6. Housings and mounting brackets shall be as recommended by the manufacturer of the tiltmeters.

7. Factory calibration of tiltmeters shall consist of calibrations on a mechanical tilting table with a range of plus or minus 1-degree in a minimum of ten equal increments.
8. Each tiltmeter shall be protected from damage by installing a protective box provided by the manufacturer, a NEMA 3R enclosure, or equivalent, of appropriate size to enclose the tiltmeter and to allow for connection to the datalogger(s).

2.06 DYNAMIC STRAIN GAUGES

- A. Provide foil resistance strain gauges as supplied by Vishay Measurements Group; Omega; JP Technologies; or approved equal.
- B. Gauges shall have 2-inch gauge length and either 120- or 350-ohm gauge resistance.
- C. Provide epoxy adhesive for mounting strain gauges, Measurements Group AE-10; or approved equal, and the same epoxy for encapsulation of gauges following mounting and wiring.
- D. Provide solvent cleaners, conditioners, neutralizers, and other accessories appropriate for gauge installation on concrete, all as recommended by the manufacturer of the strain gauges.
- E. Provide lead wires, solder, flux, soldering units, and other accessories appropriate for wiring up strain gauges, all as recommended by the manufacturer of the strain gauges.
- F. Lead wires shall be 3-conductor stranded tinned copper wire with vinyl insulation.
- G. Provide Wheatstone bridge completion circuits for strain gauges of the appropriate resistance.
- H. Provide instrumentation to supply controlled voltage to the Wheatstone bridges, balance the bridges, and record static (DC) and dynamic strain at frequencies up to 1-kHz.

2.07 IN-PLACE INCLINOMETERS

- A. Provide in-place inclinometers including, but not limited to, the following components:
 1. Inclinometer casing and couplings with all associated components and tools.
 2. Portable inclinometer probes, cables, and readout units including two each for Resident Engineer's use.
 3. In-place inclinometer tilt sensors, wheel assemblies, spacer tubing, support assemblies, and all associated components and cable.
 4. Portable readout units for in-place inclinometers.
 5. Dataloggers.

6. Software for dataloggers and portable readout unit including two each for Resident Engineer's use.
- B. Each in-place inclinometer tilt sensor shall be biaxial and shall comprise two electrolytic levels (also referred to as electro-levels), vibrating wire transducers, accelerometers, or magneto-resistive transducers. A temperature sensor shall be incorporated into each tilt sensor. The tilt sensors shall be as proven by a testing laboratory independent of the manufacturer to have the performance characteristics specified herein, and as reviewed by the Resident Engineer:
1. Minimum angular range shall be plus or minus 10-degrees.
 2. Not Used
 3. During calibration of a minimum of three tilt sensors, over the full angular range of the sensitive axis, with a cross-axis inclination vertical, and additionally with a cross-axis inclination of 5-degrees to vertical, at a constant temperature of 68-degrees Fahrenheit, a repeatability of plus or minus 40-arc-seconds or better.
 4. During temperature sensitivity testing of a minimum of two tilt sensors with the sensitive axis at an inclination of 5-degrees to vertical, and the cross-axis inclination vertical, at temperature increasing from 50- to 68-degrees Fahrenheit and subsequently decreasing from 68- to 50-degrees Fahrenheit, a maximum indicated reading change corresponding to 250-arc-seconds over the 33- to 100- to 33-degree Fahrenheit range. Short-term spikes in the plots of tilt sensor output versus time, after which the output returns to a pattern that is consistent with the output before the spike shall be ignored.
 5. During zero stability testing of a minimum of three tilt sensors over a nine day period, with the sensitive axis at an inclination of 5-degrees to vertical, and the cross-axis inclination vertical, at a constant temperature of 68-degrees Fahrenheit, a maximum deviation corresponding to 50-arc-seconds throughout the entire time period.
 6. During zero stability testing of a minimum of one tilt sensor over a 90 day period, with the sensitive axis at an inclination of 5-degrees to vertical, and the cross-axis inclination vertical, at a constant temperature of 68-degrees Fahrenheit, a maximum deviation corresponding to 50-arc-seconds throughout the entire time period.
- C. Biaxial tilt sensors shall be installed alongside wheel assemblies. The maximum spacing between wheel assemblies shall be 10-feet. Locations of tilt sensors/wheel assemblies are shown on the Contract Drawings.
- D. There shall be one electrical cable for each active biaxial tilt sensor. Electrical cable shall be as recommended by the manufacturer of the in-place inclinometers, and shall be shielded with a waterproof jacket.
- E. Spacer tubing support assemblies and protective caps shall be as recommended by the manufacturer of the in-place inclinometers.

- F. Portable readout units for in-place inclinometers shall be as recommended by the manufacturer of the in-place inclinometers.
- G. Each in-place inclinometer shall be connected to a datalogger. Dataloggers and software shall be as recommended by the manufacturer of the in-place inclinometers. Instruments shall be wired so they can be read with the portable readout unit without altering the data recorded by the datalogger.
- H. Factory calibrations of tilt sensors shall consist of calibrations on a mechanical tilting table with a range of plus or minus 2,000-micro-radians, in a minimum of ten equal increments.
- I. Inclinometer casing shall be 2.75-inch outside diameter ABS with broached internal keyways, and twist tolerance better than 1-degree per 10-foot length. Couplings shall be of the non-telescoping type.
- J. Portable inclinometer probe shall be biaxial consisting of two force balance accelerometers mounted at 90-degrees with a 2-foot wheelbase. Probe shall be supplied in a carrying case. Each probe shall be provided with a pulley from the same manufacturer as the probe. The portable inclinometer probe shall be for use during post-installation acceptance testing.
- K. Biaxial sensors may be comprised of two uniaxial sensors installed mutually perpendicular as long as the signals can be processed by the specified dataloggers and IDS units.
- L. Cable for portable inclinometer probe shall be 150-feet long, and shall incorporate neoprene sheathing, vulcanized rubber markers, and an internal wire rope core.
- M. Portable inclinometer readout unit shall be such that the time interval between recordings 2-feet apart in the casing shall enable each reading to stabilize to within plus or minus one unit of display within eight seconds. Readout unit shall include a battery charger.
- N. Software for portable inclinometer readout unit shall be as recommended by the manufacturer of the portable inclinometer readout unit.
- O. Factory calibrations of portable inclinometer probe and readout unit shall include comprehensive calibrations of the force balance accelerometers before assembly in the probe. A final calibration shall include measurement made at 10-degree intervals from minus 30- to plus 30-degrees with respect to vertical, and a comprehensive repeatability check over a smaller zone near vertical.
- P. Cement grout shall be Type I or Type II Portland cement and water. Special grout Type B shall include cement, bentonite, and water, and shall have approximately the same shear strength and compressibility as the surrounding ground.

2.08 VERTICAL MULTIPLE POSITION BOREHOLE EXTENSOMETERS

- A. The borehole extensometers shall be suitable for reading both with a mechanical readout and also with vibrating wire transducers, and shall include the following components:

1. Anchors.
 2. Rods.
 3. Protective sleeving.
 4. Reference head.
 5. Electrical cable.
 6. Mechanical readout unit.
 7. Portable vibrating wire readout unit.
 8. Datalogger.
- B. MPBX drill holes shall be of a diameter recommended by the manufacturer to accommodate the number of anchors and remote readout head as applicable scheduled for each instrument. Reduction in hole diameter with increasing depth may be considered. Anchors shall be suitable for grouting in place.
- C. Rods shall be 1/4-inch diameter stainless steel. Rods shall comprise 5-foot or 10-foot lengths, except for shorter lengths needed to create required total rod lengths, and be connected by flush screw couplings. The minimum number of couplings shall be used allowing for the constraints of the installation location.
- D. Protective sleeving shall be Schedule 40 PVC pipe.
- E. Reference heads shall conform to the following requirements:
1. The reference head shall accommodate the number of rods identified for each MPBX.
 2. The reference head shall have a low profile for installation in a manhole and shall be fully waterproof.
 3. Transducers shall be vibrating wire transducers. They shall be fully waterproof with a range of not less than plus or minus 1-inch. Range adjusters shall be used to increase the range, if necessary. Accuracy shall be plus or minus 0.1-percent of the range. The vibrating wire transducers shall be attached to the rods in a way that permits easy installation and adjustment of the transducers. Provisions shall be made for temperature measurements in each MPBX head for use in making corrections to transducer readings. A facility to check the instruments shall be included using a mechanical readout unit consisting of a depth micrometer or an analog dial gauge. Each mechanical readout unit shall be provided with a calibration standard.
 4. The vibrating wire transducers shall be wired so that they can be read both by the datalogger and also by the portable vibrating wire readout unit. Each MPBX shall be connected to a datalogger. The portable vibrating wire readout unit shall be used during installation and for subsequent duplicate readings.

5. Reference heads shall be protected against dirt and drainage by specially designed lockable covers.
- F. Electrical cable shall be as recommended by the manufacturer of the MPBXs and shall be a shielded twisted pair with a waterproof jacket.
- G. Vibrating wire readout units and dataloggers shall be as recommended by the manufacturer of the MPBXs.
- H. Cement grout shall be Type I or Type II Portland cement and water with an unconfined compressive strength of 1,500- to 2,000-psi.
- I. Factory calibrations of vibrating wire transducers shall be made by moving the core of each transducer a minimum of ten known amounts through its range, in two full cycles, in and out, using gauge blocks or a micrometer to measure its movement. The measured movement shall be compared with the indicated movement on the readout unit. Calibrations shall be made over two complete movement cycles. A thermal factor shall be provided for each batch. Transducers shall be rejected if comparative readings between cycles vary by more than plus or minus 0.002-inch.

2.09 HORIZONTAL MULTIPLE POSITION BOREHOLE EXTENSOMETERS INSTALLED IN NEW TUNNELS

- A. Install borehole extensometers as shown on the Contract Drawings.
- B. The borehole extensometers shall be suitable for reading both with a mechanical readout and also with vibrating wire transducers, and shall include the following components:
 1. Anchors, three per extensometer.
 2. Rods.
 3. Protective sleeving.
 4. Reference head.
 5. Electrical cable.
 6. Mechanical readout unit.
 7. Portable vibrating wire readout unit.
- C. MPBX drill holes shall be of a diameter recommended by the manufacturer to accommodate the number of anchors and remote readout heads as applicable and as scheduled for each instrument. Anchors shall be a hydraulically expandable type that still permit complete post-installation grouting of each hole.
- D. Rods shall be 1/4-inch diameter stainless steel. Rods shall comprise 5-foot or 10-foot lengths, except for shorter lengths needed to create required total rod lengths, and be connected by flush screw couplings. The minimum number of couplings shall be used allowing for the constraints of the installation location.

- E. Protective sleeving shall be Schedule 40 PVC pipe.
- F. Reference heads shall conform to the following requirements:
 - 1. The reference head shall accommodate the number of rods identified for each MPBX.
 - 2. The reference head shall be fully waterproof.
 - 3. Transducers shall be vibrating wire transducers. They shall be fully waterproof with a range of not less than plus or minus 1-inch. Range adjusters shall be used to increase the range, if necessary. Accuracy shall be plus or minus 0.1-percent of the range. The vibrating wire transducers shall be attached to the rods in a way that permits easy installation and adjustment of the transducers. Provisions shall be made for temperature measurements in each MPBX head for use in making corrections to transducer readings.
 - 4. The vibrating wire transducers shall be wired so that they can be read by the portable vibrating wire readout unit. The portable vibrating wire readout unit shall be used during installation and for subsequent readings.
 - 5. Reference heads shall be protected against the effects of construction operations such as blasting by being recessed a distance of 2-feet beyond the theoretical tunnel outline.
- G. Electrical cable shall be as recommended by the manufacturer of the MPBXs and shall be a shielded twisted pair with a waterproof jacket. Cable length shall be sufficient to reach the collar of the recess for making connection with the readout unit, but not so great as to make it difficult to coil the cable back into the recess after a reading is taken.
- H. Vibrating wire readout units shall be as recommended by the manufacturer of the MPBXs.
- I. Cement grout shall be Type I or Type II Portland cement and water and shall have an unconfined compressive strength of 1,500- to 2,000-psi.
- J. Factory calibrations of vibrating wire transducers shall be made by moving the core of each transducer a minimum of ten known amounts through its range, in two full cycles, in and out, using gauge blocks or a micrometer to measure its movement. The measured movement shall be compared with the indicated movement on the readout unit. Calibrations shall be made over two complete movement cycles. A thermal factor shall be provided for each batch. Transducers shall be rejected if comparative readings between cycles vary by more than plus or minus 0.002-inch.

2.10 SEISMOGRAPHS

- A. Provide 12 portable seismographs for the Resident Engineer's monitoring of the velocities of ground vibrations resulting from construction activities. Provide Instantel Inc. "BlastMate Series III", or approved equal. The seismograph shall have the following minimum features:

1. Seismic Range: 0.01- to 10-inches per second with an accuracy of plus or minus 5-percent of the measured peak particle velocity or better at frequencies between 10- and 100-Hertz, and with a resolution of 0.01-inch per second or less.
2. Acoustic Range: 88- to 144-dB(L) (referenced to 20-micro-Pascals) with an accuracy and resolution of plus or minus 1-decibel.
3. Frequency Response (Plus or Minus 3-Decibel Points) 2- to 200-Hertz.
4. Three channels for vibration monitoring plus a fourth channel for overpressure because of blasting.
5. Two Power Sources: Internal rechargeable battery and charger and 115-volts ac. Battery must be capable of supplying power to monitor vibrations continuously for up to 24 hours.
6. Capable of internal dynamic calibration.
7. Capability of printing in the field and capability to transfer data from memory to permanent storage medium. Instruments must be capable of producing strip chart recordings of readings on-site within one hour of obtaining the readings.
8. Provide computer software to perform analysis, produce reports of continuous monitoring, and to perform zero-crossing frequency analyses of waveform data on magnetic disks.
9. Self-triggering waveform capture mode that provides the following information: plot of waveforms, peak particle velocities, peak overpressure, and frequencies of peaks.
10. Continuous monitoring mode capable of recording events up to 10-seconds long, and histogram mode to record events continuously.
11. Three instruments provided with geophones capable of recording events up to 100-inches per second for close-in monitoring of NYCT tunnels. Such instruments shall also have sufficient cabling to allow remote recording from the geophones without interference to subway activity for turning the instruments on and off as needed. Contractor shall determine if line-drivers or other amplification are necessary for the required cable length. Monitoring locations are as shown on the Contract Drawings.
12. All geophones shall be external to the seismograph to allow solid bolting of the geophone to concrete surfaces with "Red Head" anchors, or approved equal.

2.11 AUTOMATED MOTORIZED TOTAL STATIONS

- A. Provide high quality precision optical survey prisms in conjunction with fully automated motorized total stations under computer control to provide real-time movement monitoring at locations identified on the Contract Drawings. The automated system shall provide the means to remotely monitor the three components of movement of precision targets mounted on buildings and structures other than subway linings and stations.
- B. The monitoring system shall provide three-dimensional displacement vectors for all the survey prisms with a measurement precision of plus or minus 1-millimeter for sight distances up to 100-meters. The system shall be configured to report the monitoring data on the Project Grid.
- C. The monitoring system shall have been proven to have the performance and precision specified herein for monitoring the deformation of structures other than tunnels at a minimum of one project.
- D. Each system shall consist of:
 - 1. A motorized total station including mounting cages, brackets, and protective arrangements.
 - 2. High quality precision optical survey prisms.
 - 3. High quality precision optical reference prisms.
 - 4. On-site equipment to operate the total station and communication with the Resident Engineer's CDS including combined power/signal box, AC to DC charger/transformer, power supply, connections, backup battery, transceiver modem, and associated cabling.
 - 5. A site to designated office data transmission link comprising either a radio modem with antenna and housing to provide wireless digital transmission of data between the total station controller and the Resident Engineer's designated office, or cable modem and cabling, and/or dedicated telephone lines or cabling as required.
 - 6. Receiver equipment at the designated Resident Engineer's office comprising a signal box and transceiver modem and cabling to connect to the Resident Engineer's CDS.
- E. The monitoring system shall be capable of providing temperature readings that coincide with the instrument readings, and shall take into account temperature and pressure variations in real-time once per cycle so that it is insensitive to the effects of refraction.
- F. The monitoring system shall include statistical analyses that shall be made at the end of each cycle of readings in order to maximize the precision of measurements.

- G. The monitoring system shall incorporate a limited search window and a limited time for searching for a survey prism so that if the search is unsuccessful because of prism damage or other causes, the system will pass to the next prism in the cycle. In this event, the result for the missing prism shall be identified as “no result”. If the system is unable to find and read this prism during the following cycle, the system shall send an alarm message indicating that the prism is missing.
- H. The monitoring system shall be capable of providing three-dimensional displacement data for a minimum of 50 survey prisms associated with each total station within a period of one hour.
- I. The monitoring system shall provide differential calculations between prisms in real time.
- J. The monitoring system shall have the ability to process a global least squares adjustment of data that are acquired by several total stations in each measurement cycle so that if one or more total stations in each measurement cycle require the use of a reference target associated with a different total station, a global monitoring network can be set up to relate to a single reference target.
- K. The monitoring system shall be capable of retaining setup information and measurements in memory for a minimum of 72 hours in case of power failure or power interruption.
- L. Contractor shall keep the total station theodolites operational within the manufacturer’s specified operating temperature range.

2.12 LIQUID LEVEL SETTLEMENT SYSTEM

- A. A liquid level settlement system (LLSS) is a network of force transducer gauges connected by liquid-carrying pipes attached to tunnel walls and support columns and used to detect vertical displacements by comparing changes between individual gauges and a reference gauge.
- B. Provide open channel type LLSS capable of measuring relative vertical displacement of plus or minus 1-inch with a system accuracy of plus or minus 0.01-inch. The LLSS shall be designed to operate for at least seven years at operating temperatures of 25- to 150-degrees Fahrenheit. Each system shall consist of an open channel pipe, referred to herein as a carrier pipe, that is half-filled with liquid and installed level, i.e., at 0-degree grade. Liquid level sensors shall be installed along the length of the carrier pipes, including at both ends, to measure changes in liquid level. Each LLSS shall be monitored remotely using a data collection system consisting of dataloggers and IDS units that can monitor the liquid level sensors automatically, process the reading signals, and forward the data to the Resident Engineer’s CDS.
- C. Each liquid level sensor shall consist of a vibrating wire transducer, chamber, cylindrical weight, thermistor, lead cable, and liquid and air tubes for connection to the carrier pipe, as manufactured by Geokon, or approved equal. The LLSS shall have been proven to have the performance and accuracy specified herein in an active subway or railroad tunnel for a minimum period of three years. The liquid level sensors shall have a range of plus or minus 1-inch and an accuracy of plus or minus 0.003-inch as determined in the laboratory. The transducer housing, chamber, and weight shall be stainless steel. The cylindrical weight shall be 4-inches diameter and shall have a conical top and bottom to prevent the accumulation of air bubbles at the

bottom and condensed water drops at the top. The chamber and weight shall be coated with Teflon or similar material to reduce surface tension forces along the weight and chamber surfaces. The sensor shall include a locking mechanism that secures the cylindrical weight and prevents damage during transport, handling, installation, and replacement.

- D. The carrier pipes shall be stainless steel and shall be sized sufficiently to allow plus or minus 1-inch of settlement. Each pipe section or at least every 20-feet, the carrier pipe shall be equipped with a baffle that dampens liquid disturbance during train passage or from other external sources. The carrier pipe sections shall be connected by watertight couplings. Before installation, all debris and oil shall be removed from all pipes and couplings. The carrier pipe shall be supported by pipe hangers that allow individual pipe sections to be leveled during installation and maintenance.
- E. The LLSS liquid shall consist of a fluid with known density and thermal properties. The liquid shall be environmentally safe, resistant to organic growth, and shall not react negatively to any carrier pipe or liquid level sensor components.
- F. The data collection system shall be capable of a complete set of readings for all liquid level sensors in an LLSS in a period of 30 minutes. The data collection system shall be equipped with a back-up battery and a connection to the CDS. A laptop computer shall be supplied for use during installation and maintenance. The laptop shall be an Intel-based PC with Microsoft Windows XP operating system, 1,200-MHz processor, 256-MB SRAM, and 40-GB hard disk. The laptop shall also be equipped with a CD-RW drive for data backup and a 56-K modem for remote access. The data collection system shall be programmed so that one set of readings of the entire LLSS takes no more than 30 minutes to accomplish.
- G. The lead cables for the liquid level sensors shall be a minimum of two short-lay twisted pairs of No. 22 AWG tinned copper wire conductors, individual shielding per twisted pair with No. 24 AWG drain wire, aluminum polyester 100-percent coverage for shield, and a low smoke emission outer jacket. All other cabling for the data collection system shall have a low smoke emission outer jacket.
- H. Provide protective covers for liquid level sensors and datalogger(s) in accordance with the manufacturer's recommendations. The respective manufacturer of the liquid level sensors and datalogger(s) shall supply the protective covers.
- I. Provide protection for all exposed cables and tubing in accordance with the manufacturer's recommendations.
- J. The system shall be designed to return to normal operation with no breaks in data magnitude continuity after passage of trains and construction blasting vibrations that range up to 2-inches per second in intensity.
- K. The LLSS detail shown on the Contract Drawings indicates a configuration with the carrier pipe alongside the sensors, requiring a horizontal dimension of approximately 12-inches between the wall of the tunnel and the end of the cantilever mount. As an alternative to the LLSS detail shown on the Contract Drawings, a configuration with the carrier pipe in-line with the sensors is acceptable, such that the horizontal dimension between the wall of the tunnel and the end of the cantilever mount is reduced to approximately 8-inches. If this configuration is selected, the system accuracy, sensor accuracy, range, carrier pipe, and cylindrical weight shall be as specified herein above.

- L. For installation of LLSSs in sloping tunnels, it may be required to split a row of liquid settlement sensors into several rows where the last sensor of the previous and the first sensor of the subsequent row share the installation location at a common structural element (stepped installation).

2.13 TUNNEL DEFORMATION MONITORING

- A. Not Used
- B. Tunnel deformation is monitored by measuring the distances between three fixed reference points mounted on the tunnel perimeter and the changes of those distances (convergence).
- C. Reference points, convergence bolts, in new tunnels under construction consist of either number eight steel rebars, which are to be anchored into rock or 3/8-inch diameter thread studs, Hilti "DX", powder actuated fastener, or approved equal, installed into the precast concrete lining. In existing tunnels, alternative fixations for reference points may be used.
- D. Provision shall be made for tunnel convergence readings in the form of precise optical measurement using precise optical instruments for absolute readings and survey targets fulfilling the following minimum requirements:
 - 1. Meet requirements for optical survey instruments specified herein.
 - 2. Use high precision survey targets.
- E. All convergence bolts read using optical survey methods shall be equipped with a connection prepared to receive a tape extensometer for manual back-up readings. The tape extensometer provided shall be an Ealey, or approved equal, with the following features:
 - 1. Direct digital readout with illuminator index lights to register correct tape tension.
 - 2. Plus or minus 0.004-inch repeatability.
 - 3. End connectors for connection to convergence bolts. Connections between the tape extensometer convergence bolts shall be such that free rotation is permitted, and the tape extensometer spans between the shortest cord between the convergence bolts.
 - 4. Fold-away winding handle.
 - 5. Carrying case.
 - 6. Tape length 66-feet.
 - 7. Weight approximately 4.5-pounds.
 - 8. Tapes punched with holes by a precise machine such that tapes are interchangeable without loss of accuracy.

9. Interchangeable with each other so that there is no need to allocate a certain tape extensometer to specific reading spans.
 10. Necessary accessories to enable the tape extensometer to be used in the specified tunnels without the need for ladders, and necessary accessories to enable convergence bolts to be incorporated into the precise optical measurement system specified.
- F. Use appropriate protection means in signal color to protect convergence bolts from dirt and damage.

2.14 GRID CRACK GAUGES

- A. If Contractor elects to install crack gauges, they shall conform to the requirements specified herein below.
- B. Grid crack gauges shall be crack monitors as manufactured by Avongard Products (USA) Ltd; or approved equal. Anchors, bolts, screws, and quick-setting epoxy shall be provided by Avongard Products (USA) Ltd.; or approved equal.

2.15 VIBRATING WIRE CRACK GAUGES

- A. If Contractor elects to install vibrating wire crack gauges, they shall conform to the requirements specified herein below.
- B. Vibrating wire crack gauges shall include vibrating wire transducers, Geokon Inc. "Model 4420"; Roctest "Model JM-S"; Soil Instruments Ltd. "Model EXVW10"; or approved equal. Range shall be 2-inches.
- C. Anchors shall be chosen to fit the surface being monitored.
- D. Cables and terminal panels shall be from the same manufacturer as the crack gauges.
- E. Portable readout units shall be as recommended by the manufacturer.

PART 3 EXECUTION

3.01 PRE-INSTALLATION ACCEPTANCE TESTS

- A. When instruments are received at the installation site, Contractor shall perform pre-installation acceptance tests to ensure that the instruments and readout units are functioning correctly before installation. Pre-installation acceptance tests shall include relevant items from the following list:
1. Examine factory calibration curve and tabulated data, to verify completeness.
 2. Examine manufacturer's final quality assurance inspection checklist, to verify completeness.
 3. Check cable length.
 4. Check tag numbers on instrument and cable.

5. Check, by comparing with procurement document, that model, dimensions, and materials are correct.
 6. Perform resistance and insulation testing, in accordance with criteria provided by the instrument manufacturer, using a gauge insulation or circuit tester that applies 2 volts or less for resistance testing and 15 volts or less for insulation testing.
 7. Verify that all components fit together in the correct configuration.
 8. Check all components for signs of damage in transit.
 9. Check that quantities received correspond to quantities ordered.
- B. During pre-installation acceptance testing of each instrument Contractor's instrumentation personnel shall complete a pre-installation acceptance test record form.
- C. An instrument that fails the specified pre-installation acceptance test shall be repaired such that it passes a subsequent pre-installation acceptance test, or shall be replaced by an identical instrument.

3.02 INSTALLATION - GENERAL

- A. Photographs of existing tunnels and buildings made during the design phase will be made available for use in assessing accessibility of instrument locations. See Supplemental Terms and Conditions for listing of reference documents. Verify that instrumentation locations shown on Contract Drawings are suitable for the intended purpose and that they will not interfere with ongoing train operations. Where they are not suitable, after submittal to and review by the Resident Engineer, move them to locations that are suitable; then install instruments in accordance with Contractor's detailed step-by-step procedures. Contractor shall install instruments in accordance with Contractor's detailed step-by-step procedures that were submitted and reviewed by the Resident Engineer.
- B. Drilling:
1. The following requirements shall apply to all Contractor and specialty subcontractor drilling activities associated with instrumentation installation, and shall apply on all property including railroad rights-of-way, private property, and city streets.
 2. Obtain NYCDOT permits that include, but are not limited to, permissible days and hours for work in each drill site.
 3. Arrange for utility clearance at each drill hole site. Inside NYCT structures, utilities must be cleared with the appropriate railroad personnel.
 4. Before beginning operations, Contractor's drilling personnel shall attend safety training.

5. Locate drill holes a minimum of 3-feet horizontally from any identified utility. Where necessary, a hole may be located within 3-feet, but in no case less than 2-feet from any utility.
6. Verify that the drill rig is electrically grounded when drilling in railroad tunnels or rights-of-way in accordance with railroad specifications unless drilling from street locations. The requirement is not dependent on the distance from electrified lines or rails.
7. Ensure that all drilling personnel working at the rig are wearing electrically insulated gloves as part of the personal protective equipment when drilling at depths from 0- to 10-feet. All hand tools shall be electrically insulated when used at the rig for hand augering/excavation.
8. Ensure that all drill holes are, without exception, hand-augered or hand-excavated to a depth of 5-feet minimum. If the hole is located within 3-feet horizontally of any identified underground utility, then hand-augering/excavation shall proceed to a minimum depth of 6-feet.
9. In New York City streets, electric or pneumatic thin wall coring will be permitted for drilling the pavement until the top of subbase. Use of powered rotary drill rigs shall not begin before hand-augering/excavation to the depth required as specified herein above.
10. Contractor may elect to proceed with excavation of a pit without first demonstrating refusal of a hand auger. The pit may be excavated using electric or pneumatic tools with a chisel to break the pavement.
11. All work at street locations shall be cordoned off. Where a pit has been excavated, backfill the pit or construct a proper working surface to ensure that the drillers proceed with a safe working surface.
12. Consider all utilities to be live or operational, terminate drilling activities immediately if utilities are encountered at the actual drill hole location, and notify the utility owner as circumstances warrant.
13. Boreholes for instruments shall be drilled by a method that results in a clean and stable hole of the required diameter to the correct depth. Boreholes shall be cased to their full depth unless strata are sufficiently competent for the hole to stay open under dry conditions. Boreholes shall be drilled using clean water. Drilling mud or polymer additives may be used if approval is granted by the Resident Engineer. In the case of installation of piezometers, drilling mud or polymer additives will not be permitted. Care shall be taken during drilling to ensure that a minimum of material is lost from outside the casing. Surging of casing will not be allowed, and flushing of drilling water up the outside of the casing shall be minimized.
14. If an instrument boring cannot be properly advanced to the required depth, or the proposed testing and instrumentation cannot be satisfactorily completed, it shall be terminated and Contractor shall perform whatever work is required to advance a replacement boring to the depth where the initial boring was terminated while using the drilling technique specified herein. In all cases, the boring shall ultimately be advanced to the depth indicated on the Contract Drawings.

15. Safely dispose of any effluent water, material cuttings, and refuse in accordance with applicable regulations. Coordinate the disposal with authorities having jurisdiction, and submit disposal plan to the Resident Engineer for review.
16. Full-depth rock cores shall be recovered from all borings that penetrate bedrock including those within the pillar area between the future station caverns to be constructed under other ESA contracts.
17. As soon as practicable, transport all soil samples and recovered rock cores to a secure MTA storage facility designated by the Resident Engineer. Protect the samples and cores from damage and exposure to the elements during transit.
18. Core barrels shall be double-tube type with non-rotating inner barrels of the Acker M Series, Christensen NWC or NWD Series, or approved equal. Wire line equipment and tools may be used. The equipment and procedures used shall be such that NX (2-1/8-inch outside diameter) cores, or, if wire line equipment is used, NQ (1-7/8-inch outside diameter) cores can be obtained in all borings. Cores shall be pulled at intervals not exceeding 5-feet unless it can be shown to the satisfaction of the Resident Engineer that larger runs produce equal or better recovery and quality of core. In any case, the first run shall be no longer than 5-feet, and no runs shall be longer than 10-feet. Core shall be pulled at the first sign of blockage or grinding. If core recovery is poor, make every effort to improve the recovery and sample quality by changing bit types and altering drilling rates, or shortening runs, by increasing drilling fluid circulation, or by whatever other methods are required.
 - a. Under exceptional conditions, cutting oil may be proposed for review by the Resident Engineer for specific holes as the work progresses.
 - b. The core obtained in each drilling operation shall be placed in wooden or fiberglass core boxes and divided into separate compartments, each the length of the box and the width of the core obtained. The core boxes shall be subject to review by the Resident Engineer. Core obtained shall be placed in these boxes in such a manner that the various strata are in the same relative position in the core box as they were in the ground. The order of placing cores shall be the same in all core boxes. The top end of each core and the bottom of the last core shall be clearly and permanently marked with its true depth. A separate core box shall be used for each boring. The outside of each box shall be marked on top with the Project name, Project number, boring number, depth, and box number. Both ends of the boxes shall be marked with the boring number and core depths. Boxes shall be fitted with handles on the ends in order to facilitate lifting.
 - c. Special care shall be taken to locate and note the depth and thickness of all clay or mud seams or cavities. These shall be clearly shown in each box and on the drilling log. Wherever core is lost or at any known seam or cavity, a spacer shall be placed in the proper relative position in the core box. The space shall be the length of the core lost

or the length of the cavity, and shall be marked with the top depth and length of the missing core and the nature of the missing segment (e.g., "lost core", "cavity", etc.). Any core that is removed from the box for testing or any other purpose shall be replaced by a spacer equal in length to the removed core, marked with the date, purpose, and name of the party responsible for the removal. The total length of core obtained and the corresponding distance drilled shall be shown on the boring log for each core pulled. Wooden blocks marked with the appropriate elevations or depths shall be inserted between each pull of core. The blocks may be marked in either depth or elevation, but not both, and the marking system shall be consistent for all borings, both for the logs and boxes used for cores.

- d. The time required to drill each 12-inches of depth shall be noted and recorded.
- 19. For horizontal drilling, adhere to the requirements of Paragraphs 1 through 17 herein above, as applicable.
- 20. Drill holes for horizontally mounted instruments at the locations and to the depths shown on the Contract Drawings. Drill holes by a method that results in relatively smooth walls with minimal washouts and enlargements. Angle holes downward at approximately 10-degrees from true horizontal to facilitate the grouting of each installed instrument for its entire length.
- C. Installation procedures for instruments in boreholes shall be such that all steps in the procedure can be quality assured. Granular bentonite shall be placed in depth increments not exceeding 2-feet. Volumes of each increment of backfilling with sand shall be small enough such that no bridging occurs. The depth to the top of each increment of sand or granular bentonite shall be checked after placement.
- D. Place grout using a tremie method with side discharge ports on the tremie pipe.
- E. Before installing any instrument through drill casing or augers, thoroughly remove all material adhering to the inside of the casing or augers, and all cuttings.
- F. Whenever withdrawing drill casing or augers during instrument installation in a borehole, take care to minimize the length of unsupported borehole and the rate of casing or auger withdrawal. Do not allow collapse of the borehole to occur. Do not allow backfill material to build up inside the casing or auger such that the instrument is lifted as the casing or auger is withdrawn. Withdraw the casing or auger without rotation. The casing or auger may be omitted, if allowed by the Resident Engineer, only where it can be shown that instrument installation without the casing or auger will not cause collapse of the borehole or in any way adversely affect instrument installation. If casing or augers are omitted, or the Resident Engineer allows withdrawal of casing or augers before instrument installation, the following requirements shall apply:
 - 1. Install the instrument in the borehole in a continuous operation, starting when instrumentation materials are first placed in the borehole, and do not interrupt before complete backfilling of the borehole to the ground surface.
 - 2. Do not leave partially completed instrument installations in unsupported boreholes overnight or longer without the prior written concurrence of the

Resident Engineer.

- G. Notify the Resident Engineer at least 24 hours before installing each instrument.
- H. Install instrumentation, in addition to that specified herein, that Contractor deems necessary to ensure the safety of personnel and the Work. Notify the Resident Engineer at least 24 hours before installing any such additional instrumentation. Data resulting from such instrumentation are referred to herein as Contractor's Data, together with data specified. Such Contractor's Data will be reviewed by the Resident Engineer only if the data are obtained from instrumentation furnished, calibrated, tested, installed, and maintained as specified herein, if the data are collected and plotted as specified herein, and if submitted to the Resident Engineer within one month of data collection.
- I. Extend installed instrumentation and reinstall roadway boxes as necessary as grade changes occur, and revise instrument reference elevations as necessary.
- J. All instruments shall be labeled with their reference number at the location where readings or measurements are taken. The labeling shall be permanent using a method or material as reviewed by the Resident Engineer.
- K. As each instrument is installed, an installation record sheet shall be prepared, including appropriate items from the following list:
 - 1. Project name.
 - 2. Contract name and number.
 - 3. Instrument type and number, including readout unit.
 - 4. Planned location in horizontal position and elevation.
 - 5. Planned orientation.
 - 6. Planned lengths and volumes of backfill.
 - 7. Personnel responsible for installation.
 - 8. Plant and equipment used, including diameter and depth of any drill casing or augers used.
 - 9. Date and time of start and completion.
 - 10. Spaces on record sheet for necessary measurements or readings required at hold points during installation to ensure that all previous steps have been followed correctly, including instrument readings made during installation.
 - 11. An inspector's log of subsurface data indicating percent recoveries, RQDs, and the elevations of strata changes encountered in the borehole where rock cores are recovered, and to the extent that is possible by recovering grab samples and observing drill water return in other boreholes. Strata nomenclature and description shall be based on profiles and boring logs contained in the Geotechnical Baseline Report and the Contract Drawings. Driller's logs are not required for instrumentation boreholes.

12. Type of backfill used.
 13. As-built coordinates in horizontal position and elevation including:
 - a. Elevation referenced to the ESA Project Elevation Datum, in which 300-feet is equivalent to NAVD-88 Elevation 0, together with the location of the point used for the elevation measurement.
 - b. Horizontal position referenced both to the Long Island Zone State Plane Grid Coordinates, as referenced to the North American Datum of 1983 (NAD 83) and to Project Baseline Station and Offset, together with the location of the point used for horizontal position measurement.
 - c. A location sketch showing the instrument number, taped horizontal distances to the instrument, measured to an accuracy of plus or minus 0.3-foot from permanent physical features in the field. A sufficient number of taped measurements shall be included on the sketch to establish a unique horizontal position for the instrument. If such features are removed, provide a new sketch, before removal, with taped measurements to other features.
 - d. See Section 01720 for surveying requirements.
 14. As-built orientation.
 15. As-built lengths and volumes of backfill.
 16. Result of post-installation acceptance test.
 17. Weather conditions at the time of installation.
 18. A space on record sheet for notes, including problems encountered, delays, unusual features of the installation, and details of any events that may have a bearing on instrument behavior.
- L. Before being accepted, all instruments are required to undergo post-installation tests that demonstrate proper installation and function. Test requirements are either included directly in this Section or are developed by Contractor during preparation of detailed step-by-step procedures that have been submitted to the Resident Engineer for review. As a minimum, an acceptance test shall consist of a series of three readings that fall within the range of repeatability stated in the accepted manufacturer's instrument data sheet.
- M. An instrument that fails the specified post-installation acceptance test shall be replaced by an identical instrument.
- N. After installation, roadway boxes shall be free draining. Roadway boxes that are not free draining shall be repaired or replaced.
- O. Submit updated as-built instrument coordinate plans to the Resident Engineer. The location plans shall be reproducible composite plans of all installed instruments plotted on 24-inch by 36-inch sheets at a scale of 1-inch equals 40-feet. The first

plans shall be submitted within one month after completion of the first instrument installation, regardless of instrument type. Updated plans shall be submitted every subsequent four weeks. Updated plans need not be submitted for periods during which no instruments have been installed. For Contractor's convenience, planned instrumentation locations will be made available by the Resident Engineer in MicroStation format.

- P. Installation through or within existing NYCT subway structures may require closure of adjacent tracks, de-energization of adjacent third rail, and flag protection during operations within the structure in accordance with Section 01160. Coordinate all such actions through the Resident Engineer.
- Q. Before instrument installation, the conditions of each instrumented area shall be photographically recorded and a standardized record submitted to document the conditions. Where applicable, the conditions of surrounding structures shall be included.

3.03 INSTALLATION OF DEEP BENCHMARKS

- A. Deep benchmarks shall be installed at the locations and depths shown on the Contract Drawings.
- B. Drill ahead of outer casing, as required, to penetrate dense soil and weathered and fractured rock.
- C. Drill and sample penetrated materials in accordance with the requirements specified elsewhere herein.
- D. The outer casing shall be seated firmly within weathered and fractured rock. Drill below the outer casing to the depth shown. Blow out soil and rock fragments from the drilled hole with compressed air of sufficient pressure introduced at the bottom of the drill hole.
- E. The bottom of the inner pipe shall be as shown, a minimum of 12-feet within sound, unweathered bedrock, as defined by the Resident Engineer, from examination of rock cores recovered by Contractor during the drilling.
- F. Relative depths of couplings on the inner and outer pipes shall be planned such that there will be no possibility of them being alongside each other at any time during construction.
- G. The annulus between the inner and outer pipes shall be filled with bentonite slurry.
- H. Grout consisting of Type I or Type II Portland cement and water shall be placed in drilled hole, and inner pipe shall be seated by penetrating into the cement grout as shown.
- I. During assembly and lowering into outer casing, centering devices shall be installed between the inner pipe and outer casing as shown.
- J. Stainless steel ball reading point shall be welded to top end of the inner pipe.

- K. After completion of installation, the as-built elevation of the stainless steel ball shall be determined to an accuracy of plus or minus 0.01-foot and its horizontal position shall be determined to an accuracy of plus or minus 0.3-foot.

3.04 INSTALLATION OF OPEN STANDPIPE PIEZOMETERS

- A. Install open standpipe piezometers at the locations shown on the Contract Drawings, to the depths shown on the Contract Drawings.
- B. Installation:
 - 1. For each open standpipe piezometer installation, drill hole using water as the drilling fluid, and support hole by using hollow stem auger or by installing temporary casing. The minimum diameter of the hole shall be 5-inches. Keep log of soils encountered during drilling and submit to the Resident Engineer.
 - 2. When drilling is completed, flush hole with clean water to remove drilling fluid.
 - 3. Place 2-feet minimum of filter sand in the bottom of the hole. Then, insert the well screen and standpipe assembly into the hole. Fill the annulus between the well assembly and the wall of the hole with filter sand to within 1-foot minimum above the well screen, withdrawing the hollow stem auger or temporary casing as the sand is placed to prevent caving of the hole around the filter medium or standpipe.
 - 4. Seal the hole with 3-feet minimum of bentonite above the filter sand and fill the remainder of the hole to 2-feet below ground surface with Portland cement grout.
 - 5. Fill the top 2-feet of the hole with lean concrete and set the terminal box and lockable cover in place flush with the surrounding ground surface. Fit the top of the standpipe with a vented screw plug.
 - 6. After completion of installation, survey the as-built collar elevation to an accuracy of plus or minus 0.01-foot and its horizontal position to an accuracy of plus or minus 0.3-foot. Prepare a well log for the observation well in accordance with applicable regulations.
- C. Before construction operations, demonstrate that each piezometer is functioning properly by adding or removing water, measuring rates at which water levels fall and rise in standpipes, and comparing the final water levels with pre-test levels, in the presence of the Resident Engineer.
- D. During construction operations, periodically demonstrate continued proper functioning of each piezometer by performing rising and falling head tests on the following anticipated schedule: every 3 months plus whenever the monitoring personnel report an apparent problem with a specific instrument. Duration is until completion of Contract Work.

- E. Protect and maintain piezometers in satisfactory working condition until completion of the Contract. Clean out all clogged piezometers by flushing with water or other suitable means.

3.05 INSTALLATION OF MOVEMENT MONITORING POINTS

- A. Movement monitoring includes measurement of both horizontal and vertical movement of facilities. Movement monitoring points shall be installed at the locations shown on the Contract Drawings. Column/building movement points shall typically be installed into vertical surfaces of buildings or into horizontal concrete and rock surfaces (e.g., sidewalks, granite curbstones). Drilled holes shall be located to avoid historically and architecturally significant design features of the structure. Holes for anchor sleeves shall be drilled into horizontal mortar joints where possible.
- B. Where structure movement points are installed on surfaces that will be snow plowed, the points shall be recessed to minimize damage. The carriage bolt in column/building movement points shall be kept permanently fixed in the anchor with thread-locking compound.
- C. After completion of installation of a movement monitoring point, the as-built location in horizontal position shall be determined to an accuracy of plus or minus 0.3-foot, and the elevation to an accuracy of plus or minus 0.01-foot.
- D. Surface movement points shall be installed as shown and as follows:
 - 1. Flexible Pavement, Transit Station Platforms, and Inverts or Safety Walks of Existing Tunnels: Use stainless steel bolts (S2) as shown, suitable for use with leveling rod.
 - 2. Rigid Pavement/Sidewalk (S1):
 - a. Drive pipe to depth shown using a coupling and nipple as striking surface.
 - b. Remove coupling and install pipe cap with read point.
 - c. Excavate area around pipe and place curb terminal box. Backfill outside of box and leave box with cover locked.
- E. Structure Monitoring Points (SM and SP):
 - 1. Drill a hole of required diameter and depth.
 - 2. Remove drilling debris from the hole by air or other suitable means.
 - 3. Assemble the expansion anchor and insert it into the hole.
 - 4. Tap outer sleeve onto wedge nut to achieve initial sleeve contact with wall of hole.
 - 5. Expand outer sleeve into tight contact with wall of hole by turning bolt until anchor is rigid within the hole. Exercise care not to strip wedge nut threads by excessive turning of bolt.

6. Install optical survey prisms as shown in accordance with the manufacturer's recommendations.
7. Placement:
 - a. Structural monitoring points (SM) on vertical surfaces consist of bent round head bolts. They shall be installed 3- to 5-feet above grade.
 - b. Structural monitoring points (SP) on buildings shown on Contract Drawings consist of two vertically offset anchors equipped with precise optical prisms. The lower installation level shall be 15-feet above grade and referred to as Level "A". For buildings of up to six stories, Level "B" shall be approximately 20-feet above Level "A". For buildings of more than six stories, Level "B" shall be approximately 60-feet above Level "A". Locations shall be determined in the field by Contractor and reviewed by the Resident Engineer.

3.06 INSTALLATION OF DYNAMIC STRAIN GAUGES

- A. Installation shall be in accordance with manufacturer's recommendations for installation for recording dynamic strain on concrete.
- B. Gauges shall be installed at locations as shown on the Contract Drawings.
- C. Preparation of concrete surface shall include a cleaning of the surface and impregnation of the concrete surface with specified epoxy adhesive.
- D. Installation of gauges to concrete shall be with the same epoxy adhesive on impregnated surface.
- E. Wiring of gauges shall be with three-wire circuit to the Wheatstone bridge, with adequate care taken that soldering operation does not damage gauges.
- F. Following wiring, gauges shall be encapsulated with the same epoxy adhesive.
- G. After completion of installation, a post-installation acceptance test shall be performed to determine that the circuits are complete and can be balanced.
- H. After completion of installation, the as-built location shall be recorded to an accuracy of plus or minus 0.3-foot.

3.07 INSTALLATION OF IN-PLACE INCLINOMETERS

- A. Inclinator casings shall be installed at the locations and depths shown on the Contract Drawings. After installation, the casing groove spiral shall not exceed one degree per 10-feet of length, the orientation of the grooves at the top of the casing shall be within 10-degrees of the planned orientation, and no part of the casing shall deviate from vertical by more than 4-percent of the depth to that part. Groove spiral and orientation and casing verticality shall be demonstrated by Contractor to the satisfaction of the Resident Engineer.

- B. Drill and sample inclinometer holes in accordance with the requirements specified elsewhere herein.
- C. Grooves shall generally be oriented such that the A-axis is perpendicular to the longitudinal axis of the tunnel or cavern to be monitored or as approved by the Resident Engineer. Groove orientation shall be maintained throughout installation.
- D. Fill the casing with non-toxic anti-freeze with a propylene glycol base as required.
- E. After completion of casing installation, a post-installation acceptance test shall be performed to verify that there is no grout in the inclinometer casing, that groove orientation and verticality are correct, and that the inclinometer probe tracks correctly in all four orientations.
- F. In-place inclinometer components shall be installed within the casing in accordance with the reviewed submittals. Each in-place inclinometer shall be cabled to a datalogger.
- G. After completion of installation of in-place inclinometer components, perform post-installation acceptance test by reading the in-place inclinometer to ensure correct functioning.
- H. After in-place inclinometer installation, the as-built location of the top of the casing in horizontal position shall be determined to an accuracy of plus or minus 0.3-foot and in elevation to an accuracy of plus or minus 0.01-foot. The point selected to determine horizontal position shall be indicated on the installation record sheet.

3.08 INSTALLATION OF TUNNEL DEFORMATION MONITORING INSTRUMENTS

- A. Existing Tunnels:
 - 1. Install reference points in arrangement shown on the Contract Drawings and in accordance with the accepted installation schedule and the requirements specified herein. All reference points shall be fixed in place so that no movement in drill hole may occur at any time during the construction period.
 - 2. Use suitable anchor types for reference points to avoid damage to the existing tunnel support lining.
 - 3. Tape extensometer readings are not permitted in existing NYCT tunnels.
- B. New Tunnels and Caverns Under Construction:
 - 1. Install convergence bolts in drill-and-blast tunnels and caverns during the installation of initial support. All convergence bolts shall be fixed in place so that no movement in drill hole may occur at any time during the construction period.
 - 2. In TBM tunnels, in areas to receive cast-in-place concrete lining in this Contract, install convergence bolts during the installation of initial support and in a way that permits integration with the installation schedule and placement of the ventilation line and other construction utilities.

3. Drill holes at convergence bolt locations to a depth that allows sufficient embedment of the convergence bolt in the existing rock.
4. Use fast setting grout for anchorage.
5. Install convergence bolts such that they protrude perpendicular from the rock or the initial shotcrete surface at installation location.
6. Convergence bolts shall be located between steel rib locations and in positions that will not be affected by action of the TBM gripper pads.
7. Temporarily protect convergence bolts from covering by shotcrete and damage, if excavation or shotcreting is carried out in close vicinity.
8. For the duration of the construction or until final cast-in-place concrete lining installation, all convergence bolts shall be protected against mud and damage using appropriate means with signal color.
9. The use of convergence bolts for support of temporary or permanent facilities (cables, pipes, fan lines, etc.) will not be permitted.
10. If partial drifts are used, all drifts will be monitored as shown on the Contract Drawings.
11. In TBM tunnels with precast concrete lining, install convergence bolts as soon as practicable after the precast concrete rings are completed in a way that permits integration with the installation schedule and placement of the ventilation line and other construction utilities.

3.09 INSTALLATION OF SEISMOGRAPHS

- A. Seismographs are portable units to be deployed immediately before any vibration-producing construction activity. Certain surface and seismograph geophone locations within NYCT tunnels will be designated before commencement of blasting. Where these locations are on concrete and known at the time of initial document submission for blasting, as indicated in Section 02414, drill and install "Red Head" anchors, or approved equal, at these locations, and show on an As-Built Drawing and in a written report where such anchors have been installed.
- B. If Contractor installs additional seismographs to collect Contractor's Data as defined elsewhere herein, vibration sensor locations shall include points on the ground surface between 3- and 6-feet from the faces of buildings. Seismograph vibration sensors shall be firmly mounted on the surface slab of concrete or asphalt, bolted into "Red Head" anchors set into surface where permissible, or firmly set in undisturbed soil with seismograph manufacturer-supplied geophone spikes.

3.10 INSTALLATION OF AUTOMATED MOTORIZED TOTAL STATIONS

- A. Installation shall be under the direction of the AMTS Specialist who shall select the locations of the prisms and total stations, based on the locations shown on the Contract Drawings and submit for review to the Resident Engineer. These locations shall take into account ambient conditions such as sight distances, lines of sight, vibration of structures, train, traffic, and pedestrian interference, and temperature diffraction effects. The locations of the reference prisms shall take into account the

need for them to be outside the zone influenced by tunnel construction. Deep benchmarks located along the tunnel alignment, but outside the probable zone of influence, should be used for this purpose to the extent possible.

- B. Immediately after completion of installation of each total station and associated prisms, perform post-installation acceptance tests to ensure that the system is functioning correctly. Post-installation acceptance tests shall be made in accordance with the detailed step-by-step procedures that were submitted as specified elsewhere herein and as reviewed by the Resident Engineer.
- C. A baseline survey and as-built locations record shall be carried out using total station surveying methods.

3.11 INSTALLATION OF LIQUID LEVEL SURVEY SYSTEM

- A. Contractor may refer to Reference Document "Photographs of Existing NYCT and MNR Facilities" for general guidance on existing conditions of underground areas to be instrumented with LLSS. Clearance envelopes for rolling stock are included in Section 01160.
- B. Install LLSS including liquid level sensors and all associated components at locations as shown on the Contract Drawings and in accordance with the manufacturer's installation procedures. Install carrier pipes so that they are level, i.e., at 0-degree grade for their entire length between sensors, and add liquid so that it rises to no greater than 1/2-diameter in the carrier pipes.
- C. Install protection for all exposed data collection components and cables in accordance the manufacturer's recommendations.
- D. Each LLSS shall be referred to a settlement sensor that is located outside the zone influenced by tunnel construction. If required, Contractor may use other means of settlement determination such as optical leveling to refer the LLSS to a stable location outside the influence zone, provided the accuracy as specified for the LLSS is achieved. Deep benchmarks located along the tunnel alignment should be utilized for this purpose to the extent possible.
- E. After installation of the LLSS, determine the as-built location of all LLSS settlement sensors, pipe segments, and other components to an accuracy of plus or minus 0.3-foot in horizontal position and plus or minus 0.01-foot in elevation.
- F. Immediately after installation of the LLSS, perform post-installation acceptance tests to ensure that the system is functioning correctly. Post-installation acceptance tests shall be made in accordance with the detailed step-by-step procedures submitted as specified elsewhere herein and as reviewed by the Resident Engineer.

3.12 INSTALLATION OF VERTICAL MULTIPLE POSITION BOREHOLE EXTENSOMETERS

- A. Approximate anchor locations indicating three, four, or five per drill hole are shown on the Contract Drawings. Final locations will be selected by the Resident Engineer after inspection of drill cores. Installed depths of anchors shall be within 6-inches of the depths indicated by the Resident Engineer.

- B. Drill and sample geologic materials in accordance with requirements specified elsewhere herein.
- C. Boreholes for MPBX shall penetrate to a depth encroaching on the future cavern or tunnel excavation clearance as shown. Suitable indicator means such as colored plastic pipe or dyed grout shall be used to indicate the presence of the MPBX to Contractor installing rock bolts from within the cavern. The proposed indicator means/methods shall be submitted to the Resident Engineer for review.
- D. Demonstrate that no part of the completed drill hole has deviated from vertical by more than 4-percent of the depth to that part.
- E. The initial settings of the vibrating wire transducers shall be as determined by the Resident Engineer.
- F. After completion of installation, but before the grout has set, verify that there is no grout or other material on the head that would obstruct the smooth movement of the rods within their protective sleeving, and perform a post-installation acceptance test by taking a manual reading on each rod, and also a vibrating wire transducer reading on each rod, to ensure correct functioning.
- G. After completion of installation, the as-built location in horizontal position shall be determined to an accuracy of plus or minus 0.3-foot and the elevation of the top of the reference head to an accuracy of plus or minus 0.01-foot.
- H. After completion of installation, perform post-installation acceptance test by reading the MPBX to ensure correct functioning.

3.13 INSTALLATION OF HORIZONTAL MULTIPLE POSITION BOREHOLE EXTENSOMETERS IN NEW TUNNELS

- A. Approximate anchor locations indicating three per drill hole are shown on the Contract Drawings. Final locations will be selected by the Resident Engineer. Installed depths of anchors shall be as indicated.
- B. Drill in accordance with recommendations of the instrument manufacturer. The instrument head recess shall be created by reaming the approximately 3-inch diameter drill hole out to approximately 5-inches, sufficient for manipulation of connections and application of protective measures between readings.
- C. Once the anchors and rods are secured in place, the drill hole shall be grouted for its entire length up to the reference head, beginning at the back of the hole, by use of a small tremie tube that is gradually withdrawn as the grout is emplaced.
- D. Drill holes shall be angled downward at approximately 10-degrees from the horizontal to facilitate grouting. No part of the completed drill hole shall deviate from its intended location by more than 4-percent of the depth to that part.
- E. The initial settings of the vibrating wire transducers shall be as determined by the Resident Engineer.

- F. After completion of installation, but before the grout has set, verify that there is no grout or other material on the head that would obstruct the smooth movement of the rods within their protective sleeving, and perform a post-installation acceptance test by taking a vibrating wire transducer reading on each rod, to ensure correct functioning.
- G. After completion of installation, the as-built location shall be defined by the determination of the tunnel side, stationing, inclination of hole, and distance above or below springline.
- H. After completion of installation, perform post-installation acceptance test by reading the MPBX to prove proper function.
- I. After each extensometer reading, including verification readings by the Resident Engineer, coil the signal cables inside the recess and pack the recess for its entire length with a strong but pliable material to serve as protection against construction operations including blasting, as applicable.

3.14 INSTALLATION OF BIAXIAL TILTMETERS

- A. Tiltmeters shall be securely mounted to the structures using methods as recommended by the manufacturer, at the locations shown on the Contract Drawings. The sensitive axes of the tiltmeters shall be mounted perpendicular and parallel to the face of the structure.
- B. Each tiltmeter or group of tiltmeters shall be cabled to a datalogger.
- C. After tiltmeter installation, perform post-installation acceptance tests by reading the tiltmeter to ensure correct functioning.
- D. After tiltmeter installation, the as-built location in vertical and horizontal position shall be determined to an accuracy of plus or minus 0.3-foot.

3.15 INSTALLATION OF CRACK GAUGES

- A. If Contractor elects to install either grid crack gauges or vibrating wire crack gauges, installation shall be done in accordance with the manufacturer's recommendations, and the as-built location recorded after completion of installation.

3.16 FIELD CALIBRATION AND MAINTENANCE

- A. Existing observation wells located along the Manhattan tunnels alignment are shown on the Contract Drawings and As-Built Drawings of ESA Contract CM016 depicting various instrument types installed previously within NYCT and at the surface in the area of the approach tunnels. In addition, at the Queens Contractor access and staging area, the following instruments are in place and functional: open standpipe piezometers; inclinometers in soil; inclinometers in slurry walls; AMTS; AMTS survey prisms and equipment to operate the total station and data transmission links to the Resident Engineer's office. Conduct regular maintenance on existing field terminals and accessible existing instruments and components until completion of Work for this Contract.

- B. When using survey instruments for collecting Additional Contractor's Data, perform an EDM calibration to determine the zero error and scale error on a calibration baseline that meets NGS standards (example Georgetown, Marlboro, etc.). The length of the calibration baseline shall span a range of distances that will be encountered during the Work. Before performing the calibration, check the adjustment of the tribrachs. The calibration shall be performed every six months, and the results applied to each distance measurement. Obtain an access permit from the appropriate agency, and make the necessary arrangements before any visit to a calibration baseline. When used for collecting Contractor's Data, Contractor's level shall be peg-tested, and adjusted if necessary once a week to check for collimation error.
- C. For inclinometer casings filled with antifreeze, as specified, maintain the concentration of the antifreeze, by replacing or adding as necessary, throughout the duration of the Contract.
- D. Once every month when MPBX readings are to be made for collecting Contractor's Data, check the mechanical readout unit within the calibration standard before any vibrating wire transducer readings are made, and verify that the reading has not varied by more than 0.002-inch from all previous such values. Correct functioning of each vibrating wire transducer shall then be verified by taking a duplicate reading with the mechanical readout unit.
- E. Field calibration and maintenance of the LLSS shall be in accordance with manufacturer's recommendations.
- F. Calibration and maintenance of the automated motorized total station systems shall be in accordance with the recommendations of the manufacturer and the Automated Motorized Total Station Specialist.
- G. Ensure that all instruments providing data for the Contract including instruments installed by others remain functional to the end of construction.
- H. Carry out maintenance in accordance with the plan reviewed by the Resident Engineer.
- I. Use qualified and accepted instrumentation personnel, replace or repair instruments that are damaged or become non-functional. Failure to effect repair or replacement within 72 hours of being notified of instrument malfunction may result in the issuance of a stop work order by the Resident Engineer.

3.17 DATA COLLECTION

- A. Take baseline readings as defined elsewhere herein on all instruments installed by Contractor (except noise and vibration, which will be collected by the Resident Engineer and confirmed with the Contractor). Confirmed these readings with the Resident Engineer as defined herein. All subsequent readings will be compared to the baseline readings to determine levels of change.
- B. The instruments exterior to the new tunnels under construction shall be handed over to the Resident Engineer for continuation of the readings for duration of the Project after baseline readings have been established.

- C. Formal initial readings for instruments are not differentiated in terms of whether they are installed in the NYCT tunnels, or on buildings located at the ground surface. In both cases, all instruments are to be read three times per 24-hour day for one calendar month, immediately after installation, except for the new tunnel deformation instrumentation. These readings shall then be used to establish the baseline readings with the Resident Engineer.
- D. The following assumed data collection schedule is presented only for estimating the storage requirements of dataloggers and IDS units required.
1. Following the baseline reading establishment as indicated in Paragraph C above, readings will continue to be taken by the Resident Engineer according to the following schedule, which is stated with respect to a given instrument location and its plan distance from the excavation heading.

Plan Distance of Instrument from Excavation Heading	Reading Frequency
Less than 25-feet	Two times per 8-hour shift
Between 25-feet and 50-feet	Once per 8-hour shift
Between 50-feet and 100-feet	Twice per 24-hour day
Between 100-feet and 200-feet	Once per 24-hour day
Between 200-feet and 500-feet	Once per 7-day week
Greater than 500-feet	Once per 30-day month

- E. Provide to the Resident Engineer access and, as required, assistance in accessing all instruments for instrument reading at any time.
- F. Submit baseline readings and sign agreement to such readings in the format provided by the Resident Engineer.
- G. Record data on field data records including, but not limited to, the following list. Record data in U.S. customary units such as feet, inches, pounds, etc.
1. Project name
 2. Contract name and number
 3. Instrument type
 4. Date and time
 5. Observer
 6. Readout unit number
 7. Instrument number
 8. Readings
 9. Remarks
 10. Visual observations

11. Other causal data including weather, temperature, and construction activities
- H. In addition to the data collected by the Resident Engineer and data required to be collected by Contractor such as groundwater levels and deformations inside the new tunnels under construction, collect data from instrumentation specified herein that Contractor believes are required to ensure the safety of personnel and the Work. Such data, together with data as specified, are referred to herein as Additional Contractor's Data. Such Additional Contractor's Data will be accepted by the Resident Engineer only if the data are collected and plotted in the format provided by the Resident Engineer, if readout unit materials and calibrations are as specified herein, and if submitted to the Resident Engineer within one month of data collection.
- I. Provide and facilitate safe access to the Work at all times for the Resident Engineer to collect data from specified instruments including existing instruments installed by others, and also from any additional instruments installed by Contractor as specified. Safe access shall include, but not be limited to, cessation of work activities, temporary relocation of obstructing materials and equipment, provision of ladders, working platforms and hoisting services, and any other needs that, in the opinion of the Resident Engineer, are necessary to ensure the safety of data collection personnel. Furnish two sets of safety equipment for use by the Resident Engineer when collecting data including, but not limited to, respirators and harnesses.
- J. The following paragraphs define formal initial readings that will be collected by the Contractor and formed the basis for establishing the baseline reading with the Resident Engineer. A series of readings from which a formal initial reading is chosen will be taken for each new instrument within a period of 15 minutes.
- K. A formal initial open standpipe piezometer reading will consist of the reading that is closest to the average of three readings with the water level indicator. The indicator will be removed from the standpipe between these three readings. Each reading other than the formal initial reading shall be a single reading with the water level indicator. Reading accuracy shall be plus or minus 0.05-foot.
- L. When collecting data, movement monitoring by surveying methods shall conform to the following requirements:
1. For vertical movement monitoring, perform runs by a single run beginning and ending on two different deep benchmarks. Use movement monitoring points as turning points or as intermediate foresights from two different turning points, allowing elevations to be adjusted and eliminating significant observational errors. The maximum length of line of sight shall be 230-feet, and the imbalance between backsight and foresight shall not exceed 30-feet. Allowable level loop misclosure shall not exceed plus or minus 0.033 times the square root of "M"-feet (where "M" is the distance of the level run in miles) for a single run between two deep benchmarks. A formal initial reading on a movement monitoring point will consist of the closest reading to the average of three elevations, from three independent level runs that meet the closure specified herein. Determine elevations established subsequent to a formal initial reading by a single run as specified herein. The least count (without estimation) of the rod and level combination shall read to 0.003-foot or less, such that the accuracy of an elevation measurement shall be plus or minus 0.01-foot (at 95-percent level of confidence).

2. For horizontal movement monitoring, if a theodolite is used, the direction measurements shall be made in two sets of direct and reverse pointings, changing the circle setting by 90-degrees between sets. Reduced directions shall be rejected if they deviate from the mean by more than 5-arc-seconds. Plumb the theodolite over the occupied point by a high precision optical plummet or mechanical centering device. When distances are measured with a tape, each distance shall be measured independently two separate times and shall be corrected for the temperature and tension of the tape. A formal initial reading on a movement monitoring point will consist of the reading that is closest to the average of three readings, from three independent set-ups, each as specified herein. Each reading other than the formal initial reading shall consist of a single set of readings, as specified herein. All readings shall be referenced to stable horizontal control points. Reading accuracy shall be plus or minus 0.03-foot. Horizontal control points will be installed by others.
- M. A formal initial MPBX reading will consist of the reading that is closest to the average of three readings with the datalogger and duplicate readings with the mechanical readout unit. Each reading other than the formal initial reading shall consist of a single reading taken with the datalogger. The elevation of the top of the anchor head shall be periodically surveyed to an accuracy of plus or minus 0.01-foot and anchor depth readings subtracted from the result for a determination of actual anchor elevation. Temperature measurements using the temperature sensors shall be made at the same time as datalogger readings. Readings on horizontal MPBX inside new tunnels under construction shall be collected by Contractor in the presence of the Resident Engineer, who will transcribe the data for inputting to the Project instrumentation database.
- N. A formal initial in-place inclinometer reading will consist of the reading that is closest to the average of three sets of readings with the datalogger and duplicate readings with the portable in-place inclinometer readout unit. Each reading other than the formal initial reading shall consist of a single set of readings taken with the datalogger. Temperature measurements using the temperature sensors shall be made at the same time as tilt sensor measurements.
- O. An inclinometer initial reading is defined as a set of readings at 2-foot intervals throughout the casing, and a second set at 180-degrees to the first set. A formal initial inclinometer reading will be selected from three readings as defined herein above, involving six complete traverses along the casing. Formal Initial Readings will be completed within 24 to 48 hours of receipt of Contractor's installation log, except as interrupted by weekends or holidays. Each reading other than the formal initial reading shall be a single reading. Check-sums (sum of two readings at the same depth but 180-degrees apart) shall be examined in the field. Except where obvious imperfections in the casing have affected the check-sums, the standard deviation of A- and B-axis check-sums over a 2-foot interval shall not exceed 0.0005-foot and 0.0010-foot, respectively.

- P. The Resident Engineer will collect baseline seismograph data before any vibration-producing construction activities to document background vibrations, and also at the start of vibration-producing activities to establish the maximum energy that can be used without surpassing acceptable vibration and overpressure levels at nearby facilities. The Resident Engineer will also monitor vibration during construction. Notify the Resident Engineer at least 24 hours before starting a new vibration-producing task. If Contractor installs additional seismographs to collect Additional Contractor's Data during construction, monitoring shall be as follows.
1. Monitoring during blasting operations shall consist of recording full waveform data to obtain peak particle velocities, overpressure levels, and corresponding frequencies.
 2. Monitoring during pile driving, rock drilling, pavement breaking, excavation, and other vibration-producing construction activity shall consist of recording peak particle velocities in histogram mode capable of being printed on a strip chart. Continuous monitoring and full waveform data shall be recorded and submitted as specified.
 3. During all monitoring of vibration-producing construction activities, document all events that are responsible for the measured vibration levels and submit the document to the Resident Engineer with the data.
- Q. Tunnel Deformation:
1. In existing tunnels, carry out formal initial readings as soon as practicable to establish the baseline readings.
 2. In new tunnels and caverns under construction, the single formal initial reading which shall also be the baseline reading shall be carried out by Contractor as soon as practicable but not later than 12 hours after installation. This and all subsequent readings shall be collected by Contractor in the presence of the Resident Engineer, who will transcribe the data for inputting to the Project instrumentation database.
- R. A formal initial set of LLSS readings will consist of the reading that is closest to the average of three readings of relative vertical position and temperature. Each reading other than the formal initial reading shall consist of a single reading of relative vertical position and temperature.
- S. A formal initial tape extensometer reading shall consist of the reading that is closest to the average of three readings, with the tape attached to the convergence bolts, that meets a repeatability of plus or minus 0.004-inch. The tape extensometer shall be removed from the convergence bolts between each of these readings and shall be untensioned and retensioned. Temperatures shall be measured and temperature corrections shall be made in accordance with the manufacturer's instructions. Each reading other than the formal initial reading shall consist of the average of two readings that meet a repeatability of plus or minus 0.004-inch with removal, untensioning, retensioning, temperature measurement, and correction as specified herein.

- T. A formal initial tiltmeter reading will consist of the reading that is closest to the average of three readings of tilt. Each reading other than the formal initial reading shall be a single reading taken with the datalogger. A temperature measurement using the temperature sensor shall be made at the same time as each reading of tilt.
- U. A formal initial dynamic strain gauge reading will consist of the reading that is closest to the average of three balanced static strain measurements (noting time and strain in microstrains) taken 15 minutes after the instrumentation is turned on. Each reading other than the formal initial reading shall consist of a balanced static strain measurement taken 15 minutes after the instrumentation is turned on, followed by:
 - 1. Static strain measurements taken 15 and 5 minutes before scheduled blast time. Coordination of timing with blasting personnel shall be established before any measurements are initiated.
 - 2. Dynamic measurements that begin at least two minutes before scheduled blast time and continue one minute beyond actual blast time.
- V. Monitoring of grid crack gauges shall be in accordance with the manufacturer's recommendations. A formal initial reading and each subsequent reading shall be a single reading.
- W. A formal initial reading of a vibrating wire crack gauge and each subsequent reading shall be a single reading.

3.18 DATA REDUCTION, PROCESSING, PLOTTING, AND REPORTING

- A. The Resident Engineer will implement an alarm system that notifies Contractor in a timely manner of significant instrumentation readings. Contractor will also have access to the electronic data that the Resident Engineer will place on the Project Limited Access Web Site for viewing and printing reports only. The Resident Engineer will provide Contractor with two - 1-day long training periods at the beginning of the Project and one day of supplemental training per month as requested by Contractor on the production of instrumentation reports from the data.
- B. If Contractor chooses to access and download data from the Web Site, the following data retrieval system is suggested as a minimum:
 - 1. Intel-based PC with Microsoft Windows XP operating system, 2.0-Ghz processor, 256-MB SDRAM, a 30-GB hard disk, and a CD drive.
 - 2. DSL modem and a dedicated telephone line.
- C. Contractor may access data from the Intranet according to the following schedules:
 - 1. For instruments monitored by datalogger, within 4 hours of data collection.
 - 2. For manually read, non-surveyed instruments, within 6 hours of data collection.
 - 3. For optically surveyed instruments, by 8:00 AM on the day following data collection.

4. When the periods specified are interrupted by weekends or holidays, the periods will be increased by up to 24 hours for each weekend day or each holiday day.
- D. The MTA does not warrant that electronic data will be available on the schedules described herein above, and it shall be understood that the MTA is not responsible for any delays or interruptions to Contractor's access to such data.
- E. The Resident Engineer will use its best efforts to provide hard copy data to Contractor in accordance with the following schedules:
1. All data provided no later than 4:00 PM on the day following the day on which data are collected.
 2. When the periods specified are interrupted by weekends or holidays, the periods will be increased by up to 24 hours for each weekend day or each holiday day.
 3. Weekly hard copy summary reports, generally within one week of data collection for data that the Resident Engineer anticipates are affected by construction activities.
- F. When the Resident Engineer determines from the data that a change has occurred, and the change, in the judgment of the Resident Engineer, is likely to require remedial or precautionary measures, the Resident Engineer will notify Contractor within a time period less than the periods specified above so that Contractor can verify the change and take appropriate action.
- G. When data indicate that a change has occurred as specified, initiate the response action(s) specified elsewhere herein.
- H. If Contractor submits Additional Contractor's Data to the Resident Engineer, the data shall be reported in the same Project data format as used by the Resident Engineer in providing data to Contractor.

3.19 LOSS OF OR DAMAGE TO INSTRUMENTATION

- A. Protect all instruments and appurtenant fixtures, leads, connections, and other components of instrumentation systems from damage due to construction operations, weather, traffic, and vandalism.
- B. If an instrument, including an existing instrument installed by others, is damaged or inoperative, Contractor's instrumentation personnel shall repair or replace the damaged or inoperative instrument within 72 hours. Where damage or improper function is due to Contractor's actions, including purchase of defective equipment, Contractor shall be responsible for repair or replacement. If an instrument wears out or is damaged through no fault of Contractor, the cost of repair or replacement will be reimbursed by the MTA. Notify the Resident Engineer at least 24 hours before repairing or replacing a damaged or inoperative instrument. The Resident Engineer will be the sole judge of whether repair or replacement is required.

3.20 DISCLOSURE OF DATA

- A. Do not disclose any instrumentation data to third parties and do not publish data without prior written consent of the MTA.

3.21 INTERPRETATION OF DATA AND IMPLEMENTATION OF PLANS OF ACTION

- A. Interpret the data collected and provided by the Resident Engineer as well as any Additional Contractor Data. Interpretation shall include making correlations between instrumentation data and specific construction activities, including non-MTA activities such as building foundations and excavations for utilities and geological conditions revealed by the Resident Engineer's mapping of new tunnels under construction. Instrumentation data shall be evaluated to determine whether the response to construction activities is reasonable.
- B. Review levels of 1/8-inch have been assigned for settlement detection instruments (total station prisms and LLSS) on structural elements of buildings within the zone influenced by tunnel construction. Alert levels of 1/4-inch have been assigned for the same instruments. These levels shall be defined collectively as Response Levels. The actions associated with these levels are defined below. Plans for such actions are referred to herein as plans of action, and actual actions to be implemented are referred to herein as response actions. Review and Alert Levels are subject to adjustment by the Resident Engineer as indicated by prevailing conditions or circumstances.
 - 1. Review Level of 1/2-inch per second has been assigned for seismograph readings at all transit structures. Alert level of 1.92-inch per second has been assigned for the same readings except NYCT 63rd Street Tunnels and Tracks 5 and 6 at Second Avenue, where dynamic strains are specified in Sections 01572 and 02414.
 - 2. Alert Level for seismograph readings for historic landmark structures is specified in Section 02414.
- C. If a Review Level is reached:
 - 1. Meet with the Resident Engineer to discuss the need for response action(s). Contractor's qualified instrumentation personnel shall attend as necessary, including subcontractor specialists such as for AMTS and LLSS. Participation may be through conference calls if specialists cannot be available in person, but all participants shall be aware of relevant instrument readings and their interpretations.
 - 2. If directed by the Resident Engineer, during the above meeting, that a response action is needed, within 24 hours of receiving instrumentation data from the Resident Engineer indicating that a Review Level has been reached, submit a detailed specific plan of action, based as appropriate on the contingency plan submitted previously.
 - 3. If directed by the Resident Engineer, implement response action(s) within 24 hours of submitting a detailed specific plan of action, so that the Alert Level is not reached.

4. Install additional instruments if directed by the Resident Engineer.
- D. Take all necessary steps so that the Alert Level is not reached. Contractor may be directed to suspend activities in the affected area with the exception of those actions necessary to avoid reaching the Alert Level.
- E. If an Alert Level is reached:
1. Stop work.
 2. Meet with the Resident Engineer to discuss the need for response action(s). Contractor's qualified instrumentation personnel shall attend as necessary, including subcontractor specialists such as for AMTS and LLSS. Participation may be through conference calls if specialists cannot be available in person, but all participants shall be aware of relevant instrument readings and their interpretations.
 3. If directed by the Resident Engineer, during the above meeting, that a response action is needed, within 24 hours of receiving instrumentation data from the Resident Engineer indicating that an Alert Level has been reached, submit a detailed specific plan of action, based as appropriate on the contingency plan submitted previously.
 4. If directed by the Resident Engineer, implement response action(s) before resuming work.

3.22 DISPOSITION OF INSTRUMENTS

- A. Portable readout units furnished to the Resident Engineer for data collection shall become the property of the MTA. Portable readout units used by Contractor during installation, during pre- and post-installation acceptance testing, and for collecting Contractor's Data shall become the property of Contractor.
- B. It is the responsibility of Contractor to ensure that all instruments installed by Contractor and existing instruments installed by others shall be operational upon completion of the Work, if they are considered by the Resident Engineer to be necessary. If directed by the Resident Engineer, remove and dispose of those portions of instruments constituting an obstruction, including deep benchmarks, open standpipe piezometers, observation wells, survey targets, extensometers, and inclinometers. The Resident Engineer will be the sole judge of whether or not removal is required. For instruments installed in boreholes, the upper 2-feet of the instrument shall be removed, together with the ground surface protection. The remaining open portions of the instrument and casing shall be backfilled with cement grout up to a level 2-feet below the ground surface, and with lean concrete in the upper 2-feet. New pavement patches shall be constructed, in paved areas, of the same material and to the same thickness as existing adjacent pavement. Disturbed or damaged surfaces shall be restored to the satisfaction of the property owner and/or the Resident Engineer, and to the condition existing before installation of the instrument.

- C. To the extent practicable, where instruments have to be removed from floors, walls, ceilings, facades, or support columns to preserve the appearance of the instrumented structure, restore the surface to its original condition to the satisfaction of the property owner and/or the Resident Engineer by use of solvents, infilling, spackling, polishing, painting, or replacement.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for fences and gates indicated on the Contract Drawings and specified herein.
- B. The Work shall consist of providing new fences and gates, maintenance of existing fences and gates, and removal and relocation of existing fences and gates including posts, fittings, barbed wire, hardware, anchors, and concrete footings, if required.

1.02 REFERENCED SECTIONS

- A. Section 03300 - Cast-in-Place Concrete

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 2. A 121 - Zinc-Coated (Galvanized) Steel Barbed Wire
 - 3. A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 4. A 153 - Zinc-Coating (Hot-Dip) on Iron and Steel Hardware
 - 5. A 392 - Zinc-Coated Steel Chain-Link Fence Fabric
 - 6. A 526 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
 - 7. A 569 - Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial Quality
 - 8. A 752 - General Requirements for Wire Rods and Coarse Round Wire, Alloy Steel
 - 9. A 824 - Metallic-Coated Steel Marcellled Tension Wire for Use with Chain Link Fence
 - 10. B 117 - Salt Spray (Fog) Testing
 - 11. F 567 - Installation of Chain-Link Fence
 - 12. F 626 - Fence Fittings
 - 13. F 900 - Industrial and Commercial Swing Gates

14. F 1083 - Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
- B. Chain Link Fence Manufacturer's Institute (CLFMI) Standards for Chain Link Fence Installation

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Product Data: Submit manufacturer's product data and specifications of the specified chain link fencing and gates.
- B. Shop Drawings: Submit detailed Shop Drawings of the fences and gates layout, including installation details of the fencing, posts, gates, hardware, and accessories for review.

1.07 DELIVERABLES

- A. Gates and fencing shall be turned over to the MTA at the end of the Contract.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General: Fencing shall include framework, barbed wire and supporting arms, concrete footings, gates, hardware, and all appurtenances and accessories as required for a complete installation.
 1. The fence shall be galvanized chain link 84-inches wide, secured top and bottom to tension wire, for an overall height of 96-inches, or it shall frame to the soffit of the structure above, with a detail that allows vertical movement of the structure above.
- B. Fence Fabric:
 1. Zinc-coated steel fabric conforming to ASTM A 392 with Class 2 coating. Mesh size 2-inches square fabricated from 9-gauge wire.
 2. Zinc-coated steel fabric, Class 1, Class 2a, and Class 2b wire and fabric types are acceptable. Mesh size 2-inches square fabricated from 9-gauge wire.

3. Selvages: Twisted and barbed at top and bottom selvages when barbed wire is used; knuckled at both selvages when barbed wire is not used.
- C. Pipe Framework: Posts and rails shall be standard weight galvanized steel pipe conforming to ASTM F 1083. Sizes and weights shall be as follows, unless an alternate fencing design by a Professional Engineer licensed in the State of New York is provided.
1. End and Corner Posts: Minimum nominal outside diameter of 2.875-inches, weighing not less than 5.79-pounds per linear foot, for end, corner, and gate posts for gates 6-feet wide and smaller. Gate posts for gate leaves from 6- to 16-feet wide shall have minimum nominal outside diameter of 4-inches, weighing 9.11-pounds per linear foot.
 2. Line Posts: Nominal outside diameter of 2.375-inches, weighing not less than 3.65-pounds per linear foot.
 3. Rails and Braces: Nominal outside diameter of 1.660-inches, weighing not less than 2.27-pounds per linear foot. Posts shall include galvanized bolted fittings to properly secure rails and braces to posts.
- D. Tension Wire: Tension wire for top and bottom edge support of fence fabric shall be No. 7 gage steel wire, conforming to ASTM A 824, Class 3, with minimum tensile strength of 80,000-psi, zinc-coated wire with zinc coating of not less than 0.80-ounce per square foot.
- E. Post Caps and Fittings: Manufacturer's standard, pressed steel or malleable iron post caps, fittings, and accessories shall conform to ASTM F 626, galvanized for Type CL and RP fencing. Post caps shall be designed to fit securely over the posts to exclude water and to carry the top pipe rail and extension arms, where indicated. All other required fittings and hardware shall be provided to fasten to the pipe posts or concrete in the manner indicated.
- F. Truss Rods: Alloy steel rods conforming to ASTM A 752, with minimum tensile strength of 80,000-psi, and minimum diameter of 5/8-inch. Provide rods with threaded ends and self-tightening galvanized turnbuckles and anchor plates. Secure anchor plates to posts and gate frames by welding.
- G. Stretcher Bars: Provide one-piece lengths equal to full height of fabric with a minimum cross-section of 1/4-inch by 3/4-inch. Provide one stretcher bar for each gate and end post, and two for each corner and pull post.
- H. Stretcher Bar Bands: Provide galvanized heavy pressed steel or malleable iron bands with a minimum cross section of 1/8-inch by 3/4-inch, spaced not over 15-inches on center, to secure stretcher bars to end, corner, pull, and gate posts.
- I. Accessories: Provide miscellaneous materials and accessories, clips, tie wires (9-gauge), anchors, and fasteners as required for a complete installation. All items shall be galvanized in accordance with ASTM A 123 or ASTM A 153 as applicable.

- J. Barbed Wire Extension Arms: Pressed steel conforming to ASTM A 526, hot-dip galvanized after fabrication, complete with provision for anchorage to end, corner, and pull posts and for attaching three rows of barbed wire to each arm. Arms shall be 45-degree angle or vertical as indicated, for three strands of barbed wire. Arms shall be integral with post top weather cap. Intermediate arms shall have hole for passage of top tension wire. Arms shall be capable of withstanding 300-pounds downward pull at outermost end of arm without failure.
- K. Barbed Wire: Two-strand, zinc-coated, 12-1/2-gauge steel wire with 14-gauge, 4-point steel barbs spaced 5 inches apart, conforming to ASTM A 121. Zinc coating shall be Class 3, 0.80 ounce per square foot for 12-1/2-gauge wire and 0.65 ounce per square foot for 14-gauge wire.
- L. Gates: Gates shall be furnished complete with all hardware and accessories as required for a complete installation.
 - 1. Gate Frames: Frames shall be fabricated from zinc-coated steel pipe members (to match posts in fencing) having a minimum outside diameter of 1.9-inches and weighing 2.72-pounds per linear foot.
 - 2. Fabrication: Conform to applicable requirements of ASTM F 900 and the following:
 - a. Assemble gate frames by welding or with fittings and rivets for rigid connections. Use same fabric as for fence. Install fabric with stretcher bars at vertical edges, and tie wires at top and bottom edges. Attach stretcher bars to gate frame at not more than 15 inches on center. Attach hardware with rivets or by other means that will provide security against removal or breakage.
 - b. Provide additional horizontal and vertical members to ensure proper gate operation and for attachment of fabric, hardware, and accessories.
 - c. Provide diagonal cross-bracing consisting of minimum 1/2-inch diameter adjustable length truss rods on gates where necessary to provide frame rigidity without sag or twist.
 - 3. Gate Hardware:
 - a. Swinging Gates: Provide gate hinges, latch, stop, and keeper for each gate leaf, conforming to applicable requirements of ASTM F 900. Provide latch with provision for locking gate with padlock.
 - b. Sliding Gates: Provide manufacturer's standard rubber-tired rollers and roller track for post-supported sliding gates. Include intermediate rollers or casters where required to prevent gate sag or deflection. Provide locking device and padlock eyes as part of latch for locking gate with padlock.

- M. Pipe Sleeves: Pipe sleeves for fence post embedment in concrete curbs, barriers, and walls shall be fabricated from steel pipe conforming to ASTM A53 and galvanized in accordance with ASTM A 123, sized to receive and support fence posts.
- N. Locks: Padlock, switch, with weather flap and 13-1/2-inch chain, with "LIRR" logo, Adams and Westlake 48-600 using Key No. 600, or approved equal.

2.02 CONCRETE

- A. Provide concrete footings for fence posts under this Section unless post frames to existing concrete slab. Concrete for posts shall have a minimum compressive strength at 28 days of 3,000-psi, using 3/4-inch maximum size aggregate and five sacks of cement minimum per cubic yard, with a maximum slump of 4-inches. Concrete materials, placing, and curing shall conform to Section 03300.
- B. Footing sizes shall be sufficient to maintain post rigidity under loading.

PART 3 EXECUTION

3.01 PREPARATION

- A. Installation of permanent fencing shall not be started until directed by the Resident Engineer.
- B. Locate fencing correctly as indicated on the Contract Drawings. Alterations to Work areas shown on Contract Drawings may be negotiated with adjacent contractors through the Resident Engineer.
- C. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, coordinate the installation of fencing closely with the installation of concrete as specified in Section 03300.
- D. Furnish galvanized steel pipe sleeves for fence posts, as applicable, for installation in formwork at time required. Supervise installation of sleeves during formwork and placing of concrete to maintain exact dimensions according to template.

3.02 INSTALLATION

- A. Install fencing and gates as indicated, in accordance with reviewed Shop Drawings, and applicable requirements of ASTM F 567 and CLFMI standards. Site-fabricate as required to complete the fence installation.
- B. Posts shall be plumb and rigid after installation. Rails shall be straight and tight. Chain link fabric shall be smooth and uniformly stretched tight and straight. Tension wires and barbed wires shall be pulled taut.
- C. Drill holes for post footings in firm, undisturbed or compacted soil. Footing holes shall be not less than 9-inches in diameter and 38-inches in depth. Post embedment in concrete shall be 36-inches. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads.

- D. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, grout or seal posts in sleeves as indicated.
- E. Privacy screen shall be installed directly on chain link fencing in accordance with manufacturer's recommendations and instructions. Privacy screen shall be installed where indicated on the Contract Drawings.
- F. Gates shall be installed plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate. Sliding gates shall operate smoothly and easily under minimum pressure.
- G. Locate and install safety and restriction signs securely as indicated on the Contract Drawings.

3.03 CONCRETE

- A. Handling and placing of concrete shall conform to the applicable requirements of Section 03300.
- B. Place concrete around posts in a continuous pour. Check each post for plumb and vertical and top alignment, and hold in position during placement and finishing operations.
- C. Trowel-finish tops of footings, and slope or dome to direct water away from posts. Set keepers, stops, sleeves, tracks, eye bolts, and other accessories into concrete as required. Wheel rolling area for sliding gates shall be steel-trowel smooth finish concrete.

3.04 ELECTRICAL GROUNDING

- A. Where a power line carrying more than 600-volts passes over fence, install ground rod at the nearest point directly below each point of crossing. Ground all fences and gates.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for Work Site restoration and rehabilitation indicated on the Contract Drawings and specified herein.
- B. This Work shall consist of restoring all roadway and sidewalk surfaces and other surfaces of whatever nature that are disturbed in connection with the construction or maintenance of the Project.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. If, after due notice and within the time specified therein, Contractor does not perform such work of placing a temporary pavement, and work that may be necessary to maintain the temporary pavement, and also sidewalk surfaces in a condition satisfactory to the Resident Engineer, the MTA, as directed by the board or officer of the City of New York having jurisdiction, may call upon the NYCDOT Bureau of Highway Operations to do such temporary paving or maintenance work as may be necessary. The cost of such work shall be deducted from any moneys due to Contractor in the first subsequent estimate made after the work has been done by the NYCDOT Bureau of Highway Operations.
- B. Compliance with Local Laws and Procedures:
 - 1. Demonstrate that the construction procedures necessary to complete the Project will be in full compliance with the law and all ordinances of the City of New York that relate to street openings, replacement of pavement, keeping open passageways and protecting the same where they are exposed and potentially dangerous to the public travel, and maintenance of street hardware.
 - 2. Follow all applicable procedures and obtain all permits required by the NYCDOT Bureau of Highway Operations, which pertain to street openings, replacement of pavement, and maintenance of street hardware.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Administrative Code of the City of New York, Local Law No. 14 - Street Openings, Replacement of Pavement, and Maintenance of Street Hardware.

2. New York City Department of Transportation (NYCDOT), Bureau of Highway Operations:
 - a. Rules and Regulations.
 - b. Standard Specifications.
 - c. Street Design, "Standard Details of Construction".
 3. New York City (NYC) Department of Parks and Recreation
- B. Maintain and guarantee all backfilling and street and other surfaces restored as directed by the Resident Engineer.

1.06 SUBMITTALS

- A. Shop Drawings: Submit Shop Drawings for sidewalks and paved areas.
- B. Product Data: Submit manufacturer's literature describing each manufactured product assembly edited to job conditions.
- C. Design Mix: Submit the proposed job mix test data. After placement of pavement, certify that mix complies with the design mix formula.

1.07 DELIVERABLES

- A. Certification of Materials: Provide two copies of materials certification signed by the material producer and the installer, stating that each material item complies with, or exceeds, specified requirements, including aggregate and asphalt.

PART 2 PRODUCTS

2.01 GENERAL

- A. Material specifications shall conform to the NYCDOT Bureau of Highway Operations Standard Specifications and as specified herein.
- B. Asphaltic concrete wearing course, 2-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.02 AF. Asphaltic concrete wearing course, 3-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.02 AG.
- C. Concrete base for pavement, 6-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.04 AC. Concrete base for pavement, 8-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.04 CC.
- D. Straight steel faced concrete curb, 18-inches deep, shall meet the requirements of NYCDOT Standard Specifications Item 4.09 AD. Depressed steel faced concrete curb, 18-inches deep, shall meet the requirements of NYCDOT Standard Specifications Item 4.09 BD. Corner steel faced concrete curb, 18-inches deep, shall meet the requirements of NYCDOT Standard Specifications Item 4.09 CD.

- E. Unpigmented 4-inch concrete sidewalk shall meet the requirements of NYCDOT Standard Specifications Item 4.13 AA. Unpigmented 7-inch reinforced concrete sidewalk shall meet the requirements of NYCDOT Standard Specifications Item 4.13 BR.
- F. Topsoil shall meet the requirements of NYCDOT Standard Specifications Item 4.15.
- G. Grass seed shall meet the requirements of NYCDOT Standard Specifications Item 4.20.
- H. Reinforced concrete pavement, bus stops, shall meet the requirements of NYCDOT Standard Specifications Item 6.32 A.
- I. Thermoplastic reflectorized pavement markings shall meet the requirements of NYCDOT Standard Specifications Item 6.44.
- J. Dense graded stone base course shall meet the requirements of NYCDOT Standard Specifications Item 6.46.
- K. Sawcutting existing pavement shall meet the requirements of NYCDOT Standard Specifications Item 6.55. Sawcutting existing sidewalk shall meet the requirements of NYCDOT Standard Specifications Item 6.55 B.
- L. Tack coat shall meet the requirements of NYCDOT Standard Specifications Item 6.58.
- M. Snow-plowable raised pavement markers shall meet the requirements of NYCDOT Standard Specifications Item 6.85.
- N. Reflective cracking membrane, 18-inches wide, shall meet the requirements of NYCDOT Standard Specifications Item 6.91.
- O. Resetting existing sidewalk subway vent gratings shall meet the requirements of NYCDOT Standard Specifications Item 7.01A and as specified herein. Steel plate cover shall meet the requirements specified under ASTM A 36. Asphalt concrete wearing course shall meet the requirements of NYCDOT Standard Specifications 4.02 AG.
- P. Resetting bus shelter shall meet the requirements of NYCDOT Standard Specifications Item 7.56.
- Q. Removing, Storing and Resetting Signs: Materials for resetting various existing street name signs, bus stop signs, and traffic signs to be salvaged, including brackets, straps, hardware, supports and other required materials, shall meet the requirements of NYCDOT Standard Specifications Item 6.86.

PART 3 EXECUTION**3.01 STREET OPENINGS**

- A. Specifications for street openings shall be as specified in the NYCDOT Bureau of Highway Operations Rules and Regulations Appendix D.
- B. Temporary pavement for sidewalk surfaces shall conform to the requirements specified for temporary asphaltic pavement in the NYCDOT Rules and Regulations Appendix C, and Local Law No. 14.
- C. Temporary curb shall conform to the NYCDOT Standard Specifications.
- D. Maintain in good condition all temporary pavement constructed by others subsequent to acceptance by the Resident Engineer.

3.02 ROADWAY, SIDEWALK, AND OTHER CONSTRUCTION

- A. Construction of roadways, sidewalks, curbs, tree pits and other construction shall be in accordance with the requirements of the NYCDOT, Bureau of Highway Operations Standard Specifications Street Design - Standard Details of Construction, and as specified herein.
- B. Construction methods for asphaltic concrete wearing course, 2-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.02 AF. Construction methods for asphaltic concrete wearing course, 3-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.02 AG.
- C. Construction methods for concrete base for pavement, 6-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.04 AC. Construction methods for concrete base for pavement, 8-inches thick, shall meet the requirements of NYCDOT Standard Specifications Item 4.04 CC.
- D. Construction methods for straight steel faced concrete curb, 18-inches deep, shall meet the requirements of NYCDOT Standard Specifications Item 4.09 AD. Construction methods for depressed steel faced concrete curb, 18-inches deep, shall meet the requirements of NYCDOT Standard Specifications Item 4.09 BD. Construction methods for corner steel faced concrete curb, 18-inches deep, shall meet the requirements of NYCDOT Standard Specifications Item 4.09 CD.
- E. Construction methods for 4-inch concrete sidewalk, unpigmented, shall meet the requirements of NYCDOT Standard Specifications Item 4.13 AA. Construction methods for 7-inch reinforced concrete sidewalk, unpigmented, shall meet the requirements of NYCDOT Standard Specifications Item 4.13 BR.
- F. Construction methods for topsoiling shall meet the requirements specified under Item 4.15 of the Standard Specifications.
- G. Construction methods for grass seeding shall meet the requirements of NYCDOT Standard Specifications Item 4.20.
- H. Construction methods for reinforced concrete pavement, bus stops, etc. shall meet the requirements of NYCDOT Standard Specifications Item 6.32 A.

- I. Construction methods for thermoplastic reflectorized pavement markings shall meet the requirements of NYCDOT Standard Specifications Item 6.44.
- J. Construction methods for dense graded stone base course shall meet the requirements of NYCDOT Standard Specifications Item 6.46.
- K. Construction methods for sawcutting existing pavement shall meet the requirements of NYCDOT Standard Specifications Item 6.55. Construction methods for sawcutting existing sidewalk shall meet the requirements of NYCDOT Standard Specifications Item 6.55 B.
- L. Construction methods for tack coat shall meet the requirements of NYCDOT Standard Specifications Item 6.58.
- M. Construction methods for snow-plowable raised pavement markers shall meet the requirements of NYCDOT Standard Specifications Item 6.85.
- N. Construction methods for reflective cracking membrane, 18-inches wide, shall meet the requirements of NYCDOT Standard Specifications Item 6.91.
- O. Construction methods for resetting existing sidewalk subway vent gratings shall meet the requirements of NYCDOT Standard Specifications Item 7.01A and as specified herein. Modify walls of subway vent to provide for placement of temporary steel plate cover and asphalt concrete wearing course material as indicated. When no longer required, as determined by the Resident Engineer, remove and dispose of steel plate cover and asphalt concrete and the frame and grate reset to proper line and grade, and restore the area as indicated.
- P. Construction methods for resetting of bus shelter shall meet the requirements of NYCDOT Standard Specifications Item 7.56.
- Q. Construction methods for removing, storing and resetting various existing signs shall meet the requirements of NYCDOT Standard Specifications Item 6.86.
- R. Construction methods for removing, storing, and resetting mail boxes shall be as specified in the NYCDOT Standard Specifications.
- S. Construction joints shall be provided in accordance with the NYCDOT Standard Details of Construction.

3.03 LAYING IN DAYLIGHT: WET WEATHER AND COLD WEATHER

- A. Spread and compact mixtures during daylight unless otherwise permitted by the Resident Engineer, and then only when satisfactory artificial light is provided.
- B. Placement of bituminous paving materials shall not be scheduled when the precipitation probability, obtained by Contractor from the U.S. Weather Bureau within three hours before the start of such operations, equals or exceeds 50-percent. Notify the Resident Engineer of the exact time at which the above information was obtained.

- C. Generally, the laying of mixtures will not be permitted in wet weather. However, the Resident Engineer may permit work of this character to continue when overtaken by sudden rain, up to the amount that may be in transit from the plant at the time. The Resident Engineer will, however, order that under these conditions no additional trucks be loaded from the plant and no additional material will be permitted to be laid.
- D. Except by permission of the Resident Engineer, no mixture shall be laid when the air temperature in the shade is below 32-degrees Fahrenheit.

3.04 FINISH OF CONCRETE AT STREET SURFACE

- A. Construct and finish off the upper 3-inches of concrete walls or slabs that extend to the street surfaces such as at ventilating openings, bus stops etc., to form a cement sidewalk.

3.05 GRASS PLOTS AND TREES

- A. Where any grass plots or trees exist along any street or in other areas occupied by Contractor, take proper precautions to protect them from injury. For every tree removed, injured or destroyed, shall set out, either in the old or new location/locations, new tree/trees, balled and platformed, in accordance with NYC Department of Parks and Recreation requirements, in such position as the Commissioner of Parks and Recreation shall indicate. The number and type of new trees shall be approved by the Commissioner of Parks and Recreation. The normal formula for replacing the removed trees is to provide an equivalent number of total caliper inches of trees. All grass plots, shrubbery and other plants removed or affected by Contractor's operations, or by the construction of the shafts of the tunnel and other tunneling operations, shall be restored, as soon as possible, to as good a condition as existed before the commencement of the Work. In replanting trees and grass plots, Contractor shall be governed by the requirements of the NYC Department of Parks and Recreation or by other authorities specially charged with the care of these trees or grass plots, and the nature and depth of the soil to be placed therein must be approved by such authorities and reviewed by the Resident Engineer.

3.06 SURFACE OUTSIDE NET LINES TO BE RESTORED

- A. Restore all street and other surfaces (including the foundations thereof) outside the net lines of excavation, except as herein otherwise specifically provided for, either adjacent to or not adjacent to the line of the Project that may have become damaged, directly or indirectly, as a result of Contractor's operations, at Contractor's own cost and expense to a condition similar to and equally as good as that existing previous to the commencement of construction.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for concrete formwork indicated on the Contract Drawings and specified herein.
- B. The Work shall consist of designing, furnishing, fabricating, erecting, and removing formwork for cast-in-place concrete specified in Section 03300.

1.02 REFERENCED SECTIONS

- A. Section 03300 – Cast-in-Place Concrete

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI):
 - 1. 301 – Specification for Structural Concrete
 - 2. 347 – Guide to Formwork for Concrete
- B. American Plywood Association (APA):
 - 1. PS-1 – Construction and Industrial Plywood
 - 2. Grades – Trademarks
- C. Western Wood Products Association (WWPA) – Western Lumber Product Use Manual

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Design Criteria: Design formwork in accordance with ACI 347.
- B. Allowable Tolerances: Set and maintain concrete forms within tolerance limits stated in ACI 347.

1.06 SUBMITTALS

- A. Before placement, submit details of pre-engineered metal forms to the Resident Engineer for review.

1.07 DELIVERABLES

None Listed

1.08 PROJECT CONDITIONS

- A. Protect formwork materials before, during, and after erection to insure acceptable finished concrete work. Also, protect in-place materials and other operations of work in connection with concrete pours.
- B. In case of damage to erected forms, make necessary repairs or replacements before concrete placement.

PART 2 PRODUCTS**2.01 MATERIALS**

- A. Lumber:
 - 1. Form framing, sheathing, and shoring shall conform to WWPA Western Lumber Product Use Manual.
 - 2. Use lumber free of material defects that would deform the finished concrete product.
- B. Plywood:
 - 1. Form Sheathing and Panels: Not less than 5/8-inch thick exterior Type B-B plywood Class I and II EXT-APA conforming to PS-1.
 - 2. Use Type II only on surfaces not exposed to view.
- C. Steel: Metal forms of a pre-engineered standard design, but conforming to the concrete sections indicated on the Contract Drawings or provided herein may be used in lieu of wood forms.
- D. Form Ties:
 - 1. Provide factory fabricated, adjustable length, removable or snap-off metal form ties conforming to ACI 347.
 - 2. Use snap-off metal ties with ends that break at least 1-1/2-inches from the face of the wall.
 - 3. Removable ties that leave holes larger than 7/8-inch are not permitted.
 - 4. Form ties fabricated on the Work Site and wire ties or flat bands are not acceptable.
 - 5. Wood spacers are not permitted within the pour.
- E. Form Coatings: Provide commercial formulation form coating compounds that will not bond with, stain, nor affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing compounds.

PART 3 EXECUTION**3.01 DESIGN CRITERIA**

- A. Design Criteria:
 - 1. Unless otherwise indicated, design, construct, erect, maintain, and remove forms and related structures for concrete work in accordance with ACI 301 and ACI 347.
 - 2. Provide openings, offsets, sinkages, keyways, recesses, moldings, rustication strips, chamfers, blocking, screeds, bulkheads, anchorages, embedded items, and other features. Select materials and provide workmanship that will assure indicated finishes.
 - 3. Design formwork to be readily removable without impact, shock, and damage to concrete surfaces and adjacent materials.

3.02 INSPECTION

- A. Before placement of concrete, inspect forms for cleanliness and accuracy of alignment.
- B. It is Contractor's responsibility to ensure the adequacy of the formwork before concrete placement.

3.03 PREPARATION

- A. Apply form coatings in accordance with manufacturer's specifications.
- B. Do not allow excess form coating material to accumulate in the form.
- C. Do not allow form coatings to come in contact with construction joints or reinforcing steel.

3.04 ERECTION

- A. Construct forms in accordance with ACI 347 to required dimensions, plumb, straight and mortar tight, and paste tight where appearance is important. Securely brace and shore forms to prevent displacement and to safely support imposed concrete load.
- B. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent the loss of concrete mortar. Locate temporary openings on forms in as inconspicuous a location as possible consistent with the requirements of the Work.
- C. Provide openings in concrete formwork of the correct size and in the proper location to accommodate other operations of construction work in the Project. Accurately place and securely support items to be built into forms.
- D. Cutting form ties back from the face of the concrete is not permitted.

3.05 FORM REMOVAL

- A. Remove forms in accordance with ACI 347 without damage to concrete and in a manner to ensure complete safety to the structure.
- B. Upon removal of forms, notify the Resident Engineer in order that an inspection of the newly stripped surfaces may be made before patching.
- C. Hammer-pack holes left by tie rods with stiff mortar of the same material as, but somewhat leaner than, that in the concrete. Render the patch inconspicuous.
- D. Remove forms in such a manner as to permit the concrete to take the stresses uniformly and gradually.
- E. Do not remove the forms for any portion of a structure until the concrete is strong enough to withstand the applied loads.

3.06 RE-USE OF FORMS

- A. Forms for re-use shall meet new form requirements with respect to its affect on poured concrete appearance and structural stability.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for concrete reinforcement indicated on the Contract Drawings and as required for Contractor-designed structures.

1.02 REFERENCED SECTIONS

- A. Section 03300 – Cast-in-Place Concrete

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI)
 - 1. SP-66 - Detailing Manual
 - 2. 318 – Building Code Requirements for Reinforced Concrete
- B. ASTM International (ASTM)
 - 1. A184 – Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
 - 2. A 185 – Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
 - 3. A 497 – Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
 - 4. A 615 – Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 - 5. A 706 - Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
 - 6. A 775 – Epoxy-Coated Reinforcing Steel Bars
- C. American Welding Society (AWS)
 - 1. D1.4 – Structural Welding Code – Reinforcing Steel

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Before placement, submit to the Resident Engineer for review, Shop Drawings that indicate the following:

1. Bar lists, bending diagrams and schedules, and placement plans and details for all reinforcing steel.
 2. Descriptions, details, dimensions, arrangements and assemblies, and locations of reinforcing steel. Include number of pieces, sizes, and markings of reinforcing steel, laps and splices, supporting devices and accessories, and any other information required for fabrication and placement.
 3. Check Contract Drawings for anchors, hangers, inserts, conduits, sleeves, grouting pipes, and any other items to be cast in concrete for possible interference with reinforcing steel. Indicate required clearances on Shop Drawings.
 4. Detail reinforcing steel in accordance with ACI SP-66. Indicate individual weight of each bar, total weight of each bar size, and total weight of all bars on the list. Base calculated weights on nominal weights specified in ASTM A 615 or ASTM A 706, as applicable.
- B. Before placement, submit to the Resident Engineer for review, manufacturer's catalog cuts and product data.
- C. Submit Quality Control Sheet (form) for each placement location before pouring concrete. The form shall verify conformance of reinforcement installation with Shop Drawings and tolerances.

1.07 DELIVERABLES

- A. Provide certification that materials conform to the specified standards.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Steel Reinforcement Bars: Roll deformed rods and bars for reinforcing concrete from first quality new billet steel. Rods and bars shall conform to ASTM A 615, Grade 60.
- B. Bar Mats: Bar mats shall conform to ASTM A 184 and be fabricated from reinforcing bars that conform to ASTM A 615.
- C. Epoxy Coated Reinforcing Bars: Where epoxy coated reinforcing bars are indicated on the contract drawings, such bars shall be epoxy coated in accordance with ASTM A 775. Any damaged epoxy coating shall be repaired with patching material conforming to ASTM A 775. Perform repairs in accordance with the patching material manufacturer's recommendations.

- D. Welded Wire Fabric Reinforcement:
1. Welded wire fabric for the reinforcement of concrete shall be of the type and cross-sectional area indicated on the Contract Drawings. The main reinforcing wires shall be parallel to the shortest dimension of the concrete slab, except where otherwise indicated on the Contract Drawings. The wire fabric shall be lapped at splices, and hooked over end beams.
 2. Plain welded wire fabric shall conform to ASTM A 185. Deformed welded wire fabric shall conform to ASTM A 497.
- E. Mechanical Splices: Mechanical splices shall conform to ACI 318 and shall be Lenton taper threaded rebar splices as manufactured by Erico Products Inc., or approved equal; or threaded coupler as manufactured by Williams Form Engineering Corporation, or approved equal.

PART 3 EXECUTION

3.01 BENDING OF REINFORCEMENT BARS

- A. Bending of reinforcement bars shall conform to the requirements of ACI 318.

3.02 PLACING OF REINFORCING STEEL

- A. Protect reinforcement bars from the weather until placed.
- B. Before placing bar reinforcement steel, remove all grease, dirt, mortar, and any other foreign substances. Remove loose rust and loose mill scale on uncoated reinforcement by wire brushing before placing of concrete.
- C. Place steel bar reinforcement in the position as indicated and within the tolerances specified. Before concrete is placed, securely fasten all reinforcement and support with chairs or other devices. Wood and plastic blocking will not be permitted.
- D. On front face (exposed face) where a smooth concrete finish is required, use nylon-coated, epoxy-coated, plastic-coated or stainless steel tie wire.
- E. No concrete shall be deposited until the placement of reinforcement has been verified to conform to the reviewed reinforcing detail drawings.

3.03 PLACEMENT IN STRUCTURAL SLABS

- A. Bar supports shall be spaced no farther apart than 4-feet center-to-center, nor shall any bar support be closer than 6-inches from the edge of any future concrete surface. Bar reinforcement shall be placed in accordance ACI 318 and the following tolerances, whichever is more stringent.
1. Distance from formwork: Plus or minus 1/4-inch
 2. Location in plane of reinforcing mat: Plus or minus 1/2-inch

- B. The structural slab bar reinforcement mats (top and bottom) shall be securely connected together. This connection may be accomplished by wiring or other means. Place connections no farther apart than 4-feet on centers. The bar supports may be used for this purpose. Connecting devices shall neither deflect the bar reinforcement nor interfere with the smooth flow of concrete.
- C. Immediately before placement of concrete verify that the reinforcing steel is positioned within the above-stated tolerances. If the allowable tolerances are exceeded, the position of the reinforcing steel shall be corrected before concrete placement.
- D. Reinforcing bars that protrude from the concrete for lapping into pours in future contracts, shall be completely brush coated with a thin layer of cement paste that is free from lumps.

3.04 INSTALLATION OF EPOXY COATED REINFORCING BARS

- A. Epoxy-coated reinforcing bars shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Coat wire bar supports with dielectric material for a minimum distance of 2-inches beyond the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars or wire shall be epoxy coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing bars shall be made of corrosion-resistant material.
- B. Fasten epoxy-coated reinforcing bars with nylon, epoxy, or plastic-coated tie wire.
- C. Splices of reinforcing bars and welded wire fabric shall be made only as required or permitted by the reviewed reinforcing detail drawings.
- D. When epoxy-coated reinforcing bars are cut in the field, coat the ends of the bars with the same material used for repair of coating damage.

3.05 REINFORCING STEEL AND WELDED WIRE FABRIC TO BE FASTENED

- A. Where reinforcing steel or welded wire fabric is used, provide satisfactory means to maintain it in the exact position it is to occupy in the completed work and to prevent it from becoming dislodged or moved in any manner.
- B. Maintain the fabric in position by the use of suitable spacers or by other means.

3.06 SPLICES

- A. Conform to the requirements of ACI 318.
- B. Welded splices shall conform to the additional requirements of AWS D1.4.

3.07 INSTALLATION OF MECHANICAL SPLICES

- A. Examine threaded bar ends to make sure they are undamaged and clean. If cleaning is required, use a wire brush.
- B. Install mechanical splices in accordance with manufacturer's recommendations.

3.08 FIELD REPAIR - EPOXY COATED BAR REINFORCEMENT

- A. Material used for field repair shall be supplied by the coating applicator.
- B. Field Repairs shall be performed in accordance with the “Guidelines For Job-Site Practices” of ASTM A 775.
- C. A reinforcing bar having coating damage exceeding the above criteria shall not be incorporated in the work and shall be removed from the Work Site.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for cast-in-place concrete indicated on the Contract Drawings and specified herein. Cast-In-Place concrete for caverns shall also meet the requirements of Section 02425.

1.02 REFERENCED SECTIONS

- A. Section 02425 – Cast-In-Place Concrete Lining
- B. Section 03100 – Concrete Formwork
- C. Section 03200 – Concrete Reinforcement
- D. Section 13115 - Corrosion Control System Testing

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI):
 - 1. 117 – Tolerance for Concrete Construction and Materials
 - 2. 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
 - 3. 301 – Specification for Structural Concrete
 - 4. 304.2 – Placing Concrete by Pumping Methods
 - 5. 305 – Hot Weather Concreting
 - 6. 306 – Cold Weather Concreting
 - 7. 308 – Standard Practice for Curing Concrete
 - 8 309 – Guide for Consolidation of Concrete
 - 9. 318 – Building Code Requirements for Structural Concrete and Commentary
 - 10. 347 – Guide to Formwork for Construction
- B. ASTM International (ASTM):
 - 1. C 31 – Making and Curing Concrete Test Specimens in the Field
 - 2. C 33 – Concrete Aggregates
 - 3. C 39 – Compressive Strength of Cylindrical Concrete Specimens

4. C 94 – Ready-Mixed Concrete
 5. C 138 – Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
 6. C 143 – Slump of Hydraulic Cement Concrete
 7. C 150 – Portland Cement
 8. C 171 – Sheet Materials for Curing Concrete
 9. C 172 – Sampling Freshly Mixed Concrete
 10. C 192 – Making and Curing Concrete Test Specimens in the Laboratory
 11. C 231 – Air Content of Freshly Mixed Concrete by the Pressure Method
 12. C 260 – Air Entraining Admixtures for Concrete
 13. C 309 – Liquid Membrane Forming Compounds for Curing Concrete
 14. C 494 – Chemical Admixtures for Concrete
 15. C 618 – Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
 16. C1059 – Standard Specification for Latex Agents for Bonding Fresh To Hardened Concrete
 17. C 1064 – Temperature for Freshly Mixed Portland Cement Concrete
 18. D 1751 – Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-Extruding and Resilient Bituminous Types)
- C. National Ready Mixed Concrete Association (NRMCA):
1. Certification of Ready-Mixed Concrete Production Facilities
 2. Inspection and Certification of Delivery Vehicles

1.04 NOTED RESTRICTIONS

- A. No concrete mix shall not be used in the work without written notice from the Resident Engineer that the mix has been reviewed.
- B. Concrete placement for the structural track invert shall not take place until corrosion control system testing, described in Section 13115, has been undertaken and measured resistance the steel reinforcement is within acceptable criteria.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)
- B. Acceptable Manufacturers:
 - 1. Ready-mix concrete production facilities shall have NRMCA certification.
 - 2. Cement shall be of a well-known brand, which has been in successful use for large engineering works in the United States for at least five years. Contractor may select two brands of cement for use in the Project. Only one brand, however, shall be used at the same time in the same part of the Project. Should an emergency arise necessitating the substitution of a third brand of cement, notify the Resident Engineer.
- C. Design Mixes and Tests:
 - 1. Employ an independent testing laboratory to prepare the design of mixes for the strength and durability requirements of concrete as indicated on the Contract Drawings and as specified herein. Perform tests and trial mixes in accordance with ASTM C 192 and ASTM C 39.
 - 2. Contractor may use previously reviewed (within the year) mixes, incorporating aggregates having the same specific gravity, size, and gradation; cements of the same type and batch weight; identical admixtures and the same water-cement ratio. If any of the mix proportions, ingredients, or constituent suppliers are changed, a separate submission for review is required.
- D. Perform tests (chemical and physical analysis) of cement at intervals of 28 days, in accordance with the requirements of ASTM C 150. If the cement does not meet the requirements of ASTM C 150, the cement shall be rejected and the Resident Engineer shall have the right to prohibit use of that brand and to require that another brand be substituted.

1.06 SUBMITTALS

- A. At least 90 days before commencing structural concreting, submit the following for review by the Resident Engineer: Concrete placement shall not begin until the Resident Engineer's review of the appropriate submittal is complete:
 - 1. Manufacturer's data and technical information. for all products and systems used in the Works, including admixtures, waterstops, curing compounds, cement brand name and other items specified, including certificate of compliance and installation instruction to be followed.
 - 2. Detailed concrete placement working drawings showing methods and equipment proposed for concrete transportation, pumping, placement by location (including concrete placement in the crown of caverns), dimensions, elevations, stations, and concrete finish, as applicable.

3. When cement is shipped and delivered to the Work Site in bulk, submit information on the proposed containers, equipment, and methods used in loading, sealing, transferring, unloading and storing.
 4. Working drawings for formwork and falsework indicating, as applicable, the locations and details of:
 - a. Anchors, shores, and braces.
 - b. Field adjustment of moveable forms.
 - c. Embedded items, including grout pipes, water stops and drainage pipes.
 - d. Mud slabs.
 - e. Cleanout chambers and other recesses.
 - f. Construction, control, and expansion joints.
 - g. Chamfer strips for exposed corners.
 - h. Materials to be used and locations of ties.
 5. Manufacturer's data and technical information for formwork and falsework system, including description and installation instructions. If the Contractor chooses a traveler type formwork system, detailed information regarding the following properties shall be provided covering as a minimum: operation and maintenance of hydraulic system, raising and lowering, leveling and superelevation, steering, flaring and propulsion.
 6. Sample of the form coating, waterstops, and other items as requested.
 7. Procedures and methods for contact grouting.
- B. Submit the following for review by the Resident Engineer within 60 days prior to starting the Work of this Section. Concrete placement shall not begin until the Resident Engineer's review of the appropriate submittal is complete:
1. Data and certificates of compliance on materials for concrete.
 2. Concrete design mixes and test results in accordance with Appendix A of this Section, certified by a Professional Engineer licensed in the State of New York. Submit certification that each admixture is compatible with other admixtures used, and is compatible with the cement, aggregate and pozzolans used. Submit target slump measurement for each mix.
 3. Test results in accordance with Appendix B of this Section certified by a Professional Engineer licensed in the State of New York.

4. Strength gain curves from trial mix tests, and proposed strength for stripping forms in each area of the works.
 5. Certification of ready mixed concrete production facilities in accordance with NRMCA. Certification shall be submitted from at least two independently owned suppliers, each of which can supply concrete of the necessary quantity and quality, and to the schedule necessary for the Works.
 6. Certification of ready mixed concrete trucks in accordance with NRMCA, or documentation to demonstrate an equivalent minimum standard.
- C. Submit for review by the Resident Engineer concrete repair methods. Concrete repair shall not begin until the Resident Engineer's review of the appropriate submittal is complete.

1.07 DELIVERABLES

- A. Provide copies of concrete test results and related slump test information taken at the pump and at the discharge end.
- B. Provide delivery tickets for all ready-mixed concrete. Tickets should note the supplier, mix designation, admixtures, time dispatched, date, Project number, and Contractor.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Inspection of Cement: Cement shall be subject to inspection at the concrete manufacturer's batch plant, and additional tests may be ordered by the Resident Engineer. The Resident Engineer shall have access at all times to inspect the methods of manufacture, handling, storage, and protection of the cement. The Resident Engineer shall have access to inspect the daily laboratory records of tests and analyses at the plant. The concrete supplier shall have in his possession, at all times, the mill certificate for each cement load being batched. The mill certificate must be presented at the Resident Engineer's request.
- B. Storage at Cement Plant: Hold all cement in storage at the cement plant to allow ample time for the tests to be made before the cement is required for use.
- C. Packages and Marking:
 1. Cement may be packed and delivered in canvas or paper bags, or it may be shipped and delivered in bulk.
 2. When cement is packed in bags, plainly mark the bags with the brand, type, and name of the manufacturer of the cement and be tightly sealed. A bag of cement shall contain 94-pounds net.

PART 2 PRODUCTS**2.01 CONCRETE**

- A. Concrete shall be ready-mix, complying with ASTM C 94.
- B. Minimum compressive strength shall be as indicated on the Contract Drawings.

2.02 PORTLAND CEMENT

- A. Cement shall conform to the requirements of ASTM C 150 Type II cement. In addition, the cement shall be of low alkali with maximum percentage limited to 0.6-percent by weight.
- B. Composition: Concrete shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures. All mix design shall be proportioned in accordance with ACI 211.1 and ACI 318.

2.03 FINE AGGREGATE

- A. Grade fine aggregate in accordance with ASTM C 33. For pumped concrete, the recommendations of ACI 304.2 shall be implemented.

2.04 COARSE AGGREGATE

- A. Grade coarse aggregate for concrete in accordance with ASTM C 33. For pumped concrete, the recommendations of ACI 304.2 shall be implemented. Unless otherwise noted, grading of coarse aggregates shall meet the requirements of ASTM C 33, Table 2, and Size No. 57 or Size No. 67.

2.05 MIXING WATER

- A. Use potable water for mixing concrete.
- B. The maximum water-cement ratio, where cement is defined as including any pozzolans, shall be 0.45.
- C. No water or ice shall be added to the mix outside the ready-mix production facility.

2.06 ADMIXTURES

- A. Add the admixtures to water, coarse aggregates, and fine aggregate at the ready-mix production facility only. Take special care to prevent direct contact of the undiluted agents with dry cement. Add each agent separately from separate dispensers to prevent direct contact of the undiluted agents.
- B. Admixtures shall not contain more than 0.05-percent chloride ions.

- C. Air-Entraining Admixture:
1. Concrete within the Queens Bellmouth and within the eastern 500-feet of the existing 63rd Street Tunnel shall be air-entrained. Air content shall meet the requirements of the BCNYS. A moderate exposure level shall be assumed.
 2. Air content in concrete for the Manhattan caverns shall not exceed 4.5-percent.
 3. Air-entraining admixtures shall conform to ASTM C 260. Products shall be Euclid Chemical Company "Air Mix" or "AEA 92"; Sika Corporation "Sika AER or AEA 15"; Master Builders "MBVR" or "Micro-Air"; Grace Construction Products "Daravair" or Darex II AEA"; or approved equal.
 4. The volume of air shall be tested in accordance with ASTM C 231.
- F. Water-Reducing Admixture: The admixture shall conform to the requirements of ASTM C 494, Type A. Admixtures shall be Euclid Chemical Company "Eucon WR75" or "WR89"; Master Builders "Pozzolith 322-N"; Sika Corporation "Plastocrete 161"; Grace Construction Products "WRDA w/Hycol"; or approved equal.
- G. Water-Reducing, Set-Retarding Admixture: Conform to the requirements of ASTM C 494, Type D. Admixtures shall be Euclid Chemical Company "Eucon Retarder-75"; Master Builders "Pozzolith 100-XR"; Sika Corporation "Plastiment"; Grace Construction Products: "Daratard-17"; or approved equal.
- H. Water-Reducing, Set-Accelerating Admixture: Conform to the requirements of ASTM C 494, Type C or Type E. The admixture manufacturer must have long-term, non-corrosive test data from an independent testing laboratory, (minimum one year's duration) using an acceptable accelerated corrosion test method that uses electrical potential measurements. Products shall be Euclid Chemical Company "Accelguard 80"; Master Builders "Pozzutec 20"; Sika Corporation "Plastocrete 161 FL"; or approved equal.
- I. High-Range Water-Reducing Admixture (Superplasticizer): Superplasticizer (ASTM C 494, Type F or Type G.) Type F products shall be Sika Corporation "Sikament 10ESL"; Sika Corporation "ViscoCrete 2100"; Grace Construction Products "Daracem 100"; or approved equal. Type G products shall be Euclid "Eucon 537"; Grace Construction Products "Daracem 100"; Master Builders "Rheobuild 716LR"; or approved equal. Superplasticizer shall not be added outside the ready-mix production facility.
- J. Pozzolans: Fly ash shall be used. The loss on ignition shall not exceed five-percent.
1. Fly ash shall be incorporated into the mixtures at a minimum rate of 15-percent and maximum rate of 25-percent by weight of total cement. Fly ash shall conform to the requirements of ASTM C 618, Class F. Sulfur Trioxide (SO₃) content shall not exceed 4-percent.

2.07 MISCELLANEOUS CONCRETE

- A. All non-structural concrete, including lean concrete and protection concrete, where called for on Contract Drawings, shall have a minimum strength of 2,000-psi at 28-days.

2.08 FORMS

- A. Forms are specified in Section 03100.

2.09 PREMOLDED FILLER

- A. Provide expansion joints with a premolded bituminous fiber joint material conforming to the requirements of ASTM D 1751, where indicated on the Contract Drawings.
- B. Joint backer rod shall be premolded, closed cell polyethylene foam rod.

2.10 EPOXY ADHESIVE

- A. The compound shall be a two-component 100-percent solids, 100-percent reactive compound suitable for use on dry or damp surfaces. Manufacturers shall be Euclid Chemical Company "Euco No. 452 MV or "Euco No. 620 MV; Sika Corporation "Sikadur 32 Hi-Mod"; or approved equal.

2.11 BONDING AGENT

- A. Bonding Agent shall be Acrylic-Bonding Agent per ASTM C1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

2.12 CURING AND SEALING COMPOUND

- A. This compound shall be VOC-complaint, shall have 30-percent minimum solids contents and shall not yellow under ultraviolet light after 500 hours of test in accordance with ASTM C 309. Manufacturers shall be Euclid Chemical Company "Super Aqua Cure VOX" or "Super Diamond Clear VOX"; Master Builders "Masterkure"; or approved equal.

2.13 BOND BREAKER

- A. Bond breaker tape shall be polyethylene or other plastic tape as recommended, non-bonding to sealant, self-adhesive, where applicable.

PART 3 EXECUTION**3.01 SLUMP REQUIREMENTS**

- A. Target slump shall be in accordance with ACI 211.1. For pumped concrete, slump shall be in accordance with ACI 304.2, but shall not exceed 6-inches at the discharge end of the pumpline.

- B. Results of slump test performed in accordance with ASTM C 143 shall not deviate from target slump by more than plus or minus 1-inch.

3.02 TRANSPORTATION

- A. The methods and equipment used for transporting concrete and the time that elapses during transportation shall be in accordance with ASTM C 94 and shall not cause appreciable segregation or slump loss in the concrete as it is delivered to the placement locations. The use of aluminum pipe for delivery of pumped concrete will not be permitted.

3.03 QUALITY CONTROL TESTING

- A. All laboratory acceptance tests (i.e. laboratory curing and compressive strength of concrete cylinders) shall be performed by licensed independent concrete testing laboratory.
 - 1. All field testing shall be done by technician qualified by education, training, and experience. The technician shall be able to provide evidence of training and experience. ACI Certification as a Concrete Field Testing Technician - Grade 1 meets this requirement.
- B. Sampling and testing for quality control during placement of concrete shall be in accordance with ASTM C 172 and shall include the following:
 - 1. Perform slump test in accordance with ASTM C 143 for the first batch of concrete each day, whenever consistency of concrete appears to vary, and whenever compression test cylinders are made at the Work Site.
 - 2. Perform air content test in accordance with ASTM C 231 for each sample of concrete from which test cylinders are made.
 - 3. Perform concrete temperature test in accordance with ASTM C 1064 every hour when air temperature is less than 50 degrees Fahrenheit or is greater than 75 degrees Fahrenheit, and one test for each set of compressive-strength specimens made.
 - 4. Compression test cylinders shall be made and cured in accordance with ASTM C 31 and ASTM C 39.
 - a. Strength test specimens shall be taken as follows: One strength test is defined as the average of three standard cylinders. Tests shall be performed at 24 hours, 7 days and 28 days. An additional test shall be performed at 12-hours if forms are to be stripped before 24-hours. The cylinders shall be molded and stored as laboratory-cured test specimens except when field-cured test specimens are required.
 - b. The number of strength tests required shall be as per the BCNYS, and supplemental requirements stated herein. As a minimum, take the specified number of cylinder samples for the required age tests on each day that more than 25-cubic yards of lining concrete are placed.
 - c. When the compression strength requirements are not met, the Resident Engineer shall be informed in writing, including suspected

reasons for the underperformance and corrective measures to avoid future occurrences. The low-strength test result provisions of the BCNYS are to be followed.

5. Determine unit weight in accordance with ASTM C 138. The concrete shall have a unit weight in the range of 140- to 150-pcf.

3.04 PLACEMENT

- A. The Resident Engineer shall be notified at least 24 hours in advance of the start of each concrete placement. Concrete shall be placed only in the presence of the Resident Engineer. Concrete shall not be placed until all formwork, steel reinforcement, waterproofing system, installation of embedded parts, and all other preparation is complete and reviewed by the Resident Engineer.
- B. Place concrete in accordance with ACI 301, ACI 304.2 and ACI 318.
- C. Consolidate concrete in accordance with ACI 309.

3.05 TIME ALLOWED FOR INITIAL STRENGTH GAIN

- A. Concrete shall be allowed to set for at least 12-hours before any work be laid upon it; no walking over or working upon it shall be allowed while it is setting.
- B. No form shall be removed until the concrete is strong enough to withstand the applied loads and self weight, as determined by a Professional Engineer licensed in the State of New York. In no case shall forms be removed until a minimum compressive strength of 1000-psi has been achieved, as determined by interpolation of the lowest strength test results from trial mix tests and field-cured quality control (sampled at the Work Site) tests. Form removal shall follow the requirements of Section 03100 and the recommendations for underground structures in ACI 347.

3.06 CURING AND PROTECTION

- A. Cure and protect concrete as specified in ACI 301 and ACI 308. Continue curing for at least ten-days. In addition, continue curing until the in-place strength exceeds 70 % of the specified compressive strength.
 1. For concrete surfaces not in contact with forms, use one of the following procedures:
 - a. Continuous sprinkling or ponding.
 - b. Application of absorptive mats of fabric kept continuously wet.
 - c. Continuous application of mist spray.
 - d. Application of waterproof sheet materials conforming to ASTM C 171.

- e. Application of the specified VOC-compliant curing compound conforming to ASTM C 309.
- 2. For concrete surfaces in contact with forms, these formed surfaces shall be cured with forms in place. When forms are removed before the full curing duration, cure the concrete until the end of the time prescribed by one of the methods indicated.

3.07 PREPARING SURFACES

- A. Thoroughly clean surfaces against which concrete is to be placed. Immediately before forms for the concrete are placed, reclean before placing concrete, as required.

3.08 BONDING

- A. Wherever possible, each pour shall be cast complete in one continuous operation. Wherever a section of concrete is necessarily left unfinished by an unavoidable interruption in concrete placement, leaving a surface, which shall be set before additional concrete can be placed, the concrete shall be consolidated thoroughly to a reasonably uniform and stable joint surface while the concrete is still plastic. Such joints shall be formed to provide a watertight bond. If deemed necessary by the Resident Engineer, the joints shall be reinforced with steel bars or dowels.
- B. In all cases of joining old, existing, or unfinished work with new work, the old surfaces shall be thoroughly cleaned. A bonding agent or epoxy adhesive shall be applied. New concrete shall be placed while the bonding compound or epoxy adhesive is still tacky. Where necessary, dovetails or grooves shall be formed and steel bars or dowels shall be used to ensure a bond.

3.09 CONSTRUCTION JOINTS

- A. Construction joints, where indicated on the reviewed placement drawings, shall be considered joints used for the sole purpose of providing for interruptions in the concrete placement. Construction joints shall be designed to transfer shear and moment at the joint. Unless otherwise indicated on the Contract Drawings, a shear key shall be provided at each construction joint.

3.10 FORMWORK

- A. Concrete formwork requirements are specified in Section 03100.

3.11 FINISH OF FORMED SURFACES

- A. All formed concrete surfaces, including walls and roofs, shall meet the requirements of ACI 117 for a "Flat" floor. The straight edge for curved surfaces shall be placed perpendicular to the curvature; smoothness around the curve shall be equivalent. Alternative measurement methods may be submitted to the Resident Engineer for review.
- B. Surfaces that do not meet the specified requirements shall be corrected by grinding to the limits specified or the concrete shall be removed and replaced.

3.12 FINISH OF UNFORMED SURFACES

- A. When the type of finish is not specified in the Contract Drawings, the following finishes in accordance with ACI 301 shall be used as applicable. Surfaces that do not meet the specified requirements shall be corrected by grinding to the limits specified or the concrete shall be removed and replaced.
1. Float Finish: For surface intended to receive roofing or waterproofing membranes.
 2. Broom Finish: Floors, ramps, benches, cavern liner footings and walking surfaces shall receive a light broom finish in a transverse direction to the flow of traffic.
 3. Scratched Finish: For surfaces to be directly covered by concrete pours in follow-on contracts.

3.13 EMBEDDED ITEMS

- A. Place and securely fix embedded items such as waterstops, anchors, sleeves, drainage pipes and anchoring steel etc. before concreting and coordinate with the placing of the reinforcing steel. Concrete reinforcement is specified in Section 03200.
- B. Aluminum pipe, conduits, and other aluminum items unless coated with coal tar or epoxy shall not be embedded in the concrete.

3.14 REPAIR OF FORMED CONCRETE

- A. Repairs necessary to produce surfaces conforming to the specified finishing requirements shall be completed within ten days after form removal.
- B. No repair of imperfections shall be undertaken until the imperfections have been inspected by the Resident Engineer, and repair method submittal has been reviewed by the Engineer.
- C. The Resident Engineer shall be informed as to when concrete is to be repaired and, unless specifically waived in each specific case, the repairs shall be performed only in the presence of the Resident Engineer.
- D. Repair concrete that is damaged or defective, including that containing spalls, broken edges, rock inclusions, honeycomb, or unconsolidated concrete, by removing the damaged or defective concrete to sound concrete and replacing.
- E. Repairs shall be made with concrete, dry pack, Portland cement mortar, epoxy-bonded concrete, or epoxy-bonded epoxy-mortar. Feather edging of replacement materials shall not be permitted. The repair mortar or concrete must be applied within the period recommended by the manufacturer of the bonding compound or epoxy adhesive.

3.15 COLD AND HOT WEATHER CONCRETING

- A. Cold Weather: unless otherwise directed, concrete shall not be placed when the ambient temperature is below 40-degrees Fahrenheit, or when the concrete is likely to be subjected to freezing temperatures before expiration of the curing period. Cold weather placement shall conform to ACI 306.
- B. Hot Weather: When the ambient temperature exceeds 85-degrees Fahrenheit, concreting procedures shall conform to ACI 305.
- C. In either of the cases (cold or hot weather), the design of mixes, tests and submittals shall be as specified herein.
- D. The temperature of concrete measured at the point of placement shall be between 40- and 75-degrees Fahrenheit.

3.16 TOLERANCES FOR CONSTRUCTION AND MATERIALS

- A. Tolerances for concrete construction and materials shall conform to ACI 117 unless otherwise noted. For the purpose of ACI 117, tolerances shall be for cast-in-place concrete buildings. Class of surface shall be Class B.

APPENDIX A
CONCRETE MIX DESIGN SUBMITTAL

PROJECT

EAST SIDE ACCESSCONTRACT CM009

DATE

1. Trial Mix Designed by:

2. Specified Strength (fc'):

3. Concrete Supplier:

4. Materials (by Brand):

a. Cement:

b. Fine Aggregate:

c. Coarse Aggregate:

d. Admixtures:

1) Air Entrainment
Agent

2) Water Reducer

3) High Range Water Reducer:

4) Water Reducing
Set Retarding

5) Pozzolan

a) Fly Ash

b) Silica Fume

c) Others (if any)

5. Gradations:

	Fine Aggregate (Percent)	Coarse Aggregate (Percent)
1"		
3/4"		
3/8"		
No. 4		
No. 8		
No. 16		
No. 30		
No. 50		
No. 100		
Fineness Modulus		
Specific Gravity		

6. Batch Weights per Cubic Yard Trial Mixes:

	#1	#2	#3	#4
Cement, Lbs.				
Sand, Lbs.				
Coarse Aggregate, Lbs.				
Total Water, Gals.				
Admix. Air Entrainment, Lbs.				
Admix. Water Reducer, Lbs.				
Air Content, %				
Initial Slump, In.				
Final Slump, In.				
Unit Weight, pcf				
w/c Ratio, Lbs/Lbs				

7. Compressive Strengths Trial Mixes:

Strength, psi	#1	#2	#3	#4
12 –hours: <ul style="list-style-type: none"> • Cylinder 1 • Cylinder 2 • Cylinder 3 • Average 				
24 –hours: <ul style="list-style-type: none"> • Cylinder 1 • Cylinder 2 • Cylinder 3 • Average 				
2-Days: <ul style="list-style-type: none"> • Cylinder 1 • Cylinder 2 • Cylinder 3 • Average 				
7-Days: <ul style="list-style-type: none"> • Cylinder 1 • Cylinder 2 • Cylinder 3 Average 				
28-Days <ul style="list-style-type: none"> • Cylinder 1 • Cylinder 2 • Cylinder 3 • Average 				

8. Recommended Mix #:

APPENDIX B

PROJECT _____

MIX# _____

Number of Test Cylinders
Evaluated _____

Standard Deviation (S) _____

F'cr (required average
Compressive strength in psi) = $f'_c + 1.34S$
or = $f'_c + 2.33S - 500$
whichever is larger

Refer to ACI 301 for increased deviation factor when fewer than 30 tests are available.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for steel fiber reinforced cast-in-place concrete indicated on the Contract Drawings and specified herein. Requirements of Sections 02425 and 03300 shall apply, except as modified and supplemented herein.

1.02 REFERENCED SECTIONS

- A. Section 02425 – Cast-In-Place Concrete Lining
- B. Section 03100 – Concrete Formwork
- C. Section 03300 – Cast-in-Place Concrete

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI):
 - 1. 544.1 – State of the Art Report on Fiber Reinforced Concrete
 - 2. 544.2 – Measurement of Properties of Fiber Reinforced Concrete
 - 3. 544.3 – Guide for Specifying, Proportioning, Mixing, Placing, and Finishing Steel Fiber Reinforced Concrete
 - 4. 544.4 – Design Considerations for Steel Fiber reinforced Concrete
- B. ASTM International (ASTM):
 - 1. A 820 –Steel Fibers for Fiber-Reinforced Concrete
 - 2. C 128 –Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
 - 3. C 143 – Slump of Hydraulic Cement Concrete
 - 4. C 157 –Length Change of Hardened Hydraulic - Cement Mortar and Concrete
 - 5. C 995 –Time of Flow of Fiber-Reinforced Concrete Through Inverted Slump Cone
 - 6. C 1018 –Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)
 - 7. C 1116 –Fiber-reinforced Concrete and Shotcrete

1.04 NOTED RESTRICTIONS

- A. See Section 03300.

1.05 QUALITY CONTROL

- A. Design Mixes and Tests:
1. See Section 3300. The compressive tests required in Section 03300 shall be undertaken on samples without steel fibers.
 2. Perform shrinkage test on each trial mix in accordance with ASTM C 157
 3. Verify the post-crack equivalent flexural strength toughness of each mix in accordance with ASTM C 1018 using 6-inch by 6-inch beams at 7-days and 28-days. Submit certified test reports, using a minimum of six replications.
- B. Steel fiber reinforced concrete shall be in accordance with ASTM C 1116, ACI 544.1, ACI 544.2, ACI 544.3, and ACI 544.4, except as specified herein.

1.06 SUBMITTALS

- A. Submit the following for review by the Resident Engineer within 60 days prior to starting the Work of this Section. Do not begin concrete placement until the Resident Engineer's review of the appropriate submittal is complete:
1. Details of the steel fiber weighing and dosing equipment at the batching plant; method of dosing, mixing and mixing time; and methods of checking an even distribution of fibers has been achieved in the fresh and hardened concrete.
 2. Drying shrinkage test data as determined in accordance with ASTM C 157.
 3. Detailed description of procedures for delivering concrete to the work site, transporting below ground, forming, casting, and curing concrete. Include plans to control shrinkage and temperature cracking, with supporting data, calculations, and shrinkage test results.
 4. Concrete design mixes and test results in accordance with Section 03300 and as specified herein, certified by a Professional Engineer licensed in the State of New York.
 5. Submit target time of flow or slump measurement for each mix. Time of flow shall be within the recommended range in ACI 544.3 and shall not vary by more than 25-percent from the target value.
- B. At least 90 days before commencing structural concreting, submit the following for review by the Resident Engineer: Do not begin concrete placement until the Resident Engineer's review of the appropriate submittal is complete:

Manufacturer's data, technical information and sample (20-pounds) for steel fibers, including certificate of compliance and dosing instructions to be followed.

- C. Submit for review by the Resident Engineer concrete repair methods for fiber reinforced concrete. Concrete repair shall not begin until the Resident Engineer's review of the appropriate submittal is complete.
- D. See Section 03300 for additional submittal requirements.

1.07 DELIVERABLES

- A. See Section 03300.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Store fibers in dry sealed containers/bags until ready for use, free from corrosion, oil, grease, chlorides and deleterious materials which may reduce the efficiency of the fibers, the durability of the structure, the bond between the fibers and the concrete, or cause any other harm to the structure. Metallic coatings, such as copper or brass (only applied as lubricant for wire drawing) or zinc, will be permitted.
- B. See Section 03300 for additional requirements.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Steel Fibers:
 - 1. Steel fibers shall be ASTM A 820 Type I, cold-drawn wire with a minimum tensile strength of 145,000-psi. Fibers shall have deformed ends, a minimum length of 2-inches, a maximum diameter of 0.035-inch and an aspect ratio (length/diameter) from 55 to 70. Loose steel fibers that can cause balling during mixing shall not be used. Fibers shall be glued in clips.
 - 2. The minimum steel fiber content shall be 50-pounds per cubic yard.
 - 3. Add fibers at the ready-mix production facility using automatic dosing equipment only.
- B. Other concrete constituents shall be in accordance with Section 03300.

2.02 FORMS

- A. Forms are specified in Section 03100.

PART 3 EXECUTION**3.01 QUALITY CONTROL TESTING**

- A. All laboratory tests shall be performed by licensed independent concrete testing laboratory, as specified in Section 03300.
- B. Perform slump test in accordance with Section 03300, except where use of ASTM C 995 is recommended by ASTM C 1116. Frequency of testing shall be in accordance with Section 03300.
- C. Perform test of fiber content in fresh concrete for the first batch of concrete from each separate batching plant each day, whenever consistency of concrete appears to vary, and whenever compression test cylinders are made at the Work Site. Take three random samples, each having a minimum volume of 2.5-gallons, which shall be filled in one lift directly from the mixer.
- D. The volume of each sample shall be determined by weighing in air and water (similar to method given in ASTM C 128). The fibers shall be washed out from each sample or separated with a suitable magnetic device. The fibers shall be cleaned, dried and then weighed to nearest 0.1-ounce. Fiber volume per cubic yard shall be determined by dividing the weight of the fibers by the weight of the sample.
- E. Measured fiber content shall not be less than 90-percent of the design fiber content from an average set of six samples; and 80% of the design fiber content for each individual sample.

3.02 BONDING

- A. Joining old, existing, or unfinished work with new work, shall be in accordance with Section 03300. Steel fibers shall be left extending from the prepared surface.

3.03 FINISH OF EXPOSED SURFACES

- A. No fibers shall protrude from exposed surfaces.

3.04 REPAIR OF FORMED CONCRETE

- A. Concrete repairs shall be in accordance with Section 03300. Steel fibers shall be left extending from the prepared sound concrete surface.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for the application of shotcrete at the locations indicated on the Contract Drawings and specified herein.
- B. Definitions:
 - 1. “Dry Mix Process” is defined as shotcrete in which a premixed blend of cement and aggregate is propelled through a hose by compressed air to a nozzle. Water is added to the cement and aggregate mixture at the nozzle and the intimately mixed ingredients are projected onto the surface. Accelerator is added to shotcrete mixture at the nozzle in such a way that the quantity can be properly regulated.
 - 2. “Finish Shotcrete” is defined as plain shotcrete layer or layers applied over the shotcrete lining or over exposed rock to achieve a smooth surface that conforms to the smoothness criteria shown on the Contract Drawings.
 - 3. “Plain Shotcrete” is defined as a Portland cement concrete mix containing admixtures to provide quick set, high early strength, and satisfactory adhesion and that is conveyed through a hose and pneumatically projected at high velocity onto a surface.
 - 4. “Rebound” is defined as the shotcrete constituents that fail to adhere to the surface to which shotcrete is being applied.
 - 5. “Shotcrete Lining”: See Section 03375.
 - 6. “Steel Fiber” is defined as discrete, hard drawn, bent steel fibers uniformly distributed in shotcrete to improve the bending capacity and durability of shotcrete.
 - 7. “Steel Fiber Reinforced Shotcrete” is defined the same as “plain shotcrete” except that in addition to the plain shotcrete mix, steel fibers are incorporated into the mix.
 - 8. “Wet Mix Process” is defined as shotcrete in which all the ingredients except accelerator are mixed before introduction into the delivery hose. Accelerator is added to shotcrete mixture at the nozzle in such a way that the quantity can be properly regulated.

1.02 REFERENCED SECTIONS

- A. Section 02407 - Tunnel and Cavern Excavation by Drill and Blast
- B. Section 03200 - Concrete Reinforcement
- C. Section 03300 - Cast-in-Place Concrete
- D. Section 03375 - Shotcrete Lining

1.03 CITED STANDARDS

- A. American Concrete Institute (ACI):
 - 1. 506.1 – State-of-the-Art report on Fiber Reinforced Shotcrete
 - 2. 506R - Guide to Shotcrete
 - 3. 506.2 - Materials, Proportioning, and Application of Shotcrete
 - 4. 506.3R - Guide to Certification of Shotcrete Nozzlemen
 - 5. Committee 660 - Shotcrete Nozzleman Certification Examination
- B. ASTM International (ASTM):
 - 1. A 82 - Steel Wire, Plain, for Concrete Reinforcement
 - 2. A 185 - Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
 - 3. A 615 - Deformed and Plain Billet Steel Bars for Concrete Reinforcement
 - 4. A 820 – Steel Fibers for Fiber Reinforced Concrete
 - 5. C 31 - Methods of Making and Curing Concrete Test Specimens in Field
 - 6. C 33 - Concrete Aggregates
 - 7. C 39 - Compressive Strength of Cylindrical Concrete Specimens
 - 8. C 42 - Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
 - 9. C 78 - Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
 - 10. C 94 - Ready-Mixed Concrete
 - 11. C 150 - Portland Cement
 - 12. C 192 - Making and Curing Concrete Test Specimens in the Laboratory
 - 13. C 260 - Air-Entraining Mixtures for Concrete
 - 14. C 266 - Time of Setting of Hydraulic Cement Paste by Gillmore Needles
 - 15. C 309 - Liquid Membrane-Forming Compounds for Curing Concrete
 - 16. C 494 - Chemical Admixtures for Concrete
 - 17. C 618 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete

18. C 685 - Concrete Made by Volumetric Batching and Continuous Mixing
19. C 1018-Flexural Toughness and First-Crack Strength of Fiber Reinforced Concrete (using Beam with Third Point Loading)
20. C 1077 - Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
21. C 1102-Time of Setting of Portland Cement Pastes Containing Accelerating Admixtures for Shotcrete
22. E 329 - Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
23. E 548 - Guide for General Criteria Used for Evaluating Laboratory Competence

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

A. Applicator Qualifications:

1. Work shall be performed by personnel regularly engaged in shotcrete application in tunnels.
2. Employ qualified nozzlepersons who have had previous experience and training in shotcrete application on at least two projects of comparable nature. Perform Work under immediate supervision of foreperson with at least three years experience (or as approved by the Resident Engineer) in Work of a similar nature. Have each nozzleperson confirm their qualifications by demonstrating acceptable proficiency in uniform shotcrete application on vertical and overhead test panels before beginning production.
3. Shotcrete work shall be performed by personnel who have experience in Plain and Steel Fiber Reinforced Shotcrete (SFRS) application.
4. Each crew shall demonstrate, to the satisfaction of the Resident Engineer, acceptable proficiency in the application of shotcrete to vertical and overhead surfaces in field tests prior to beginning production work. Acceptable proficiency for the crew is defined as the crew being capable of placing shotcrete that meets the requirements of these Specifications, and that nozzlepersons meet the requirements of proficiency required by ACI Committee C 660. Crews lacking acceptable proficiency, as determined by the Resident Engineer, shall not be permitted to work on the Project.
5. Provide operators qualified to perform work conforming to requirements of ACI 506R and 506.3R with ACI nozzleperson certification in accordance with ACI Committee 660 requirements.

- B. Regulatory Requirements: OSHA safety requirements for working platforms or lifting equipment, and personal protective equipment.
- C. Uniformity of Materials: In production shotcrete work, use the same cement, aggregate and water used in accepted test areas and test units. Maintain specified strength.
- D. Testing Agency Qualifications:
 - 1. An independent Testing Agency, as reviewed by the Resident Engineer and certified with State of New York having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
 - 2. Personnel conducting field tests as specified in this Section shall be qualified as ACI Concrete Field Testing Technician, Grade 1 in accordance with ACI standards, or an equivalent certification program.
- E. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.
- F. Mix Design and Testing Prior to Production:
 - 1. Develop shotcrete mix by laboratory compatibility tests and field trials as specified at least 60 days before the actual production application of shotcrete.
 - 2. To ascertain compatibility of ingredients and optimum proportions, develop shotcrete mix having strength and characteristics meeting the requirements specified herein.
 - 3. Perform compatibility tests to determine cements and additives to be used in field trial mixes. Determine initial and final set for additive concentrations of varying percentages of cement content by weight contemplated for use in the Work.
 - 4. Make laboratory and field trial mixes with ingredients identical to those proposed for use in the Work.
 - 5. Accelerating Admixture:
 - a. Use accepted accelerating admixture to develop quick set as follows:
 - 1) Time of initial setting: Three minutes maximum.
 - 2) Time for final setting: Twelve minutes maximum.
 - b. Sodium silicate admixtures shall not be used.
 - c. Determine time of setting in accordance with ASTM C 266 with the following additional requirements:

- 1) Use minimum possible time interval to attain proper mixing without disturbing initial set of paste.
 - 2) Additional modifications to accommodate quick-set accelerators shall be reviewed by the Resident Engineer.
6. Standard Concrete Cylinder Testing: Choose materials and proportions so that three cast cylinders 6-inches by 12-inches made with no additive will achieve average minimum strength at 28 days of 5,000-psi. Cast cylinders in accordance with ASTM C 192 and test in accordance with ASTM C 39. Cast and test three cylinders minimum for each combination of materials proposed.
7. Pre-Construction Field Trial:
 - a. After completion and acceptance of laboratory tests, make field trials using selected mixes to accommodate capability of equipment, workmanship, and material under field conditions prior to actual application of shotcrete. Employ the same equipment that will be used in the Work.
 - b. Make field application of each mix selected for field trial on at least three horizontal overhead and three vertical test panels to simulate construction conditions. Test panels shall have reinforcement installed in the size and configuration to be installed in the Work.
 - c. Shoot test panels into a box measuring not less than 3-feet square and with a depth sufficient to include the reinforcement layers planned for the production work, placed in the same configuration relative to the shotcrete layer thicknesses planned for the production work.
 - d. The panels shall not be moved for nine hours after spraying and shall be kept without disturbance and covered by a polyethylene sheet until the time of coring.
 - e. Cure test panels in accordance with ASTM C31.
 - f. Within 24 hours after applying shotcrete, obtain a minimum of nine full-depth, 3-inch diameter cores, from each panel.
 - g. Average three cores from each panel to comprise one test.
 - h. Perform field trial work in the presence of the Resident Engineer.
 - i. Cut specimens in accordance with ASTM C 42 except as otherwise specified. Soaking of specimens before testing is prohibited.
 - j. Achieve progressive compressive strengths as follows:

- 1) Average strength of six tests with the bolt driving method, three overhead and three vertical, at 10 hours; 800-psi minimum.
 - 2) Average core compressive strength of six tests, three overhead and three vertical, at 24 hours; 1,800-psi minimum.
 - 3) Average core compressive strength of six tests, three overhead and three vertical, at 28 days; 5,000-psi minimum.
 - 4) No individual core compressive strength test at 28 days falls below the required 28-day strength by more than 500-psi.
8. Proportions: Proportion shotcrete mixes equivalent to those of concrete mix having between 6.5 and 8.5 bags of cement per cubic yard.

G. Testing During Construction:

1. From the in-situ shotcrete lining, furnish 3-inch diameter core test specimens with a minimum length of 6-inches, three for each 25-cubic yards of material used in the shotcrete lining, in locations specified by the Resident Engineer.
2. Take additional cores from the completed Work on the date, and at the locations requested by the Resident Engineer.
3. Cut the cores to a length equal to the diameter and test the cores in accordance with ASTM C 42 and as specified.
4. Cure specimens in accordance with ASTM C 31.
5. After application of the first 250-cubic yards of shotcrete, the Resident Engineer may call for test specimens at a reduced rate of less than three for each 25-cubic yards of shotcrete.
6. Additional specimens will be required upon failure of original cores. Should additional specimens show acceptable strength, the Work will be accepted. If additional specimens show unacceptable strength, the Work will be rejected. Furnish additional specimens as necessary to satisfy the requirements of this Section.
7. Minimum clearance between core voids shall be 1-foot. Plug voids caused by coring operation with material equal to shotcrete in-place and workmanship to ensure continuity of the lining with respect to strength and appearance.
8. Core holes shall not be arranged in a continuous row.
9. Shotcrete compressive strength requirements determined by testing during construction.

- a. Average strength of three tests from one area: 1,400-psi when tested at 24 hours after application.
 - b. Average strength of three cores from one area: 3,500-psi minimum when tested at 7 days.
 - c. Minimum strength of a single core: 3,200-psi when tested at 7 days.
 - d. Average strength of three cores from on area: 5,000-psi minimum when tested at 28 days.
 - e. Minimum strength of a single core: 4,670-psi at 28 days.
10. Toughness: Steel Fiber Reinforced Shotcrete shall have the following strength and toughness properties determined in accordance with ASTM C 1018:
- a. Average first crack flexural strength at seven days: greater than 700-psi.
 - b. Residual strength factor $R_{20,50}$ at seven days: 40.

1.06 SUBMITTALS

- A. At least 60 days before commencing production shotcrete application, submit the following for review by the Resident Engineer:
1. Product Data: For each type of manufactured material and product indicated.
 2. Samples: On completion of field trial, submit at least 54 test specimens of each trial mix, nine from each test panel, proposed for use in the Work together with relevant data that demonstrates conformance with specified requirements.
 3. Certifications:
 - a. Material Certificates signed by manufacturers, certifying that each of the following items complies with requirements:
 - 1) Cementitious materials and aggregates
 - 2) Steel fibers
 - 3) Reinforcement
 - 4) Admixtures
 - 5) Curing materials

4. Design Mixes: For each shotcrete mix, submit alternative mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments, with an explanation of how the particular circumstances affect the shotcrete mix, and how the alternative mix designs specifically address the negative impacts of those circumstances.
 5. Remedial Procedures: Submit procedures to remediate Work that fail the requirements specified in this Section.
 6. Resumes of proposed nozzlepersons and shotcrete foreperson. Proposed nozzlepersons shall also meet the ACI certification requirements specified herein.
- B. At least 20 days before commencing shotcrete application, submit the following for review by the Resident Engineer:
1. ACI Certification for each nozzleperson demonstrating proficiency in applying shotcrete sideways and overhead to the maximum thickness and with the same reinforcement as will be used in the production shotcreting.
 2. Detailed plan showing methods and proportions to be used in such tests. The Resident Engineer may inspect tests and materials at any time.
 3. Certified material test reports from a qualified testing agency without adjustment for type or size of specimen.
 4. Curing procedures for production shotcrete.

1.07 DELIVERABLES

- A. Provide testing results from in-situ shotcrete lining placement during construction.

1.08 PROJECT CONDITIONS

- A. In applying shotcrete containing toxic ingredients, the nozzlepersons and helpers shall wear appropriate hoods supplied with filtered air, free of toxic or objectionable material. Gloves and necessary protective clothing also shall be worn. This protective equipment shall be specifically designed for protection from the particular materials included in the mix.
- B. Ensure proper delivery, handling, and storage of materials to prevent any contamination, segregation, or damage. Store cement in a dry place and use it within 6 months of its documented date of manufacture. Store any admixtures in weather-tight enclosures to guard against dampness, evaporation, freezing, contamination, or other damage. The minimum temperature of aggregates used for shotcrete production shall be 40-degrees Fahrenheit.
- C. Alkali hydroxides and other chemicals contained in shotcrete admixtures can cause skin and respiratory irritation. Adequate safety measures that are specifically designed to address the types of skin and respiratory irritations caused by shotcrete mix materials shall be taken as required in the Contractor's health and safety plan.

- D. Working areas for shotcrete shall be well illuminated.

PART 2 PRODUCTS

2.01 CEMENT

- A. Cement shall be Portland cement in accordance with ASTM C 150, Type I or Type III.

2.02 AGGREGATE

- A. Aggregates shall be uniformly well graded, and shall not exhibit extremes of variation, in accordance with ASTM C 33, grading size No. 67 and ACI 506.2
- B. Specific Gravity: 2.55 minimum.
- C. Maximum aggregate size: 1/2-inch.

2.03 WATER

- A. Water: Potable and complying with ASTM C 94

2.04 ADMIXTURES

- A. Admixtures shall be according to ASTM C 494, Type C, with the following additional requirements:
 - 1. Admixtures shall be used to provide quick set, high early strength and improved adhesion.
 - 2. Admixtures shall not contain any water-soluble chlorides or materials corrosive to steel or those that can cause detrimental effects such as cracking or spalling.
 - 3. The admixtures shall either be in conformance with the referenced standard or have a document history of satisfactory performance in a mix of similar proportions.
 - 4. Air-entraining admixtures shall conform to ASTM C 260.

2.05 REINFORCEMENT

- A. Steel reinforcement shall conform to ASTM A 615, Grade 60. Welded wire fabric shall conform to ASTM A 185 and shall be fabricated from cold drawn steel wire conforming to ASTM A 82. Welded wire fabric shall be as indicated on the Contract Drawings and specified.
- B. Comply with applicable requirements specified in Section 03200.

C. Steel Fibers:

1. Steel fibers shall conform to ASTM A 820, Type I or II, with an aspect ratio of 45 to 85. Fibers shall be of a single length ranging from 3/4- to 1-1/2-inch.
2. Fibers shall be of the bent or deformed end type. Straight or continuously corrugated fibers shall not be used.
3. Polypropylene fibers shall not be used.

2.06 SHOTCRETE MIXES

- A. Have aggregate and cement proportioned by an accepted batching plant based on weight or volume and in accordance with the applicable requirements of Section 03300.
- B. Use the mixed material within one hour after adding cement, if no hydration control admixtures are used.
- C. Accurately proportion and mix additive(s) with other ingredients.

PART 3 EXECUTION**3.01 EXAMINATION OF SUBSTRATE SURFACES**

- A. Examine earth, rock, concrete, and masonry substrate surfaces, as applicable, and determine that such substrate surfaces have been properly prepared as specified herein.
- B. Reinforcing steel shall be properly placed and tied with sufficient clearances and shall be free of grease, oil, loose rust, and other coatings that may impair bond with shotcrete.
- C. Proceed with shotcrete placement only when substrate surfaces and Work Site conditions have been reviewed by the Resident Engineer.

3.02 PREPARATION OF SUBSTRATE SURFACES

- A. Remove loose material, mud and other foreign matter from new surfaces and those on which a shotcrete layer has already been applied, e.g., joints that will receive additional shotcrete.
- B. Substrate surfaces shall be scaled to remove all loose material before placing shotcrete.
- C. Action shall be taken to control water and prevent it from adversely affecting the shotcrete layer. Water inflows that may cause deterioration of the shotcrete, or prevent adherence to the substrate, shall be diverted by channels, chases, pipes or other appropriate means to the invert.

- D. Thickness Pins: Thickness measuring pins may be used to establish layer thickness and surface planarity. Install pins at a spacing and of type as reviewed by the Resident Engineer.

3.03 EQUIPMENT

- A. All equipment shall be operated, tested, and maintained in accordance with the manufacturer's instructions for the entire duration of excavation and lining work until the tunnels and caverns are substantially complete.
- B. Aggregate and cement may be batched by weight or by volume. If volumetric batching is used, a minimum of one weight batching check shall be made every seven operating days to insure that the design mix is being achieved. Weighing equipment shall be capable of batching with the accuracy specified in ASTM C 685.
- C. The shotcrete equipment shall be capable of feeding materials at a regular rate and ejecting shotcrete from the nozzle at velocities that will allow adherence of the materials to the surface being shotcreted with a minimum rebound and maximum adhesion and density.
- D. The air and water supply system shall be capable of supplying the delivery machine and hose at pressures and volumes recommended by the manufacturer of the machine. No air supply system shall be used that delivers air contaminated by oil.
- E. The required equipment for the dry mix process or wet mix process shall be set up according to the recommendation of the manufacturer.
- F. Equipment shall be thoroughly cleaned at least once per shift.

3.04 APPLICATION

- A. After cleaning, keep surfaces moist until shotcrete is applied.
- B. Air and substrata temperatures shall be maintained at 40-degrees Fahrenheit or higher during shotcreting and for a minimum of seven days following shotcreting. When water is encountered, suitable means, as specified herein, shall be undertaken to direct the water away from the area to be shotcreted.
- C. Hold nozzle at predetermined distance and position so that stream of flowing material is applied as nearly as possible at right angles to the surface.
- D. Layer the shotcrete maintaining a steady motion with the nozzle while building up to the specified thickness.
- E. Apply shotcrete of uniform consistency to maximize binding, cohesion, and density, and to minimize rebound, segregation, and sagging.
- F. Rebound shall not be reused.

- G. Acceptable shotcrete is dense, uniform concrete without honeycombing, segregation, or discernible weakness of bond between layers. If shotcrete as placed does not meet these criteria, remediate the deficiencies as specified.
- H. Sequence of Operations: See Section 03375.

3.05 CURING

- A. Ensure that shotcrete exhibits proper strength with minimum cracking and shall apply curing measures if necessary to achieve these requirements.

3.06 FIELD QUALITY CONTROL

- A. The following describes the minimum inspection and testing required for the Work of this Section. The implementation does not relieve the Contractor from the responsibility to provide the Work in accordance with the Contract, applicable codes, regulations, and governing authorities. The following testing and inspection elements are provided as a minimum list for the Contractor to use to generate his complete field quality control program.
- B. Sampling and Testing: Sampling, and laboratory and field testing shall be as specified elsewhere herein.
- C. Plant and Field Inspection: Shotcrete work will be subject to detailed inspection at the plant and in the field.
 - 1. Verify that shotcrete placement procedures are followed.
 - 2. Verify that cold-weather or hot-weather placing procedures of shotcrete are strictly followed.
 - 3. Verify that the shotcrete delivery tickets contain the following information:
 - a. The strength of the mix of shotcrete being delivered.
 - b. The exact time the cement and aggregate were discharged into the delivery truck.
 - c. List of admixtures and proportions.
 - d. Name of supplier.
 - e. Name of batching plant and location.
 - f. Serial number of ticket.
 - g. Truck number and batch number.
 - h. Project designation (Contract number and location).
 - i. Amount of water added.

- j. Type and brand of cement.
 - k. Weight of cement.
 - l. Maximum permissible amount of water to be added at the site, if required.
 - m. Mix design designation.
 - n. Signature of a responsible employee of the shotcrete supplier.
4. If, upon reaching the Work Site, ready-mix shotcrete cannot be placed within the specified time limits, or if the type of shotcrete delivered is incorrect, the Resident Engineer will reject the load for use, and it shall be removed from the Work Site.
5. A record of each field quality control inspection shall be submitted to the Resident Engineer, covering the quality and quantity of shotcrete materials, mixing and placing of shotcrete and the general progress of the Work.
6. Take prompt action to correct conditions that have resulted in or could result in submission of materials, products, or completed construction that do not conform to the requirements of the Contract.
7. Batch Plant Inspection: At the start of the Project, observe and evaluate the following for compliance with the Contract.
- a. Condition of batching equipment.
 - b. Condition of materials.
 - c. Type of materials used.
 - d. Mixing time.
 - e. Delivery time.
 - f. Additional pertinent controls depending on weather, Work Site conditions, and other factors affecting the Work.
 - g. Inspect aggregate stockpiles and storage practices. Check for unacceptable material handling that may cause segregation or contamination within the stockpiles.
 - h. Inspect trucks used to transport concrete to assure that they are clean and in a condition to deliver a uniform mix.
8. Preparatory Inspection: Preparatory inspection shall be performed before beginning work.
- a. Check materials for proper storage to assure adequate protection against damage and deterioration.

- b. Check to assure that required inspections and observations are being performed.
 - c. Review Contract requirements with each person involved in performing the Work.
 - d. Check examination results of nozzle men and allow only individuals who passed the test to perform the Work.
9. Inspection: Initial inspections shall be performed as soon as practical after each and every segment of the particular item of Work have been accomplished in order to provide visual evidence that the shotcrete mix and the application are producing the desired results.
- a. Check for workmanship. Initial inspection for workmanship shall include shotcrete placement and finishing.
 - b. Assure that damaged and/or defective materials are removed from the Work Site and replaced.
 - c. Pre-placement Inspection: Check all of the following prior to excavation of next round or section. Do not permit excavation to start until all are satisfactory.
 - 1) Verify that sufficient quantities of all materials are on hand to permit continuous placement and completion.
 - 2) Verify location, dimensions, alignment, and grade.
 - d. Assure that damaged or defective Work is corrected.
 - e. Note and discuss any deficiencies observed and corrective action to be taken. If corrective action is to be taken, conduct an additional initial inspection to verify that proper adjustments, corrections, or revisions have been made.
 - f. Assure that accomplishment of corrective action is in accordance with requirements.
10. Follow-up Inspections: Follow-up inspections shall be performed daily, and more frequently as necessary, and shall include continued testing and examinations to assure continued conformance with Contract requirements.
- a. Conveying and Placing Operations:
 - 1) Check requirements pertaining to placing fresh shotcrete.
 - 2) Verify that the time between completion of mixing and placement in final position is within the maximum allowed as specified herein.

- b. Correct deficiencies in shotcrete work that inspections have indicated as non-conforming.
 - c. Perform additional inspections as necessary to reconfirm any non-conformance of original work and to show conformance of corrected work.
 - d. Do not allow any addition to or building upon non-conforming work unless correction can be made without disturbing the continuing work. Corrections of non-conforming work shall be made in accordance with remedial procedures specified herein.
 - e. Work accomplished shall be considered satisfactory only when inspections show that all variances have been corrected in an acceptable manner and that the completed Work is in conformance with the Contract.
 - f. Inspection results shall be certified by the Field Quality Control Representative. This certification shall attest that, to the best of his knowledge, information, and belief, and based on observations and inspections, all shotcrete work is complete, is free of mistakes and errors, and is in conformance with the requirements of the Contract.
- C. Defective Shotcrete:
- 1. Shotcrete that lacks uniformity, exhibits segregation, honeycombing, lamination, shows cracking, lacks adequate bonding, lacks watertightness, or fails to meet the specified strength requirements shall be regarded as defective shotcrete.
 - 2. The Resident Engineer reserves the right to halt further placement of shotcrete and/or to order removal of defective shotcrete and its replacement with acceptable corrective shotcrete.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for the installation of the shotcrete lining at the locations indicated on the Contract Drawings and specified herein including the Approach Tunnels, TBM Assembly Chamber and adjoining Starter Tunnels, GCT 5 Wye Caverns and adjoining Starter Tunnels, GCT 3 Wye Caverns, cross passages, central instrument room, and cross flue.
- B. Definitions:
 - 1. “Flashcrete”: 2-inch thick shotcrete layer placed after excavation on a temporary excavation wall in staged excavations as required to seal and protect the ground material from deterioration and initial loosening.
 - 2. “Initial Support”: See Sections 02270 and 02407.
 - 3. “Lattice Girder”: A lightweight, three dimensional steel frame made to act as a unit by connecting all components with lacing bars; used in conjunction with shotcrete for shotcrete lining reinforcement.
 - 4. “Shotcrete”: Portland cement concrete applied by spraying from a nozzle and propelled by compressed air. See Section 03370.
 - 5. “Shotcrete Lining”: A reinforced shotcrete layer of minimum thickness as shown on the Contract Drawings. The shotcrete lining is reinforced with welded wire fabric or steel fibers, and lattice girders where shown on the Contract Drawings. The shotcrete lining is placed after excavation on exposed perimeter surfaces to provide initial support, acting alone or in combination with other rock reinforcement or additional initial support elements.

1.02 REFERENCED SECTIONS

- A. Section 02270 – Rock Reinforcement and Initial Support
- B. Section 02407 - Tunnel and Cavern Excavation by Drill and Blast
- C. Section 02495 – Geotechnical and Structural Instrumentation
- D. Section 03370 – Shotcrete
- E. Section 05120 - Structural Steel

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

- A. Do not begin drill-and-blast excavation until required submittals have been made and have been reviewed by the Resident Engineer.

1.05 QUALITY ASSURANCE

- A. Applicator and installer's experience shall comply with the requirements specified in Section 03370.
- B. Lattice girder fabrication and installation tolerances shall be determined by Contractor and submitted for review by the Resident Engineer.
- C. General Smoothness Criteria: Contractor shall provide shotcrete with a surface as shown on the Contract Drawings.

1.06 SUBMITTALS

- A. At least 60 days before commencing shotcrete application, submit the following for review by the Resident Engineer:
 - 1. Lattice girders: submit a 2-foot long sample of lattice girder, with accessories, which show full cross section and type to be used. Submit three such samples of lattice girder for each lattice girder type.
 - 2. Shotcrete: Refer to Section 03370.
 - 3. Shop drawings showing shotcrete lining indicating all structural and construction details and geometry including tolerances.
 - 4. Shop drawings showing shotcrete lining installation details and sequences following excavation in each round in conjunction with blasting the following round.
 - 3. Procedures to fill over-break with shotcrete and installation of shotcrete and its sequence and timing to meet specified smoothness criteria.
 - 4. Shop drawings showing fabrication details, geometry including tolerances, design, specifications and other data pertaining to the fabrication for lattice girders.
 - 5. Calculations for lattice girders and lattice girders connection details.

1.07 DELIVERABLES

- A. Provide results of testing lattice girder segments.

1.08 DELIVERY, STORAGE, AND HANDLING**A. General:**

1. Load, transport, unload, and store structural materials to keep them clean and free from damage.
2. Store materials on platforms, skids, or other supports above the ground and ensure proper drainage and protection from corrosion.
3. Have shotcrete on hand in adequate quantities and ready for application at the face at all times.

B. Lattice Girders:

1. When handling and shipping lattice girders, prevent bending, scraping, or overstressing members.
2. Block projecting parts likely to be bent or damaged during handling with timber or other acceptable material.
3. Do not start replacement of bent or damaged pieces, until repair method is reviewed by the Resident Engineer.

1.09 PROJECT CONDITIONS AND SAFETY

- A. Maintain an average of a five-day supply of shotcrete and reinforcing elements including welded wire fabric, lattice girders, and steel fibers, as applicable, on-site to prevent work delays. No excavation will be allowed without having sufficient shotcrete and shotcrete components on-site.
- B. Maintain constant and adequate supply of shotcrete and reinforcing elements including welded wire fabric and steel fibers as applicable at tunnel and/or chamber heading during excavation, so that shotcrete may be applied at any time.
- C. Have sufficient quantity of shotcrete components, welded wire fabric, lattice girder, and steel fibers as applicable on the Work Site required to support one full excavation round during the excavation period, and ready to immediately mobilize into the tunnel. No excavation will be allowed without having sufficient shotcrete on-site.

1.10 PRE-INSTALLATION MEETING

- A. Before commencement of any Work under this Section, and when directed by the Resident Engineer, meet at the Work Site to review installation and coordination procedures. Among other topics, the coordination meeting shall address scheduling and method of shotcrete application, standard of workmanship, material selection, testing and quality control requirements, detailed requirements of design mixes, application procedures, off-site batching requirements, coordination of the work with other trades, preparation of surfaces contiguous with this Work, adjacent construction, and interferences, if any. The meeting shall be attended by any and all trades, manufacturer's representatives, and other interested parties whose work will be affected by the execution of the Work under this Section including, but not limited to, the following:

1. Resident Engineer
2. Contractor
3. Shotcrete Subcontractor, as applicable
4. Testing laboratories
5. Ready-mix shotcrete supplier, as applicable
6. Any other Subcontractor and/or material supplier or manufacturer required
7. Admixture manufacturer
8. Lattice girder supplier

PART 2 PRODUCTS

2.01 STEEL

A. Lattice Girders:

1. General Requirements:
 - a. All lattice girders shall consist of three primary retaining bars as shown on the Contract Drawings, shall be connected by stiffening elements as per the manufacturer's design. The bars shall be designed to:
 - 1) Facilitate shotcrete penetration into and behind the girder, to minimize the creation of spray shadows.
 - 2) Provide good quality bonding between the steel and shotcrete, to form a composite structure and a continuous shotcrete lining.
 - b. The lattice girders shall have section properties about the neutral axis in the section perpendicular to the longitudinal axis of the girder as shown on the Contract Drawings. At least 5-percent of the total moments of inertia shall be provided by the stiffening elements.
 - c. To ensure stability against buckling the maximum spacing between stiffening elements shall be less than three times the cross sectional height of the girder.
2. Dimensions:
 - a. Lattice girder geometry shall be developed by Contractor to suit intended shotcrete lining reinforcement.

- b. The lattice girders shall be designed and fabricated to meet minimum clearances under consideration of inaccuracy of placement during construction, material and construction tolerances, and anticipated ground deformation.
- 3. Testing:
 - a. Test lattice girder segments of typical length randomly selected from standard stock by the Resident Engineer for testing by Contractor. All testing shall be observed by the Resident Engineer.
 - b. Test segments in single point flexure with loading and constraints representative of the in-situ conditions of the girder. The gradually applied load and deflection of the girder at the point of application shall be measured and recorded until failure occurs to verify that the girder satisfies minimum structural requirements.
 - c. Replace faulty lattice girders at no additional cost to the MTA.

2.02 FABRICATION OF LATTICE GIRDERS

- A. Each of the primary retaining bars of a lattice girder segment shall be composed of only one piece of high strength steel having a yield strength of 70-ksi or more.
- B. The connection elements at the end of lattice girder segments shall be constructed of angled structural steel having yield strength of 36-ksi or more, or of welded flat steel ensuring similar strength characteristics.
- C. Fabricate lattice girders in accordance with Section 05120 except for the following:
 - 1. Inspection of groove and fillet welds by visual inspection only.
 - 2. Grinding to remove nicks resulting from flame cutting is not required.
 - 3. Planning and facing of sheared edges or bearing surfaces is not required.
 - 4. Sub-punching or sub-drilling of bolt holes is not required.
 - 5. Portions of bearing members such as butt and foot plates need not be straightened, planed and connected after fabrication.

2.03 SHOTCRETE

- A. See Section 03370.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with applicable requirements of Section 03370 install shotcrete lining as shown on the Contract Drawings and specified herein.

1. Excavate headings as shown on the Contract Drawings.
 2. Install shotcrete lining as shown on the Contract Drawings and as specified in Section 02406.
- B. Lattice Girders:
1. Install to conform to excavated shape as defined on the Contract Drawings. Consider variability of materials, construction tolerances, and initial lining deflection to determine required dimensions. Provide minimum embedment as shown on the Contract Drawings.
 2. Secure lattice girder segments by use of temporary wood blocking or other appropriate means to maintain position during shotcrete application.
 3. Provide butt plates for lattice girder segments and connection elements as shown on the Contract Drawings. Ensure tight connection of all elements.
 4. Remove any temporary blocking before continuing shotcrete lining installation into the bench.
- C. Shotcrete:
1. See Section 03370.
 2. Install shotcrete lining to provide required thickness as shown on the Contract Drawings.
1. Spraying shotcrete through two layers of reinforcement shall not be permitted.
 2. Rebound shall not be incorporated into shotcrete lining.
 3. Remove any rebound or foreign material from construction joints before continuing shotcrete lining installation.
- D. Detection of Movement: As specified in Section 02495.

3.02 APPLICATION OF SHOTCRETE LINING

- A. Apply shotcrete lining in accordance with the sequences shown on the Contract Drawings and the following requirements:
1. Minimum thickness of shotcrete layer at any point as shown on the Contract Drawings and specified. Use adequate thickness indicators such as steel pins at a spacing as reviewed by the Resident Engineer.
 2. Fill all over-excavation and overbreak with shotcrete in accordance with the general smoothness criteria.
 3. The finished shotcrete lining may not encroach into the design lines as shown on the Contract Drawings.

4. Remove laitance, loose material, and rebound.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for drilling and cement grouting in the Manhattan tunnels including pre-excavation grouting operations ahead of the advancing TBMs for rock stabilization and controlling groundwater inflow into tunnels, post-excavation operations for water cut-off purposes, backfill grout, check grout, and contact grouting of lined areas of the tunnel.
- B. Work includes all materials, labor, tools, and equipment necessary to perform all grouting work in the Manhattan TBM tunnels, and transport, storage, and handling of all materials and products.
- C. Definitions:
 - 1. Additives: Any natural or chemical product added to the grout mix to reduce admixture bleed water, lower mix viscosity and cohesion, and enhance penetrability.
 - 2. Backfill Grouting: Grouting to fill the annular space between the one-pass segmental tunnel lining and the excavated surface.
 - a. “Primary” backfill grouting utilizes the TBM’s continuous backfill grout injection system.
 - b. “Secondary” backfill grouting utilizes segment lifting/grouting holes.
 - 3. Cement Grouting: Injection of cementitious grout mix under controlled pressure through grout pipes placed at locations as required in a specified zone to fill water-bearing fissures, joints, or fractures.
 - 4. Check Grouting: Grouting to fill voids or loosened zones between the one-pass segmental tunnel lining and the excavated surface to replace ground loss, utilizing segment lifting/grouting holes.
 - 5. Contact Grouting: Grouting through pre-placed grout/vent pipes, to fill voids and/or leaks between the initial ground support/excavated surface and the final cast-in-place concrete in tunnels, cross-passages and caverns.
 - 6. Effective Grouting Pressure: The mean injection pressure estimated at the midpoint of a particular stage, while the grout is being pumped.
 - 7. Grout: Water-cement mix that may include additives such as accelerators, superplasticizers and others.
 - 8. Micro-Fine Cement Grout: Mixture containing cement with a fineness of at least 650 Blaine (m²/kg) and 99-percent of the material finer than 40-microns and 50 percent of the material finer than 8-microns.

9. Pre-Excavation Grouting: Injection of grout materials through:
 - a. Probe holes and grout holes drilled in advance of the tunnel face (in front of the TBM cutterhead) from within the tunnel being mined.
 - b. Grout holes drilled from a completed section of one tunnel to the area in advance of the tunnel face (in front of the TBM cutterhead) of an adjacent tunnel that is being or will be mined.
10. Post-Excavation Grouting: Injection of grout materials from the excavated tunnel, behind the tunnel face to reduce water inflows.
11. Refusal: A grout take of less than 1-cubic foot over two minutes with the grout pump operating at 100-percent of the maximum specified injection pressure.
12. Specified Grouting Pressure: The pressure recorded at the collar of the grout hole while the grout mix is being pumped.
13. Stage: The partial or complete length of a grout hole to be pressure tested or grouted.
14. Stage Grouting: In general, the drilling of a hole, and the subsequent pumping of the grout mix in such holes, blocked in one or more stages by means of packers at pre-established depths and/or in successive stages. Upstage grouting implies drilling a hole to full depth, water pressure testing it stage by stage, flushing the hole, and grouting the hole from its bottom end towards the surface (collar) in successive stages by setting the packers at predetermined depths, and so forth, in as many cycles as required, allowing sufficient time between successive stages for complete setting of the injected grout.
15. Water/Cement Ratio: The proportion by volume of cement grout mix between the amounts of water and loose cement, plus any additive. As weight batching shall generally be used, water-cement ratios shall be reported both as volume ratio and equivalent weight ratios.

1.02 REFERENCED SECTIONS

- A. Section 02406 – Tunnel Excavation by TBM
- B. Section 02413 – Tunnel Boring Machine (TBM)
- C. Section 02425 – Cast-in-Place Concrete Lining
- D. Section 02427 – Precast Concrete Tunnel Lining
- E. Section 03300 – Cast-in-Place Concrete

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. C 39 - Compressive Strength of Cylindrical Concrete Specimens
 - 2. C150 - Portland Cement
 - 3. C 266 - Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
 - 4. C 494 - Chemical Admixtures for Concrete
 - 5. C 618 - Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture for Portland Cement Concrete
 - 6. C 989 - Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

1.04 NOTED RESTRICTIONS

- A. Do not begin grouting operations until the following conditions have been met:
 - 1. Required submittals have been made and reviewed by the Resident Engineer.
 - 2. Pre-construction inspections have been completed by the Resident Engineer and pre-construction documents have been provided to Contractor.
 - 3. Installation of geotechnical and structural instrumentation has been completed and initialized.
 - 4. Required personnel with qualifications specified herein are available on Work Site to perform the Work.
 - 5. All necessary equipment and materials required to perform the Work are on the Work Site, of sufficient quantity and in good working order along with the personnel qualified to perform grouting operations in accordance with this Section.

1.05 QUALITY CONTROL

- A. The grouting program shall be performed under the supervision of a grouting specialist having a minimum of 15 years experience (or as approved by the Resident Engineer) in underground grouting applications including projects with grout mixes, equipment, grouting methods, and control testing similar to that specified herein.
- B. The grouting supervisor(s) shall have a minimum of 10 years experience (or as approved by the Resident Engineer) in similar grouting projects. The grouting supervisor(s) shall be present on-site at all times during grouting operations.
- C. Be responsible for all phases of the quality control and workmanship of the Work covered by this Section, and shall ensure that the Work is accomplished in accordance with the Contract Drawings and Specifications.

- D. All drilling and grouting activities shall be documented. Prepare and maintain legible records of the Work, copies of which shall be submitted to the Resident Engineer as specified herein.
- E. Quality control procedures shall be established by Contractor and reviewed by the Resident Engineer. Such procedures shall be followed to ensure that the Work is accomplished in accordance with the Contract Documents.
- F. Rejection criteria for aged grout will be strictly enforced. Generally, grout that is not placed within two hours of the time of mixing shall not be used unless a retarder specially formulated to suspend hydration is used.
- G. Backfill, check, and contact grouts shall remain effective for the design life of 120 years. The grouts shall not degrade, shrink, or lose strength to an extent that the tunnel would be damaged or become unserviceable as a result.

1.06 SUBMITTALS

- A. At least 60 days before commencing tunneling operations, submit the following for review to the Resident Engineer:
 - 1. Resumes describing the experience of the grouting specialist and grouting supervisor(s).
 - 2. Grout mixes, including proprietary mixes, and injection methods for each type of grout, meeting the requirements of this Specification and certified by a Professional Engineer registered in the State of New York. Information given shall include:
 - a. Mix designs, including testing of trial mixes.
 - b. Mixing and delivery systems which shall be consistent with planned maximum TBM advance rate.
 - c. Grout gel times.
 - d. Design cylinder strengths at the end of one ring construction cycle (backfill grouting).
 - e. Design cylinder strengths at times after placement.
 - f. Proposed minimum operational and maximum grouting pressures with regard to the vertical tunnel alignment/cover.
 - g. Requirements for sampling and testing during production.
 - h. Theoretical grout volume including consideration for the use of any TBM copy cutters, and proposed minimum grout volume.
 - 3. Manufacturer's product data, material safety data sheets, material qualification data and certification that materials meet specification materials for each type of grout.

4. General Grouting Procedures:
 - a. Procedures for disposal of waste grout and water
 - b. Acceptance criteria for completed grouting
 - c. Methods for assuring that grout injection does not damage surrounding or adjacent infrastructure, structures, facilities and utilities.
5. Backfill Grouting: Description and Shop Drawings of grouting equipment, their arrangement and grouting procedures and methods.
6. Check Grouting: Description and Shop Drawings of grouting equipment, their arrangement, grout pipe materials, grout materials, grouting procedures and methods, and measures for ensuring voids or loosened/disturbed zones are filled and stabilized.
7. Pre-Excavation and Post-Excavation Grouting: Description and Shop Drawings of grouting equipment, their arrangement and grouting procedures and methods. Procedures of drilling grout holes, hole layouts, and method of preventing excessive groundwater inflow.
8. Contact Grouting: Description Shop Drawings of grouting equipment, their arrangement, grout pipe materials, grouting procedures and methods, and measures for ensuring the integrity of the final cast-in-place concrete and the waterproofing membrane, where applicable.
9. Drilled Holes Through Segments: Diameter of drilled holes and the means of drilling and means of attaching grout pipes to the holes.
10. Submit certifications of calibration of pressure gauges and flow meters from manufacturers.
11. Description of planned and contingent grouting procedures including sequences and procedures for injection, and procedures for altering mix proportions based on observed grout takes.
12. Procedure for disposal of waste grout and water, acceptance criteria for completed grouting
13. Methods for assuring that grout injection does not damage adjacent structures.
14. Forms to be used in completing daily records.

1.07 DELIVERABLES

- A. Prepare, maintain, and transmit the following records after each shift of grouting, for each type of grouting (backfill, check, pre-excavation, post-excavation, contact):

1. Drill hole number, location, length, diameter, and orientation, estimated quantity of any water inflows intercepted, and observations of drilling action and any zones of hole instability or voids encountered.
 2. Injection records for each grout hole including dates, start and finish times, mix type and batch number, number of bags of cement used, gallons of water per bag, initial groundwater pressures, injection point pressures, grout quantities injected, modifications to the mixes, pressures (initial, average, and final), rates of pumping, and comments and incidents recorded during the grouting such as leaks or grout resurgence.
 3. Grout strength test results.
- B. Prepare, maintain, and provide the following performance records on a weekly basis of grouting, for backfill and check grouting:
1. For backfill and check grouting (together and separately), calculate a rolling 10 ring average grout take (volume) which shall be provided, in both hard and electronic copies.
 2. Grout mix routine test results.
- C. In addition to the grouting shift reports, prepare drawings updated daily with longitudinal profiles of the grout holes showing drilling depths and grout takes for each stage of all grout holes, and also maintain a database of all grout records, updated at least on a weekly basis, complete with summary statistics and graphs of all related data. Transmit copies of these profiles to the Resident Engineer on a weekly basis.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Transport, store, and handle all materials as prescribed by the manufacturers of these materials in original, unopened containers with the manufacturer's name, product labels, product identification, and as detailed on the accepted data sheets. Protect materials from mechanical and environmental damage. All required materials shall be delivered to the site at least one day before commencing grouting operations. Maintain sufficient amounts of required materials to assure continuous grouting operations at any time during the Project.
- B. Furnish cement either in sacks or in bulk. Use material in chronological order of delivery. If furnished in bulk, provide accurate weighing devices to properly measure cement weight.
- C. Assure that cement is free from lumps or foreign matter. Screen all cement and lime to remove any lumps or foreign matter before introducing it to the mixer.
- D. Fly ash and ground granulated blast furnace slag (GGBFS), if used, shall be packaged and stored in accordance their respective ASTM standards.

1.09 PROJECT CONDITIONS

- A. Coordinate the grouting operations with all other construction involved with the tunnel excavation.

PART 2 PRODUCTS**2.01 MATERIALS****A. General:**

1. All grouting materials used shall meet the requirements specified herein.
2. Do not use materials including admixtures that are toxic or cause any hazard to workers or the environment.
3. Cement: Unless specified otherwise, all cement grouts shall use Portland cement conforming to ASTM C150, Type II and Section 03300. Cement that has become wet in storage or is more than 5 weeks old in site storage shall not be used. Assure that cement/lime is free from lumps or foreign matter.
4. Water: Potable water shall conform to Section 03300 and shall be compatible with other grout mix materials.
5. Admixtures shall conform to ASTM C 494, shall be compatible with other grout materials, and shall not promote steel corrosion.

B. Fly Ash: Conform to Section 03300 and ASTM C 618.

C. Ground Granulated Blast Furnace Slag: Conform to ASTM C 989.

2.02 EQUIPMENT

A. Backfill grouting equipment shall be in accordance with Section 02413.

B. Rotary or percussion drilling equipment shall be used to drill grout holes, and shall be of sufficient power and versatility to bore holes at any angle with the diameters and to the depth as shown on Contractor's hole layout drawings, in accordance with this Section and Sections 02406, 02413, and 02427.

C. Equipment used for mixing and injecting grout shall be designed for underground grouting service, and shall be capable of satisfactorily mixing and agitating the grout and forcing it into the grout holes at a uniform flow rate under constant pressure. Arrangement of grouting equipment shall provide for continuous circulation of grout in the system and shall permit accurate pressure control. Equipment and lines shall be kept clean by constant circulation of grout and by periodic flushing.

D. The grouting equipment to be provided shall include effective and exact batching and mixing mechanisms and precision gauges, and shall be able to keep admixtures in suspension. The equipment shall supply and pump the grout mix to and within the holes in a continuous and uninterrupted manner and at any specified constant pressure. Each set of grouting equipment provided for the Work shall include at least the following:

1. One main and one stand-by pump. Pumps shall have sufficient capacity to operate effectively at low pressure and with no more than 5-percent variation in the grouting pressure. A fitting shall be installed at the pump intake to supply the required flushing water for clearing of pipes and grout holes, plus a by-pass system connecting the pump discharge to the sump tank. The pumps shall be provided with interconnecting pipes and valves to permit immediate transfer if necessary to stand-by equipment to ensure uninterrupted grouting.
 2. A high-speed colloidal mixer capable of thoroughly mixing water, cement, sand, and additives. The mixer shall be provided with a device capable of accurately measuring the amount of the various ingredients, and shall be of sufficient capacity to ensure that continuous grouting is performed at the maximum specified flow rate.
 3. A sump tank (agitator) with the ability for keeping in suspension all solid materials contained in the mixture. It shall be provided with screens that allow retaining and removing from the mixer any hardened grout or unwanted material. The capacity of the agitator shall not be less than that required for the mixer. The injected volume shall be computer-controlled, and the sump tank shall be calibrated in tenths of the volume injected.
 4. All valves, flow meters, pressure hoses, pipes, casings, packers, plugs, fittings, and necessary tools to perform the grouting work in accordance with the Specifications.
 5. Single and double packers, consisting of rubber or leather tubes or rings, that are hydraulically, mechanically or pneumatically expandable, that can be installed singly or in pairs in a hole, at any design depth, to isolate any given segment within the hole without leakage over the full range of injection pressures required for the tunnel grouting operations. When expanded, the packers shall be capable of withstanding without leaks for a period of at least ten minutes, water pressures equal to the maximum grout pressure that they will have to withstand.
- E. At the point of injection, suitable valves and accurate, calibrated pressure gauges shall be provided so that the pressure and grout flow at the grout hole may be regulated and monitored by increasing or decreasing the flow in the grout return line.
- F. Use equipment that will not permit the specified pressure to be exceeded for each grout type. Provide suitable stop valves at the collar of each hole for use in maintaining pressure as required until grout has set.
- G. Provide two pressure gauges, one at the grout pump and the other on the manifold hook up at the collar of each hole being grouted. Check accuracy of gauges periodically, or at direction of the Resident Engineer, with an accurately calibrated high precision pressure gauge which shall be maintained in working order and available at all times during grouting operations.

2.03 GROUT MIXES

- A. A suitable grout mix shall be proposed for each set of ground conditions to be encountered along the tunnel drives.
- B. Grouts shall be sufficiently fluid as to ensure that they flow freely under pressure into all of the space to be filled.
- C. Grouts shall be capable of resisting washout by groundwater and of supporting construction loads and rock loads.
- D. Backfill Grouting:
 - 1. Backfill grout to develop an unconfined compressive strength not less than 50-psi at 28 days, compatible with pumping and placing requirements.
 - 2. Primary backfill grout shall achieve a minimum 6 x 12 cylinder strength of 8-psi before the next 'shove' commences. Design set-up times to be compatible with TBM advance rates, and planned or unplanned work stoppages.
- E. Check Grouting: Develop a compressive strength of approximately 30-psi.
- F. Pre-Excavation Grouting:
 - 1. Materials: Unless otherwise directed by the Resident Engineer, use ordinary, sulfate-resisting, high early strength or micro-fine cement, as appropriate for the particular application.
 - 2. Mixes:
 - a. Additives to increase flowability shall be added as required.
 - b. Grout set times per ASTM C266 shall be:
 - i. Initial set: 60 minutes.
 - ii. Final set: less than 120 minutes.
- G. Post-Excavation Grouting Materials: Use Portland cement grout or micro-fine cement grout materials as appropriate for the particular ground conditions requiring treatment.
- H. Contact Grouting: Grout mix proportions and strength requirements shall be in accordance with the provisions of Section 02425.

PART 3 EXECUTION**3.01 GENERAL**

- A. Notify the Resident Engineer of all proposed grouting operations and perform all drilling and grouting operations in the presence of the Resident Engineer.

- B. No grouting shall be performed without appropriate calibrated pressure gauges in place and in working order.
- C. Monitor water infiltration rates as required to determine the need for pre-excavation or post-excavation grouting.
- D. Grout Hole Drilling:
 - 1. Drill grout holes at the locations, directions, inclinations and spacing, and to the diameters and lengths as shown on the submitted and reviewed working drawings.
 - 2. Holes shall be drilled wet and a constant flow of return water shall be maintained at all times. Except where expressly directed by the Resident Engineer, Contractor will not be permitted to use lubricants or other additives to the drilling water as an aid to drilling grout holes, except a combined air/water flush for deep holes in excess of 50-foot length.
 - 3. When drilling of each hole is complete, install suitable fittings to make connections for grout injection that will not leak at the maximum injection pressure to be used in the work. Provide a valve at each connection.
 - 4. Clearly label all grout hole locations for easy identification. Protect grout holes from becoming obstructed before grout injection by means of a cap or plug at the collar of the hole.
- E. All grouting shall proceed from lower holes to holes at higher elevation as grouting proceeds.
- F. Upon completion of grouting at each connection, close the connection valve and leave it in place until the grout has set.
- G. Grout that is not placed within two hours of the time of mixing shall not be used unless a retarder specially formulated to suspend hydration, as reviewed by the Resident Engineer, is used.
- H. No substantial accumulation of wasted or leaked grout shall be allowed in the tunnel invert at any time.

3.02 TESTING OF TRIAL MIXES

- A. Trial mixes shall be tested to demonstrate that each mix design meets the properties specified.
- B. For grouts that rely on rheology, trial mixes shall be tested for the following, as a minimum:
 - 1. Grading Curves: These should be obtained for the individual constituents and the combined mix.
 - 2. Cylinder Tests (compressive strength): Standard cylinders, tested for compressive strength in accordance with ASTM C 39.

3. Segregation: A sample of fresh mortar is prepared in a graduated test cylinder. The bleed water volume and mortar volume are measured at 1, 2, 3, and 8 hours.
 4. Relaxation: Cylinders of mortar are made and cured for 15 days and 45 days. After curing the cylinder is stripped and the sample placed vertically, unsupported. The height of the sample is measured at regular intervals up to 24 hours. Relaxation is reported as a loss of height of the mortar sample.
 5. Washout Test: A sample of fresh mortar is placed in a perforated container of known volume and mass. The container and sample are dropped through a 3.28-foot (1 meter) column of water five times within 15 minutes of mixing. The wash-out is calculated as the percentage loss of sample.
 6. Bleeding under Pressure: The mortar is tested in a Bariod filter press for 7.5 minutes under 14.5-psi (1 bar).
 7. Workability: Use a standard slump cone.
 8. Cohesion: Measure using a laboratory vane apparatus.
 9. Internal Friction: A sample of mortar is prepared and fog cured at 73.5-degrees Fahrenheit until testing. The sample is placed in a triaxial cell and tested to determine apparent cohesion and angle of internal friction. The sample should not be consolidated or force saturated prior to testing.
 10. Set limiting values for all of these tests specified herein above, as reviewed by the Resident Engineer. In addition, establish a quality control regime, including some or all of these tests, for the production grout.
- C. Work Site trials for each mix and delivery system shall be carried out prior to the commencement of tunneling to demonstrate that the proposed system works with the adopted equipment. The trials shall also demonstrate the properties of each grout mix and its suitability for the ground conditions.

3.03 BACKFILL GROUTING

- A. Backfill grouting between precast tunnel lining and excavated surface in TBM driven tunnels - Refer to Sections 02406, 02413, and 02427.
- B. Primary backfill grouting of the annular space behind the segments shall take place continuously and simultaneously as the TBM(s) progresses forward. The grout shall be injected automatically as the machine advances. The TBMs shall not be advanced without grouting. Grouting shall continue until at least both the minimum volume and minimum pressure criteria, as submitted and reviewed, have been satisfied, but not exceeding the maximum pressure, as reviewed by the Resident Engineer.

- C. Secondary backfill grouting of the annular space behind the segments shall be carried out from the TBM(s) backup trailing gear at every second ring. Secondary backfill grouting will utilize the 'crown' segment lifting/grouting holes, which shall be extended through the exterior surface of the segment by drilling in a manner that does not cause damage to the concrete beyond the intended diameter of the hole.
- D. Mix and pressure inject grout in proportions indicated or required. Do not exceed maximum reviewed pressures. Grout pressures shall be controlled as to prevent damage to the tunnel lining, surface blow-out, settlement/heave and contamination of overlying Metro North Railroad ballast.
- E. Testing – During production, strength testing of the primary backfill grout at 1-hour, 3-hours, and 6-hours after the time of placement shall be carried out at least once every five rings built or daily, whichever is more frequent. The timing for testing may be extended beyond 6-hours if this reflects the actual time between injection and shoving.
- F. To confirm the effectiveness of the backfill grout used (whether dependant on rapid setting or rheology), the change in level of the invert of at least five of the first 20 production rings, and at least one ring in 50 thereafter, shall be measured. Measurement points shall be installed immediately after primary backfill grouting for that ring, and shall be measured before and after shoving for the next five rings. Movement under the weight of the back-up equipment shall also be measured. The vertical movement of the ring at any time from completing primary backfill grouting to the end of the back-up shall not exceed plus or minus 2-inches.

3.04 CHECK GROUTING

- A. Check grouting will utilize segment lifting/grouting hole, which shall be extended through the exterior surface of the segment by drilling in a manner that does not cause damage to the concrete beyond the intended diameter of the hole.
- B. If excessive ground loss is detected through muck volume measurements, increase placement of backfill grout, geotechnical instrumentation, or by other methods, investigate the presence of voids or loosened zones by drilling through the tunnel crown at each segment, and injecting grout above the crown until the ground has stabilized.
- C. Drill and perform check grouting within 20-feet of the tail shield.
- E. Do not exceed maximum pressures as submitted and reviewed. Grout pressures shall be controlled as to prevent damage to the tunnel lining, surface blow-out, settlement/heave and contamination of Railroad ballast.

3.05 PRE-EXCAVATION GROUTING

- A. Perform pre-excavation grouting in front of the TBM in advance of excavation to stabilize the ground ahead and/or reduce water inflows into the tunnel in the event that the following ground water inflows are experienced:
 - 1. Water inflow for 1/2 hour or more exceeds 25-gpm from any individual probe hole.

2. Total water inflow for 1/2 hour or more exceeds 50-gpm from (two or more) probe holes.
 3. Loss of flushing water during probe hole drilling is more than 50% in a single hole.
- B. Grouting of the holes shall proceed in accordance with the submitted and reviewed grout injection sequence plan. If total grout takes in any hole exceeds 50 sacks of cement (94-pounds each), or the grouting pressure exceeds 250-psi, stop grouting of this hole.
- C. Upon completion of grouting in primary grout holes, drill two secondary verification holes, between the pattern primary grout holes. If inflow from any of these verification holes exceeds 25-gpm, repeat the grouting procedure. Grout the secondary grout holes and repeat a set of two tertiary verification holes. Tertiary grouting shall follow identical procedures. All grouting shall proceed from the invert upwards.
- D. Before advancing the excavation, grout shall be allowed to cure for at least two hours.

3.06 POST-EXCAVATION GROUTING

- A. Post-excavation grouting or cut-off grouting, using either ordinary cement or micro-fine cement, will be performed in the event that the sustained groundwater inflow into the excavated tunnel is as per the following criteria or as directed by the Resident Engineer:
1. Sustained water inflow is greater than 50-gpm over any 20-linear feet length in the tunnels and cavern enlargements.
 2. Follow the grouting procedures as outlined above and in accordance with the Contractor's submitted and reviewed grouting plan
- B. At the completion of excavation operations, the total allowable amount of water inflow from all new completed excavations, based on the type of final liner selected by the Contractor, shall be as follows:
1. For the precast segmented concrete liner alternative, the total inflow from the new tunnels, caverns and intersecting structures, prior to the installation of the remaining cast-in-place concrete liner, shall not exceed 600 gpm, in addition to the flow from the existing tunnels.
 2. For the cast-in-place concrete liner alternative, the total amount of water inflow from all new excavations, prior to installation of the cast-in-place concrete liner, shall not exceed 1000 gpm, in addition to the flow from the existing tunnels.
 3. For both alternatives, the total amount of water inflow, measured over any 50 linear feet of excavations before installation of a concrete liner, shall not exceed 50 gpm.

3.07 CONTACT GROUTING

- A. Contact grouting behind the cast-in-place concrete liner shall be in accordance with the provisions of Section 02425.

3.08 PROOF OF GROUTING IN PRECAST CONCRETE LINER

- A. Investigate the effectiveness of primary and secondary backfill grouting system, as follows:
 - 1. Proof drilling and grout coring shall be carried out in the crown of every fifth ring initially for the first 100 rings of each tunnel drive, to verify a completely grouted annular space and to verify the strength of the grout. Proof-drilling shall utilize segment lifting/grouting hole, which shall be extended through the exterior surface of the segment by drilling in a manner that does not cause damage to the concrete beyond the intended diameter of the hole.
 - 2. Following the first 100 rings of each tunnel drive, proof drilling shall be carried out in the crown of every 20th ring. If primary and secondary backfill grouting system is shown to be working consistently and satisfactorily, the requirements for this proof drilling may be relaxed at the discretion of the Resident Engineer.
 - 3. Proof drilling of the last 50 rings of each drive shall be carried out in the crown of every fifth ring.
 - 4. If voids are encountered behind the segments by proof drilling, carry out check grouting to completely fill voids.
 - 5. Proof drilling shall be taken at least 4-inches into the natural, undisturbed ground.
 - 6. Proof drilling, grout coring, and any necessary regrouting shall be carried out within one week of the erection of the ring but not less than 50-feet from the trailing edge of the tail shield.

3.09 EVALUATION OF RECORDS OF GROUTING OF PRECAST CONCRETE LINER

- A. The amount of grout used shall be recorded. This quantity shall be compared to the theoretical quantity; if the quantity installed differs from the theoretical quantity by more than 20-percent over or 10-percent under, the cause of the difference shall be determined and corrected by Contractor.
- B. In the event that a void or cavity is suspected, propose a method of investigating for such a void or cavity. If necessary following the investigation regROUT the tunnel lining by check grouting to ensure all voids are filled. Investigation and regROUTING of the tunnel lining shall take place within 8-hours of the void suspected. Following the discovery of one or more voids, check grouting may be required in areas to demonstrate that no further voids exist.

- C. If one or more voids is suspected, the Resident Engineer shall be notified immediately.

3.10 CLEAN UP

- A. During grouting Work, provide accepted methods for adequate collection and disposal of waste grout and waste water produced by grouting operations. No substantial accumulation of wasted or leaked grout shall be allowed in the tunnel invert at any time.
- B. Before final acceptance of the Work, clean interior surface of tunnel lining and restore surface to original condition, as nearly as practicable.
- C. Any grout that reaches the surface, or railroad ballast, or inside utility lines shall be removed and restored to its original condition.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment necessary for installation of concrete unit masonry of the types as indicated on the Contract Drawings, and specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. C 33 - Concrete Aggregates
 - 2. C 90 - Load Bearing Concrete Masonry Units
- B. National Concrete Masonry Association (NCMA).

1.04 NOTED RESTRICTIONS

- A. Do not use metal reinforcing or ties having loose rust or other coatings including ice, which will reduce or destroy bond.

1.05 QUALITY CONTROL

- A. Concrete masonry units shall be obtained from a single manufacturer for each different product required. Each product shall be cured by one process to obtain uniform texture and color (or uniform blend in the variation thereof), for each continuous area and for visually related areas.
- B. Review installation procedures and coordinate with other work that must be integrated with masonry.

1.06 SUBMITTALS

- A. Product Data: Submit manufacturer's data for each type of concrete masonry unit required, including certified copies of laboratory test reports and other data as may be required to show compliance with specified requirements.

1.07 DELIVERABLES

None Listed

1.08 PROJECT CONDITIONS

- A. Protect masonry materials during storage and construction from wetting by rain, snow, seepage, or ground water and from soilage or inter-mixture with earth or other materials.

- B. Protect grout and mortar materials from deterioration by moisture and temperature. Store in a dry location or in waterproof containers. Keep containers tightly closed and away from open flames. Protect liquid components from freezing. Comply with manufacturer's recommendations for minimum and maximum temperature requirements for storage.
- C. Prevent grout or mortar from staining the face of masonry to be left exposed or painted. Immediately remove grout or mortar in contact with such masonry. Protect sills, ledges, and projections from droppings of mortar.
- D. Special care shall be taken to keep the cavity between unit masonry wythe and backup material free of excessive buildup which will act as a bridge for water penetration through the wall construction. Constant monitoring of this area shall be required to ensure that the bottom of the cavity shall not be filled with mortar dropping and that there is no mortar buildup between face wythe and backup.
- E. Cold Weather Protection:
 - 1. Use Type III high early strength cement when temperature falls below 40-degrees Fahrenheit. Remove any ice or snow formed on masonry bed by carefully applying heat until top surface is dry to the touch. Remove all masonry determined by the Resident Engineer to be frozen or damaged by freezing conditions. Perform the following construction procedures while the work is progressing. When the outside air temperature is 20-degrees Fahrenheit and below, heat sand and mixing water to a minimum of 70-degrees Fahrenheit and maximum of 160-degrees Fahrenheit, provide enclosures and auxiliary heat to maintain air temperature above 32-degrees Fahrenheit; do not lay units that have a temperature of less than 20-degrees Fahrenheit; the units should be heated to about 40-degrees Fahrenheit, to prevent sudden cooling of the heated mortar. Use salamanders or other heat sources on both sides of walls under construction; use windbreaks when wind is in excess of 15-miles per hour.
 - 2. When mean daily air temperature is 40-degrees Fahrenheit and below, maintain masonry temperature above 40-degrees Fahrenheit for five days using weather-resistive membrane, insulating blankets, enclosures and supplementary heat, electric heating blanket, infrared lamps, or other acceptable methods of protection for both completed masonry and masonry not presently being worked on.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Exposed Faces: Provide manufacturer's standard color and texture, unless otherwise indicated. Wherever concrete units are indicated to be painted, provide fine-textured units.
- B. Reinforcement: 9-gauge truss type joint reinforcement.
- C. Samples of all materials to be employed shall be submitted before proceeding with masonry work.

2.02 CONCRETE MASONRY UNITS

- A. Concrete masonry units shall comply with the following classifications, weights, grades, curing, and other requirements.
 - 1. Size: Manufacturer's standard units with nominal face dimensions of 16-inches long by 8-inches high (15-5/8-inches by 7-5/8-inches actual), unless otherwise indicated.
 - 2. Type: Provide Type I, moisture-controlled units. Cure units by autoclave treatment at a minimum temperature of 350-degrees Fahrenheit and a minimum pressure of 125-psi. Limit moisture absorption to 25-percent of saturation during delivery and until time of installation. Concrete units may also be cured by low-pressure steam method resulting in the same properties.
 - 3. Exposed Faces: Manufacturer's standard color and texture unless otherwise indicated.
 - 4. Description of Weight Classification: All concrete masonry units shall be normal weight, except where noted as lightweight units, which shall use concrete aggregate complying with ASTM C 33 and produce dry net unit weight of not more than 125-pcf.
- B. Concrete masonry units shall be manufactured to meet the allowable minimum standards:
 - 1. Hollow Load-Bearing Block: ASTM C 90, normal weight classification.

PART 3 EXECUTION**3.01 INSPECTION**

- A. Examine the areas and conditions under which unit masonry work is to be installed. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Except for absorbent units specified to be wetted, lay masonry units surface dry and adjust mortar mix to conform to the degree of water absorption for the individual masonry units. Do not wet concrete masonry units.

3.03 INSTALLATION

- A. Build single-wythe walls to the actual thickness of the masonry units, using units of nominal thickness indicated.
- B. Build chases and recesses for the work of other trades. Provide not less than 8-inches of masonry between chase or recess and jamb of openings, and between adjacent chases and recesses.

- C. Leave openings for equipment to be installed before completion of masonry work. After installation of equipment, complete masonry work to match work immediately adjacent to the opening.
- D. Cut masonry units using motor-driven saws to provide clean, sharp, unchipped edges. Cut units as required to provide pattern shown and to fit adjoining work neatly. Use full-size units without cutting wherever possible.

3.04 LAYING MASONRY UNITS

- A. Measure and batch materials either by volume or weight, such that the required proportions for mortar can be accurately controlled and maintained. It is recommended that all batch materials be prepackaged to ensure consistency of proportions in the mortar mix. Measurement of sand by shovel will not be permitted.
- B. Mix mortars with the maximum amount of water consistent with workability to provide maximum tensile bond strength within the capacity of the mortar.
- C. Do not use mortar that has begun to set or if more than two hours has elapsed since initial mixing. Retemper mortar during the two-hour period only as required to restore workability.
- D. Layout walls in advance for accurate spacing of surface bond patterns with uniform joint widths and to properly locate openings, movement type joints, returns, and offsets. Avoid the use of less-than-half-size units at corners, jambs and wherever possible at other locations.
- E. Lay exposed masonry in the bond pattern shown or, if not shown, lay in running bond with vertical joint in each course centered on units in courses above and below. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than 2-inches. Bond and interlock each course of each wythe at corners. Do not use units with less than 4-inch horizontal face dimensions at corners or jambs.
- F. Lay solid concrete masonry units greater than 4-inches in thickness with divided bed joints unless full bedding indicated. Keep drainage channels (if any) free of mortar. Form head joints with sufficient mortar so that excess will be squeezed out as units are placed in position. Butter both sides of units to be placed, or butter one side of unit-in-place and one side of unit-to-be-placed.
- G. Maintain constant joint widths, except for minor variations required to maintain bond alignment. If not shown, lay walls with 3/8-inch mortared joints. Rake out mortar in preparation for application of caulking or sealants where masonry abuts a dissimilar material and at expansion joints.
- H. Cut joints flush for masonry walls, which are to be concealed or to be covered by other materials, unless otherwise indicated. Tool exposed joints slightly concave, unless otherwise indicated.
- I. Remove masonry units disturbed after laying; clean, and reset in fresh mortar. Do not pound corners at jambs to fit stretcher unit which have been set in position. If adjustments are required, remove units, clean off mortar and reset in fresh mortar.

- J. Fill the vertical longitudinal joint between wythes solidly with mortar where and to the extent indicated.
- K. When stopping and resuming work, rake back 1/2-unit length in each course. Clean exposed surfaces of set masonry, wet units lightly (if required) and remove loose masonry units and mortar prior to laying fresh masonry.
- L. As the work progresses, build-in items specified under this and other sections of the Specifications. Fill in solidly with masonry around built-in items. Fill space between hollow metal frames and masonry solidly with mortar. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath in the joint below and rod mortar or grout into core.

3.05 HORIZONTAL JOINT REINFORCING

- A. Provide continuous horizontal joint reinforcing as shown in details and as specified herein. Fully embed longitudinal side rods in mortar for their entire length with a minimum cover of 5/8-inch on exterior side of walls and 1/2-inch on interior side of walls. Lap reinforcement a minimum of 6-inches at ends of units. Do not bridge control and expansion joints with reinforcing. Reinforce all unit masonry walls with continuous horizontal joint reinforcing unless specifically noted to be omitted.

3.06 ANCHORING MASONRY WORK

- A. Provide anchoring devices as required.
- B. The base of the wall shall be doweled into existing stair/floor slab with 1/2-inch diameter, 16-inch long galvanized steel dowels, 18-inches on center, embedded 4-inches into concrete.

3.07 REPAIR, POINTING, AND CLEANING

- A. Remove and replace masonry units which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in fresh mortar or grout, pointed to eliminate evidence of replacement.
- B. During the tooling of joints, enlarge any voids or holes, except weep holes, and completely fill with mortar. Point-up all joints including corners, openings and adjacent work to provide a neat, uniform appearance, properly prepared for application of caulking or sealant compounds.
- C. Cleaning of CMU: Clean concrete unit masonry to comply with masonry manufacturer's directions and applicable NCMA "Tek" bulletins.
- D. Protect the masonry work from deterioration, discoloration or damage during subsequent construction operations. Normal weathering of masonry work, exposed to the weather after completion, will be acceptable, provided other conditions and activities do not interfere and result in an unacceptable condition.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for structural steel indicated on the Contract Drawings and structural steel required by Contractor-designed systems.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

- A. American Institute of Steel Construction (AISC):
 - 1. Manual of Steel Construction Allowable Stress Design
 - 2. Specifications for Structural Steel Buildings
 - 3. Code of Standard Practice for Steel Buildings and Bridges
 - 4. Allowable Stress Design Specification for Structural Joints Using ASTM A325 or A490 Bolts
- B. American National Standards Institute (ANSI):
 - 1. B18.2.1 – Square and Hex Head Bolts and Screws (Inch Series) Including Hex Cap Screws and Lag Screws
 - 2. B18.2.2 – Square and Hex Nuts (Inch Series)
- C. American Railway Engineering and Maintenance-of-Way Association (AREMA):
 - 1. Manual for Railway and Maintenance-of-Way Engineering
- D. ASTM International (ASTM):
 - 1. A 36 – Carbon Structural Steel
 - 2. A 53 – Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 3. A 108 – Steel Bars, Carbon, Cold Finished, Standard Quality
 - 4. A 185 – Steel Welded Wire Reinforcement, Plain, for Concrete
 - 5. A 325 – High Strength Steel Bolts
 - 6. A 490 – Alloy Steel High Strength Bolts

7. A 563 – Carbon and Alloy Steel Nuts
 8. A 572 – High-Strength Low-Alloy Columbium-Vanadium Structural Steel
 9. A 709 – Carbon and High Strength Low Alloy Structural Steel Shapes, Plates, and Bars and Quenched and Tempered Alloy Structural Steel Plates for Bridges
 10. A 653 – Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 11. B 695 – Coatings for Zinc Mechanically Deposited on Iron and Steel
 12. F 436 – Hardened Steel Washers
 13. F 1554 – Steel Anchor Rods
- E. American Welding Society (AWS):
1. D1.1 – Structural Welding Code – Steel
 2. D1.5 – Bridge Welding Code
 3. QC-1 – Certification of Welding Inspectors

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Errors in Plans:
1. Field verify all existing dimensions shown on the Contract Drawings. Notify the Resident Engineer of any discrepancies found.
 2. Be responsible for the dimensional accuracy of the Work including Shop Drawings. The review of Shop Drawings by the Resident Engineer shall not relieve Contractor of its responsibility for dimensional layout and fit.
- B. Weld Testing: All non-destructive testing procedures and techniques, as well as inspector and laboratory technician qualifications shall be in accordance with AWS D1.1, Section 6.7. The provisions of AWS D1.1, Section 6.9.3 shall be followed.
- C. Notice of Rolling: Contractor shall be required to give advance notice to the Resident Engineer before the start of structural steel fabrication at the mill or assembly at the shop. No material shall be rolled or work done before the Resident Engineer has been notified.

- D. Acceptance and Rejection of Materials: Make detailed reports of the inspection and of any defects found in the material or workmanship.
- E. Handling and Storage: All parts shall be protected during transportation. After delivery of materials to the Work Site or in storage, place materials on skids at least 12-inch above the ground and keep materials in good condition.
- F. Marking and Shipping: Every piece of steel shall have its identification mark applied to the surface of the steel. Members exceeding 5 tons shall also have the weight marked. Fasteners of one length and diameter, and loose nuts or washers of each size shall be packed separately. The manufacturers or distributors shall stamp or affix a lot identification or date of manufacturer code marking to each outer shipping container, box, or key. A list and description of the contained material shall be plainly marked on the outside of each container.
- G. Cost of Testing: Furnish test specimens as necessary. Provide all required equipment, tools, instruments, material samples, inspection services, and labor required for the testing.
- H. Facilities for Inspection: Inspectors shall be allowed free access to the necessary parts of the mill(s) and shop(s).

1.06 SUBMITTALS

- A. Mill Orders: Submit name(s) of the AISC certified steel supplier/fabricator. Contractor shall be required to place mill orders before review of Shop Drawings; Contractor, however, shall be responsible for the correctness of the mill orders (quantities and material designations) except where changes or corrections are made to the Contract Drawings after the order is placed. The addition of details that are solely for clarifying the work will not be considered changes or corrections in the context of this Paragraph.
- B. Shop Drawings: Submit structural steel Shop Drawings for review. The Shop Drawings shall include but not be limited to the following items:
 - 1. Erection plans
 - 2. Fabrication details of all new structural steel members
 - 3. Modification details of existing structural steel members
 - 4. Connection details (bolted and/or welded)
 - 5. Field welding details (submit coupon test results for existing steel), including welding procedures and welder qualifications in conformance with AWS D1.1.
- C. Product Data: Submit technical data for review and information including, but not limited to, the requirements of this Section. Orders and shipping statements shall be submitted as follows:

1. Furnish the name, address, and telephone number of steel supplier(s) and/or fabricator(s).
 2. Submit two copies of all material orders; two copies of all mill-shipping statements; and four copies of all shop shipping statements.
 3. The shop shipping statements shall show the weights of members of fabricated pieces, as recorded by Contractor in the presence of the Resident Engineer.
- D. Welding:
1. Submit qualifications of proposed welding consultant.
 2. Submit six copies of the welding procedure document.
 3. Submit radiographs and certified inspection reports.
- E. Contractor-Designed Structural Steel: Furnish design drawings and calculations sealed by a Professional Engineer licensed in the State of New York.

1.07 DELIVERABLES

- A. Provide AWS Certifications for all welders.

PART 2 PRODUCTS

2.01 MATERIALS

- A. All materials shall be new.
- B. Structural Steel:
1. Structural steel for permanent construction shall conform to ASTM A 709, Grades 50 or 50W unless otherwise noted.
- C. High Strength Bolts:
1. High-strength bolts shall conform to ASTM A 325. Flat circular washers and square or rectangular beveled washers shall conform to ASTM F 436.
 2. Alloy high strength bolts shall conform to ASTM A 490. Hex nuts shall conform to ASTM A 563 Grade "DH" or better. Flat circular washers and square or rectangular beveled washers shall conform to ASTM F 436. Where necessary, washer may be clipped on one side to a point not closer than 7/8 of a bolt diameter from the center of the washer.
 3. Unless otherwise specified herein, bolts shall be full-body bolts conforming to the dimensions for heavy hexagon structural bolts specified in ANSI B18.2.1 with heavy hex nuts specified in ANSI B18.2.2.

- D. Steel Studs: Steel studs shall be solid flux filled, cold-finished carbon steel, conforming to ASTM A 108.
- E. Welding Electrodes and Rods: AWS D1.1, E70xx; AWS D1.5 for members supporting vehicular and rail loads.
- F. Zinc Coating: ASTM B 695, Class 50 for threaded products.
- G. Anchor rods shall conform to ASTM F 1554.
- H. Structural steel for temporary members shall conform to ASTM A 36, ATSM A 709, Grades 36, 50 or 50W.

2.02 EQUIPMENT

- A. Impact wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.
- B. A hydraulic tester for setting and checking impact wrenches and a hand torque wrench (with dial gauge) together with facilities for setting and checking shall be readily available.

2.03 FABRICATION

- A. Fabrication of Structural Steel:
 - 1. Annealing Steel: Except in minor details that have been partially heated, shall be properly annealed.
 - 2. Finished members shall be true to line and free from twist, bends, and open joints.
- B. Shop Assembly:
 - 1. Material Straightened In the Shop: All rolled material before being laid off or worked in any way shall be straight. If straightening or flattening is necessary, it shall be performed by methods that shall not damage the materials. After punching and before assembling, the material shall again be straightened. Sharp kinks and bends may be cause for rejection.
 - 2. Planing Sheared Edges: Sheared edges of material more than 5/8-inch in thickness and carrying calculated stress shall be planed to a depth of 3/16-inch. Coping shall be avoided where possible and where coping is necessary, the cut shall be filleted.
 - 3. Bearing and Abutting Surfaces Planed: All abutting surfaces shall be accurately milled or faced to insure even bearing, unless otherwise indicated on the Contract Drawings.
 - 4. Sole plates of plate girders shall have full contact with the girder flange. Sole plates shall be milled or press straightened.

5. Stiffeners and Web Plates:
 - a. Stiffeners of plate girders or beams carrying stress shall be faced on the ends where the load is applied and brought to a true contact bearing with the flange; the other ends of the stiffeners shall be sheared square and brought to a tight fit with the flange. All other stiffeners shall be sheared square and brought to a tight fit with the flange to provide full bearing. Web splice plates and fillers under stiffeners shall be cut to fit within 1/8-inch of the flange on each end.
 - b. Stiffeners and splice plates shall not be crimped. Use filler plates as required. When bolts carrying computed stress pass through fillers, the fillers shall be extended and adequately bolted to distribute the total stress uniformly.

2.04 SOURCE QUALITY CONTROL - WELD TESTING

- A. All shop welds and field welds shall receive a 100-percent visual examination to verify that weld quality, sizes, lengths, and locations match the Contract Drawings and reviewed Shop Drawings.
- B. Full penetration welds greater than 3/8-inch thickness and all shop welds shall undergo radiographic inspection over at least 25-percent of their area by an approved testing laboratory.

PART 3 EXECUTION

3.01 PREPARATION

- A. Flame Cutting Existing Steel: The use of flame cutting for removal of existing steel shall not be permitted where flame cutting poses the potential to damage (either in strength or appearance) portions of steel that will remain. Remove existing steel by sawing or other methods. Flame cut edges shall be straight and the minimum distance from cut edge to any fastener holes shall be 1-1/2 times the fastener diameter plus 3/8-inch.
- B. Protection - Temporary Support:
 1. Install the temporary support system without any interference with or encroachment on clearances required for railroad or vehicular operations.
 2. The installation procedure, design calculations, and Shop Drawings for the temporary support system, shall be stamped and signed by a Professional Engineer licensed in the State of New York.
- C. Surface Preparation – High Strength Bolted Connections:
 1. Before installing new bolt in a hole, remove all nicks, burrs, corrosion, scale, paint and foreign substances from inside of the hole and from the surfaces around the hole, with a power tool grinding wheel to ensure proper setting of the nut, the bolt head and the washers.

2. When assembled, de-scale the contact surfaces, or carry the normal tight mill scale. They shall be free of paint, lacquer, dirt, oil, loose scale, burrs, pits, or other defects.

3.02 ERECTION

- A. Workmanship: All work shall be erected plumb, square, and true to lines and levels in accordance with Contract requirements and within tolerances of the AISC Code of Standard Practice for Steel Buildings and Bridges and the AREMA Manual for Railway and Maintenance-of-Way Engineering.
- B. Field Assembly: Set structural frames accurately to liens and elevations indicated. Align and adjust various members forming part of complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment. Level and plumb individual members of structure within specified AISC tolerances or more stringent tolerances when shown on the Contract Drawings. Establish required leveling and plumbing measurements at mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature of structure when completed and in service.

3.03 HIGH STRENGTH BOLTING

- A. High-strength bolt installation and tightening shall be in accordance with AISC Specifications.
- B. Use workers experienced and competent in the use of tightening procedures by the "turn-of-nut" method with high-strength bolts in tightening gangs.
- C. Field Connections:
 1. Match Marking: Match-mark connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections.
 2. Securely bolt the erection of all splices and field connections and fill 50-percent of the holes with bolts and drift pins. Light drifting will be permitted in order to draw the parts together, but drifting for matching unfair holes will not be permitted. Ream or drill unfair holes.

3.04 WELDING

- A. Welding will not be permitted for members or connections subjected to impact or fatigue loading unless otherwise indicated on the Contract Drawings. Shop welding of new structural steel parts is allowed. Perform field welding as shown specifically on Contract Drawings. Detail all structural welds on the Shop Drawings.
- B. Perform all welding in accordance with AREMA standards and AISC Specifications. Use electric arc welding with a metallic electrode. Welder qualifications, welding procedures, methods, and inspection of welds shall be in accordance with AWS D1.1.

- C. All welded joint procedures shall be pre-qualified as defined in AWS D1.1, Section 5, and thereby exempt from test or qualification.
- D. In the absence of pre-qualified welding procedure, conduct tests as specified by AWS D1.1 to qualify the procedures.

3.05 FIELD QUALITY CONTROL

- A. The workmanship and finish shall be equal to the best practices in modern fabrication shops. Material at the shops shall be kept clean and protected from the weather as far as practicable. Clean unpainted structural steel and remove scale and rust before encasing in concrete.
- B. Weld Testing:
 - 1. All field welds shall undergo dye-penetrant or magnetic particle testing. All full penetrating field welds shall be tested as specified herein.
 - 2. Hire a qualified welding consultant on a full-time basis to monitor and supervise all field-welding. The welding consultant shall have a minimum of five years (or as approved by the Resident Engineer) related experience and shall be required to provide certification that all field welds are sound and conform to the applicable codes.
 - 3. The welding consultant must be present to witness all field welding.
- C. Weldability of Existing Steel: At locations that will be field welded, remove steel coupons from nearby existing steel members and test them for chemical composition and weldability at an independent testing laboratory. The testing laboratory shall prepare a report indicating: the type of steel; chemical composition; weldability; and the matching electrode and appropriate welding process. Submit the test results to the Resident Engineer for review before the start of any field welding.
- D. Bolted Connections:
 - 1. Upon completion of each connection, it shall be inspected mechanically to see the bolts have been torqued to at least the specified minimum tension. A hand torque wrench calibrated for torque at minimum tension may be used. Establish this calibration by torquing a bolt to the minimum tension in the hydraulic tester; then torquing the nut slightly tighter and reading the foot-pounds required to turn the nut after the nut has been set in motion.
 - 2. For field connections, check at least 10-percent of the bolts in any connection and not less than one bolt of each size in each connection for tension. Should any bolt fail to meet requirements of this test, retighten all bolts in that connection, and recheck the connection.

3. For shop connections, upon delivery at the Work Site, and before erection, check at least 10-percent of the bolts in any connection, and not less than one bolt of each size in each connection, for tension. Should any bolt fail to meet the requirements of this test, retighten all the bolts in that member by properly adjusted power wrenches, and recheck each connection in that member before the member is erected.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for the installation of the waterproofing system indicated on the Contract Drawings and specified herein. The permanent waterproofing system will be installed in Wye Caverns GCT 3 and GCT 5, the Central Instrument Room (CIR), Cross-Flue, cast in place tunnels, and other locations indicated on the Contract Drawings. The waterproofing system is placed between the shotcrete lining or exposed rock in the bored tunnels and the cast-in-place structural concrete lining.
- B. Definitions:
1. BA Anchor: Rigid plastic shell with an inside thread and membrane flange used to aid in creating watertight penetrations through the membrane for suspending reinforcing cages from the crown of the cavern.
 2. Control and Grouting Pipes: Pipes typically installed near water barrier intersections to control the water tightness of individual membrane sections. If leakage occurs the pipes are used for remedial grouting.
 3. Double Weld: Machine welded seam achieved by use of automatic hot-double-wedge welding equipment.
 4. Drainage System: System of perforated side wall drain pipes located at or near the bottom of the structures to collect groundwater drained through the geodrain/geotextile behind the waterproofing membrane which is then conducted into the structures' permanent drainage system. The drainage system includes non-perforated transverse pipes, inspection chambers, and clean-outs. After the completion of future contracts, the sidewall pipes and transverse pipes will be permanently submerged.
 5. Geodrain: Composite panel consisting of a rigid HDPE geonet drain core and filter fabric bonded on both sides providing a groundwater channel and protection of the synthetic membrane from sharp projections on the surface to which the membrane is applied. Held in place by nailed attachment disk.
 5. Geotextile: Non-woven polypropylene filter fabric providing a groundwater channel and protection of the synthetic membrane from sharp projections on the surface to which the membrane is applied. Held in place by nailed attachment disk.
 6. Inspection Chamber: Man-hole with cover as shown on the contract drawings to enable inspection of sidewall drain pipes for maintenance purposes.
 7. Leveling Pad: Low strength concrete placed under sidewall drain pipes to achieve desired slope and / or elevation as shown on the Contract Drawings.

8. Membrane: Synthetic waterproofing membrane specifically formulated for sealing underground structures against intruding groundwater. Held in place by welding to attachment disk.
9. Attachment Disk: Disk of membrane-compatible material, incorporating a cushioned washer that is nailed to the substrate through the geodrain/geotextile.
10. Porous Concrete: Cement bonded porous subgrade material.
11. Re-groutable Hose: Grouting hoses made of synthetics equipped with a valve system, which excludes grout return flow from outside into the grouting hose. The grouting hose must allow multiple grouting passes.
12. Sectioning: Water barriers arranged to seal off individual membrane sections. Used in conjunction with control and grouting pipes to create a system that promotes control of water tightness and facilitates leakage repair by grouting.
13. Single Weld: Hand welded seam consisting of a tack weld, a thin continuous weld, and a rolled end weld. Single seams are sealed with liquid PVC at membrane welds.
14. Stainless Steel Clamping Strip: Strip to terminate PVC membrane at pre-cast concrete elements in the running tunnels. The strip is attached using anchors in pre-drilled holes to achieve a tight fit. A neoprene pad is placed between membrane and concrete to enhance water tightness.
15. Temporary Construction Drainage: Perforated drainpipe installed to divert water inflow to temporary sump pumps.
16. Temporary Relief Pipe: Temporary groundwater relief pipe installed in the invert or sidewalls as needed for groundwater pressure relief during construction.
17. Terminal Box: Synthetic box with water tight feed-through connections for re-groutable hoses to house the grouting and ventilation ends of the re-groutable hoses. A numbering system must be applied to clearly identify each port.
18. Water Barrier: A base seal waterstop welded to the membrane.
19. Waterproofing System: Layered system consisting of synthetic membrane and geodrain/geotextile to prevent intrusion of groundwater into the interior of the finished structure.

1.02 REFERENCED SECTIONS

- A. Section 02270 – Rock Reinforcement and Initial Support
- B. Section 02406 – Tunnel Excavation by TBM
- C. Section 02425 – Cast in Place Concrete Lining
- D. Section 02495 – Geotechnical and Structural Instrumentation

- E. Section 03370 – Shotcrete
- F. Section 03300 – Cast in Place Concrete
- G. Section 03605.- Tunnel Grouting

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. D 568 - Rate of Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position
 - 2. D 638 - Tensile Properties of Plastics
 - 3. D 1593 - Nonrigid Vinyl Chloride Plastic Sheeting
 - 4. D 1621 - Compressive Properties of Rigid Cellular Plastics
 - 5. D 1777 - Measuring Thickness of Textile Materials
 - 6. D 1785- Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
 - 7. D 3776 - Mass per Unit Area (Weight) of Woven Fabric
 - 8. D 3786 - Hydraulic Bursting Strength of Knitted Goods and Non-Woven Fabrics: Diaphragm Bursting Strength Tester Method
 - 9. D 4533 - Trapezoid Tearing Strength of Geotextiles
 - 10. D 4632 - Breaking Load and Elongation of Geotextiles (Grab Method)
 - 11. D 4716 - Transmissivity

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Products:
 - 1. Supply and install only products specifically designed and manufactured for this type of construction.
 - 2. Select manufacturers who are regularly engaged in the production of similar materials for underground structures.

- B. Obtain certification of compliance with Specification requirements from the manufacturer before delivery and installation.
- C. Supervision and Training of Personnel:
 - 1. Execute all installation and testing under the direct supervision of an individual with minimum five years experience (or as approved by the Resident Engineer) in the installation of waterproofing systems for underground structures using membrane materials as specified.
 - 2. Provide trained personnel for installation and testing operations. The installer must have a minimum of five years of experience (or as approved by the Resident Engineer) in the installation of flexible membranes in underground waterproofing installations. The proficiency of each welder shall be demonstrated in the field and shall be reviewed by the Resident Engineer.
- D. Inspection and Testing:
 - 1. Surface Inspection and Acceptance:
 - a. Inspect all surfaces to which waterproofing will be applied to prior to waterproofing installation for compliance with the surface preparation criteria defined herein.
 - b. Inspect area to be waterproofed in presence of the waterproofing installer's quality control representative and the Resident Engineer.
 - c. Do not allow installation of any element of the waterproofing system until all deficiencies have been corrected. Re-inspect area after corrective action has been taken.
 - d. Do not allow waterproofing installation outside an accepted area.
 - e. Use Surface Acceptance Forms, reviewed by the Resident Engineer, to release an area for waterproofing installation. Obtain the waterproofing installer's quality control representative's signature on the Surface Acceptance Form.
 - f. Distribute signed Surface Acceptance Forms with the Inspector Daily Reports.
 - 2. Installation Inspection: During installation of any element of the waterproofing system inspect the following:
 - a. Use of specified materials.
 - b. Proper storing and handling of material.
 - c. Ambient temperature.
 - d. Seam direction and layout as per Contractor Shop Drawings.

- e. Number of attachments.
 - f. Proper overlap of membrane at seams for welding.
 - g. Application of welds as specified.
 - h. Execution of penetrations and other details as per Shop Drawings or Contract Drawings.
 - i. Location and elevation of water barriers.
 - j. Location and elevation of control and grouting pipes.
 - k. Temporary, radial terminations at concrete lining start and end bulk heads.
 - l. Correct face of geodrain/geotextile facing inwards.
 - m. Elevation and gradient of pipes.
 - n. Within inspection chambers, correct pipe to connect with trough.
3. Testing:
- a. Perform tests in the presence of the Resident Engineer.
 - b. Perform tests as installation progresses. Repair and retest seams that fail before continuing installation.
 - c. At double welds perform test by applying internal air pressure between seams as specified herein.
 - d. At single welds, including heat welding at water barriers or special fittings, check all welds for continuity by inspection methods as specified herein.
 - e. Reject defective work and request repair.
 - f. Use Waterproofing Installation Acceptance forms, reviewed by the Resident Engineer to release an area for waterproofing installation. Obtain the waterproofing installer's quality control representative and the Resident Engineer's signature on the Waterproofing Installation Acceptance Form.
 - g. Distribute signed Waterproofing Installation Acceptance Forms with the Daily Reports.
4. Protection and Pre-Pour Inspection:
- a. Check integrity of waterproofing during and after installation of rebar, formwork and during concrete pours.
 - b. Check for adequate relief of water behind membrane.

- c. Verify that only penetrations for permanent purposes have been installed with details in accordance with the Contract Drawings.
- E. Pre-Installation Conference: A pre-installation conference with all responsible parties in attendance shall be held prior to commencement of field operations to establish procedures to obtain optimum working conditions and to coordinate this Work with related and adjacent work. Agenda for meeting shall include review of special details.
- F. Performance Requirements:
 - a. At GCT 3, GCT 5, Central Instrument Room, Transformer Niche and Cross-Flue, no water leakage shall be acceptable and the structures shall be watertight. Damp patches are not permitted.
 - b. At cast in place running tunnels, cross-passages and sump pump chamber, water inflow into the tunnel shall not exceed 100-gallons per any 1,000-feet of tunnel per day and 10-gallons per any 30-feet of tunnel per day. Leakage shall be restricted to damp patches on the face of the concrete. Damp patches shall be defined as wet areas with no visible film of water.
 - c. Inflow requirements for precast-segment lined tunnels are given in Section 02406.
 - d. Inflow requirements for unlined tunnels are given in Section 03605.

1.06 SUBMITTALS

- A. Submit resume of waterproofing installation supervisor.
- B. Product Data/Catalogue Cuts: Submit the following items:
 - 1. Geodrain
 - 2. Geotextile
 - 3. Membrane
 - 4. Water barrier
 - 5. Stainless steel clamping strip and neoprene pad
 - 6. Re-groutable hose
 - 7. Terminal box
 - 8. BA Anchor
 - 9. Perforated side wall drain pipes
 - 10. Non-perforated transverse pipes

11. Clean-out pipes including end caps
 12. Control and grouting pipes
 13. Remedial grouts
- C. Shop Drawings shall be submitted a minimum 30 days prior to the start of Work to the Resident Engineer for review. Do not proceed with waterproofing installation without reviewed Shop Drawings. Submit plans, sections and details of the following:
1. Sequence of waterproofing installation relative to construction sequence.
 2. Sheet layout of geodrain/geotextile.
 3. Sheet layout of membrane splice locations and type of welds.
 4. Build-up of layered waterproofing.
 5. Layout of water barriers for sectioning including location of control and grouting pipes.
 6. Layout of any temporary construction drainage in connection with temporary sumps and intended procedures for maintenance during construction.
 7. Layout of drainage system including perforated sidewall drain pipes, leveling pad, transverse pipes, and porous concrete.
 8. Layout of parts of drainage system to be left in place after completion of construction and prior to start of construction of the follow-on contract.
 9. Details of:
 - a. Waterproofing terminations.
 - b. Waterproofing at penetrations including but not limited to drain pipes and sleeves.
 - c. Placement of contact grouting pipes as related to the waterproofing installation.
 - d. Location of re-groutable hoses along with the location of terminal boxes placement of hoses within the terminal boxes, color-coding, identification systems, and grout type.
 - e. Support of reinforcement cages.
 - f. Attachment assembly.
 - g. Control and grouting pipe assembly.

- h. The intended control measures to protect perforated pipes, non-perforated pipes and grout pipes from concrete and grout intrusion during concrete pours and contact grouting (see Section 02425 for contact grouting).
 - i. Drainage system including perforated, non-perforated pipes, manholes and cleanouts.
 - j. Layout of drain pipes within inspection chambers as shown on the Contract Drawings.
- D. Waterproofing protection plan/narrative and details describing the intended procedures to prevent damage during construction operations such as, installation of formwork, reinforcement, and embedded items, construction traffic and placement of concrete.
- E. Manufacturer's Recommendations and Procedures: Submit the following information:
 - 1. Storage
 - 2. Handling
 - 3. Welding
 - 4. Attachment
 - 5. Testing
 - 6. Installation equipment
 - 7. Detection of physical damage
 - 8. Methods of local repair
- F. Installer certification showing that the installer is approved for the installation work by the system supplier.
- G. Material and Safety Data Sheets for all products/materials of membrane waterproofing system.
- H. Material Samples:
 - 1. Geodrain: 1-square foot
 - 2. Geotextile: 1-square foot
 - 3. Membrane: One square foot including double welded seam 1-foot long
 - 4. Attachment Assembly: Three each including nail
 - 5. Water Barrier: 1-foot length welded to membrane

6. Control and Grouting Pipe: 1-foot length (including flange) including any protection measures be used to prevent clogging during placement of concrete and contact grouting such as packing rods, caps and or other measures selected.
 7. Silicone paste: Two - 4-ounce jars
 8. Stainless steel metal hose clamp: One each
 9. BA Anchor: One each (including threaded rod)
 10. Stainless Steel Clamping Strip: 1-foot length with fasteners
 11. Neoprene Strip: 1-foot length
 12. Re-groutable hose with attachment assembly: 3 feet
 13. Terminal box: 1 box
 14. Remedial grout: Two - 4-ounce jars
 15. Perforated and Non-perforated Drainage Pipes: 3-foot length each
 16. Nails and washers for the termination of membrane at concrete leveling pad or substrate as shown on the Contract Drawings
 17. Hydrophilic o-ring: Two
- I. Field Samples: Submit the following:
1. Double weld samples, three feet long, from each double wedge-welding machine, prior to the start of daily shift.
 2. Prepare and submit field samples daily prior to seam welding.
- J. Leak Remediation Plan: Leak remediation plan shall include, but not be limited to, grouting plan, procedures and materials for work within the area of sectioning, grouting through re-groutable hoses at waterproofing terminations, and for repair work outside the extent of sectioning.

1.07 DELIVERABLES

- A. As-Built Drawings: Provide As-Built Drawings for the following items:
1. Control and Grouting Pipes:
 - a. Location and elevation of control and grouting pipes
 - b. Date of pipe installation
 - c. Date of concreting

- d. Names of workers and supervisors for respective work
- 2. Water Barriers: Location and elevation of water barriers and size of sections
- 3. Re-groutable hoses and terminal boxes:
 - a. Location of hoses and terminal boxes.
 - b. Labeling of re-groutable hose grouting and vent ends.
 - c. Detailed instructions for grouting and vacuuming, materials data and other information pertinent to future maintenance.
- B. Reports/Records: Provide the following reports and records:
 - 1. Surface Acceptance Form and Waterproofing Installation Acceptance Form.
 - 2. Completed and signed Surface Acceptance Form before start of installation.
 - 3. Waterproofing Installation Acceptance Form immediately after completion of an installation/testing area.
- C. Certification of compliance with the requirements of this Specification for geodrain, geotextile, and membrane.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials and products in labeled packages. Store and handle in strict compliance with manufacturer's instructions, recommendations, and material safety data sheets. Place material on smooth surface free of rocks or other protrusions that may damage the material. Protect from damage from sunlight, weather, excessive temperatures, and construction operations. Remove damaged material from the Work Site and dispose of in accordance with applicable regulations. Protect hydrophilic materials, mastic and adhesives from exposure to moisture.
- B. The amount of combustible material, including all PVC membranes, stored underground shall be kept to a minimum. Quantity shall be limited to the amount required within the current working shift or following working shift. Other materials, except for emergency items, shall be removed to a surface storage area.
- C. Combustible materials stored underground shall have suitable fire-fighting equipment conspicuously located nearby. Storage areas for combustible materials shall be cool and dry, shall be isolated from the general working area and shall have well-placed notices warning of the fire risk. They shall not be in, or in the vicinity of, any shaft or tunnel opening, or on any escape route, and shall be protected by a form of construction that has a fire-resistance period of not less than 30 minutes.

1.09 WARRANTY

- A. Provide a warranty for the water tightness of the structure for up to five years beyond the date of Substantial Completion.

PART 2 PRODUCTS**2.01 WATERPROOFING SYSTEM**

- A. Geodrain: Composite panel consisting of a rigid HDPE geonet drain core and filter fabric bonded on both sides. Use JDR Enterprises, Inc. "J-Drain 1000," or approved equal.
- B. Geotextile: Non-woven polypropylene geotextile of uniform thickness and surface texture with the following minimum physical properties and testing methods:

Physical Properties	Values	Test Method
Thickness	285-mils	ASTM D 1777
Unit Weight	22-oz/sy	ASTM D 3776
Grab Tensile Strength	285-lbs	ASTM D4632
Elongation	85%	ASTM D 4632
Trapezoid Tear Strength	135-lbs	ASTM D 4533
Burst Strength	400-lb/sq in	ASTM D 3786
Chemical Resistance	pH value 2 - 13	---

- C. Membrane: Polyvinyl chloride (PVC), waterproofing membrane of uniform thickness and surface texture. PVC membrane non-reinforced with the following minimum physical properties under respective testing methods:

Physical Properties	Values	Test Method
Thickness:	0.100"	ASTM D 374
Ultimate Tensile Strength:	2,200-psi	ASTM D 638
Ultimate Elongation:	230%	ASTM D 638
Low Temperature Impact:	pass @ -20°F	ASTM D 1593
Chemical Resistance:	ph-value 2 to 13	---
Flammability:	Self-Extinguishing	ASTM D 568

2.02 WATERPROOFING SYSTEM ACCESSORIES

- A. Attachments: Membrane attachment disk manufactured of membrane compatible material with minimum 3-inch diameter with one steel washer embedded in disk and attached as shown on the Contract Drawings.
- B. Water Barrier: Continuous PVC strip weldable to membrane with embedment ribs of the following minimum dimensions:
- 16-inch width with 6 ribs of 1.1-inch minimum rib height (including base).
 - Intersections of water barriers pre-fabricated on-site or by manufacturer.

- C. Control and Grouting Pipes: 1-inch nominal pipe size polyvinyl chloride (PVC) pipe schedule 40; ASTM D1785, length as shown on the Contract Drawings.
- D. Stainless Steel Clamping Strip: 13-gauge, minimum 2 1/2 inch wide with holes every 6 inch for placement with stainless steel anchors, Hilti type or approved equal, suited for intended purpose installed in pre-drilled holes in concrete pre-cast lining. Edges shall be smoothed and shall be free from burrs and sharp protrusions to prevent damage to the waterproofing membrane.
- E. Neoprene Pad: Continuous closed cell neoprene pad, 1/4 inch thick and minimum 2 1/2 inch wide. Compatible with stainless steel clamping strip.
- F. Re-Groutable Hoses:
 - 1. Re-groutable hose system shall include tough, flexible and chemically inert tubes with a minimum internal hole diameter of 3/8", connecting tubes, junction boxes, grout, pumps and all other items required for their installation and use. The injection tube system shall be suitable for resinous or cementitious grout and be capable of re-injection to seal joints. The re-groutable hose shall be the FUKO Injection Hose System by BBZ USA, Inc or approved equal.
 - 2. Miscellaneous materials: Colored vent ends, junction boxes, anchor clips, closure plugs and all other accessories shall be as specified and supplied by the hose manufacturer.
 - 3. Terminal boxes shall be heavy duty plastic made for embedment in the concrete and of adequate size for housing and protection of the injection hose grouting and vent ends. Boxes shall be securely fixed during concreting operations. Boxes shall be fitted with front covers mounted flush with the surrounding concrete surface.
- G. BA Anchor:
 - 1. Rigid PVC shell with inside thread and 12-inch diameter compatible flange for providing watertight welded seal to tunnel membrane. Rigid PVC shell minimum 8-inches long with outside grooves and 5/8-inch diameter inside thread for application of threaded steel rod.
 - 2. Epoxy resin to grout PVC shell and flange in place prior to attachment to membrane.
- H. Temporary Relief Pipe: 1 to 8 inch nominal size polyvinyl chloride (PVC) pipe Schedule 40, ASTM D 1785; each with fitted cap.
- I. Hydrophilic Waterstops: As specified in Section 02425.
- J. Remedial grout for injection through control and grouting pipes within sectioning is specified elsewhere herein.

- K. Remedial grout for injection through re-groutable hoses at waterproofing terminations shall be water soluble, hydrophilic, acrylate-ester resin grout: BBZ USA, Inc. Duroseal Inject 1K/2K injection resin, or approved equal.
- L. Hydrophilic O-Ring: Pre-formed or cut-to-fit modified chloroprene rubber type o-ring with compatible adhesive.

2.03 DRAINAGE SYSTEM

- A. Perforated Sidewall Drain Pipe: 6-inch diameter perforated HDPE drain pipe; Type N12 by Advanced Drain Systems, Inc., or approved equal, with smooth internal walls and perforations in the upper 120-degree arc of the pipe.
- B. Transverse Drain Pipe: 6-inch non-perforated HDPE drain pipe; Type N12 by Advanced Drain Systems, Inc., or approved equal, with smooth internal walls.
- C. Upright Cleanout Pipe: Between transition and cleanout, 4-inch non-perforated HDPE drain pipe; Type N12 by Advanced Drain Systems, Inc., or approved equal, with smooth internal walls.
- D. Fittings: transitions, and other fittings as required by Advanced Drain Systems, Inc., or approved equal, to be compatible with transverse and sidewall drain pipes.
- E. Cleanouts: Cast iron cleanout with taper thread and bronze plug, by Jay R. Smith Mfg. Co., No. 4293L, or approved equal.
- F. Hose Clamp: Stainless Steel hose clamp suitable for 6-inch diameter pipe, with compatible silicon paste.
- G. Porous Concrete:
 - 1. Aggregate: Section 03300, 4,000-psi 28-day strength concrete except without sand
 - 2. Cement: Type II Portland Cement
 - 3. Mix Design:
 - a. Cement Content: Two bags per cubic yard of concrete
 - b. Water/Cement Ratio: Maximum ratio: 0.5 by weight
 - 4. Design mix as to provide porous concrete with free permeability but stable enough to maintain required shape.

2.04 GROUT FOR LEAK REMEDIATION WITHIN SECTIONING

- A. For leak remediation, grout shall be DeNeef "HA Flex LV", or approved equal.

PART 3 EXECUTION**3.01 PREPARATION OF SURFACE****A. General:**

1. Prepare surface according to the criteria specified herein and shown in the Contract Drawings.
2. All surfaces shall be free of oils, grease, and gasoline.

B. At Shotcrete Lining and exposed rock surface:

1. Remove all loose shotcrete and debris.
2. Cut off and patch all projecting portions of rock bolts and dowels, flush with the face of the shotcrete or rock surface and remove temporary supports and hangers installed for construction purposes. Any protrusions of more than 1/2-inch shall be covered with shotcrete, quick setting grout, or mortar such that no sharp edges are present. Shotcrete shall not protrude beyond design line of permanent concrete liner.
3. Ensure that all embedded elements of the shotcrete lining are covered by at least 1-inch of shotcrete before installing geodrain/geotextile and membrane.
4. Steel fiber reinforced concrete shall be covered with plain shotcrete with a minimum thickness of 1-inch before waterproofing installation.
5. For overall smoothness of shotcrete surfaces apply general smoothness criteria as shown on the Contract Drawings.
6. Repair damaged or spalled surfaces, voids, and cracks having depths greater than 1/2 inch with shotcrete, quick-setting grout, or mortar.
7. Internal and external corners are to receive a 2-inch chamfer.

3.02 INSTALLATION OF WATERPROOFING SYSTEM**A. Installation of Geodrain/Geotextile and Membrane:**

1. Attachment:
 - a. Place attachment assemblies in surface depressions to achieve tight fit of geodrain/geotextile.
 - b. Provide minimum of two attachments per 10-square feet of waterproofing area.
 - c. Provide additional attachments where necessary to achieve secure support and tight fit to shotcrete lining.

2. Geodrain/Geotextile:
 - a. Place geodrain/geotextile prior to the installation of waterproofing membrane.
 - b. Place geodrain/geotextile sheets such as not to create gaps nor overlaps between individual sheets.
3. Membrane:
 - a. Install membrane with sufficient overlap for welding. Trim overlap if necessary to achieve tight fit.
 - b. Use radial seams in all typical tunnel cross-sections unless otherwise directed.
 - c. Provide double wedge welded seams unless otherwise approved.
 - d. Test all welds as specified.
- B. Installation of Drainage System:
 1. Construct leveling pads as shown and as required.
 2. Side wall perforated drainage pipes and non-perforated transverse pipes: Place side wall drain pipes in invert on concrete leveling pad and transverse pipes as shown.
 3. Clean-outs and inspection chambers: Install at locations and to dimensions as shown on the Contract Drawings. Ensure that sidewall pipe that is connected to a cleanout enters the channel in the inspection chamber.
 4. Porous Concrete: Place around sidewall drain pipes as shown.
 5. Connection to temporary drainage piping shall be as shown on the Contract Drawings.
 6. Cleaning of drain pipes: Following completion of the concreting work of structures perform an initial cleaning of longitudinal side wall drain pipes and transverse pipes to remove any blockage such as to assure a free drainage and flow through pipes.
- C. Installation of Water Barriers for Sectioning:
 1. Install water barrier at all construction joints, contraction joints, expansion joints and at other locations and elevations shown on the Contract Drawings.
 2. Install water barriers such that radial and vertical concrete pour joints always fall in center between the ribs of the water barrier.
 3. Weld water barriers to membrane with two single welds along the edges.

4. Clean water barriers from dirt, debris and concrete spill prior to concrete pour.
- D. Control and Grouting Pipes:
1. Install control and grouting pipes as shown on the Contract Drawings prior to concrete lining placement.
 2. Arrange exact location of control and grouting pipes to avoid interference with rebar or embedments.
 3. Ensure that control and routing pipes are protected by methods reviewed by the Resident Engineer during concrete lining pour and contact grouting. Protection methods shall ensure that the control and pipes are free of any concrete, contact grout or debris and may be readily used for the intended purpose.
- E. Installation of Re-groutable Hoses:
1. Installation, inspection, injection, and vacuuming operations shall be in accordance with the re-groutable hose system manufacturer's instructions and shall be carried out by an approved applicator of the re-groutable hose system manufacturer or under the direct supervision of the re-groutable hose system manufacturer's representative. Reinjectable hoses shall be tested by injecting water through them.
 1. Reinjectable hose terminal box shall be located in accessible locations as follows:
 - a. Tail Tracks: Higher than 1-ft above top of rail.
 - b. Bench Side: At, or above, tunnel springline.
 - c. Opposite Bench: Higher than 1-ft above top of rail.
 3. Reinjectable hoses shall be overlapped to form a continuous circumferential seal at the locations indicated..
- G. Installation of Stainless Steel Clamping Strip:
1. Verify that precast ring to which stainless steel strip is to be attached is free from cracks or other defects.
 2. Fill spalls, recesses, sockets and joints between segments before attaching neoprene pad to the segments. Locate bolts at 6 inch centers, but no more than 1 1/2 inches from the end of each strip.
 2. Place waterproofing membrane onto the neoprene pad and install stainless clamping strip as shown on the Contract Drawings. Maximum gap between steel strips shall be 1/4 inch. Apply washers and bolts and tighten bolts sufficiently to ensure watertight seal.

3.03 TESTING OF MEMBRANE WELDS

- A. General:
 - 1. Perform tests in the presence of the Resident Engineer.
 - 2. Perform tests as installation progresses. Repair and retest seams that fail before continuing installation.
 - 3. Maintain and distribute to the Resident Engineer written records of test results, repairs, and retesting every time an installation section is completed.
- B. Double Welds: Perform test by applying internal air pressure between seams as follows:
 - 1. Test Pressure: 30-psi.
 - 2. Performance requirements: Air pressure loss shall be less than 10-percent after 10 minutes.
- C. Single Welds:
 - 1. Including heat welding at water barriers or special fittings.
 - 2. Check all welds for continuity by either of the following inspection methods. Single welds at membrane splices or patches to be tested prior to the application of liquid PVC:
 - a. Run a rounded screwdriver along the joint after the weld has cooled.
 - b. Blow stream of air under high pressure against the weld and observe opening of the weld. Re-weld and test any discontinuity.
- D. Replace or repair sections of the membrane determined to be defective.

3.04 PROTECTION OF WATERPROOFING

- A. Where reinforcement is placed, use approved methods to achieve required spacing between membrane and rebar.

3.05 LEAK REMEDIATION

- A. Observe structure interior and control and grouting pipes by regular inspection for water leakage until final completion of the Contract.
- B. If structure arch, joints or control and grouting pipes indicate water infiltration in excess of specified limits, undertake remedial measures consisting of:
 - 1. Grout through control and grouting pipes using suitable grouts to provide a remedial, secondary waterproofing layer by grout within the section that indicates a leak.

2. If any leakage appears at a joint containing a reinjectable hose, inject grout in accordance with hose manufacturer's recommendations. Repeat, as required, until leakage stops. Following any grout injection operation, clean out all hoses used with a vacuum process and leave prepared for future procedures.
 3. Determine injection pressure by means of on-site demonstration; do not exceed structural capacity of the structure.
- C. Do not penetrate or puncture membrane except for permanent purposes using proven water tightness techniques to be reviewed by the Resident Engineer.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for waterproofing in the Bellmouth indicated on the Contract Drawings and specified herein.
- B. Primary membranes are factory-made composites of cross-laminated high-density polyethylene (HDPE) film, and additionally of self-adhesive rubberized asphalt for post applied applications and pressure sensitive synthetic adhesive for pre-applied (blindsided) applications.

1.02 REFERENCED SECTIONS

- A. Section 02425 - CIP Concrete Liner

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. C 836 – High Solids Content, Cold Liquid Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
 - 2. D 217 – Cone Penetration of Lubricating Grease
 - 3. D 412 – Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
 - 4. D 570 – Water Absorption of Plastics
 - 5. D 882 – Tensile Properties of Thin Plastic Sheeting
 - 1. D 903 – Peel or Stripping Strength of Adhesive Bonds
 - 2. D 1876 – Peel Resistance of Adhesives (T-Peel Test)
 - 3. D 1970 – Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steel Roofing Underlayment for Ice Dam Protection
 - 4. D 3767 – Practice for Rubber - Measurement of Dimensions
 - 5. D 5385 – Hydrostatic Pressure Resistance of Waterproofing Membranes
 - 6. E 96 – Water Vapor Transmission of Materials
 - 7. E 154 – Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover
- B. National Institute for Occupational Safety and Health (NIOSH):
 - 1. Publication “A” – Recommended Standard for Occupational Exposure to Asphalt Fumes

1.04 NOTED RESTRICTIONS

- A. Control workers' exposure to asphalt fumes in the work place by adhering to the recommendations developed by NIOSH.

1.05 QUALITY CONTROL

- A. All waterproofing materials including primer shall comply with applicable Federal, State, and local VOC regulations.
- B. Obtain certification of compliance with Specification requirements from the manufacturer before delivery and installation.
- C. Contractor will be required to demonstrate that he has the necessary skill and experience required to perform Work of this nature. None but competent persons skilled in this kind of Work shall be employed to apply the composite membranes and accessories.
- D. Pre-Installation Conference: A pre-installation conference with all responsible parties in attendance shall be held before commencement of field operations to establish procedures to obtain optimum working conditions and to coordinate this work with related and adjacent work. Agenda for meeting shall include review of special details and flashing.

1.06 SUBMITTALS

- A. At least 60 days before commencement of the Work, submit information for review to the Resident Engineer:
 - 1. Product data.
 - 2. Manufacturer's instructions.
 - 3. Shop Drawings.
 - 4. Reinjectable waterstop hose run locations, junction box locations, color-coding, identification systems, and grout mix designs.

1.07 DELIVERABLES

- A. For reinjectable waterstop hose systems, provide Operation and Maintenance Manuals containing detailed instructions for grouting and vacuuming, materials data and other information pertinent to future maintenance.
- B. Provide Record Drawings showing as-built locations of all hoses and corresponding junction boxes.
- C. Provide certification of compliance with Specification requirements.

1.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Work Site in the manufacturer's sealed containers, marked with the manufacturer's name and brand indicating the grade and quality of the materials. Materials showing evidence of damage, deterioration, or having been opened shall be rejected.
- B. Check the labels on the materials against the materials reviewed for use on the Project.
- C. Remove rejected materials from the Work Site before the application of membrane waterproofing is started.
- D. Store materials to prevent physical damage or contamination. Protect the materials from oils, greases, waxes, sunlight, and solvents. Protect hydrophilic materials, mastic, and adhesives from exposure to moisture.

PART 2 PRODUCTS**2.01 WATERPROOFING MEMBRANE**

- A. Post-applied waterproofing membrane shall be a factory-made composite with a thickness of 60-mils of cross-laminated polyethylene film and 56-mil of self-adhesive rubberized asphalt conforming to W.R. Grace "Bituthene System 4000", or approved equal.
- B. For blind-side application, including invert slab waterproofing, the membrane waterproofing shall be pre-applied sheet waterproofing membrane, W.R. Grace "Bituthene Preprufe 160R" for vertical and overhead applications and W.R. Grace "Bituthene Preprufe 300R" for invert applications, or approved equal. The membrane shall form an integral and permanent bond to poured concrete to prevent water migration at the interface of the membrane and structural concrete.
- C. The membrane waterproofing shall be weather and UV-resistant and shall conform to the following:

Property	Bituthene System 4000 Membrane	Bituthene Preprufe 160R	Bituthene Preprufe 300R
Thickness, ASTM D 3767, Method A	0.060" nominal	0.032" nominal	0.046" nominal
Low Temperature Flexibility, ASTM D 1970	Unaffected at -45°F	Unaffected at -10°F	Unaffected at -10°F
Tensile Strength, Membrane, ASTM D 412 (Die C) Modified	325-psi min.	---	---
Tensile Strength, Film, ASTM D 882, Modified	5,000-psi min.	4,000 psi min.	4,000 psi min.
Elongation, Ultimate Failure of Rubberized Asphalt, ASTM D 412 Modified	300% min.	300% min.	300% min.
Crack Cycling, 100 Cycles, ASTM C 836	Unaffected at -25°F	Unaffected at -10°F	Unaffected at -10°F

Property	Bituthene System 4000 Membrane	Bituthene Preprufe 160R	Bituthene Preprufe 300R
Lap Adhesion at Minimum Application Temperature, ASTM D 1876 Modified	5.0-lbs/in. width min.	2.5-lbs/in. width min.	2.5-lbs/in. width min.
Peel Strength, ASTM D 903	9.0-lbs/in. width min.	5.0-lbs/in. width min.	5.0-lbs/in. width min.
Puncture Resistance, Membrane, ASTM E 154	50-lbs min.	100-lbs min.	180-lbs min.
Resistance to Hydrostatic Head, ASTM D 5385	231-ft. min.	231-ft min.	231-ft min.
Exposure to Fungi, 16 Weeks	Unaffected	Unaffected	Unaffected
Permeance, ASTM E 96 Water Method	0.05-perms max.	0.01-perms max.	0.01-perms max.
Water Absorption, 72 hours, ASTM D 570	0.1% max.	0.5% max.	0.5% max.

- D. Vertical Protection: Where wall will be backfilled, to protect waterproofing membrane from damage, use minimum 1-inch, 1-pound density expanded polystyrene held in place with manufacturer's recommended adhesive.
- E. Chemical resistant tape: Provide manufacturer's recommended hydrocarbon resistant polyester acrylic tape for overbanding the lap selvedge of the composite HDPE/rubberized asphalt sheet membrane.
- F. Miscellaneous materials: Surface conditioner, mastic, liquid membrane, tapes and accessories shall be specified and supplied by the membrane manufacturer.
- G. Temporary protection/drainage board shall be W. R. Grace "Hydroduct Drainage Composite", or approved equal.

2.02 INJECTION TUBE SYSTEMS

- A. Injection tube system shall include tough, flexible and chemically inert tubes with a minimum internal hole diameter of 3/8-inch, connecting tubes, junction boxes, grout, pumps and all other items required for their installation and use. The injection tube system shall be suitable for resinous or cementitious grout and be capable of re-injection to seal joints.
- B. Miscellaneous materials: Colored vent ends, junction boxes, anchor clips, closure plugs and all other accessories shall be as specified and supplied by the hose manufacturer. Grouts shall be as specified by the hose system manufacturer.

2.03 CONSTRUCTION JOINT TUBES, SEALS AND STRIPS

- A. Bentonite Joint Pack Tubes: Containing Wyoming type high swelling sodium bentonite in dry granules sealed between absorbent, biodegradable material.
- B. Bentonite Joint Seals: Controlled prehydration gel containing not less than 10-percent high swelling Wyoming type bentonite by weight and having a worked penetration of 300 maximum and 250 minimum tested in accordance with ASTM D 217.

- C. Hydrophilic waterstops shall be based on modified chloroprene rubber, shall have a delayed swell action to prevent premature expansion prior to concreting and shall have a volumetric increase of not less than 120-percent. Miscellaneous materials: adhesive, mastic, and accessories shall be supplied by, or as recommended by, the waterstop manufacturer.

PART 3 EXECUTION

3.01 PREPARATION OF SURFACE

- A. Thoroughly clean existing concrete surfaces to which waterproofing is to be applied.
- B. All surfaces where waterproofing is to be applied shall be made dry (including sealing of all leaks) before applying the waterproofing.
- C. Substrates for receiving membranes shall be smooth and sound. Comply with substrate preparation requirements in the following order of precedence, as shown on Contract Drawings, as noted below and as recommended by the membrane manufacturer.
- D. For concrete substrates (including cast-in-place walls), make substrate smooth by applying a mortar bed or troweled shotcrete, as necessary, to meet the following criteria. A straight edge with a length between 3-inches and 10-feet long placed against the substrate shall not be further from the substrate at any point along its length than the lesser of four inches or ten percent of the distance between ends of the straight edge. This criterion will apply for straight edges of all lengths within the given range, at all orientations, at all points on a substrate face, including across panel joints and construction joints. Repair recesses over 0.5-inch in length and 0.25-inch deep and finish flush with surrounding surface. Fill form tie holes with concrete and finish flush with surrounding surface. Remove loose or scaling concrete to sound, unaffected concrete, and repair exposed area. Grind irregular construction joints to suitable flush surface. Cure concrete for at least seven days before post-application of the waterproofing.
- E. For steel frame and lagging mined excavation, securely attach plywood substrate to the framing. Plywood thickness, framing, and attachments shall ensure that substrate does not move during concreting. Contact grouting shall be in accordance with Section 02425.
- F. Substrate shall not extend beyond neat line of final structure.
- G. Provide bevels or fillets where membrane surfaces will intersect.
- H. Cast in place concrete protected by membrane waterproofing shall be dry to the touch and free from all visible leakage, seepage, and dampness.

3.02 APPLICATION

- A. Application of all waterproofing systems shall be in accordance with the manufacturer's instructions.

- B. Waterproofing membranes, strips, and seals shall be firmly fixed in place so that they cannot be displaced during concreting.
- C. Install hydrophilic waterstops just before concreting and place as near as possible to the face subject to hydrostatic pressure in accordance with the manufacturer's requirement of minimum edge distance. Cutting, splicing and adhesion shall be in accordance with the manufacturer's instructions.
- D. Injection Tube Systems: Set junction boxes into the concrete in locations shown on Contract Drawings. Where no location is shown, install junction boxes in locations that are readily accessible and that do not interfere with future functions of the structure. Test the injection hose by injecting water through them.

3.03 MEMBRANE JOINTS

- A. Place membrane waterproofing so that at any joint there is an overlap of at least 3-inches at the ends and edges of each strip of membrane.
- B. Lap all joints in membrane waterproofing not laid in a continuous operation to secure a full lap of at least one-foot at the ends and edges. For lapping onto existing membranes, clean and repair existing membrane, and use tape and adhesive as required, to seal joint.
- C. Use membrane manufacturer's recommended liquid membrane to tie in existing waterproofing to new sheet membrane waterproofing.
- D. Seal lap joints in W.R. Grace "Bituthene System 4000 Series Membrane with Preprufe Tape", or approved equal.

3.04 LEAKS TO BE STOPPED

- A. Any membrane waterproofing that is found to leak at any time before Substantial Completion shall be made watertight.
- B. If any leakage appears at a joint containing a reinjectable hose, at any time prior to Substantial Completion, inject grout, in accordance with hose manufacturer's recommendations. Repeat, as required, until leakage stops. Following any grout injection operation, clean out all hoses used with a vacuum process and leave prepared for future procedures.

3.05 PRECAUTIONS AFTER LAYING MEMBRANE WATERPROOFING

- A. When concrete protection course is poured or sprayed against the membrane waterproofing material, take care not to break, tear, or damage in any way the outer surface of the membrane. Place the concrete as soon as practicable after the membrane waterproofing is laid. Do not place the protection layer until waterproofing has been inspected by the Resident Engineer. Do not walk, place loads, or work upon exposed membrane waterproofing.

- B. Place waterproofing protection over membrane waterproofing, as indicated on the Contract Drawings and in accordance with manufacturer's recommended procedures. Particular attention is called to protection of the membrane waterproofing during construction and therefore, the protection must be placed immediately upon completion of the placement of membrane waterproofing and before subsequent work that may result in damage thereto.
- C. Where membrane waterproofing is applied to concrete mud slabs, protect said membrane with two layers of 1/4-inch plywood. Remove protection incrementally for placement of reinforcing steel.
- D. Ensure that rebar chairs used in reinforced concrete inverts are compatible with the waterproofing membrane system.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for installation of custom hollow metal stainless steel doors and frames shown on the Contract Drawings and as specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. A115 Series – Steel Door Hardware Standards
- B. ASTM International (ASTM):
 - 1. A 167 – Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - 2. A 276 – Stainless Steel Bars and Shapes
 - 3. C 1363 – Thermal Performance of Building Assemblies by Means of a Hot Box Apparatus
 - 4. E 90 – Laboratory Measurement of Airborne-Sound Transmission Loss of Building Partitions and Elements
 - 5. E 413 – Classification for Rating Sound Insulation
 - 6. F 476 – Test Methods for Security of Swinging Door Assemblies
 - 7. F 593 – Stainless Steel Bolts, Hex Cap, Screws, and Studs
 - 8. F 594 – Stainless Steel Nuts
- C. Door and Hardware Institute (DHI):
 - 1. Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames
- D. National Fire Protection Association (NFPA):
 - 1. 80 v Fire Doors and Fire Windows
- E. Underwriters Laboratories (UL)
 - 1. Building Materials Directory

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Shop Drawings: Submit drawings for doors showing types, sizes, locations, metal-gauges, hardware provisions, installation details, and other details of construction.
- B. Manufacturer's Installation Procedures: Submit manufacturer's currently recommended installation procedures for doors along with the Shop Drawings.
- C. Certificates of Conformance or Compliance: Submit certificates from the manufacturer attesting that doors and accessories meet the requirements specified.
- D. Submit structural calculations confirming structural performance as specified.

1.07 DELIVERABLES

- A. Certificate of Label Construction - Oversize Fire Rated Door Assemblies: For door assemblies shown on the Contract Drawings exceeding sizes of tested assemblies that require fire rating, provide certificate of label construction from UL indicating that door and frame assembly conforms to the requirements of design, materials, and construction as established by individual listings for tested assemblies.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Protect doors from damage during delivery, storage, and handling. Clearly mark manufacturer's brand name. Store doors in dry locations with adequate ventilation, free from dust or water, and in such a manner as to permit easy access for inspection and handling. Handle doors with care to prevent damage. Replace damaged items that cannot be restored to like-new condition with new items.

PART 2 PRODUCTS**2.01 MATERIALS**

- A. Manufacturers: Subject to compliance with requirements, stainless steel hollow metal and thermal rated doors, frames, and panels shall be as manufactured by Steelcraft; Moli-Metal, Inc.; Pioneer Industries Division CORE Industries, Inc.; or approved equal.

- B. General: Except as specified herein, all components of hollow metal door including, but not limited to, frames, doors, reinforcements, inserts, and accessories associated with hollow metal door installation including, but not limited to, angles, plates, bars, spacers, cover plates, and anchorages as indicated on the Contract Drawings, shall be of commercial quality stainless steel Type 316.
- C. Sheet, Plate, Bar, and Shaped Metals: Best quality stainless steel furniture stock, hot-rolled, annealed and polished, stretcher leveled and free from scale, blisters, pits, and other defects, as follows:
 - 1. Plate, Sheet, and Strip: ASTM A 167.
 - 2. Bars and Shapes: ASTM A 276.
 - 3. Grade: Type 316.
 - 4. Finish: No. 4 satin, directional grids.
- D. Inserts, Bolts, and Fasteners:
 - 1. Nuts and Bolts: ASTM F 593 and ASTM F 594.
 - 2. Inserts or Shims: ASTM A 276.
 - 3. Grade: Type 316.
- E. Door Insulation: Fiberglass, mineral wool, urethane, or similar type accepted material, resistant to fire, moisture, vermin, mildew, and rot, meeting requirements specified herein below.
- F. Stainless Steel Angle for Use as Lintels Over Niche Doors: 4-inches by 7-inches by 3/8-inch by length determined by field measurement for bearing.
- G. Fabric Flashing: Rubberized asphalt sheet membrane, 60 units; W.R. Grace "Bituthane System 4000", or approved equal.
- H. Pea Gravel: Pre-washed rounds with a minimum diameter of 3/8-inch and a maximum diameter of 5/8-inch. Crushed or jagged stones shall not be acceptable.
- I. Exterior Doors: 35-psi wind.
- J. Track Level Doors: 40-psi (train piston action) in either direction.

2.02 CONSTRUCTION FEATURES

- A. Provide hollow metal doors that have been pre-tested and certified by the manufacturer to conform to ASTM F 476, Grade 40, Table X5.1.
- B. Fire Rated Door Assemblies: Where fire rated door assemblies are shown on the Contract Drawings, provide fire rated door and frame assemblies in accordance with NFPA 80 that have been tested, listed, and labeled in accordance with UL requirements.

- C. Temperature Rise Rating: At stairwell enclosure doors shown on the Contract Drawings, provide doors that have a temperature rise rating of 450 degrees Fahrenheit maximum in 30 minutes of fire exposure.
- D. Sound Rated (Acoustical) Assemblies:
 - 1. Provide door and frame assemblies that have been fabricated as sound-reducing type, tested in accordance with ASTM E 90 and STC classified in accordance with ASTM E 413.
 - 2. Unless otherwise shown on the Contract Drawings, provide acoustical assemblies with sound ratings of STC 33 or better.
- E. Thermal Rate (Insulating) Assemblies:
 - 1. Provide hollow metal doors that have been fabricated as thermal insulating units and tested in accordance with ASTM C 1363.
 - 2. Unless otherwise shown on the Contract Drawings, provide unit U-value rating of 0.24-BTU (hours per square foot per degree Fahrenheit) or better.

2.03 FABRICATION

- A. General:
 - 1. Fabricate stainless steel hollow metal units rigid and free from defects, warp, or buckle. Accurately form metal to sizes and profiles shown on the Contract Drawings. Factory-fit and assemble units where possible.
 - 2. Identify Work that cannot be permanently factory assembled before shipment and provide required connector splines or plates to assure proper assembly at Work Site. Weld exposed joints continuously, grind, and make smooth, flush, and invisible. Do not use metallic filler to conceal manufacturing defects. Finish shall be as specified elsewhere herein.
 - 3. Fasteners: Unless otherwise shown on the Contract Drawings, provide countersunk Allen head for exposed screws and bolts.
- B. Finish Hardware Preparation:
 - 1. Prepare stainless steel hollow metal doors and frames to receive mortised and concealed finish hardware including cutouts, reinforcing, drilling, and tapping in accordance with approved finish hardware. Schedule and templates shall be provided by hardware supplier. Comply with applicable requirements of ANSI A115 Series.
 - 2. Reinforce stainless steel hollow metal units to receive surface applied hardware. At Contractor's option, drilling and tapping for surface applied finish hardware may be done at the Work Site.
 - 3. As per the Contract Drawings, locate finish hardware in accordance with DHI requirements.

C. Doors:

1. Unless otherwise shown on the Contract Drawings, provide flush design doors, 1-3/4-inch-thick, fully welded seamless construction. Provide hollow metal panels, if any, of same materials, construction, and finish as hollow metal doors.
 - a. Face Sheets: Minimum 11-gauge face.
2. Reinforce inside of doors with continuous vertical steel channels not less than 1/8-inch thick. Space 6-inches on center maximum. Spot-weld at no more than 5-inches on center to both face sheets.
3. Reinforce tops and bottoms of doors with 1/8-inch-thick horizontal steel channels welded continuously to outer sheets.
 - a. Close top and bottom edges with extended bent edges of 14-gauge front panel to provide weather seal. Provide weephole openings in door bottoms to permit escape of entrapped moisture.
 - b. Provide intermittent horizontal 1/8-inch steel channels directly perpendicular from hinges in between verticals for full width of door. These horizontal members shall have weepholes.
4. Unless otherwise required for acoustical or thermal assemblies, provide filler or fiberboard, mineral wool board, or other insulating material solidly packed full-door height to fill voids between inner core and reinforcing members.
5. Fit hollow metal doors in their respective frames with the following clearances:
 - a. Jambs and Head: 1/8-inch.
 - b. Meeting Edges, Pair of Doors: 1/8-inch.
 - c. Bottom: 1/8-inch at threshold.
6. Fit fire-rated doors with clearances as specified in NFPA 80.

D. Frames:

1. Provide stainless steel hollow metals frames for doors as shown on the Contract Drawings.
2. Fabricate frames of full-welded unit construction with corners mitered, reinforced, continuously welded full depth and width of frames. Terminate bottom of frames at finished floor surface. Knock-down type frames will not be permitted.
 - a. Frames: Minimum 11-gauge.

- b. For openings over 4 feet wide, provide continuous 12-gauge steel channel stiffener for full width of opening, welded to back of frame at head.
- 3. Provide removable spreader bar across bottom of frames; tack weld to jambs and mullions.
- 4. Provide 28-gauge steel grout boxes welded to frame at back of hardware mortise on frames.
- 5. Provide 14-gauge stiffeners welded in frames for welding of clip angles as shown on the Contract Drawings.
- E. Jamb Anchors:
 - 1. In-Place Concrete or Masonry: Anchor continuous flat bar with a minimum 1/2-inch-diameter stainless steel chemical anchors at 6-inches from top and bottom and 24-inches on center, and minimum two per side.
 - 2. Field-weld fully minimum 14-gauge, 4-inch wide clips to continuous flat bar and to stiffeners.
- F. Finish Hardware Reinforcement: Reinforce doors and frames for required finish hardware as follows:
 - 1. Piano/Continuous Hinges: 10-gauge sheet to backup custom fabricated 1/8-inch stainless steel plate casing for stainless steel piano/continuous hinges.
 - 2. Mortise Locksets and Dead Bolts: 14-gauge steel sheet secured with not less than four spot-welds.
 - 3. Strike Plate Clips: Steel plate 3/16-inch thick by 1-1/2-inches wide by 3-inches long.
 - 4. Panic Hardware: Reinforce as required to receive panic hardware and conceal flush bolts as per Door Schedule.
 - 5. Flush Bolts: 12-gauge steel sheet secured with not less than four spot-welds.
 - 6. Surface Applied Closers and Coordinators: 12-gauge steel sheet secured with not less than ten spot-welds.
 - a. Provide reinforcement for surface closers on all doors and frames.
- G. Astragals: Provide minimum overlap in accordance with NFPA 80 on double door. Active leaf shall overlap inactive leaf.
- H. Bars and Shapes: Provide stainless steel bars and shapes of dimension and profile as indicated on the Contract Drawings for custom localized installations.

PART 3 EXECUTION**3.01 PREPARATION**

- A. Before frame installation, protect frame as required to minimize damage.

3.02 INSTALLATION

- A. Install in accordance with reviewed Shop Drawings, manufacturer's data, and as specified herein.
- B. Provide anchorage devices for securing hollow metal frames to in-place construction. Use drilled-in anchorage devices and bolts.
- C. Placing Frames:
 - 1. Set in position as shown on the Contract Drawings, aligned and braced until permanent anchors are set. After wall construction is complete, remove temporary braces and spreaders leaving surfaces smooth and undamaged.
 - 2. Place frames at fire rated openings in accordance with NFPA 80.
 - 3. Make field splices in frames, if any, as detailed on reviewed Shop Drawings. Weld and finish to match shop work.
- D. Door Installation: Maintain door clearances as specified elsewhere herein.

3.03 FIELD ADJUSTMENTS AND FINAL CLEANING

- A. Upon completion of the Work, clean all doors and frames, both sides. Clean with a mixture of lemon oil and a mild, non-abrasive detergent. Polish scratched or marred surfaces as required to restore finish and render acceptable.
- B. Check and readjust operating finish hardware items. Remove and replace doors or frames that are warped, bowed, or otherwise unacceptable.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for rodent control as specified herein.
- B. Before commencing construction and excavation operations within the limits of this Contract, obtain the services of a Certified Applicator. The Certified Applicator shall survey the Work Site and the surrounding areas to evaluate and develop a program to treat all visible signs of rodent burrows and indications of rodents.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

None Cited

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. New York State Department of Environmental Conservation (NYSDEC)
 - 2. New York State Department of Health (NYSDOH)
- B. Contractor warrants and represents that all Subcontractors involved in the Work shall possess all permits and/or licenses required and relating to the application of "Restricted Pesticides", as well as any Federal, State, or local permits required for placing of pesticides, the removal, transportation, and disposal of carcasses, bait, boxes, etc.
- C. The Certified Applicator shall have a current "Certification Identification Card", issued pursuant to Environmental Conservation Law Section 33-0905 for the use and handling of restricted pesticides.
- D. The Certified Applicator shall give all notices, post all signs, make all reports, and comply with all Federal, State, and local laws, ordinances, rules, and regulations applicable to the Work.
- E. The application and disposal of any pesticides, containers, carcasses, and baiting cages shall conform and comply with the laws, rules, regulations, and requirements of the District Office of the New York State Department of Health, the New York State Department of Environmental Conservation, and any agency having jurisdiction.

1.06 SUBMITTALS

- A. Submit the rodent control program to the Resident Engineer for review. The program shall include, but not be limited to, copies of Material Safety Data Sheets (MSDS), a catalog of the rodenticide to be used, the manufactured to be used, the placement procedures, and the removal and disposal of carcasses.

1.07 DELIVERABLES

- A. Provide a statement signed by the Certified Applicator after the initial treatment and after each follow-up inspection, reporting the type of rodenticide, the form, and location and amount of bait placed, and visible results of rodent control for each treatment.
- B. Provide information on the type of antidote as noted on the rodenticide label.

PART 2 PRODUCTS**2.01 MATERIALS**

- A. Rodenticides shall be Roussel Uclaf's "Vengeance Rodenticide", Bell Laboratories "Ditrac Super Sile Blox, or approved equal.

PART 3 EXECUTION**3.01 GENERAL**

- A. The Certified Applicator shall treat all visible rodent burrows with rodenticide in accordance with manufacturer's label instructions, not more than seven days before construction begins in that particular area. The rodenticide shall be applied in accordance with the manufacturer's directions.
- B. The Certified Applicator shall supply all necessary signs for posting rodenticide chemicals, bait boxes, and supplies for the placing, transporting, and disposal of carcasses.
- C. The Certified Applicator shall supply, all Signage of Precautionary Statements as hazards to humans and domestic animals, statement of practical medical treatment, and the antidote for rodenticide used at the Work Site.
- D. Place the rodenticide bait either in tamperproof bait stations or in areas inaccessible to humans, domestic animals, pets, or as determined by the Certified Applicator.
- E. Check the treated areas daily for a minimum of four follow-up inspections. Renew the bait on each inspection as necessary to restore the bait to the original amount.

- F. Remove and dispose of all visible carcasses of rodents at the time of placing or inspecting the bait box, in an acceptable manner, and in accordance with the laws, rules, regulations, and requirements of the District Office of the Department of Environmental Conservation and any Federal, State, or local agency having jurisdiction.
- G. The Certified Applicator shall be responsible to maintain the Work Site, free of rodents and carcasses.
- H. The Certified Applicator shall be available until completion of the Project, or at such time by written notice from the Resident Engineer, that the Work Site is clean and free of rodents and carcasses.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for corrosion control system testing as specified herein.

1.02 REFERENCED SECTIONS

- A. Section 03300 – Cast-in-Place Concrete
- B. Section 16062 – Bonding for Corrosion Control

1.03 CITED STANDARDS

- A. National Association of Contractors (NACE):
 - 1. RP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. Perform quality control as required by applicable codes, reference standards, and the Contract Documents.

1.06 SUBMITTALS

- A. Before concrete placement, submit the following for review by the Resident Engineer:
 - 1. List of the instruments proposed to be used to perform the required testing including the manufacturer's name, type of instrument, model number, serial number, and current calibration certificate for each instrument.
 - 2. Layout of each system being tested, showing locations of system components, per Section 16062, including test stations.
 - 3. Instrument hook-up for each test.
 - 4. Qualifications of NACE-certified Corrosion Specialist including name, certification number, a brief description of three similar projects with the name, telephone number, and contact person of the owner.
 - 5. Layout showing lengths and extent of reinforcement to be placed and bonded, per Section 16062, before testing.

1.07 DELIVERABLES

- A. Provide test results including certificates of inspection.

PART 2 PRODUCTS**2.01 TEST EQUIPMENT**

- A. DC Voltmeter: Use a multi-scale DC voltmeter with the following features:
1. Type: Center zero or digital
 2. Minimum Sensitivity: 1-megaohms per volt
 3. Accuracy: Accurate to within 1-percent of full scale
 4. Full Scale Ranges:
 - a. 0- to 10-millivolts
 - b. 0- to 100-millivolts
 - c. 0- to 1-volt
 - d. 1- to 10-volts
 - e. 0- to 100-volts
- B. DC Ammeter: Use a multi-scale DC ammeter, or a millivolt meter and shunts, with the following features:
1. Maximum Shunt Voltage Drop: 20-millivolts.
 2. Accuracy: Accurate to within 1-percent of full scale.
 3. Full Scale Ranges:
 - a. 0 to 1 ampere
 - b. 0 to 10 amperes
 - c. 0 to 100 amperes
- C. Resistivity Meter: Use a self-contained synchronous vibrator, battery-powered instrument capable of providing readings unaffected by the resistance of leads or probes.
- D. DC Power Source:
1. Use a 6- or 12-volt automotive type wet cell battery or nickel cadmium rechargeable dry type battery.

2. For circuits having a high internal resistance; use multiple batteries, a DC generator, or a portable cathodic protection rectifier.
- E. Test Wires:
 1. Conductor: Stranded copper of assorted sizes and lengths to suit test conditions
 2. Insulation: 600-volt, minimum, neoprene insulation in perfect condition
- F. Steel probes for making electrical contact with buried structures in absence of test stations
- G. Slide-Wire Resistors:
 1. Range: 0- to 400-ohms
 2. Capacity: 15-ampere over the full range of adjustment.
- H. Reference Electrode: Use a saturated copper-copper sulfate reference half cell with a ceramic porous plug.
 1. Length: 5 inches.
 2. Diameter: 1 3/8 inches or 3 inches.
- I. Holiday Detector: Ring type, sizes as needed.
- J. Miscellaneous Tools: As required for making wire connections, splicing, and similar operations.

PART 3 EXECUTION

3.01 PREPARATION

- A. Prepare layouts of the systems being tested, showing the locations of system components and proposed test stations.
- B. Prepare an instrument hook-up for each test.

3.02 PERFORMANCE

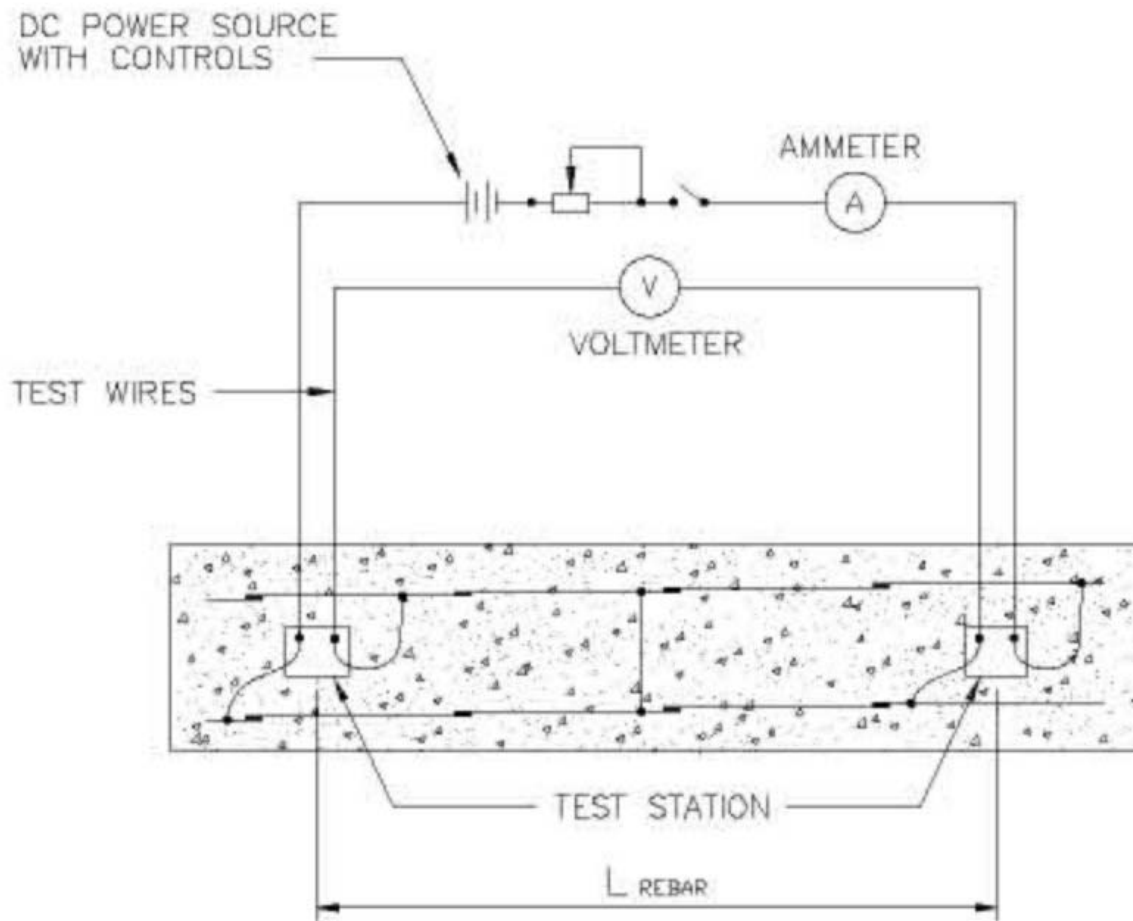
- A. Perform testing before and after concrete pour.
- B. Refer to Section 03300 regarding concrete requirements.

3.03 FIELD QUALITY CONTROL**A. Reinforcing Steel Electrical Continuity Testing:****1. Test Procedure:**

- a. Connect the instruments and power source to two adjacent test stations wires to test steel reinforcement electrical continuity as shown in Figure 1 herein.
 - 1) Use separate sets of wires for voltage and current circuits.
- b. Perform the test as specified for the single bond resistance test.
- c. Calculate the longitudinal resistance of the welded reinforcing steel by dividing the summation of change in voltage by the summation of change in current.

2. Acceptance Criteria:

- a. The measured concrete steel reinforcement resistance shall not exceed the calculated theoretical resistance by more than 10-percent.
- b. Theoretical resistance of steel reinforcement maybe determine by multiplying previously measured resistance of single rebar to the number of welded longitudinal rebar connected together at ends of test section by collectors bars.

FIGURE 1 – REINFORCING STEEL CONTINUITY TEST**END OF SECTION**

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, equipment, personnel, safety devices, and spill prevention and cleanup materials as required for the Work to be performed and for the removal/disturbance and disposal of lead containing waste. This shall include, but is not limited to, industrial vacuum cleaning equipment, equipped with HEPA filters capable of removing paint waste, and providing personal protective equipment to all personnel who will enter the Work Site or who will be in contact with hazardous waste. Contractor is also required to provide protective equipment to persons outside of their employment who may be required to visit the Work Site.
- B. Materials potentially containing lead-based paint (LBP) potentially impacted during construction include steel beams. Estimated quantities of LBP associated with this Project are included in Table 2 herein.
- C. These Specifications shall provide for utilization of removal methods and containment systems, as required, that shall eliminate or minimize the risk of worker and community exposure to lead dust/debris generated during LBP removal, as well as disposal requirements which conform to all applicable Federal, State and local laws and regulations. LBP management work shall include the removal and off-site management of LBP associated with the Work described herein above. The LBP shall be removed intact on the components, with a minimal disruption to the painted surface or shall be removed from the components expected to be disturbed during construction.
- D. It is not necessary to remove all LBP from impacted components.
- E. All materials associated with LBP removal, including LBP chips and spent sand blast media containing lead shall be considered contaminated and must be managed properly. The material associated with LBP removal shall be managed in accordance with United States Environmental Protection Agency (USEPA) and New York State Department of Environmental Conservation (NYSDEC) regulations. Contractor shall be responsible for obtaining all required permits and/or approvals for their selected LBP management method(s).
- F. If Contractor uses Subcontractor(s) to perform any of the Work under this Specification including laboratory work and waste disposal, this Specification shall apply to all such Subcontractor(s) as if specifically referred to herein.
- G. Contractor or its Subcontractor(s) shall perform all Work necessary to carry out the proper identification, removal, collection, handling, storage, classification, testing, transportation and disposal of LBP in accordance with all applicable laws, codes, rules and regulations and the requirements of this Specification, including but not limited to SSPC Industrial Lead Paint Handbook, Volumes 1 and 2.
- H. Those activities which will require removal of LBP include:
 - 1. Surface preparation to remove loose, flaking, peeling paint
 - 2. Drilling, cutting, bolt and rivet removing, etc.

3. Scarification
 4. Other required paint removals
- I. Contractor is required to field verify all job conditions, quantities, and locations of LBP which will be impacted as part of the renovation prior to the submittal of their bid.
 - J. Employ a Certified Industrial Hygienist (CIH) to prepare a Contract-specific Safety and Health Plan (SHP) and Safe Work Plan (SWP) as required in Section 01545 and to develop a personal air monitoring program in accordance with OSHA 29 CFR 1926.62, good industrial hygiene practices, and the requirements stated herein.
 - K. Contractor must submit certification that all documents and permits required will be submitted prior to the start of Work.
 - L. Upon review by MTA, the Resident Engineer will provide an original signed Certificate for Removal of all LBP. No removal and disposal activities shall take place without this signed Certificate for Removal prominently posted at the Work Site. All activities involving the removal of LBP must cease upon expiration of the Certificate for Removal; Work cannot resume until a request for a certificate renewal has been submitted to the Resident Engineer for review.

1.02 REFERENCED SECTIONS

- A. Section 01330 – Submittal Procedures
- B. Section 01545 – Safety and Health Plan
- C. Section 02105 – Chemical Sampling and Analysis

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI):
 1. Z87.1 - Eye Protection.
 2. Z88.2 - Practices for Respiratory Protection
- B. Steel Structures Painting Council (SSPC):
 1. Guide 6 - Guide for Containing Debris Generated During Paint Removal Operations;
 2. 93-02 - Industrial Lead Paint Removal Handbook, 2nd Edition, Volume I;
 3. 94-18/95-06 - Project Design, Industrial Lead Paint Removal Handbook, Volume II;

1.04 NOTED RESTRICTIONS

- A. Disturbance to the sheathing of the LBP components shall be kept to a minimum.
- B. The LBP components shall be placed together in 6-mil PVC lined, steel containers. LBP contaminated materials shall be kept separated from other contaminated materials removed from the Work Site.
- C. Crushing of the LBP components to facilitate transportation shall be conducted only after the component has been placed into the lined container.
- D. All systems components are assumed to be energized until confirmed to be de-energized.

1.05 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Occupational Safety and Health Administration (OSHA)
 - a. 29 CFR 1910 - Occupational Safety and Health Standards
 - b. 29 CFR 1926 - Safety and Health Regulations for Construction
 - 2. United States Environmental Protection Agency (USEPA)
 - a. 40 CFR 260-263 - Hazardous Waste Regulations
 - 3. United States Department of Transportation (USDOT)
 - a. 49 CFR 171-180 - Hazardous Material Transportation Regulations
 - 4. New York State Department of Environmental Conservation (NYSDEC)
 - a. 6 NYCRR Part 360 - Solid Waste Regulations
 - b. 6 NYCRR Part 364 - Waste Transportation Regulations
 - c. 6 NYCRR Part 370-374 and 376 - Hazardous Waste Regulation
 - 5. New York State Department of Health (NYSDOH)
 - a. 173.14 – Safety Standards for Lead Based Paint Abatement
 - 6. New York City Department of Environmental Protection (NYCDEP)
 - a. Title 15, Rules of the City of New York (RCNY) Chapter 19 - Use of Public Sewers
 - b. Limitations for Effluent to Sanitary or Combined Sewers
- B. Comply with the OSHA Lead Construction Standard (29 CFR Part 1926.62) for their personnel and Subcontractors.

- C. The laboratory used for testing shall be Environmental Laboratory Accreditation Program (ELAP) certified for all parameters required.
- D. All treatment, storage and disposal (TSD) and recycling facilities and transporters which Contractor intends to use to treat and/or transport and dispose LBP hereunder shall be approved for use by MTA prior to any removal from the Work Site. MTA reserves the right to inspect Contractor's transporters, equipment storage facility, and TSD Facility at any time prior to or subsequent to the award of this Contract.
- E. Should any problems arise regarding the TSD or recycling facility chosen to accept the LBP for treatment and disposal that would require the return of such LBP to Contractor or MTA or should such TSD or recycling facility have violated any environmental regulation which would result in any regulatory enforcement action, immediately notify MTA in writing of such situation, and make provisions for the lawful storage of the LBP until an alternate TSD or recycling facility can be located by Contractor and approved by MTA.
- F. Contractor shall have a certified USEPA/NYS Lead Supervisor on-site at all times during the Work and ensure that all employees, including Subcontractors, are qualified and experienced in the work of preparing and removing and disposing of the LBP which they shall perform under this Contract. All employees shall be knowledgeable in the pertinent environmental regulations and in personal protection and other safety procedures. All lead abatement workers must have valid USEPA/NYS Lead Worker certifications.
- G. Contractor and/or its Subcontractors involved in any activity that may impact LBP (i.e., LBP sampling, lead abatement, and abatement design) shall have demonstrated a minimum three years (or as approved by the Resident Engineer) of experience in lead hazard assessment and management, environmental and personal air monitoring, worker protection and training, and lead remediation specification writing.
- H. The Subcontractor(s) performing paint removal or other lead management work shall be considered Lead Subcontractor(s).
- I. Prior to using any Subcontractor(s) to perform any of the other lead management work under this Specification, including laboratory work, Submit an executed "Statement of Qualifications of Lead Subcontractor" for each such Subcontractor to the Resident Engineer for his review and approval.
- J. Hazardous Waste: Contractor and/or its Subcontractors involved in any activity that relates to the handling, storage or disposal of hazardous waste shall demonstrate a minimum two (2) years of experience in hazardous waste management.
- K. The Subcontractor(s) transporting hazardous waste shall be considered Hazardous Waste Subcontractor(s).
- L. Prior to using any Subcontractor(s) to conduct any hazardous waste management including laboratory work, submit an executed "Statement of Qualifications of Hazardous Waste Subcontractor" for each such Subcontractor to the Resident Engineer for his review and approval.

- M. Provide documentation that the minimum insurance criteria have been met.
- N. Identify all legal or administrative actions or proceedings in which Contractor (or any proposed Subconsultant(s) or Subcontractor(s) and testing laboratory) has been involved within the last five years which were brought by the USEPA, the NYCDEP, NYSDEC, (OSHA), or any other agency having safety, health or environmental responsibilities or functions.
- O. East Side Access (ESA) Program Management Team
 - 1. Waste Management Plan

1.06 SUBMITTALS

- A. LBP Management Plan
 - 1. Prepare a detailed LBP Management Plan (LBPMP) outlining the specific methods and controls to be used during the performance of this Work. Submit the LBPMP to the Resident Engineer within 30 days after Award of Contract. The Resident Engineer will review, provide notice to proceed or request revision and resubmission of the LBPMP. Do not implement this LBPMP until Notice to Proceed is received from the Resident Engineer. The Resident Engineer's notice to proceed shall not be considered an approval, but an indication that the LBPMP is consistent with the requirements specified in this Section.
 - 2. Information to be included in the LBPMP regarding overall conduct and work practices to be employed on this Project is required and shall include, at a minimum:
 - a. Employee information and training - This shall include copies of all licenses, training certification, permits, and notifications that are required by 29 CFR Part 1926.62, including laboratory certifications.
 - b. Medical Surveillance and Medical Removal Protection: Provide a written program describing frequency and type of blood testing, medical removal, and physical examinations. Certifications for the laboratory conducting blood work, certifications of occupational physician, and copies of blood lead testing for all crew members and competent persons shall be provided, including a description of the medical surveillance program and plan that includes the items required by OSHA 29 CFR Part 1926.62.
 - c. Exposure Assessments: Provide program Work Site exposure assessments documenting compliance with OSHA Permissible Exposure Limits (PELs) and Action Levels, and provide certifications for the laboratory conducting air sampling analysis.
 - d. Personal protective equipment - including respiratory protection and protective clothing.

- e. Signs and Restricted Zones: Provide a written program for establishing restricted zones and use of Lead Work signs.
 - f. Written Compliance Program: Provide this in accordance with OSHA 29 CFR Part 1926.62, including a Respiratory Protection Program and documentation of fit testing.
 - g. Work area preparation - including Work Site access and security plans.
 - h. Personal Hygiene Facilities and Equipment/Decontamination Zone: Describe the decontamination procedures of personnel, and equipment including procedures for showers, break areas, and change areas. Include catalog cuts for the decontamination unit and hand wash station.
 - i. The location and quantities of LBP to be removed.
 - j. Engineering and Work Practice Controls – This shall include a written program describing the method of lead removal, air monitoring, containment/collection systems, equipment and safety procedures. Include catalog cuts for power tools/hand tools with HEPA attachments.
 - k. Housekeeping: Provide a written program describing cleaning frequency, cleaning with HEPA vacuums, cleaning with biodegradable lead detergents, containerizing, storing, and disposing of lead dust and paint chips.
 - l. Material Safety Data Sheets (MSDS): Provide documentation for all chemicals to be used as part of the LBP management.
 - m. Visible Assessments: Provide a written program for assessment of visible emissions.
 - n. Pre- and Post-management sampling protocols and action levels.
 - o. Procedures for handling and disposing of waste materials.
 - p. Procedures for final decontamination, clean up, and clearance.
 - q. Detailed work and performance schedule.
3. A Waste Handling Plan shall be included within the LBPMP that addresses that proper handling and disposal of all waste, which includes:
- a. Transporter Qualifications, Experience, and Permits including the names, addresses, qualifications, and contact persons for the proposed transporter(s) of hazardous waste, non-hazardous waste, and waste water. Provide evidence that each transporter has current registration and permits, as required.

- b. Disposal Facility Qualifications, Experience and Permits that include the name, address, telephone number, and contact person for each waste disposal facility proposed for use in the Contract. Provide evidence that each disposal facility has current registrations and permits for the operation of such facilities, or written approval from the state (and by the USEPA or other local agency, if applicable) in which it operates.
- 4. A Contingency Plan and Emergency Procedures shall be included in the LBPMP as follows:
 - a. Submit a Contingency Plan and Emergency Procedures to respond to fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water at the Work Site.
 - b. The plan must describe arrangements agreed to by local police departments, fire departments, hospitals, and state and local emergency response teams.
 - c. The plan must list names, addresses, and phone numbers of all persons qualified to act as emergency coordinators; and include a list of all emergency equipment at the Work Site (fire extinguishers, spill control equipment, communications and alarm systems and decontamination equipment).
 - d. The plan must include an evacuation plan for workers to describe signals to be used to begin evacuation routes, and alternate evacuation routes.

1.07 DELIVERABLES

- A. Within five working days of completion of field activities associated with the LBP management portion of the Project, provide all Project documentation. These documents shall include, but not be limited to, the following:
 - 1. Daily Project Logs/Reports
 - 2. Waste disposal manifests
 - 3. Analytical results from all samples collected
 - 4. Clearance certificate(s)
- B. Material removal locations shall be surveyed and presented by Contractor on As-Built Drawings in a format acceptable to the Resident Engineer, as defined in Section 01330.
- C. Provide for information and records, copies of all records indicating that the renovation work has been performed in compliance with lead paint management requirements.

- D. A summary of the techniques used to comply with these regulations shall be submitted by Contractor.
- E. Maintain a daily Project log documenting each day's activities. This will be provided to the MTA after Project completion.
- F. The starting and completion dates of the management work shall be documented by Contractor.
- G. Maintain a log of worker training certifications; medical surveillance and blood lead level records. These records shall be available for inspection at the Work Site at all times.
- H. Maintain a log of worker training certifications; medical surveillance and blood lead level records. These records shall be available for inspection at the Work Site at all times.
- I. Provide Final Counter-Signed Shipping Documentation to Resident Engineer: Solid waste and universal waste documents will be provided to the Resident Engineer within seven days of shipment from the Work Site, and will include a copy of the weight ticket from the receiving facility. Hazardous waste documents will be provided to the Resident Engineer within forty-five (45) days of shipment from the Work Site, and will include a copy of the weight ticket from the receiving facility.
- J. Provide a complete analytical package of Toxic Characteristic Leaching Procedure (TCLP) test results of waste samples within four weeks after sample collection.
- K. Initial Shipping Documentation to Resident Engineer: Provide the shipping documents to the Resident Engineer within two days of waste leaving the Work Site. The documents shall include a description of the material, the on-site source, and copies of all paperwork that accompanied the shipment.
- L. If contaminated waste is generated during LBP removal, provide a complete analytical package of wastewater test results of waste sample collection within four weeks after sample collection.
- M. Waste Manifests: Provide one copy of:
 - 1. Executed and signed manifest for each load of waste material transported from the Work Site. Provide the manifest within one day of shipment.
 - 2. Executed waste manifest form signed by a responsible party of the disposal facility. Provide the form within one day of receipt. If the copy is not received within 45 days from the date of shipment, contact the Resident Engineer, and assist as directed, in efforts to locate the shipment, and in the completion of the USEPA Exception Reports in accordance with 40 CFR 262.42.
 - 3. Certificate of final disposal for each manifest or certificate of recycling for recycled material. Provide the certification within one day of receipt.

- N. Bills of Lading: Provide bills of lading for the disposal of all non-hazardous municipal/construction waste within one week of the date of shipment.
- O. Wastewater: Provide written documentation of the receipt of disposal of all wastewater within one week of the date of shipment.
- P. Prior to issuance of Certificate of Final Completion, provide the MTA and/or the MTA's Authorized Representative with a letter report presenting the results of the inspections conducted to verify the final clearance of the Work Site, surrounding property, waterways, equipment, buildings, and structures.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

- A. Furnish all labor, materials, services, permits, and equipment necessary to carry out the LBP contaminated component removal and disposal activities (which includes removal, handling, storing, transporting, and off-site disposal of LBP contaminated components).
- B. The following equipment and material shall be used, at a minimum, for proper execution of the LBP management work under this Section. Additional equipment and materials shall be used, as required, for activities to be conducted in accordance with applicable regulations. The use of additional or alternate materials and equipment shall be included in the LBPMP, and shall be subject to the satisfaction of the Resident Engineer. All equipment and materials shall be in new or "like new" condition and in good working order:
 - 1. Respiratory Protection in accordance with the approved Respiratory Protection Program contained in the LBPMP.
 - 2. High Efficiency Particulate Air (HEPA) Vacuum Filtration Systems: All vacuum equipment employed at the Work Site shall utilize HEPA filtration systems that are 99.97 percent efficient to 0.3 microns particulate size. Vacuums shall be equipped with appropriate size brushes, crevice tools and other angular tools necessary for proper cleaning of all surfaces.
 - 3. Decontaminated Wastewater Filtration System: The system shall, at a minimum, contain a three-stage filtering system with a final filter not greater than 0.5 microns. The filtration system shall be adequate to meet the NYCDEP's "Limitations for Effluent to Sanitary or Combined Sewers" lead discharge limitations and any other applicable regulations and permits.
 - 4. Two layers of securely attached 6-mil PVC sheeting shall be used to cover the Work Site. The sheeting shall extend 20 feet from the edge of the Work Site and 20 feet from the base of the container used for off-site disposal, and secured to the ground.
 - 5. Off-site waste transportation containers shall be USEPA and USDOT approved solid enclosed containers, lined with two layers of 6-mil PVC sheeting and locked and secured at all times.

6. Temporary electrical cords and outlets shall be of an approved type, connected to a source of power outside of the Work Site, and protected by a ground fault circuit interrupter (GFCI) as directed by the Resident Engineer.

PART 3 EXECUTION

3.01 CONTAINMENT

- A. It is to be considered that all painted surfaces are lead-containing. Activities requiring removal of LBP shall be performed using methods and containment which will minimize production and dispersion of airborne particulates and paint chips. Such activities and corresponding containment include, but are not limited to:
 1. Removal of loose, flaking, peeling paint by misting and scraping with hand tools;
 2. Drilling or cutting operations using tools equipped with HEPA vacuum attachment;
 3. Removal of paint by use of power tools (needle scalers, close abrasive blasting, etc.) equipped with HEPA vacuum attachment;
 4. Removal of paint by use of approved chemical strippers;
 5. Removal of paint by use of power tools not equipped with vacuum attachments;
 6. Removal of paint by use of abrasive blasting; or
 7. A combination of the above methods.
- B. Ensure that the required containment prevents LBP from contaminating adjacent areas, buildings, waterways or the environment in any fashion. This shall include any water runoff from wet removal methods.
- C. Supply all equipment and materials needed to contain Project emissions, releases, waste, and/or debris as follows, in accordance with this Section and Table 1 herein.
 1. When Chemical Stripping is used as a paint removal method, use SSPC Class 3C containment, in accordance with this Specification and Table 1 herein.
 2. When Hand Tool Cleaning is used as a paint removal method, Contractor shall use SSPC Class 3P containment.
 3. When Power-Assisted Hand Tool Cleaning is used as a paint removal method, Contractor shall use power tools equipped with HEPA-filtered vacuum shrouds within SSPC Class 3P containment.

4. When Solvent Cleaning is performed in connection with paint removal or painting, Contractor shall use a containment class equivalent to the associated cleaning and/or painting operation being performed (e.g. for chemical stripping, power-assisted hand tools etc.).
5. Contractor shall thoroughly examine the structure to verify its ability to support a containment system including wind loads that can be impaired on it. The containment design should also be constructed to keep bridge drains open and maintaining traffic throughout the Project.
6. Contractor shall prohibit the release of lead or into any storm sewers and all Work shall be halted if spills or emissions are observed entering any storm sewers.

3.02 SITE ACCESS AND SECURITY

- A. Provide security for all Work and storage areas. All storage areas containing hazardous materials including LBP waste shall be fully enclosed and secured at all times when personnel are not present to oversee the material. All storage areas containing hazardous materials shall be clearly labeled as containing hazardous materials with signs in both English and Spanish. Storage is limited at this Work Site and the storage of waste containers shall be coordinated with the MTA and the Resident Engineer.
- B. The LBP management work area is to be restricted to authorized, trained, and protected personnel. A list of authorized personnel shall be established prior to job start and posted in Contractor's Work Site office. Contractor is responsible for updating their list.
 1. Post appropriate warning signs at each entrance of the Work Site. Signs shall be conspicuous; at least 20-inches by 14-inches with lettering at least 2-inches in height and read:

WARNING
LEAD PAINT REMOVAL HAZARD
UNAUTHORIZED ENTRY PROHIBITED
NO SMOKING, EATING OR DRINKING
ALLOWED IN WORK AREA

2. Contractor will be notified by the MTA of any other authorized visitor prior to his/her entry to the Work Site. The MTA shall be responsible for providing documentation of training and certification.
3. Entry into the Work Site by unauthorized individuals shall be reported immediately to the Resident Engineer by Contractor.
4. A logbook shall be maintained in Contractor's Work Site office. Anyone who enters the LBP management Work Site must record their name, affiliation, time in, and time out for each entry.

- C. Contractor shall have control of Work Site security during operations in order to protect work efforts, equipment, and property. If Work Site security is deemed insufficient by the Resident Engineer or MTA, they reserve the right to provide additional security, at Contractor's expense.
- D. Employ a qualified, accredited Lead Abatement Supervisor, as per 40 CFR Part 745, on-site during all phases of lead management work. Maintain proper security at all times.

3.03 SCHEDULING AND COORDINATION

- A. Mobilize immediately upon acceptance of all of Contractor's submittals by the MTA and/or their Authorized Representative.
- B. The Work is to be carried out diligently to completion. Prior to mobilization, furnish to the MTA and/or the Resident Engineer, a schedule showing agreed upon starting and completion dates for each Work area.
- C. No Work shall be conducted on holidays or weekends. Any exception to this requirement requires the prior written approval of the MTA and/or the Resident Engineer.

3.04 TRAINING

- A. All employees must be trained in accordance with 29 CFR 1926.62 prior to initial assignment to areas where there is a possibility of exposure to lead over the Action Level (AL) of 30 micrograms per cubic meter. This training must include a description of the OSHA lead standard, the sources of lead exposure, the uses and limitations of respirators, the purpose of getting a blood lead test, the purpose of the initial exposure assessment, their rights to the results of blood tests and air monitoring, and the methods of controlling the level of lead exposure to a minimum.

3.05 WORKER PROTECTION

- A. All worker protection requirements apply to Contractor and Subcontractor personnel on the Work Site who are exposed to lead or have potential to disturb lead. Contractor is responsible for maintaining a program in accordance with 29 CFR 1926.62, at a minimum, and shall be responsible for protecting and training his employees on worker safety, health hazards, etc. relating to lead.
- B. Personal Hygiene Practices/Facilities: Provide for stall shower/washroom and lavatory facilities and hygiene practices in accordance with OSHA 29 CFR 1926.62. Water from the shower shall be managed in accordance with the approved LBPMP. Enforce and follow good personal hygiene practices during LBP management activities.
- C. Provide portable eyewash stations and first aid equipment, as required by the Project Safety and Health Plan, inside all Work areas.

3.06 EXPOSURE MONITORING

- A. An exposure assessment is the primary means of determining the airborne concentration of lead that workers are being exposed to. Ensure that workers are not exposed to lead at concentrations greater than the Permissible Exposure Limit (PEL) of 50 micrograms per cubic meter (mg/m^3) over an eight-hour time weighted average (TWA).
- B. If available, Contractor may use exposure assessment data obtained within the last 12 months from previous jobs conducted under similar work conditions, control methods, work practices, and environmental conditions as a basis for an exposure assessment. The use of historical or objective data in this manner is subject to prior approval by the Resident Engineer.
- C. Respiratory Protection Equipment. All workers inside the LBP Management Work Site will wear the proper respirator for the airborne lead concentration generated, as per OSHA 29 CFR 1926.62. A formal respiratory protection program must be prepared and implemented in accordance with OSHA 29 CFR 1926.62.

3.07 RESPIRATORY PROTECTION

- A. Contractor is responsible for maintaining adequate controls to ensure worker safety for the duration of this Work. After feasible engineering controls and work practices have been implemented, use respiratory protection to maintain workers' exposures to lead to below the PEL.
- B. The use of respirators is required for all workers, inspectors, observers, or other personnel who enter areas where airborne exposures exceed or are expected to exceed the PEL, or when entering regulated areas.

3.08 PROTECTIVE CLOTHING AND EQUIPMENT

- A. Provide protective clothing and equipment in accordance with ANSI Z88.2 and ensure they are worn by all employees whose exposures exceed the PEL, or enter regulated areas.
- B. Do not remove or clean the clothing by any means that reintroduces lead in the ambient air such as brushing, shaking, or blowing. The use of vacuums equipped with HEPA filters for cleaning is considered an acceptable method to remove dust from clothing and limit exposure to ambient dust.
- C. Furnish all containers, specialty items, and labels required for the disposal of LBP.
- D. All materials, equipment, and tools shall be properly cleaned at the end of the Work shift to remove LBP dust and prevent contamination of personnel and/or clean areas. Proper cleaning shall be accomplished using HEPA vacuum equipment to remove loose dust followed by cleaning with washing agent (power tools shall be wet wiped).
- E. Respiratory Protection must be provided in accordance with the approved Respiratory Protection Plan and the accepted Project Health and Safety Plan.

- F. Temporary electrical cords and outlets shall be of an approved type and connected to a source of power outside of the Work Site and protected by a GFCI as directed by the Resident Engineer.
- G. HEPA Vacuum Filtration Systems: All vacuum equipment employed in the Work Site shall utilize HEPA filtration systems that are 99.97% efficient to 0.3 microns particulate size. Vacuums shall be equipped with appropriate size brushes, crevice tools and other angular tools necessary for proper cleaning of all surfaces.
- H. Water Filtration System: Water used for showering in the decontamination area and any other lead-contaminated water must be filtered prior to containerization for off-site disposal or disposal into the existing sewer system with NYCDEP approval. The system shall, at a minimum, contain a three-stage filtering system with a final filter not greater than 0.5 microns. The filtration system shall be adequate to meet the NYCDEP's "Limitations for Effluent to Sanitary or Combined Sewers" lead discharge limitations of the local publicly owned treatment works and any other applicable regulations and permits. Testing and approval of any water discharge must be provided to the Resident Engineer.

3.09 PAINT REMOVAL

- A. At no time will Contractor be permitted to perform any Work which may impact upon LBP until authorization from the Resident Engineer is obtained.
- B. Acceptable LBP removal methods for this Project include the use of chemical strippers, hand tools, and power-assisted hand tools.
 - 1. Chemical Strippers: The chemical stripping solvent shall not be a hazardous material or result in a hazardous waste under USEPA regulations. Provide all product instructions and MSDS from the manufacturer.
 - 2. Hand Tools: Hand tools such as wire brushes and manual sanding shall be implemented where LBP removal utilizing chemical strippers is not completely effective.
 - 3. Hand Held Power Tools: All hand held power tools shall be equipped with HEPA filtered vacuum attachments. Specifically, flanged units such as "needle guns" can be utilized for abating joints, bolts, and surfaces.
- C. Torch-cutting, open flame burning, rivet/bolt busting, power tool use and/or any other work which shall disturb LBP shall be permitted only after all visible paint has been removed from the substrate surface for a minimum distance of six (6)-inches on all sides of the area.
- D. During all cleanup procedures and at the end of each work day on which LBP removal has taken place, the Work Site will be HEPA vacuumed and swept clean of all dust and debris. The dust and debris will be cleaned using the "wet-sweeping" technique, or a light spray/mist of water will be used to dampen the dust/debris prior to sweeping. Dry sweeping is prohibited.

- E. The Resident Engineer may conduct visual inspections, air sampling, and/or wipe tests to determine compliance with specified procedures and clearance standards, in accordance with all applicable regulations.
- F. The Resident Engineer will inspect the facilities daily, as necessary, to monitor compliance with these Specifications and may be on-site at all times during the performance of LBP management.
- G. The Resident Engineer is not limited by the inspection requirements as noted above; additional safety and health inspections may occur randomly.
- H. Fully cooperate with all monitoring efforts, including periodic observation of work practices, and provide for personal air monitoring, clearance inspections and clearance sampling, and any other sampling as necessary to document that the Project LBP management activities are being performed safely and in conformance with the approved LBPMP and all applicable Federal, State and local regulations.

3.10 PROJECT MONITORING AND TESTING

- A. Conduct monitoring of worker lead exposure in a manner to comply with the monitoring requirements of 29 CFR 1926.62.
- B. Fully cooperate with all monitoring efforts conducted by the Resident Engineer, including periodic observations of work practices.
- C. Provide for clearance inspections and clearance sampling, and any other sampling as necessary to document that the LBP Management activities are being performed safely and in conformance with these Specifications, the LBPMP, and all applicable Federal, state, and local regulations.
- D. Ensure that dust generated during all Work is controlled in accordance with Federal, state, and local regulations. Implement OSHA requirements for the suppression of dust.
- E. Ambient Air Quality for TSP Lead:
 - 1. Three days of baseline monitoring shall be performed prior to Project startup and will be analyzed for total lead using EPA Method SW 746-7420.
 - 2. Daily air monitoring shall be performed during the LBP removal. All samples shall be setup down wind of the abatement area in accordance with SSPC 95-06.
 - 3. Air sampling results in excess of 1.5-ug/m^3 over a 24-hour period or greater than the pre-abatement level will be cause for the Project to stop until corrections to the containment are made to comply with this level.

- F. Wipe Sampling:
1. Baseline wipe sampling shall be required prior to Project startup in the general Work area and will be analyzed for total lead using EPA Method SW-846-7420.
 2. At least one clearance wipe sample will be collected in the identical location of the background wipe sample(s) and analyzed for total lead using EPA Method SW-846-7420. Contractor will have met the wipe sampling clearance criteria if the clearance sample results are less than 800-ug/ft² or equal to or less than the lead concentration of the associated background sample.
 3. At least one clearance wipe sample will be collected from inside each Work area containment. For SSPC Containment Classes 1A, 2A, 1W, and 2W, if the results of any clearance wipe samples collected from inside the containment exceed 100-ug/ft², the Work area shall be recleaned utilizing HEPA vacuum and/or wet wiping procedures by Contractor. This process will be followed by a second clearance wipe test at the cost of Contractor. For all other SSPC Containment Classes, Contractor will have met the wipe sampling clearance criteria if the clearance wipe sample results are less than 800-ug/ft².
- G. All air and wipe sampling and monitoring described herein shall be performed by the Resident Engineer.

3.11 WASTE HANDLING, PACKAGING, AND STORAGE

- A. General: Perform sampling and analysis as may be required to assure the proper and legal handling of the waste in accordance with Section 02105. Samples may be composited for analysis with the consent of MTA. If any chemical analysis or sampling is performed by or on behalf of Contractor, its Transporter, or its Treatment Storage and Disposal facility (TSD), Contractor, must provide a copy of such analysis to MTA. (Note: Painted metal may be designated as recyclable and disposed of at a scrap metal facility for reuse or resale, if accepted by that facility.)
- B. Ensure that its waste disposal Subcontractor warrants and represents possession of all permits and/or licenses required under the Resource Conservation and Recovery Act (RCRA), as well as any state or local permits or licenses required for removal, repackaging, transportation, and disposal of hazardous waste.
- C. Verify that all waste is transported to the appropriate recycling or disposal facility within 60 days after waste is generated. With the Resident Engineer's written approval, waste may be stored at the Work Site for an additional 30 days, but in no event shall waste be stored at the Work Site for more than ninety (90) days. If the signed manifest is not received from the disposal facility within 45 days of shipment, as directed by the Resident Engineer, initiate the USEPA Exception Report in accordance with 40 CFR 262.42, and take all steps necessary to locate the manifest or waste. Ensure that the waste disposal Subcontractor provides completed shipping documents for all hazardous wastes removed, which contain the information required under 40 CFR Part 262 Subpart B (herein after the "Manifest Form") and 6 NYCRR Part 372, as well as all Certificates of Disposal which specify where each component of all wastes removed from MTA property

is ultimately treated or disposed, and copies of weight receipts for the waste, to ensure the accurate compliance with regulatory fees by MTA.

- D. Ensure that the waste disposal Subcontractor provides completed shipping documents, hereinafter referred to as "Bills of Lading", for all non-hazardous "industrial" waste removed from MTA property.
- E. Transportation Requirements: Ensure that the waste disposal Subcontractor providing waste transportation services possesses a valid Waste Hauler's permit issued pursuant to the NYSDEC regulations, 6 NYCRR Part 364. In addition, if the waste is to be transported and disposed of out of New York State, permits for those states through which the waste will be transported and for where it will be disposed shall be required. It is Contractor's responsibility to ensure that the waste disposal Subcontractor correctly determines which permits are required and to provide such permits for review and approval of MTA.

3.12 SCHEDULES

- A. Whether identified or not, Contractor shall be responsible for the removal of all LBP associated with the renovation work. Table 2 (attached) summarizes the known and/or estimated quantities of LBP to be addressed by this Section.
- B. Contractor is responsible for verifying the quantities of LBP requiring management prior to their bid. All LBP that is impacted by construction must be managed in accordance with this Section, and must not cause a release of lead to the environment. Contractor must verify their understanding of the Project and the limits of Work by describing the LBP quantities and management methods in the LBPMP described in this Section.

TABLE 1
Containment Criteria for the Method of Cleaning Painted Surfaces (Washing and Paint Removal)¹

Methods of Cleaning ¹⁰	Containment SSPC Class ²	Containment Material Flexibility	Containment Material Permeability ³	Support Structure	Material Joints	Containment Entryway	Ventilation System Required	Negative Pressure Required	Exhaust Filtration Required
Hand Tool Cleaning ⁴	3P	Rigid or Flexible	Permeable or Impermeable	Minimal	Partially Sealed	Overlapping or Open Seam	Natural	Not Required	Not Required
Power Tool Cleaning w/ Vacuum ⁴	3P	Rigid or Flexible	Permeable or Impermeable	Minimal	Partially Sealed	Overlapping or Open Seam	Natural	Not Required	Not Required
Power Tool Cleaning w/o Vacuum ³	2P	Rigid or Flexible	Permeable or Impermeable	Rigid or Flexible	Fully Sealed	Overlapping or Open Seam	Natural ⁵	Not Required	Not Required ⁵
Chemical Stripping ⁶	3C	Rigid or Flexible	Permeable or Impermeable	Minimal	Partially Sealed	Open Seam	Natural ⁶	Not Required	Not Required ⁶
Wet Methods ⁷	2W	Rigid or Flexible	Impermeable	Rigid or Flexible	Fully Sealed	Overlapping	Natural ⁷	Not Required	Not Required ⁷
Pressure Washing	NA	Flexible	Mesh (25 mil Openings)	Rigid, Flexible or Minimal	Partially Sealed	Open Seam	Natural	Not Required	Not Required
Abrasive Blast Cleaning (SP 5,6, 10) ^{8,9}	1A	Rigid or Flexible	Impermeable	Rigid or Flexible	Fully Sealed	Airlock or Resealable	Mechanical	Required	Required
Abrasive Blast Cleaning (SP 7) ^{8,9}	2A	Rigid or Flexible	Impermeable	Rigid or Flexible	Fully Sealed	Resealable or Overlap	Mechanical	Required	Required

¹ This Table provides general design criteria only. It does not guarantee that specific controls over emissions will occur because unique Work Site conditions must be considered in the design. See also SSPC 93-02 and 94-18, Industrial Lead Paint Removal handbook, Volumes I and II.

² This SSPC Classification is based is on SPCC Guide 6. Note that for the Work over water, water booms or boats with skimmers must be employed, where feasible, to contain spills or releases. Debris must be removed daily at a minimum.

- ³ Permeability addresses both air and water as appropriate. In the case of water or chemical removal methods, the containment materials must be resistant to both chemicals and water. Ground covers or base of containment floor should always be impermeable, and of sufficient strength to withstand the impact and weight of the debris and the equipment used for collection and clean-up.
- ⁴ Do not use ground covers and/or free hanging tarpaulins as the sole means of providing controls over releases without the prior written consent of the Resident Engineer.
- ⁵ Ventilation is not required provided the emissions are controlled as specified in this Section, and provided worker exposures are properly controlled. If unacceptable worker exposures to lead or other heavy metals occur (per 29 CFR 1926.62), incorporate a ventilation system into the containment.
- ⁶ Ground covers or base of containment floor must always be impermeable and of sufficient strength to withstand the weight and impact of the debris and the equipment used for cleaning. If debris escape through the seams or permeable containment materials, then additional sealing of seams and joints is required and/or replacement of permeable materials with impermeable. All containment materials and materials used for sealing must be resistant to both chemicals water. If unacceptable worker exposures to lead or other heavy metals occur (per 29 CFR 1926.62), incorporate a ventilation system.
- ⁷ This method includes high pressure water jetting with and without abrasive, and wet abrasive blast cleaning. Although both permeable and impermeable containment materials are included, ground covers and the lower portions of the containment must be water impermeable with fully sealed joints, and of sufficient strength and integrity to facilitate the collection and holding of the water and debris for proper disposal. Ventilation is not required provided the emissions are controlled as specified in this Section, and provided worker exposures are properly controlled. If unacceptable worker exposures to lead or other heavy metals occur (per 29 CFR 1926.62), incorporate a ventilation system into the containment.
- ⁸ Containment materials must be sufficient strength to withstand the impact and weight of the abrasive and the equipment used for cleaning. Ground covers must also extend beyond the containment boundary to capture escaping debris.
- Vacuum-blast cleaning shall not be employed using ground covers and/or free hanging tarpaulin as a means of containment unless Contractor has demonstrated that such containment is the equal of SSPC Class 1A containment and has obtained the Resident Engineer's prior written approval therefore.
- ⁹ When using wet methods to achieve an SP 5, 6, 7 or 10 level of surface preparation, the Containment shall be in accordance with SSPC Class 2W as shown above for the Wet Methods. When using abrasive blast cleaning for coating repairs or for miscellaneous structural steel repairs, the Containment shall be in accordance with SSPC Class 2A as shown for SSPC-SP 7.
- ¹⁰ For all SP 1: Solvent cleaning surface preparation, utilize a containment class equivalent to the associated cleaning and/or painting operation being performed (e.g., power assisted hand tools, abrasive blast cleaning, painting, etc.).

TABLE 2

LOCATION	LBP CONTAINING COMPONENTS
12 th Street Shaft	Steel Beams (3)

END OF SECTION

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for the final engineering, furnishing, installation, and testing of an ac control cabinet to monitor and control the 13.2-kV incoming lines, the 13.2-kV transformer secondary breakers, the 13.2-kV bus tie breakers, and five 13.2-kV feeder breakers.
- B. Substation Annunciator

1.02 REFERENCED SECTIONS

- A. Section 16340 – Medium Voltage Metal Clad Switchgear for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI)
 - 1. C37.21 – Standard for Control Switchboards
- B. Institute of Electrical and Electronic Engineers (IEEE)
- C. National Fire Protection Association (NFPA)
 - 1. 70 – National Electrical Code (NEC)
- D. National Electrical Manufacturers Association (NEMA)
 - 1. ICS 4 – Industrial Control and Systems: Terminal Blocks
- E. Insulated Cable Engineers Association (ICEA)
- F. Instrument, Systems, and Automation Society (ISA)
 - 1. 18.1 – Annunciator Sequences and Specification
- G. Underwriters Laboratories (UL)
 - 1. 83 – Nos. 14 - 4/0 AWG and 250-2000 kc/mil sizes of 600-volt, single-conductor, thermoplastic-insulated wires and cable. Branch-circuit, gasoline-resistant, oil-resistant, reagent-resistant, and submersible-pump cables

1.04 NOTED RESTRICTIONS

- A. The design, fabrication, and installation of the ac control panel shall be reviewed by the Consolidated Edison Company of New York (ConEd) prior to acceptance of the substation.

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

- A. Shop Drawings: Submit complete details for nonstandard fabricated items, arrangement of all components, mounting requirements, interconnections, and nameplate legends.

- B. Product Data: Submit manufacturer's catalog cuts, material specifications, installation instructions, and other pertinent data for all components to be furnished
- C. Submit detail theory of operation of the control panel.
- D. Submit a complete factory testing plan that is in accordance with ANSI and IEEE standards.

1.07 DELIVERABLES

- A. Provide eight hard copy sets and one CD-ROM of Operation and Maintenance Manuals.
- B. Provide Certified Factory Production Test Reports.
- C. Certification: Provide manufacturer's certifications that all products furnished meet the specified requirements.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The AC control cabinet shall conform to ANSI C37.21 and shall be the operating point for all circuit breakers. Local operation, in "Test" position, is provided on each breaker cubicle. It shall house circuit breaker control switches, and indication lights. The AC control panel shall have a mimic bus showing the bus arrangement of the switchgear and the breaker control switches and indication lights shall be located in the proper position on the mimic bus.
- B. The AC control cabinet shall be an indoor, vertical, enclosed cabinet suitable for installation where the ambient air temperature may vary from minus 15- to plus 104-degrees Fahrenheit, with humidity varying from 0- to 70-percent non-condensing.
- C. Control switches shall be mounted on the front panel as shown on the contract drawings. No devices shall be mounted on the side panels.
- D. Control and transfer switches shall be as described in Section 16340.
- E. Indicating lamp assemblies shall be as described in Section 16340.
- F. Provide a mimic bus made of red- colored, high-strength, thermosetting plastic. Nameplates shall be used to identify the system components such as, circuit breakers, feeders, and transformers.
- G. All control wiring to external devices shall be continuous from terminal block to terminal block. Provide 20-percent spares for future use.
- H. A mechanical clamp-type connector shall be furnished for grounding the control cabinet. The connector shall be capable of receiving No. 2/0 AWG stranded copper ground cable.
- I. Provide fusible pullout disconnect switches for the 120-vac and 125-vdc supplies, strip heaters and thermostat to control the temperature and humidity, and terminal blocks for all wiring. In addition, provide extra-flexible stranded wire for wiring from devices on the front panel to the stationary part of the control cabinet.

2.02 CONTROL REQUIREMENTS

- A. The following paragraphs indicate the intent of the control schemes.
- B. The control circuits for the control of the five line circuit breakers (52-L1, 52-L2, 52-L3, 52-L4, and 52-L5) shall be wired through control selector switches.
- C. The control circuits for the control of the five transformer secondary circuit breakers (52-M1, 52-M2, 52-M3, 52-M4, and 52-M5) shall be wired through control selector switches.
- D. The control circuits for the control of the four tie circuit breakers (52-TB1, 52-TB2, 52-TB3, and 52-TB4) shall be wired through control selector switches.
- E. The control circuits for the control of the five feeder circuit breakers (52-F1, 52-F2, 52-F4, 52-F5, and 52-F5) shall be wired through control selector switches.
- F. The AC line circuit breakers of the substation shall be automatically locked out by overcurrent relay operation. Lockout relays (86-L1, 86-L2, 86-L3, 86-L4, and 86-L5) shall be mounted in their respective incoming line circuit breaker and trip both the incoming line circuit breaker and the transformer secondary breaker.
- G. The undervoltage relays 27-L1, 27-L2, 27-L3, 27-L4, 27-L5 and overvoltage relays 59-L1, 59-L2, 59-L3, 59-L4 and 59-L5 shall trip their respective Incoming Feeder Circuit Breakers 52-L1, 52-L2, 52-L3, 52-L4, and 52-L5 in the event of an undervoltage or overvoltage condition for a pre-determined duration.

2.03 ANNUNCIATOR PANEL

- A. Provide a solid state annunciator unit with plug-in windows, factory-wired, assembled and tested, complete with components required for its proper operation, as manufactured by Allen-Bradley, Panalarm Division Series 90, Rochester Instruments Series AN31, or approved equal. The annunciator panel shall be located at the upper area of the Control Panel. The annunciator shall be furnished with a flasher and shall be suitable for flush mounting. In addition, the annunciator shall be provided with the following features:
 - 1. Acceptance of normally open or normally closed field contacts. Field contact-voltage shall be supplied by the annunciator internal power supply.
 - 2. Momentary input signals shall lock in and require manual reset.
 - 3. The annunciator shall include an integral power supply that can operate on 125-volts.
 - 4. Number of points and annunciator window size shall be as shown on the Contract Drawings.
- B. The following annunciator accessories shall be provided:
 - 1. "Test", "Acknowledge", and "Reset" pushbuttons, mounted on the annunciator
 - 2. One audible horn, mounted behind a perforated grill on the Control Panel. Provide horn cutoff switch

3. A common alarm output shall be provided for remote indication
4. The annunciator shall have the capability to communicate via an RS-232 or RS-485 port.
- C. The annunciator shall provide an audible, as well as visible, indication for an abnormal condition and shall perform the functions described in Table 1.
- D. Each annunciator point shall provide a normally-closed contact for remote indication that will open for an abnormal condition and will reclose on return to normal.
- E. Annunciator windows shall have white nameplates with black engraving, approximately three inches by three inches in size and back lighted with two lamps in parallel. Minimum average life of lamps at operating-voltage shall be 5,000 hours. Relamping shall be from front of panel. A switch for turning off the panel for a protracted station outage shall be provided.
- F. The annunciator system shall operate from a 125-volts DC supply and have a power failure relay for both local and remote indication when the dc-voltage fails. The power failure relay and associated alarm point shall operate from the 120-volts AC auxiliary power circuit of the control cabinet. The annunciator shall be able to operate at a minimum of 105-volts DC. Three push buttons shall be provided for acknowledge, reset, and test.
- G. All alarm positions, including spaces for future use, shall be fully equipped with solid-state modules and light boxes.
- H. The audible alarm shall be an electric horn mounted inside the control cabinet.
- I. Sequence of operation shall be ISA-2C in accordance with ISA 18.1, as follows:
 1. Operating Sequence: Table 1 shows the standard operating sequence for the annunciator. In addition, the annunciator shall not reset if the condition goes to normal prior to the operation of the Acknowledge button. Once the alarm has been acknowledged and prior to it being reset, the annunciator sequence shall not be re-initiated if the alarm point cycles from abnormal to normal to abnormal. Each sequence has four basic objectives:
 - a. To alert the local personnel to an abnormal or status condition
 - b. To indicate the nature of the condition
 - c. To require an action by personnel
 - d. To indicate when the system returns to normal from an abnormal condition.
 - e. To alert responsible party located remotely from the substation by automatic telephone dialer.

TABLE 1		
CONDITION	LAMPS	AUDIBLE
NORMAL	OFF	OFF
ABNORMAL	FLASH	ON
ACKNOWLEDGE	STEADY ON	OFF
NORMAL	STEADY ON	OFF
RESET	OFF	OFF
NORMAL	OFF	OFF
TEST	FLASH	ON

2. Annunciation Functions: Provide a suitable design for the annunciator system.
- J. Provide panel with pushbuttons, lights, and horns as follows:
1. Annunciator LAMP TEST, ACKNOWLEDGE, and RESET pushbuttons; black, heavy duty oil-tight with nameplates of black-face white core plastic laminate
 2. Annunciator potential indicating light; white, heavy duty oil tight, 132 volts DC
 - a. Horn: Heavy duty rated for continuous operation from panel supply power
- K. Provide panel with heavy-duty terminal blocks with insulating barrier and marker strips and wiring to accommodate all annunciator connections

2.04 CONTROL SWITCHES AND ACCESSORIES

- A. Control Switches:
1. Nineteen control switches CS-L1, CS-L2, CS-L3, CS-L4, CS-L5, CS-M1, CS-M2, CS-M3, CS-M4, CS-M5, , CS-TB1, CS-TB2, CS-TB3, CS-TB4, CS-F1, CS-F2, CS-F3, CS-F4, and CS-F5, each with two indicating lights. Control switches shall be Electroschneider make Type W-2, or General Electric Type SB-1. The indicating lights shall be General Electric Type ET-16, or approved equal, with translucent red and green lenses.
 2. Circuit breaker control switches shall be of the heavy-duty rotary, multi-position, cam operated, and multi-stage type, with dust cover. Switch contacts shall be silver-to-silver, rated for 600-volts AC and a continuous current of 20 Amperes. Each circuit breaker control switch on the mimic panel shall have red and green targets. Each switch shall be equipped with engraved plastic escutcheon or nameplate identifying its function and position. Control switches shall have pistol grip handles. In the circuit breaker "test" position, remote control from the AC Control Panel will be

disabled so that only the control switch on the circuit breaker cubicle can operate the breaker.

PART 3 - EXECUTION**3.01 PREPARATION**

- A. Ensure substrates are in suitable condition to receive the work of this Section.

3.02 INSTALLATION

- A. Install the ac control cabinet in accordance with approved Shop Drawings and manufacturer's instructions.
- B. Install wiring from the switchgear assemblies and to other devices so that it performs the intended function.

3.03 TESTING

- A. Provide complete factory testing plan in accordance with ANSI and IEEE. Include in the factory testing plan any additional tests as may be necessary to assure that all equipment is satisfactory and in accordance with applicable standards and this specification. Perform all tests in accordance with the approved factory-testing plan.
- B. Provide four weeks advance notice to the Resident Engineer so that arrangements can be made for a representative to witness the tests.
- C. Perform field function tests to demonstrate the successful installation of the AC control cabinet and system integration.

END OF SECTION

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for the final engineering, furnishing, and the installation of fire detection and alarm system.

1.02 REFERENCED SECTIONS

- A. Section 16340 – Medium Voltage Metal-Clad Switchgear for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. National Fire Protection Association (NFPA)
 - 1. 70 – National Electric Code (NEC)
 - 2. 72 – National Fire Alarm Code
- B. Underwriters Laboratories (UL)

1.04 NOTED RESTRICTIONS

- A. All Fire Detection and Alarm wiring shall be in dedicated conduit.

1.05 QUALITY CONTROL

- A. Material Standard: Material supplied under this Section shall conform to UL requirements. Where standards have not been established by UL, standards of quality and performance shall be those of the specified manufacturer.
- B. Inspection and Test: Satisfy the Resident Engineer by inspection and test that the equipment furnished and installed will perform in accordance with the specifications.

1.06 SUBMITTALS

None Noted

1.07 DELIVERABLES

- A. Four hard copy sets and one CD-ROM of Operation and Maintenance manuals with Test Procedures.

PART 2 - PRODUCTS**2.01 MATERIALS**

- A. Design, furnish, install, and test an electronic Fire Alarm and Detection System for the detection of fire and smoke, rate-of-rise of the temperature, and the alarm of these conditions in the substation enclosure. As a minimum, the system shall be composed of the following principal components:
 - 1. Dead Front Enclosure:
 - a. The enclosure shall have provisions for securing the fire alarm control panel and other modules to the enclosure and have provisions for mounting the enclosure to the wall.

- b. The enclosure shall provide a locking mechanism, and protect all function switches/buttons to prevent unauthorized access to the fire alarm control panel.
 - 1) All switches and controls shall be provided with windows on the hinged door to view visual displays.
 - c. All fire alarm, trouble, and power indication lights shall be visible when the enclosure door is closed and locked.
 - d. Cabinet shall be manufacturer's standard, with pin and tumbler type lock, provided with six sets of keys.
 - 2. Fire Alarm Zones: The Control Panel shall have one fire alarm zone that is integral to the control panel and one set of system trouble contacts that is integral to the control panel.
 - 3. Electronic Supervision:
 - a. The System shall have electronic supervision of all manual and automatic detection circuits. The electronic supervision of the control panel and the devices shall be continuous. The system shall indicate a loss of supervisory capability by annunciating a trouble condition.
 - b. The system shall supervise the placement of modules and generate a trouble indication when a module is removed from the Fire Alarm Control Panel (FACP).
- B. Detectors and Initiating Devices:
 - 1. Provide detectors that are activated by products of combustion. They shall have sensitivity not less than the minimum required, and shall be listed and approved by UL. Further, the detectors shall not be subject to alarm as the result of rapid changes of humidity, nor shall they contain material that would require licensing by the Nuclear Regulatory Commission for this application. The selected detector shall not be activated by the expulsion of ionized gases during normal operation of the substation circuit breakers.
 - a. If ionization detectors are selected, the detectors shall be plug-in units containing two chambers. It shall be possible to check the sensitivity of the unit by an approved test set, and it shall be possible to readjust the detectors' sensitivity as required. Each unit shall contain no moving parts and shall require no replacement or adjustment after an alarm has been initiated and the system restored to normal.
 - b. Each detector shall be provided with a standard base that can accommodate a thermal rate-of-rise detector without additional wiring. The base shall have screw terminals for making all connections and have incorporated in it, a neon indicator that shall provide visual indication of the detector initiating an alarm.

2. Manual Activation: The system shall have an approved mechanical device for manual activation. The normal manual control shall be located such as to be conveniently accessible at all times.
 - a. This control shall cause the complete system to operate and activate all audible and visual indicating devices. Mechanical controls shall not require a pull of more than 40-pounds nor movement of more than 14-inches to initiate operation.
- C. Combination Horn and Light:
 1. Audio-visual alarm devices may be combination horn/lamp units with built-in alarm flasher. Lamp bulbs shall be replaceable only from the rear, shall be vibration-proof mounted, and shall be protected by a red lens. Units shall be red with legend "Fire" in white letters on the lens.
 - a. Activation of a detector or manual pull station shall illuminate the respective zone circuit lamp in the control panel.
 - b. Transmit a signal to the control panel.
 - c. Light an individual lamp on the alarm annunciators.
 - d. Turn off the ventilation system fans and close all dampers.
 - e. Turn off all AC power equipment within the substation.
- D. Emergency Back-Up Power: The system shall include emergency power backup. Upon loss of AC power supplying the control unit, the system shall automatically transfer to stand-by battery power supplied by the control unit for a minimum of 24 hours.
- E. Fire Alarm Control Panel (FACP):
 1. The FACP shall be a zone annunciated, non-coded system, manual and automatic, fully supervised, UL listed, local and remote type, as described herein.
 2. The FACP shall contain an automatic-type battery charger capable of recharging the batteries within 14 hours.
 3. Control shall include the proper number of initiating circuits, indicating circuits, relay control circuits, supervisory circuits, and power supplied as required. All end-of-line devices shall be located in the control panel. Four wire loop-detecting circuits are preferred.
 4. To prevent the panel from inadvertently being left in "silence" mode, the trouble signal and indicating signal silence switch shall be of the self-restoring type that cannot be left in an abnormal position.

5. The Control Panel shall have adequate four-wire loop-detecting circuits and zones. Systems that cannot receive an alarm from all detectors, even though there is a single-fault condition in the detection loop, shall not be acceptable. The detection circuit shall provide power for all ionization detectors four-wire loop wiring.
6. Systems that power detectors from power sources separate from the detector circuit with four wire loop wiring, shall monitor the power source and independent wiring to each zone so "true" trouble and alarm by zone is achieved for reliability and ease of maintenance.
7. The control panel shall have a trouble and an alarm lamp for each detection circuit. Systems that have a common trouble lamp only, or rely on a combination of indicators that require operator interpretation to determine if there is an alarm or trouble, or which zone has given an alarm condition, shall not be acceptable.
8. 120-volts ac normal power shall be monitored and a power-on lamp shall be provided. Upon power outage, the system shall light a power trouble lamp and automatically switch to standby batteries.
 - a. The Control Panel shall also monitor the batteries, and upon low battery voltage, light the low battery trouble lamp and initiate a trouble alarm.
 - b. System ground detection shall be provided for the alarm system. Upon ground detection, the ground detection lamp shall light and a trouble signal indicated. Provide a lamp test switch to test all alarm lamps on the control panel.
9. All alarms shall lock-in the FACP and the device until both the initiating device has been restored to normal and the system control unit is reset. Alarm may be silenced, but subsequent alarms from another zone shall cause the signals to resound.
 - a. The system shall have a "Time Out" module or circuit that will automatically silence the audible fire alarm. The time shall be selectable between zero and five minutes.
10. When the system is restored and the horn silenced, a system trouble alarm shall be initiated. Any fault on the system which would prevent the transmission of an alarm signal, shall initiate a trouble alarm.
 - a. The audible trouble alarm may be silenced by operating a momentary silencing switch, but the visual trouble signal shall remain lighted. After the fault has been corrected, the trouble circuit shall automatically reset to normal.

- b. All remote trouble indicating devices shall operate identically, including the self-resetting feature. Faults on any zone shall cause an individual zone trouble indicator to light. The Control Panel shall include a momentary lamp test switch that shall light all visible indicators in the Control Panel when operated. The system shall indicate trouble when horns are silenced at the same time that alarm circuits are in non-alarm condition.
- 11. The Control Module shall be a solid-state modular assembly mounted on channels facilitating easy removal for repair and ease of expansion.
- 12. The Control Module shall supply all necessary power for the control panel and all detectors, and shall contain a battery charger to charge the batteries.
- 13. An accessory relay module shall provide the necessary relays and devices for functions such as remote annunciation, closing dampers, and shutting down fans or other electrical devices. All relays shall be supervised, of high-quality, fitted with dust-tight plastic covers and plug-in basis, UL listed and rated for a minimum of 5-amperes at 120-volts ac.
- 14. Individual zones shall have a switch to bypass that zone that will prevent the zone from activating the system; it shall also annunciate a system trouble.
- F. Fire detection and alarm equipment shall be interconnected using wire and cables recommended by the manufacturer of the fire alarm and detection system.
- G. Remote Alarms: Provide an automatic telephone dialer system to specifically alert the appropriate authority of fire detection. Design the system to be a reliable element of the fire detection and alarm system.

PART 3 - EXECUTION**3.01 PREPARATION**

- A. Ensure substrates are in suitable condition to receive the work of this Section.

3.02 INSTALLATION OF SYSTEM

- A. The fire detection and alarm systems shall be installed in accordance with the manufacturer's recommendations and requirements of the State of New York.
- B. Make the necessary test and demonstrations to receive a certificate as required by the State of New York.
- C. Test the systems in accordance with the approved Installation Test Procedure.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for the plumbing work and tunnel drainage system equipment installation indicated on the Contract Drawings and specified herein.

1.02 REFERENCED SECTIONS

- A. Section 03300 - Cast-in-Place Concrete
- B. Section 13115 - Corrosion Control System Testing
- C. Section 15205 - Tunnel Drainage System

1.03 CITED STANDARDS

- A. American Society of Mechanical Engineers (ASME):
 - 1. A13.1 - Scheme for the Identification of Piping
 - 2. B1.20.1 - Pipe Threads, General Purpose (Inch)
- B. American Welding Society (AWS):
 - 1. D1.1 - Structural Welding Code - Steel
- C. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. The equipment covered by the Contract Documents shall be standard equipment of proven performance as manufactured by reputable companies. Equipment shall be designed, constructed, installed and tested in accordance with the best practices of the trade, and shall operate satisfactorily upon installation.
- B. The calculations and drawings submitted under this Contract shall be prepared in accordance with ISO 9001 procedures for quality assurance and quality control. Each calculation/drawing shall include a “designed by” and “checked by” title block. All calculations and drawings submitted under this Contract shall be signed and sealed by a Professional Engineer licensed in the State of New York.

1.06 SUBMITTALS

- A. Refer to Section 15205.

1.07 DELIVERABLES

None Listed

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Follow the manufacturer's product information for unloading, storing, and moving equipment and accessories.
- B. Refer to Section 15205 for specific equipment delivery, storage and handling requirements.

1.09 FINISHES

- A. Refer to Section 15205 for specific finishes instructions.

1.10 WORK SITE CONDITIONS

- A. Assume operation, maintenance, control and testing of temporary plumbing, drainage, water treatment and fire protection systems that were furnished and installed under previous contracts. Coordinate transfer of existing temporary systems with Resident Engineer. Verify the performance and stability of previous contracts temporary systems with the Resident Engineer before re-commissioning.
- B. Previous contracts temporary plumbing, drainage, water treatment and fire protection systems shall be modified or upgraded, as necessary, by Contractor to meet the requirements of the Contract. All Works under this Contract are to be left intact, in-place and in good working condition, and shall be turned over to the MTA at Substantial Completion.

1.11 PROGRESS OF THE WORK

- A. The basic mechanical requirements provided herein, and the specific mechanical requirements provided within the individual Division 15 Specifications are not intended to impact or impede the progress of Contractor's tunnel construction Work. These requirements are generally applicable to the finished condition of the Work, which includes equipment and systems that are to be operated and maintained by later contractors and the MTA. Any requirements specified herein that are deemed to impact or impede the progress of the Work shall be identified to the Resident Engineer.
- B. Select appropriate mechanical equipment and installation methods to suit the in-progress condition of the tunnel construction. Contractor is solely responsible for the in-progress condition of the mechanical equipment and systems during the course of the Work.

PART 2 PRODUCTS**2.01 PIPE AND PIPE FITTINGS, AND JOINING MATERIALS**

- A. Refer to Section 15205 for specific pipe and fitting materials and joining methods, and specific joining materials not listed below.

PART 3 EXECUTION**3.01 PROTECTION OF THE WORK**

- A. Cover openings in conduits and piping, and temporarily seal to protect from contamination.
- B. Protect materials and equipment from damage due to environmental conditions. Use protective cover, and protect from surface water by using raised platforms.
- C. Protect unfinished Work at the end of each Workday from damage, contamination, and moisture by the use of plugs, caps, or covers.
- D. Protect piping and valves from damage pending performance of system tests.
- E. Protect installed thermometers and gauges from accidental damage by construction activity.
- F. Following installation, and before final embedment, use temporary protective covers and fixtures to prevent damage from traffic and overburden loads that would damage or displace embedments.
- G. Clean piping, valves, and equipment installed under this Work. Drain and flush piping to remove grease and foreign matter.
- H. Locations of Equipment: As shown on the Contract Drawings.

3.02 INSTALLATION OF PIPING

- A. Install piping parallel to walls, floors, and ceilings, unless indicated otherwise. Clear obstructions, preserve headroom, and keep openings and passageways clear.
- B. Should structural features or other work prevent running of pipes or setting of equipment at locations indicated, necessary minor deviations will be permitted.
- C. Expanding or swagging of tubing to fit IPS fitting sockets will not be permitted.
- D. Use reducing fittings where change in pipe size occurs. Reducing bushings shall not be used unless otherwise indicated.
- E. Use couplings only where required pipe runs between fittings are longer than standard length of pipe being used.

- F. Make exposed polished or enameled piping connections to fixtures or equipment with special care to avoid damage to finished surfaces. Knurled pipe wrenches such as "Stilson Wrenches" shall not be used on chrome plated or polished stainless or aluminum tubing or equipment.
- G. Make changes in direction only with fittings.
- H. Use proper length bolts for each size flange on flanged connections; bolts with excessive length of exposed threads will not be permitted. A minimum of three full threads is required to be exposed beyond the nut after tightening the assembly.
- I. Prevent entry of foreign matter during handling, assembling, and installation. Use compressed air, wire brush, solvent, and other acceptable means to remove scale, dirt, and other foreign matter from interior of piping before final connections are made. Protect open ends of pipe by capping, plugging, or other acceptable means.
- J. Anchor piping subject to expansion or contraction in a manner permitting strains to be evenly distributed and alleviated by swing joints or expansion loops.
- K. Flush out and blow out piping systems.
- L. Ream pipe ends to remove burrs.
- M. Install all piping with sufficient pitch to insure adequate drainage and venting.
- N. Provide unions or flanges in piping connections to equipment.
- O. Electrically isolate connections between ferrous piping and piping with dielectric couplings or fittings.
- P. Install class of piping as indicated.
- Q. Do not run water piping over electric switchboards, transformers, or electric motor starters.
- R. Protect against external corrosion of pipes which pass through, under, or otherwise in contact with soil, cinders, concrete, or other corrosive material. Protect by protective wrappings, as specified, or by other acceptable means.
- S. Install components with pressure rating equal to or greater than system operating pressure.
- T. Storm Drain Piping: Run horizontal drainage piping as straight as practicable, and at a uniform pitch.
- U. Verify final equipment locations for roughing-in.

3.03 PIPING JOINT CONSTRUCTION**A. General:**

1. Use tools specifically designed for pipe cutting; de-burr all cut pipe ends. Make joints leak-tight. Test, and remake leaky joints with new materials. Thread cement or caulking shall not be used to remake leaky joints.
2. Do not use a sharp-toothed wrench in making up brass pipe or chrome-plated items. Thread and length of threads shall be in accordance with ASME B1.20.1. Use a thread lubricant on male threads suitable for the proposed pipe service.
3. All welded pipe joints, qualification of welders, and testing shall be in accordance with AWS D1.1.

3.04 INSTALLATION OF PIPE SLEEVES:**A. General Requirements:**

1. Provide a pipe sleeve where each pipe passes through an exterior or interior wall, floor, ceiling, or roof, and at other locations indicated.
2. Set pipe sleeves parallel to the pipes that pass through them.
3. Do not install sleeves in structural members except where indicated.
4. Secure sleeves to concrete forms to prevent displacement during placing of concrete.
5. Build sleeves into new walls and slabs as Work progresses
6. Install sleeves large enough to provide 1/2-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than 6-inch NPS.
 - b. Steel, Sheet-Metal Sleeves: For pipes 6-inch NPS and larger.
7. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants.
8. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated.
9. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.

B. Sleeves through Interior Walls, Floors, and Ceilings:

1. Install permanent sleeves of steel pipe with steel plate anchors as indicated.

2. Where sleeves cannot be installed such as at connections to floor drains, do not allow pipes to be in contact with reinforcing steel.
 3. Cut pipe sleeves through walls flush with the finished wall surfaces. Sleeves through interior floors shall project minimum six inches above the finished floor, and six inches below the finished ceiling surface.
 4. Where pipes pass through fire-rated walls, floors and ceilings, install fire-rated packing in the opening between the pipe and pipe sleeve as required by UL for the applicable fire rating.
- C. Sleeves through Exterior Below-Grade Walls, Floors, and Ceilings:
1. Sleeves more than 15-feet below grade:
 - a. Install a cast iron sleeve with compression seals.
 - b. Install the sleeve assembly and seals so that there is complete electrical isolation between the carrier pipe and all metallic components of the sleeve including membrane and pressure clamps.
 2. Sleeves 15-feet or less below grade:
 - a. Install a steel sleeve with modular link seals.
 - b. Seal the annular space between the sleeve and pipe with insulating type modular link seals. Assemble the links loosely with bolts to form a continuous rubber belt around the pipe with a compression plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tighten the bolts so that the sealing elements expand providing electrical isolation between the pipe and sleeve and a hydrostatic seal.
 3. Provide sufficient radial clearance beyond pipe or pipe plus coating to accommodate installation of sealing elements.
 4. Extend exterior coating on buried piping flush with exterior surface of sealing element at outer membrane clamp.
 5. Caulking or other types of mastic or lead and oakum joints are not acceptable for exterior below-grade penetrations.
 6. Provide a gasket coated with the gasket manufacturer's recommended lubricant between the contact faces of the flanges.
- D. Join pipe and fittings as follows and as specifically required in individual piping specification Sections:
1. Cast Iron Soil Pipe: Neoprene Gasketed Plain Spigot End Pipe: Insert gaskets, lubricate inside of gaskets and outside of pipe, and join together with suitable tool, as recommended by manufacturer.

2. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:
 - a. Note internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 - b. Apply appropriate tape or thread compound to external pipe threads, unless dry seal threading is specified.
 - c. Align threads at point of assembly.
 - d. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
 - e. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
3. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
4. Mechanical Joints: EDPM gasket for cut grooved pipe joints only, lubricate inside of gaskets and outside of pipe, and join together with suitable tool, as recommended by manufacturer.

3.05 EQUIPMENT INSTALLATION

- A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment giving right of way to piping installed at required slope.
- E. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

3.06 LABELING AND IDENTIFYING

- A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
 - 1. Stenciled Markers: ASME A13.1.
 - 2. Plastic markers, with application systems. Install on insulation segment if required for hot water piping.
 - 3. Locate pipe markers as follows: if piping is exposed in finished spaces, machine rooms, and accessible maintenance spaces, such as shafts, tunnels, plenums, and exterior non-concealed locations:
 - a. Near each valve and control device.
 - b. Near each branch, excluding short takeoffs for fixtures and terminal units. Mark each pipe at branch, if flow pattern is not obvious.
 - c. Near locations if pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.
 - d. At access doors, manholes, and similar access points that permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.
 - f. Spaced at maximum of 50-foot intervals along each run. Reduce intervals to 25-feet in congested areas of piping and equipment.
- B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of mechanical equipment.
 - 1. Lettering Size: Minimum 1/4-inch high lettering for name of unit if viewing distance is less than 24-inches, 1/2-inch high lettering for distances up to 72-inches and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
 - 2. Text of Signs: Provide name of identified unit. Include text to distinguish between multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- C. Pipe and Valve Identification:
 - 1. Pipe Markers:
 - a. Provide pipe markers of semi-rigid plastic that are accessible for maintenance operations (except piping in finished spaces). Include direction-of-flow arrows.

- b. Color code marker background with a clearly printed legend to identify the contents of the pipe. Conform colors and legend to ASME A13.1.
 - c. Install adjacent to each valve and fitting at each pipe passage through wall, floor, and ceiling construction; at each pipe passage to underground; and on 25 foot centers on horizontal pipe runs.
- 2. Valve Markers:
 - a. Provide valve markers of satin finished aluminum faced black plastic backed, 1-1/2-inches in diameter. Letters shall be 1/4-inch high and numbers shall be 1/2-inch high; both shall be engraved. Marker fasteners shall be either meter seals, four-ply 18-gauge stainless steel wire stainless steel "S" hooks, or meter seals. Markers shall bear identification as indicated.
 - b. Fasten to valve body to be easily read.
- D. Adjusting: Relocate identifying devices as necessary for unobstructed view in finished construction.

3.07 PAINTING AND FINISHING

- A. Exposed, uninsulated piping, galvanized or otherwise, shall be painted with three coats of paint.
- B. Preparation, and Application of Paint: Apply paint to exposed piping according to the following, unless otherwise indicated:
 - 1. Exterior, Ferrous Piping: Use semi-gloss, acrylic-enamel finish. Include two finish coats over rust-inhibitive metal primer.
 - 2. Exterior, Galvanized-Steel Piping: Use semi-gloss, acrylic-enamel finish. Include two finish coats over galvanized metal primer.
 - 3. Exterior, Ferrous Supports: Use semi-gloss, acrylic-enamel finish. Include two finish coats over rust-inhibitive metal primer.
- C. Do not paint piping specialties with factory-applied finish.
- D. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.08 CONCRETE BASES

- A. Coordinate concrete work with Section 03300.
- B. Construct concrete bases of dimensions indicated, but not less than 4-inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3,000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03300.

3.09 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B. Field Welding: Comply with AWS D1.1.

3.10 CORROSION CONTROL

- A. Dissimilar metals including stainless steel and galvanized steel in contact with each other, shall be protected against corrosion using protective measures specified in Section 13115.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools and equipment, and performing all operations necessary for tunnel drainage system in the Bellmouth Area as indicated on the Contract Drawings and specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. D 2996 – Filament Wound Fiberglass (Glass Fiber Reinforced Thermosetting-Resin) Pipe
- B. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems

1.04 NOTED RESTRICTIONS

- A. Furnish all labor, materials, tools, and equipment and perform Work and all operations necessary for track drainage construction.
- B. Workers shall be experienced and skilled in the installation of track drainage lines and appurtenances.

1.05 QUALITY CONTROL

- A. The equipment covered by the Contract Documents shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, installed and tested in accordance with the best practices of the trade, and shall operate satisfactorily upon installation.
- B. The calculations and drawings submitted under this Contract shall be prepared in accordance with ISO 9001 procedures for quality assurance and quality control. Each calculation/drawing shall include a “designed by” and “checked by” title block. All calculations and drawings submitted under this Contract shall be signed and sealed by a Professional Engineer licensed in the State of New York.
- C. When Work in any area is completed, clean the area, replace the all covers, and leave the area in conditions satisfactory to the Resident Engineer.
- D. Care shall be taken when storing pipe and appurtenances so as not to damage MTA property. Any property so damaged shall be repaired at Contractor’s expense.

1.06 SUBMITTALS

- A. Submit manufacturer's product information and data, material data safety sheets, type and finish, and other pertinent data to show compliance with referenced standards and these Specifications.
- B. Submit Shop Drawings of piping layout drain inlets, sizes, type, and configuration as necessary.

1.07 DELIVERABLES

- A. Provide the following deliverables:
 - 1. Certificate of Compliance
 - 2. Special Tools List
 - 3. As-Built Drawings
 - 4. Operations and Maintenance Manual
 - 5. Field Test Report
 - 6. Spare Parts List

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Properly receive, handle, and store all materials and equipment in conformance to the manufacturer's requirements.
- B. Maintain all equipment installed following manufacturer's instructions until acceptance by the MTA.

1.09 WORK SITE CONDITIONS

- A. Excavations in which products will be buried shall be dry. Inspect surface and structures to, and on, which the tunnel drainage system will be installed before the commencing the Work of this Section. Provide surfaces and structures capable of supporting the system and its weight.
- B. Coordinate the installation of the tunnel drainage system with other tunnel systems and components to avoid conflicts of installation. Drawings are diagrammatic and not necessarily to scale. Do not scale drawings for exact locations of installations of pipelines, drain inlets, valves, and equipment.
- C. Assume operation, maintenance, control, and testing of existing tunnel drainage system. Coordinate transfer of existing systems with the Resident Engineer.
- E. Previous contracts' tunnel drainage shall be modified or upgraded, as necessary, by Contractor to meet the requirements of this Contract.
- F. All Works under this Contract shall be left intact, in-place, and in good working condition, and shall be turned over to the MTA at Substantial Completion.

PART 2 PRODUCTS**2.01 MATERIALS**

- A. Embedded track drainage piping shall be unlined fiberglass reinforced pipe complying with ASTM D 2996.
 - 1. Pipe: Smith Fibercast Red Thread II; or approved equal, bell and spigot.
 - 2. Fittings: Manufactured bell fittings.
 - 3. Joints: Epoxy resin adhesive compatible with pipe and fittings used.

2.02 EXPANSION JOINTS

- A. FRP expansion joints shall be fabricated in accordance with pipe manufacturer's recommendations for 24-inch maximum expansion.

PART 3 EXECUTION**3.01 PREPARATION**

- A. Clean piping installed under this Section. Drain and flush piping to remove grease and foreign matter. Surfaces and structures on which piping will be installed shall be capable of supporting piping at design elevations during concrete placement. Provide supports for piping to be embedded in concrete as indicated on reviewed Shop Drawings.

3.02 INSTALLATION

- A. Install piping where indicated. Set pipe and fittings to line and grade before joints are made up.

3.03 FIELD TESTING

- A. Do not cover piping to be buried until inspecting, testing and acceptance of piping have occurred.
- B. Fill track drainage with water and allow to stand for not less than 30 minutes without leaking. Provide temporary seals at ends of piping section to be tested. Repair leaks and retest piping until the system exhibits no leaks.

3.04 CLEANING

- A. Cleaning of installed piping shall consist of removing foreign material from products.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for furnishing and installing electrical conduits, fittings, wires, cables, and associated accessories, complete in place, indicated on the Contract Drawings and specified herein.

1.02 REFERENCED SECTIONS

None Referenced

1.03 CITED STANDARDS

- A. American Association of State Highway and Transportation Officials:
 - 1. H20 – Highway Design Standards – Wheel Loading
- B. American National Standards Institute (ANSI):
 - 1. C2 – National Electrical Safety Code
 - 2. C80.1 – 90, Rigid Steel Conduit, Zinc Coated
- C. ASTM International (ASTM):
 - 1. A 123 –Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2. A 153 –Zinc (Hot-Dip) on Iron and Steel Hardware
 - 3. D 2105 - Longitudinal Tensile Properties of Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube
- D. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. C37.35 –Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches
- E. National Electrical Manufacturer's Association (NEMA):
 - 1. 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)
 - 2. FB-1 - Fittings, Cast Metal Boxes and Conduit Bodies for Conduit Electrical Metal Tubing and Cables
 - 3. KS-1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
 - 4. TC-14, Part A - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

- F. National Fire Protection Association (NFPA)
 - 1. 70 – National Electrical Code (NEC)
 - 2. 101 - Life Safety Code
- G. Underwriters Laboratories (UL):
 - 1. 1 – Flexible Metal Electrical Conduit
 - 2. 6 – Rigid Metal Electrical Conduit
 - 3. 50 – Cabinets and Boxes
 - 4. 98 – Enclosed and Dead Front Switches
 - 5. 198E – Class R Fuses
 - 6. 360 – Liquid-Tight Flexible Steel Conduit
 - 7. 514B – Fittings for Conduit and Outlet Boxes

1.04 NOTED RESTRICTIONS

- A. Interface and coordinate with work included, in-progress, or to be performed under other sections of the Specifications, or by other contractors.
- B. Leave temporary and interim electrical work and equipment in place for maintenance and operation of systems for the duration of the Contract.

1.0 QUALITY CONTROL

- A. Regulatory Requirements:
 - 1. Uniform Fire Prevention and Building Code Title 19 of the New York Codes, Rules, and Regulations (BCNYS)
- B. Where material standards have not been established by UL, standards of quality and performance shall be those of other recognized industry standards unless otherwise noted.
- C. Inspection and Tests: Certify, by inspection and tests, that the equipment and systems provided and installed as part of the Contract will satisfy the performance requirements specified herein. Perform these tests and/or inspections both before equipment is shipped to the Work Site and during acceptance and startup testing at the Work Site.
- D. Inspection of the materials and equipment shall be made at the point of delivery. However, the Resident Engineer reserves the right to make any tests or inspections that are deemed necessary at the vendor's manufacturing facility. In the event that the inspection is conducted at the vendor's facility, the Resident Engineer shall have free entry at all times while Work is being performed, and to all parts of the facility that involve the manufacture of the pertinent materials and equipment. Notify the Resident Engineer when the materials and equipment are

being fabricated or shipped to the Work Site in order that the desired inspections can be made.

- E. Provide warranty for a minimum of one year for all electrical equipment unless noted otherwise. The warranty period begins after final acceptance of the equipment or system.

1.06 SUBMITTALS

- A. List of Materials: At least 30 days before beginning the Work of this Section, submit a list of materials and equipment proposed for use together with applicable standards. Provide the name of the manufacturer, the brand name, and the catalog number of each item.
- B. Shop Drawings:
 - 1. Submit Shop Drawings for review showing the exact location and arrangements of conduits stubbed into equipment, cabinet, pull boxes and assigned spaces, conduit sleeves for exposed conduits, and for fabricated work being furnished and installed under the Contract Specifications. Submit such drawings before rough-in work, fabrication, and within ample time to prevent delays in the Work. Include complete electrical wiring diagrams for equipment and equipment installation.
 - 2. Submit catalog cuts and/or assembly drawings for all electrical materials installed under the Contract including:
 - a. Conduit and fittings (each type)
 - b. Supporting equipment
 - c. Disconnect switches
 - d. Wire and cable
- C. Submit coordination data for fuses.

1.07 DELIVERABLES

- A. Certificates of Compliance with Applicable Standards: The label or listing of the specified agency will be acceptable evidence.
- B. Field Test Reports: Submit certified reports of field tests, verifying performance of equipment and systems with Contract Specification requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Ship each unit or component securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Mark each item, unit, or component in accordance with applicable reference standard.

- C. Store materials in a secure and dry facility and in original packaging in a manner to prevent soiling, physical damage, wetting, or corrosion prior to installation.
- D. Where possible, maintain protective coverings until installation is complete, and remove at Contract closeout.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Furnish new materials and equipment of the design, size and rating indicated.
- B. Furnish materials and equipment bearing label or classification listing of a nationally recognized testing laboratory, where UL standards exist, and such product labeling or listing is available.
- C. All electrical materials shall comply with NFPA 70 (NEC).
- D. Provide products that are free from defects that may impair performance, durability, or appearance and of the commercial quality best suited for the purpose indicated or specified herein.
- E. Steel conduit and accessories shall be hot-dipped galvanized rigid steel conduit.

2.02 TEMPORARY POWER SYSTEMS AND LIGHTING SYSTEMS

- A. General:
 - 1. Furnish and install all material and equipment required for temporary power and lighting systems. All materials and equipment shall be new.
 - 2. Maintain temporary electrical systems for the duration of the Contract.
- B. Power Systems:
 - 1. Provide NEMA 3R service equipment of sufficient capacity and voltage rating to support construction activities. Service feeders and equipment shall be in accordance with the requirements of the Consolidated Edison of New York (ConEd). Provide temporary utility company metering equipment, protective and disconnecting devices. Enclosure shall be suitable for the duration of the Contract. Service feeder(s) shall have ground fault protection.
 - 2. AC power feeder cables for installation between the respective temporary electrical service equipment and the Work Site, sump pumps, if any, and Contractor's construction staging area, shall be stranded copper conductors, 600-volt insulation, with three separate single conductor cables and one separate identified full size ground cable. Conductor cables shall be NEC, Type USE insulated. Ground cable shall be NFPA 70 (NEC), Type XHHW. Install all temporary cables in conduits. Conduits shall be protected. Trench covers shall be suitable for AASHTO H20 wheel loading.

3. Provide rigid galvanized steel conduits on wall and ceiling to route all power cables.
 4. Saw cut sidewalks, where applicable, for temporary conduit trench. Install protective trench cover. Restore sidewalk after all temporary conduits are removed.
 5. Provide an outdoor, weather-resistant enclosure for the load center feeding the sump pumps. Connect feeders for sump pumps to individual load center circuit breakers. Provide load center with main and branch circuit breakers.
 6. Power feeder cables shall have sufficient capacity to transmit the required power without exceeding a voltage drop of three percent between the temporary substations, construction service equipment or load centers, and the most distant load.
 7. Load center enclosures for construction power and support of existing systems shall be NEMA 3R drip-proof. Provide load center for sump pumps with three-pole circuit breakers suitable to feed pumps.
 8. Provide 120-volt, single phase receptacles in substation in accordance with the NEC.
- C. Lighting:
1. The average maintained illumination within the substation shall be at least 40-footcandles (horizontal). Design, furnish, and install a substation lighting system in accordance with the maintained foot-candle level.
 2. The tunnel emergency exit door and interior corridors and stairway are the access route to the substation room. Provide all required normal and emergency lighting along with the personnel access route to the substation in accordance with NFPA 101.

2.03 CONDUIT

- A. Rigid Galvanized Steel (RGS) Conduit and Accessories:
1. Provide conduit, couplings, elbows, bends, sealing fittings, and nipples conforming to ANSI C80.1 and UL 6, with each length bearing manufacturer's stamp and UL label. All conduits shall be threaded.
 2. The minimum nominal conduit size shall be 3/4-inch.
 3. The male threads of conduit and fittings shall be hot-dip galvanized in such a manner as to keep the threads clear of excess zinc. Female threads may be electro-galvanized instead of hot-dipped. Conduit accessories such as lock nuts, bushings, and connectors shall be zinc-coated. All conduit fittings shall be threaded and shall conform to NEMA FB-1. No setscrew fittings shall be used. No running threads will be permitted.

4. Bushings for conduits 1-1/4-inches and larger shall have a nylon-insulated insert, and shall be concrete-tight.
5. Conduit bends shall be fabricated in a conduit-bending machine. Conduit shall not be bent utilizing a bending tool. The radius of the curve of the inner edge of any bend shall be not less than six times the internal diameter of the conduit. Factory bends shall be utilized wherever possible. All factory bends shall be similar in construction to and of a type designed for use with the conduit.
6. Touch-up galvanized coating where the original galvanized coating on conduit or on galvanized steel has been removed due to handling or for other reasons. Replace galvanizing coating for male threads when conduit is field cut. No cold galvanizing spray shall be used. Apply touch up galvanizing with a brush. Galvanized coating shall be ZRC cold galvanizing compound, or approved equal.
7. Conduit sleeves shall be galvanized rigid steel.
8. Three-piece couplings, Erikson fittings, and split couplings shall be concrete-tight.
9. All conduit fittings, such as "T", "C", "L" and "E" fittings, shall be galvanized cast iron as manufactured by Appleton Electrical Products, Killark, Crouse Hinds, or approved equal.
10. Expansion/deflection fittings shall be hot-dip galvanized, watertight, NEMA Type 4 and concrete-tight. Fittings shall permit movement of conduit in any direction of one inch from normal and angular misalignment of the axis of coupled conduit runs in any direction up to 30-degrees. Fittings shall be as manufactured by Appleton Electrical Products, O.Z. Gedney, Spring City Electrical Manufacturing Company, or approved equal.
11. Expansion fittings shall be hot-dipped galvanized, watertight, NEMA Type 4 and concrete-free. Fittings shall permit expansion and contraction of conduit up to four inches in the axial direction, two inches in either direction, for expansion joints only. Fittings shall be as manufactured by Appleton Electrical Products, O.Z. Gedney, Spring City Electrical Manufacturing Company, or approved equal.

B. Fittings and Accessories:

1. Provide separable watertight hub fittings with a gasket, separate nylon insulated throat, and a case hardened locknut.
2. Provide bushings of nylon insulated metallic and grounding type.

C. Liquid-Tight Flexible Metallic Conduit and Fittings:

1. Provide conduit consisting of a core of flexible galvanized steel with an extruded watertight jacket, zero halogen, low smoke type overall. Jacket shall be moisture-proof and oil-proof, conforming to UL 360. The minimum radius bends of flexible conduit without cracking.
2. Provide conduits with a continuous copper-bonding conductor spiral wound between the convolutions, as required by NEC.
3. Provide fittings conforming to UL 514B, cadmium or zinc coated.
4. Furnish conduits of 1-1/4-inches diameter and smaller with a continuous copper bonding conductor spiral wound between the convolutions.
5. Liquid-tight flexible conduit 1-1/4-inches and smaller shall be Type UA flexible conduit. Liquid-tight flexible conduit larger than 1-1/4-inches shall be Type EF flexible conduit.
6. Liquid tight connectors for flexible metallic conduits shall be of steel, straight, 45-degree and 90-degree as required for conduits up to one inch in size and of malleable iron for conduits over one inch in size. All connectors shall have insulated throats.

D. Flexible Metal Conduit:

1. Flexible galvanized steel conduit shall conform to UL 1.
2. Fittings shall be of a type specifically designed for use with conduit and shall conform to UL 514B.

E. Fiberglass Reinforced Epoxy (FRE) Electrical Conduit and Fittings:

1. Non-metallic conduit and conduit fittings shall be as follows:
 - a. Conduit and fittings, encased in concrete shall be suitable for underground purposes.
 - b. Do not use metallic ties when constructing embedded conduit system. Assembly concrete encased conduits using plastic base and intermediate spacers to provide a minimum spacing of 7-inches between centerlines of parallel conduits.
2. Furnish UL listed in accordance with Article 352 of the NEC for underground use.
3. Furnish material that has the following minimum properties:
 - a. Exposed ducts shall conform to ANSI and NEMA TC-14A.
 - b. Tensile Strength: The minimum longitudinal tensile strength of the duct shall not be less than 9,000-psi when tested in accordance with ASTM D 2105.

- c. Dielectric Strength: The minimum dielectric strength shall be 500-volts per mil when tested in accordance with ASTM D 149.
- d. Heat Distortion: The minimum heat distortion temperature shall be 215 degrees F when tested at 265 psi in accordance with ASTM D 648.
- e. Fire Resistance: FRE duct and fittings shall exceed the standard governed by UL 651, Section 12. In this standard, vertical specimens shall self-extinguish within five seconds after any of three successive 60 seconds flame applications.
- f. Flame Spread: Surface flammability of conduit and fittings shall not exceed a maximum index rating of 30 when tested in radiant heat in accordance with ASTM E 162.
- g. Smoke Density: The specific optical density of smoke generated by solid materials in the duct and fittings (in either the flaming or non-flaming mode), shall not exceed 25 within four minutes after start of test, in accordance with ASTM E 662.
- h. Toxicity: Smoke toxicity shall not exceed the following values in parts per million (PPM):

Gases	Values (max P.P.M.)
Hydrogen Chloride	0
Hydrogen Bromide	0
Hydrogen Cyanide	<1
Hydrogen Sulfide	0
Ammonia	0
Aldehydes as HCHO	<10
Oxides of Nitrogen	<50
Carbon Dioxide	<12,500
Carbon Monoxide	<250

- 4. Elbows and fittings shall be manufactured from the same resin/hardener/glass systems and by the same filament wound system as the conduit.
- F. Flammability rated as self-extinguishing, and having the following minimum properties:
- 1. Tensile strength, ASTM D 638 at 78-degrees Fahrenheit: 6,000-psi
 - 2. Flexural strength, ASTM D 790: 11,000-psi
 - 3. Compressive strength, ASTM D 695: 8,500-psi
 - 4. Hardness (Durometer D), ASTM D 2240: -77
 - 5. Water Absorption, Percent Maximum, in 24 Hours at 72-Degrees Fahrenheit, ASTM D 570: 0.03

- 6. Dielectric Strength, Volts Per Mil, ASTM D 149: 1,100
- 7. Thermal Conductivity: 1.3-BTU per square foot per degree Fahrenheit per inch
- G. Fabricate expansion fittings from material similar to the type of conduit with which they are to be used. Include a factory-installed packing ring, designed to prevent the entrance of moisture, and a pressure ring. In addition, include a grounding ring or a grounding conductor for metallic expansion couplings.

2.04 CONDUIT SUPPORTS

- A. Provide one-hole conduit straps for supporting up to one-inch conduit. Straps shall be galvanized steel or malleable iron. Maximum spacing of straps shall be 8-feet on center.
- B. Provide two-hole heavy-duty conduit straps for supporting conduit larger than one-inch. Heavy-duty straps shall be galvanized steel. Strap size shall be 3/4-inch. Maximum spacing shall be 5-feet on center.
- C. Provide riser clamps for supporting vertical conduit runs. Riser clamps shall be galvanized steel with two or three bolts and nuts and 4-inch ears.
- D. Provide "C" clamps for supporting conduit. "C" clamps shall be black malleable iron galvanized or plated steel with hole for threaded steel rods. "C" clamps will not be permitted for supporting vertical conduit risers.

2.05 EQUIPMENT SUPPORTS

- A. Provide prefabricated channels as indicated or required.
- B. Standard structural steel channels, 1-1/2- by 1-1/2-inches or 1-5/8- by 1-5/8-inches, 12-gauge, cold formed, lipped channel, and designed to accept special spring-held, hardened steel nuts for securing anchor bolts or hangar rods and other attachments. All securing equipment shall be compatible with the channel and shall be galvanized steel.
- C. Channel depth shall be as required to satisfy the load requirements and safety factor.
- D. Two or more channels may be welded together to form members of greater strength.
- E. Galvanize after fabrication in accordance with ASTM A 123 or A 153, as applicable.
- F. Prefabricated channel shall be epoxy-coated at locations indicated on the Contract Drawings.

2.06 OUTLET BOXES

- A. Boxes shall be corrosion-resistant cast, copper free aluminum Type FS or FD.

- B. Provide cast-metal faceplates with spring-hinged waterproof caps suitably configured for each application, including faceplates, gasket, and stainless steel or brass screws or fasteners. Faceplate material shall match the type of box.
- C. Covers shall be of same thickness as boxes. Secure in position by means of No. 10-24 stainless steel machine screws. Arrange covers to be readily and conveniently removed.
- D. Junction boxes shall be zinc-coated (galvanized) inside and outside. Where outlet boxes are used as junction boxes, they shall not be smaller than 6-inches square by 2-1/2-inches deep. Provide such boxes with flat blank covers.
- E. Concealed switch boxes shall be not less than 4-inches square by 1-1/2-inches deep, unless otherwise indicated. Provide covers with rectangular openings of proper size and shape for the devices installed. Provide special boxes, as required, to suit the kind of service and location requirements.
- F. Provide brackets, supports, hangers, fittings, bonding jumpers, and other accessories, as required.
- G. Provide neoprene gaskets 1/8-inch thick for all cast boxes. Provide fire-resistant gaskets for pull boxes installed at the conduits for emergency equipment, feeder cables, and fire protection circuits.

2.07 DISCONNECT (SAFETY) SWITCHES

- A. Safety Switch Type Disconnecting Devices: Provide safety switch disconnecting devices, enclosed, conforming to IEEE C37.35.
- B. Heavy Duty Safety Switches (600-Volts AC):
 - 1. Provide heavy-duty safety switches having electrical characteristics, ratings, and accessories, as indicated.
 - 2. Provide switches with NEMA 3R outdoors, and with metal nameplates, front cover mounted, containing a permanent record of switch type, catalog number, and horsepower ratings.
 - 3. Provide handle with visible blades; reinforced fuse clips; non-teasible; positive; quick-make quick-break mechanism; and padlockable in the OFF and ON positions. Provisions for at least three locks in the OFF position shall be provided.
 - 4. Provide switches meeting NEMA KS-1 and UL 98 requirements.
 - 5. Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the "ON" position, and to prevent closing of the switch mechanism when the door is open. Provide means to permit authorized personnel to release the interlock for inspection purposes. Fused switches shall use Class R fuse holders.

6. Switches shall be 3-pole or single-pole, single throw, 240- or 600-volts. Voltage, ampere, and phase ratings shall be as indicated on the Contract Drawings. Where ratings are not indicated, size the switch and fuse in accordance with equipment nameplate data and NEC requirements. The UL listed short circuit rating of the switch shall be 200,000-RMS symmetrical amperes when Class R or Class J fuses are used with the appropriate rejection scheme.

2.08 FUSES

- A. General: Provide a complete set of fuses for each fusible switch. Coordinate time current characteristic curves for fuses servicing motors, or connected in series with circuit breakers, or other circuit protective devices for proper operation.
- B. Fuses shall have a voltage rating not less than the circuit voltage.
- C. Cartridge fuses, current-limiting type (Class R) shall conform to UL 198E, Class RK-5, time delay type. Associated fuse holders shall be Class R only.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

- A. Install electrical materials, equipment, and accessories in locations as indicated, rigid, and secure, plumb and level, and in alignment with related and adjoining work to provide a complete and operable system. Do not weld electrical materials for attachment or support.
- B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the Work Site to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.
- C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the Work rigidly. Comply with BCNYS requirements for Seismic Zone 4 location.
- D. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, or appearance of the installations. Determine exact locations of conduit and indicate such on the Shop Drawings.
- E. Coordinate the trade size, type, and general routing and location of conduits, raceways, and boxes in the field.

3.02 TEMPORARY POWER AND LIGHTING SYSTEMS

- A. Service Entrance Equipment: Install the service entrance equipment in accordance with the requirements of the Standard Specification for the Consolidated Edison Company of New York. Install feeders, conduit, and metering, protective devices and disconnect switches.

B. Power Feeders and Distribution:

1. Install feeder(s) from point-of-service to construction power system equipment.
2. Perform field tests as specified herein.
3. Install temporary power, control, communication, and signal conduits to avoid interference with construction.
4. Locate power feeders required to service the load centers throughout the Work Site. Extend power feeders progressively, as required.
5. Support power cables using cable grips to prevent damage to cables installed in conduits. At a minimum, support cables at the top and midpoint of each shaft. Secure cable grips as required, to support the vertical cable installation.

3.03 CONDUIT AND FITTINGS

A. Electrical Conduit Installation Requirements:

1. Install conduit in accordance with the NFPA 70 (NEC) and as indicated. Prevent concrete and other materials from entering and obstructing the conduit, outlets, and pull and junction boxes. Do not use conduit smaller than 3/4-inch. All conduit fittings shall be threaded.
2. Unless otherwise indicated, make conduit bends in accordance with the NEC, with not more than three quarter bends, 270-degrees total, per run of conduit. Where more bends are required in a particular run, install pull boxes, as required, to facilitate pulling conductors even if not indicated.
3. Provide and install metallic numbering tags indicating the conduit number on both ends of each conduit.
4. Properly support and anchor conduit to be embedded to maintain correct location and spacing and to prevent flotation during concreting operations. If necessary, provide suitable metal supports.
5. Install conduit so that moisture collecting in the conduit will be drained to the nearest outlet or pull box.
6. Provide expansion fittings in conduit runs, where required, to compensate for thermal expansion.
7. Metallic conduits shall be electrically and mechanically continuous and connected to ground by bonding to the grounding system, where required.
8. Apply conductive, anti-seizing compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Terminate the conduit in appropriate boxes at motors, switches, outlets, and junction points.

9. Support individual horizontal conduits not larger than 1-1/2-inches in diameter by means of one-hole conduit straps with back spacers or individual conduit hangers.
 10. Space conduits installed against concrete surfaces 1/4-inch away from the surface by clamp backs or other means that is approved by the Resident Engineer.
 11. Support individual horizontal conduits larger than 1-1/2-inches in diameter by individual hangers and forged steel conduit strap for vertical runs.
 12. Install liquid-tight flexible metal conduit at motor connections and where required, so that liquids tend to run off the surface and not drain toward fittings. Provide sufficient slack to reduce the effects of vibration. Running threads are not acceptable. Where necessary for connecting to rigid conduits, use right and left hand couplings.
 13. Make changes in direction with symmetrical bends or cast metal fittings. Make field-made bends and offsets with a conduit-bending machine. Do not install crushed or deformed conduits. Trapped conduits shall be avoided. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Clean conduits of all obstructions.
 14. Conduits shall be of such size and so installed that the required conductors may be drawn in without injuring or excessive strain.
 15. Examine carefully all conduits and fittings before installing and all pieces having splits, breaks, blisters, or defects shall be set aside and removed from the Work Site.
- B. Liquid-Tight and Metallic Flexible Conduit:
1. Install flexible metal conduit so that liquids tend to run off the surface and not drain toward fittings. Provide sufficient slack to reduce the effects of vibration.
 2. Provide suitable flexible conduit connections at all motors with the minimum length practicable.
 3. Extend flexible conduit into the termination fitting as far as practicable.
 4. Provide flexible conduit between three-feet and six-feet in length for equipment subject to vibration, noise transmission, or movement, and for all motors. Install flexible conduit to allow twenty percent slack. Minimum size shall be 3/4-inch diameter. Use liquid-tight flexible conduit.

3.04 JUNCTION AND PULL BOXES:

- A. Install so that covers are readily accessible after completion of the installation.

3.05 DISCONNECT (SAFETY) SWITCHES

- A. Perform all Work in accordance with the applicable requirements of the NEC. Install disconnect switches where shown on the Contract Drawings. Mount enclosures so that the front and sides are vertical.

3.06 DEVICES SUBJECT TO MANUAL OPERATION

- A. Operate each device, subject to manual operation, at least five times, demonstrating satisfactory operation each time.

END OF SECTION

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for the final engineering design, furnishing, installing, and testing the complete grounding and bonding systems that includes the following equipment:
 - 1. Substation ground grid
 - 2. Medium voltage (cable tape or strand) shields and armor
 - 3. Non-current carrying parts and enclosures of electrical equipment
 - 4. Metallic conduits and wireways
 - 5. Transformer neutral conductors
 - 6. Equipment grounding conductors and bonding jumpers
 - 7. Grounding of electric service neutral conductors
 - 8. Circuit ground wires

1.02 REFERENCED SECTIONS

- A. Section 13430 – AC Control Cabinet for Medium Voltage Substation Work
- B. Section 16120 – Wire and Cable for Medium Voltage Substation Work
- C. Section 16154 – Auxiliary Electrical Equipment for Medium Voltage Substation Work
- D. Section 16270 – Medium Voltage Dry-Type Power Transformers for Medium Voltage Substation Work
- E. Section 16340 – Medium Voltage Metal-Clad Switchgear for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. Con Edison (ConEd)
 - 1. Con Ed Technical Specification EO-2022, Rev. 14, Paragraph 3.5 Substation Ground Loops
- B. Institute of Electrical and Electronic Engineers (IEEE)
 - 1. C2 – National Electrical Safety Code (NESC), Section 9
 - 2. 142 – Grounding (Green Book)
 - 3. 80 – Design Criteria for Grounding Design
- C. National Fire Protection Association (NFPA)
 - 1. 70 – National Electrical Code (NEC)
- D. Underwriters Laboratories (UL)
 - 1. 467 – Grounding and Bonding

1.04 NOTED RESTRICTIONS

- A. The ground area directly above the substation is outside the limits of this Contract and shall not be included in the grounding system design.

1.05 QUALITY CONTROL

- A. Each item shall be UL-listed.

1.06 SUBMITTALS

- A. Submit the following for review by the Resident Engineer:
 - 1. Final Engineering Drawings
 - 2. Shop drawings:
 - a. Location of ground rods, connectors, cables, and details of connections, terminations, and access points
 - b. Manufacturer's catalog data for all proposed materials with installation recommendations
 - c. Procedures and equipment for testing resistance and electrical continuity
 - 3. Certification: Certified test reports verifying the ground resistance of the ground grid at the time of installation, and verify that each ground bus when connected to the ground grid does not exceed specified values

1.07 DELIVERABLES

None Noted

1.08 PERFORMANCE REQUIREMENTS:

- A. Design, furnish, install, and test the completed grounding system. Assume responsibility to obtain Professional Engineering services to perform the grounding system analysis and design. Grounding System shall provide safe touch and step potentials in accordance with IEEE 80.
- B. Provide the services of an independent testing agency to perform the final grounding system resistance-to-earth tests and provide a certified test report.

PART 2 - PRODUCTS**2.01 GROUNDING AND BONDING EQUIPMENT**

- A. General Requirements: UL 467.

PART 3 - EXECUTION**3.01 PREPARATION**

- A. Ensure substrates are in suitable condition to receive the work of this Section.

3.02 GROUNDING INSTALLATION

- A. In addition to the requirements specified herein, the grounding installation shall conform to Con Edison substation grounding requirements as specified in the ConEd Technical Specification EO-2022, Rev. 14, Paragraph 3.5.
- B. Ground Bus: Install ground bus bar along the interior perimeter of the substation building as required for equipment ground and/or bonding connections.
- C. Equipment Grounding Conductor: Provide equipment grounding copper conductor in accordance with NFPA 70 requirements.
- D. Grounding of Service Equipment:
 - 1. Ground in accordance with NFPA 70.
 - 2. Ground substation metal enclosures, the substation building structure, the ground bus in switchgear and panelboards, to ground bus provided in substation room, using insulated ground conductor.
- E. System Neutral Grounding:
 - 1. General: Provide three-phase ac secondary distribution system wye points connected with neutral grounding at the source.
 - 2. Install system neutral and ground bus and equipment ground conductor or both.
 - 3. Solidly ground neutral deriving equipment.
 - 4. Connect secondary wye neutral points to ground.
- F. Equipment Grounding:
 - 1. AC panelboards, disconnect switches, switchgear:
 - a. Connect continuous equipment ground bus by copper ground wire to building or facility ground bus.
 - 2. Ground wiring channels, metallic conduit, rigid galvanized steel, flexible conduits, metallic boxes, panelboards, and transformer enclosures. Ground the ground bus with copper ground conductors sized as specified in the NEC.
 - 3. Lighting Fixtures, and Equipment: Ground in accordance with NFPA 70.
- G. Grounding for Personnel Safety: Bond exposed metallic structures, ac equipment enclosures, ductwork, and metallic piping, to local ground bus using insulated grounding conductors.

3.03 FIELD TESTING

- A. Provide the service of an independent certified testing agency certified by the National Electrical Testing Association to perform soil resistivity testing, ground grid design, calculations and analysis, and final design of the substation ground grid and substation grounding system.

- B. Test ground resistance of ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.
- C. Ground resistance not to exceed five ohms.
- D. To fulfill the maximum resistance requirement, install additional ground rods or use enhancement materials, or a combination of both, as required.
- E. Test metallic conduit and raceways, equipment enclosures, metallic cable troughs, metallic structures, and light standards for continuity to grounding system.
- F. Test resistance of connections and conductors between ground bus in substation for electrical continuity.
- G. Conduct tests in the presence of the Resident Engineer's representative.
- H. Provide to the Resident Engineer a certified test report of the grounding system and ground test values.

END OF SECTION

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for furnishing all labor, materials, tools, and equipment, and performing all operations necessary for bonding of the reinforcing steel in the structural track invert as indicated on the Contract Drawings and as specified herein.
- B. Definitions:
 - 1. Longitudinal Reinforcing Steel: Longitudinal bars are those parallel with the longest dimension of a structural element.

1.02 REFERENCED SECTIONS

- A. Section 03200 – Concrete Reinforcement
- B. Section 13115 – Corrosion Control System Testing

1.03 CITED STANDARDS

- A. ASTM International (ASTM):
 - 1. B3 – Soft or Annealed Copper Wire
- B. American Welding Society (AWS):
 - 1. D1.4 – Structural Welding Code – Reinforcing Steel

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

- A. The Work shall meet the requirements of applicable codes, cited standards, and the Contract Documents.
- B. All welding shall be performed by welders certified by AWS. Contractor shall possess all licenses, registrations, and certifications.
- C. All welding and extra steel for bonding shall be shown on the reinforcing Shop Drawings. Refer to Section 03200 for reinforcement requirements.

1.06 SUBMITTALS

- A. Before bonding work for stray current/corrosion control, submit the following to the Resident Engineer for review:
 - 1. Shop Drawings showing locations of stray current test boxes and locations of pigtails for future connections.
 - 2. Product data of specified, manufactured materials.

3. Test procedures, data collection sheets, and resumes of persons proposed for conducting these tests.
4. Welding licenses, registrations, and certifications.

1.07 DELIVERABLES

- A. Provide copies of certified test reports of stray current test wire connections and reinforcement continuity including methods of measurement.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Furnish Class B stranded, annealed copper bare conductors conforming to ASTM B 3.
- B. Furnish conductors' size as shown on the Contract Drawings.
- C. Aluminum conductors are not permitted.
- D. Hermetically sealed test boxes shall be galvanized steel enclosure, 6-inches by 6-inches by 4-inches, as manufactured by Hoffman Enclosures, or approved equal.
- E. For exothermic welds, furnish "Cadweld" exothermic materials and products, or approved equal.

PART 3 EXECUTION

3.01 EXOTHERMIC WELDING

- A. Clean and dry the surface to be welded. Wire brush or file the point of contact to a clean bare metal surface.
- B. Use welding cartridges and molds for the type of weld shown on the Contract Drawings, and perform welding in accordance with the manufacturer's recommendations. Ignition of the powder must produce molten copper that welds the conductors to each other or to a surface, as required. Do not use worn or damaged molds.
- C. After welds have been completed and cooled, brush slag from the weld area and thoroughly clean the joint.
- D. Where exothermic connections made between copper wire and steel surfaces are direct buried, coat the connection with a coal tar epoxy coating before backfilling, and also coat the entire area of the steel surface disturbed by the exothermic welding.
- E. Unless otherwise indicated, use exothermic welding for all underground cable to cable splices, tees, crosses, etc., and cable to steel and cast iron, and underground cable lug terminations.

- F. Use exothermic welding for reinforcement steel, or structural steel.
- G. Test all welds by striking with a two-pound steel hammer.
- H. Replace any defective welds.
- I. Where exothermic welds are made to a galvanized surface, remove the galvanizing using a grinding wheel to expose a clean surface. After welding, touch up the steel surface with zinc rich primer.

3.02 BONDING REQUIREMENTS FOR STRUCTURAL TRACK INVERT

- A. Tack weld all longitudinal reinforcing splices in the structural track invert in conformance with the requirements of AWS D1.4. Install a transverse collector bar welded to all longitudinal bars at each end of the track invert limits. Install a flush mounted test box in the track invert or walls at locations shown on Contract Drawings.
- B. At each corner of the invert, weld a No. 1/0 cable to each layer of the bonded reinforcing steel and provide a 10-foot long (minimum) pigtail (looped).

3.05 FIELD QUALITY CONTROL

- A. Perform electrical continuity testing in accordance with Section 13115.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for design, furnishing, and installation of wire and cable.
- B. The requirements described in this Section for medium voltage power cable are for all medium voltage cables except those used specifically as electric service cables between the property line manholes and the Incoming Line breakers. Refer to Section 16210 for requirements for medium voltage cables used as electric service circuits.

1.02 REFERENCED SECTIONS

- A. Section 02300 – Earthwork for Medium Voltage Substation Work
- B. Section 02950 - Street and Site Restoration
- C. Section 16060 – Grounding and Bonding for Medium Voltage Substation Work
- D. Section 16210 – Electric Utility Services for Medium Voltage Substation Work
- E. Section 16950 – Testing for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. Association of Edison Illuminating Companies (AEIC)
 - 1. CS-6 – Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69-kV
- B. American National Standards Institute (ANSI)
 - 1. N45.2 – Guide For Procurement of Power Station Equipment
- C. ASTM International (ASTM)
 - 1. B-6 –Zinc
 - 2. B-496 – Compact Round Concentric Lay – Stranded Copper Conductors
- D. Insulated Cable Engineer’s Association (ICEA)
 - 1. S68-516 – Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- E. Institute of Electrical and Electronic Engineers (IEEE)
- F. National Fire Protection Association (NFPA)
 - 1. 70 – National Electrical Code (NEC)
- G. National Electrical Manufacturers Association (NEMA)
 - 1. ICS 2 – Standard for Industrial Control Devices and Controllers and Assemblies

H. Underwriters Laboratory (UL)

1. 1072 – Shielded and Non-shielded Single and Multiple Conductor Power Cables

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Noted

1.06 SUBMITTALS

- A. Product Data: Submit manufacturer's catalog cuts, Shop Drawings and material specifications for cable to be furnished.
- B. Submit certified flame retardation test reports and data for tests performed not more than 12 months prior to submittal.

1.07 DELIVERABLES

- A. Certification: Provide manufacturer's certification that furnished 15 kV-class cable meets specified requirements.

PART 2 - PRODUCTS**2.01 WIRE AND CABLE**

A. 15-kV EPR Insulated Single Conductor Shielded Power Cable:

1. The cable shall meet the requirements of ICEA S68-516 and be suitable for use on services and feeders, indoors or outdoors, in wet or dry locations, as open runs of cable, in cable tray, in conduit, ducts or as aerial cable. The cable shall be UL listed as sunlight resistant.
 - a. The cable shall be single conductor, insulated with an ozone-resistant and discharge-resistant, flexible, thermoset ethylene propylene rubber (EPR) dielectric and meet or exceed the latest editions of the following industry standards: ICEA S-68-516, AEIC CS-6, ASTM B 6, and UL 1072.
 - b. The cable shall be rated 90-degrees C for continuous normal operation, 130-degrees C for emergency overload operation, and 250-degrees C for short circuit conditions. Emergency overload operation may occur for periods up to 1500 hours cumulative during the life of the cable.
 - c. The power cable design and construction shall have a performance record demonstrating a minimum of 10 years successful operating experience in utility and industrial power cable applications.

2. Conductor:
 - a. The conductor shall be annealed after stranding, uncoated, soft copper wire, Class B, stranded, compressed concentric round per ASTM B 496.
 - b. Conductors shall meet the electrical resistance requirements of ICEA S-516.
3. Conductor Shield:
 - a. An extruded layer of semi-conducting ethylene propylene rubber thermosetting compound that is compatible with the insulation thermosetting compound, will be applied directly over the conductor and have a volume resistivity not in excess of 50 ohm-meters at 90-degrees Centigrade and minimum elongation of 100-percent after an air oven test at 120-degrees Centigrade.
 - b. The shield shall be in intimate contact with the strands and shall be clean stripping from the conductor and inseparably bonded to the overlying insulation.
4. Conductor Insulation:
 - a. Ethylene-propylene rubber, 133-percent insulation level, with an extruded semi-conducting strand screen
 - b. The minimum average insulation thickness shall be suitable for 133-percent insulation level. The thickness at any cross-section of the insulation shall be not less than 90-percent of the specified minimum average thickness.
 - c. The insulation shall be triple-tandem extruded, with the conductor and insulation screens and passed through a continuous vulcanization tube in a single pass to prevent inter-surface contamination. Three separate inline extruder heads shall perform the extrusion process.
5. Insulation Shield: The insulation shield shall be an extruded semi-conducting all EPR compound verifiable with infrared spectrometry with a volume resistivity not in excess maximum acceptable values when tested in accordance with AEIC No. CS-6 requirements.
6. Metallic Shield: The insulation semi-conducting shield shall be flat strap tin or alloy coated copper 15 mils by 175 mils of 15 straps. It shall be applied helically with a minimum overlay of 25-percent.
7. Jacket: A nonmetallic high temperature jacket of high molecular weight gray polyethylene shall be extruded over the sheath. The minimum jacket thickness shall be 65 mils. The jacket shall be rated as low smoke, zero halogen material.

8. Splicing: Resident Engineer shall review the splice kit. Additionally, the splice kit shall be carefully selected so as to maintain the mechanical strength of the cable system and provide a water resistant seal. Submit Engineering data to the Resident Engineer for review prior to procurement. Splice kits shall be Raychem Products, or an approved equal.
 9. Indoor High Voltage Cable Terminations Heat-shrinkable tubing kit type for indoor use, with grounding accessory kits, in accordance with the characteristics of the medium voltage cable furnished. Shrinkable tubing kits to be pre-stretched shrinkable tubing and contain all necessary components to reinstate cable insulation, metallic shielding/grounding system and overall jacket. Termination kits shall be Raychem Products, or an approved equal.
- B. Control and Instrument Wiring
1. Control wiring for each switchgear cubicle shall be enclosed in a raceway or in compartments isolated from the primary circuits and shall conform to NEMA ICS 2.
 2. Control and secondary cable shall be tinned copper, minimum Class B, stranded. Cable shall have insulation Type SIS, rated 90-degrees Centigrade, 600 volt, heat resistant, and flame retardant. Wires crossing hinged joints and swing panels shall be flexible Class K stranded.
 3. All control wiring leaving the switchgear, and spare contacts, shall be wired to terminal blocks. Direct connections between devices located in different vertical sections are not acceptable.
 4. Wiring shall be sized for the duty required.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Ensure substrates are in suitable condition to receive the work of this Section.

3.02 INSTALLATION

- A. Install all power and control cables continuous, without splices, between terminations.
- B. Install single conductor cable in conduit or cable tray.
- C. To facilitate cable pulling, use UL-listed lubricant such as Polywater 'J' and/or as recommended by the approved cable manufacturer.
- D. Terminate high voltage cable, using the specified termination kits, in accordance with the manufacturer's recommendations.
- E. Ground cable shields in accordance with Section 16060.
- F. Excavate in accordance with Section 02300.
- G. Restore street, sidewalks, ventilation plenums, and curb in accordance with Section 02950, and NYCDOT requirements.

3.03 TESTING

- A. Refer to Section 16950 for cable test requirements.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. The engineering design, furnishing, installing and testing of auxiliary electrical equipment installed inside the substation building including:
 - 1. Panelboards (120/208 volt)
 - 2. Automatic transfer switches
 - 3. Other low voltage equipment, as required

1.02 REFERENCED SECTIONS

- A. Section 16060 – Grounding and Bonding for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. Institute of Electrical and Electronic Engineers (IEEE)
- B. National Electrical Manufacturer's Association (NEMA)
 - 1. PB 1-2000 – Panelboards
- C. National Fire Prevention Association (NFPA)
 - 1. 70 – National Electrical Code (NEC)
- D. Underwriter's Laboratories, Inc. (UL)
 - 1. 1008 – Transfer Switch Equipment
 - 2. 50 – Enclosures for Electrical Equipment
 - 3. 67 – Panelboards

1.04 NOTED RESTRICTIONS

- A. None Noted

1.05 QUALITY CONTROL

- A. Select manufacturers that regularly engage in the production of these types of equipment and who have supplied these types of equipment for at least five years.
- B. All breakers shall be UL listed for enclosed operation at 100 percent nameplate rating.

1.06 SUBMITTALS

- A. Submit Shop Drawings and catalog cuts.

1.07 DELIVERABLES

- A. Provide Operation and Maintenance Manuals.

PART 2 - PRODUCTS**2.01 GENERAL REQUIREMENTS**

- A. Select products that are new, that provide a high level of reliability, and are UL-labeled.

2.02 AUTOMATIC TRANSFER SWITCH

- A. When included in the substation design, and subject to compliance with the requirements, provide automatic transfer switch products by Automatic Switch Company, Russell Electric, or approved equal:
- B. Automatic transfer switch shall consist of a power transfer module and a control module, interconnected to provide complete automatic operation. The automatic transfer switch shall be mechanically held and electrically operated by a single solenoid mechanism energized from the source to which the load is to be transferred. The switch shall be rated for continuous duty and be inherently double throw. It shall be mechanically interlocked to ensure only one of the two possible positions, normal or alternate maybe in operation. It shall incorporate an overlapping neutral (make before break) that shall be rated the same as the phase contacts.
- C. Rating: To be determined by Contractor

2.03 208Y/120V PANELBOARDS

- A. Panelboards shall be new and comply with the following industry standard:
 - 1. NEMA Standard PB 1-2000
 - 2. UL Standards
 - a. Cabinets and Boxes – UL 50
 - b. Panelboards – UL 67
- B. Rating: To be determined by Contractor

PART 3 - EXECUTION**3.01 INSTALLATION – GENERAL**

- A. Ensure substrates are in suitable condition to receive the work of this Section.

3.02 INSTALLATION

- A. Install panelboards in accordance with manufacturer's instructions, with top circuit breakers, no higher than six feet above finished floor. Provide minimum one and one-half inch air space between panelboards, panels, and wall.
- B. The automatic transfer switch with bypass isolation switch shall be in accordance with the manufacturer's instructions. The mounting height to the top of the transfer switch cabinet shall not exceed six feet – six inches with an air space of one and one-half inch between the wall and the automatic transfer switch.

- C. Conduits shall enter the automatic transfer switch from the top and exit at the side to connect to the panelboard.

3.03 TESTING

- A. Submit field test procedure for testing the auxiliary electrical equipment to the Resident Engineer for review.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Criteria for engineering design, material specification, furnishing, and installation of electric services to the construction power substation including the following elements:
 - 1. Coordination with and approval from Con Edison during design and start-up to obtain power.
 - 2. Electrical service entrance interface manholes in street, concrete and encased ducts from street, electric service cables and conduits.
 - 3. Installation of current transformers (CT's) and potential transformers (PT's), primary wiring of CT's and PT's, secondary wiring and conduits of CT's and PT's, wiring and conduit to metering equipment, and other related equipment required to complete the electric services
 - 4. Metering instrumentation wiring and outdoor meter mounting cubicles
 - 5. Grounding of service neutral.

1.02 REFERENCED SECTIONS

- A. Section 02950 – Street and Site Restoration
- B. Section 16060 – Grounding and Bonding for Medium Voltage Substation Work
- C. Section 16950 – Testing for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. Association of Edison Illuminating Companies (AEIC):
 - 1. CS6-96 – Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cable
- B. American National Standards Institute (ANSI):
 - 1. N45.2 – Quality Assurance Program Requirements For Nuclear Facilities
- C. ASTM International (ASTM):
 - 1. B6 –Zinc
 - 2. B496 –Compact Round Concentric-Lay-Stranded Copper Conductors
 - 3. D2240 –Rubber Property-Durometer Hardness
- D. Consolidated Edison Co. of New York (ConEd): While not necessarily a complete list, the following ConEd Standards and documents provide guidance about applicable ConEd requirements for the installation of electric services for this Project. The design for, and the construction of, the Medium Voltage Substation and electric service circuits, shall comply with the latest ConEd Standards as of the date of Notice to Proceed.

1. EO-17 – Purchase and Test Specification for Ethylene Propylene Rubber Insulated Cables 5,000 to 35,000 Volts
2. EO-2022 – General Specification for High Tension Service
3. EO-3299-D – Low Voltage Phasing Facilities Drawing for Three-Phase, Four-Wire High Tension Feeders – Manual 5
4. EO-2468-B – Cable Manhole Type M11-6 Installation
5. MES 713 – Layout and Wiring For Panel Mount HT Metering With Radial Low Tension Auxiliary
6. EO-4035 – Operation and Maintenance of Equipment on High Tension Customer’s Premises
7. EO-6025 – Cable Arc-Proofing Procedures – Manual 3
8. MES 350 – High Tension Metering Installations
9. MES 713A – Panel Wiring Diagram Radial Low Tension Auxiliary
10. MES 731A – Wiring Diagram for Metering High Tension Services Billing Recorder
11. EO-6130-C – Flared Conduit for Primary Cable Manhole Entrance
12. EO-5024, Requirements for Construction of 120/208 Volt Network Installations
13. Booklet entitled, “Approved Electric Service Equipment”
14. Booklet entitled, “Electric Service Rules”
- E. Insulated Cable Engineer’s Association (ICEA):
 1. S-68-516 – Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- F. Institute of Electrical and Electronic Engineers (IEEE):
 1. 1202 – Flame Testing of Cables For Use In Cable Tray In Industrial and Commercial Occupancies
 2. C2 – National Electrical Safety Code (NESC)
- G. National Electrical Manufacturers Association (NEMA):
- H. National Fire Protection Association (NFPA)
 1. 70 – National Electrical Code (NEC)
- I. Underwriters Laboratories (UL):
 1. 1072 – Shielded and Non-Shielded Single and Multiple Conductor Power Cables

1.04 NOTED RESTRICTIONS

- A. Provide engineering and design of the electrical service requirements to the Resident Engineer for review, and ConEd for review and approval prior to procurement and installation of the switchgear assemblies, including:
 - 1. Detailed relay protection coordination analysis.
 - 2. Relay selection.
 - 3. Proposed relay setting values.
 - 4. Circuit breaker control and protection schemes.
 - 5. Narrative description of circuit breaker operation.
 - 6. Manufacturer's shop drawings including equipment layouts, elevation and Section views.
 - 7. Three electrical service entrance (Con-Ed) interface manholes locations, sizes, accessories, installation details, conduit termination details, pulling eye locations, and other requirements as required by Con-Edison
- B. Electric service cable manufacturer, size, and specifications shall be approved by ConEd prior to procurement and installation. Submit cable specification details to the Resident Engineer and ConEd for review and approval.
- C. Provide the substation single line diagram and other pertinent Engineering drawings, including the substation equipment layout and circuit breaker control and protection schemes.
- D. The work of providing the electric services and the locations for electric service-related equipment shall conform to the requirements of ConEd. Assume responsibility to obtain approval from ConEd for all aspects of the design, construction, and selection of materials for the electric services.

1.05 QUALITY CONTROL

- A. Comply with applicable quality procedures.

1.06 SUBMITTALS

- A. Product Data: Manufacturer's catalog cuts, shop drawings, and material specifications for all components shall be furnished.
- B. Certification: Manufacturer's certification that all equipment meets specified requirements including ConEd electric service requirements approved by the utility company.
- C. Certified flame resistance test reports and data for tests performed not more than 12 months prior to submittal.
- D. Submit for approval to NYCDOT, Contractor's proposed Maintenance and Protection of Traffic Plan (MPT). No street work will be permitted before an approved MPT plan is in place.

- E. Final Engineering Design drawings shall include, but are not limited to:
 - 1. Plan and Elevations
 - 2. Overall equipment dimensions
 - 3. Weights of components
 - 4. Product description
 - 5. Design and application ratings
 - 6. Performance data on service reliability
- F. Cable manufacturer's factory production test reports.

1.07 DELIVERABLES

- A. Certified factory test reports
- B. As-Built drawings

PART 2 - PRODUCTS

2.01 WIRE AND CABLE

- A. 15 kV EPR Insulated Single Conductor Shielded Power Cable (for use at nominal 13.2 kV voltage) in accordance with ConEd Specification No. EO-17:
 - 1. The cable shall meet the requirements of ConEd and this Specification, and be suitable for use on electric services, indoors or outdoors, in wet or dry locations, or in conduit and ducts. The cable shall be UL-listed as sunlight resistant.
 - a. The cable shall be single conductor UL-listed, insulated with an ozone and discharge resistant, flexible, thermoset ethylene propylene rubber dielectric and meet or exceed the latest editions of the following industry standards: ICEA S-68-516, AEIC CS6-96, ASTM B-6, UL 1072.
 - 2. Conductor:
 - a. The conductor shall be annealed after stranding, uncoated, soft copper wire, Class B, stranded, compressed concentric round per ASTM B-496.
 - b. Conductors shall meet the electrical resistance requirements of ICEA S-68-516.
 - 3. Conductor (Strand) Shielding:
 - a. The shield shall be in intimate contact with the strands and shall be clean-stripping from the conductor and inseparably bonded to the overlying insulation. No tape shall be applied under the extruded shield.

- b. The thickness of the conductor shield shall be 15 mils semi-conducting material.
- 4. Conductor Insulation:
 - a. Thermoset ethylene-propylene rubber, 133 percent insulation level, with an extruded semi-conducting strand screen
 - b. The insulation shall be triple-tandem extruded with the conductor and insulation screens and passed through a continuous vulcanization tube in a single pass to prevent inter-surface contamination. The extrusion process shall be performed by three separate inline extruder heads thereby permitting the measurement and accurate individual control of the thickness of each layer of compound as the cable is being manufactured.
- 5. Insulation Shield: The outer surface of the insulation shield shall be continuously printed with contrasting colored ink: Remove “Semi Conducting Layer”, when splicing or terminating.
- 6. Metallic Shield: Contractor to make the appropriate selection.
- 7. Jacket:
 - a. A nonmetallic high temperature jacket of high molecular weight gray polyethylene shall be extruded over the sheath. The jacket thickness shall be not less than 65 mils.
 - b. The following identifying legend shall be printed on the jacket with contrasting ink every three feet:
 - 1) Manufacturer’s Name
 - 2) Year Of Manufacture
 - 3) Conductor Size
 - 4) Voltage Rating
 - 5) Insulations Type
 - 6) Jacket Type
- 8. Splicing: Submit splice kit data for review and approval by ConEd and the Resident Engineer prior to procurement. Additionally, the splice kit shall be carefully selected so as to maintain the mechanical strength of the cable system. Engineering data shall be submitted for ConEd and Resident Engineer’s review and approval.
- 9. Indoor High Voltage Cable Terminations: Heat shrinkable tubing kit type for indoor use, with grounding accessory kits, in accordance with the characteristics of the medium voltage cable furnished. Shrinkable tubing kits to be pre-stretched shrinkable tubing and contain all necessary components to reinstate cable insulation, metallic shielding/grounding system and overall jacket.

2.02 MANUFACTURERS

- A. Select a manufacturer who is regularly engaged in the production of similar wire and cable. The following cable manufacturers have been approved as suppliers for this Project:
 - 1. The Okonite Company
 - 2. Boston Insulated Wire
 - 3. BICC
 - 4. Rockbestos Surprenant Cable Corporation
 - 5. Pirelli Cable
 - 6. Rome Cable
- B. The cable shall be UL-listed.
- C. Certification: Manufacturer's certification that furnished 15 kV cable meets specified requirements including ConEd requirements.

2.03 HIGH VOLTAGE UTILITY METERING CABINET

- A. Provide high voltage metering cabinets for utility metering of the 13.2 KV electric service circuits per ConEd Specification and Standard Drawings.

2.04 UNDERGROUND CONDUITS AND DUCTS

- A. Electric service underground ducts shall be five-inch IPS, fiberglass duct, concrete encased for service below ground.
- B. All lengths of duct and fittings shall have interference-type joint or other method to provide a high pull out strength of at least 1000 pounds. Joints shall be made watertight by applying epoxy adhesive.
- C. Elbows shall be provided with bend radius that conforms to the cable manufacturer's recommendations, and as determined by the number of bends, sidewall pressure, and pulling tension.
- D. Spare electric service ducts shall be provided in accordance with ConEd Standard EO-2022.

2.05 MANHOLES FOR ELECTRIC SERVICE INCOMING CABLES

- A. Provide manholes constructed to the requirements of ConEd Specification EO-2468-B - Cable Manhole Type M11-6. Submit shop drawings for manholes to the Resident Engineer for review and to ConEd for approval prior to manufacture.

PART 3 - EXECUTION**3.01 PREPARATION**

- A. Ensure substrates are in suitable condition to receive the work of this section.

3.02 INSTALLATION

- A. Install all power and meter instrument cables continuous, without splices, between terminations.
- B. To facilitate cable pulling, use UL-listed lubricant recommended by cable manufacturer.
- C. Seal cable at duct terminations using either Jack Moon or General Signal/O-Z Gedney compression-type, watertight duct plugs. Seal all empty spare ducts in manholes, ducts entering the substation, and/or cable vaults.
- D. Support cable installed in manholes at each insert location with cable brackets, racks, and insulators. Provide brackets of suitable length with one insulator for each cable.
- E. Terminate high voltage cable, using the specified termination kits, in accordance with the manufacturer's recommendations.
- F. Provide grounding of cable shields in accordance with IEEE C2, 92B2.2, Section 16060, and the cable manufacturer's recommendations. The maximum shield-to-ground potential shall not exceed 25 volts.
- G. Contractor shall construct three property line manholes and route duct banks in accordance with Con Edison requirements and approval.
 - 1. One possible layout of the three property line manholes and duct bank routing are indicated on Reference Drawing CM009-CP-0005.
- H. Prior to excavation of the manholes and/or duct banks, Contractor shall call for utility mark-outs.
- I. Saw cut pavement and initially excavate by hand to uncover utilities in proximity to the new manholes and duct banks.
- J. Restore street, sidewalks and curb in accordance with Section 02950 and NYCDOT requirements.

3.03 TESTING

- A. Refer to Section 16950 for test requirements.
- B. ConEd Inspection and Testing: After complete substation installation, arrange for Con Edison inspection and testing. Obtain Con Edison approval for services.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for the final engineering and design, the furnishing, and the installation of two substation control battery systems including the batteries, battery charger, battery racks, dc distribution panelboards, and accessories to provide dc control power for the substation.

1.02 REFERENCED SECTIONS

- A. Section 16950 – Testing for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. Institute of Electrical and Electronic Engineers (IEEE)
 - 1. 450 – Recommended Practice For Maintenance, Testing And Replacement Of Large Lead Storage Batteries For Generating Stations And Substations
 - 2. 485 – Recommended Practice For Sizing Large Lead Storage Batteries
- B. National Electrical Manufacturer's Association (NEMA)
 - 1. 250 – Enclosure For Electrical Equipment
 - 2. AB-1 – Molded Case Circuit Breakers
 - 3. IBC-1 – Definitions and Precautionary Labels for Lead-Acid Industrial Storage Batteries
 - 4. P-1 – Panelboards
 - 5. PE-5 – Constant Potential Type Electric Utility Battery Chargers
- C. National Fire Protection Association (NFPA)
 - 1. 70 – National Electric Code (NEC)
 - 2. 101 – Life Safety Code
- D. Underwriters Laboratories (UL)
 - 1. 67 – Panelboards
 - 2. 877 – Requirements for Circuit Breakers

1.04 NOTED RESTRICTIONS

- A. No more than 90 days shall elapse between final manufacturing date of batteries and installation with a functional battery charger.
- B. Do not commission batteries until power is available for the battery charger, and the battery charger is installed, commissioned, and fully operable.

1.05 QUALITY CONTROL

- A. Only select manufacturers that are regularly engaged in the manufacture of batteries and battery chargers and only provide products that have proven reliability in similar applications.

1.06 SUBMITTALS

- A. Before installation, submit the following information:
 - 1. Manufacturer's product description, catalog data, and information for batteries and battery charger.
 - 2. Manufacturer's arrangement, wiring, and detail drawings.
 - 3. Design calculations for battery and battery charger that demonstrate that the battery is properly sized for the substation control power requirements.

1.07 DELIVERABLES

- A. Provide Operation and Maintenance Manuals
- B. Provide As-Built Drawings

1.08 SPECIAL REQUIREMENTS

- A. Two separate and redundant battery systems shall be provided and configured as required by Consolidated Edison Company of New York (ConEd). Install the two battery systems within the substation in accordance with the requirements of ConEd. Final acceptance of the battery system is contingent upon approval by ConEd.

PART 2 - PRODUCTS**2.01 BATTERIES**

- A. Batteries shall be maintenance-free type batteries, either lead calcium or nickel cadmium, as recommended by the manufacturer of the medium voltage switchgear.
- B. Batteries shall have a 10-year warranty; one full year replacement, and nine years prorated.
- C. Acid stratification of the electrolyte shall not be allowed to happen.

2.02 BATTERY RACK AND ACCESSORIES

- A. Provide two or three-tier structural steel racks for installing the batteries. The battery racks shall be provided with insulating plastic strips to cover all supports, hold-downs, and restraining rails that are in contact with battery cells. In addition, the battery racks shall be painted with one finish coat of acid-resistant paint and be provided with an electrolyte resistant plastic mat under each battery rack to contain electrolyte drips. These mats shall have a 0.25-inch raised lip and extend 1.25-inches outside the rack.

2.03 BATTERY CHARGERS

- A. Battery charger shall be microprocessor-controlled, completely automatic, fully regulated, convection cooled, and provide a temperature-compensated constant output voltage.
- B. The charger shall be a filtered unit capable of operating as a dc power supply. The battery and its associated charger shall be connected in parallel. The charger, in addition to charging the battery, shall be capable of carrying the continuous connected load. The battery shall supply the balance of the heavy short time current demands. When the ac supply to the charger is interrupted, the battery shall supply all of the required power for the specified load duty cycle.
- C. Battery charger shall be rated as follows:
 - 1. Capacity: In accordance with its associated battery size and capable of charging totally discharged battery while simultaneously supplying maximum substation control power load.
 - 2. Recharging: Shall be able to recharge the battery to 85-percent of the battery capacity in eight hours maximum.
 - 3. Input Voltage: 208-volt, 3-phase, 60-Hertz ac.
 - 4. Output Voltage: 130-volts dc, nominal, with float and equalize voltage selector switch.
 - 5. Output Current: In accordance with its associated battery size and continuous dc load.
- D. The ac power feeder for each battery charger shall be supplied from the 120/208-volt, 3-phase, 4-wire, ac panel, which is supplied from an automatic transfer switch feed by 120/208-volt substation auxiliary power as a normal source and existing ConEd 120/208-volt power from the distribution panel as an alternative source.

2.04 BATTERY CIRCUIT BREAKER

- A. A two-pole, external-handle operated, circuit breaker shall be provided to permit isolation of the battery. The rating and size shall be coordinated with the dc output circuit breaker in the battery charger. The circuit breaker shall be mounted in a NEMA Type 1 enclosure adjacent to the battery rack. The circuit breaker shall provide short circuit protection for the battery, and main cables to the dc distribution panelboards.
 - 1. The circuit breaker shall be provided with the required auxiliary contacts for providing local and remote alarms. It shall be arranged to alarm when fused disconnect switch is opened.

2.05 DC DISTRIBUTION PANELBOARD

- A. General: DC panelboard shall comply with the requirements of NEMA PB-1 and certified to UL 67 and shall be suitable for two-wire, 125 volts dc ungrounded power distribution service. Panelboard shall be equipped with branch circuit breaker type disconnects complying with NEMA AB1.
- B. Enclosure: Panelboard shall be furnished with the required number of branch circuit breakers for substation.
- C. Circuit Breakers:
 - 1. Rated for the symmetrical interrupting current at 125 volts DC; two pole; UL 877, with appropriate ratings.
 - 2. Circuit Breakers Of The Same Ratings: Interchangeable, quick-make, quick-break, front-of-panel bolt-on type.
 - 3. Terminals: Rated solderless type, suitable for copper conductors sized at maximum rated terminal capacity.
- D. The requirements specified in Con Edison Technical Specification EO-2022, Rev. 14, Article 10.9 - DC Power Systems shall be complied with in full in the detail design, procurement, installation and operation of the DC Battery Power System.

PART 3 - EXECUTION**3.01 PREPARATION**

- A. Ensure substrates are in suitable condition to receive the work of this Section.

3.02 INSTALLATION

- A. Install battery and specified equipment per manufacturer's recommendation, plumb and level and in true alignment with related adjoining work.

3.03 TESTING

- A. Obtain the services of battery manufacturer's technical services to provide technical assistance during installation and startup of the battery systems.
- B. Provide to the Resident Engineer a field test plan for review at least six weeks prior to scheduling final commissioning tests.
- C. Test battery and charger per field test plan review and approved by the Resident Engineer and in accordance with Section 16950 for additional requirements.

END OF SECTION

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. The design and construction requirements for medium voltage dry-type transformers with all equipment and devices assembled as specified herein.

1.02 REFERENCED SECTIONS

- A. Section 16060 – Grounding and Bonding for Medium Voltage Substation Work
B. Section 16120 – Wire and Cable for Medium Voltage Substation Work
C. Section 16950 – Testing for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI):
1. C2 – National Electrical Safety Code (NESC)
 2. C37-91 – Guide for Protection: Relay Applications to Power Transformers
 3. C57.105 – Application of Transformer Connections in Three-Phase Distribution Systems
 4. C57.12.01 – General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
 5. C57.98 - Guide to Transformer Impulse Tests
- B. National Electrical Manufacturers Association (NEMA)
1. TR-1 - Transformers, Regulators, and Reactors
- C. National Fire Protection Association (NFPA)
1. 70 – National Electrical Code (NEC)

1.04 NOTED RESTRICTIONS

- A. The transformer dimensions shall be as shown on the Reference Drawing No. CM009-CP-0031. The maximum overall limiting dimensions of the transformer shall not exceed the following:

Width:	126-inches
Depth:	66-inches
Height:	132-inches

1. These dimensions shall include the necessary bus work for connecting the primary and secondary of the transformers directly to the 13.2-kV switchgear units installed adjacent to the transformer without the need for bus transition units.
2. For the purpose of transporting the transformers in and out of their installed positions through the limited aisle space (6-feet-0-inches wide) and from in and out of the substation through the existing equipment hatch

(10-feet wide), the core and coil assembly of the transformers shall be designed for removal from the enclosure. The maximum dimensions of core and coil assembly shall be such as to be able to be transported through the available aisle space and moved out of or into the substation through the hatch.

1.05 QUALITY CONTROL

- A. Submit Shop Drawings to the Resident Engineer for review, and to Consolidated Edison Company of New York (ConEd) for review and approval prior to manufacturing.

1.06 SUBMITTALS

- A. Shop Drawings: Submit complete construction details including dimensions, weights, nameplate data, and other related characteristics. In addition, provide rigging instructions, center of gravity determination, control diagrams for relays and heaters.
- B. Product Data: Submit manufacturer's catalog cuts, material specifications, installation instructions, and other pertinent data for all components to be furnished.
- C. Submit Factory Test Results for all production-type tests.

1.07 DELIVERABLES

- A. Maintenance Instruction Manual: Four hard copies and one electronic file copy on CD-ROM.
- B. Electronic file copy of shop drawings, factory test report, field commissioning report, and other related data, contained on CD-ROM.
- C. Certification: Manufacturer's certification that the transformer furnished meets the specified requirements. Certification shall be based upon factory test results for this product or the results of design tests of products constructed to the requirements of this Specification.

1.08 SPARE TRANSFORMER

- A. Provide one spare, completely assembled and tested, transformer and assume responsibility for storing and securing the transformer off-site in a dry and temperature-controlled warehouse.
- B. The transformer must have identical impedance characteristics as the other installed transformers that operate in parallel.

1.09 RATINGS

- A. Provide transformers with ratings and characteristics appropriate for the duty and function as required for the power loads of this Contract.

PART 2 - PRODUCTS**2.01 MANUFACTURERS**

- A. The transformers shall be either cast coil transformers manufactured by Dynapower and ABB or vacuum-impregnated type manufactured by Virginia Transformers, or approved equal, all in full conformity with the Specification requirements and in compliance with Con Edison requirements and acceptable to Con Edison. Both types of transformers shall have width and depth of in accordance with the dimensions shown on the equipment arrangement Contract Drawing CM009-CP-0031. In any event, the dimensions of the transformer shall not exceed the maximum dimension specified herein.
- B. The manufacturer shall not exceed the limiting dimensions specified in Article 1.04 and be in full compliance with this Specification, and have prior acceptance from Con Edison that its product will be accepted. Additionally, the manufacturer must satisfy Con Edison's comments on shop drawings, and obtain their final acceptance of the installed equipment.

2.02 CONSTRUCTION FEATURES

- A. General:
 - 1. The average temperature rise of the transformer windings shall be rated as 115 degrees C and the transformer shall be built utilizing Class H 220 degrees Centigrade insulation.
 - 2. The transformer shall be designed not to exceed the specified temperature rise when the unit is operated continuously at full nameplate rating. The transformer shall be capable of carrying 100 percent of the nameplate rating in a 40 degrees Centigrade maximum ambient temperature without exceeding the specified temperature rise.
 - 3. The transformer shall include a temperature monitoring and alarm system.
 - 4. Transformers shall be capable of withstanding stresses resulting from operating conditions, including external and internal short circuits without distortion or other damage. In addition, the transformers shall be designed to withstand the large inrush currents due to starting and operation of Tunnel Boring Machine.
 - 5. Transformers shall have provisions to facilitate moving and maintenance as follows:
 - a. A structural steel base with jack step skids to provide movement in either direction and also provide a means for attaching shipping skids
 - b. Pulling eyes
 - c. Lifting lugs for lifting the complete transformer assembly by overhead crane

- d. Lugs for lifting cover only to expose the core and coil in the field for repair purposes
 6. Alarm control and indication contacts shall terminate in a separate termination box or compartment with separate access through the enclosure. All wiring of contacts for alarm, control, or indication shall be wired to terminal strips.
 7. The type and method of neutral grounding shall be approved by ConEd.
 8. Polarity, angular displacement, and lead markings shall be in accordance with IEEE C57 standard identification.
 9. All accessories shall be located in accordance with IEEE standards.
 10. Primary and secondary areas shall be furnished of sufficient size to accommodate connections of the incoming conduits, cables, stress cones, and other such items.
 11. The transformer shall have leveling provisions for installation on an existing concrete floor.
- B. Ratings:
1. The ratings of the transformer shall be as follows:
 - a. KVA rating: 3,750-kVA
 - b. Primary Voltage: 13,200 volts Delta
 - c. Secondary Voltage: 13,200 volts Wye
 - d. Total Losses: Less than 2-percent
 - e. Winding Temperature Rise Not to Exceed: 115 degrees Centigrade
 - f. Type of Cooling: AA
 - g. BIL Rating: 95-kV BIL or higher on both primary and secondary
 - h. Impedance (Percent) 6-percent plus or minus 7.5-percent
 - i. Taps (Fully Rated): Two - 2.5-percent above; two - 2.5-percent below normal
- C. Transformer Internal Construction:
1. The transformer shall be capable of withstanding both the electrical and mechanical stresses resulting from handling and operating conditions, including external and internal short circuits without distortion or other damage.
 2. Core Construction:
 - a. Cores shall be constructed of stepped-miter cut, high-grade, grain-oriented, non-aging silicone steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux

densities shall be kept well below saturation, to allow for a minimum of 10 percent over voltage excitation.

- b. Core laminations shall be free of burrs, core plated and stacked without gaps.
- c. The core shall be clamped together with heavy steel channels designed to apply equal pressure to top and bottom yoke ends and centers. All core clamps shall be insulated with high-temperature insulation.
- d. The serial number shall be stamped on the core in a conspicuous place.

3. Coils:

- a. The impulse rating of the transformer must equal or exceed the basic impulse level specified by ANSI for the application voltage class. The basic impulse level shall be inherent to the winding design and is to be obtained without the use of supplemental surge arresters.
- b. The primary and secondary windings shall be wound with high conductivity copper. The coil insulation materials shall be a 220-degrees Centigrade-rated insulation system.
- c. Coil windings shall be fully protected from voltage stresses and mechanical stresses due to shock, stresses of operation, or fault conditions.

4. Insulation and Ratings:

- a. The transformer insulation shall be designed to withstand, without flashover or any apparent damage, the basic lightning impulse insulation level (BIL) as specified in ANSI C 57.12.90.
- b. The transformer impedance shall be based on the lowest self-cooled rating and shall be within 7-1/2 percent of the impedance in accordance with ANSI. However, the impedance values of the transformers provided under this Contract shall allow the parallel operation of these transformers.

D. Cooling System: The transformer cooling system shall be self cooled AA.

2.03 FABRICATION

- A. Each transformer shall be assembled, tested, and shipped as a single complete unit.

2.04 ENCLOSURE

- A. The base of the enclosure shall be furnished with ground pads located on the opposite corners.

- B. The base shall have jacking pads and shall be constructed of heavy steel members to permit skidding or rolling in any direction.
- C. The core shall be visibly grounded to the frame by means of a flexible grounding strap.
- D. The enclosure shall be a NEMA 2 ventilated enclosure for indoor use and shall be designed to provide ventilation for the transformer. Hinged doors or removable panels shall be provided to permit access to the off-load tap changer.

2.05 ACCESSORIES

- A. The transformer shall be equipped with a nameplate per ANSI C57.12.01.
- B. The transformer shall have provisions for changing the tap settings under no-load conditions, using flexible links on the face of each primary coil. Provide a nameplate that depicts the various tap settings.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Firewalls shall be provided in accordance with the Con Edison Specification EO-2022 and as shown on the equipment arrangement Drawing CM009-CP-0031. The firewalls shall have minimum two-hour fire rating.
- B. The ambient temperature inside the substation and each of the equipment rooms shall not exceed 40-degrees Centigrade, and the average ambient temperature for any 24-hour period shall not exceed 30-degrees Centigrade.

3.02 FIELD INVESTIGATION

- A. Prior to installation of the proposed transformers, the Contactor must remove concrete encasement at one floor beam to column connection and measure the connection sizes of all bolts, plates, angles, etc. The Contractor must also determine the floor beam size. After determining the beam size and after measuring all elements of the connection, the Contractor's Engineer must determine the capacity of the connection and submit this information to the Resident Engineer for review. The Resident Engineer will determine if additional structural support is necessary to safely support the final layout of the five selected transformers.

3.03 INSTALLATION

- A. Each transformer shall be installed and connected in accordance with the manufacturer's recommendations, and in conformance with ANSI C2 and NFPA 70.
- B. Prior to energization, each transformer shall be field-tested.

3.04 TESTING

- A. Refer to Section 16950 for test requirements.

- B. The transformer windings shall be dielectric tested per requirements of ANSI C57.12.91 and Con Edison requirements.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for medium voltage metal-clad draw-out switchgear for the Substation.
- B. Substation facility requirements including lighting, heating, and ventilation.
- C. Substation operation and maintenance training.
- D. Substation Operation and Maintenance Documents.
- F. Metal-clad non-ventilated, weatherproof, three phase, 15-kV bus ducts.

1.02 REFERENCED SECTIONS

- A. Section 13430 – AC Control Cabinet for Medium Voltage Substation Work
- B. Section 13850 – Fire Detection and Alarm System for Medium Voltage Substation
- C. Section 16060 – Grounding and Bonding for Medium Voltage Substation Work
- D. Section 16240 – Battery Power System for Medium Voltage Substation Work
- E. Section 16950 – Testing for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. American National Standards Institute (ANSI)
 - 1. C37.04 – Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities
 - 2. C37.06 – Standard for Switchgear - AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis- Preferred Ratings and Related Required Capabilities
 - 3. C37.09 – Standard Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 4. C37.20.2 – Metal-Clad and Station-Type Cubicle Switchgear
 - 5. C37.21 – Control Switchboards
 - 6. C37.46 – Power Fuses and Fuse Disconnecting Switches
 - 7. C37.54 – Standard for Switchgear – Indoor Alternating Current High-Voltage Circuit Breakers Applied as Removable Conformance Test Procedures
 - 8. C37.55 – Standard for Switchgear – Metal-Clad Switchgear Assemblies – Conformance Test Procedures
 - 9. C37.90 – Relays and Relay Systems Associated with Electric Power Apparatus

- 10. C57.13 – Requirements for Instrument Transformers
- B. Consolidated Edison Company of New York (ConEd)
 - 1. EO-2022 – General Specification for High Tension Service
 - 2. MES350 – High Tension Metering Installations
- C. National Electrical Manufacturers Association (NEMA)
 - 1. ICS 2 – Standard for Industrial Control Devices and Controllers and Assemblies
 - 2. ICS 4 – Terminal Blocks for Industrial Equipment and Systems
 - 3. SG 4 – Alternating-Current High-Voltage Circuit Breakers
- D. National Fire Protection Association (NFPA)
 - 1. 70 – National Electrical Code (NEC)
 - 2. 72 – National Fire Alarm Code Handbook
 - 3. 101 – Life Safety Code
- E. Underwriters’ Laboratories, Inc. (UL)
 - 1. 94 – Test for Flammability of Plastic Materials for Parts in Devices and Appliances
 - 2. 198 C – High-Interrupting Capacity Fuses Current Limiting Types

1.04 NOTED RESTRICTIONS

- A. None Noted

1.05 QUALITY CONTROL

- A. Switchgear and all components of types and sizes required shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.
- B. Entities manufacturing equipment shall have experience on at least two projects involving complexities similar to those required under this Contract.
- C. Circuit breaker units shall be new and of the type and rating approved by ConEd.
- D. The switchgear assembly and circuit breakers shall be suitable for, and certified to meet, all applicable seismic requirements of New York City Seismic Code for Zone 2A application.
- E. The switchgear manufacturer and their equipment shall already have pre-qualification and approval with ConEd.
- F. The substation, complete with all medium voltage circuit breakers, ac control panel, and all other related equipment, shall be approved for operation by ConEd prior to final acceptance of the Resident Engineer.

1.06 SUBMITTALS

- A. Furnish drawings on D size paper (34-inch by 22-inch size). Approval and final prints shall be submitted folded and collated. Submit detail operation sequence of the high voltage switchgear, ac control cabinet, and annunciation window with drawings and schematics and obtain necessary approval before start of switchgear production and procurement. Refer to Section 13430 – AC Control Panel for Medium Voltage Substation Work.
- B. Submit the following Shop Drawings, Catalog Cuts, and Samples:
 - 1. Shop Drawings:
 - a. Legend, Abbreviations, General Notes, and Drawing List
 - b. Outline drawings indicating overall dimensions, shipping sections, weights, and aisle space requirement for removable equipment
 - c. Switchgear rigging and installation drawings including anchoring details, locations of sills, and anchor bolts
 - d. Elementary diagrams (terminal configurations) for removable circuit breakers, relays, and meters
 - e. Structural drawings showing available space for busway, conduit, and cable connections
 - f. Bus arrangement including dimensions and ampere rating of all busbars
 - g. Bill of Materials for all equipment including item description, rating, and location
 - h. One line diagram showing all ratings, main connections, and location of all instruments including relays, transformers, and meters
 - i. Three line diagrams showing all instrument connections including relays transformers and meters
 - j. Electric control interlock diagram with functional description
 - k. Removable circuit breaker elementary diagrams
 - l. Ground and Test device elementary diagram
 - m. Front view of each vertical section showing all panel-mounted equipment
 - n. Front view of all internal panels of switchgear cubicles and control panels, showing all control devices such as relays
 - o. Dimensional sectional view of each type of switchgear compartment

- p. Complete point-to-point wiring diagrams or schedules indicating the internal wiring of each component and the interconnections between components.
 - q. Nameplate schedule and details
 - r. List of special tools required for operation and maintenance of all equipment
 - s. Structural and architectural plans, elevations and details
 - t. Equipment layout
 - u. Floor coordination plan showing conduit entries and support steel
 - v. Plans, elevations, and connection diagrams of the heating and ventilation system
 - w. Wall and ceiling-mounted equipment support details
2. Catalog Cuts:
- a. Relays
 - b. Control wiring
 - c. Terminal blocks
 - d. Switchgear space heaters
 - e. Thermostats
 - f. Bus insulation materials
 - g. All types of fuses and circuit breakers
 - h. Family of time-current characteristics curves for all types of fuses, relays, and trip devices
 - i. Instrument transformer characteristic curves and burden
 - j. Metering system devices, including hardware and software
 - k. G & T Device
 - l. Switchgear breaker element
 - m. Panelboards
 - n. Transfer switches
 - o. Batteries and racks
 - p. Chargers
 - q. Kirk keys
 - r. Annunciator
 - s. Ground bus
3. Calculations:

- a. Heating/cooling calculations to support maintenance of the required temperature range. State all assumptions.
 - b. Battery selection calculations. Include assumed values for all control devices requiring dc power. Also include basis for selection of battery chargers.
 - c. Current transformer saturation calculations
4. Operation and Maintenance Manuals:
- a. Maintenance documentation, including manuals, shall include descriptive material that will enable the Medium Voltage Substation operator to maintain the supplied equipment at the optimum level. The document shall provide guidelines for isolating the cause of malfunction and for the removal, repair, and replacement of all devices.
 - b. Each manual, in addition to the information described above, shall contain the following:
 - 1) Calibration data curves, wiring diagrams, and other pertinent information for all components provided.
 - 2) Operational procedure, both manual and automatic.
 - 3) Recommended preventive maintenance schedules.
 - c. Spare Parts List: Furnish a list of recommended spare parts. The list shall contain the prices and availability. Recommendation for spare parts is not an obligation to purchase any such parts.

1.07 DELIVERABLES

- A. Furnish four hard copy sets and one CD-ROM of the following deliverables:
 - 1. Certified factory test report
 - 2. Special tools required for operation and maintenance of the circuit breaker switchgear
 - 3. Operation and Maintenance Manuals for the entire Medium Voltage Substation
 - 4. Operation and Maintenance diary
 - 5. Trouble log
 - 6. As-Built Drawings and Specifications for the Medium Voltage Substation
- B. Furnish one set of all special tools required for the erection, operation, and maintenance of all equipment furnished.
- C. Provide a renewal parts catalogue.

1.08 DESIGN AND PERFORMANCE REQUIREMENTS

- A. The Medium Voltage Substation shall be designed as a manually operated substation with remote communication of alarms to a designated location via telephone dialer. Incorporate into the substation equipment design the appropriate alarms as required to enable personnel who are not on-site on weekends, to be alerted to abnormal conditions. In addition, provide a separate automatic dialer to transmit fire alarm information directly to the New York City Fire Department. Provide the alarm communication system design during the design phase of the Work.
- B. The switchgear shall be of new construction that is designed, manufactured, and tested in accordance with the latest revision of the applicable ANSI, NEMA, and UL Standards. Where a discrepancy exists between the various standards, the most stringent requirements shall apply.
- C. In addition to this specification, the design and installation of the substation switchgear shall conform to the requirements of ConEd. These requirements include adherence to the latest issue of the ConEd Specification EO-2022, and other applicable specifications, approval of all manufacturer's shop drawings and product selections, and final acceptance of the installed equipment after inspection.

PART 2 - PRODUCTS

2.01 RATINGS

- A. The substation switchgear shall have Continuous Rating of 1200 amperes and the following ratings:

Service Voltage:	13.2 kV
Rated Maximum Voltage:	15 kV
Nominal 3-Phase MVA Class:	1000 MVA
Rated Control Voltage:	125 vdc

2.02 CONSTRUCTION FEATURES

- A. General:
 - 1. The switchgear assembly shall be of the metal-clad type, suitable for indoor use, containing drawout vacuum circuit breakers. The switchgear assembly shall be furnished complete with fuses, instrument transformers, relays, meters, associated devices described herein, and conforming to ANSI C37.04, C37.06, C37.09, C37.20.2, C37.54, C37.55, and NEMA SG4.
 - 2. All circuit breakers shall be arranged within minimum spacing with appropriate approval.
 - 3. No polyvinyl chloride (PVC) materials, insulation, or products shall be used in switchgear, except for removable insulating boots on bus work.
 - 4. Electric service circuits and distribution feeders shall be fitted with four ground studs; one on each phase and one on the ground bus, and shall

extend outside the cubicle according to Con Ed specification EO-2022. The ground studs shall be provided with covers. The covers shall be constructed to allow for easy removal with a hotstick. Provide the following switchgear Manufacturer-supplied equipment:

- a. Hotstick
- b. Grounding cables per ConEd requirements

B. Barriers:

1. Each individual vertical section shall be segregated from adjacent sections by means of steel barriers extending all the way to the rear of the section.
2. Each individual cable compartment shall be provided with a steel barrier between the cable compartment and the main bus to protect against inadvertent contact with the main or vertical bus bars, and to ensure that no live connections are accessible in the rear of each section except the circuit breaker load connections.

C. Buses:

1. All bus work shall be of copper. Buses shall be supported on isolated supports of high-impact, non-tracking, high quality insulation material and braced to withstand the magnetic stresses developed by currents equal to the largest circuit breaker close, sustained, and interrupting ratings. All buses, taps and primary interconnections shall be insulated with an approved insulating material for the full BIL rating and the service voltage. Heat shrink, epoxy dip or Lexan sleeving are acceptable as an insulating material for buses.
2. Insulating barriers shall be provided where primary buses pass through from one vertical section to another.
3. Provide a copper ground bus extending the entire length of the switchgear cable compartments. All the metal parts of the structure shall be effectively connected to this bus.
4. A 120/208-volt, 3-phase, 4-wire ac circuit shall run to each switchgear lineup with a single-phase ac connection at each unit for space heaters and lights.

D. Utility Metering Cubicle:

1. Provide a separate barriered-off utility metering compartment complete with hinged doors. Bus work shall include provisions for mounting utility company current transformers as required by the utility company. Potential transformers (PT's) and current transformers (CT's) for utility metering shall be in separate compartments with separate padlockable entrance doors.
2. Service entrance switchgear section shall comply with UL requirements that include Service Entrance Label, incoming line isolation barriers, and

neutral connection to switchgear ground for solidly-grounded wye systems.

3. Metering wiring shall be in accordance with ConEd Specification MES350, latest revision. Wiring must run from CT's/PT's directly to the meter and without intermediate terminal block. CT/PT installation shall be approved by ConEd. CT's and PT's will be provided by ConEd. Install and make connections for all PT's and CT's required for ConEd revenue metering operation within the substation.
4. Wiring and installation of phasing receptacles and neon glow tubes shall be in accordance with appropriate ConEd specifications and drawings.

E. Control and Auxiliary Power Wiring:

1. The control circuits between the stationary units and the removable circuit breakers shall be made by means of self-aligning, multi-contact, male and female devices. Only the female contacts shall be energized when the circuit is disconnected. The female contacts shall be recessed to prevent accidental shorting of the control circuits.
2. Suitable means shall be provided for completing the control circuits between the stationary unit and the removable circuit breaker when the breaker is withdrawn to the test position. If jumpers consisting of a plug and receptacle connected by a flexible cable are used, the contact enclosures shall be polarized to assure proper insertion of the plug in the receptacle. If jumpers are used, two sets of control jumpers shall be furnished.
3. If the stationary secondary disconnecting devices are used, re-engagement shall not be affected manually unless the circuit breaker is in the test position and its frame is connected to the switchgear ground bus. Circuit arrangement shall permit trip and close checks and checking of circuit breaker interlocking system when in the test position.
4. 125 volts DC auxiliary power circuits shall run the entire length of the switchgear.
5. The protection for control and auxiliary power circuits shall be provided by re-settable molded case circuit breakers.
6. Each circuit breaker shall be equipped with an approved closing mechanism for operation on 125 volts dc. The 125 volts dc trip coil shall function properly when its applied voltage varies from 70 volts to 150 volts.

F. Removable Circuit Breaker Unit:

1. Each removable circuit breaker unit shall include a mechanically and electrically trip-free, three-pole vacuum-break (SF₆ not permitted) interrupting device, designed so that when operating within the specified rating, neither combustible material nor flame will be emitted. Furnish the circuit breaker complete with operating mechanisms, primary and secondary disconnecting devices, mechanical position indicator and mechanical interlocks on a mobile frame. The design shall be such as to permit three positions of the breaker; connected, test, and disconnected. The circuit breaker removable element shall be held in positive position when in "Connected", "Test", and "Disconnected" positions. Mechanical interlocks shall prevent racking a closed circuit breaker into the switchgear compartment and also prevent moving the closed circuit breaker in and out of the "Test" and "Connected" position within the switchgear compartment. For the Con Edison Incoming Feeder Circuit Breakers, key interlock system per requirements of Article 8.1 of the Con Edison Technical Specification EO-2022, Rev. 14 shall be provided. The key interlock system shall require the key to be inserted to rack in or out the circuit breaker from the cell. The key interlock system shall keep the key captive and not allow it to be removed when the circuit breaker is in the "Connected" position.
2. The removable circuit breaker units and stationary structure shall be assembled in accurate jigs to insure that circuit breakers of the same type and ratings shall be interchangeable with the exception of key interlocks, which reflect individual assignments for a particular breaker position. Like parts of all circuit breakers of the same type and rating shall be interchangeable. A check of interchangeability shall be made in the factory and again in the field by inserting a common circuit breaker in each stationary unit of the same type and rating, and inserting each breaker in its own unit.
3. An auxiliary switch shall be mounted on the stationary housing (switchgear metal barrier) to indicate the connected position of the removable circuit breaker. In addition to the contacts required for the operation of the circuit breaker, the position switch shall consist of two normally-open and two normally-closed spare contacts.
4. When the auxiliary switch on the circuit breaker cannot meet the number of contacts required, an auxiliary switch mounted on the stationary housing shall be provided. In addition to the contacts required for the operation of the circuit breaker, the position switch shall consist of two normally-open and two normally-closed spare contacts.

5. All trip and closing circuits shall be interlocked with an appropriate circuit breaker auxiliary contact to open the tripping or closing circuit after the required operation has been achieved. An anti-pumping device shall be provided in the control scheme.
 6. The circuit breaker shall be permanently mounted on wheels in such a manner that will permit the circuit breaker to be easily removed from its cubicle and moved within the switchgear room without the use of any accessory devices. The use of a separate hand truck or lifting device for removal of the circuit breaker is not permitted.
 7. The circuit breaker shall use a stored energy mechanism for opening and closing operation.
 8. The charging mechanism shall automatically be discharged before the circuit breaker can be withdrawn from, or inserted into, the switchgear.
 9. Provide E-MAX type CMD-1D coil monitoring relays for all circuit breaker trip coils.
- G. Ground and Test (G&T) Device:
1. Two ground and test devices each with three stabs shall be provided for the 13.2-kV switchgear. One G&T device for Con Edison's use to ground and test the incoming feeders and the other to ground and test the load side feeders by the ESA Project Contractor. The ratings of the Con Edison G&T device shall have the applicable rating of the incoming feeder circuit breakers, except for the fault interrupting rating. The ratings of the G&T device used by the ESA Project Contractor shall have the applicable ratings of the load side feeder circuit breakers, except for the fault interrupting rating.
 2. The charging motor shall have the same operating voltage rating as the circuit breaker.
 3. The charging mechanism shall automatically be discharged before the G&T device can be withdrawn from, or inserted into, the switchgear.
 4. The G&T device shall be key interlocked per ConEd standards. The manufacturer shall have made the G&T for ConEd customer service before and have at least one unit in service.
 5. Facilities shall be provided to operate the G&T device from a remote position via a 25-foot minimum umbilical cord with a pushbutton control station.
 6. Each G&T device shall be equipped with key interlocks to allow for the grounding and testing of the medium voltage feeders.

7. For the Con Edison G&T Device, three fully-rated voltage receptacles shall be provided on the front of the device with an individual connection to a corresponding phase on the line side of the G&T Device to allow testing of the incoming feeder. The G&T Device for use by the ESA Project Contractor shall be provided with three fully rated voltage test receptacles for load side testing of LIRR equipment. The receptacle group shall be furnished with a shutter to isolate the receptacles while not in use. The shutter shall be key interlocked in such a manner that it cannot be opened unless the G&T device is closed and the ground is applied. The key interlock shall allow the G&T device to be tripped open only after the test receptacle shutter is closed or after the proper test probes are inserted and locked into the receptacles. The receptacles shall be interlocked with the operation of the G&T device to insure that the probes can only be removed when the G&T device is in the GROUNDED position.
 8. Each G&T device shall be equipped with a manually-operated selector switch to ground either the line side or the load side of the G&T device. The manually-operated selector switch shall have a key interlock to inhibit operation of the switch unless the electrical distribution system has been secured. The G&T shall have line and load sets of test receptacles similar to those described above.
 9. One set of test probes and cables included as attachments shall be provided with each G&T device. The probes and cables shall be rated at the same voltage and insulation rating as the associated switchgear and circuit breakers.
 10. Key interlocks shall be supplied on shutter to open and lock the test port shutters.
- H. Circuit Breaker Test Cabinet:
1. A circuit breaker test cabinet shall be provided for the switchgear assembly. The test cabinet shall permit the operation of the circuit breaker or G&T device outside the switchgear.
 2. The test cabinet shall be equipped with the following devices:
 - a. On/Off Control power switch
 - b. Control power indicating light
 - c. Close button
 - d. Open button
 - e. Cord and female secondary disconnect device similar to switchgear stationary unit
- I. Substation Auxiliary and AC Control Power System: The Substation Auxiliary and AC Control Power System consists of a 208/120-volt, 3-phase, 4-wire, 60-Hz ac power system. The 208/120-volt auxiliary and control power system consists

of 13.2-kV-208/120-volt step-down transformer supplied from the substation's 13.2-kV feeder and 208/120-volt circuit breaker Power Switchboard and 208/120-volt Power Panel. An alternate feed from the existing Con Edison supplied 208/120-volt Power Distribution Panel in the Vent Control Room shall provide 208/120-volt power for battery chargers and emergency lighting through automatic transfer switches. The Circuit Breaker Panel is supplied from the automatic transfer switch.

J. Instrument Transformers and Meters:

1. Instrument transformers shall conform to ANSI C 57.13.
2. Select potential transformers having the correct secondary rating, ratio, and accuracy class. Voltage transformers shall be capable of a burden at least double the connected load, to allow for portable instruments connected to the test blocks. Voltage transformers shall be provided with primary current limiting fuses. Voltage and/or control power transformer and fuse assemblies shall be mounted on drawout carriages with primary and secondary disconnecting devices, so arranged that upon withdrawal of the carriage, the fuses are disconnected and transformer primaries grounded. A shutter shall isolate primary bus stabs when carriages are withdrawn.
3. All current transformer windings ratios shall provide a five-amp secondary current with ratio and accuracy in accordance with ConEd Standard EO-2022 (mains and ties). Current transformers shall not saturate when operated at 20 times rated current. Current transformers shall be capable of a burden at least double the connected load to allow for portable instruments connected to the test blocks. All current transformers shall be terminated in shorting blocks. Submit calculations showing that saturation will not occur for the available short circuit current with the burden of the provided relays and meters.
4. Select all current transformers to withstand the thermal and mechanical stresses imposed by the maximum available system fault. Submit the current transformer ratings and supporting calculations for approval.
5. Ground the secondary of instrument transformers using a copper conductor not smaller than #10 AWG and connected to a ground bus located as closely as possible to the transformer.
6. Potential and control power transformers primaries, where connected to ground, shall be grounded with a copper conductor not smaller than #6 AWG which shall be insulated for line-to-ground voltage and terminated at the grounding bus in a lug. The connection to the bus shall be so designed that it can be easily disconnected and isolated for proof testing. Each ground wire shall be one continuous run without intervening splices or terminal blocks between the transformers and the ground point.

7. Metering system shall be the following:
 - a. Digital Metering System (DMS)
 - 1) The Digital Meter System shall be compact, all-in-one built, panel mounted, for measuring current, volts, kW, kVA, kVAR, HZ, and power factor. It shall be installed on each unit of the switchgear where metering is required. It shall be connected through current and potential transformers and in accordance with the manufacturer's instructions. The DMS shall be mounted on the front of the switchgear within reach of an observer near eye-level. The DMS shall be capable of being used as a stand-alone monitoring unit. The DMS shall have the capability to communicate via an RS-232 or RS-485 port. The DMS shall be supplied with the manufacturer's standard software, which shall be capable of adequately representing all of the functions described herein.
 - 2) Provision shall be included to enable the integration of the kW, kVA and kVAR values of each service into a single 15-minute demand value, with retention of time and date for the integrated values. Additional capability to store maximum values for periods roughly analogous to billing cycles shall also be provided.
 - K. Indicating Lamps: Indicating lamps shall be light emitting diodes (LED) of the low voltage, low burden series resistor type or GE ET-16 lamps. Lamps shall be replaceable from the front of the panel. Indicating lamps for breaker position shall operate off of breaker auxiliary contacts.
 - L. Terminal Blocks:
 1. All terminal blocks shall have screw-type terminals, with barrier, and be rated for 600 VAC, 20 amperes minimum, with identifying marker strips. Terminal blocks for current transformer secondary connections shall be of the short-circuiting type.
 2. Suitable warning signs shall be provided for each switchgear cubicle having the following description: "WARNING - HIGH VOLTAGE - KEEP OUT".

2.03 RELAYS, CONTROL SWITCHES AND FUSES

- A. Over current relays shall be supplied as solid-state, single-phase units. The device numbers indicate the functions associated with the specified relay. Equip relays with trip indicating targets for both time and instantaneous functions. Include relay elements and design features as follows:
 1. Overcurrent Relaying for each incoming line circuit breaker:

- a. Three - single-phase solid-state time and instantaneous overcurrent relays Device 50/51 and one ground solid-state time and instantaneous overcurrent relay, Device 50N/51N for each incoming line circuit. The relay shall be ABB Type MICRO-51/FT, No. 446F1201 for phase protection and No. 446F1101 for ground protection, or equivalent from Basler, GE, or Schweitzer.
 - b. One undervoltage relay, Device 27 and one overvoltage relay, Device 59. The Device 27 relays shall be GE No. 12IAV54E14A with a setting range of 32- to 80-volts, and the device 59 relays shall be GE No. 12IAV51AIA with a setting range of 55- to 140-volts, or approved equivalent relays from ABB, Basler, or Schweitzer.
 - c. One - three-phase microprocessor-based high speed transformer differential protection relay for two winding transformers, Device 87T. The unit shall include Device 51G for time overcurrent protection of the transformer secondary neutral ground connection. The three-phase multi-function relay unit shall include digital metering package, which can measure per phase current, voltage, kilowatts and kilovars; three-phase kilowatts, kilovars, and power factor, and also display of load profile. The three-phase relay with metering package shall be ABB Type TPU-2000R, No. 588V1411-61010, or approved equivalent from GE, Basler, or Schweitzer.
2. Transformer Secondary Overcurrent Protection: Transformer overcurrent protection consists of the following protective devices. Device 32 and Device 67 shall trip transformer secondary circuit breaker directly whereas the Devices 50/51 and 50N/51N trips the incoming line circuit breaker and transformer secondary circuit breaker through hand reset lockout relay, Device 86M1.
- a. Time and instantaneous overcurrent protection of each phase and ground of each transformer, Devices 50/51 and 50N/51N.
 - b. Directional overcurrent protection for each phase, Device 67 of each transformer.
 - c. Reverse power protection, Device 32 for each transformer.
 - d. Microprocessor-based multi-function relay, which includes all the protective devices specified above, can be provided subject to approval of Con Edison. Microprocessor-based multi-function relay, ABB Type DPU-2000R, No. 587R1411-61000, or approved equivalent from GE, Basler, or Schweitzer.
3. Bus Differential Protection: Bus differential relays, Device 87B, shall be single-phase, high-impedance, high-speed, solid-state devices with three devices (one per phase) for each zone of protection. The bus differential relays shall trip all the circuit breakers in the protective zone through bus

- differential lockout relay, Device 86B. The bus differential relay shall be ABB No. 419B0042, or approved equivalent from GE, Basler, or Schweitzer.
4. Feeder Primary Protection: Microprocessor-based three-phase and ground time and instantaneous overcurrent relay, Devices 50/51 and 50N/51N with current metering for each feeder, ABB Type MSOC, No. 474M1411-6000, or approved equivalent from GE, Basler, or Schweitzer.
 5. Relay design features:
 - a. Semi-flush mounting dustproof case
 - b. Relay units mounted on drawout assembly
 - c. Test plug feature for testing relay elements in place
 - d. Dead front target reset
 - e. Silver-to-silver surfaces on drawout disconnecting and test plug contacts
 - f. Current rating of relay trip contacts: 30 amperes at 250 volts closing and 5 amperes continuous
 - g. Equal in quality of design and construction, and having operating characteristics with time dial and tap adjustments, ABB make, Type CO relays or approved equal
 - h. Equip with external reset, positive action operation indicators
- B. Protective relays shall conform to ANSI C 37.90 and be of the semi-flush mounted, removable type, with built-in test facilities. The secondary of current transformer shall be automatically short-circuited when the relay is removed from its case. Auxiliary relays shall be surface mounted and front connected.
1. Subject to approval by ConEd, select protective relays and relay ranges. Perform final relay coordination analysis, calibrate, and set all relays for selective coordination of all circuit breakers. Submit the relay coordination analysis to the Resident Engineer for review and to ConEd for approval prior to calibration, setting of relays, and energizing the substation incoming line breakers. Provide at least 60 calendar days for the review of the analysis and adjust the Project Schedule accordingly.
 2. Control transfer and instrument switches shall be of the heavy-duty rotary, multi-position, cam operated, and multi-stage type, with dust cover. Switch contacts shall be silver-to-silver, rated for 600 VAC and a continuous current of 20 Amperes. Each circuit breaker control switch on the mimic panel shall have red and green target. Each switch shall be equipped with engraved plastic escutcheon or nameplate identifying its function and position. Handle styles shall be pistol grip for control, and oval for instrument or transfer switches. In the circuit breaker "test" position, all relays, remote control and any other automatic trip will be

disabled so that only the control switch on the circuit breaker cubicle mimic panel can operate the breaker.

3. Medium voltage fuses current limiting type, conforming to ANSI C 37.46
4. Provide low voltage fuses in control circuits.
5. Surface-mount accessory equipment on the inside of the rear panel of their respective circuit breaker cubicle. All connections shall be easily accessible through the front door of the switch cabinet enclosure.

2.04 SWITCHGEAR INSTALLATION

- A. The lineups of metal clad medium voltage switchgear, along with all their indicated accessories shall be pre-engineered at the factory as integrated lineups. Assume responsibility for the complete engineering and design, equipment selection, and construction of the substation as an integrated system. Provide an equipment arrangement having adequate clearances, access, and workspace that best utilize the Work Site. The substation shall conform to ANSI C37.20.2 and ConEd requirements.
- B. Construction Features
 1. The switchgear layout shall provide adequate room for all required circuit breakers, panel boards, G&T devices, the control batteries, the ac control panel, the annunciator panel, space for withdrawing circuit breaker operating mechanisms, and any other related equipment. Con Edison has reviewed the equipment layout shown on Drawing CM009-CP-0031 for compliance with their requirements, and their comments have been incorporated. The Contractor's Design Engineer is advised to follow the suggested design in performing the detailed design as shown on the drawings in order to obtain expedient approval from Con Edison, which is critical for meeting the schedule.
 2. Each circuit breaker compartment, control, relay, and metering compartment, PT compartment shall be provided with formed hinged doors with handles and three-point latches. The rear of the switchgear units shall be provided with full-height hinged doors with stiffeners and three-point latch and handle. All rear doors shall be capable of opening to 270 degrees with intermediate positions and shall have positive door stop at each position.

2.05 ACCESSORIES

- A. All the manufacturers' standard accessories shall be provided for all equipment, devices, or components required by this Section. Include a complete set of standard tools in a tool cabinet. Provide a minimum of two racking handles, two manual charging handles, and two neon glow sticks.

2.06 DC CONTROL POWER

- A. A fully redundant battery system having a nominal output voltage of 125 volts dc shall be provided for circuit breaker control power and shall be provided in strict accordance with the requirements of Con Edison Technical Specification EO-2022, Rev. 14, Article 10.9, and the requirements of section 16240 – Battery Power System for Medium Voltage Substation Work of this Specifications. Sufficient battery capacity shall be provided in each of two complete battery units to carry all control and relay loads for eight hours and then perform the greatest switchgear duty, such as tripping all circuit breakers simultaneously, or closing a minimum of eight breakers with the charger de-energized. Size each battery supply for the total load and operation of both the electric service incoming and feeder switchgear assemblies at the substation.

2.07 FACTORY TESTING

- A. The switchgear, and all its accessories, shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchgear shall be tested to assure the accuracy of the wiring, and the functioning of all the equipment. Refer to Section 16950 for specific test requirements.

PART 3 - EXECUTION**3.01 SHIPPING**

- A. Delicate equipment, such as removable drawout circuit breaker operating mechanisms, shall be placed in individual shipping containers that shall be fastened to the building or group-crated for shipment. Moving parts of electrical or mechanical equipment shall be blocked and/or taped to avoid movement or vibration in shipment.
- B. Secure non-moving parts that may shift in transportation.
- C. A list of all temporary equipment restraints, which were installed at the factory, shall accompany the shipment to serve as a checklist for installation and energization.
- D. Assume responsibility to provide equipment internal bracing, as required, for the rigging of the equipment in a non-standard position through the equipment hatch.

3.02 FIELD SUPERVISION

- A. Provide the service of a qualified, factory-trained switchgear manufacturer's representative to provide technical field support in the installation and start-up of the switchgear specified in this Section. Assume responsibility to require the switchgear manufacturer's representative to provide technical direction and assistance in the following requirements:
 - 1. Switchgear assembly
 - 2. Equipment alignment
 - 3. Equipment checkout and calibration

4. Field testing
5. Trouble shooting

3.03 INSTALLATION

- A. Switchgear shall be transported within the construction site, unloaded, uncrated, handled, stored, rigged into place, installed, including assembly of all component parts, and wired in accordance with the manufacturer's recommendations, applicable ANSI standards, and the requirements specified in this Section. Re-assembly and reconnection shall be performed using the checklist prepared at the factory during disassembly.
- B. Provide all equipment, supervision, labor, rigging, tools, including, but not limited to, special equipment such as cranes.
- C. Follow the manufacturer's recommendations for preparation of the mounting surface and the fastening of the equipment. The switchgear shall be set, aligned, and leveled in place, using shims where necessary, and shipping sections shall be bolted together.
- D. Bus splices shall be cleaned and bolted together, and insulated by use of insulating boots, if provided for that purpose.
- E. The removable circuit breaker operating mechanisms shall be installed in the housings and the rails adjusted, if required, for smooth travel of the circuit breakers. Main and secondary contacts on the removal and stationary sides shall be checked for tightness and adjusted if loose. Covers or enclosures shall be securely bolted in place.

3.04 FIELD TESTS

- A. Field tests and inspection for commissioning medium voltage switchgear shall be performed per the switchgear manufacturer's recommendations, and applicable ConEd requirements. Minimum tests shall include complete equipment operation checks, hi-pot and megger tests. Require that the manufacturer shall attend field-testing to insure proper test procedures are used. Demonstrate operation of all breakers and G&T device both inside and outside the cubicle. Coordinate and arrange for ConEd to be available to witness the substation equipment operation as a completed installation.
- B. In the event that testing does not meet the requirement for proof of satisfactory performance specified herein, repeat the test. The Resident Engineer reserves the right to decide whether a test must be repeated. Assume ownership of devices failing the repeated tests and deemed un-repairable by the Resident Engineer.

3.05 TRAINING

- A. Provide training sessions at the construction site for maintenance personnel. Include two eight-hour training sessions for six personnel assigned to operate the substation.

- B. Provide training sessions that are conducted by the switchgear manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, and major components within the assembly. In addition, the training shall include routine maintenance and diagnostic evaluation/problem solving techniques.
- C. Provide all test equipment required for the training session.
- D. Provide training manuals, diagrams, and other maintenance-related materials

3.06 SUBSTATION OPERATION LOG

- A. Provide a Maintenance and Operation Log that accounts for all equipment maintenance, failure, repair, replacement, alarms, and records all operation-related activities. The log shall also include all electric service circuit failure and/or revisions.

3.07 SUBSTATION HEATING AND VENTILATION

- A. Provide a complete heating and ventilation system to maintain the ambient substation temperature within acceptable temperature and humidity limits for the substation equipment. The relative humidity shall not exceed 60-percent. The average ambient temperature within the substation, over any 24-hour period, shall not exceed 30-degrees Centigrade, and shall not be less than 10-degrees Centigrade. In addition, the maximum ambient temperature shall not exceed 40-degrees Centigrade at any time. Assume responsibility and related costs to maintain the substation ambient temperature within these limits throughout the Contract period. In addition, assume responsibility to provide heating and ventilation, equipment to maintain an ambient temperature and relative humidity that is suitable for a manned substation.
- B. Provide a mechanical system design, furnish, and install all necessary mechanical equipment, ventilation ducts, louvers, and a mechanical equipment room to accommodate the equipment.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)

PART 1 - GENERAL**1.01 SECTION INCLUDES**

- A. Requirements for factory and field-testing by Contractor, on electrical equipment furnished under this Contract.

1.02 REFERENCED SECTIONS

- A. Section 13430 – AC Control Cabinet for Medium Voltage Substation Work
- B. Section 13850 – Fire Detection and Alarm System for Medium Voltage Substation Work
- C. Section 16060 – Grounding and Bonding for Medium Voltage Substation Work
- D. Section 16210 – Electrical Utility Services for Medium Voltage Substation Work
- E. Section 16270 – Medium Voltage Dry-Type Power Transformers for Medium Voltage Substation Work
- F. Section 16340 – Medium Voltage Metal-Clad Switchgear for Medium Voltage Substation Work

1.03 CITED STANDARDS

- A. Association of Edison Illuminating Companies (AEIC):
 - 1. CS 6 - Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 KV
- B. American National Standards Institute (ANSI):
 - 1. C37.09 - Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 2. C37.20.2 - Metal-Clad and Station-Type Cubicle Switchgear
 - 3. C37.54 - Conformance Test Procedures for Indoor Alternating-Current Medium Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear
 - 4. C37.55 - Switchgear - Metal-Clad Switchgear Assemblies - Conformance Test Procedures
 - 5. C57.12.91 - Test Code for Dry-Type Distribution and Power Transformers
- C. Consolidated Edison (ConEd):
 - 1. 1. EO-17 - Purchase and Test Specification for Ethylene-Propylene Rubber Insulated Cables 5,000- to 35,000-Volts
- D. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 1202 – Flame Testing of Cables
- E. National Fire Protection Association (NFPA):
 - 1. 70 - National Electric Code (NEC)

F. National Electrical Safety Code (NESC)

1.04 NOTED RESTRICTIONS

None Noted

1.05 QUALITY CONTROL

None Listed

1.06 SUBMITTALS

A. Test procedures and reports, for tests specified, shall conform to the requirements herein. Six copies of each test procedure shall be submitted to the Resident Engineer for review at least 60 days prior to performing the tests.

1. Detailed test procedures will not be required if such procedures are adequately described in ANSI, IEEE or NEMA Standards or standards reviewed by the Resident Engineer and copies of the standards are submitted with the related test. Include the following in all detailed test procedures (minimum requirement):
 - a. Test purpose
 - b. Applicable standards or code including specific paragraph or section reference
 - c. Equipment to be tested
 - d. Test equipment
 - e. Chronological step-by-step test sequence
 - f. Pass/fail acceptance criteria
 - g. Test data form for recording and documenting test information
 - h. Pass/fail test conclusions
 - i. Signature of personnel
 - j. Date of testing
2. No testing shall commence until the Resident Engineer reviews the test procedures.
3. No testing shall commerce until all control equipment, keypads, alarms, detectors, and switches have been checked as an integrated system in accordance with the manufacturer's recommendations.
4. Contractor shall prepare test reports. Two copies shall be submitted for Engineer review and comments. After acceptance, six final copies of the certified test report shall be submitted to the Resident Engineer.

1.07 DELIVERABLES

A. Four hard copies and one CD-ROM of the certified test reports for all field tests

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION**3.01 FACTORY TESTING****A. Medium Voltage Power Transformer:**

1. The transformer shall be completely assembled, and tested at the factory in accordance with ANSI C57.12.91.
2. Tests shall include, but not be limited to, the following.
 - a. Resistance measurement for each winding on the rated voltage connections prorated to the reference. Data sheets shall indicate resistance of the coils in series.
 - b. Turns ratio tests at nominal voltage tap and at all other tap connections
 - c. Polarity, phase relation, and phase rotation (angular displacement) at nominal voltage tap
 - d. No-load loss at 100 and 110 percent rated voltage
 - e. Excitation losses and current at rated 90 percent and 110 percent rated voltage
 - f. Impedance and load loss at 25, 50, 75 and 100 percent rated current on rated voltage connections
 - g. Temperature Rise Tests: Certified test results of previously-built units of the type and size specified will be accepted in lieu of actual tests.
 - h. Applied potential tests
 - i. Induced potential tests
 - j. Impulse Test on All Terminals: Test may be conducted on one transformer of each type and rating. Windings shall be designed and constructed so that there will be no corona discharge during any of the impulse tests. Should that unit fail the test, all other units shall be tested. In the event that the selected transformer fails the test, all transformers of same type and rating will be tested. Any transformer that fails the test will not be accepted, nor will a repaired damaged transformer be accepted.
 - 1) Tests shall be in accordance with ANSI C57.12.91.
 - 2) One test shall be at reduced voltage, one at full wave, and two chopped waves.
 - 3) The reduced wave shall have a crest value between 50 and 70 percent of the full wave amplitude. The chopped wave shall

be chopped no sooner than 1.5 microseconds from point of origin.

3. Audible Sound Level Test: Provide a transformer design that limits the audible sound level not to exceed 62 db.
 4. Partial Discharge Test
- B. Medium Voltage Circuit Breakers:
1. The switchgear shall be tested in accordance with the Production Test outlined in ANSI C37.20.2 and ANSI C37.55 and shall include but not be limited to the following:
 - a. Dielectric Tests
 - b. Mechanical Operation Tests
 - c. Grounding of Instrument Transformer Cases Tests
 - d. Electrical Operation and Control Wiring Tests
 2. All circuit breakers shall be tested in accordance with the Production Tests outlined in ANSI C37.09 and C37.54 and shall include but not be limited to the following:
 - a. Current transformer test
 - b. Nameplate check
 - c. Resistors, heaters, and coils check tests
 - d. Control and secondary wiring check tests
 - e. Clearance and mechanical adjustment check tests
 - f. Mechanical operational tests
 - g. Timing test
 - h. Store energy system test
 - i. Low frequency withstand voltage tests on major insulation components
 - j. Low frequency withstand voltage tests on control and secondary wiring

3.02 FIELD TESTING

- A. General Requirements:
1. After installation of the system has been completed, conduct functional and operational tests, similar to the witnessed factory tests, to verify the system has been properly installed and operating including the following system elements:
 - a. Medium voltage power transformer
 - b. 15 kV Class Circuit breakers

- c. Relay Protection system
 - d. AC Control Panel
 - e. Substation control battery system
 - f. Substation grounding system
 - g. Fire Alarm system
 - h. Electric Service Cables
 - i. Distribution Cables 15 kV
- B. Medium Voltage Power Transformer:
- 1. The transformer shall be completely assembled, wired, and tested in accordance with manufacturer's recommendations.
 - 2. Testing shall be performed in the following manner:
 - a. Before any tests are performed, continuity and correctness of all windings shall be checked and all ground connections shall be checked and tested.
 - b. Equipment ground resistance shall have a maximum acceptable ground resistance when measured to the substation ground bus or building steel. Each winding of the transformers shall be checked for freedom from ground per the manufacturer's recommendations.
 - c. With primary disconnect breaker open, the transformer secondary windings and switchgear cubicle grounded to the test ground, and any current transformers shorted, each transformer primary winding shall be given a megger test and high potential test immediately followed by a second megger test. The test shall include all taps for voltage adjustment.
 - d. Each transformer secondary winding rated greater than 600 volts shall be given a megger test and a high potential test with the secondary breaker racked in, but in the open position, and the neutral lead (if applicable) disconnected, the switchgear bus grounded to the test ground, and any current transformer shorted. Upon successful completion of the high potential test, perform a follow-up megger test to detect any damage incurred by high voltage stress.
 - e. The sequence of megger and high potential test shall be as follows:
 - 1) Megger test shall be applied to determine condition of insulation.
 - 2) The high potential test shall be applied only if the megger test passes minimum requirements.
 - 3) The successful high potential test shall be followed immediately by another megger test in order to detect any damage incurred by high voltage stresses. Utilize only dc

high potential voltage and in accordance with recommendations by the transformer manufacturer.

- f. Each transformer secondary winding operating at 600 volts or less shall be given megger test only. The test shall include any taps for voltage adjustment.
 - g. Apply megger and high potential test on each transformer winding between all phases tied together and ground. All windings and adjacent cables or breaker contacts not included in the test shall also be grounded.
 - h. All control, alarm, and metering circuits shall be checked for proper operation.
 - i. Values of all results of all tests shall be in accordance with the manufacturer's recommendations.
- 3. Circuit Breaker Control and Sequence Tests:
 - a. Develop test procedures for function tests and for control and sequence tests of all circuit breakers and submit to the Resident Engineer for approval prior to testing for the following work:
 - 1) Commissioning of Controls for Incoming Line AC Circuit Breaker 52-L1. (Similar for 52-L2, 52-L3, 52-L4, and 52-L5)
 - 2) Commissioning of Controls for Bus Tie Circuit Breaker – TB1 (Similar for 52-TB2, 52-TB3, and 52-TB4)
 - 3) Commissioning of Controls for Transformer Breaker 52-M1 (Similar for 52-M2, 52-M3, 52-M4, and 52-M5)
 - 4) Commissioning of Controls for Feeder Breaker 52-F1 (Similar for breaker 52-F2, 52-F3, 52-F4, and 52-F5)
- C. Fire Alarm System: Develop test procedures for function tests of the fire alarm system and submit to the Resident Engineer for approval prior to testing.
- D. Battery/Battery Charger Test: Develop test procedures for function tests of the battery systems and submit to the Resident Engineer for approval prior to testing. Include the following test values in the testing plan:
 - 1. Specific gravity
 - 2. Cell voltage
 - 3. Equalize charge
- E. 13.2 kV Electric Service Cable:
 - 1. Design Tests: Vertical tray flame test in accordance with IEEE 1202 – Flame Testing of Cables for Use in Industrial and Commercial Occupancies.
 - 2. Production Tests:

- a. Submit production test procedure for ConEd and Resident Engineer review and approval.
 - b. A conductor-to-ground test for five minutes shall be applied in accordance with the voltage level specified in ConEd Standard EO-17.
 - c. Corona Test: Each reel of shielded power cable shall comply with the partial test requirements of AEIC CS-6-87 Section F.
 - d. Perform applicable tests described in ConEd Standard EO-17 Paragraph 8.0.
- F. 13.2 kV (15 kV-class) Power Cable Other than Electric Service Cable:
- 1. Design Tests: Vertical tray flame test in accordance with IEEE 1202.
 - 2. Production Tests:
 - a. Submit production tests to the Resident Engineer for review prior to installation of the cable.
 - b. A conductor-to-ground test at specified ac test voltage for five minutes shall be applied.
 - c. Corona Test: Each reel of shielded power cable shall comply with the partial discharge test requirements of AEIC CS-6, Section F.

END OF SECTION

(THIS PAGE INTENTIONALLY LEFT BLANK)